

*Taras Shevchenko National University of Kyiv
(Faculty of Cybernetics)
University of Defence, Brno, Czech Republic
International Institute for Applied Systems Analysis
(Austria)
Glushkov Institute of Cybernetics of NAS of Ukraine
System Analysis Committee of Presidium National
Academy of Sciences of Ukraine
Academy of Sciences "Vysha Skola" of Ukraine
Brno Local Chapter of Union of Czech Mathematicians
and Physicists*

XX International Conference

PROBLEMS OF DECISION MAKING UNDER UNCERTAINTIES (PDMU-2012) September 17-21, 2012

ABSTRACTS

Brno, Czech Republic

**Kyiv
2012**

УДК 007 (100)(06)
ББК 32.81я43

INTERNATIONAL PROGRAM COMMITTEE

A.Nakonechny (Ukraine) - Chairman

**F.Chernousko (Russia), A.Chekriy (Ukraine),
J.-F.Emmenegger (Switzerland), Yu.Ermoliev
(Austria), I.Gaishun (Belarus), I.Herlin (France),
S.Hudak (Slovakia), J.Kaluski (Poland),
V.Korolyuk (Ukraine), A.Kurzhanskii (Russia),
A.Lindquist (Sweden), J.Michalek (Czech
Republik), I.Sergienko (Ukraine), Ya.Savula
(Ukraine), Yu.Shestopalov (Sweden), O.Zakusylo
(Ukraine)**

NATIONAL ORGANIZING COMMITTEE

A.Anisimov – Chairman

V. Holcner - Chairman

**M.Bartish, I.Beyko, M.Bratychuk, Ya. Chabanuk,
V.Donchenko, O.Iksanov, F.Garashchenko,
P.Knopov, P.Kostrobi, E.Lebedev, I.Lyashenko,
V.Martsenyuk, N.Semenova, F.Sopronyuk,
A.Vlasyuk, Ya.Yeleiko, V.Zaslavsky**

LOCAL ORGANIZING COMMITTEE

P.Zinko - Chairman

**O.Lukovych, E.Kapustyan, M.Loseva, T.Korobko,
O.Pavluchenko, M.Sedlačík, L.Doudová,
J.Neubauer, M.Šmerek, E.Hájková, K.Vopatová,
M.Vágner, J.Moučka, Z.Zemánek, K. Lepka**

ISBN 978-966-8725-07-4

CONTENT¹

СОДЕРЖАНИЕ

Bakhrushin V.E., Bakhrushin A.V.

Peculiarities of non-linear cross-correlation analysis with different methods of bond strength determining 15

Bakhrushin V.E., Dudko I.O., Ignakhina M.O.

The procedure of distribution models identification from empirical data 16

Beyko I., Valid AlBain

Extremal strategies in pursuit-evasion differential games 17

Beyko I., Shchyrba O.

Interior point methods for optimization of distribute processes 18

Beyko I., Zinko P.

Solve-operator methods for optimization of controlled stochastic processes 19

Biletskyi A., Biletsky B.

Intracellular processes modeling using active particles 22

Biriukov D., Zaslavsky V.

Risk models for critical infrastructure protection planning 23

Bomba A., Gavryliuk V., Terebus A.

Complex modeling of filtration processes in hydraulic structures under uncertainties 25

Bratiichuk M., Protopop Iu.

Erlang retrial queues with hysteresis strategies of input flow 26

Chabanyuk Y., Gorun P.

Asymptotic view of generator of jumping optimization procedure in markov media in diffusion approximation scheme 27

Ceranka B., Graczyk M.

Some new construction of regular E-optimal spring balance weighing design for even number of objects 28

¹ The abstracts are publishing in authors edition
Тезисы печатаются в авторской редакции

Chechelnitski A., Gubeladze A., Kucherenko O.	
Diffusion approximation of multichannel queues at the network models with the parallel structure and common flow	29
Correll Ray	
Reformulating problems to give better solutions.....	31
Demchuk M. B.	
Justifications of grouting models.....	32
Dolenko G.A.	
Methodological approach to forming evaluation system for innovation economic development	34
Donchenko V.S.	
Some examples of membership functions out of fuzzy theory: principal consequence.....	35
Donchenko V.S., Zinko T.P.	
Object representatives: vector and matrix in mathematical modelling ..	37
Emelichev V. A., Korotkov V. V.	
Stability analyses of lexicographic optimum of Markowitz's BI-criteria problem with wald's and savage's criteria	38
Fusek, M., Michálek, J.	
Statistical inference of left-censored samples from weibull distribution.....	40
Golodnikov A.N., Knopov P.S.	
Some approaches to pattern recognition.....	41
Golubeva K.M.	
Image segmentation of nuclei	41
Graczyk M.	
On a-optimality of spring balance weighing	42
Grebennik I., Lytvynenko O., Titova O.	
Optimization of linear functions on cyclic permutations.....	43
Herlin Isabelle, Huot Etienne	
Predicting surface currents from uncertain image observations	44

Holcner Vladan

European defense sector in 21st century – dealing with increasing uncertainty 45

Holešovský, J., Popela, P.

Stochastic extensions of a traffic assignment problem 46

Hübnerová Z., Doudová L.

Comparison of powers of some tests in one-way anova type model with negative binomial distribution 46

Iemets O.O., Yemets` O.O.

About the problem of growing of a discrete fuzzy number carrier during algebraic operations 47

Iksanov A.

On the number of empty boxes in the bernoulli sieve 48

Ilkiv V. S.

Probabilities for existence of solution of the problem with nonlocal conditions for a system of pde with spatial shifts 48

Ivanchuk V.V.

Automation of rectification process in food industry 49

Jakowska-Suwalska K., Wolny M.

Support planning model of demand for materials in coal mine 50

Kaluski Jan

Application of the stackelberg duopoly model to decision problem in mining enterprises resolution 51

Kapustyan O.V., Kapustian O.A.

Approximated regulator in optimal control problem for parabolic inclusion 53

Khalymon O.

A new time-saving variant of Korpelevich's method for variational inequality problems 54

Khimka U., Chabanyuk Y.

Fluctuations of stochastic optimization procedure with impulse perturbations 55

Khusainov D., Manovytska D.

About one model of the disease transmission process 56

Kindyaliuk A., Prytula M.

Finite dimensional reduction of nonlinear hydrodynamic thin layered flows evolution on invariant twodimensional submanifold..... 57

Kiykovska O., Chabanyuk Y.

Dynamic random evolutions in asymptotic small diffusion scheme 59

Klesov O. I.

Almost sure convergence of risk processes 60

Korkuna N., Tseheluk H.

Mathematical model of optimal tax rate 61

Korolyuk V., Dolenko G., Lobach S.

Approach to evaluation of distribution of intervals between terroristic ACTS 62

Krejčová Bc. Iva, Bína Ing. Vladislav

Means of parallel programming in managerial decision making..... 62

Křivánková Lenka

Continuous-time models in portfolio theory 63

Kukurba V.R., Chabanyuk Ya.M., Kinasch O.M.

Convergence of the stochastic optimization procedure with Semi-Markov's switchings in diffusion approximation scheme 64

Lebedev E.A.

State – dependent retrial queues 65

Lebedeva T.T., Semenova N.V., Sergienko T.I.

Vector discrete optimization problems: a stability analysis 66

Lebyedeva T.S., Shpylovyi P.B., Ozerov M.V.

On a model of the transition layer of thin-film structures 68

Livinska H.

The transitional and stationary regime for network of the type
 $[M_t | G | \infty]^r$ 69

Lutskiv A., Lupenko S., Zagorodna N.

The creation of cryptographic keys based on on-line signature 70

Maksishko N. Use of discrete nonlinear dynamics tools in decision-making on the stock market	72
Martsenyuk V.P., Andrushchak I.Ye., Gandzyuk N.M., Klymuk N.Ya., Kuchvara O.M., Mayhruk Z.V. Decision support system for medical system research	73
Martsenyuk V.P., Bagrij-Zayats O.A. On optimal control problem in model of pathological formation growth based on the richard dynamics	78
Martsenyuk V.P., Chernetskyy D.V. Optimal control by the process of aerosols sedimentation of heavy metals.....	79
Martsenyuk V.P., Gandzyuk N. M. Construction of the exponential estimate in the compartment system with distributed delay based on Hale-Lunel's inequalities.....	80
Martsenyuk V.P., Melenchuk I.B., Kravets N.O. Physiologically-based pharmacokinetic modeling of nanoparticles.....	81
Martsenyuk V.P., Sarabun R.O. Generation of synthetic ecg-signals with the help of mesharry model...	82
Mashchenko S.O., Bovsunivskiy O.M. The alternatives selection problem on the fuzzy set of clear goals	83
Maykhruk Z.V. Research of nonlinear dynamics and chaos characteristics in the models of medical-biological processes.....	84
Mazal Jan, Stodola Petr, Mokrá Ivana Mathmodelling of the tactical activities	85
Mazal Jan, Stodola Petr, Rybanský Marian Integration of the geographical and perational analyssesin the tactical maneuver management.....	85
Mazal Jan, Stodola Petr Traffic management optimization and its modeling.....	86
Menshikov Yu.L. About methods of decision adoption under uncertainties.....	86

Morozov D. Functional representation of automorphisms of rooted spherical homogeneous tree	87
Muzychuk A. Informational and sociological effect on decisions under uncertainty ...	88
Nakonechny O.G., Donchenko V.S., Zinko P.M. Guaranteed estimation of the observations matrix for systems with variable structure	89
Neubauer J., Odehnal J. Selected quantitative methods of economic time series description.....	91
Nochvai V., Kryvakovska R. Uncertainty analysis in information system for air quality management.....	92
Odehnal J., Neubauer J. Model of military spending and economic growth.....	93
Okhremenko A.E., Stepanov O.V., Chernij D.I. Mobile Systems for forecasting and decision support information	94
Osadcha O., Skripnik N. The scheme of partial averaging for one class of hybrid systems	96
Pashko A.A. Simulation of random fields on the sphere in functional spaces	98
Pastushenko V., Stetsenko A. Development of neo-fuzzy model of non-saturated part of soil	100
Podlipenko Yu. K., Grishchuk N.V., Kovalyuk A. Optimal estimation of functionals from solutions to transmission problems for linear parabolic equations by point observations	101
Podlipenko Yu., Shestopalov Yu. Approximate minimax estimates of functionals from right-hand sides of maxwell equations	102
Polyakov V., Zhelizko V. Hydrodynamic deformations in porous media: theory and applications.....	103

Ponomarov V.	
On approximation of controlled retrieval queues	104
Pryshchepa O.	
Retrieval queues with limited number of retrievals	105
Redych O.	
Decision-making in the management of the tax authorities on the basis of integrated performance indicators	106
Rozora I., Lukovych O.	
On simulation of stochastic processes with accuracy and reliability ..	107
Sant Lino	
Harnessing empirical characteristic function convergence behaviour .	108
Savula Ya., Dyyak I., Mykhaskiv V., Olendiy O.	
Computer modelling of composites using heterogeneous numerical schemes	109
Sedlačík, M., Odehnal, J., Michálek, J.	
Statistical analysis of dependences between terrorist threat and political and economic developments.....	110
Semenov V.V.	
Genetic algorithms of solving of vector discrete optimization problems	111
Shatyрко O., Khusainov D.	
Modeling processes of the population dynamics.....	112
Shchestyuk N., Shabalin D.	
Chaotic deterministic systems for risky asset models	113
Shestopalov Yury	
Collective mark setting in discrete models of decision making	114
Shkilniak O.S.	
Logical means of dynamic and information systems description taking into consideration uncertainty and incompleteness	116
Shpak P., Yeleyko Y.	
Some properties of killed Markov decision processes	117

Sklenar J., Borg D. S., Popela P.

Application of reinforcement learning in airline revenue management..... 118

Slabospitsky A.S.

Recurrent parameter estimation algorithms with splitted structures for nonlinear systems under uncertainties by least squares method with minimal deviation norm from ‘attraction’ points 119

Sojda Adam

Determination of enterprise value by using the a fuzzy pay-off method for real option valuation 120

Stadlober Ernst, Scheibelhofer Peter

Regression trees and random forests for predictive maintenance in semiconductor manufacturing 121

Stefanyshyn D.V.

Experience the accident risk assessment on some large dams..... 122

Stojar R.

Decision making in environment of asymmetric conflicts 123

Sudavtsova V.S., Shevchenko M.A., Kudin G. I., Kudin V.G., Kobilinskaya N. G.

Calculation of the components thermodynamical activities of the binari melts 123

Usar I., Makushenko I.

Retrial queues with cotrolled of input flow 125

Vergunov V.

State monetary policies based on the control of the demand of alternative assets 126

Vergunova I.

The algebraic functional structures for the analys of the agrotechnologies..... 127

Vlasyuk A.P., Drozdovskiy T.A.

Mathematical modelling of building ground foundation stress-strain state change under fixing 128

Vlasyuk A.P., Fedorchuk N.A.

Mathematical modelling of stressed deformed state change of soil dam base with core under heat-mass transfer 131

Vojtová Michaela

Optimization of deterministic population dynamics models 133

Voloshchuk S.D.

Mathematical modeling of dynamical systems with uncertain initial-boundary condition 134

Vopatova Kamila

Iterative bandwidth selection in kernel discriminant analysis 135

Zahorodnii Yu., Korobko T.

About one random search algorithm of parameters identification for one model of developing system 135

Žampachová Eva

Stochastic optimization of a transversely vibrating cantilever beam ... 137

Zaslavska O.

Optimization problems of infrastructure facilities allocation 138

Zhernovyi K.

Hysteresis strategy for $M^{\theta}/G/1/m$ queue with two-speed service and blocking of input flow 140

Zhuk S., Frank J., Herlin I., Nakonechny O.G.

Iterative minimax optical flow estimation from a sequence of satellite images..... 141

Zhyrytskyy V.

Methods of distract analysis of test tasks in remote learning system «VITAVA» 142

Анафиев А.С.

Оптимизационные модели с прецедентной начальной информацией..... 143

Анищенко В.А.

К вопросу об уточнении методики решения задач экологического менеджмента 144

Близорукова М.С., Максимов В.И.

О реконструкции неизвестных характеристик систем с
последствием при измерении части координат 146

Валеев К.Г., Шушарин Ю.В.

Дифференциальные уравнения с запаздывающим аргументом,
описывающие немарковский случайный процесс..... 147

Власюк А.П., Багнюк О.М.

Идентификация неизвестных параметров источника загрязнений в
двухмерных нестационарных задачах массопереноса 148

Власюк А.П., Дроздовский Т.А.

Математическое моделирование изменения напряженно-
деформированного состояния грунта при нагнетании в него
вязящего раствора 150

Власюк А.П., Цветкова Т.П.

Математическое моделирование массопереноса при фильтрации и
лагопереносе в насыщенно-ненасыщенных слоистых грунтах.... 152

Дигас Б.В., Розенберг В.Л.

Оптимизационная модель биполярного рынка квот на выбросы
парниковых газов..... 154

Дидковская Б.В., Навродский В.А.

Моделирование типичных зависимостей объемов экспорта
Украины в европейские страны 155

Гаркуша Н.И.

Экологические модели динамики. дискретная модель лесли с
последствием 156

Заворотный А.Л., Касьянюк В.С.

Парето-оптимальный подход к задаче восстановления
функциональных зависимостей в условиях нечеткости 157

Зайченко Ю.П., Гасанов А.С.

Сравнительный анализ методов прогнозирования макроэкономи-
ческих показателей Украины 158

Ивохин Е.В., Аджубей Л.Т., Харченко И.И.

Использование нейронных сетей для прогнозирования нечетких
данных 159

Искендеров А.Д., Ягубов Г.Я., Ибрагимов Н.С., Мусаева М.А.	
Задача идентификации для нелинейного нестационарного уравнения Шредингера по наблюдению на всей области	160
Касьянюк В.С.	
Об использовании теоретико-возможностного подхода к задаче обработки и интерпретации измерений.....	162
Квасний М. Н., Голубец В. В.	
ARIMA-LI прогноз качества кредитного портфеля банка.....	163
Козин И.В.	
Неманипулируемый механизм выбора с сепарабельной целевой функцией	167
Лукашив Т.О., Никитин А.В.	
Об устойчивости в среднем квадратическом в целом управляемых стохастических динамических систем случайной структуры с пуассоновыми возмущениями.....	169
Ляшенко И.Н., Тадеев Ю.П.	
Оптимальное управление инвестициями в производственные фонды, интеллектуальный капитал, охрану окружающей среды.....	171
Максимов В.И.	
О реализации заданного качества процесса управляемой системы в условиях неопределенности	172
Мензатов Л.Ш., Лебедев Е.А.	
Об оптимальном управлении потоками в сетях Эрланга	174
Назарага И.М.	
Об одном подходе к нахождению темпа научно-технического прогресса	176
Наконечный А. Г.	
Прогнозные оценки решений начально-краевых задач для уравнений параболического типа в условиях неопределенности	177
Наконечный А.Г., Демиденко С.В.	
Гарантированные оценки интенсивности источников в задачах переноса и диффузии	178

Наконечный А.Г., Шушарин Ю.В.

Об устойчивости на конечном интервале времени решений
стохастических дифференциальных уравнений 180

Огуленко А.П., Кичмаренко О.Д.

Схема полного усреднения динамических систем на временных
шкалах 181

Савула Я., Щербата Г., Щербатый М.

Анализ чувствительности решений задач гетеродиффузии при-
месного вещества относительно изменений параметров среды 182

Семенов В.В.

Межрегиональное выравнивание в системе межбюджетных
трансфертов Украины 183

Стеля О.Б., Стеля И.О.

Решение обратной задачи переноса загрязнений речным
потоком 184

Тарасова О.В.

Об основных подходах к моделированию медиапоказателей 185

Тимофеева Н.К.

Обобщение метода структурно-алфавитного поиска 186

Чухрай Л.В., Чухрай В.Є.

Минимаксное оценивание в гиперболических уравнениях с раз-
рывными коэффициентами при неполных наблюдениях 187

Шарапов М.М., Обруч Т., Маренец О.

Статистическая обработка результатов тестирования программой
INDEX 189

Шарапов М.М., Пархомец А.Д.

Реализация отношения предпочтения в условиях
неопределенности 190

Шахно С.М., Ярмола Г.П.

Условия сходимости двухпараметрического метода типа хорд для
решения нелинейных уравнений с учетом погрешностей
округлений 191

PECULIARITIES OF NON-LINEAR CROSS-CORRELATION ANALYSIS WITH DIFFERENT METHODS OF BOND STRENGTH DETERMINING

Bakhrushin V.E., Bakhrushin A.V.

Vladimir.Bakhrushin@gmail.com

Cross-correlation analysis is a widely used method for solving the problems of bond strength determining at dynamics of several parameters. One of the problems that arise at its application is the possibility of non-linear bonds. In this case the results of bond strength may be significantly underestimated. The most popular statistical software, such as Statistica, SPSS and so on has no tools for determining of non-linear cross-correlation. Only the Pearson correlation coefficient is available for time-series correlation analysis. Therefore, it was proposed in [1] to use the sample determination coefficient as an index of bond strength for such problems solving and appropriate software was developed. It may be calculated as $K_d = 1 - SS_{err} / SS_{tot} = SS_{reg} / SS_{tot}$, where SS_{err} – residual sum of squares, SS_{tot} – total sum of squares, SS_{reg} – regression sum of squares. For the sample coefficient of determination SS_{err} is calculated for the model of the piecewise constant function, for which one of the series is preordered in ascending order. Lately it was shown [2] that the accuracy and reliability of obtaining determination coefficient values may be essentially increased if the unknown model values are calculated as moving averages of initial data. But in this case another difficulty for the cross-correlation analysis may occur. It consists in the fact, that within the statistical error such coefficient of determination is independent on lag. Thus it is proposed to use proposed in [2] method for the time series, one of which is preordered in ascending order. Appropriate software is designed.

References

1. Бахрушин В.Є., Павленко В.Є., Петрова С.В. Застосування показників нелінійної кореляції для побудови й аналізу крос-кореляційних функцій // Складні системи і процеси. – 2009, № 2. – С. 78 – 85.
2. Бахрушин В.Є. Методи оцінювання характеристик нелінійних статистических зв'язей // Системні технології: Регіональний міжвузівський збірник наукових праць. Дніпропетровськ, 2011. – № 2(73). – С. 9 – 14.

THE PROCEDURE OF DISTRIBUTION MODELS IDENTIFICATION FROM EMPIRICAL DATA

Bakhrushin V.E., Dudko I.O., Ignakhina M.O.

Vladimir.Bakhrushin@gmail.com

The usual procedure of distribution model identification involves forming hypothesis about the type of distribution and its verification by means of one or more standard criteria. Model parameters are given either a priori or determined by the sample moments, such as arithmetic mean and standard deviation for the normal distribution.

This procedure arose when it was not possible to use modern computing power. Today there is a sense to enter one more step – refinement of parameters by using the procedure of minimization of some objective functional [1]. As an objective functional it is advisable to use the residual sum of squares or the maximum absolute residual value. First of them corresponds to ω^2 test and the second – to the Kolmogorov – Smirnov test. In some case objective functional minimization gives an opportunity essentially close the model to the empirical distribution function.

But there is a serious problem, that the critical values of criteria are determined within some assumptions about the type of model and on model parameters determination procedure. Most commonly it is assumed that its values were determined regardless of the sample. Sometimes the sample distribution moments are used as parameters. But in this case critical values are smaller. It can be assumed that using of minimization step will further reduce the critical values, but we don't know their exact values. So we propose to use standard criteria of models adequacy, such as residuals properties for solving the problem. The validity of this approach is confirmed by the practice of distribution models identification and computer experiments.

References

1. Бахрушин В.Е. Проблемы идентификации моделей распределения случайных величин с применением современного программного обеспечения // Успехи современного естествознания. – 2011. – № 11. – С. 50 – 54.

EXTREMAL STRATEGIES IN PURSUIT-EVASION DIFFERENTIAL GAMES

I.Beyko¹, Valid AlBain²

¹National Technical University of Ukraine “Kyiv Politechnic Institute”

²Syria University

ivan.beyko@gmail.com

Using convex approximations of the families of optimal terminal surfaces of terminal states we develop numerical algorithms for designing extremal control strategies of the minmax time pursuit-evasion differential game:

$$\begin{aligned} T_{v,u} &= \arg \max_v \min_u t \mid x_{i_x}(t) = y_{i_y}(t), \\ i_x &\in I_x \subset \{1, \dots, q\}, \quad i_y \in I_y \subset \{1, \dots, n\}, \\ \frac{dx(t)}{dt} &= f(x(t), u(t)), \quad x(t) \in R^q, \quad u(t) \in U \subset R^r, \\ \frac{dy(t)}{dt} &= h(y(t), v(t)), \quad y(t) \in R^n, \quad v(t) \in V \subset R^m. \end{aligned}$$

The designed extremal strategies use observation data $(\tau, x(\tau), y(\tau))$ to calculate extremal controls

$$\bar{u}(\tau) = \arg \max_{u \in U} (\varphi(\tau), f(\bar{x}(\tau), u)), \quad \bar{v}(\tau) = \arg \max_{v \in V} (\psi(\tau), h(\bar{y}(\tau), v)),$$

where $(\bar{x}, \bar{y}, \varphi, \psi,)$ is the solution of the boundary value problem

$$\begin{aligned} \frac{d\bar{x}(t)}{dt} &= f(\bar{x}(t), \bar{u}(t)), \quad \frac{d\bar{y}(t)}{dt} = h(\bar{y}(t), \bar{v}(t)), \\ \frac{d\varphi(t)}{dt} &= -[f'_x(\bar{x}(t), \bar{u}(t))]^T \varphi(t), \quad \frac{d\psi(t)}{dt} = -[h'_y(\bar{y}(t), \bar{v}(t))]^T \psi(t), \quad t \in [\tau, T], \\ \bar{x}(\tau) &= x(\tau), \quad \bar{y}(\tau) = y(\tau), \quad \bar{x}_{i_x}(T) = \bar{y}_{i_y}(T), \quad \varphi_{i_x}(T) = \psi_{i_y}(T), \quad i_x \in I_x, \quad i_y \in I_y, \\ t &\in [\tau, T]. \end{aligned}$$

To calculate extremal controls in real time the iterative algorithm is proposed. At the first step we calculate (x, y, φ, ψ) satisfying initial conditions

$$\varphi_{i_x}(0) = \psi_{i_y}(0) = y_{i_y}(0) - x_{i_x}(0) \quad \text{for } i_x \in I_x, \quad i_y \in I_y;$$

$$\varphi_{i_x}(0) = 0 \quad \text{для } i_x \notin I_x, \quad \psi_{i_y}(0) = 0 \quad \text{for } i_y \notin I_y, \quad x(0) = x^0, \quad y(0) = y^0$$

in search for the first moment $T \geq 0$ satisfying $z(t) = 0$, where

$$z(t) \triangleq (\varphi(t), y(t) - x(t)), \quad \frac{dx(t)}{dt} = f(x(t), \bar{u}(t)), \quad \frac{dy(t)}{dt} = h(y(t), \bar{v}(t)),$$

$$\frac{d\varphi(t)}{dt} = -[f'_x(x(t), \bar{u}(t))]^T \varphi(t), \quad \frac{d\psi(t)}{dt} = -[h'_y(y(t), \bar{v}(t))]^T \psi(t),$$

$$\bar{u}(\tau) = \arg \max_{u \in U'}(\varphi(\tau), f(x(\tau), u)), \quad \bar{v}(\tau) = \arg \max_{v \in V'}(\psi(\tau), h(y(\tau), v)).$$

If for all $i_x \in I_x$, $i_y \in I_y$

$$|\bar{x}_{i_x}(T) - \bar{y}_{i_y}(T)| \leq \varepsilon, \quad |\varphi_{i_x}(T) - \psi_{i_y}(T)| < \varepsilon,$$

then the ε -extremal control is obtained. Otherwise the following new values of $\varphi(0), \psi(0)$ are calculated

$$\varphi(0) := (\varphi(0) + \lambda \bar{\varphi}(0)) / \|\varphi(0) + \lambda \bar{\varphi}(0)\|, \quad \psi(0) := \bar{\psi}(0) / \|\bar{\psi}(0)\|,$$

$$\frac{d\varphi(t)}{dt} = -[f'_x(x(t), \bar{u}(t))]^T \varphi(t), \quad \bar{\varphi}_{i_x}(T) = \begin{cases} y_{i_y}(T) - x_{i_x}(T), & i_y \in I_y, \\ 0, & i_y \notin I_y, \end{cases}$$

$$\frac{d\psi(t)}{dt} = -[h'_y(y(t), \bar{v}(t))]^T \psi(t), \quad \bar{\psi}_{i_y}(T) = \psi_{i_y}(T) + \lambda \varphi_{i_x}(T)$$

by choice of λ in order to satisfy the inequality $z(T) > 0$.

The developed iterative procedures for the ε -extremal control calculation are implemented in the design of optimized three-level real-time pursuit-evasion strategies. The sensitivity problems of the designed strategies are investigated.

INTERIOR POINT METHODS FOR OPTIMIZATION OF DISTRIBUTE PROCESSES

Beyko I., Shchyrb O.

National Technical University of Ukraine “Kiev Politechnic Institute”

ivan.beyko@gmail.com

Using interior point methods we develop numerical algorithms for optimizing control processes described by linear partial differential equations. In order to design direct optimization algorithms the linear state equations are discretized to obtain a linear programming optimization problem that are solved by efficient liner programming interior point algorithms. In this way implementation of power computers allow the handling of a great variety of complicated optimization problems. Taking into account that discretized models of many-dimensional partial differential equations become of grate dimension we consider calculation problems of interior point methods in infinite-dimensional spaces. Numerical realizations comprise continuation techniques, inexact Newton methods, discretization

schemes, and error estimators of linear solvers for optimal control problems with partial differential equations. The encountered difficulties of existence and convergence of the central path are discussed by application of inexact path following methods of interior point type formulations in infinite dimensional optimal control problems.

SOLVE-OPERATOR METHODS FOR OPTIMIZATION OF CONTROLLED STOCHASTIC PROCESSES

¹Beyko I., ²Zinko P.

¹National Technical University of Ukraine “Kiev Politechnic Institute”

²Taras Shevchenko National University of Kyiv, Ukraine

ivan.beyko@gmail.com

We develop computational solve-operator procedures for stochastic processes simulation and risk optimization under parametric uncertainties. In a rather general form the solution u^* of a risk optimization problem is defined as the minimizer $u^* = \arg \min_{u \in \Omega} \bar{F}(u)$ of a risk function $\bar{F}(u) = E \max_{q \in Q} \bar{f}(u, q, \theta)$, where u is the control input, q is an uncertainty parameter, θ is a random variable defined on a probability space (Θ, Σ, P) , $\bar{f}(u, q, \theta)$ is a random performance function, $\bar{F}(u)$ is the expected performance indicator, Q is a set of uncertainty, and Ω is a feasible control set.

We consider time and space multidimensional interdependent risk processes where the random performance function $\bar{f}(u, q, \theta) = \tilde{f}(x(u, q, \theta), u, q, \theta)$ depends on the stochastic process $x(u, q, \theta)$ that is simulated by the graph-operator system

$$\begin{aligned} A(x, u, q, \theta) &\triangleq (A_1(x, u, q, \theta), \dots, A_{N_k}(x, u, q, \theta)) = 0, \\ A_k(x, u, q, \theta) &\triangleq (A_{k1}(x_{k1}, z_{k1}, u_{k1}, q_{k1}, \theta_{k1}), \dots, \\ &\dots, A_{kN_{ks}}(x_{kN_{ks}}, z_{kN_{ks}}, u_{kN_{ks}}, q_{kN_{ks}}, \theta_{kN_{ks}})), \\ (x, u, q, \theta) &\triangleq \{(x_k, u_k, q_k, \theta_k)\}_{k=1}^{N_k}, \quad (x_k, u_k, q_k, \theta_k) \triangleq \{(x_{ks}, u_{ks}, q_{ks}, \theta_{ks})\}_{s=1}^{N_{ks}}. \end{aligned}$$

The ks -th subsystem $A_{ks}(x_{ks}, z_{ks}, u_{ks}, q_{ks}, \theta_{ks}) = 0$ of the graph's k -th knot describes interdependences between the ks -th subsystem's states x_{ks} , controls u_{ks} , uncertainty parameters q_{ks} , random parameters θ_{ks} , and influences z_{ks} with the subsystem environment, $z_{ks} = \varphi_{ks}(x, u, q, \theta)$, $k = \overline{1, N_k}$, $s = \overline{1, N_{ks}}$.

Computational procedures for calculation $x_{ks}(u_{ks}, q_{ks}, \theta_{ks}, z_{ks})$ depend on types and dimensions of algebraic, differential, or general algebraic-integral-differential equations that describe the ks -th subsystem. In order to design efficient computational procedures for calculating $x_{ks}(u_{ks}, q_{ks}, \theta_{ks}, z_{ks})$ there are successful attempts in search for adequate approximations of stochastic subsystems $A_{ks}(x_{ks}, z_{ks}, u_{ks}, q_{ks}, \theta_{ks}) = 0$ by simplified SDE:

$$\begin{aligned} dx_{ks}^1(t) &= a_{ks}^1(u_{ks}, q_{ks}, \theta_{ks}, z_{ks})dt + b_{ks}^1(u_{ks}, q_{ks}, \theta_{ks}, z_{ks})dw(t), \\ dx_{ks}^2(t) &= x_{ks}^2(t)(a_{ks}^2(u_{ks}, q_{ks}, \theta_{ks}, z_{ks})dt + b_{ks}^2(u_{ks}, q_{ks}, \theta_{ks}, z_{ks})dw(t)), \\ dx_{ks}^3(t) &= a_{ks}^3(u_{ks}, q_{ks}, \theta_{ks}, z_{ks})x_{ks}^3(t)dt + b_{ks}^3(u_{ks}, q_{ks}, \theta_{ks}, z_{ks})dw(t), \end{aligned}$$

or by more general SD systems

$$\begin{aligned} dx_{ks}^4(t) &= (A(u(t), q(t), \theta(t), t)x_{ks}^4(t) + c(u(t), q(t), \theta(t), t))dt + \\ &\quad + B(u(t), q(t), \theta(t), t)dw(t) \end{aligned}$$

with known trajectories formulae

$$\begin{aligned} x_{ks}^1(t) &= x_{ks}^1(t_0) + a_{ks}^1(u_{ks}, q_{ks}, \theta_{ks}, z_{ks})(t - t_0) + b_{ks}^1(u_{ks}, q_{ks}, \theta_{ks}, z_{ks})w(t - t_0), \\ x_{ks}^2(t) &= \exp((a_{ks}^2(u_{ks}, q_{ks}, \theta_{ks}, z_{ks}) - (b_{ks}^2)^2(u_{ks}, q_{ks}, \theta_{ks}, z_{ks})/2)(t - t_0) + \\ &\quad + b_{ks}^2(u_{ks}, q_{ks}, \theta_{ks}, z_{ks})w(t - t_0)), \\ x_{ks}^3(t) &= x_{ks}^3(t_0) \exp(a_{ks}^3(u_{ks}, q_{ks}, \theta_{ks}, z_{ks})(t - t_0)) + \\ &\quad + b_{ks}^3(u_{ks}, q_{ks}, \theta_{ks}, z_{ks}) \int_{t_0}^t \exp(a_{ks}^3(u_{ks}, q_{ks}, \theta_{ks}, z_{ks})(t - \tau))dw(\tau), \\ x_{ks}^4(t) &= \Phi(t)x_{ks}^4(t_0) + \Phi(t) \int_{t_0}^t \Psi(\tau)(c(u(\tau), q(\tau), \theta(\tau), \tau) + B(u(\tau), q(\tau), \theta(\tau), \tau))dw(\tau), \end{aligned}$$

where $\Phi(\cdot)$ and $\Psi(\cdot)$ are the fundamental matrices of the associated homogeneous system and of its conjugate system, and $w(t) \triangleq (w_1(t), \dots, w_n(t))$ are Brownian movements

$$\begin{aligned} dw_i(t) &\triangleq w_i(t + dt) - w_i(t), \quad E(dw_i^2(t)) = \sigma_i^2 dt, \\ E(dw_i(t)dw_j(t)) &= 0 \quad \text{for } i \neq j. \end{aligned}$$

Trajectories x of subsystems that are described by nonlinear stochastic differential systems

$$\begin{aligned} dx(t) &= a(x(t), u, q, \theta)dt + b(x(t), u, q, \theta)dw(t), \\ a(\cdot) &= \{a_i(\cdot), i = \overline{1..n}\}, \quad b(\cdot) = \{b_{ij}(\cdot), i = \overline{1..n}, j = \overline{1..m}\}, \end{aligned}$$

may be calculated by iterative Euler-Maruyama method

$$x(t_{i+1}) = x(t_i) + a(x(t_i), u, q, \theta)(t_{i+1} - t_i) + b(x(t_i), u, q, \theta)(w(t_{i+1}) - w(t_i))$$

or by Milstein's higher-order method

$$x(t_{i+1}) = x(t_i) + a(x(t_i), u, q, \theta)(t_{i+1} - t_i) + b(x(t_i), u, q, \theta)(w(t_{i+1}) - w(t_i)) + \frac{1}{2} b(x(t_i), u, q, \theta) b^T(x(t_i), u, q, \theta) ((w(t_{i+1}) - w(t_i))^2 + t_i - t_{i+1}).$$

Probability densities $p \triangleq p(x, t | x_0, t_0)$ for random vectors $x(t) \in R^n$,

$a(\cdot) = (a_1(\cdot), \dots, a_n(\cdot))$, $\bar{b}_{ij}(\cdot) = \frac{1}{2} \sum_{k=1}^n b_{ik}(\cdot) b_{jk}(\cdot)$ are calculated as solutions of the

Fokker-Planck equations

$$\frac{\partial p(x, t)}{\partial t} = - \sum_{i=1}^n \frac{\partial}{\partial x_i} [a_i(x(t), u, q, \theta) p(x, t)] + \sum_{i=1}^n \sum_{j=1}^n \frac{\partial^2}{\partial x_i \partial x_j} [\bar{b}_{ij}(x(t), u, q, \theta) p(x, t)].$$

$$a(\cdot) = (a_1(\cdot), \dots, a_{n_{ks}}(\cdot)), \quad \bar{b}_{ij}(\cdot) = \frac{1}{2} \sum_{k=1}^{n_{ks}} b_{ik}(\cdot) b_{jk}(\cdot).$$

We develop higher order solve operator methods to calculate trajectories $x_{ksi}(t, p, q, \theta)$ of general control processes

$$\begin{aligned} t_0 &= \bar{t}(u_{ks0}, q_{ks0}, \theta_{ks0}, z_{ks0}) \in R, \quad x_{ks0}(t_0) = \bar{x}_{ks0}(t_0, u_{ks0}, q_{ks0}, \theta_{ks0}, z_{ks0}) \in R^{n_{ksx}}, \\ dx_{ksi}(t) &= a_{ksi}(x_{ksi}(t), u_{ksi}, q_{ksi}, \theta_{ksi}, z_{ksi}, t, \omega_{ksi}(x_{ksi}(t), t_i, q_{ksi}, \theta_{ksi}, z_{ksi}, t)) dt, \quad t \in [t_i, t_{i+1}], \\ t_{i+1} &= \tau(x_{ks(i-1)}(t_i), t_i, u_{ksi}, q_{ksi}, \theta_{ksi}, z_{ksi}) > t_i, \\ x_{ks(i+1)}(t_{i+1}) &= \psi(x_{ksi}(t_{i+1}), t_{i+1}, u_{ks(i+1)}, \theta_{ks(i+1)}, z_{ks(i+1)}), \end{aligned}$$

where $\theta_{ksi} \in \mathbb{R}^{n_{ksi}}$ are random vectors defined by distribution functions $\tilde{F}_{ksi}(\tilde{\theta}_{ksi} | (x_{ks(i-1)}(t_i), t_i, q_{ks(i-1)}, \theta_{ks(i-1)}, z_{ks(i-1)}))$. For given $\bar{q}$, $\bar{u}$, and for given realization $\bar{\theta}$ of θ , the trajectory $x(\tau) \triangleq x(\tau, \bar{u}, \bar{q}, \bar{\theta})$ satisfies the differential equation

$dx(\tau)/d\tau = f(x(\tau), \tau) \triangleq a(x(\tau), \bar{u}, \bar{q}, \bar{\theta}, \tau, \omega(x(t_i), t_i, \bar{u}, \bar{q}, \bar{\theta}, \tau))$ and it's s -order approximation $\bar{x}(t+h)$, $\bar{x}(t+h) = x(t+h) + O(h^s)$, $s=k+l+1$, is calculated [1] by

$$\bar{x}(t+h) = p(t+h) + \int_t^{t+h} Q(\tau) (f(p(\tau), \tau) - dp(\tau)/d\tau) d\tau,$$

using $p(\cdot)$ and $Q(\cdot)$ satisfying

$$p(\tau) = x(\tau) + O(h^l), \quad dQ(\tau)/d\tau = -Q(\tau)A(\tau) + O(h^k), \quad Q(t+h) = I.$$

To calculate u that minimizes the risk function

$$E \max_{q \in Q} \tilde{f}(x(u, q, \theta), u, q, \theta)$$

we implement stochastic generalized gradient methods [2] and stochastic minimax algorithms [3].

References

1. Бейко І.В., Зінько П.М. Методи високих порядків для розв'язування задач Коші та багатомірних крайових задач за допомогою асимптотично-розв'язуючих операторів// Математичне та комп'ютерне моделювання, Кам"янець-Подільський національний університет, Інститут кібернетики імені В.М.Глушкова НАН України, - Кам"янець-Подільський: К-ПНУ, 2009. - Вип.1. - С.18-25.
2. Ermoliev Y.M., Norkin I.V. Stochastic generalized gradient method with application to insurance risk management. IR-97-021, Int. Inst. for Appl. Syst. Anal., Laxenburg, Austria. 1997. – 19 p.
3. Бейко І.В., Зінько П.М., Наконечний О.Г. Задачі, методи і алгоритми оптимізації: Навчальний посібник. — Рівне: Національний університет водного господарства та природокористування, 2011. — 624 с.

INTRACELLULAR PROCESSES MODELING USING ACTIVE PARTICLES

Biletskyi A., Biletskyy B.

Kyiv National Taras Shevchenko University

V.M. Glushkov Institute of Cybernetic of NAS of Ukraine

borys.biletskyy@gmail.com

We develop computational framework for modeling and simulation of intracellular processes. The processes are coordinated by introducing multiple locally interacting particles corresponding to the proteins in living cells. The particles affect the flow of the specific processes, so that the particle concentration represents all the processes currently running in the system.

The particles are able changing the environments due to the algorithmically defined interactions. Each particle in the configuration has a real value associated with it which measures the local stability of the configuration. The system dynamics is implemented in a way that the interactions are used for switching between configurations, configurations with lower cumulative stability appear less frequently during the evolution of the system.

Composite particles can be composed of simpler ones using different types of bonds, so that the resulting particle inherits the properties of the nested particles. We consider the particles with inner structure represented by a tree. Such representation allows calculating the particle properties given its structure and encoding any particle

including all its properties in a linear sequence of symbols from some finite alphabet.

The proposed framework is implemented as a separate Scala-library. The library was used for real life processes modeling such as: auto-oscillating reaction, composite particle self-assembly and decay, particle foraging and membrane transport. The processes studied are available online as Java-applets.

RISK MODELS FOR CRITICAL INFRASTRUCTURE PROTECTION PLANNING

Biriukov Dmytro¹, Zaslavsky Volodymyr²

¹National Institute for Strategic Studies, Kyiv, Ukraine

²Taras Shevchenko National University of Kyiv, Ukraine

¹**biryukov@niss.gov.ua**, ²**zas@unicyb.kiev.ua**

Last two decades characterized by increased scale and number of natural disasters, technogenic accidents and terrorist activities. To resist numerous threats G8 countries were compelled to develop effective mechanisms to protect national critical infrastructures (CI). Due to legislative acts of USA, Canada and EU the CI is considered as systems and assets, whether physical or virtual, vital to national security, governance, public health and safety, economy and public confidence [1]. CI provides enormous benefits, services, and opportunities for government, business and people, but, simultaneously CI is highly vulnerable for numerous threats that may have serious effects, such as cutting populations off from clean water, power, transportation, or emergency supplies. The risk models are used to support decision on CI protection measures planning and resource allocation and therefore to mitigate these threats.

Despite the developed mathematical techniques of the risk theory, there is a significant difficulty for CI risk modeling. These difficulties are connected with the following.

(a) Uncertainty. Information on threats is unknown, classified or there is lack of statistics. Risk analysis can seldom be performed on the basis of large statistical databases because they may not exist, and full information may not be available at the time when decisions need to be made [2].

(b) Interdependency. Much effort is currently being spent to develop

models that accurately simulate CI behavior and identify interdependencies [3]. Because of the interdependence of CI that result multiple cascade effect, estimation of the value of risk for catastrophic events considered as a hard problem [4]. CI can be seen as so-called “system-of-systems”, they consists of multiple, heterogeneous, distributed, occasionally independently operating systems embedded in networks at multiple levels, which evolve overtime [5].

(c) Sector and threat type specifics. CI components are different in various sectors (banking, transport, energy, defense industrial base, emergency services, water supply etc.) and they exposed to different threats. Respectively, a number of specific methods for risk assessment, standards and guidance were developed. A case of terrorism risk assessment shows that common used measures based on expected values are unsuitable and a case-specific approach should be developed [6]. For example, we propose an extension of logic-probabilistic technique to model scenarios of attack on CI facilities and assess probability of attack success [7].

References

1. Radvanovsky R., McDougall A., Critical Infrastructure: Homeland Security and Emergency Preparedness. – CRC Press, 2009. – 318 p.
2. Paté-Cornell M.E., Risk and Uncertainty Analysis in Government Safety Decisions // Risk Analysis. – 2002. – 22(3). – pp. 633–646.
3. Critical Infrastructure Interdependency Modeling: A Survey of U.S. and International Research // P. Pederson, D. Dudenhoeffer, S. Hartley, M. Permann. - Idaho National Laboratory, DoE, 2006. - 116 p.
4. Catastrophic Risk Management and Economic Growth / Interim report IR-00-058, IASA, November, 2000. – 12 p.
5. Eusgeld I., Nan C., Dietz S., ‘System-of-systems’ approach for interdependent critical infrastructures // Reliability Engineering and System Safety. – 2011. – 96. – pp. 679 – 686.
6. Aven T., Renn O., The Role of Quantitative Risk Assessments for Characterizing Risk and Uncertainty and Delineating Appropriate Risk Management Options, with Special Emphasis on Terrorism Risk // Risk Analysis. - 2009. – 29(4). – pp. 587 - 600.
7. Modeling and assessment of threat scenarios for critical infrastructure facilities / D.S.Biriukov, V.A.Zaslavskyy, V.V.Yevhiyenko, O.V.Franchuk // NaUKMA Scientific Notes. - 2009. – Vol.99: Computer Science. - pp. 97 - 102.

COMPLEX MODELING OF FILTRATION PROCESSES IN HYDRAULIC STRUCTURES UNDER UNCERTAINTIES

A. Bomba, V. Gavryliuk, A. Terebus

Rivne State Humanitarian University

Abomba@ukr.net, im_vova@ukr.net, anna.terebus@gmail.com

The method for the numerical solution of nonlinear model boundary-value problems on finding of quasiconformal mappings is modified for the case when the filtration process is considered in a porous medium with free boundaries restricted by the flow surfaces and equipotential surfaces, particularly in a spatial earth dam with a longitudinal drainage (as a managing parameter) on the impenetrable foundation (in Fig.1) whenever the tail-water exists. Hereby we state an optimization problem on a determination of minimum length of the drain layer to collect seepage.

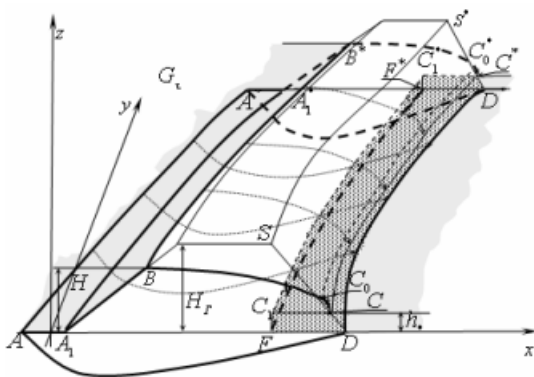


Fig. 1 An earth dam with a drain layer

We used ideas of the method of block iterations when we built (and proved) a corresponding algorithm, which was based on alternate “freezing” of the south for conformity parameter, internal and boundary net knots of curvilinear domain etc.

References

1. Бомба А.Я. Математичне моделювання нелінійних фільтраційних процесів в просторових середовищах з вільними межами / А.Я. Бомба, В.І. Гаврилюк, А.В. Терєбус // Вісник Тернопільського державного технічного університету. – 2011. – Том 16. – № 4. – С. 168-177.

ERLANG RETRIAL QUEUES WITH HYSTERESIS STRATEGIES OF INPUT FLOW

¹Bratiichuk M., ²Protopop Iu.

¹Silesian University of Technology, Gliwice, Poland

²Kyiv Taras Shevchenko National University

Mykola.Bratiichuk@polsl.pl , 15082008@ukr.net

We deal with a retrial queue of the type $E/M/1$ in which the interarrival intervals of primary calls have an Erlang distribution and intensities of repeated calls and of the service process are supposed to be constant. The input flow of the customers is subjected to the hysteresis strategies which means that there are two different levels, say h_1 and h_2 , $0 < h_1 \leq h_2$ and two regimes for the input flow. The first regime means that the input flow follows Erlang distribution with parameters n , λ_1 while the second one means that the parameters of input flow are equal to m , λ_2 . The system operates as follows. Let $\xi(t)$ be the number of customers in the orbit at the time t and $0 < \xi(0) < h_1$. If $t < \tau = \inf\{t : \xi(t) = h_2\}$ the customers arrive at the system according to the first regime. At the time τ the input flow starts to follow the second regime. That regime remains till the number of customers in the orbit reaches the level h_1 at which time the input flow starts to follow the first regime again and the process repeats. We consider both truncated model and the model with unlimited orbit. The explicit formulae for steady state distribution of the customers in the system are obtained and an optimization problem for such a system is considered as well.

References

1. Falin G.I., Templeton J.G.C. Retrial queues.- London Chapman and Hall, 1997. - 331 p.

ASYMPTOTIC VIEW OF GENERATOR OF JUMPING OPTIMIZATION PROCEDURE IN MARKOV MEDIA IN DIFFUSION APPROXIMATION SCHEME

Yaroslav Chabanyuk, Pavlo Gorun

Lviv Polytechnic National University

yaroslav_chab@yahoo.com, Pavlo.Gorun@gmail.com

The jumping procedure of stochastic optimization (PSO) with Markovian switchings in diffusion approximation scheme has view

$$u^\varepsilon(t) = u + \sum_{k=0}^{\nu(t/\varepsilon^{1/\gamma})-1} a_k^\varepsilon \left(\nabla_b C(u_k^\varepsilon; x_k^\varepsilon) + \varepsilon^{-1} C_0(u_k^\varepsilon; x_k^\varepsilon) \right), \quad t \geq 0, \\ u^\varepsilon(0) = u, \quad (1)$$

in notation [1], $\nabla_b C(u, \cdot) = \{(C(u^+; \cdot) - C(u^-; \cdot)) / 2b(t)\}$, $u^\pm = u \pm b(t)$. Additionally, γ – rate of time normalization, $x_n = x(\tau_n), n \geq 0$ – embedded Markov chain in uniform ergodic Markov process $x(t), t \geq 0$, in standard phase states space $(X, \mathbf{X})$ with generator Q [2] and potential R_0 . The regression function $C(u; x)$, $u \in R$, $x \in X$, satisfies the condition of existence of global solution accompanying systems $du_x(t)/dt = C'_u(u_x(t); x)$, $x \in X$, with assumption of a single extreme u^* . In (1) there are $u_n^\varepsilon = u^\varepsilon(\tau_n^\varepsilon)$, $x_n^\varepsilon = x(\tau_n^\varepsilon)$, $a_n^\varepsilon = a/(\tau_n^\varepsilon)^\alpha$, $\tau_n^\varepsilon = \tau_n / \varepsilon^{1/\gamma}$, $n \geq 0$, $\alpha \geq 1/2$. Norming PSO (1) has view:

$$v^\varepsilon(t) = t^\gamma \left(u^\varepsilon(t) / \varepsilon - C_0^\varepsilon(t) \right),$$

where diffusion perturbation has form

$$C_0^\varepsilon(t) = \varepsilon^{-2} \sum_{k=0}^{\nu(t/\varepsilon^{1/\gamma})-1} a_k^\varepsilon C_0(u_k^\varepsilon; x_k^\varepsilon).$$

Next let's consider three-component Markov process (MP)

$$v^\varepsilon(t), C_0^\varepsilon(t), x_t^\varepsilon := x(t / \varepsilon^{1/\gamma}), \quad t \geq 0. \quad (2)$$

Lemma. Generator of MP (2) on test functions $\varphi(v; \cdot) \in C^2(R)$ has representation:

$$\mathbf{L}_t^\varepsilon \varphi(v; x) = \varepsilon^{-1/\gamma} Q \varphi(\cdot; \cdot; x) + \varepsilon^{-1/\gamma} \mathbf{L}_0^\varepsilon \varphi(v; w; x),$$

where

$$\begin{aligned} \mathbf{L}_0^\varepsilon \varphi(v; w; x) = & q(x) \mathbf{P} \left[\varphi(v + \varepsilon^{\alpha/\gamma-1} t^{\gamma-\alpha} a \nabla_b C\left(\frac{\varepsilon}{t^\gamma} z; x\right); w + \right. \\ & \left. + \varepsilon^{\alpha/\gamma-2} t^{-\alpha} a C_0\left(\frac{\varepsilon}{t^\gamma} z; x\right); y\right) - \varphi(v; w; y) \Big] + \varepsilon^{1/\gamma} \frac{\gamma}{t} v \varphi'_v(v; w; x), \end{aligned}$$

$$\mathbf{P} \varphi(\cdot; \cdot; y) = \int_X P(y, dz) \varphi(\cdot; \cdot; z), \quad z = v + t^\gamma w,$$

where w – standard Wiener process.

References

1. GORUN P. P., CHABANYUK YA. M., SEMENYUK S. A., 2012. Convergence of discrete stochastic optimization procedure in diffusion approximation scheme. Thesis of Vth International conference OPTIMA-2012: “Modern problems of mathematical modeling, forecasting and optimization”. Kamenets Podolsky. – P. 27-28.
2. KOROLYUK V., LIMNIOS N, 2005. Stochastic Systems in Merging Phase Space. World Scientific Publishing. – 330 p.

SOME NEW CONSTRUCTION OF REGULAR E-OPTIMAL SPRING BALANCE WEIGHING DESIGN FOR EVEN NUMBER OF OBJECTS

Ceranka B., Graczyk M.

Department of Mathematical and Statistical Methods

Poznań University of Life Sciences

bronicer@up.poznan.pl, magra@up.poznan.pl

The problem of determining new experimental designs under given optimality criterions is presented. Related problems are shown in the papers [1], [2], [3]. Here, there are presented some issues connected with the spring balance weighing designs and with the construction of the design matrix satisfying the criterion of E-optimality. The incidence matrices of partially incomplete block designs are used to construction of the regular E-optimal spring balance weighing design.

References

1. Jacroux M., Notz W. (1983). On the optimality of spring balance weighing designs. The Annals of Statistics 11, 970-978.
2. Katulska K., Rychlińska E. (2010). On regular E-optimality of spring balance weighing designs. Colloquium Biometricum 40, 165-176.
3. Pukelsheim F. (1993). Optimal design of experiment. John Wiley and Sons, New York.

DIFFUSION APPROXIMATION OF MULTICHANNEL QUEUES AT THE NETWORK MODELS WITH THE PARALLEL STRUCTURE AND COMMON FLOW

Chechelnitski A., Gubeladze A., Kucherenko O.

Taras Shevchenko National University of Kyiv

che@unicyb.kiev.ua

The parallel construction of the processes of calculations and treatment information is one of basic principles, used for planning modern computer networks. It allows to get a high speed and substantial economy of time. That is why an analysis of mathematical models with the parallel operating systems of service and general input flows are very important. .

In this paper we will consider the model which consists of r nodes $E_1, \dots, E_r$. Each node operates as a queueing systems $M / M / \infty$. It means that node E_i has a Poisson input flow of calls (exponential interarrival times) $y_i(t)$ with the parameter $\lambda_i > 0$, $i = \overrightarrow{1, r}$. The calls arrive one at time and immediately take one of servers. Each node has an infinite number of servers. Correspondingly, the service time in the node E_i , $i = \overrightarrow{1, r}$ has exponential distribution with the parameter $\mu_i > 0$, $i = \overrightarrow{1, r}$. Each call can be served only in one node. After service completion calls leaves the nodes. In addition we suppose that the batch which consists of r calls arrive semiteonsly at the all nodes according to a Poisson process $y(t)$ with the parameter $b > 0$. All nodes operate in parallel way in order to provide service in the batch of r calls. The construction of our model implies that in general the calls enter our model according to a multidementional Poisson input flow

$(\nu_1(t), \dots, \nu_r(t))$ with parameter $\lambda_i > 0$, $i = \overrightarrow{1, r}$, $b > 0$, and the component $\nu_i(t)$ has the following representation $\nu_i(t) = y_i(t) + y(t)$. Denote by $Q(t) = (Q_1(t), \dots, Q_r(t))$, $t \in [0, T]$ the number of calls in the nodes of our model at time t . We will study the transient behavior of the multidimensional queueing process $Q(t)$ in heavy traffic conditions. This means that characteristics $\mu_i > 0$, $i = \overrightarrow{1, r}$ of our model depend on a scaling parameter n , $n \rightarrow +\infty$ in the following way: 1) $\mu_i^{(n)} = \mu_i / n$, $i = \overrightarrow{1, r}$. Denote by $Q_n(t) = (Q_1^{(n)}(nt), \dots, Q_r^{(n)}(nt))$, $t \in [0, T]$ the numbers of calls in the nodes of our model at time nt . We assume as well that the initial number of calls is 0 in each node: 2) $Q_i^{(n)}(0) = 0$, $i = \overrightarrow{1, r}$. For process $\xi_n(t) = (\xi_1^{(n)}(t), \dots, \xi_r^{(n)}(t))$, where $\xi_i^{(n)}(t) = n^{-1/2} (Q_i^{(n)}(nt) - \alpha_i(t)n)$, $\alpha_i(t) = (\lambda_i + b)(1 - e^{-\mu_i t})$, $i = \overrightarrow{1, r}$ (so $\xi_n(t)$ is a normalized queueing process $n^{-1/2} (Q_n(nt) - \alpha(t)n)$, where $\alpha(t) = (\alpha_1(t), \dots, \alpha_r(t))$) we prove a convergence in uniform metric to a diffusion process. Let us prove this fact.

Theorem 1. Suppose that conditions 1) and 2) hold. Then the sequence of processes $\xi_n(t) = (\xi_1^{(n)}(t), \dots, \xi_r^{(n)}(t))$ converges in uniform metric in any interval $[0, T]$ to a diffusion process $\xi(t)$, $\xi(0) = \xi_0 = 0$ with infinitesimal mean $a(x) = (a_1(x), \dots, a_r(x))$ and diffusion matrix B , $(a_1(x), \dots, a_r(x)) = (-\mu_1 x, \dots, -\mu_r x)$,

$$B = \begin{pmatrix} (\lambda_1 + b)(2 - e^{-\mu_1 t}) & b & \dots & b \\ b & (\lambda_2 + b)(2 - e^{-\mu_2 t}) & b & b \\ \vdots & b & \ddots & b \\ b & \dots & b & (\lambda_r + b)(2 - e^{-\mu_r t}) \end{pmatrix}$$

References

1. Chechelnitzski A.A., (1999) Asymptotical properties of Erlang Queueing systems with dependent Poisson input flow. Top, v.7, 221-229.

REFORMULATING PROBLEMS TO GIVE BETTER SOLUTIONS

Ray Correll

rho.environmetrics@bigpond.com

There are cases where the problem as presented to a statistician appears to be impractical but the problem can be modified slightly to give a solution that is acceptable to the statistician and the client. We consider several problems where this occurred.

A request was made to estimate the under-recording of fire starts by powerlines. The client expected the statistician was to examine the company's records of fire starts. The statistical team sought data from the local fire authorities and obtained in effect an independent data set. A capture mark recapture technique was used to obtain an objective assessment of the under reporting.

A second example was a requirement to sample the high wall of an open cut mine. Obtaining samples from the high wall was difficult and dangerous – impossible to take samples at random points. An alternative was to sample the drill cores that had been obtained in advance of the mining.

Other examples will be presented from a range of applications. These examples will include both successes and further challenges.

Conclusion. Many problems can be solved more readily if they can be refocussed in to a more tractable form. This can only be achieved when there is close collaboration between the statistician and other investigators. Establishing such a relationship takes effort but the results are worthwhile.

JUSTIFICATIONS OF GROUTING MODELS

M. B. Demchuk

National university of water management and natural resources use
nbdemch@mail.ru

Before creations of foundations on weak soil plots, to make better elastic properties of soil tracts the grouting operations are performed. In this technique a cement grout is injected under high pressure (10–30 bars) into a water saturated or dry porous medium. The aim is reached after the grout hardening.

The infiltrate is composed of particles that are responsible for the phenomenon called the deep bed filtration or the depth filtration. Depending on particle and pore throat sizes two limiting cases are distinguished in the description of this phenomenon. In the first case, large particles are trapped by small pore throats. Whereas in the second case, small particles deposit over large pore bodies and large pore throats that result in a gradual reduction of pore throat sizes [1].

Grouting is rather costly and time consuming. Its regime is determined by concentration distribution evolution [2]. Therefore, a calculation of this evolution using mathematical modeling is important.

This distribution contains the high gradient region that corresponds to the transition from a soil with the maximal cement concentration to a soil with the zero one. The injection pressure used in fieldworks is so high that the width of this zone is much smaller than the distance covered by the cement in the soil [3]. Therefore, this zone can be substituted by a sharp boundary between the fluid with maximal cement concentration and the one with the zero cement concentration [4]. Thus, real scale grouting can be modeled by a problem with a free moving boundary. But if a grouting model does not have a free moving boundary, then it can be referred to the class of problems about pollution propagation.

A grouting model does not take into account all aspects of a simulated system [4]. Comparison of model calculations with laboratory measurements justifies a set of assumptions used in a model formulation. The following example illustrates the fact that the amount of information such comparison provides depends upon uncertainty values of the compared quantities. Let us assume that two compared quantities can take only integer values from segments with lengths $2 \cdot n_1 + 1$ and $2 \cdot n_2 + 1$ respectively with equal probability. Let us also assume that $n_1 < n_2$ and that during the comparison two values turned

out to be exactly equal. The number of cases when realizations of these quantities coincide equals $(2n_1 + 1) \cdot (2n_2 + 1)$, and the number of cases when these realizations coincide in the case of their mathematical expectations being equal equals $2n_1 + 1$. Thus, we can conclude that in the case when the realizations of compared quantities are identical the probability of their mathematical expectations being equal equals $1/(2n_2 + 1)$ [5].

In this work it is shown that in the existing grouting models belonging to the class of problems about pollution propagation the comparison of model calculations with laboratory measurements provides small amount of information due to the significant values of errors in the input data. Consequently, attention should be paid to the precision of laboratory measurements.

Afterwards, the investigation will be conducted to check the hypothesis that during real scale cement grout injection in sand the deep bed filtration can be neglected.

References

1. Sharma M. M. Transport of particulate suspensions in porous media: model formulation / M. M. Sharma, Y. C. Yortsos // American Institute of Chemical Engineers Journal. — 1987. — Vol. 33, No. 10. — P. 1636—1643.
2. Bouchelaghem F. Mathematical and numerical filtration-advection-dispersion model of miscible grout propagation in saturated porous media / F. Bouchelaghem, L. Vulliet // International journal for numerical and analytical methods in Geomechanics. — 2001. — Vol. 25, № 12. — P. 1195—1227.
3. Демчук М. Б. Математичне моделювання процесу нагнітання в'язучого розчину в пористе середовище / М. Б. Демчук // Математичне та комп'ютерне моделювання: зб. наук. пр. Сер. фіз.-мат. науки. — 2010 р. — Вип. 4. — С. 61-75.
4. Bear J. Introduction to modeling of transport phenomena in porous media / J. Bear, Y. Bachmat. — Dordrecht: Kluwer Academic Publishers, 1990. — 553 p. — ISBN 0-7923-1106-X.
5. Демчук М. Б. Узгоджена модель нагнітання цементного розчину в насичене пористе середовище / М. Б. Демчук // Наукові записки НАУКМА. Серія: комп'ютерні науки. — 2011 р. — Т. 125. — С. 46–51.

METHODOLOGICAL APPROACH TO FORMING EVALUATION SYSTEM FOR INNOVATION ECONOMIC DEVELOPMENT

Dolenko G.A.

Taras Shevchenko National University of Kyiv, Ukraine

galinadolenko2006@yandex.ru

The innovation economic development research domain offers huge potentialities. The aim of this paper is the evaluation of effectiveness of innovation economic development of organizational system with the help of the fuzzy sets theory and the elements of applied statistics. The model and the method of evaluation of effectiveness of economic development of organizational system are proposed to consideration. The methodology is illustrated through example of Ukraine. Statistical data over the years 2010-2011 is used for calculations.

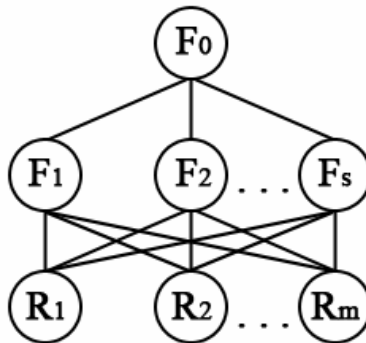


Fig.1. Tree indicators for evaluating the effectiveness of economic development

The mathematical model of result indicators definition problem for regional economic development was proposed in the paper [1], as the following: $\langle T, L, \Phi \rangle$.

T is a result indicators tree (fig.1.).

T is built on the base of the hierarchy decomposition of problem.

On the first level of hierarchy T is the main goal F_0 of organizational system.

Criteria of socio-economic development of organizational system F_s , $s = 1, \dots, S$, (sub goals of F_0) are represented on the second level of hierarchy T .

Subsystems R_i , $i = 1, \dots, m$ of organizational system are represented on the third level of hierarchy T . For example, for the task of regional development indicators evaluation R_i , $i = 1, \dots, m$, are ratings of regions [2].

Φ - system of preference relations of some factors over others at each level of hierarchy T :

$$\Phi = \{F_i(\varphi)F_j | \varphi \in (\succ, \approx), i \neq j\}$$

Linguistic variable L is linguistic values:

$L = \{\text{Very Low Level (VL), Low Level (L), Average Level (A), High Level (H), Very High Level (VH)}\}$.

L is a set of qualitative assessments of levels for each criterion and each subsystem in the hierarchy T , that we want to find.

In the paper we propose methodological approach to forming evaluation system for innovation economy development.

References

1. Dolenko G., Manovytska D. *Multicriteria decision making problem of evaluating the effectiveness of Ukrainian regional economic development*// PDMU-2011 (XVI I International Conference- Problems of Decision Making under Uncertainties), Ukraine, Skhidnytsia, May 23-27, 2011, 20-21.
2. <http://www.kmu.gov.ua>

SOME EXAMPLES OF MEMBERSHIP FUNCTIONS OUT OF FUZZY THEORY: PRINCIPAL CONSEQUENCE

V.S. Donchenko

Taras Shevchenko National University of Kyiv, Ukraine

voldon@unicyb.kiev.ua

It is the common place, that Fuzziness is the mean for uncertainty handling. But what it is that “uncertainty” the fuzziness handles with”? How does it do that? Standard answers on these questions commonly reproduced by the addicts of Fuzzy are out of math common sense. One can find details see, for example, in [1-2].

What is the “uncertainty” by itself? Is it mathematics? If not, where ought one to look for the origin of the conception? How

does the uncertainty sort with the Fuzziness? What is primary between these two? There are some more pertinent questions related to place of Math and Applied Math in definitions and applications of the uncertainty and Fuzziness as well as to the role of the Heuristics in Applied researches. Uncertainty surely is the first in discussing about priority within the mentioned pair. For example, Pospelov and his school [3] share this opinion. They consider the Fuzziness to be the mean for the uncertainty handling but not vice versa.

Author shares the opinion that the pretensions of fussy theory to be universal mean for uncertainty handling are unreasonable(details in [1-2],mentioned above). But the next examples of membership functions out of fuzzy theory make this clearly obvious. Namely, these are: any probability; each column of transition matrix of a Markov chain; logit- and probit regression and its generalization; multiset theory. Variety of examples and correspondent theories make it impossible to apply them specifically in the terms of membership functions.

References

1. Donchenko V. Fuzzy Sets as a mean for uncertainty handling: Math, Applied Math, Heuristics // New trends in Data mining.- Editors: Krassimir Markov, Vitalii Velichko, - ITHEA.- Kiev, Ukraine – Sofia, Bulgaria. Number 28.– P. 236-237.
2. Донченко В.С. Неопределённость и математические структуры в прикладных исследованиях/ Human aspects of Artificial Intelligence International Book Series Information science & Computing.– Number 12. – Supplement to International Journal “Information technologies and Knowledge”. –Volume 3.–2009. – P. 9-18.
3. Пospelov Д. Из истории развития нечетких множеств и мягких вычислений в России.- In Новости искусственного интеллекта. – 2001. – №2-3.

OBJECT REPRESENTATIVES: VECTOR AND MATRIX IN MATHEMATICAL MODELLING

Donchenko V.S., Zinko T.P

Taras Shevchenko National University of Kyiv, Ukraine

voldon@unicyb.kiev.ua

The objects of investigation in Mathematics after Georg Cantor (math structures) are the sets plus “ties” between its elements. So, math modelling is designing in math “parts plus ties”, which reproduce “part plus ties” in the real object, modeled.

So, the question of critical importance in math modeling is which math objects represents “parts” and which - “ties” ones. The “parts” are considered to be “representatives” of the object under modelling. These “representatives” should be chosen in such a way that variety of math structuring means were sufficient to convey the object structure.

It is comm. place to choose “representatives” constructed to be finite ordered collection of characteristics (corteges): quantitative (numerical) or qualitative (non numerical). Such corteges are numerical as a rule, i.e. are vectors from Euclidian space R^n . Such choice is determined as by the variety of the ties: linear operations (addition and scalar multiplying), scalar product and correspond norm, as well as by advanced techniques of operating with the objects in such spaces.

It is noteworthy to say, that space $R^{m \times n}$ of all matrixes of a fixed dimension $m \times n$ may represent alternative example of Euclidean space. But it is used much less frequently for “environment space” for the “representatives”. This situation is determined by much more less perfectness in technique developed for the matrix in comparison with the vectors such as classical matrix methods and classical linear algebra methods. SVD-technique and methods of Generalized or Pseudo Inverse (G-inverse) or inverse according by Moore – Penrose among them(see, for, example [1,2], also [3]).

The development of G-inverse technique for the Euclidean space $R^{m \times n}$ of matrixes is represented in the report, including SVD-representation for linear operator on matrix corteges with the following designing of orthogonal projectors, “grouping” operators and so on, as well as application of the technique developed for solving classification problem for matrix representatives (see, also[4]).

References

1. Albert A.E. Regression and the Moore-Penrose pseudoinverse. – Academic Press. – 1972 . – 180 p.

2. Adi Ben-Israel, Thomas N.E. Greville Generalized Inverses. Theory and Applications.–Second Edition–Springer-Verlag New York, Inc–2003–420p.
3. Кириченко Н.Ф. Аналитическое представление возмущений псевдообратных матриц.// Кибернетика и системный анализ. – 1997. – № 2. – С. 98–107.
4. Донченко В. Евклидовы пространства числовых векторов и матриц: конструктивные методы описания базовых структур и их использование.// International Journal “Information technologies & Knowledge”. – 2011. – Vol. 5. – Number 3. –P.203–216.

STABILITY ANALYSES OF LEXICOGRAPHIC OPTIMUM OF MARKOWITZ’S BI-CRITERIA PROBLEM WITH WALD’S AND SAVAGE’S CRITERIA

Emelichev V. A., Korotkov V. V.

Belarusian State University

emelichev@bsu.by, wladko@tut.by

We consider a bi-criteria discrete variant of the investment management, based on Markowitz’s portfolio theory [1], with two ordered criteria, namely with Wald’s maximin efficiency criteria [2]

$$\min_{i \in N_m} \sum_{j \in N_n} e_{ij} x_j \rightarrow \max_{x \in X}$$

and Savage’s minimax risk criteria

$$\max_{i \in N_m} \sum_{j \in N_n} r_{ij} x_j \rightarrow \min_{x \in X}.$$

Here $N_n = \{1, 2, \dots, n\}$ is the set of investment alternative projects (assets); N_m is the set of market states (situations); $x = (x_1, x_2, \dots, x_n) \in X \subseteq \{0, 1\}^n$ is an investment portfolio, where $x_j = 1$, if investment project $j \in N_n$ is implemented, and $x_j = 0$ otherwise; e_{ij} is an assessment of efficiency of project $j \in N_n$ in the situation when the market is in the state $i \in N_m$; r_{ij} is a risk value of missed opportunity of project $j \in N_n$ when the market is in the state $i \in N_m$. Those the initial data of the problem are the efficiency matrix $E = [e_{ij}] \in \mathbf{R}^{m \times n}$ and the risk matrix $R = [r_{ij}] \in \mathbf{R}^{m \times n}$.

In this context, a bi-criteria investment Boolean problem $Z^m(E, R)$ with Wald's and Savage's ordered criteria means the problem of searching the set of lexicographically optimal portfolio $L^m(E, R)$.

The stability radius of the portfolio $x^0 \in L^m(E, R)$ is defined as follows: $\rho^m(x^0) = \sup \Xi$, if $\Xi \neq \emptyset$, and $\rho^m(x^0) = 0$, if $\Xi = \emptyset$, where $\Xi = \{\varepsilon > 0 : \forall (E', R') \in \Omega(\varepsilon) (x^0 \in L^m(E + E', R + R'))\}$, $\Omega(\varepsilon) = \{(E', R') \in \mathbf{R}^{m \times n} \times \mathbf{R}^{m \times n} : \|E'\| + \|R'\| < \varepsilon\}$,

$\|A\| = \sum_{i \in N_m} \sum_{j \in N_n} |a_{ij}|$, $A = [a_{ij}] \in \mathbf{R}^{m \times n}$. Thus, the stability radius defines an extreme level of the initial data perturbations of the problem $Z^m(E, R)$, preserving lexicographic optimality of the portfolio.

Theorem. The stability radius $\rho^m(x^0)$ of a portfolio $x^0 \in L^m(E, R)$, $m \geq 1$, has the following lower and upper bounds

$$\varphi \leq \rho^m(x^0) \leq 2\varphi,$$

where

$$\varphi = \min_{x \in X \setminus \{x^0\}} \max_{i \in N_m} \min_{k \in N_m} \left(\sum_{j \in N_n} e_{kj} x_j^0 - \sum_{j \in N_n} e_{ij} x_j \right).$$

Earlier in [4] we announced similar bounds of extreme level of parameter perturbation when new Pareto-optimal portfolios of Markowitz's multicriteria investment Boolean problem with several Wald's criteria.

This work was supported by the Republican Foundation of Fundamental Research of Belarus (the project F11K-095).

References

1. Markowitz H. M. Portfolio selection: efficient diversification of investments / H. M. Markowitz. – Oxford: Blackwell, 1991.
2. Wald A. Statistical decision functions / A. Wald. – New York: Wiley, 1950.
3. Savage L. J. The foundations of statistics / L. J. Savage. – New York: Dover, 1972.

4. Emelichev V. A., Korotkov V. V. Stability analysis of multiple criteria investment Boolean problem with Wald's criteria // Abstracts of the 25st Conference of European Chapter on Combinatorial Optimization (ECCOXXV). Antalya. Turkey. April 26–28, 2012. – P. 8.

STATISTICAL INFERENCE OF LEFT-CENSORED SAMPLES FROM WEIBULL DISTRIBUTION

Fusek, M., Michálek, J.

Brno University of Technology, Brno, Czech Republic

fusek.m@gmail.com

michalek@fme.vutbr.cz

Censored samples are very frequent in many different branches of statistical applications ([2]). The paper focuses on application of censored samples in environmental studies, where the samples are often left censored. Many articles about left censored data with normal distribution have been published in the past years ([1, 3]). The results published in environmental applications usually assume left censoring and normal distribution of studied variables. Also left censored samples from exponential distribution, which are a special case of censored samples from Weibull distribution, were studied ([4, 5]). However, for the left censored samples from Weibull distribution, which are frequent in environmental applications, there are only few general comments based on the maximum likelihood approach. In this contribution, maximum likelihood approach to doubly left-censored samples from Weibull distribution is used. The exact Fisher information matrix is derived and used for determination of confidence intervals for parameter estimates. These results are compared with those obtained from the empirical Fisher information matrix on simulated data. Finally, the results are demonstrated on environmental data of biotic matrices contamination.

References

1. Aboueissa, A. E.-M. A. *Maximum likelihood estimators of population parameters from multiply censored samples*. Environmetrics Vol. **20** (3), p. 312-330, 2009
2. Cohen, A. C. *Truncated and Censored Samples*. CRC Press, 328 pages, ISBN: 0824784472, 1991.
3. El-Shaarawi, A. H., Esterby, S. R. *Replacement of censored observations by a constant: An evaluation*. Water Research **26** (6), p. 835-844, 1992.

4. Fusek, M., Michalek, J. *Statistical inference of doubly left-censored samples from exponential distribution*. XIX. International conference PDMU, Abstracts, p.23. Mukachevo, April 23-27, 2012.
5. Mitra, S., Kundu, D. *Analysis of the left censored data from the generalized exponential distribution*, Journal of Statistical Computation and Simulation, **78** (7), p. 669-679, 2008.

SOME APPROACHES TO TO PATTERN RECOGNITION

Golodnikov A.N., Knopov P.S.

V.M.Glushkov Institute of Cybernetic of NAS of Ukraine
knopov1@yahoo.com

Problems of pattern recognition consist in constructing a unified model, which combines both observable and hidden parameters of the object. As examples of such models one often considers Gibbs random fields. The crucial point in such models is the estimation of the parameters of the Gibbs distribution. In this talk we suggest an approach for the choice of the Gibbs distribution, which is based on the obvious fact that one can take an arbitrary distribution which agrees with already known a priori information, as a “true” Gibbs distribution. Therefore the distributions on which the maximal and minimal values of the probabilities of the observed object are achieved, are of special interest. We show that such problems can be reduced to linear programming problems.

IMAGE SEGMENTATION OF NUCLEI

Golubeva K.M.

Taras Shevchenko National University of Kyiv, Ukraine
katrin_g@bigmir.net

Two methods were suggested for the segmentation of images (nuclei of buccal epithelium). They are adaptive threshold method and method based on the 3σ rule.

Thresholding in image processing is based on the previous choice of the so-called threshold of brightness. The last one is required for partitioning the image into two clusters. The algorithm assumes that the image to be thresholded contains two classes of pixels (foreground and background) then calculates the optimum threshold separating those two classes so that their combined spread (intra-class variance) is minimal. Minimizing the intra-class variance is the same as maximizing inter-

class variance [1]. Let N be the total number of pixels of image, L be the number of shades of gray, and n_i be the number of pixels with shade of gray I , then inter-class variance is computed

$$\sigma_{C_1 C_2}^2 = \omega_1 \omega_2 (\mu_2 - \mu_1)^2,$$

where $\omega_1 = \sum_{i=1}^k p_i$, $\omega_2 = 1 - \omega_1$, $p_i = n_i / N$, $\mu_1 = \frac{1}{\omega_1} \sum_{i=1}^k i p_i$,

$$\mu_2 = \frac{1}{\omega_2} \sum_{i=k+1}^L i p_i.$$

According to the classic empirical 3σ rule in practice the confidence interval $(m(x) - 3\sigma(x), m(x) + 3\sigma(x))$ contains at least 95% of the values of general population [2], $m(x)$ is mathematical expectation and $\sigma(x)$ is variance of stochastic variable x . Thus, after calculating of the confidence interval of standard background it becomes possible separating image into two clusters.

The advantages of the method based on the 3σ rule are simplicity and high speed of computation. But the algorithm uses standard images of background of nuclei that are processed. Adaptive threshold method doesn't use standard images, but it has more complex implementation, therefore, its realization takes more time.

References

1. Otsu N. A threshold selection method from gray-level histograms / N. Otsu // Trans. Sys., Man., Cyber. — 1979. — Vol. 9, № 1. — P. 62–66.
2. Ключин Д. А. Доказательная медицина / Д. А. Ключин, Ю. И. Петунин. — М. : И. Д. Вильямс, 2008. — 320 с.

ON A-OPTIMALITY OF SPRING BALANCE WEIGHING

Graczyk M.

Department of Mathematical and Statistical Methods

Poznań University of Life Sciences

magra@up.poznan.pl

The problems related to the optimality criterions of specific experimental design is presented in many papers in literature, see [1-5]. Here, the problem of determining an A-optimal spring balance weighing design under assumption that the measurement errors have different variances and they are uncorrelated is considered. The lower bound of the trace of the information matrix is given and the conditions determining the optimal design are presented, also. The incidence

matrices of the balanced incomplete block designs and the group divisible designs are used to constructions of the regular A-optimal spring balance weighing design.

References

1. Graczyk M. (2011). A-optimal biased spring balance weighing design. *Kybernetika* 47, 893-901.
2. Graczyk M. (2012). Notes about A-optimal spring balance weighing design. *Journal of Statistical Planning and Inference* 142, 781-784.
3. Jacroux M., Notz W. (1983). On the optimality of spring balance weighing designs. *The Annals of Statistics* 11, 970-978.
4. Masaro J., Wong C.S. (2008). Robustness of A-optimal designs. *Linear Algebra and its Applications* 429, 1392-1408.
5. Pukelsheim F. (1993). *Optimal design of experiment*. John Wiley and Sons, New York.

OPTIMIZATION OF LINEAR FUNCTIONS ON CYCLIC PERMUTATIONS

¹Grebennik I., ²Lytvynenko O., ³Titova O.

Kharkiv National University of Radio Electronics

¹ Igorgrebennik@gmail.com, ² litvinenko1706@gmail.com,
³ titovaolga90@gmail.com

The problem of minimizing a linear function on the set of cyclic permutations is considered: $L(x) = \sum_{i=1}^n c_i x_i$, where $c_1 \dots c_n$ are the given real coefficients, and $x_1, x_2, \dots, x_n$ take the values of all possible cyclic permutations of generating elements $a_1 < a_2 < \dots < a_n$. The report proposes an exact and heuristic solution for this problem.

The report introduces the concept of partial permutation, analyses the combinatorial properties of these permutations associated with the formation of new cycles by adding a new element to the partial permutation. Corresponding propositions are formulated and proved.

For the exact solution of the problem branch and bound algorithm is used. At every step of the algorithm each of the generating elements not included in the current partial permutation joins it. It is the technique of branching.

For each partial permutation the estimate of the objective function is calculated. A partial permutation with the better estimate undergoes further branching. The full cyclic permutation with the best objective

function value is an intermediate solution. Branching continues until there is no partial permutation with the better estimate than the intermediate solution.

At the beginning of the heuristic solution all the possible partial permutations of length q are constructed. After this a certain fraction of permutations having the best evaluation of the objective function is selected. Next, other generating elements are joined to each of the selected permutations. Then the “best” permutations are selected again. The process continues until the length of the permutations reaches n .

The results of computer experiments on the exact and heuristic solution of the problem are described and analyzed.

PREDICTING SURFACE CURRENTS FROM UNCERTAIN IMAGE OBSERVATIONS

Isabelle Herlin, Etienne Huot

l’Institut national de recherche en informatique (Inria), France

Isabelle.Herlin@inria.fr Etienne.Huot@inria.fr

The paper describes an innovative approach to estimate motion from uncertain image observations of the Black Sea. Unlike most image processing methods, which apply a Tikhonov regularisation in order to solve the aperture problem, our approach relies on a dynamic model of the surface currents. This dynamic model is obtained from an approximation of the Navier-Stokes equations for motion and expresses the transport of image brightness by the velocity field. An image assimilation method is defined in order to solve these evolution equations with constraints linked to image observations. As the dynamic model is also uncertain, a weak formulation of data assimilation is applied, that allows controlling the model error. The paper discusses both issues:

- Noisy image data. This requires the definition of dedicated observation error covariance matrices. In particular, these matrices allow to process images contaminated by acquisition noise or partly occluded by clouds. This is of major interest due to the cloud coverage over Black Sea.
- Uncertain model. This also requires the definition of the error covariance matrix. A dual method has been developed to estimate motion in that context. Improvements obtained by including this error in the control are described in the paper.

Results are quantified on synthetic images and the method is illustrated and discussed on satellite data. Perspectives of the work concern the short-term prediction of surface currents.

EUROPEAN DEFENSE SECTOR IN 21ST CENTURY – DEALING WITH INCREASING UNCERTAINTY

Vladan Holcner

University of Defence, Brno, Czech Republic

Vladan.holcner@unob.cz

Planning and managing defense sectors in most European countries has become a rather gamble in many aspects. First, the will of the nations – or their political representatives – to spend national resources on defense has become less predictable. This can be demonstrated e.g. by the shift from the model of general conscription to all-volunteer forces or – and above all – by the amount of public funds allocated to the military. National defense systems (as well as international) represent long-term projects exposed to the risk of not fulfilling medium- and long-term financial commitments declared by national governments. This fact has become the key factor determining defense sectors in most Western and Central European countries over the past decade.

This key factor is reflected in many other areas like in the labor market where due to limited budgets military might lose its competitiveness when recruiting personnel competent for military service. Another area relates to the level of technology affordable for domestic forces in relation to technology of both partners and potential enemies.

The key factor is naturally linked to the uncertain future threat and uncertain nature of future enemies. As remained unclear and far distant from the today's ordinary lives, this makes the will of nations to prepare for their defense even more complicated.

Not directly related to the economic burden of defense but of particular importance, particular military operations naturally result in casualties. When planning military operations like those in Afghanistan, it is necessary to estimate own casualties and take them into account as an integral part of the overall burden resulting from the efforts when achieving political and military goals of given operation.

This paper focuses on selected aspects of the risks described above and outlines possible ways of dealing with them in a streamlined and transparent way.

STOCHASTIC EXTENSIONS OF A TRAFFIC ASSIGNMENT PROBLEM

Holešovský, J., Popela, P.

Brno University of Technology, Brno, Czech Republic

y107238@stud.fme.vutbr.cz

popela@fme.vutbr.cz

The purpose of the paper is to study properties of the original stochastic extensions of a traffic assignment problem (TAP). Various versions of the deterministic TAP belong among problems that are carefully investigated for a long time. Therefore, the authors have identified recent challenges in the research directions towards stochastic and bilevel programming approaches and try to tackle them in a novel way. Studied modifications of models are accompanied by illustrating examples that are implemented in GAMS.

COMPARISON OF POWERS OF SOME TESTS IN ONE-WAY ANOVA TYPE MODEL WITH NEGATIVE BINOMIAL DISTRIBUTION

Zuzana Hübnerová¹, Lucie Doudová²

Institute of Mathematics, Brno University of Technology,
Czech Republic

¹ hrdlickova.z@fme.vutbr.cz , ² Lucie.Doudova@unob.cz

When analyzing biological, insurance or reliability data the negative binomial (NB) distribution is often encountered. This paper is concerned with models, where the expected value and the shape parameter of the NB variable possibly depend on one factor. Particularly, the tests of an equality of the expected values under various assumptions about the values of the shape parameters are inspected with regard to the empirical size and power. The testing procedure in the case, when the hypothesis of an equality of the shape parameters is not rejected, is of the main interest. An extensive simulation study aims at answering questions that might arise in this situation.

ABOUT THE PROBLEM OF GROWING OF A DISCRETE FUZZY NUMBER CARRIER DURING ALGEBRAIC OPERATIONS

O.O. Iemets, O.O. Yemets`

Poltava University of Economics and Trade

yemetsli@mail.ru, yemets2008@ukr.net

During performing of a number of operations with fuzzy numbers [1], growing of the carrier of a discrete fuzzy number occurs. However several gradations are enough for describing qualitative phenomena. Therefore let set the problem of the reduction of the number of carrier elements with the realization of an opportunity to save the information about values. It is proposed that the information is given by the fuzzy number. One of methods is presented in the report.

Let we have a fuzzy number $A = \{(a_1 | \mu_1), \dots, (a_n | \mu_n)\}$ for describing a variable. It is necessary to describe this variable by a fuzzy number with a carrier which has $k < n$ carrier elements

Describe this procedure by reduction A to B in a general view. Let $A = \{(a_1 | \mu_1), \dots, (a_n | \mu_n)\}$, without restricting the generality, consider $a_1 < a_2 < \dots < a_n$. It is necessary to get the reduction of the number A down to the number B (corresponding A) with k elements. Denote $B = \{(b_1 | \eta_1), \dots, (b_n | \eta_k)\}$. Split the interval $[a_1, a_n]$ into k intervals $\Delta_i = [a_1 + h(i-1), a_1 + hi]$, where $h = \frac{a_n - a_1}{k}$, $i = 1, 2, \dots, k$ (for $i = k$ the right end of interval is included: $[a_1 + h(k-1); a_1 + hk]$). Find their middles: $b_i = a_1 + h(i - \frac{1}{2}) = a_1 + \frac{a_n - a_1}{k}(i - \frac{1}{2})$, $i = 1, 2, \dots, k$. Find the value η_i of membership function for each b_i : $\eta_i = \sum_{j: a_j \in \Delta_i} a_j \mu_j / \sum_{j: a_j \in \Delta_i} a_j$, $i = 1, 2, \dots, k$. Thereby B is defined.

It is proposed to investigate the properties of the operation of reduction in further researches.

References

1. Oleg Iemets, Oleksandra Yemets`. Solving of combinatorial optimization problems on fuzzy sets: Monograph. PUET. Poltava, 2011. 239 p. (in Ukrainian).

ON THE NUMBER OF EMPTY BOXES IN THE BERNOULLI SIEVE

Alexander Iksanov

Taras Shevchenko National University of Kyiv, Ukraine

iksan@univ.kiev.ua

Suppose we are given a multiplicative random walk (a stick-breaking set) generated by a random variable W taking values in the interval $(0,1)$ and a sample from the uniform $[0,1]$ law which is independent of the stick-breaking set. The Bernoulli sieve is a random occupancy scheme in which 'balls' represented by the points of the uniform sample are allocated over an infinite array of 'boxes' represented by the gaps in the stick-breaking set. Assuming that the number of balls equals n I am interested in the weak convergence of the number of empty boxes within the occupancy range as n approaches infinity. Depending on the behavior of the law of W near the endpoints 0 and 1 the number of empty boxes can exhibit quite a wide range of different asymptotics. These will be carefully discussed with an emphasis on the methods exploited.

References

1. Gneden A. The Bernoulli sieve revisited/A.Gneden, A. Iksanov, P. Negadajlov [and others.]/Ann.Appl.Probab.-2009.-V.19.-P. 1634-1655.
2. Gneden A. Small parts in the Bernoulli sieve/ A.Gneden, A.Iksanov, U.Roesler// Discrete Math. Theoret.Comp.Sci.-2008.-V.AI.- P. 239-246.
3. Iksanov A. On the number of empty boxes in the Bernoulli sieve I / A.Iksanov // Stochastics.-2012+, accepted for publication.
4. Iksanov A. On the number of empty boxes in the Bernoulli sieve II /A. Iksanov // Stoch. Proc. Appl.-2012+, accepted for publication.

PROBABILITIES FOR EXISTENCE OF SOLUTION OF THE PROBLEM WITH NONLOCAL CONDITIONS FOR A SYSTEM OF PDE WITH SPATIAL SHIFTS

Ilkiv V. S.

Lviv Polytechnic National University, Ukraine

ilkivv@i.ua

Let $\mathcal{D}^p = [0, T] \times \Omega_{2\pi}^p$ be a cylindrical domain of variables (t, x) , where $\Omega_{2\pi}^p = (\mathbb{R}/2\pi\mathbb{Z})^p$ a p -dimensional torus, $p \geq 2$, $T > 0$, $(t, x) = (t, x_1, \dots, x_p)$. In the domain $\mathcal{D}^p$ we consider the following

problem with nonlocal boundary conditions in time variable t for the system of partial some order differential equations

$$\frac{\partial u}{\partial t} = A_1(D)u_{\xi_1} + \dots + A_Q(D)u_{\xi_Q} + f, \quad (1)$$

$$u|_{t=0} - \mu u|_{t=T} = \varphi. \quad (2)$$

A unknown vector-function $u = u(t, x)$ has the size m , u_{ξ} is the vector-function u of vector shift $\xi \in \Omega_{2\pi}^p$ by variable x , vector-function $f = f(t, x)$ and $\varphi = \varphi(x)$ are given functions, $\mu \in \mathbb{C}$. The operators $A_1(D), \dots, A_Q(D)$ are differential polynomials with constant matrix complex coefficients, where $D = (-i\partial/\partial x_1, \dots, -i\partial/\partial x_p)$.

Solvability of the problem (1), (2) is a random event (for some values of the vector $\bar{\xi} = (\xi_1, \dots, \xi_{Q_1})$, where $Q_1 \leq Q$, the solution exists, but for others – does not exists [1]) in probability space with the space of elementary events $\Omega_{2\pi}^{pQ_1}$. An elementary event is the choice of the problem (1), (2) at fixed shift value $\bar{\xi} \in \Omega_{2\pi}^{pQ_1}$. We establish the conditions of solvability of the problem (1), (2) with probability of one and unique solvability conditions and uniform upper bound of norm the problem solution with predetermined close to one probability.

References

1. Ільків В. С. Розв'язність нелокальної задачі для систем рівнянь з частинними похідними зі зсувами аргументів // Наук. вісник Ужгород. ун-ту. Сер. матем. і інформ. – 2010. – Вип. 21. – С 72–85.

AUTOMATION OF RECTIFICATION PROCESS IN FOOD INDUSTRY

Vasyl V. Ivanchuk

National University of Water Management and Natural Resources
ivanchuk.v@mail.ru

Wash rectification process is characterized by energy consumption, complexity of processes of mass transfer, instability of technological parameters [1].

Currently the most widely used in manufacturing is three-column wash rectification unit (WRU) of indirect action, for which a wide range of automation systems is developed and there is a permanent

improvement [2]. However, a drawback of such units is high consumption of thermal energy and cooling water.

To solve this problem a diagram of automatic control of wash rectification unit of indirect action including the main stream processes and their means of automatic control and regulation was developed.

In order to ensure optimal consumption of energy streams is proposed, except the stabilization of the main technological parameters WRU, the introduction of automatic calculation and adjustment of reflux ratio, which in its turn affects the cost of energy resources.

Reflux ratio is based on the following parameters: the reflux expense, the strength of reflux, the expense of the original product, the strength of the original product.

Reflux ratio is regulated by changing the steam into the column at the appropriate changes in water supply reflux condenser [1].

Besides the proposed methods to determinate the control and stabilization of additional parameters of the WRU in system of automation offered introduction of an artificial neural network [3], which will provide high quality final product, to ensure the balance of material and energy flows and their rational use.

References

1. P.S. Tsygankov Distillation units of alcohol industry / P.S. Tsygankov. - Moscow: Light and food industry, 1984. – 336 p.
2. A.A. Stopakevych Analysis of the modern state of systems management wash rectification units of alcohol production / A. Stopakevich, J.K. Todortsev // AA Eks. - № 2.-2009. - P. 180-184.
3. A.P. Rothstein, Intelligent technology of identification: fuzzy logic, genetic algorithms, neural networks / A. P. Rothstein. - Vinnitsa.: Universum-Vinnitsa, 1999. – 320p.

SUPPORT PLANNING MODEL OF DEMAND FOR MATERIALS IN COAL MINE¹

Katarzyna Jakowska-Suwalska, Maciej Wolny

The Silesian University of Technology, Poland, Gliwice

katarzyna.suwalska@polsl.pl; maciej.wolny@polsl.pl

The multicriterial model of demand for materials in coal mine is presented in the work. The model is built on basis of historical data of

¹ This work was supported financially by the Polish Ministry of Science and Higher Education within a grant N N524 552038, 2010.

material consumption (per ton of coal production) and there are considered two criteria in the model:

$$(a) \sum_{t=1}^n |x_{it} - z_i| \rightarrow \min, \text{ for } i = 1, 2, \dots, n,$$

$$(b) F_i(z_i) \rightarrow \min, \text{ for } i = 1, 2, \dots, n,$$

where x_{it} is a consumption of i -th material ($i=1,2,\dots,n$) in period t ($t=1,2,\dots,T$); z_i is a decision variable, which means i -th material order volume (per ton of planned coal production); $F_i(\cdot)$ is a distribution function of i -th material consumption. There is presumed in the work that volume of i -th material consumption is a continuous random variable with known distribution. In proposed model it is also assumed that costs of materials order volume are limited. Considered problem with the two criteria is solved by using goal programming and as a result two non-dominated solutions are received. The game-theoretical approach to multicriteria decision problems is used to choose the final solution. This part of work deals with multicriteria discrete (finite) decision problem as a game between the criteria – the game is played in DM's mind. The game is analyzed using non-cooperative stability definitions and concept of risk dominance.

APPLICATION OF THE STACKELBERG DUOPOLY MODEL TO DECISION PROBLEM IN MINING ENTERPRISES RESOLUTION²

Jan Kaluski

The Silesian University of Technology, Poland, Gliwice

jan.kaluski@polsl.pl

In the work on the basis of [3] the Stackelberg Duopoly Model (SDM) for receiving the payoffs of the two-person non-zero-sum game to resolution the decision problem in mining enterprises is presented. The work consists of four parts. After introduction, in the second part, some methods of modeling and resolving the bimatrix game are shown. Two-person game with one leader and one follower is considered and discussed [1,2]. In the third part on the ground of the SDM the original method receiving of the elements of $(n \times m)$ dimensional bimatrix game is presented. The new method determines the payoffs players as profit for

² This work was supported financially by means a Polish Science within a grant N N524 552038, 2010.

each player. The next, n and m pure strategies for two players are considered. One example to explain the new method is given. The example concerning two mining enterprises output a coal. The leader in this game is fictitious. The Table 1 shows the Stackelberg (2x3) dimensional bimatrix for two players as profits (in Polish zloty) per each player. In the Table 1 variables Q_A and Q_B are output in millions tons per each enterprise.

Table1.The Stackelberg bimatrix game for decision problem

	Q_B^1	Q_B^2	Q_B^3
Q_A^1	(1030;592,5)	(1629,4;116,5)	(1359,4;299,3)
Q_A^2	(-200;1234,5)	(-200;292,5)	(-200;779,5)

On the ground of bimatrix game the Stackelberg equilibrium was calculated from the following formula:

$$\min_j a_{i_0j} = \max_i \min_j a_{ij} = S^*(A).$$

where $i = 1,2; j = 1,2,3$ and $S^*(A)$ is profit of Stackelberg for the leader. According to a formula above we determined the optimal strategies as pair (1,1) and the profit **(1030,592,5)** - corresponding to this pair of strategies - is Stackelberg result of balance.

Simultaneously the equilibrium of the SDM (when the number of pure strategies for two players is infinite) also was calculated [2]. The result was **(851,330)** for output $Q_A = 3,4m \ln.tons$ and $Q_B = 1,6m \ln.tons$.

Finally we can conclude that application of the Stackelberg Duopoly Model allows to create the bimatrix hierarchical non-zero-sum game for resolution the decision problem in mining enterprises.

References

1. Chen C. L., and Cruz I. B. Jr.: Stackelberg solution for two person games with biased information patterns. IEEE Trans. Autom. Control. Vol AC – 17, no. 6.Dec. 1972.
2. Stackelberg V. H.: The Theory of the Market Economy. Oxford, U. K.: Oxford University Press, 1952.
3. Kaluski J.: Modelling of decision support using the Stackelberg Duopoly Model to bimatrix hierarchical non-zero-sum game. 13-th International conference “Modern information and electronic technologies”. Odessa, 4-8 June, 2012

APPROXIMATED REGULATOR IN OPTIMAL CONTROL PROBLEM FOR PARABOLIC INCLUSION

Kapustyan O.V., Kapustian O.A.

Taras Shevchenko National University of Kyiv
alexkap@univ.kiev.ua, olena.kap@gmail.com

The construction of regulator for infinite-dimensional optimal control problem is one of important in the modern control theory. This problem arises in applications where the medium characteristics change over time, and the interaction functions are discontinuous on a phase variable. In this paper we consider the optimal stabilization problem with non-autonomous perturbations in coefficients and fixed parameters $g \in H$, $\gamma > 0$

$$\begin{cases} \frac{dy}{dt} + A_\varepsilon(t)y \in F_\varepsilon(t, y) + g \cdot v(t), & t > 0, \\ y(0) = y_0 \in H, \end{cases} \quad (1)$$

$$v(\cdot) \in U = L^2(0, +\infty), \quad (2)$$

$$J(y, v) = \int_0^{+\infty} (\|y(t)\|^2 + \gamma v^2(t)) dt \rightarrow \inf \quad (3)$$

and corresponding unperturbed problem when $\varepsilon = 0$. We assume that the unperturbed problem has the unique solution $\{y, u\}$ and its regulator $u[y]$ can be found in feedback form.

Under general conditions on non-autonomous perturbations of differential operator $A_\varepsilon(t)$ and non-Lipshitz multivalued interaction function $F_\varepsilon(t, y)$ we prove the solvability of the problem (1) - (3) and we prove that regulator $u[y]$ of the unperturbed problem realizes approximated stabilization on solutions of perturbed problem (1) - (3).

References

1. *Kapustyan O.V., Kapustian O.A., Sukretna A.V.* Approximated stabilization for nonlinear parabolic problem // Ukrainian Mathematical Journal, 2011. – Vol. 63, № 5. – pp. 654-661.
2. *Kapustian O.A.* Approximated stabilization problem for parabolic inclusion // Num. and Appl. Math. Journal, 2011. - №1(104). – pp. 62-67.

A NEW TIME-SAVING VARIANT OF KORPELEVICH'S METHOD FOR VARIATIONAL INEQUALITY PROBLEMS

O. Khalymon

Taras Shevchenko National University of Kyiv, Ukraine

holyman.login@gmail.com

Broad class of problems are oftenly posed to equilibrium problems. A great number of methods has been designed for solving them, including gradient methods. Important special case of variation inequalities is intensively researched. It's known that the simplest of gradient methods require strong monotony conditions to converge. Extragradient methods are one of the means to handle this hindrance. In [1] G. Korpelevich proposed an extragradient algorithm, which converges with monotonous and Lipschitz continuity conditions only.

Much research effort has been dedicated to generalise this method. For example, [2] introduced time-saving (in sence of computations for a single iteration) modification of Korpelevich's method where the second projection onto main set had been replaced by specific subgradient projection.

We have analyzed and compared several classic search algorithms for variational inequalities and their modifications. Also, we introduced own method (a new time-saving modification), which showed itself more effective than classical ones for main sets of complicated structure and proved its weak convergence.

References

1. *Корпелевич Г.М.* Экстраградиентный метод для отыскания седловых точек и других задач. – Экономика и мат. методы. – 1976. – Т.12, №4. – С.747-756.
2. *Ляшко С.И., Семенов В.В., Войтова Т.А.* Экономичная модификация метода Корпелевич для монотонных задач о равновесии. – Кибернетика и системный анализ, 2001. – №4. – С. 146-154.

FLUCTUATIONS OF STOCHASTIC OPTIMIZATION PROCEDURE WITH IMPULSE PERTURBATIONS

Ulyana Khimka, Yaroslav Chabanyuk

The continuous stochastic optimization procedure (SOP) is set by the evolutionary equation [1]:

$$du^\varepsilon = a(t)[\nabla_b C(u^\varepsilon(t), x(t/\varepsilon^4))dt + \varepsilon d\eta^\varepsilon(t)] \quad (1).$$

where $C(u, \cdot) \in C^3(R)$ - a regression function, $u \in R$, $x \in X$, is depends on the evenly ergodic Markov processes $x(t), t \geq 0$, in the dimensional phase states space $(X, \mathbf{X})$, with the generator Q , the stationary distribution $\pi(B), B \in X$, and the potential R_0 [2], $\nabla_b C(u, \cdot) = (C(u^+, \cdot) - C(u^-, \cdot)) / 2b(t)$, $u^\pm = u \pm b(t)$, $b(t) = b/t^{1/4}$, $a(t) = a/t$, $a > 0, b > 0$.

Let the condition of balance (CB1) $\Pi b_1(x) = \int_X \pi(dx) b_1(x) \equiv 0$, $b_1(x) = \int_R w \Gamma(dw, x)$ where Γ - the generator on the family processes $\eta^\varepsilon(t, x), t \geq 0, x \in X$. For the existence of an extremum point u_0 of the averaged system $du(t)/dt = C'(u(t))$ is a sufficient condition of balance $\Pi C'(0, x) = 0$.

Consider the normalized fluctuations $v^\varepsilon(t) = \varepsilon^{-1}[u^\varepsilon(t) - \varepsilon \eta^\varepsilon(t)]$.

Theorem. Let the CB1, CB2 and the conditions of convergence [1] SOP (1) be satisfied, the functions $C'(u, x), C''(u, x)$ are uniformly bounded on at x . Then the weak convergence $(v^\varepsilon(t), \eta^\varepsilon(t)) \rightarrow (\zeta(t), W_\sigma(t))$, $\varepsilon \rightarrow 0, t > 0$, takes place. The limiting process $(\zeta(t), W_\sigma(t))$ is given by the generator $L\varphi(v, w) = (ac/t)(v + w)\varphi'_v(v, w) + (a^2/2t)B\varphi''_w(v, w)$, where $c = \int_X \pi(dx)C''(0, x)$, $B = \int_X \pi(dx)C'(0, x)R_0C'(0, x)$.

References

1. U.T.Khimka, Ya.M.Chabanyuk. Stochastic Optimization Procedure Convergence with Markov Switching in the Average Scheme.// Математичні студії,- 2010,- vol.34, № 1. pp.101-105.
2. V. Korolyuk, N. Limnios. Stochastic Systems in Merging Phase Space. / World Scientific Publishing. - 2005. - 330P.

ABOUT ONE MODEL OF THE DISEASE TRANSMISSION PROCESS

Khusainov D., Manovytska D.

Taras Shevchenko National University of Kyiv, Ukraine

dkh@unicyb.kiev.ua

The report considers one of the mathematical models of the transmission of infectious diseases. Here, $x(t)$, $y(t)$, $z(t)$ denote the proportions of the susceptible, infective and recovered individuals, respectively. The function $f(x, y)$ describes the number of meetings of susceptible people $x(t)$ and infective people $y(t)$. It is assumed that the disease is transmitted only when susceptible and infective people meet. Then, the dynamics of the disease spread can be described by the following system of the ordinary differential equations:

$$\begin{aligned}\dot{x}(t) &= \lambda - \mu x(t) - \beta x(t)y(t), \\ \dot{y}(t) &= \beta x(t)y(t) - (\mu + \gamma)y(t), \\ \dot{z}(t) &= \gamma y(t) - \mu z(t), \\ \lambda > 0, \mu > 0, \beta > 0, \gamma > 0.\end{aligned}$$

It is easy to see that adding all the equations, we obtain

$$\frac{d}{dt}(x(t) + y(t) + z(t)) = \lambda - (\mu x(t) + \mu y(t) + \mu z(t)).$$

Hence, we obtain the first integral of the system

$$x(t) + y(t) + z(t) = e^{-\mu t} (x(0) + y(0) + z(0)) + \frac{\lambda}{\mu} (1 - e^{-\mu t}).$$

And $x(t) + y(t) + z(t) \rightarrow \frac{\lambda}{\mu}$ will be performed for $t \rightarrow +\infty$, which

means that the number of susceptible, infective and recovered people will tend to a constant value.

In the report an investigation of the singular points and the phase portrait of the system as a whole are made. The influence of the parameters on the system dynamics is determined.

The influence of the delay is considered separately. At the same time, the following system is reviewed:

$$\begin{aligned}\dot{x}(t) &= \lambda - \mu x(t) - \beta x(t)y(t - \tau), \\ \dot{y}(t) &= \beta x(t)y(t - \tau) - (\mu + \gamma)y(t), \\ \dot{z}(t) &= \gamma y(t) - \mu z(t), \quad \tau > 0.\end{aligned}$$

FINITE DIMENSIONAL REDUCTION OF NONLINEAR HYDRODYNAMIC THIN LAYERED FLOWS EVOLUTION ON INVARIANT TWODIMENSIONAL SUBMANIFOLD

Arkadii Kindyaliuk, Mykola Prytula
Ivan Franko National University of L'viv, Ukraine
mykola.prytula@gmail.com

Let us consider finite dimensional reduction [1, 3] of dynamical system [2]

$$\begin{cases} u_t = k_1 h_{xxx} + k_2 u u_x, \\ h_t = k_2 (u h)_x \end{cases} \quad (1)$$

on invariant submanifold

$$M^2 := \{(u, h) \in M \subset C_l^\infty(R^1, R^2) : \text{grad} L_2[u, h] = 0\}$$

of critical points [1] of the following Lagrange functional

$$L_2[u, h] := \int_{x_0}^{x_0 + l} \left(c_1(u + h) + c_\eta u h + \frac{1}{2} c_g (k_1 h_x^2 - k_2 u^2 h) \right) dx.$$

Canonical Hamiltonian variables q, p on submanifold $M^2 \subset M$ are $q := h$ and $p := c_g h_x$.

Theorem. *The nonlinear hydrodynamic system of thin layered flows evolution (1), reduced on the invariant submanifold $M^2 \subset M$ is exactly equivalent to the set of two commuting canonical Hamiltonian flows:*

$$\begin{cases} \frac{dq}{dx} = \frac{\partial h_2^{(x)}}{\partial p} = \frac{1}{k_1 c_g} p, \\ \frac{dp}{dx} = -\frac{\partial h_2^{(x)}}{\partial q} = c_1 + \frac{c_\eta^2}{2c_g k_2} \frac{1}{q^2}, \end{cases}$$

and

$$\begin{cases} \frac{dq}{dt} = \frac{\partial h_2^{(t)}}{\partial p} = \frac{c_\eta}{k_1 c_g^2} p, \\ \frac{dp}{dt} = -\frac{\partial h_2^{(t)}}{\partial q} = \frac{c_1 c_\eta}{c_g} + \frac{c_\eta^3}{2c_g^2 k_2} - \frac{c_1^2 c_\eta}{2c_g^2 k_2} \frac{1}{q^2}, \end{cases}$$

that are Liouville-Arnold completely integrable by quadratures systems. The corresponding Hamiltonians $h_2^{(x)}, h_2^{(t)} \in D(M^2)$ expressed in canonic variables are:

$$h_2^{(x)} := -\frac{c_1 c_\eta}{c_g k_2} + \frac{1}{2k_1 c_g} p^2 - \frac{c_1^2}{2c_g k_2} \frac{1}{q} - \left(c_1 - \frac{c_\eta^2}{2c_g k_2} \right) q,$$

$$h_2^{(t)} := -\frac{c_1^2}{c_g} - \frac{c_1 c_\eta^2}{c_g^2 k_2} + \frac{c_\eta}{2k_1 c_g^2} p^2 - \frac{c_1^2 c_\eta}{2c_g^2 k_2} \frac{1}{q} - \left(\frac{c_1 c_\eta}{c_g} + \frac{c_\eta^3}{2c_g^3 k_2} \right) q.$$

Hamiltonian functions $h_2^{(x)}, h_2^{(t)} \in D(M^2)$ have been found from determining relationships:

$$\frac{dh_2^{(x)}}{dx} := -(\text{grad} L_2[u, h], (u_x, h_x)),$$

$$\frac{dh_2^{(t)}}{dx} := -(\text{grad} L_2[u, h], (u_t, h_t)).$$

References

1. Blackmore D. Nonlinear dynamical systems of the mathematical physics: spectral and differential-geometrical integrability analysis./D. Blackmore, A.K. Prykarpatsky, V. Hr. Samoylenko // World Scientific Publ., NJ, USA, 2011.
2. Hentosh O. Differential-geometric and Lie-algebraic foundations of investigating nonlinear dynamical systems on a function manifolds. The second edition. /O. Hentosh, M. Prytula, A. Prykarpatsky // L'viv University Publ., L'viv, Ukraine, 2006. (in Ukrainian). – 408p.
3. Kindyaliuk A.A. Bihamiltonity of hydrodynamic model of thin layered flows evolution /A.A. Kindyaliuk, M.M. Prytula // XVIII International conference PROBLEMS OF DECISION MAKING UNDER UNCERTAINTIES PDMU-2011 (19-23 September 2011p. – Yalta, Ukraine). Abstracts. P. 93. (in Ukrainian).

DYNAMIC RANDOM EVOLUTIONS IN ASYMPTOTIC SMALL DIFFUSION SCHEME

Olha Kiykovska, Yaroslav Chabanyuk

Lviv polytechnic national university

olja.kiykovska@gmail.com, yaroslav_chab@yahoo.com

The dynamic random evolution in asymptotic small diffusion scheme is defined by the solution of evolution equation [1]:

$$du^\varepsilon(t) = C(u^\varepsilon(t); x(\frac{t}{\varepsilon^3}))dt + \varepsilon^{-1}C_0(u^\varepsilon(t); x(\frac{t}{\varepsilon^3}))dt + \varepsilon^{1/2}\sigma(u^\varepsilon(t); x(\frac{t}{\varepsilon^3}))dW(t),$$

where the regression function $C(u, x), u \in R^d$ depends on uniformly ergodic Markov process $x(t), t \geq 0$ in the merging phase space state $(X, \mathbf{X})$, u is the random evolution, W is a Wiener process, and ε is a small parameter series [2]. For the generator Q of a Markov process $x(t), t \geq 0$, with stationary distribution $\pi(B), B \in X$, it is determined the potential operator R_0 [2].

The velocity function

$$C^\varepsilon(u; x) = C(u, x) + \varepsilon^{-1}C_0(u; x), u \in R^d, x \in X,$$

satisfies the balance condition

$$\Pi C_0(u; x) = \int_X \pi(dx) C_0(u; x) = 0.$$

The Markov random evolution is characterized of coupled Markov process generator $u^\varepsilon(t), x_t^\varepsilon = x(\frac{t}{\varepsilon^3}), t \geq 0$, [3]

$$L^\varepsilon(x)\varphi(u; x) = \varepsilon^{-3}Q\varphi(u; x) + \varepsilon^{-1}Q_1(x)\varphi(u; x) + Q_2(x)\varphi(u; x),$$

$$Q_1(x)\varphi(u; x) = C_0(u; x)\varphi'(u; x),$$

$$Q_2(x)\varphi(u; x) = C(u; x)\varphi''(u; x) + \frac{1}{2}\varepsilon\sigma^2(u; x)\varphi''(u; x).$$

Theorem. Let the uniformly ergodic Markov process $x(t), t \geq 0$, satisfy the balance condition, then the exponential generator converges weakly to the limiting generator [3]

$$H^\varepsilon\varphi^\varepsilon(u; x) \rightarrow H\varphi(u), \varphi^\varepsilon(u; x) \rightarrow \varphi(u), \varepsilon \rightarrow 0,$$

on perturbing test-functions

$$\varphi^\varepsilon(u; x) = \varphi(u) + \varepsilon \ln[1 + \varepsilon\varphi_1(u; x) + \varepsilon^2\varphi_2(u; x)].$$

The limiting exponential generator is defined by terms:

$$H\varphi(u) = C(u)\varphi'(u) + \frac{1}{2}B^2(u)[\varphi'(u)]^2 + \frac{1}{2}\varepsilon\sigma^2(u)\varphi''(u),$$

where $B^2(u) = 2\Pi C_0(u; x)R_0C_0(u; x) + \sigma^2(u)$,

$$C(u) = \int_X \pi(dx)C(u, x), \quad \sigma^2(u) = \Pi\sigma^2(u; x).$$

References

1. KIYKOVSKA O.I., CHABANYUK YA. M., 2012 Convergence of stochastic process with Markov switching.// *Matematychni Studii.* – 2012. – vol.32 no.2 – P. 203-208.
2. KOROLYUK V. S., LIMNIOS N. Stochastic Systems in Merging Phase Space/: World Scientific Publishing, - 2005. - 330 p.
3. KOROLYUK V.S. Large deviation problem for Markov random evolution with independent time-scale in the asymptotic small diffusion scheme// *Ukr.math.journ.* – 2010, T.62, №5, - P. 643- 650.

ALMOST SURE CONVERGENCE OF RISK PROCESSES

O. I. Klesov

National Technical University of Ukraine “KPI”

klesov@math.uni-paderborn.de

We consider a risk process where the number of claims is denoted by $N(t)$. The process $N(t)$ is constructed from a sequence $S(n)$ being of a general structure. In particular, we do not assume that $S(n)$ are partial sums of independent identically distributed random variables (in this sense, $N(t)$ is the so-called *generalized renewal process*, see [1]). In this way, we may model nonhomogeneous claim processes.

Assuming some ergodic properties of the auxiliary sequence $S(n)$, we find the almost sure behavior of the risk processes. In some cases, the converse is also true, namely the behavior of the risk process determines those of the auxiliary sequence $S(n)$.

References

1. V. V. Buldygin, K.-H. Indlekofer, O. I. Klesov, and J. G. Steinebach, *Pseudo regularly varying functions and generalized renewal processes*, TBiMC, Kyiv, 2012, 440 pp. (Ukrainian)

MATHEMATICAL MODEL OF OPTIMAL TAX RATE

N. Korkuna, H. Tseluk

Ivan Franko National University of L'viv, Ukraine

a.natali.m@mail.ru

The subject of research is determination of the optimal total tax rate of economic entities. The dependence of tax rates and tax revenue volume can be described by the 'Laffer curve', that was proposed by American economist Arthur Laffer. The economic meaning of this curve is that the increase in tax rates is not always accompanied by increased tax revenues.

To determine the optimal tax rate, we propose the mathematical model:

$$D(x) = \lambda x^{\alpha} (1 - x^2)^{\beta},$$

where $D(x)$ - the budgetary income from taxation, x ($0 \leq x \leq 1$) - tax rate, $\lambda > 0$, $\alpha > 0$, $\beta > 0$ - parameters that determine the curve.

The total tax rate at which contributions to the budget will be maximum, expressed by the formula:

$$x = \left(\frac{\alpha}{2\beta + \alpha} \right)^{1/2}.$$

Ukraine has a situation where businesses are forced to move (in whole or in part) in the informal sector due to excessive tax burden. In Ukraine, according to Goskomstat, in 2010 the number of "illegals" who worked in the informal sector increased by 179.3 thousand persons. Logical to assume that with further increase in tax rate the number of companies in the "shadow" will increase. In this case we propose to calculate the revenues with the formula:

$$D(x) = \lambda x^{\alpha} (1 - Tx^2 - x^2)^{\beta},$$

where T - relative number of firms operating in the "shadow".

Then the optimal value of the total tax rate is expressed by the formula:

$$x = \sqrt{\frac{\alpha}{(1 + T)(\alpha + 2\beta)}}.$$

APPROACH TO EVALUATION OF DISTRIBUTION OF INTERVALS BETWEEN TERRORISTIC ACTS

Korolyuk V., Dolenko G., Lobach S.

Taras Shevchenko National University of Kyiv, Ukraine
vskorol@yahoo.com, GalinaDolenko2006@yandex.ua,
s.w.a.t.oc.team@gmail.com

Terrorism prediction problems have received considerable attention, especially since 9.11.2001. The main aim of our research is to check statistical hypothesis about the distribution of intervals between terroristic acts and its parameters. To achieve it, we suggested program engine, which dynamically searches and accumulates information about terroristic acts on-line. At the present time, the database, which was generated by this program, includes over 12000 items.

We consider that the interval between offences ξ is a random variable. The main hypothesis consisted in exponential distribution of ξ for countries, which have got the label of “flashpoint”: Iraq, Afghanistan, India. The research purpose was to define distribution parameter λ_0 as well. We used the least square method to find it [1]. Then, Kolmogorov-Smirnov test was applied to examine the main hypothesis [1].

As a result, hypothesis wasn't declined by this test with any statistical significance level in bound $\alpha \leq 0,15$, which gave offences time distribution for mentioned countries.

References

1. Прикладная статистика: Основы моделирования и первичная обработка данных. Справочное издание. С.А. Айвазян, И.С. Енюков, Л.Д. Мешалкин, – М.:Финансы и статистика, 1983. – 471 с.

MEANS OF PARALLEL PROGRAMMING IN MANAGERIAL DECISION MAKING

Bc. Iva Krejčová, Ing. Vladislav Bína, Ph.D.

Faculty of Management in Jindřichův Hradec,
University of Economics in Prague, Czech Republic
xkrei09@vse.cz, bina@fm.vse.cz

The contribution deals with an example of computationally hardly feasible problem of decision making under uncertainty. Namely it concerns the well known Monte Carlo approach to the random generation of scenarios in case of operating profit based on factors with given probability distributions. The aim is to obtain an approximate

distribution of profit which provides an important information source for the decision maker.

Though the simplest (and commonly used) solutions of the problem assume mutual independence of all factors, this is usually not correct. Therefore, an important issue comprises the correct representation of dependence relations which can be based on the means of correlations or some more advanced approaches (e.g. copulas).

As the accuracy naturally grows with the increasing number of scenarios generated, in more complicated cases it may be computationally hardly feasible to perform the simulation sequentially. In such cases it appears to be reasonable to employ the means of parallel computing.

The contribution presents a theoretical basis as well as the practical implementation of an illustrative task of economical results using a cluster of PCs programmed in C language with employment of the MPICH parallel environment.

CONTINUOUS-TIME MODELS IN PORTFOLIO THEORY

Lenka Křivánková

Department of Mathematics and Statistics,
Faculty of Science, Masaryk University, Czech Republic
142474@mail.muni.cz

We proceed from the classical Markowitz portfolio theory in the static framework. A Markowitz efficient portfolio gives the highest expected return for a given amount of risk. The extension of this model leads to the fund separation theorem of CAPM [1].

The first solution to the dynamic portfolio problem in continuous time was introduced by Merton [2]. He assumed that prices of assets follow an Ito process with constant expected return and covariance of returns, and also market equilibrium.

We present the Olson-Rosenberg paradox [3], which demonstrates a contradiction between the assumption of stationary distribution of returns and the separation theorem on the one hand and the assumption of market equilibrium on the other hand.

One consistent approach in the dynamic setting is given by Stochastic Portfolio Theory of R. Fernholz [4]. The rates of return and volatilities follow stochastic processes and equilibrium is not assumed.

We will also discuss another approach to the Olson-Rosenberg paradox, which leads to nonlinear stochastic differential equations.

References

1. Tobin J. Liquidity Preference as Behavior Towards Risk // Review of Economic Studies. – 1958. – Vol. 25 – p. 65-86.
2. Merton R. C. Optimum Consumption and Portfolio Rules in a Continuous-Time Model // Journal of Economic Theory. – 1971. – Vol. 3 – p. 373-413.
3. Rosenberg B., Ohlson J. A. The Stationary Distribution of Returns and Portfolio Separation in Capital Markets: A Fundamental Contradiction // Journal of Financial and Quantitative Analysis. – 1976. – Vol 11. – p. 393-402
4. Karatzas I., Fernholz R. Stochastic Portfolio Theory: an Overview // Handbook of Numerical Analysis. – 2009. – Vol. 15. – p. 89-167.

CONVERGENCE OF THE STOCHASTIC OPTIMIZATION PROCEDURE WITH SEMI-MARKOV'S SWITCHINGS IN DIFFUSION APPROXIMATION SCHEME

Kukurba V.R., Chabanyuk Ya.M., Kinasch O.M.

Lviv Polytechnic National University

vkuku@i.ua

Continuous stochastic optimization procedure with semi-Markov's switchings in diffusion approximation scheme is defined by the evolution equation

$$du^\varepsilon(t) = \nabla_{b(t)} C(u^\varepsilon(t); x(t/\varepsilon^2)) + \varepsilon^{-1} C_0(u, x), t \geq 0, u^\varepsilon(0) = u_0, \quad (1)$$

where $u \in R$, $\nabla_{b(t)} C(u; x) = (C(u + b(t); x) - C(u - b(t); x)) / 2b(t)$,

$a(t) > 0$, $b(t) > 0$, and regression function $C(u; x)$ depends on uniformly ergodic semi-Markov's process $x(t) > 0, t \geq 0$, in the dimensional space phase of states $(X, \mathbf{X})$, that is defined by kernel $Q(x, B, t) = P(x, B)G_x(t)$, where $G_x(t)$ - is the function of distribution of time spent in the current state $x \in X$. Associated Markov process $x_0(t), t \geq 0$ is defined by the generator $\mathbf{Q}$ [1].

Lemma. The extended compensating operator L_t^ε [2] of procedure (1) on the test functions $\varphi(u, \cdot) \in C^2(R)$ can be determined by the relation:

$$L_t^\varepsilon \varphi(u, x) = \varepsilon^{-1} Q \varphi(u, x) + G_t^{\varepsilon, 1}(x) Q_0 \varphi(u, x)$$

$$\text{where } G_t^{\varepsilon, 1}(x) = \int_0^\infty \overline{G}_x(s) C_{t+\varepsilon s}^\varepsilon(x) C_{t+\varepsilon s}^{\varepsilon, t}(x) ds, \quad Q_0 = q(x) P,$$

$$P \varphi(x) := \int_X P(x, dy) \varphi(y), \quad C_t^\varepsilon(x) \varphi(u) = [C_t(x) + \varepsilon^{-1} C_0(x)] \varphi(u),$$

$$C_0(x) \varphi(u) = C_0(u; x) \varphi'(u), \quad C_t(x) \varphi(u) = a(t) \nabla_{b(t)} C(u; x) \varphi'(u).$$

References

1. Korolyuk V. Stochastic Systems in Merging Phase Space. /V. Korolyuk, N. Limnios// World Scientific Publishing, - 2005. - 330P.
2. Kukurba V. R. Generator of difference procedure of optimization with semi-Markov's switchings. /Kukurba V.R., Chabanyuk Ya.M., Budz I.S.// International Conference: PDMU. Abstracts. May 23-27, Ukraine - 2012. - C.173-174.

STATE – DEPENDENT RETRIAL QUEUES

Lebedev E.A.

Taras Shevchenko National University of Kyiv, Ukraine

leb@unicyb.kiev.ua

Classical retrial queues are characterized by the following feature: a call arriving when all servers accessible for him are busy leaves the service area but after some random time repeats his demand. This feature plays a special role in several computer and communication networks as well. Other applications include stacked aircraft waiting to land, queues of retrial shoppers and so on. The last results of retrial queues theory are accumulated in [1].

A retrial queue with m servers is given by three parameters: λ is a rate of input Poisson flow of primary calls, μ is a service rate and ν is a rate of repeated attempts. As a rule, a service process

$$Q(t) = (Q_1(t), Q_2(t)) \in S = \{0, 1, \dots, m\} \times \{0, 1, \dots\}$$

is two-dimensional one where $Q_1(t)$ is a number of occupied servers at $t \geq 0$ moment of time, $Q_2(t)$ is a number of retrial calls.

In this presentation it's assumed that the parameters λ, μ, ν may be depended on the moving phase state $(i, j) \in S$ of the service

process $Q(t)$: $\lambda = \lambda_{ij}, \mu = \mu_{ij}, \nu = \nu_{ij}$. From a mathematical standpoint the assumed dependence complicates the retrial queue model. In this case the method of generating functions which proved its effectiveness for the classical models (see, for example, [2]) is not applicable. Using for special domains of phase space S a balance of probability flows for state-dependent queues in stationary regime it has been obtained the vector-matrix formulae (or recurrent calculating schemes) for stationary probabilities (see [3], [4]).

Later on this approach was used to find optimal parameters for state-dependent retrial queues in a set of threshold and hysteresis strategies. Thus, a class of models under consideration extends the field of applications.

References

1. Artalejo J.R., Gomez-Corral A.. Retrial queueing systems. – Springer-Verlag, 2008. – 317 p.
2. Falin G.I. and Templeton J.G.C. Retrial queues. – Chapman & Hall, 1977. – 329 p.
3. Lebedev E.A., Usar I.Ya. On retrial queues with controlled input flow // Reports of Ukrainian Academy of Sciences. – 2009. – N 5. – P. 52-59.
4. Lebedev E.A., Ponomarev V.D. Retrial queues with variable service rate // Cybernetics and Systems Analysis. – 2011. – Vol. 47. – N 3. – P. 434-441.

VECTOR DISCRETE OPTIMIZATION PROBLEMS: A STABILITY ANALYSIS³

T.T. Lebedeva, N.V. Semenova, T.I. Sergienko

V.M. Glushkov Institute of Cybernetic of NAS of Ukraine
nvsemenova@meta.ua, lebedtt@i.com.ua

A discrete vector optimization problem $Z(M(F, X))$: $\max\{F(x) \mid x \in X\}$, is considered, which consists of search of elements optimal set solutions $M(F, X) \in \mathfrak{M} = \{Sl(F, X), P(F, X), Sm(F, X)\}$, where, $\mathfrak{M} = \{Sl(F, X), P(F, X), Sm(F, X)\}$, $P(F, X)$ – set of Pareto-optimal solutions, $Sl(F, X)$ – of Slater-optimal solutions, $Sm(F, X)$ –

³ This work was supported by the State Foundation of Fundamental Research of Ukraine (the project 41.1/031).

set of Smale-optimal solutions. Necessary and sufficient conditions of T_2 -, T_3 -, T_4 - and T_5 -stability of $Z(M(F, X))$ problem, where $M(F, X) \in \mathfrak{M}$, are established. It is shown that the concept of these stability types can be taken to two notions defined below with respect to stability of feasible solutions and helps to expose nature of perturbations actions in input data on the feasible, optimal and non-optimal solutions. Let $\bar{\mathfrak{M}} = \mathfrak{M} \cup \{X, X \setminus P(F, X), X \setminus S\ell(F, X), X \setminus Sm(F, X)\}$ -collection of subsets of set X and $\mathcal{M}$ is any element from $\bar{\mathfrak{M}}$. We will choose a number $\delta > 0$ and set of the perturbed input data arbitrarily $u(\delta) = (u_1(\delta), u_2(\delta)) \in O_\delta(u)$. We will designate $\mathcal{M}_{u(\delta)}$ subset of the perturbed feasible set $X_{u_2(\delta)}$, proper a set as subset $\mathcal{M}$ of feasible set X . We suppose a point $x \in \mathcal{M} \in \bar{\mathfrak{M}}$ **stably belong to the set**, if such, that $\forall u(\delta) \in O_\delta(u) : x \in \mathcal{M}_{u(\delta)}$, and **non- stably belong to the set** $\mathcal{M}$ in other case. The set $\text{Ker}(\mathcal{M})$ of all points which stably belongs to the set $\mathcal{M} \in \bar{\mathfrak{M}}$ makes the **kernel of stability of set** $\mathcal{M}$. We suppose that a point $x \in X$ **does not belong stably** to the set $\mathcal{M} \in \bar{\mathfrak{M}} \setminus \{X\}$, if $\exists \delta > 0 : \forall u(\delta) \in O_\delta(u) \ x \notin \mathcal{M}_{u(\delta)}$. We will designate $\Omega(\mathcal{M})$ the set of all points $x \in X$, **not belongings stably** a set $\mathcal{M}$. Obviously, $\forall \mathcal{M} \in \bar{\mathfrak{M}} \setminus \{X\} : \text{Ker}(X \setminus \mathcal{M}) \subseteq \Omega(\mathcal{M}) \subseteq X \setminus \mathcal{M}$. For example, if the partial criteria and the restrictions of problem are presented quadratic functions, theorems are just. Let $M(F, X) \in \mathfrak{M}$.

Theorem 1. $Z(M(F, X))$ is T_2 -stable $\Leftrightarrow$ when among its feasible solutions exists even one, which stably belong to the set $M(F, X)$, i.e. $\text{Ker}(M(F, X)) \neq \emptyset$.

Theorem 2. $Z(M(F, X))$ is T_4 -stable $\Leftrightarrow \text{Ker}(M(F, X)) = M(F, X)$.
Let $M(F, X) \neq X$.

Theorem 3. $Z(M(F, X))$ is T_3 -stable $\Leftrightarrow X \setminus M(F, X) = \Omega(M(F, X))$.

Theorem 4. $Z(M(F, X))$ is T_5 -stable $\Leftrightarrow \text{Ker}(M(F, X)) = M(F, X)$ and $X \setminus M(F, X) = \Omega(M(F, X))$.

ON A MODEL OF THE TRANSITION LAYER OF THIN-FILM STRUCTURES

Lebyedyeva T.S., Shpylovyi P.B., Ozerov M.V.

V.M. Glushkov Institute of Cybernetic of NAS of Ukraine

Today there is a need in the high resolution method of analysis of interfaces in thin-film structures suitable for regular use in the process of development of the technology, as well as in the manufacture of thin-film products. Method of anodization profiles provides information about the microstructural characteristics of thin films and their interfaces by testing the changing of the dU/dt (U) during anodic oxidation of the structure, where U is the voltage across the sample.

However, for the calculation of the films thickness and the width of the interface and the concentration profiles of the materials it is necessary to create a mathematical model of the transition layer taking into account the statistical regularities in the distribution of materials into interface.

This work represents the creation of such a model and its application to calculate the characteristics of the interface of thin-films structures *metall₁-metall₂* (*metall₁* is the top layer). By creating a model the authors used the methods of nonlinear regression and the Gaussian approximation.

The above model is valid only for structures for which the rate of growth voltage during oxidation of the upper layer $(dU/dt)_1 < (dU/dt)_2$. Attempts to investigate the growth of anodic oxide when $(dU/dt)_1 > (dU/dt)_2$ were taken in [1]. It was found that under these conditions it is possible the nanostructuring of anodic oxide layer. Construction of a mathematical model then is much more complicated and requires additional research.

On the basis of the model the software was developed and characteristics of thin-film structures on the basis of niobium and aluminum, used in superconducting electronics and optical sensors on the evanescent fields were calculated [2, 3].

References

1. Pringle, J.P.S. The anodic oxidation of superimposed metallic layers: theory // *Electrochem. Acta.* – 1980. – Vol. 25. – pp. 1423-1437.
2. Войтович И.Д., Лебедева Т.С., Курлов С.С., Шпилевой П.Б. Оптические биосенсоры на многослойных тонкопленочных структурах // *Электроника и связь*, №2(55), 2010, С. 174-179

3. Lebyedeva T.S. at el. Modeling and Data Processing for Thin-Film Optical Sensors // Proceedings of 6-th IEEE International Conference on Intelligent Data Acquisition and Advance Computing System:Technology and Application, Praga-2011, Volume 1, pp.119-124.

THE TRANSITIONAL AND STATIONARY REGIME FOR NETWORK OF THE TYPE $[M_t | G | \infty]^r$

Hanna Livinska

Taras Shevchenko National University of Kyiv

livinskaav@gmail.com

Let consider a queuing network $[M_t | M | \infty]^r$ with parameters: $\lambda_i(t)$, $i=1,2,...,r$ is a rate of the input Poisson flow of calls at i -th node; μ_i , $i=1,2,...,r$ is the service rate in i -th node; $P = \|p_{ij}\|_1^r$ is the switching matrix.

Let $Q_i(t)$, $i=1,2,...,r$ be the number of calls in the i -th node of this network at the t moment of time. We study the transitional regime for $Q(t) = (Q_1(t), ..., Q_r(t))$, $t \geq 0$ and introduce the generating function: $\Phi(s, t) = Es_1^{Q_1(t)} \times ... \times s_r^{Q_r(t)}$, $|s_i| \leq 1$, $i=1,2,...,r$, $s = (s_1, ..., s_r)$.

Theorem 1. *For the service process in the transitional regime*

$$\Phi(s, t) = \left(\prod_{j=1}^r \left[1 - \sum_{k=1}^r (1 - s_k) p_{jk}(t) \right]^{i_j} \right) \times \exp \left\{ - \sum_{k=1}^r (1 - s_k) \rho_k(t) \right\},$$

where $Q'(0) = (i_1, i_2, ..., i_r)$, $\rho_k(t) = \sum_{j=1}^r \int_0^t \lambda_j(u) p_{jk}(t-u) du$,

$$P(t) = \|p_{ij}(t)\|_1^r = \exp(\Delta(\mu)(P - I)t), \quad \Delta(\mu) = \|\mu_i \delta_{ij}\|_1^r.$$

This theorem was subsequently generalized to the case $[M_t | G | \infty]^r$ -networks and there was obtained a special form of Jackson's law for networks with nonhomogeneous periodic Poisson flow.

Note that the formulas obtained in this work generalize the results of [1] for homogeneous Markov networks of this type.

References

1. Anisimov, V.V., Lebedev, E.A. Stochastic queuing networks. Markov models. - K.: Lybid, 1992. - 208 p.

THE CREATION OF CRYPTOGRAPHIC KEYS BASED ON ON-LINE SIGNATURE

Lutskiv A., Lupenko S., Zagorodna N.

Ternopil Ivan Pul'uj National Technical University

landriy@gmail.com

Given research is devoted to the development of on-line signature authentication system. Software for authentication could be considered separately, but its desired feature is capability of integration in information systems with other types of authentication data. Main steps of the person registration in authentication system are shown on figure 1.

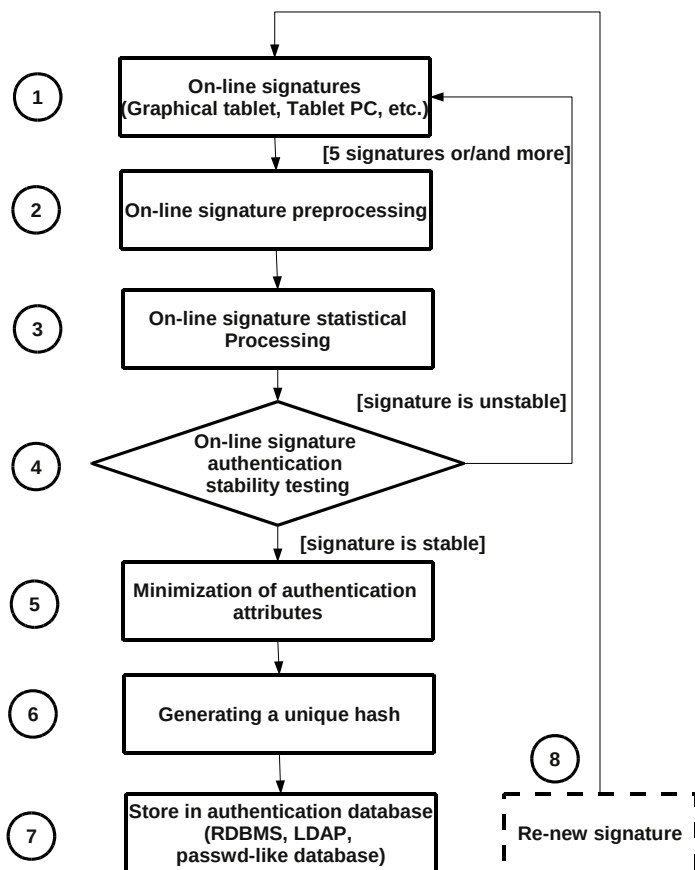


Figure 1 - General person registration scheme

One of the fundamental problems of the on-line signature authentication system exploitation is a creation of stable, reliable and unique authentication keys compatible with usual password hash by size and form. This approach will give a possibility to increase the application of on-line signature authentication systems significantly.

Available general methodology mostly concerns the static biometry data. Therefore investigation and development of the cryptographic key based on dynamic biometric personal attributes is a scientific problem of great importance. It is required to create cryptographically stable and unique standards-valued biometric keys. Development of new methods if this problem solution will allow to apply this methodology not only to on-line signature, but to whole class of other dynamic biometry data, including “keyboard handwriting” and pronunciation of voice phrases.

Steps 1–5 are investigated in [1-3]. Step 7 is standard for different information systems. According to collected logging data (quantity of false rejects) a person is recommended by authentication system to renew his on-line signature using re-registration on 8th step. This paper concern step 6, where key should be obtained.

Development of common methods of a unique encryption key creation based on on-line signature is carried out by authors. This key should represent person by the dynamic biometric pattern and at the same time be cryptographically strong. Web-page of this project is available at: <http://www.nalabs.te.ua/signature/>.

References

1. *Луцків А.М.* Математичне моделювання і обробка динамічно введеного підпису для задачі аутентифікації особи у інформаційних системах: Дис. ...кандидата техн.наук: 01.05.02; - Захищена 03.06.2008; Затв. 03.12.2008. - Тернопіль, 2008. - 276с.
2. *Загородна Н. В.* Удосконалення математичної моделі динамічного підпису шляхом урахування сили натиску в процесі його відтворення / Н. В. Загородна, С.А. Лупенко, Ю.Ш. Наботов // Збірник наукових праць Військового інституту телекомунікацій та інформатизації Національного технічного університету України „Київський політехнічний інститут”. – Випуск № 2. – Київ: ВІТІ НТУУ „КПІ”, 2011.— С.47-57.
3. *Загородна Н. В.* Удосконалення методу попередньої обробки динамічного підпису шляхом урахування кута нахилу / Н. В. Загородна, С.А. Лупенко, Ю.Ш. Наботов // Вісник ТНТУ. — Тернопіль, 2011. — Том 17. — № 2. — С.164-174.

USE OF DISCRETE NONLINEAR DYNAMICS TOOLS IN DECISION-MAKING ON THE STOCK MARKET

Maksishko N.

Zaporizhzhya National University

maxishko@ukr.net

The infrastructure of the stock market have changed in a globalized economy and use of new information technologies, which led to a complete review of concepts and models as a function of the market in general and certain types of businesses associated with the issuance and trading of securities, including broker-dealer services, etc.

Investigation of the structure and dynamics of the Ukrainian stock market has revealed that the stock market is a complex, nonlinear system. Of existing mathematical methods to predict not only the correct value, but even in the right direction of the dynamics of the stock market is rather limited.

The aim of this research is the use of discrete nonlinear dynamics methods [1] to analyze the behavior of the index and futures on the index of Ukrainian shares.

As a result of a complex fractal analysis we established the existence of long-term memory in the dynamics, obtained quantitative estimates system characteristics of the dynamics, which made it possible:

a) to estimate the degree of predictability of the dynamics at different time intervals and sections;

b) to determine the parameters and build a hybrid prognostic model that is based on the model of a homogeneous structure (CA), and compared with other methods, provides a more accurate forecast.

References

1. Максишко Н. К. Моделивання економіки методами дискретної нелінійної динаміки : монографія / Н. К. Максишко ; наук. ред. проф. В. О. Перепелиця. – Запоріжжя : Поліграф, 2009. – 416 с.
2. Official site Ukrainian birzha [Electronic resource] . - Access mode: <http://www.ux.ua>.

DECISION SUPPORT SYSTEM FOR MEDICAL SYSTEM RESEARCH

**V.P.Martsenyuk, I.Ye.Andrushchak, N.M.Gandzyuk,
N.Ya.Klymuk, O.M.Kuchvara, Z.V.Mayhruk**

I.Ya. Horbachevsky Ternopil State Medical University, Ukraine

Topicality of the theme. The current state of health care is closely related to orientation on evidence-based medicine, the main directions of which are: standardization of health care and medical research, active use of decision support systems in medical research, development of clinical information systems.

Overcoming contradictions between the amount of medical information and the possibility of its full analysis is possible with the use of information systems in medicine that are based on methods of modeling, system analysis and decision making theory.

At the same time the basis for decomposition in algorithms of system analysis in medicine is the content model of a disease. The disease implies the integration of pathological processes, characterized by restriction of protective and adaptive effects and decrease of working capacity of a human being. Hence, the determinant in the disease analysis should be study of the pathological process. In addition, the use of models of diseases in clinical practice must take into account such processes, as pharmacokinetics and pharmacodynamics of a medical preparation.

On the other hand, systematic and analytical substantiation of application of schemes and methods of treatment should be based on adequate financial models, such as medical insurance with the calculation of the duration of a patient's stay at the stage of the disease, the cost of treatment, determining the basic indicators of health insurance policy.

The above-mentioned problem encourages to the development of informational-analytical decision making support system aimed at solving the tasks of choosing optimal treatment schemes on the basis of integration of the pathological process and medical insurance models. The characteristics of pathological process, indicators of toxicity of treatment as well as basic parameters of health insurance policy are the criteria of quality in such models.

The main statements. One of the most complex pathological processes is the process of pathological formation growth. We suggest to use Homperfs dynamics for the description of tumor growth. Therefore,

as the basic model the anti-tumor immunity model, taking into account the influence of the damaged target-organ on the immune response, is proposed. Besides, the practical tasks associated with radiotherapy and radiosurgery (gamma-knife, cyber-knife) treatment require consideration of impulse effects in such models.

It should be noted, that the impulse differential equations in general form may not have any solution, even when the corresponding differential equations are quite smooth. Therefore, evaluation of solutions of the system in the terms of model parameters in explicit form is suggested.

The model can be used for the description of pathological process of tumor growth and for choosing treatment schemes in the tasks of optimal management. At the same time, the tasks of health insurance in case of oncologic diseases require consideration of models for defining the basic indicators of an insurance policy – survival of the patient, amount of premiums, calculation of the cost of treatment and others. This requires consideration of the probabilistic models of multi-staged diseases.

We have proposed a multi-staged model of oncological disease as a compartment process for which are known laws of distribution of period of the patient's stay at each stage. So, a four-staged model of the disease has the following form (Fig. 1):

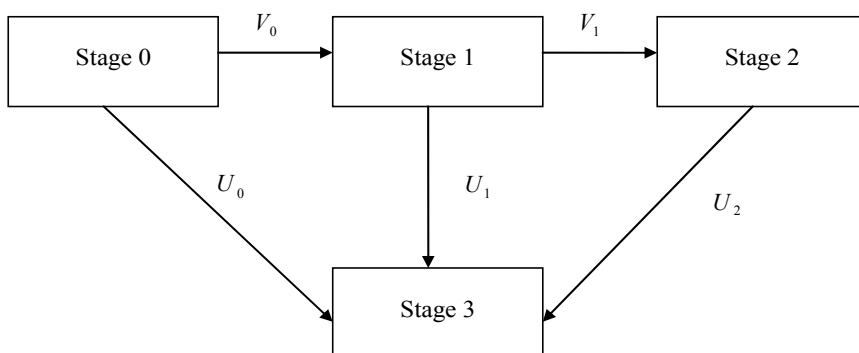


Fig. 1 Compartment model of four-staged disease.

Here V_i , $i = \overline{0,2}$ - is duration of a patient's stay at a stage i , $i = \overline{0,2}$ before the transition to the stage $i + 1$, $i = \overline{0,2}$; U_i - is time of a

patient's stay at the stage i , $i = \overline{0,2}$ before death, that is the transition to stage 3. Here, with the aim of correctness consider that $V_2 = U_2$.

In order to obtain transition probabilities and calculate the number of insurance functions such random values are introduced:

$$\begin{aligned} H_i &= \min(U_i, V_i), i = \overline{0,2}, \\ W_i &= U_i - V_i, i = \overline{0,2}, \\ Y_{ij} &= \sum_{k=1}^j H_k, i \leq j = \overline{0,2}. \end{aligned}$$

The main result of the research states:

Theorem 1. Transitional probabilities $q_{ij}(t), i \leq j = \overline{0,2}$ can be calculated in accordance with the ratio:

$$\begin{aligned} q_{ij}(t) &= P\{S(t) = j / S(0) = i\} = P\{W_k > 0, k = \overline{i, j-1}\} (P\{Y_{ij} > t / W_k > 0, k = \overline{i, j-1}\} - \\ &- P\{Y_{ij-1} > t / W_k > 0, k = \overline{i, j-1}\}). \end{aligned} \quad (1)$$

Suppose further exponential distribution of values U_i and V_i , $i = \overline{0,2}$, that is :

$$U_i \sim \text{Exp}(\theta), i = \overline{0,2}, V_i \sim \text{Exp}(\lambda_i), i = \overline{0,1}. \quad (2)$$

Theorem 2. In case of assumption (2) concerning the nature of value distribution U_i and V_i , $i = \overline{0,2}$, transitional probabilities $q_{ij}(t), i \leq j = \overline{0,2}$ can be calculated as follows:

$$\begin{aligned} q_{00}(t) &= e^{-(\theta_0 + \lambda_0)t}, t > 0. \\ q_{01}(t) &= \frac{\lambda_0}{\theta_0 + \lambda_0} \left(\frac{\theta_0 + \lambda_0}{\theta_1 + \lambda_1 - \theta_0 - \lambda_0} e^{-(\theta_1 + \lambda_1)t} - e^{-(\theta_0 + \lambda_0)t} \right), t > 0. \\ q_{02}(t) &= \frac{\lambda_0 \lambda_1}{(\theta_0 + \lambda_0)(\theta_1 + \lambda_1)} \left(\frac{(\theta_0 + \lambda_0)(\theta_1 + \lambda_1) e^{-\theta_2 t}}{(\theta_1 + \lambda_1 - \theta_0 - \lambda_0)(\theta_2 - \theta_1 - \lambda_1)\theta_2} - \frac{(\theta_0 + \lambda_0)}{(\theta_1 + \lambda_1 - \theta_0 - \lambda_0)} e^{-(\theta_1 + \lambda_1)t} \right), t > 0. \\ q_{03}(t) &= 1 - q_{00}(t) - q_{01}(t) - q_{02}(t), t > 0, \\ q_{11}(t) &= e^{-(\theta_1 + \lambda_1)t}, t > 0, \\ q_{12}(t) &= \frac{\lambda_1}{\theta_1 + \lambda_1} \left(\frac{\theta_1 + \lambda_1}{\theta_2 - \theta_1 - \lambda_1} e^{-\theta_2 t} - e^{-(\theta_1 + \lambda_1)t} \right), t > 0, \\ q_{13}(t) &= 1 - q_{11}(t) - q_{12}(t), t > 0, \end{aligned}$$

$$q_{22}(t) = e^{-(\theta_2 + \lambda_2)t}, \quad t > 0,$$

$$q_{23}(t) = 1 - e^{-(\theta_2 + \lambda_2)t}, \quad t > 0.$$

It should be noted, that assumption (2) concerning exponential distribution of values U_i and V_i , $i = \overline{0,2}$, although it gives a clear view of the formulas for calculating transition probabilities and can be applied in many cases, but still it does not completely correspond to tumor growth, which, as it is experimentally proved, corresponds to Homperpts dynamics. This given distribution law subjects survival of patients with cancer, and time of their stay at the stages of the disease. So, further we will also consider the case, when the values U_i, V_i , $i = \overline{0,2}$ have Homperpts distribution, that is $U_i \sim G(\mu_i, \eta_i)$, $V_i \sim G(\alpha_i, \beta_i)$, $i = \overline{0,2}$. At the same time redefinition of Homperpts distribution parameters is used, according to which:

$$F_{U_i}(t) = 1 - \exp \left[-e^{\frac{t - \mu_i}{\eta_i}} \right],$$

$$F_{V_i}(t) = 1 - \exp \left[-e^{\frac{t - \alpha_i}{\beta_i}} \right], \quad i = \overline{0,2}.$$

Further, we will consider the case when $\eta_i = \beta_i$ $i = \overline{0,2}$.

Theorem 3. Let $U \sim G(\mu, \eta)$ and $V \sim G(\alpha, \beta)$ - be random variables distributed according to Homperpts distribution, and $\eta = \beta$. Then the difference $W = U - V$, distributed according to the distribution law with density:

$$f_{U-V}(t) = \frac{e^{\frac{t + \mu + \alpha}{\eta}}}{(e^{\frac{\mu}{\eta}} + e^{\frac{t + \alpha}{\eta}})^2}. \quad (3)$$

In calculating the total time of stay on the stages of the disease in this case, we will certainly come to the special functions. As an example is the following result, obtained in case of the model in the absence of mortality at intermediate stages of the disease.

Theorem 4. Let V_0 be distributed accordingly $G(\mu, \eta)$, and V_1 - accordingly $G(0, \eta)$ - are independent random variables. Here $\mu, \eta > 0$.

Then the random variable $Y = V_0 + V_1$ has a distribution function

$$F_Y(t) = 1 - 2\sqrt{Z} K_1(2\sqrt{Z}), \quad (4)$$

where $Z = e^{\frac{t-\mu}{\eta}}$, and $K_1(\cdot)$ is modified Bessel function of second kind.

Below is the order of calculation in the model of insurance functions related to the level of premiums, expected benefits and longevity. More information about such insurance functions is described in [Bowers, N.L., Yerber, H.U., Hickmen, J. C., Jones, D.A. and Nesbitt, C.J. (1997), Actuarial Mathematics, 2-d ed., Schaumbury Illionis, The Society of Actuaries.]

It is obvious, that the parameters of an insurance policy should result from the cost of medical services that will be provided. So, the cost of $-t$ year policy with continuous annuity $\bar{a}_i(t)$ must correspond the expected cost of medical services for a person, who is currently at the stage i , taking into account the cost of \$ 1 in the future. For example, the cost of medical services for a person who is now at the stage $i = 0, 1$, which during the time $(0, t)$ becomes the final stage 2, may be calculated as follows:

$$H(t, i) = \int_0^t (c_{1i} + c_{2i} e^{h_i s}) e^{-\delta s} q_{i2}(s) ds, \quad \text{where } c_{1s}, c_{2s}, h_1 \text{ are}$$

positive constants.

Here c_{1i} is some fixed cost of medical services for the stage i (for example, the cost of the basic treatment), $c_2 e^{h_i s}, (0 < s < t)$ is the variable cost of treatment, which is determined by the initial stage i and time s .

Conclusions. In the research mathematical methods are developed, that underlie the decision-making support system of insurance providing of cancer treatment. It is shown, that the model, which is suitable for adequate description of the pathological process of growth of abnormal formation is the model based on impulse differential equations of Homperpts dynamics. On the other hand, the calculation of insurance functions and cost of treatment leads to the necessity of development of probabilistic model of multi-staged disease,

where the distributions of period of stay at the stages of oncologic disease correspond to Homperfs distribution.

ON OPTIMAL CONTROL PROBLEM IN MODEL OF PATHOLOGICAL FORMATION GROWTH BASED ON THE RICHARD DYNAMICS

V.P. Martsenyuk, O.A. Bagrij-Zayats

I.Ya. Horbachevsky Ternopil State Medical University, Ukraine
marceniuk@yahoo.com, bagrijzayats@gmail.com

The theory of optimal control has been well developed for over forty years. With the advances of computer technique, optimal control is now widely used in multi-disciplinary applications such as biological systems, communication networks and socio-economic systems etc. As a result, more and more people will benefit greatly by learning to solve the optimal control problems numerically.

Treatment of a pathogenic disease process is interpreted as the optimal control of a dynamic system. Evolution of the disease is characterized by a non-linear ordinary differential equation that describes concentrations of pathogens, plasma cells, and antibodies, as well as a numerical indication of patient health. Without control, the dynamic model evidences sub-clinical or clinical decay, chronic stabilization, or unrestrained lethal growth of the pathogen.

The dynamic equations are controlled by therapeutic agents that affect the rate of change of system variables. Optimal control solutions that defeat the pathogen and preserve organ health are demonstrated. It is shown that control theory can point the way toward new protocols for treatment and remediation of human diseases.

Interaction of laser irradiation and biological systems are investigated. The pathological formation growth based on Richard dynamics are considered.

Pontryagin maximum principle is applied in this work to find the optimal control of the pathological formation growth. The general solution of the controlled system is obtained. Finally, numerical example are presented to explain the analytical solution.

OPTIMAL CONTROL BY THE PROCESS OF AEROSOLS SEDIMENTATION OF HEAVY METALS

V.P. Martsenyuk, D.V. Chernetskyy

**I.Ya. Horbachevsky Ternopil State Medical University, Ukraine
dmitroch7@gmail.com**

Modern production of heavy industry is accompanied by a large release of aerosols of heavy metals into the atmosphere, which are harmful to the workers' health of these enterprises. There are two ways to reduce this harmful effect: modernization of production (which will reduce release of harmful substances); optimization of microclimate at the enterprises, that will speed up sedimentation of dust of heavy metals. The most effective is combination of these both methods. In modern terms the first way is more effective, but it is also very costly, which often becomes an obstacle for its realization. Next we will focus on the second method.

The process of heavy metals aerosol sedimentation depends on the rate of aggregation of nanoparticles of these metals, which in its turn depends on the air temperature. So, with the elevation of temperature the intensity of Brownian motion increases, which will accelerate the formation of nanoparticles of large size, which will form sediment by the action of gravity. However, the elevation of temperature will cause increase of upward flow of air, which will increase the amount of aerosol in the air.

Also a significant factor for accelerated sedimentation of heavy metals dust is air irrigation (washout), but this will increase humidity in the premises that is often harmful to production.

For an optimal selection of the above-mentioned parameters we use the apparatus of optimal control. We construct a function of aerosol sedimentation rate depending on the number of aerosol particles at a certain level and the probability of collision of these particles. It depends on the environment temperature, viscosity and density of the air, particle size (or their conglomerates). Next we consider finding the minimum of this function by taking the temperature as a control. The solution of this problem will be those optimal conditions in which the dust sedimentation rate of heavy metals will be maximal. So, the concentration of harmful nanoparticles at the human respiratory tract level is minimal, i.e., their effects on the organism will be minimal.

It should be noted, that in case of necessity to increase concentration of aerosol in the air, we similarly construct the function of

aerosol sedimentation rate in this environment, and again turn to the problem of optimal control. So, we can regulate the concentration of certain aerosols in the air column, according to the production requirements.

CONSTRUCTION OF THE EXPONENTIAL ESTIMATE IN THE COMPARTMENT SYSTEM WITH DISTRIBUTED DELAY BASED ON HALE-LUNEL'S INEQUALITIES

V.P. Martsenyuk, N. M. Gandzyuk

I.Ya. Horbachevsky Ternopil State Medical University, Ukraine
nadiagan84@gmail.com

Compartment systems with delay arise in a number of problems of population dynamics, pharmacokinetics, mathematical epidemiology, and others.

The solution of these equations even in the linear case results in approximate calculations, which is not very convenient for finding explicit solutions of such problems as:

- determine the time t^* , when the number of infected people will be less than a certain level i^* (mathematical epidemiology);
- assess the time, when there will be no more d^* units of the medical preparation in the patient's organism (pharmacokinetics) etc.

A number of papers is devoted to the construction of exponential estimates for the systems with delay. Yet, the most promising, in our opinion, is the method of construction of the whole class of exponential estimates on the basis of Hale-Lunel's inequality.

So, the aim of our work is application of the approach on the basis of Hale-Lunel's inequality for construction of the exponential estimate of solution of compartment systems with distributed delay.

In this work the method of construction of the exponential assessment of solutions of linear compartment system with delay is developed. With this aim, the linear functional of Lyapunov-Krasovskiy and Hale Lunel's inequality have been used. The result is illustrated by pharmacokinetic model in anesthesiology.

PHYSIOLOGICALLY-BASED PHARMACOKINETIC MODELING OF NANOPARTICLES

Martsenyuk V.P., Melenchuk I.B., Kravets N.O.

**I.Ya. Horbachevsky Ternopil State Medical University, Ukraine
melenchuk_i@mail.ru**

Nanoparticles or nanotechnology were explored through pharmacokinetic studies for a variety of biomedical usages including: delivering and targeting drugs; enhancing therapeutic durations and effects through controlled release mechanisms and/or binding to nanoparticles; reversing multidrug resistance; manipulating and influencing tissue distributions for therapeutic efficacy; evading reticulo-endothelial system for longer bioavailability; affecting drug pharmacokinetics by manipulating particle size and charge or through encapsulation; imaging application through the unique physicochemical properties of nanoparticles; and potentiating drug effects. “Classical pharmacokinetics” refers to those empirical noncompartmental or compartmental pharmacokinetic studies routinely practiced in pharmaceutical industry. Unlike classical pharmacokinetics, the compartments of a PBPK model have anatomical and physiological identity and related significance. This is a major difference from empirical noncompartmental or compartmental pharmacokinetic modeling approaches. PBPK models can be used to describe concentration–time profiles in individual tissue/organ and in the plasma or blood. When the concentration of a certain target tissue, rather than the plasma concentration, is highly related to a compound’s efficacy or toxicity, PBPK modeling will be a more useful tool than classical pharmacokinetic models for describing PK/PD relationship and thus make a better prediction of the time course of drug effects resulting from a certain dose regimen for the compound of interests. Furthermore, PBPK models in combination with absorption simulation and quantitative structure–activity relationship approaches will bring us closer to a full prediction of drug disposition for pharmaceutical new entities, and help streamline the selection of lead drug candidate in the drug discovery process. Lastly, unlike empirical noncompartmental and compartmental pharmacokinetics, PBPK modeling is a powerful tool for extrapolation, be it for inter-species, inter-routes, inter-doses, inter-life stages, etc.

GENERATION OF SYNTHETIC ECG-SIGNALS WITH THE HELP OF McSHARRY MODEL

V.P. Martsenyuk, R.O. Sarabun

I.Ya. Horbachevsky Ternopil State Medical University, Ukraine
romasar86@gmail.com

New biomedical algorithms of processing electrocardiosignals are usually evaluated by their application for electrocardiogram, which are kept in a large database. Having access to the realistic artificial ECG signals it is possible to facilitate this assessment. In this work a review of the model, designed for generating synthetic signals of ECG, is made and it is realized as a software environment.

To construct the model a system of three nonlinear differential equations proposed by McSharry in the article [1] is used. The model generates an ECG trajectory in three-dimensional space with coordinates (x, y, z) . Some tines on the ECG such as P, Q, R, S, T, are displayed by means of trajectory motion relative to the axis z . They are found by fixed angles $\theta_P, \theta_Q, \theta_R, \theta_S, \theta_T$ on a circle in the plane (x, y) .

The saoftware environment is realized as a package of Java-classes. It includes the following packages and classes. The Fde package is used for obtaining the numerical solution of differential equations. The Graph package contains the classes, intended for graphic visualization of equation solutions. The mcsharry package contains classes describing McSharry's model. It includes the following classes: McSharryECGSystem – describes the right parts of the differential equations of the model; McSharryECGSystemGraph – is used for constructing graphs of solutions of the corresponding equations; McSharryECGSystemGraphMenu – is a class, that describes the menu charting; McSharryECGSystemInputDataFrame – is a class-frame for the introduction of the initial model parameters.

The developed software environment enables its publication in the form of the Internet project.

References

1. McSharry P., Clifford G., Tarassenko L., Smith L. A dynamical model for generating synthetic electrocardiogram signals. IEEE Transaction On biomedical Engineering, 2003;50(3):289-294.

THE ALTERNATIVES SELECTION PROBLEM ON THE FUZZY SET OF CLEAR GOALS

S.O. Mashchenko, O.M. Bovsunivskiy

Taras Shevchenko National University of Kyiv, Ukraine

msomail@yandex.ru, bovs@email.ua

The problem of rational selection of alternatives, in which the goal of individual decision-maker (IDM) is defined by the fuzzy set of clear targets, is considered.

Let be X – universal set of alternatives which are given by the fuzzy set of alternatives D and clear sets G_i , $i \in N = \{1, \dots, n\}$, that can expresses (characterize) the IDM's goal. Sometimes the IDM can't clearly specify which clear sets G_i , $i \in N$ are relevant when making decisions, but may determine some fuzzy subset $\tilde{N} \subseteq N$ of these sets. Then the IDM's goal may be defined by the intersection $\tilde{G} = \bigcap_{i \in \tilde{N}} G_i$ [1,2]

of fuzzy set $\tilde{N}$ of crisp sets G_i , $i \in N$. In this case, for each fixed alternative $x \in X$ value of membership functions of fuzzy set $\tilde{G}$ also create fuzzy set and can be define as so-called type-2 fuzzy set (fuzzy set with membership function that has fuzzy set of values; T2FS).

It was developed a constructive representation of the membership function of T2FS - $\tilde{G}$, considered the properties of this set. In paper also proposed method of the alternatives selection from the fuzzy set $\tilde{G}$ on the fuzzy set of alternatives D ; indicated the existence of maximizing alternative.

References

1. Машченко С.О. Прийняття рішень за нечіткою множиною відношень переваги / С.О. Машченко, О.М. Бовсунівський // Вісник Київського університету. Серія: фіз.-мат. науки. – 2011. – № 3. – С. 131 – 136.
2. Машченко С.О. Нечеткие индивидуально-оптимальные равновесия / С.О. Машченко // Кибернетика и вычислительная техника. – 2010. – № 156. – С. 34 – 44.

RESEARCH OF NONLINEAR DYNAMICS AND CHAOS CHARACTERISTICS IN THE MODELS OF MEDICAL- BIOLOGICAL PROCESSES

I.Ya. Horbachevsky Ternopil State Medical University, Ukraine
Maykhruk Z.V.

The hidden tendency of nonlinear dissipative systems to the irregular movements has been remained unexplored for a long time. The study of such systems was limited by the area of regular behavior, which is characterized by regular attractors (a fixed point, a limit cycle or a torus). In the study of dissipative systems a whole new world was discovered by Edward Lorenz, who developed a simplified hydrodynamic model for meteorology, which is derived from the simplified Navier-Stokes equation. In this work on the example of medico-biological processes the basic characteristics of dissipative system are studied, which are volume contraction in phase space and the concept of regular attractors that characterize the correct movement. Next chaotic motion is considered, which is studied by classical means, such as power spectrum and autocorrelation, as well as by modern geometric and numerical methods, such as Lyapunov exponents, correlation dimensions and Kolmogorov entropy, that are used for characteristic of a strange attractor.

Autocorrelation $\bar{a}(s) = \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T f(t+s)f(t)dt$ and
spectrum of power $P(\omega) = \lim_{T \rightarrow \infty} \frac{1}{2T} \left| \int_{-T}^T f(t)e^{-i\omega t} dt \right|^2$ are

equivalent representations of one and the same evolutionary process. However, each of them has different characteristics of output signal $f(t)$. Autocorrelation reflects memory of the internal communications of the system, while the spectrum shows us the dominant fundamental frequencies.

With the help of Lyapunov exponents a number of results has been obtained as to their relation to the attractor dimension according to Lyapunov, concerning assessment of entropy by Kolmogorov-Sinai due to positive Lyapunov exponents.

In clinical application it is important to know the largest Lyapunov exponent σ_1 of chaotic motion, as it allows you to get assessment of the so-called relaxation time t^* .

MATH MODELLING OF THE TACTICAL ACTIVITIES

Jan MAZAL¹, Petr STODOLA², Ivana MOKRÁ³

University of Defence, Czech Republic

¹jan.mazal@unob.cz, ²petr.stodola@unob.cz, ³ivana.mokra@unob.cz.

In context of the latest technological approach to the human activities, it also affects the military area. The development and increasing demands on combat information systems leads to the state, where these systems slowly reaching its technological edge and the next way of its development lays in optimization of the tactical command and control process. The future of the 21-st century battlefield is turning in a one perspective to the tactical decision support based on math modeling of tactical activities in a real time. This problematic consists of the wide spectra of the operational and multi-criteria problems. This article is dedicated to one of the thorniest problem of contemporary asymmetric battlefield, namely math solution of the optimal area surrounding including computer application and simulation of the mentioned problem.

INTEGRATION OF THE GEOGRAPHICAL AND OPERATIONAL ANALYSES IN THE TACTICAL MANEUVER MANAGEMENT

Jan MAZAL¹, Petr STODOLA², Marian RYBANSKÝ³

University of Defence, Czech Republic

¹jan.mazal@unob.cz, ²petr.stodola@unob.cz, ³rybansky@unob.cz.

The latest military trends are setting the demanding requirements to the contemporary operations. The focus is laid on the quality and proper integration of underlay analyses, necessary for the effective decision process execution. These trends are apparent since the year 2002 and escalating in the context of building geographical and tactical criteria database. This plays the decisive role as an input to the weighted and conditional geo-tactical layer integration. Possibilities, combinations and algorithmic approach could be really wide, mainly in

the area of conditional and stable tactical configuration search. Solved problem, described in the article is dedicated to the optimal maneuver management in a wide context of tactical, meteorological and geographical conditions. This is the fundamental fragment of the operational and tactical tasks, what we could solve by these days (thanks to a high computing power of the latest computer technology).

TRAFFIC MANAGEMENT OPTIMIZATION AND ITS MODELING

Jan MAZAL¹, Petr STODOLA²

University of Defence, Czech Republic

¹jan.mazal@unob.cz, ²petr.stodola@unob.cz.

The paper deals with the issue of the optimal traffic flow focused on effective exploitation of all traffic segments, considering the traffic density, time and situational dependence and dynamical condition in the road net. Solution of this problem is dependent on the time density estimation of the partial traffic segments and the procedural modification of the road (math) graph in each iteration process of the shortest path algorithm. Practical integration of the suggested solution with advanced car GPS and communication systems would be considered as a high improvement of the traffic management in a common and limited environment. It also enables to identify or potentially predict the critical configurations and find optimal redirection of the traffic.

ABOUT METHODS OF DECISION ADOPTION UNDER UNCERTAINTIES

Menshikov Yu.L.

Dnepropetrovsk National University, Dnepropetrovsk, Ukraine

Menshikov2003@list.ru

Mathematical models of real processes and computer calculation are using for decisions adoption under uncertainties [1].

Let us consider the connection between external input z and output u_δ of real process has the form $A_p z = u_\delta$, where A_p is some approximate operator of real process.

Among the most typical algorithm of decisions adoption is based on forecast of behavior physical process by help of adequate

mathematical description of this process (operator A_p) in deterministic and stochastic statements taking into account the inaccuracy of operator A_p . The positive decision will be adopted if the forecast corresponds to waiting result. The negative decision will be accepted in other case. The synthesis of adequate mathematical description reduces to solution of special inverse problem. The value of solution inaccuracy of this inverse problem can be great.

But in some cases for adoption of decision the more deep investigation is necessary to make. For example, conclusion about right choice of mathematical description of process (operator A_p) has to execute on basis of comparison of functions $A_p z$ and u_δ which is given from measurement. If the choice is true then the positive decision will be accepted. The surface of moon is hard or not, the machine works in normal regime or not, patient is alive or not, chosen scenario is true or not, for example. The situation is complicated because for adoption of decision it is necessary to have the size of operator deviation A_p from exact operator A_{ex} . Such evaluation of deviation cannot be executed on principle. The possible algorithm of this problem solution was suggested.

References

1. Трухаев Р.И. Модели принятия решений в условиях неопределенности / Р.И. Трухаев. – Москва: Наука, 1981. – 311 с.

FUNCTIONAL REPRESENTATION OF AUTOMORPHISMS OF ROOTED SPHERICAL HOMOGENEOUS TREE

Morozov D.

The National University of Kyiv-Mohyla Academy, Ukraine, Kyiv
denis.morozov178@gmail.com

The study of the group of automorphisms of a of rooted spherical homogeneous tree is an important practical problem of discrete and computer mathematics. Portraits technics for automorphisms is illustrative, but technically difficult. Besides it does not allow to work directly with infinite-state automorphisms. Representation of automorphisms by continuous extension of isometric functions (defined on natural number series) provides a convenient apparatus for work on automorphisms of large or infinite number of states.

The following constructive theorem can construct a wide class of functions which define the automorphisms of rooted spherical homogeneous tree.

Theorem 1

The set of ring isometrics Z_2 is the class of adjacency by subgroup of strictly compressive functions concerning operation elementwise add in compressive functions group.

Theorem 2

Polynomial is an isometry if and only if the coefficient a_i is odd 2-adic number, sum of the coefficients with even numbers greater than 0 is an even 2-adic number and sum of the coefficients with odd numbers more than 3 is even 2-adic number.

**INFORMATIONAL AND SOCIOLOGICAL EFFECT ON
DECISIONS UNDER UNCERTAINTY**

Muzychuk A.

Ivan Franko National University of L'viv, Ukraine

pnc_andriy@mail.lviv.ua

The introduction of a new product onto the market can change the way consumers, or at least some of them, view established brands. This might be by drawing attention to some quality which was not previously much regarded, or it might make people give different weightings to the established qualities when making their decisions. Consumers are acting as Decision Makers (DMs) who have to evaluate and select one of available alternatives. This selection can be done once or periodically. Introducing the new alternative to the available set can be seen as “new information” for the DM.

In recent paper the natural extension of the concept of adopting evaluation rules in repeated decisions under uncertainty when the additional information becomes available introduced in [1] is suggested based on the assumption that the set of available alternatives for DM are dynamically changing from time to time. In the model not only the DM's experience gained during the analyzing outcomes from previous selections, but “sociological effect”, i.e. how one DM influences another, is also taken into account. Among other assumptions is that behavior of environment describes with Markov Chain.

Evaluation rules are created using OWA operator introduced in [2]. Despite the fact the OWA is widely used in different field to build

evaluation functions, there are some issue with using this approach [3] that is discussed in the paper as well.

References

1. Muzychuk A. OWA weight updating in repeated decision making under the influence of additional information / A. Muzychuk // International Journal of Intelligent Systems. – 2011. – Volume 26, Issue 7. – p. 591–602.
2. Yager R. On ordered weighted averaging aggregation operators in multi-criteria decision making / R.R.Yager // IEEE Transactions on Systems, Man and Cybernetics. – 1988. – Vol.18. – p. 183–190.
3. Dimitar F. On the issue of obtaining OWA operator weights / Filev Dimitar, Ronald R. Yager // Fuzzy Sets and Systems – 1998. – Volume 94, Issue 2. – p. 157–169.

GUARANTEED ESTIMATION OF THE OBSERVATIONS MATRIX FOR SYSTEMS WITH VARIABLE STRUCTURE

Nakonechnyi O.G., Donchenko V.S., Zinko P.M.

Taras Shevchenko National University of Kyiv, Ukraine

nakonechniy@unicyb.kiev.ua

The special type of the estimations are proposed for consideration in the report in the case of the vector functions observations

Let the vector function $x_1(t, s) \in R^{N_1}$ and $x_2(t, s) \in R^{N_2}$ are the solutions of equations:

$$\begin{aligned} \frac{dx_1(t, s)}{dt} &= f_1(x_1, t), \quad x_1(t_0, s) = x_0, \quad t_0 < t < s, \\ \frac{dx_2(t, s)}{dt} &= f_2(x_2, t), \quad x_2(s, s) = g(x_1(s, s)), \quad s < t < T, \end{aligned} \quad (1)$$

where $f_1(x_1, t), f_2(x_2, t), g(x_1)$ – some vector functions, which guarantee solvability of equations (1).

Let also vector functions $y_i(t), i = 1, 2$ are observed, each of them are of the form

$$y_i(t) = \int_{T_1}^{T_2} H(s) x_i(t, s) ds + \xi_i(t),$$

where $H(s)$ – the matrix function, $t_0 < T_1 < T_2 \leq T$, $t_0 < t < T, \xi_i(t)$ – realizations of uncorrelated mean square continuous

vector random processes with correlation functions $R_1(t_1, t_2)$ and $R_2(t_1, t_2)$, respectively.

It is also assumed, that the matrix function $H(s)$ is unknown. There two basic variants of additional supposition relatively this function. These are the next ones: 1) it belongs to some set G of continuous functions; 2) it belongs to Sobolev' space.

As to correlation functions $R_1(t_1, t_2)$, $R_2(t_1, t_2)$. They are supposed to be unknown and are the ones which belong to some sets F_1 and F_2 correspondingly.

We explore the problem of constructing the guaranteed linear mean square estimation (GLMS) $\hat{H}(s)$ for the function $H(s)$, namely, that one, which determined by the relations

$$\begin{aligned} \min_{\hat{H}} \sup_{G, F_1, F_2} \int_{T_1}^{T_2} \|H(s) - \hat{H}(s)\|^2 ds = \\ = \sup_{G, F_1, F_2} \int_{T_1}^{T_2} \|H(s) - \hat{\hat{H}}(s)\|^2 ds = \sigma^2. \end{aligned} \quad (2)$$

Explicit form of the GLMS as the solution of optimization problem (2) exists under certain assumptions. Also, the relevant example, when correspondent estimation are reasonable to be found one can find in [3]. Namely, it is the case, when the observations are of the form

$$y_i(t) = \int_{T_1}^{T_2} H(s) L^{(i)}(t, s) ds + \xi_i(t), i = 1, 2,$$

where $H(s)$ – the scalar function

and the vector functions

$$L^{(i)}(t, s) = \left(L_1^{(i)}(t, s), L_2^{(i)}(t, s) \right)^T \text{ and } \left(L_1^{(i)}(t, s), L_2^{(i)}(t, s) \right), i = 1, 2$$

are correspondingly the solutions of the next systems of the equations, correspondingly:

$$\frac{dL_1^{(1)}(t, s)}{dt} = \left(a_1^{(1)} + a_2^{(1)} L_1^{(1)}(t, s) \right) \left(L_0 - L_1^{(1)}(t, s) - L_2^{(1)}(t, s) \right), L_1^{(1)}(0, s) = L_{10}^{(1)},$$

$$\frac{dL_2^{(1)}(t,s)}{dt} = \left(a_1^{(1)} + a_2^{(1)} L_2^{(1)}(t,s) \right) \left(L_0 - L_1^{(1)}(t,s) - L_2^{(1)}(t,s) \right), L_2^{(1)}(0,s) = L_{20}^{(1)},$$

under $0 < t < s$ та $L_i^{(2)}(s,s) = L_i^{(1)}(s,s) + \theta_i$, $i = 1, 2$,

and

$$\frac{dL_1^{(2)}(t,s)}{dt} = \left(a_1^{(2)} + a_2^{(2)} L_1^{(2)}(t,s) \right) \left(L_0 - L_1^{(2)}(t,s) - L_2^{(2)}(t,s) \right),$$

$$\frac{dL_2^{(2)}(t,s)}{dt} = \left(a_1^{(2)} + a_2^{(2)} L_2^{(2)}(t,s) \right) \left(L_0 - L_1^{(2)}(t,s) - L_2^{(2)}(t,s) \right),$$

under $s < t < T$,

with some real number θ_i , $i = 1, 2$ – which may be unknown.

References

1. Михайлов А.П. Модели информационной борьбы / А.П. Михайлов, Н.А.Маревцева // Математическое моделирование. – 2011. – Т.23, №10. – С. 19 - 32.
2. Наконечний О.Г. Оцінювання параметрів в умовах невизначеності / О.Г.Наконечний // Наукові записки КНУ імені Тараса Шевченка, серія: «Кибернетика». – 2004. – С.102–111.
3. Nakonechny O.G. Modeling and predictive estimations of information treats under uncertainties // O.G. Nakonechny, V.S. Donchenko, P.M. Zinko / Abstracts XIX International Conference Problem of decision making under uncertainties. – Mukachevo, Ukraine. April 23-27, 2012. – pp. 29–33.

SELECTED METHODS OF ECONOMIC TIME SERIES DESCRIPTION

Neubauer J., Odehnal J.

University of Defence, Brno, Czech Republic

jiri.neubauer@unob.cz, jakub.odehnal@unob.cz

The article is focused on selected quantitative methods which can be used for description of economic time series. Vector autoregressive models and cointegration analysis play an important role in description of economic events (see Johansen (1995) or Lütkepohl (2007)). Multidimensional non-stationary process is called cointegrated if there is a linear combination of its one-dimensional components, which is stationary or trend-stationary. Economic time series are predominantly

non-stationary, nevertheless, one can find linear links which keep that whole system in so-called long-term equilibrium. Next useful tools for analysis of economic time series are methods of change point detection. Authors compare standard statistical methods of change point detection (see Csörgö, M. and Horváth, L. (1997)) with the method based on the sparse parameter estimation (see Neubauer, J. and Veselý, V. (2010, 2011)). All mentioned methods are applied to real economic data sets.

Keywords: time series, vector autoregressive model, cointegration, change point detection

References

1. CSÖRGÖ, M. and HORVÁTH, L. (1997). *Limit Theorems in Change-Point Problem*. Wiley, New York.
2. JOHANSEN, S. (1995) *Likelihood-based Inference in Cointegrated Vector Auto-regressive Models*. Oxford: Oxford University Press. ISBN 0-19-877450-7.
3. LÜTKEPOHL, H. (2007) *New Introduction to Multiple Time Series Analysis*. Berlin: Springer-Verlag. ISBN 978-3-540-26239-8.
4. NEUBAUER, J. and VESELÝ, V. (2011) Change Point Detection by Sparse Parameter Estimation. *Informatica*, **22**(1), 149–164.
5. NEUBAUER, J. and VESELÝ, V. (2010) Detection of Changes in the Czech Consumer Price Index by Sparse Parameter Estimation. *Forum Statisticum Slovacum*. **6**(5), p. 180–185. ISSN: 1336-7420

Acknowledgment: supported by the grant GAČR P402/10/P209 and by institutional support of MoD of the Czech Republic.

UNCERTAINTY ANALYSIS IN INFORMATION SYSTEM FOR AIR QUALITY MANAGEMENT

Nochvai V.^{1,2}, Kryvakovska R.²

¹The National State Tax Service University of Ukraine

²Pukhov Institute for Modeling in Energy Engineering, National Academy of Science Ukraine, Kyiv
volivn@ukr.net

The model for decision making in air quality management is considered. It is associated with large uncertainties due to incomplete data, errors of models and not precisely defined criteria for decision making. Neglect of the uncertainty could lead to erroneous decisions. Thus, the study of the reliability of data in information systems of environment management and uncertainty cutting is an actual problem. For this purpose the methods of optimization under uncertainty and

fuzzy decision-making models are considered relatively to the main sources of uncertainty. As a tool to deal with the probabilistic characteristics of information flows in the system of decision-making the Bayesian networks are analyzed.

The usual task of multi-objective optimization relating to air quality control is considered here. Generalized criteria for n_c - cost functions with a given $\mathbf{p}$ vector of preference expresses minimizing of environmental cost functions (air quality damage) and the emission (Q) control cost to ensure quality standards in the most effective way using the technical and economical means:

$$F(Q) = \sum_{i=1}^{n_c} \rho_i w_i(Q, q) \rightarrow \min, \text{ where } q - \text{random parameter that}$$

characterizes the error and incompleteness of data estimates.

The optimization task for air quality management was written also in the form of fuzzy decision making model. It enables the decision-makers to set thresholds for possible constraint violations and deviations from the desired targets. Vector relaxation is applied for search of satisfactory deviation from the ideal point.

The interaction with a decision-maker through the user interface is necessary to provide implementation of the optimization model in the fuzzy decision support system. For this purpose, the corresponding structure of the data flow in the information system is proposed on the base of web-interaction.

MODEL OF MILITARY SPENDING AND ECONOMIC GROWTH

Odehnal J., Neubauer J.

University of Defence, Brno, Czech Republic

jakub.odehnal@unob.cz, jiri.neubauer@unob.cz

The article is focused on evaluation of relationship between the military spending and economic growth. Authors (e.g. Dunne (2001), Kollias (2004)) investigated the causal relationship between variables in accordance with economic theory which presents that military spending as a part of government spending can affect national economy through various channel (e.g. through Keynesian-type aggregate demand stimulation). The aim of this article is to investigate and describe existence of relationship and when it exists, its nature and direction. To analyse the military spending in selected countries, authors employ

method of statistical analysis and analysis of multiple time series analysis.

References

1. KOLLIAS, Ch., MANOLAS, G., PALEOLOGOU, S. (2004) *Defence expenditure and economic growth in the European Union A causality analysis*. Greece: Journal of Policy Modeling, pp. 553–569.
2. DUNNE, P., NIKOLAIDOU, E. AND VOUGAS, D. (2001) *Defence spending and economic growth: a causal analysis for Greece and Turkey*. Defence and Peace Economics 12, pp. 1–26.
3. HARTLEY, K., SANDLER, T. (2001) *The Economics of Defence (Impacts of Military Expenditures: Growth, development and Military Expenditure)*. Volume 1. Part 3. Massachusetts: Edward Elgar Publishing, Inc. ISBN 1-85278-945-X.
4. JOHANSEN, S. (1995) *Likelihood-based Inference in Cointegrated Vector Auto-regressive Models*. Oxford: Oxford University Press. ISBN 0-19-877450-7.
5. LÜTKEPOHL, H. (2007) *New Introduction to Multiple Time Series Analysis*. Berlin: Springer-Verlag. ISBN 978-3-540-26239-8.

Acknowledgment: supported by the grant GAČR P402/10/P209 and by institutional support of MoD of the Czech Republic.

MOBILE SYSTEMS FOR FORECASTING AND DECISION SUPPORT INFORMATION

Okhremenko A.E., Stepanov O.V., Chernij D.I.

Taras Shevchenko National University of Kyiv, Ukraine

Technology of forecasting [1,3-5], using simulation software and systems, provides less time processing, high accuracy results and, simultaneously, prevents risks in making responsible decisions. The existing systems for forecasting of the continuation of evolutionary processes require powerful computational resources. Computer systems of such purposes [5], usually located in project offices, which carry out the development of general construction project. But, during the construction, engineers often need mobile systems, which (using rapid modeling) can provide clarification aerohydrodynamical parameters and other physical processes that occur inside or outside of some technical constructions and structures.

The mobile system for rapid prediction of aerohydrodynamical processes based on a simplified mathematical model [1,3] and the effective application of computing technologies was developed [2,4].

The system allows to determine the flow characteristics of randomly located open loops of arbitrary geometry. Similar modeling mobile systems can be installed on Tablets (Pic. 1) or on smartphones (Pic. 2) with touch screens. Adaptive interface provides a convenient introduction of geometric characteristics of design or construction for which is necessary to determine flow characteristics. Adaptive interface provides a convenient introduction of geometric characteristics of design or construction for which is necessary to determine flow characteristics.



Fig.1

Mobile modelling system installed on iPad.



Fig.2

Mobile modelling system installed on smartphone with touch screen

References

1. Довгий С.А., Лебедь А.Г., Литвин И.Н., Черний Д.И. Технологии прогнозирования эволюции физических процессов для систем поддержки принятия решений. // 10 Міжнародна науково-практична конференція: «Сучасні інформаційні технології управління екологічною безпекою, природокористуванням, заходами в надзвичайних ситуаціях», 5-9 вересня 2011р., Київ-Харків-АР Крим, 2011, Збірник наукових праць, С.5-36.
2. Довгий С.А., Лифанов И.К. Методы решения интегральных уравнений.- К.: Наукова думка, 2002, 344с.
3. Довгий С.А., Лифанов И.К. и др. Рекомендации по оценке аэрации территории в жилой застройке г.Москвы.- М.: Макс-Пресс-2006, 160с.

4. Черній Д.І., Головенко А.Д. Технологія експрес-прогнозу нестационарних нелінійних аераційних та гідрологічних процесів// International Workshop “PROBLEMS OF DECISION MAKING UNDER UNCERTAINTIES” (PDMU-2008), Abstracts, September 22-27, 2008, Cremia (Novy Svit), Ukraine, pp.127-128.

5. Черній Д.І., Гаркуша В.І., Риженко А.І., Кашпур О.Ф. Програмна система для дослідження аерогідродинамічних процесів.//Наукові розробки Київського національного університету імені Тараса Шевченка.-Частина 1. Природничі науки.- Київ: ВПЦ “Київський університет” – 2009, с.137.

THE SCHEME OF PARTIAL AVERAGING FOR ONE CLASS OF HYBRID SYSTEMS

O. Osadcha, N. Skripnik
olga.osadcha.ua@gmail.com

The hybrid system, where one equation is a differential equation with Hukuhara derivative and the second one is an ordinary differential equation, is considered. The interest in such systems follows from the fact, that some parameters of the model may be accurate, while the rest may contain the noise, errors and inaccuracies.

Consider a hybrid system with a small parameter

$$\begin{cases} D_H X = \varepsilon F(t, X, y), & X(0) = X_0, \\ \dot{y} = \varepsilon g(t, X, y), & y(0) = y_0, \end{cases} \quad (1)$$

where $t \geq 0$ is time, $X \in D_1 \subset \text{conv}(R^n)$, $y \in D_2 \subset R^m$, $\varepsilon > 0$ is a small parameter.

With system (1) the following partially averaged system is assigned

$$\begin{cases} D_H \tilde{X} = \varepsilon \tilde{F}(t, \tilde{X}, \tilde{y}), & \tilde{X}(0) = X_0, \\ \dot{\tilde{y}} = \varepsilon \tilde{g}(t, \tilde{X}, \tilde{y}), & \tilde{y}(0) = y_0, \end{cases} \quad (2)$$

where

$$\lim_{T \rightarrow \infty} \frac{1}{T} h \left(\int_0^T F(t, X, y) dt, \int_0^T \tilde{F}(t, X, y) dt \right) = 0, \quad (3)$$

$$\lim_{T \rightarrow \infty} \frac{1}{T} \left\| \int_0^T g(t, X, y) dt - \int_0^T \tilde{g}(t, X, y) dt \right\| = 0. \quad (4)$$

Theorem. Let in the domain $Q = \{(t, X, y) : t \geq 0, X \in D_1, y \in D_2\}$ the following conditions fulfill:

- 1) the multivalued mappings $F(t, X, y), \tilde{F}(t, \tilde{X}, \tilde{y})$ and vector-functions $g(t, X, y), \tilde{g}(t, \tilde{X}, \tilde{y})$ are continuous in t , uniformly bounded by constant M and satisfy Lipschitz condition in X, y with constant λ ;
- 2) limits (3) and (4) exist uniformly with respect to $X \in D_1$ and $y \in D_2$;
- 3) the solution $(\tilde{X}(t), \tilde{y}(t))$ of system (2) with initial conditions $\tilde{X}(0) = X_0 \in D_1' \subset D_1, \tilde{y}(0) = y_0 \in D_2' \subset D_2$ is defined for all $t \geq 0, \varepsilon \in (0, \sigma]$, and $\tilde{X}(t)$ belongs with some ρ -neighborhood to the domain $D_1, \tilde{y}(t)$ belongs with some ξ -neighborhood to the domain D_2 .

Then for any $\eta > 0$ and $L > 0$ there exists such $\varepsilon_0(\eta, L) \in (0, \sigma]$, that for $0 < \varepsilon \leq \varepsilon_0$ and $0 \leq t \leq L\varepsilon^{-1}$ the following inequalities hold

$$h(X(t), \tilde{X}(t)) < \eta, \|y(t) - \tilde{y}(t)\| < \eta,$$

where $(X(\cdot), y(\cdot))$ and $(\tilde{X}(\cdot), \tilde{y}(\cdot))$ are the solutions of systems (1) and (2) accordingly with initial conditions $X(0) = \tilde{X}(0) \in D_1', y(0) = \tilde{y}(0) \in D_2'$.

In case when the multivalued mappings $F(t, X, y), \tilde{F}(t, \tilde{X}, \tilde{y})$ and vector-functions $g(t, X, y), \tilde{g}(t, \tilde{X}, \tilde{y})$ are periodic in time, the more exact estimate can be obtained.

SIMULATION OF RANDOM FIELDS ON THE SPHERE. IN FUNCTIONAL SPACES

A.A. Pashko

European University, Kyiv, Ukraine,
pashkoua@mail.ru

It was constructed models random fields in functional spaces. This models approximate random fields with a given accuracy and reliability in of simulation in functional spaces are received.

Let S_d sphere in R^d . Let $\xi(x)$ - random continuous on the average to quadratic, random field on a sphere. This field it is

possible to depict in a kind [1]
$$\xi(x) = \sum_{m=0}^{\infty} \sum_{l=0}^{h(m,d)} \xi_m^l S_m^l(x),$$

where $\{\xi_m^l\}$ – are independent sub-Gaussian random variables,

$E(\xi_m^l)^2 = \sigma_m^2$, $l = 1, \dots, h(m, d)$, $S_m^l(x)$ – orthonormal spherical accordions of degree m , $h(m, d)$ - is an amount of accordions and

$$\sum_{m=1}^{\infty} h(m, d) \sigma_m^2 < \infty.$$

Let
$$\xi_M(x) = \sum_{m=0}^M \sum_{l=0}^{h(m,d)} \xi_m^l S_m^l(x).$$
 The $\xi_M(x)$ is approximate

model for $\xi(x)$ with by accuracy $\delta > 0$ and reliability α in some functional space, if

$$P\left\{\|\xi(x) - \xi_M(x)\| \geq \delta\right\} < 1 - \alpha,$$

where $\|\cdot\|$ - norm in functional space.

Theorem 1. Let there is a droningly undiscerning

sequence $\{b_k > 0\}$, $b_k \rightarrow \infty$, $k \rightarrow \infty$, and $\sum_{s=1}^{\infty} c_s (J(s))^{\frac{1}{2}} < \infty$

where
$$J(s) = \sum_{k=1}^s h(k, d) b_k^2 \sigma_k^2, \quad c_s = 3^{d-1} (s)^{(d-1)} \left(\frac{1}{2} - \frac{1}{p}\right) \left(\frac{1}{b_s} - \frac{1}{b_{s+1}}\right),$$

then for $\varepsilon > \sum_{s=M+1}^{\infty} c_s (J(s))^{\frac{1}{2}}$ and $D(M) = \sum_{s=M+1}^{\infty} c_s (J(s))^{\frac{1}{2}}$

$$P\left\{\left\|\xi(x) - \xi_M(x)\right\|_p > \varepsilon\right\} \leq \frac{\varepsilon}{(D(M))} \exp\left\{-\frac{\varepsilon^2}{2D^2(M)}\right\} \exp\left\{\frac{1}{2}\right\}.$$

Let $\xi(x)$ - linear isotropic random fields in $L_{u_2}(\Omega)$ - space.

Theorem 2. If $\sum_{m=1}^{\infty} h(m, d) \cdot \sigma_m^2 \cdot m^{d-1} < \infty$, for $\delta > 0$ and α

$$P\left\{\left(\int_{S_d} |\xi(x) - \xi_N(x)|^2 dx\right)^{\frac{1}{2}} \geq \delta\right\} \leq \left(u \left(\frac{\delta^2}{C_{u_2} \cdot C \cdot \sum_{m=N+1}^{\infty} h(m, d) \cdot b_m \cdot m^{d-1}} \right)\right)^{-1}$$

$$\text{where } \sum_{m=1}^{\infty} h(m, d) \cdot b_m \cdot m^{d-1} \leq \frac{\delta^2}{u^{(-1)}\left(\frac{1}{\varepsilon}\right)} \cdot C_{u_2} \cdot C$$

References

1. Yadrenko M.I. (1980) *Spectral Theory of random fields*. "Vyshcha shkola", Kyiv.
2. Kozachenko Yu.V., Pashko A.A., Rozora I.V. (2007) *The Simulation of Random Processes and Fields*. Zadruga, Kyiv.
3. Dzjamko V.Yo, Moza A.I., Pashko A.O. (2011) Simulation of solution of hyperbolic equation. *Bulletin of Taras Shevchenko National University of Kiyv*, No. 4, pp.16-20

DEVELOPMENT OF NEO-FUZZY MODEL OF NON-SATURATED PART OF SOIL

V. Pastushenko, A. Stetsenko

National university of water management and environmental use, Rivne
vteren@gmail.com , s_anastasia@ukr.net

The water-air conditions of soil on the drain-humidifier double-sided action systems with underground moistening are controlled by groundwater level's changes. Forecasting of plants' needs in water during vegetative period is very important for water and energy resources saving during the soil's moisture control. The problems of adaptation and self-instruction of soil's moisture's automated control systems in the conditions of stochastic weather factors' actions and control object characteristics' changing are steel opened. The control object in such systems is the non-saturated part of soil, in which the plants' root-age is situated. Stochastic disturbances – weather conditions – constantly influence on the object, that's why it has a stochastic uncertainty. The task of this work is to develop a mathematical model of non-saturated part of soil for soil's moisture forecasting on the base of neo-fuzzy neural network in the form of $W_{k+1}^h = NN(P_{k+1}, D_{k+1}, L_{k+1}, W_{k-1}^h, W_k^h)$, where input parameters are rainfalls P (mm), deficit of air's moisture D (mbar), groundwater level L from the light surface (m). The output parameter is the sucking soil's pressure W^h (m) in the fixed soil's level h , which is connected with soil's moisture by means of the main hydro-physical characteristic. $NN()$ - neural network transformation, k - current step. Results of modeling for different soil's levels are presented in the table 1.

Table 1
Results of neo-fuzzy models' work for sucking soil pressure's forecasting in non-saturated part of soil

Soil's layer	Mean square deviation	
	training	testing
h=0-10 sm	0.2725	0.2798
h=10-20 sm	0.1353	0.1471
h=30-40 sm	0.08413	0.08158

FOPTIMAL ESTIMATION OF FUNCTIONALS FROM SOLUTIONS TO TRANSMISSION PROBLEMS FOR LINEAR PARABOLIC EQUATIONS BY POINT OBSERVATIONS

Yu. K. Podlipenko¹, N.V. Grishchuk², A. Kovalyuk³

¹Taras Shevchenko National University of Kiev, Ukraine

²Niger Delta University, Nigeria

³ASA Institute of Computer Technology, NY, USA,

¹**youripl@mail.ru**, ³**akovalena@aol.com**

We elaborate methods of minimax estimation for values of functionals from solutions to transmission problem for linear second order parabolic equations with uncertain data.

It is assumed that right-hand sides of equations, boundary, transmission, and initial conditions entering into corresponding BVPs as well as second moments of noises in point observations are unknown and subjected to quadratic restrictions.

Our approach makes it possible to find optimal linear, with respect to observations, estimates of functionals from unknown solutions corresponding to the "worst" realizations of perturbations.

When the restrictions on unknown deterministic data of the boundary value problems of transmission are given completely or partly, we prove the theorems on a general form of minimax mean square estimates for functionals from solutions the considered BVPs as well as the theorems on the errors of estimation.

Using the method of transposition, we establish that the minimax estimates are expressed via solutions of some systems of integro-differential equations of the special type and prove the unique solvability of these equations.

APPROXIMATE MINIMAX ESTIMATES OF FUNCTIONALS FROM RIGHT-HAND SIDES OF MAXWELL EQUATIONS

Yu. Podlipenko¹, Yu. Shestopalov²

¹ Taras Shevchenko National University of Kiev, Ukraine

²Karlstad University, Karlstad, Sweden

¹ yourip@mail.ru, ² yourshes@kau.se

In our previous studies [1] we obtained, in particular, optimal estimates of functionals from right-hand sides of equations entering the statements of interior Maxwell problems with incomplete data using a minimax approach. Our approach was as follows. Let D be a domain bounded by a perfect conductor and occupied by a "dissipative" dielectric with unknown electric current density J belonging to a certain bounded set of vector-functions square integrable in D .

The considered problem of estimation was: by observations of electric and magnetic fields E and H to estimate linear continuous functionals from J under the assumption that observations are linear transformations of E and H perturbed by additive random noises with zero means and unknown second moments also belonging to a certain given set in the corresponding Hilbert space. We determined linear with respect to observations optimal estimates of right-hand sides of Maxwell equations from the condition of minimum of the maximal mean square error of estimation taken over the above subsets. Such estimates were called minimax or guaranteed estimates.

We developed the methods for obtaining such estimates expressed in terms of solutions to special variational equations.

In this work we obtain approximate minimax estimates via solutions of linear algebraic equations and show their convergence to the optimal estimates using the Galerkin method for solving the aforementioned variational equations.

This work was supported by the Visby Program of the Swedish Institute.

References

1. Podlipenko Y., Shestopalov Y. *Guaranteed estimates of functionals from solutions and data of interior Maxwell problems under uncertainties*/Y. Podlipenko, Y. Shestopalov. - Springer Conf. Proc. Second Annual Workshop on Inverse Problems within the Visby Program, Sunne, Sweden, 2012 (submitted) - 29 p.

HYDRODYNAMIC DEFORMATIONS IN POROUS MEDIA: THEORY AND APPLICATIONS

Polyakov V., Zhelizko V.

Institute of Hydrodynamics NASU, KNUBA

Polyakov_IGM@list.ru, zhelizko_v@ukr.net

A theory of hydrodynamic deformations in cohesionless porous media has been worked out based on exact solutions of mathematical tasks of two classes. It's an effective instrument for studying deformation regularities and consequences. The basic models consist of interrelated deformation and hydrodynamic submodels solved sequentially. The theory is able to provide reliable prediction of developing and reaching the steady physico-mechanical state for cohesionless soils. Drainage quite often operates at extreme conditions (intensive infiltration, high groundwater table and pressure in head horizon). Uncertainties arise when considering by theoretical methods groundwater flow and hydrodynamic deformations jointly because of considerable difficulties with the above conditions formalization. It's principally possible to remove the uncertainties if valid initial information is available and when modeling the deformation and flow processes as far as the first one comes to end and the second one becomes stabilized. But this way is unpractical. So, having in mind necessity, at least, of approximate deformations effect accounting we suggest to use, firstly, empirical data from full-scale observations, secondly, steady-state solutions of drainage tasks for soil subjected to deformations of the first (piping) and the second (structure ordering) types. Coming from the conception and the method of hydrodynamic resistances, a whole number of formulae have been deduced to calculate components of the general hydrodynamic resistance which adequately characterize improvement of soil water at different deformation scenarios. Associated in overall technique the formulae allow to extend essentially the application field of the popular method of simplified calculating drain parameters generalizing them to cohesionless and low-cohesion soils without any modification. Detailed quantitative analysis has been performed at numerous typical examples and in respect to a workable system of horizontal drains. It was established that drainage discharge can increase and hydraulic losses decrease due to hydrodynamic deformations by several tens of percent. So both types of deformations often make an important contribution to groundwater dynamics under drainage control.

ON APPROXIMATION OF CONTROLLED RETRIAL QUEUES

Vadym Ponomarov

Taras Shevchenko national university of Kyiv

vponomarov@gmail.com

The research of wide class of retrial queueing systems faces the problem of calculating characteristics of the system with the Poisson input flow. Markov chain that describes service process in such system is multidimensional and has infinite state space. Transition matrix of such process usually does not have special properties that would streamline the explicit solution of Kolmogorov set of equations. In addition, the probabilities of transition between states of the controlled system depend on its current state that complicates their obtaining even more. Therefore only the simplest models are explicitly researched on this moment (see, for example, [1], [2]).

This paper deals with the Markov model of the retrial queue with the Poisson incoming flow and controlled service rate. Characteristics of this system are approximated by characteristics of the system with the finite state space. It operates similarly to the original input system but has a restriction on maximum queue length. That means that the request which arrives when all servers are busy and there are M retrial customers on the orbit is lost. Such restriction on the state space allows us to write explicit formulas for stationary probabilities of the truncated system in terms of its parameters (see [3]).

The intuition indicates that, if we choose truncation level M large enough, then the truncated model converges to the original one. In general case the accuracy of such approximation depends on many factors: parameters of the system, truncation level, control policy and so on. So this problem should be investigated in more details. In this paper we discuss the closeness between stochastic characteristics of the input and finite system conditionally to their parameters. Several rather general policies of service rate switching are taken into account.

References

1. Artalejo J.R., Gomez-Corral A. Retrial queueing systems // Springer-Verlag, Berlin, 2008.
2. Falin G.I., Templeton J.G.C. Retrial Queues // Chapman and Hall, London, 1997.
3. Lebedev E.A., Ponomarov V.D. Retrial queues with variable service rate // Cybernetics and Systems Analysis – 2011. - Volume 47. - Issue 3. – p. 118-126.

RETRIAL QUEUES WITH LIMITED NUMBER OF RETRIALS

Pryshchepa Oksana

Taras Shevchenko National University of Kyiv

o.prischepa@gmail.com

Retrial queues are characterized by following feature that a primary customer who finds busy the service facility upon arrival immediately leaves the servers area, but some time later he repeats his demand. Between retrials he is said to be in 'orbit'. Such retrial queuing systems have been widely used to model the many practical situations.

In this work, we consider the retrial queue where the number of retrials of each customer is limited by two attempts. Customer arrive from outside according to a Poisson process with rate λ . Service times of customers are independent of each other and have an exponential distribution with parameter μ . The customer finding server busy upon arrival join orbit. Each customer is allowed to attempt the server request at most three times including primary attempt by an external arrival and if a customer fails to enter the service at second retrial, then the customers leaves the system without service. We assume that period between successive retrials are exponentially distributed with parameter ν_1 for first retrial and ν_2 for second retrial.

The system state at time t can be described by means of a process $Q(t) = (Q_0(t), Q_1(t), Q_2(t))$, where $Q_0(t)$ is the number of busy servers at time t , $Q_1(t)$ is the number sources for first repeated attempt at time t , $Q_2(t)$ is the number sources for second repeated attempt at time t . The process $Q(t)$ is a continuous time Markov chain with $S = \{0,1\} \times \{0,1,\dots\} \times \{0,1,\dots\}$ as the state space. Truncating the states of $Q_k(t)$ by finite number, say $N_k, k = 1,2$, the resulting process is the level depend quasi-birth-and-death process and the matrix analytic method is used for founding of stationary probabilities.

References

1. Artalejo J.R., Gómez-Corral A. Retrial Queueing Systems. A Computational Approach. - Springer, 2008, 318 p.
2. Falin G. I. and Templeton J. G. C. Retrial queues. - London: Chapman and Hall, 1997. - 328 p.

DECISION-MAKING IN THE MANAGEMENT OF THE TAX AUTHORITIES ON THE BASIS OF INTEGRATED PERFORMANCE INDICATORS

Olexandr Redych

National University of State Tax Service of Ukraine

redich@asta.edu.ua

The paper highlights the features of the methodology of the integral convolution of indicators for decision-making in activities of tax authorities of Ukraine.

The structural model of quality management should be based on a system of decision support and risk management system. The core of the quality management system should be a system of formation and evaluation of key performance indicators (KPI) and integral criterias, etc.

The paper presented the appropriate mathematical models to ground the decisions and results of calculations.

Analysis of the results of calculations indicate the possibility of applying the proposed methodology of integral criterias:

- For in-depth analysis of the results of operational processes of the tax authorities, and indeed, for human resources management based on key indicators (KPI);
- To determine the interdependence of quality operations, socio-economic status of regions and other external factors;
- For classification (determining the location (rating)) the tax authority.

In particular, the results reverse interdependence integral quality of the tax authorities and socio-economic development of regions, indicates that these findings need further investigation to identify factors causing such interdependence.

Systematic calculation of dynamic series of key performance indicators, their analysis based on modern technologies of data mining will enable more accurate forecasting of tax revenues to take account of external factors, to set reasonable objectives for quantitative analysis of tax risks and reduce their impact on overall result of the tax offices of Ukraine.

ON SIMULATION OF STOCHASTIC PROCESSES WITH ACCURACY AND RELIABILITY

Rozora I., Lukovych O.

Taras Shevchenko National University of Kyiv, Ukraine

irozora@bigmir.net

Simulation of stochastic processes is one of an important sphere in probability theory and its applications because of wide use in different fields, e.g. in social and economic sciences, actuarial and financial mathematics, engineering, physics and so on.

A lot of scientists worked on problem of model construction for stochastic processes and fields. Some of them are S. Yermakov, G. Mikhailov, M. Yadrenko, Yu. Kozachenko, V. Ogorodnikov, S. Prigarin and others.

Let $(\Omega, \mathcal{F}, P)$ be probability space and $t \in [a, b]$. Consider a Gaussian separable centered second-ordered stochastic process with known correlation function

$$R(t, s) = EX(t)\overline{X(s)} = \int_a^b f(t, \lambda)\overline{f(s, \lambda)}d\lambda$$

Then the process $X(t)$ is represented in series

$$X(t) = \sum_{k=0}^{\infty} \xi_k a_k(t),$$

where $a_k(t)$ are some coefficients and ξ_k are centered non-correlated random variables with variance 1.

Definition 1. The process $X_N(t)$ is called the model of process $X(t)$, if $X_N(t) = \sum_{k=0}^N a_k(t)\xi_k$.

It's clear that the deviation in a such case is equal to

$$\tilde{X}_N(t) = X(t) - X_N(t) = \sum_{k=N+1}^{\infty} a_k(t)\xi_k.$$
 Taking into account the

derivative of the process we consider a quadratic form $Y_N(t) = \tilde{X}_N^2(t) + (\tilde{X}_N'(t))^2$.

The conditions on $Y_N(t)$ under which the model approximates the process with given reliability and accuracy taking into account the derivative in some Banach space are studied.

HARNESSING EMPIRICAL CHARACTERISTIC FUNCTION CONVERGENCE BEHAVIOUR

Lino Sant

University of Malta

`lino.sant@um.edu.mt`

The estimation of parameters for Levy processes has generated a substantial amount of research, lately with a strong injection of interest coming from applications in finance. In effect the central problem can be framed as parameter estimation from readings coming from an infinitely divisible distribution. This link leads naturally to empirical characteristic functions which had been studied and used as statistical tools in much the same way as empirical processes had been earlier. Results related to the weak convergence of empirical characteristic functions to a Gaussian processes have not been exploited as fully as they might have been. Authors were discouraged by the fact that this type of convergence cannot always take place within the Banach space of continuous functions. Nevertheless, the Hungarian construction was exploited to study strong convergence properties of this process through Kiefer and Brownian bridge constructions using the stochastic integral. Interest has lately shifted to other methods of estimation like empirical likelihood and the generalized GMM. A natural context wherein to reconsider the whole problem would be that of Gaussian processes defined over carefully selected Hilbert spaces of functions over $\mathbb{R}$, the domain of characteristic functions. In this talk this last idea is expanded against the background of parallelisms and contrasts between these many estimators and viewpoints which are highlighted and put into perspective with particular reference to ways in which integrated squared error estimation can be studied and improved.

COMPUTER MODELLING OF COMPOSITES USING HETEROGENEOUS NUMERICAL SCHEMES

Savula Ya., Dyyak I., Mykhaskiv V., Olendiy O.

Ivan Franko National University of Lviv,

savula@franko.lviv.ua

We have considered some mechanics problems (theory of elasticity, contact problem, wave propagation) for which coupled boundary element and finite element approximations are suitable. The periodically layered materials and the systems with randomly distributed quasi spherical micro-inclusions are widely used in building and aviation engineering, automobile industry, geophysics etc. In recent years, computer modeling of composite materials have received increasing attention in computational mechanics. Despite of the great progress of computer technologies in the last decades, numerical analysis of heterogeneous structures still encounters significant difficulties. The increasing complexity and heterogeneity of real-world applications, coupled with similarly complex and heterogeneous parallel and distributed computing systems, have led to the development and deployment of advanced computational infrastructures that provide programming and efficient runtime management support for such implementations. Investigation of the damage in the components of the composite can be divided into two stages: at the first stage we have to solve the problem on the effective constant of composites (homogenization problem) and at the second stage using the solution of homogenization problem (linear) and iterative method we can determine the nonlinear deformative properties of composite, where nonlinearity is caused by micro-damaging in the components.

On the base of the weak formulation and the iteration method parallel Dirichlet domain decomposition schemes for solution of unilateral frictionless two-body contact problems of elasticity using the penalty method. These schemes have been generalized for multibody contact problems and their convergence has been proved. We propose wider class of parallel mixed Dirichlet and Neumann domain decomposition methods for frictionless contact problems.

We considered 3-D time-harmonic elastic wave diffraction problems for the randomly distributed volumetric rigid massive inclusions. Numerical results concern the displacements of inclusion and the distributions of contact tractions on the interface were obtained by direct boundary element method.

STATISTICAL ANALYSIS OF DEPENDENCES BETWEEN TERROSIST THREAT AND POLITICAL AND ECONOMIC DEVELOPMENTS

Sedlačik, M., Odehnal, J., Michálek, J.

Faculty of Economics and Management, University of Defence,
Brno, the Czech Republic

marek.sedlacik@unob.cz , jakub.odehnal@unob.cz

michalek@fme.vutbr.cz

The statistical analysis of dependences between terrorist attacks (intensity of a terrorist threat) and development of selected political parameters relevant to setting adequate counterterrorist policy is the goal of the paper. Problem of evaluation of terrorist behavior ranks among topical economic and econometric issues. For instance, Gaibullov, Sandler (2008) examine the impact of terrorism on economic growth by long time series analyses. Enders, Sandler (1996) also estimate the negative and significant impact of terrorism on foreign direct investment in the case of Spain and Greece. Blomberg, Hess and Weerapane (2004) utilized a model demonstrating that the probability of terrorist attacks has proven to be higher in better democratically developed countries and countries with higher revenues. Chen, Siems (2004) estimates relation between terrorist attacks and returns of financial markets. The cost and impact of terrorism on tourism industry are discussed in Enders, Sander (1991). These authors constructed a time series model and found out that terrorism decreased the number of visitors in Spain.

To quantify the independent variable, authors selected data published by the World Bank evaluating the quality of administration in selected countries by means of 6 variables. The first variable designated as Voice and Accountability assesses the quality of administration in compliance with the evaluation of the level of political, civil and human rights in individual countries. The second variable Political Instability and Violence should assess the probability of possible violent threat for the given country or the level of political instability in the country. Government Effectiveness, i.e. the third variable, comprises the public service quality assessment, the level of bureaucracy and reliability of the government in the given country. The next variable Regulatory Burden assesses the regulatory burden of the country, and Rule of Law or the

legal order quality comprises the assessment of public trust in social norms and the level of conformity to them.

The risk of Terrorism will be described by generalized linear model. Also the classification of states according to the relationship among response variable and covariates will be given using cluster analysis and regression trees.

References

1. JOHNSON, R. A., WICHERN, D. W. (2007). Applied Multivariate Statistical Analysis, Pearson Prentice Hall, ISBN 0-13-18-187715-1.
2. BLOMBERG, S. B., HESS, G., WEERAPANA, A. (2004). Economic Conditions and Terrorism European Journal of Political Economy, Vol. 20, pp. 463-478.
3. CHEN, A., SIEMS, T. (2004). The Effects of Terrorism on Global Capital Markets. European Journal of Political Economy, Vol. 20, pp. 349-366.
4. ENDERS, W., SANDLER, T. (1991). Causality Between Transnational Terrorism and Tourism: The Case of Spain. Terrorism, Vol. 14:1, pp.49-58.
5. ENDERS, W., SANDLER, T. (1996). Terrorism and Foreign Direct Investment in Spain and Greece. Kyklos, Vol. 49, pp. 331-52.
6. FAHRMEIR, L., TUTZ, G.(1994). Multivariate Statistical Modelling Based on Generalized Linear Models. Springer-Verlag.
7. GAIBULLOEV, K., SANDLER, T. (2008). Growth Consequences of Terrorism in Western Europe. Kyklos, vol. 61, pp.411-424.

GENETIC ALGORITHMS OF SOLVING OF VECTOR DISCRETE OPTIMIZATION PROBLEMS

Semenov V.V.

V.M. Glushkov Institute of Cybernetics of NAS Ukraine

hunt.semen@gmail.com

The multicriteria problem are investigated:

$\min \{f(x) | x \in X\}$, $X \subseteq Z^n \subset R^n$, $X \neq \emptyset$, $|X| < \infty$, f – vector function, $f: E \rightarrow F$, so the problem is to find such a point $\bar{x} \in X$, that $f(X) \cap (f(\bar{x}) - K \setminus \{0\}) = \emptyset$. Denote by $E_K(f, X)$ a set of solutions of the problem, and elements from this set will be called Pareto optimal solutions. Multicriteria optimization problems can generate a large sets of Pareto optimal solutions. Identifying the best solutions for a very large number of Pareto optimal solutions can be difficult. Therefore PMD is useful to be able to get a small set of preffered Pareto optimal

solutions. This discrete optimization problem is analyzed to obtain optimal subsets of solutions of large sets of Pareto optimal solutions. Consider a new concept called Pareto border's rank. The solutions directly on the boundary have rank 1. If we delete these solutions, and then calculate a new boundary, the solutions on this boundary will have rank 2, etc. This procedure is called **non-dominated sorting**. Rank is not the only way to use the Pareto boundary for calculating advantages. We can also determine the strength of the solution equal to the number of solutions that are Pareto dominated by this solution. The strength of the solution can be used as its advantages. But strength does not always shows how close located the solution to the Pareto boundary. Indeed, the solutions at the edges of boundary is often not so strong as the solutions far from the boundary. Rather than strength we can determine the **weakness** of the solution as the number of solutions that dominates the present. Obviously the solutions on the Pareto boundary have weakness 0, and the solutions away from the boundary have higher weakness. Some more successful version of the solution weakness is its **insignificance**: the combined total strength of all solutions that dominates the present. It is preferably the insignificance was as little as possible. Non-dominated solution have the insignificance equals 0. Measure of similarity is calculated as the distance to other solutions, in particular, to the k -th nearest solution.

MODELING PROCESSES OF THE POPULATION DYNAMICS

Oleksandra Shatyrko, Denys Khusainov

Taras Shevchenko National University of Kyiv,

AlexShatyrko@gmail.com, khusainov@unicyb.kiev.ua

The considerable part of mathematical models are described by systems of the ordinary differential equations of the form

$$\dot{x}(t) = K[x(t)]x(t). \quad (1)$$

Here $K[x(t)]$ square matrix, indicating the dependence of the rate of increase from the phase coordinates. If the matrix $K[x(t)]$ is linear, then the model is a system with a quadratic right-hand side. In particular, if the model is a scalar, we obtain the Verhulst's model. In general, the system (1) with linear part $K[x(t)]$ can be written in vector-matrix form

$$\dot{x}(t) = [A - X^T(t)B]x(t). \quad (2)$$

Here $A = \{a_{ii}\}$, $i = \overline{1, n}$ - square diagonal matrix with constant coefficients, $B = \{B_1, B_2, \dots, B_n\}^T$ - rectangular $n^2 \times n$ - matrix consisting of the symmetric square $n \times n$ - matrices B_i , $i = \overline{1, n}$, on which in i - column is the vector $b_i^T = (b_{i1}, b_{i2}, \dots, b_{in})$, $X^T(t) = \{X_1(t), X_2(t), \dots, X_n(t)\}$ - rectangular $n \times n^2$ - matrix, consisting of a square $n \times n$ - matrices $X_i(t)$, on which in i - rows are the vectors $x(t)$, the other elements are zero.

We investigate non-zero equilibrium point x_0 of the system (2), located in the first quadrant. In the case of asymptotic stability of the linear part of the non-zero equilibrium position, the guaranteed stability region of the singular point x_0 will be

$$G_{n_0} = \max_{r>0} \{G_r : G_r \subset G_0\}, \quad G_r = \{y \in R^n : y^T H y < r^2\},$$

$$G_0 = \{x \in R^n : |y| < R\}.$$

As a rule, more adequate are mathematical models described by systems of functional differential equations with time-delay

$$\dot{x}(t) = [A - X^T(t - \tau)B]x(t). \quad (3)$$

Investigation of stability of non-zero equilibrium point of system (3) is carried out. The Lyapunov function method with the additional condition of B.S.Razumihin is chosen as apparatus of investigation.

CHAOTIC DETERMINISTIC SYSTEMS FOR RISKY ASSET MODELS

Shchestyuk N., Shabalin D.

National University "Kiyv-Mohila Academy", Ukraine

Natalyshch@gmail.com , Den.shabalin@gmail.com

We should present an alternative to linear asset prices model that are driven by "chaos". It is known that a chaotic deterministic system can appear to behave as if it were "random", and it can be difficult in practice to decide whether an apparently random time series has been generated by a stochastic or a chaotic (non-linear) deterministic model or a combination of the two. It would be of great interest to scientists if fluctuations, previously thought to be random, turned out to have a deterministic explanation.

In this paper various sorts of ARIMA - models for real stock price, which are driven by chaotic deterministic model (logistic map and other) rather by “white noise”, are considered. The correlation structures of log-returns for stochastic and chaotic deterministic models are compared. Problem of distinguishing between chaotic and stochastically random series by various statistical methods is investigated. An application demonstrating stock prices based on chaotic time series have been written.

References

1. Chatfield C., The analysis of time series, Chapman&Hall / CRC, 2005, 283 p.
2. Pesaran M.H., Potter S.M. Nonlinear Dynamics, Chaos and Econometrics. New York:Wiley, 1993.
3. Ширяев А.Н. Основы стохастической финансовой математики, Фазис, М., 1998, 488 с.

COLLECTIVE MARK SETTING IN DISCRETE MODELS OF DECISION MAKING

Yury Shestopalov

Karlstad University, Karlstad, Sweden

youri.shestopalov@kau.se

We develop mathematical methods to make collective decision or determine collective mark that enable one to compare the events and make their ranking. A non-statistical approach proposed in [1] and further developed in this work is based on the analysis of information stored as a special family of integer matrices. We perform construction of a chain of nonlinear ‘quality’ functionals that leads to the possibility of unambiguous collective mark setting. This topic is related to discrete mathematical models of the decision making under uncertainties [2].

We address the situation when a large group of respondents answer several times to a questionnaire consisting of many items by setting marks in a K -digit scale; the answers are collected correspondingly as a K -adic matrix $A = [a_{ij}]$ with the entries that are integers satisfying $1 \leq a_{ij} \leq K$ (every entry is a 'mark' in a K -digit scale). We define a nonlinear map on the set κ^{nm} of $n \times m$ K -adic matrices and a binary relation on the set of images of this map suitable for the required analysis (purpose) and finally obtain a ranking of the event. Note that κ^{nm} is a subset of the set I^{nm} of $n \times m$ integer matrices which is not closed

with respect to algebraic operations (addition, multiplication by a number).

Define a *counting-mark function* $F_{Cm}: \kappa^{nm} \rightarrow I^{mK}$, which ‘rolls up’ initial K -adic matrix A to an integer matrix $F = [f_{ik}] = F_{Cm}(A)$ containing the information concerning occurrence of (repeating) marks in the columns of A : f_{ik} is the number of figures k ($k = 1, 2, 3, \dots, K$) in the i th column of A . Next, define a *ranking function* $F_{Ra}: I^{mK} \rightarrow \kappa^{mK}$ which creates ranking matrix RA collecting the information on the order of row index of a matrix F in I^{mK} . A *total-ranking function* $F_{TRa}: \kappa^{mK} \rightarrow I^K$ specifies the ranking of ranking matrix RA : the i th component of the total-ranking vector $\mathbf{t} = F_{TRa}(RA)$ is the sum of all values of the i th column of matrix RA . The last operation $F_{Ra}(\mathbf{t})$ that has values on the set of $K!$ different K -adic vectors with non-repeating components (a subset of κ^K) forms the ranking as a column vector by setting its first component equal to the mark (index) with the highest rank and so on, to obtain finally the total-ranking vector $\mathbf{T} = \Phi(A) = F_{Ra}(F_{TRa}(F_{Ra}(F_{Cm}(A))))$ as a result of superposition Φ of all the constructed operations. The latter can be unambiguously associated with a natural number T which will be a collective mark in the complete $K!$ -point scale of the event evaluated in terms of matrix A . More precisely, the sets of $m \times K$ integer matrices or $n \times m$ K -adic matrices can be divided into $K!$ equivalence classes $\sigma_T = \{F: \Phi_I(F) = T\}$, where $\Phi_I(F) = F_{Ra}(F_{TRa}(F_{Ra}(F)))$, or $\tau_T = \{A: \Phi(A) = T\}$ with respect to their (equal) collective marks $T = 1, 2, 3, \dots, K!$. For the given quiz parameters m (number of items) and n (number of respondents) one can perform, in the given mark scale, detailed description of these classes including calculation of the number of elements in each class.

Conclusion: we have proposed an algorithm that, in a K -digit mark scale, enables one to establish a correspondence between the set of K -adic matrices and $K!$ (collective) marks independently of the (row) size of initial matrix A . Clearly, this mark scale is sufficiently rich to satisfactory take into account fine differences in the background information given by matrix A and perform comparison of the event evaluated several times as a sequence of the quiz matrices where the number of respondents may vary.

This work was supported by the Visby program of the Swedish Institute.

References

1. Shestopalov Y. Collective decisions: some problem statements and mathematical methods/Y. Shestopalov//Proc. XVIII Int. Conf. *Problems of Decision Making under Uncertainties* (PDMU-2011), Abstracts. September 19-23, 2011. Yalta, Ukraine. – P.33-34.
2. Донской В.И., Башта А.И. Дискретные модели принятия решений при неполной информации/ В.И. Донской, А.И. Башта. – Симферополь: Таврия, 1992. –225 с. (Donskoj V., Bashta A. Discrete mathematical models of the decision making under uncertainties/ Donskoj V., Bashta A. –Simferopol': Tavria, 1992. –225 p.)

LOGICAL MEANS OF DYNAMIC AND INFORMATION SYSTEMS DESCRIPTION TAKING INTO CONSIDERATION UNCERTAINTY AND INCOMPLETENESS

Oksana S. Shkilniak

Taras Shevchenko National University of Kyiv

me.oksana@gmail.com

Modern information and program systems are generally based on the apparatus of mathematical logic. Temporal logics are successfully used for dynamic systems description and modelling, software systems specification and verification. In particular, epistemic modal logics are used for description of intelligence systems, databases and knowledge bases with incomplete information. Such logics are usually based on classical predicate logic. However, classical logic has some fundamental restrictions; it's based on traditional total single-valued mappings which don't allow taking into account sufficiently such properties of subject-domain information as incompleteness, partiality, uncertainty. This leads to a problem of construction of new program-oriented logical formalisms based on wide classes of partial mappings. Composition-nominative logics of quasi-ary partial predicates [1] could be such a formalism.

Composition-nominative modal logics combine facilities of traditional modal logics and logics of quasi-ary predicates. Modal transition logics [2] are an important variant of composition-nominative modal logics; they are based on modal transition systems (MTS). Within the scope of the latter, multimodal (MMS) and temporal (TMS) modal systems were specified. Epistemic modal systems are special case of multimodal systems.

This paper concerns the study of first-order MTS of partial predicates. We specify functional-equational MMS, and define functionally stable MMS which allow of carrying superposition over modalities. Relation of logical consequence for sets of formulas of TMS and MMS, specified with state names, is introduced and studied.

The introduced logics can be of effective use for dynamic and information systems description taking into consideration uncertainty and incompleteness.

References

1. Nikitchenko M., Shkilniak S. Mathematical Logic and Theory of Algorithms. Publishing house of National Taras Shevchenko University of Kyiv, 2008, 528 p. (in Ukrainian).
2. Nikitchenko M. , Shkilniak O., Shkilniak S. Construction of modal logics of temporal and epistemic type using composition-nominative approach, Bulletin of Taras Shevchenko National University of Kyiv, Series: Physics and mathematics, vol 3, 2011, pp. 204–211. (in Ukrainian).

SOME PROPERTIES OF KILLED MARKOV DECISION PROCESSES

Shpak P., Yeleyko Y.

Ivan Franko University of Lviv, Ukraine

prshpak@gmail.com , yikts@yahoo.com

We consider killed Markov decision processes [2] with crash function

$$c(x_t^*) = - \sum_{i=m+1}^l \sup_{a_i \in A_i} g(a_i)$$

defined on killed state and probability distribution P^*

$$P^*(l) = \begin{cases} \mu(x_m)\pi(a_{m+1}|x_m)p(x_{m+1}|a_m)...\pi(a_n|h_{n-1})p(x_n|a_n), & \forall t \ x_t \neq x_t^* \\ \mu(x_m)\pi(a_{m+1}|x_m)p(a_{m+1}|x_m)...\pi(a_k|h_{k-1})p(x_k^*|a_k), & x_k = x_k^* \end{cases}$$

in space $l \in L = X \times (A \times X)^{n-m}$.

Let $Z_\mu^k = (X, A, j, p_k, q_k, r_k, c_k, \mu_k)$ be sequence of killed Markov decision processes with finite set of states and set of actions on time interval $[m, n]$

If the following conditions take place:

$$\begin{aligned}
&\forall t \in [m, n], \forall a_t \in A_t, \forall x_t \in X_t : p_k(x_t | a_t) \xrightarrow{k \rightarrow \infty} p(x_t | a_t), \\
&\forall t \in [m, n], \forall a_t \in A_t : q_k(a_t) \xrightarrow{k \rightarrow \infty} q(a_t), \\
&\forall x_n \in X_n : r_k(x_n) \xrightarrow{k \rightarrow \infty} r(x_n), \\
&\forall x_m \in X_m : \mu_k(x_m) \xrightarrow{k \rightarrow \infty} \mu(x_m), \\
&\forall t \in [m, n] : c_k(x_t^*) \xrightarrow{k \rightarrow \infty} c(x_t^*)
\end{aligned}$$

the behavior of the limit killed Markov decision process., its assessment and optimal policy are examined.

References

1. Дынкин Е.Б., Юшкевич А.А. Управляемые марковские процессы и их приложения, Москва, 1975. - 334 с.
2. Пароля Н. Р., Єлейко Я. І. Обривні керовані марковські процеси на скінченному інтервалі часу для скінченних моделей // Вісник Львівського університету. Серія механіко-математична. – 2010. – №72 – С. 243 – 254.

APPLICATION OF REINFORCEMENT LEARNING IN AIRLINE REVENUE MANAGEMENT

¹Jaroslav Sklenar, ²David Stephen Borg, ³Pavel Popela
University of Malta

¹jaroslav.sklenar@um.edu.mt

²davidborg@gmail.com ³popela@fme.vutbr.cz

Revenue Management (RM) is nowadays an essential tool used in large industries, especially by airline companies. This tool aims at optimising revenues by a better control of several factors; predominantly inventory and pricing. In the paper we consider a stochastic optimal control problem which consists of finding an optimal policy to when it is profitable (or not) for an airline company to accept a group booking request. The trade-off is well known. Accepting a group request results in blocking the seats that would otherwise be available to normal single passengers by groups requesting a discounted price in the early days a flight is open for booking with a relatively high probability of future drop-outs (individual cancellations). On the other hand rejecting most group requests might result in under-booking of the planes. So an optimal policy of when and under what conditions should the group requests be accepted is required. Our attempt to solve this

problem is based on the Infinite Horizon Stochastic Dynamic Programming (SDP) approach. More specifically, the decision making problem is described as a Markov Decision Problem (MDP). The states are based on the time till the departure and the number of seats booked at the time. The state definition is of course a simplification of a more complicated real booking situation. Nonetheless, this resulted in almost 3 million different states that make the classical solution based on transition and reward matrices intractable. To overcome the curse of dimensionality and especially the curse of modelling, we have applied the solution technique called Reinforcement Learning (RL). In the SDP context this technique is based on simulation of rewards associated with the decisions. A policy close to optimum could thus be found in an acceptable time without the need of transition probabilities and rewards.

RECURRENT PARAMETER ESTIMATION ALGORITHMS WITH SPLITTED STRUCTURES FOR NONLINEAR SYSTEMS UNDER UNCERTAINTIES BY LEAST SQUARES METHOD WITH MINIMAL DEVIATION NORM FROM ‘ATTRACTION’ POINTS

Alexander S. Slabospitsky

Taras Shevchenko National University of Kiev

sl@univ.kiev.ua

More effective on-line parameter estimation procedures are proposed for nonlinear dynamic object with special structure when each individual equation of state has its own parameter vector $\alpha^{(j)}$, viz.:

$$x_j(k+1) = f_j^T(x(k), u(k), k) \alpha^{(j)} + g_j(x(k), u(k), k) + \xi_j(k), \quad j = \overline{1, n}, \quad k \in \mathbb{N},$$

where vector functions $f_j(x(k), u(k), k)$ and $g_j(x(k), u(k), k)$ are given,

$x(k) = (x_1(k), x_2(k), \dots, x_n(k))^T$, $u(k)$, $\xi(k) = (\xi_1(k), \xi_2(k), \dots, \xi_n(k))^T$ are state, control and disturbance vectors respectively.

The least squares estimation problem of unknown parameter vector $\alpha = \text{column}(\alpha^{(1)}, \alpha^{(2)}, \dots, \alpha^{(n)})$ for this system is considered in non-classical case when this estimate may be not unique and additionally ‘attraction’ point $\alpha_*(N)$ for parameter vector α is known at any moment N , $N = 0, 1, 2, \dots$. The least squares estimate $\hat{\alpha}(N)$

with minimal deviation norm from ‘attraction’ point $\alpha_*(N)$ at any moment N is suggested as unique estimate in this situation, viz.:

$$\hat{\alpha}(N) = \tilde{F}_N^+ \tilde{x}_N + \left[E - \tilde{F}_N^+ \tilde{F}_N \right] \alpha_*(N), \quad N \in \mathbb{N},$$

where $\tilde{F}_N = \text{column}(F(x(1), u(1), 1), \dots, F(x(N), u(N), N))$,

$$F(x(k), u(k), k) = \text{diag}\left(f_1^T(x(k), u(k), k), \dots, f_n^T(x(k), u(k), k)\right),$$

$$\tilde{x}_N = \text{column}(x(2) - g(x(1), u(1), 1), \dots, x(N+1) - g(x(N), u(N), N)),$$

$$g(x(k), u(k), k) = \text{column}(g_1(x(k), u(k), k), \dots, g_n(x(k), u(k), k)),$$

(⁺) — Moore-Penrose pseudoinverse operator.

The splitted recursive procedures for estimate $\hat{\alpha}(N)$ by least squares method with minimal deviation norm from ‘attraction’ point $\alpha_*(N)$ at any moment N and for corresponding residual sum of squares are derived under these non-classical assumptions.

DETERMINATION OF ENTERPRISE VALUE BY USING THE A FUZZY PAY-OFF METHOD FOR REAL OPTION VALUATION

Adam Sojda

Silesian University of Technology, Poland

adam.sojda@polsl.pl

The term value has many meanings, for each person value may mean something different. One can talk about book, fair, liquidation values. The scope of applicability of these concepts depends on their usefulness, credibility and preferences of the subject conducting the evaluation. one of the sources of enterprise value creation is broadly understood investment due to which future income may be expected. in this thesis it was assumed that the enterprise value stems from expected future profits, generated by the enterprise and discounted with an appropriate interest rate.

Enterprise value is calculated on the basis of the following formula:

$$V = \sum_{t=1}^n \frac{FCF_t}{(1+WACC)^t} + \frac{RV_n}{(1+WACC)^n}$$

The pay off-method calculates the real option value form pay-off distribution as follows:

$$ROV = \frac{\int_{-\infty}^{\infty} A(x)dx}{\int_{-\infty}^{\infty} A(x)dx} \times E(A_+)$$

Three scenarios concerning cash flows in a certain enterprise were determined: the most beneficial, the most likely and an unfavorable as well as corresponding residual values. For each of them the V value is determined separately. The resulting fuzzy V is the payoff distribution for the synergies investment.

The option value may be determined from the received fuzzy V value. If the whole distribution is above zero option value is nothing else than fuzzy average value of fuzzy V.

REGRESSION TREES AND RANDOM FORESTS FOR PREDICTIVE MAINTENANCE IN SEMICONDUCTOR MANUFACTURING

Ernst Stadlober , Peter Scheibelhofer

Graz University of Technology, Austria

e.stadlober@tugraz.at

Peter.Scheibelhofer@austriamicrosystems.com

We present a universally applicable methodology for predictive maintenance based on classification and regression trees used for both exploratory data analysis and modeling. Such approaches yield an intuitive insight into multivariate data sets and are especially suitable for complex processes with nonlinear relationships. For prediction we use a method that utilizes an ensemble of classification and regression trees called *Random Forests*. Such aggregations of a large number of models may offer improved accuracy of prediction.

Tree-based methods are non-parametric modeling techniques which can be used for a wide range of applications. The suggested method will be applied for predictive maintenance of an ion implantation tool where the residual life time until next maintenance is defined as the time- to-event response variable. Measures of variable importance inherent to Random Forests reduce the pool of 20 predictor variables to at most 5 relevant predictors. The final model with 400 trees

explains about 81% of the variance. In the critical time frame of 72 hours (Friday to Sunday) before failure the standard error of the prediction is reduced to 12 hours. This application demonstrated the potential of predictive maintenance in wafer production and equipment control.

EXPERIENCE THE ACCIDENT RISK ASSESSMENT ON SOME LARGE DAMS

Dmytro V. Stefanyshyn

The Institute of Telecommunications and Global Information
Space of the NAS of Ukraine
dvstefanyshyn@yahoo.com

Accident risk is the main part of general dam construction risk [1-4]. Taking into account accident risk at design stage of dams and under construction allows optimizing of their parameters and makes it possible to choose dam variants with the lowest risks. Risk assessment of accidents on dams under operation allows: 1) determine importance and take into account different uncertainties and factors, which can disturb reliability and safety of dams; 2) determine contributions of different accident factors into total risk; 3) identify the most risky accident scenarios on dams; 4) exercise accident risk management measures for dams.

In the report some examples of risk assessment of accidents on large dams are considered to provide their safety and support decision making processes. There are examples of two variants of the Rogunskaya dam comparison, safety supporting of the Boureya dam under construction and Sayano-Shushenskaya dam under operation.

References

1. The use of risk analysis to support dam safety decisions and management. Trans. of the 20-th Int. Congress on Large Dams. Vol. 1. Q. 76. 19-22 September. Beijing-China. 2000. 896 p.
2. Stefanyshyn D.V. Assessment of accident risks to support safety of the Boureya dam / D.V. Stefanyshyn // Proc. of Int. Scientific School "Modelling and Analysis of Safety and Risk in Complex Systems". June 24-28, 2008. Saint-Petersburg, Russia. pp. 377-382.
3. Stefanyshyn D.V. Chosen case studies on risk assessment and making decision under stochastic uncertainty/ D.V. Stefanyshyn. Kyiv, Azimuth-Ukraine, 2009. 103 p. (in Ukrainian language).

4. Romanchuk K.G. Probabilistic simulation of two untypical accidents occurred at hydropower plants / K.G. Romanchuk, D.V. Stefanyshyn // Proc. of Int. Scientific School “Modelling and Analysis of Safety and Risk in Complex Systems”. 28.06-02.07, 2011. Saint-Petersburg, Russia. pp. 316-322.

DECISION MAKING IN ENVIRONMENT OF ASYMMETRIC CONFLICTS

Richard Stojar, PhD.

University of Defence, Czech Republic

richard.stojar@unob.cz

The contribution deals with the decision making process in an environment of hybrid threats and with its difference from previous decision making process in traditional conflict. It describes the process of rationalization of decision making process and subsequent possible demands on current and future commandants who will face the asymmetric and indeterminate battlefield and flexible enemy.

CALCULATION OF THE THERMODYNAMIC ACTIVITIES OF THE COMPONENTS OF BINARI MELTS

Sudavtsova V.S., Shevchenko M.A., Kudin G. I.¹,

Kudin V.G.¹, Kobilinskaya N. G.¹

Frantsevitch Institute for Problems of Materials Science of NASU

¹ Taras Shevchenko National University of Kiev, Ukraine

sud@ipms.kiev.ua

When the activities of components of the metallic A-B melts are not studied, though knowledge of them gives more information on the interaction between components, we can calculate them by the theory of ideal associated solutions (IAS). For the calculation we use the thermochemical properties (obtained by us or found in literature), and also the phase diagram. Usually, we select 2-5 associates for each system, which are often similar to the intermetallics observed in the solid alloys, and the most stable in melts at high temperature are the associates AB, A₂B, AB₂, A₃B, AB₃. Adding any other associates to the model generally doesn't cause any significant effect, because their

concentrations prove to be very low. The IAS model is based on the expression of negative deviations of thermodynamic properties of melts from the ideal ones by forming some amount of associates $A_{i_n}B_{j_n}$ with parameters ΔS_n and ΔH_n . So the next equations are implemented:

$$x_n = \exp\left(\frac{\Delta S_n}{R} - \frac{\Delta H_n}{RT}\right) a_A^{i_n} a_B^{j_n}, \quad a_A + a_B + \sum_{n=1}^N x_n = 1,$$

$$\Delta H = \left(\sum_{n=1}^N \Delta H_n x_n\right) / \left(1 + \sum_{n=1}^N (i_n + j_n - 1)x_n\right),$$

$$\Delta G = RT \frac{x_A \ln x_A + x_B \ln x_B + \sum_{n=1}^N x_n \left(\frac{\Delta G_n}{RT} + \ln x_n\right)}{1 + \sum_{n=1}^N (i_n + j_n - 1)x_n}.$$

Methods of numerical search of the Gibbs energy minimum allow us to obtain the values of a_A , a_B , x_n for the given set of parameters ΔS_n and ΔH_n . Finally, changing these parameters, and also composition and number of chosen associates, it is possible to reach a good accordance with all experimental data (phase diagram, calorimetric and other) simultaneously in the majority of cases. The parameters ΔS_n and ΔH_n are not totally free: in the model used by us the following equations are taken:

$$\Delta H_n < (\Delta H_{n-1}(c_{n+1} - c_n) + \Delta H_{n+1})(c_n - c_{n-1}) / (c_{n+1} - c_{n-1}),$$

$$\Delta S_n < \frac{\Delta S_{n-1}(c_{n+1} - c_n) + \Delta S_{n+1}(c_n - c_{n-1})}{c_{n+1} - c_{n-1}},$$

where $c_n = \frac{j_n}{i_n + j_n}$, and $c_{n-1} < c_n < c_{n+1}$ are the molar parts of component B in these three associates (including monomers).

The thermodynamic parameters of these associates, and also intermetallics, which correspond to the optimized model, usually

correlate between each other. If we know the concentrations x_n of all the associates and pure components, and also Gibbs energies of pure components and their compounds in a solid state, it is easy to calculate, whether the formation of the selected solid phase is thermodynamically advantageous at the given temperature. Basing on this, it is possible to solve the direct thermodynamic task – to build a phase diagram of the A-B system using the data on the properties of associates in this system. It can be realized when we search the temperature, at which at least one solid phase can form from the solution, for each composition of the latter. It can be done, for example, if we select a large interval of temperature, which surely consists the liquidus temperature, and search this temperature, for example, by the method of binary search, dividing the interval of the possible temperature by two with every iteration.

The final result is a set of values of the enthalpies and entropies of formation of associates and solid intermetallics, which agree with all the known experimental data on the liquid and solid alloys of the given system A-B. Optimization by the IAS model can correct the small (within the experimental error) deviations in the mixing enthalpies of melts, and also can extrapolate the thermodynamic values onto the unstudied range of concentrations. These procedures have been already executed by us for a great quantity of metallic systems, especially containing Al, Si, Sc, Mn, Fe, Co, Ni, Cu, Y, Sn, lanthanides and some other transition metals.

RETRIAL QUEUES WITH COTROLLED OF INPUT FLOW

I.Usar, I.Makushenko

Taras Shevchenko National University of Kyiv, Ukraine

usar@unicyb.kiev.ua

We deal with a retrial queue of the type $M/M/m$ in which intensity of primary calls depends on the number of customers in the orbit [1],[2]. The intensities of repeated calls and the service process are supposed to be constant. Variable character of the input flow rate allows to consider the system under different strategies. In the report we consider two variants: threshold and hysteresis strategies.

We consider both truncated model (i.e., the number of places in the orbit is limited) and model with unlimited orbit.

The explicit formulae for steady state probabilities enable to propose an effective algorithm for optimal decision making which consists in finding of optimal position for a level to maximize some objective functional. As such a function we took the following

$$W(h) = C_1 S_1 - C_2 S_2 - C_3 S_3 \rightarrow \max ,$$

where S_1 is the number of calls have being served; S_2 - the number of calls which become repeated calls; S_3 - the number of switching of the input flow; C_1 - income associated with service of a call; C_2 - penalty connected with a refusal in service; C_3 - penalty connected with a switching of the input flow rate.

References

1. Falin G.I., Templeton J.G.C. Retrial queues. – London Chapman & Hall, 1997. – 331 p.
2. Anisimov V.V., Artalejo J.R. Analysis of Markov multiserver retrial queues with negative arrivals // *Queueing Systems*. – 2001. – Vol.39. – pp. 157-182.

STATE MONETARY POLICIES BASED ON THE CONTROL OF THE DEMAND OF ALTERNATIVE ASSETS.

Vergunov V.

Taras Shevchenko National University of Kiev

v_47@bigmir.net

The problem of regulating demand for cash assets as a regulators of the financial sector of the country is an important aspect of central banks around the world.[1]Empirically is possible in most cases to determine the moment when you need to take regulatory action. But it is impossible accurately and specifically define the volume and direction of influence, especially in large economies. [2]

This requires constant monitoring of the stock market as a market of alternative asset. Assuming that the demand for domestic market for currencies of other countries on a small enough that it does not take into account. To get animage of the currency market to build market model. Perhaps even very crude.[3] It is proposed to use fuzzy sets. From the division of sectors in which companies are direct

competitors. It is very simple, but the main purpose of this model to identify those assets that need attention.

Then by using Ito process possible to build a credible alternative asset price. With its specific forecast asset returns. [4] It is possible predict the demand for them, as a result opportunity to take clear the steps to regulate supply.

References

1. Абель Э., Бернанке Б. Макроэкономика. 5-е изд. – Спб.: Питер, 2010. – 768 с.
2. Bernanke B.S., Mihov I. Measuring Monetary Policy. The Quarterly Journal of Economics, August 1998
3. Buckley, J. Solv in gfuzzy equations in economics and finance // FuzzySets&Systems, 1992, # 48.
4. Макибани Дж. М., Ноурзад Ф. Колебания процентной ставки и спрос на деньги // Quarterly Review of Economics and Business. 1986. – с. 73-83.

THE ALGEBRAIC FUNCTIONAL STRUCTURES FOR THE ANALYS OF THE AGROTECHNOLOGIES

Vergunova I.

Taras Shevchenko National University of Kyiv, Ukraine

vergunova@bigmir.net

On the example of technology grow crops are considered approaches to the analysis of agricultural technologies [1, 2] on the basis of the functional structures.

Functional structures built on the basis of a pre-existing generic algorithms [1] and the main agrotechnological process parameters.

Are held simplifying transformations for functional network of agricultural technology, which is described by the language of algorithmic algebras [3].

Simplifying transformations that are used, allow to obtain a pessimistic estimates for a set of indicators. These indicators make it possible to take into account the economic and environmental components, quality (be free from defects) of agricultural technology, taking into account the condition of minimization of average total cost or maximization of defect-free technology.

Obtained consolidation for the constructed of probability graphs [2, 3]. This procedure is done with a view to calculate the costs and

quality of the agricultural technology. Taken into account presence of resources that are replenished and not replenished.

References

1. Вергунов В. А. Методичні рекомендації з вибору оптимальних технологій вирощування культур за їх формалізованими описами / В. А. Вергунов, І. М. Вергунова. – К. : 2010. – 64 с.
2. Вергунова І. М. Основи математичного моделювання в захисті рослин / І. М. Вергунова. – К. : Нора-прінт, 2006. – 236 с.
3. Ротштейн А. П. Проектирование бездефектных человеко-машинных технологий / А. П. Ротштейн, П. Д. Кузнецов. – К. : Техника, 1992. – 180 с.

MATHEMATICAL MODELLING OF BUILDING GROUND FOUNDATION STRESS-STRAIN STATE CHANGE UNDER FIXING

A.P. Vlasyuk, T.A. Drozdovskiy

National University of Water Management and Nature Resources Use

A.P.Vlasyuk@rambler.ru, coldion@gmail.com

The problem of hydropower building (HB) (fig. 1) foundation stress-strain state (SSS) change mathematical modeling is considered. It means SSS evaluation both in injection domain Ω_1 and in soil layer domain Ω_2 .

Mathematical model of this problem under isothermal conditions in common notation could be represented by the following boundary value problem [1, 2]:

- SSS equation for the displacement vector $\vec{u} = (U, V)$ components in the fixing domain Ω_1 :

$$\mu \cdot \Delta U + (\lambda + \mu) \frac{\partial}{\partial x} \left(\frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} \right) = X, \quad (1)$$

$$\mu \cdot \Delta V + (\lambda + \mu) \frac{\partial}{\partial y} \left(\frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} \right) = Y,$$

- Newtonian fluid time-independent pressure equation in the deformable soil skeleton of the injection domain Ω_1

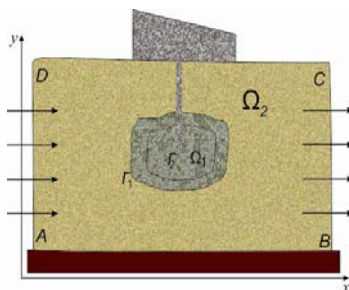


Fig.1. HB ground foundation

$$\frac{\partial}{\partial x} \left(k(\varepsilon) \frac{\partial h}{\partial x} \right) + \frac{\partial}{\partial y} \left(k(\varepsilon) \frac{\partial h}{\partial y} \right) = 0, \quad (2)$$

- SSS equation for the displacement vector $\vec{u} = (U, V)$ components in the filtration domain:

$$\begin{aligned} \mu(c) \cdot \Delta U + (\lambda(c) + \mu(c)) \frac{\partial}{\partial x} \left(\frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} \right) + \left[\frac{\partial \lambda(c)}{\partial x} \cdot \left(\frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} \right) + \right. \\ \left. + 2 \frac{\partial U}{\partial x} \frac{\partial \mu(c)}{\partial x} + \frac{\partial \mu(c)}{\partial y} \left(\frac{\partial U}{\partial y} + \frac{\partial V}{\partial x} \right) \right] = X, \end{aligned} \quad (3)$$

$$\begin{aligned} \mu(c) \cdot \Delta V + (\lambda(c) + \mu(c)) \frac{\partial}{\partial y} \left(\frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} \right) + \left[\frac{\partial \lambda(c)}{\partial y} \cdot \left(\frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} \right) + \right. \\ \left. + 2 \frac{\partial V}{\partial y} \frac{\partial \mu(c)}{\partial y} + \frac{\partial \mu(c)}{\partial x} \left(\frac{\partial U}{\partial y} + \frac{\partial V}{\partial x} \right) \right] = Y, \end{aligned}$$

- groundwater filtration equation

$$\vec{V} = -k(c) \text{grad } h, \quad \text{div } \vec{V} = 0, \quad (4)$$

- dissolved substance mass transfer equation

$$\text{div}(D(c) \cdot \text{grad}(c)) - (v(c), \text{grad}(c)) - \gamma \cdot (c - C_m) = \sigma \frac{\partial c}{\partial t}, \quad (5)$$

with appropriate boundary condition

a) for the displacement vector components

$$U = V = 0, \quad (x, y) \in AB \cup CD, \quad [U] = [V] = 0, \quad (x, y) \in \Gamma_1,$$

$$(\lambda + 2\mu) \frac{\partial U}{\partial x} + \lambda \frac{\partial V}{\partial y} = 0, \quad \frac{\partial U}{\partial y} + \frac{\partial V}{\partial x} = 0 \quad (x, y) \in AD \cup BC \cup \Gamma_2;$$

b) for pressure:

$$h|_{AD} = \tilde{H}_1(x, y), \quad h|_{BC} = \tilde{H}_2(x, y), \quad (-k \nabla h, \vec{n})|_{ABCD} = 0, \quad h|_{\Gamma_1} = \frac{p_0}{\rho_0 g}, \quad h|_{\Gamma_2} = -y;$$

c) for injection front points (floating boundary Γ_1)

$$(v, \vec{n}) = \sigma \frac{\partial \varphi}{\partial t};$$

d) for dissolved substances concentration:

$$c(x, y, 0) = C_0(x, y),$$

$$\left. \frac{\partial c}{\partial \vec{n}} \right|_{AD \cup BC} = 0, \quad c|_{CD} = 0, \quad (vc - D \nabla c, \vec{n})|_{\Gamma_1} = 0.$$

Here: $\lambda, \mu, \lambda(c), \mu(c)$ are Lamé coefficients, X, Y – mass force components, c – dissolved substance concentration, h – pressure, $\varepsilon = f(\sigma)$, σ – porosity coefficient, k – filtration coefficient, $\vec{n}$ – unit boundary normal vector.

Conformal and quasiconformal mathematical model problem conversion to the parametrical rectangle variables ξ, η was performed. Problem numerical solution has been obtained via finite differences method with floating boundary domains numerical conformal mapping application, successive upper relaxation method and A. Samarskiy monotone local one-dimensional use. The boundary value problem computational algorithm and appropriate software have been developed.

The conducted mathematical and computer modeling makes it possible to provide fixing domain contour quantitative and qualitative assessment and hydropower structures foundations stress-strain state change, the structures' carrying capacity, facilities stability and reliability.

References

1. Сергиенко И.В., Скопецкий В.В., Дейнека В.С. Математическое моделирование и исследование процессов в неоднородных средах. - Киев: Наук.думка, 1991. - 432 с.
2. Власюк А.П., Дроздовський Т.А. Математичне моделювання зміни НДС ґрунтового масиву при наявності еволюційуючих каверн/ Тез. доп. XVII Всеукр. наук. конф. "Сучасні проблеми прикладної математики та інформатики", Львів, 2011, - С. 113.

MATHEMATICAL MODELLING OF STRESSED DEFORMED STATE CHANGE OF SOIL DAM BASE WITH CORE UNDER HEAT-MASS TRANSFER

A.P.Vlasyuk, N.A.Fedorchuk

National University of Water Management and Nature Resources Use,
Ukraine, Rivne

A.P.Vlasyuk@rambler.ru, N.A.Fedorchuk@mail.ru

The problem of modelling stressed deformed state (SDS) change of soil dam base with core under heat-mass transfer on the availability of free surface of ground waters is considered (see Fig. 1).

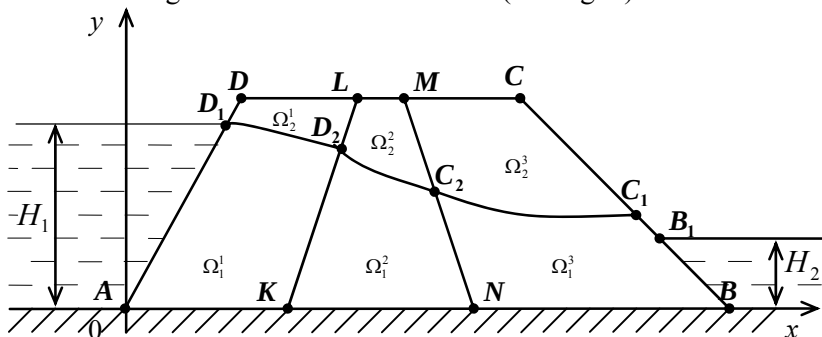


Fig.1. SDS of soil dam base with core under heat-mass transfer

The mathematical model of this problem in two-dimensional statement in generally accepted designations may be described by the following boundary value problem [1, 2]:

$$\begin{aligned} & \mu(c, T) \Delta U + (\lambda(c, T) + \mu(c, T)) \frac{\partial}{\partial x} \left(\frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} \right) + \left[\frac{\partial \lambda(c, T)}{\partial x} \left(\frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} \right) + \right. \\ & \left. + 2 \frac{\partial \mu(c, T)}{\partial x} \frac{\partial U}{\partial x} + \frac{\partial \mu(c, T)}{\partial y} \left(\frac{\partial U}{\partial y} + \frac{\partial V}{\partial x} \right) \right] - (2\lambda(c, T) + 2\mu(c, T)) \alpha_T \frac{\partial T}{\partial x} = X, \end{aligned} \quad (1)$$

$$\begin{aligned} & \mu(c, T) \Delta V + (\lambda(c, T) + \mu(c, T)) \frac{\partial}{\partial y} \left(\frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} \right) + \left[\frac{\partial \lambda(c, T)}{\partial y} \left(\frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} \right) + \right. \\ & \left. + 2 \frac{\partial \mu(c, T)}{\partial y} \frac{\partial V}{\partial y} + \frac{\partial \mu(c, T)}{\partial x} \left(\frac{\partial U}{\partial y} + \frac{\partial V}{\partial x} \right) \right] - (2\lambda(c, T) + 2\mu(c, T)) \alpha_T \frac{\partial T}{\partial y} = Y, \end{aligned}$$

$$\nabla \cdot (\mathbf{D}(c, T) \nabla c) - \mathbf{v} \nabla c - \gamma(c - C_m) + \nabla \cdot (\mathbf{D}_T \nabla T) = n \frac{\partial c}{\partial t}, \quad (2)$$

$$\nabla \cdot (\lambda_T \nabla T) - \rho c_\rho v \nabla T = c_T \frac{\partial T}{\partial t}, \quad (3)$$

$$v = -K(c, T) \nabla h + v_c(c) \nabla c + v_T \nabla T, \quad \text{div } \vec{v} + \frac{\partial n}{\partial t} = 0, \quad (4)$$

$$h|_{AD_1} = \tilde{H}_1, \quad h|_{BB_1} = \tilde{H}_2, \quad (v, n)|_{AB} = 0, \quad h|_{C_1 B_1 \cup \Gamma} = y, \quad \Gamma = D_1 D_2 \cup D_2 C_2 \cup C_2 C_1, \quad (5)$$

$$c|_{AD_1} = \tilde{C}_1, \quad (q_c, n)|_{\Gamma_1} = 0, \quad \Gamma_1 = AB \cup BB_1 \cup B_1 C_1 \cup \Gamma, \quad (6)$$

$$T|_{AD_1} = \tilde{T}_1, \quad T|_{\Gamma_2} = \tilde{T}_2, \quad \Gamma_2 = D_1 D \cup DC \cup CC_1, \quad T|_{C_1 B_1} = \tilde{T}_3, \quad T|_{BB_1} = \tilde{T}_4, \quad (q_T, n)|_{AB} = 0, \quad (7)$$

$$[h]|_{\Gamma_3} = 0, \quad [c]|_{\Gamma_3} = 0, \quad [v]|_{\Gamma_3} = 0, \quad [q_c]|_{\Gamma_3} = 0, \quad \Gamma_3 = KD_2 \cup NC_2, \quad (8)$$

$$[T]|_{\Gamma_4} = 0, \quad [q_T]|_{\Gamma_4} = 0, \quad \Gamma_4 = \Gamma \cup KL \cup NM, \quad (9)$$

$$q_c = v c - D(c, T) \nabla c - D_T \nabla T, \quad q_T = \rho c_\rho v T - \lambda_T \nabla T, \quad (10)$$

$$(v, n)|_{\Gamma} = n \frac{\partial \varphi}{\partial t}, \quad (11)$$

$$\sigma_n = 0, \quad \tau_s = 0, \quad (x, y) \in AD_1 \cup D_1 D \cup DC \cup CC_1 \cup C_1 B_1 \cup BB_1, \quad (12)$$

$$u_n = u_s = 0, \quad (x, y) \in AB, \quad (13)$$

$$[u_n] = [u_s] = 0, \quad [\sigma_n] = [\tau_s] = 0, \quad (x, y) \in \Gamma \cup KD_2 \cup D_2 L \cup NC_2 \cup C_2 M, \quad (14)$$

$$c(x, y, 0) = \tilde{C}_0(x, y), \quad (x, y) \in \Omega_1, \quad T(x, y, 0) = \begin{cases} \tilde{T}_0^1(x, y), & (x, y) \in \Omega_1, \\ \tilde{T}_0^2(x, y), & (x, y) \in \Omega_2, \end{cases} \quad (15)$$

$$\text{where } \Omega_1 = \bigcup_{i=1}^3 \Omega_1^i, \quad \Omega_2 = \bigcup_{i=1}^3 \Omega_2^i; \quad \varphi(x, y, t) = (y - h(x, y, t))|_{\Gamma} = 0$$

describes free surface Γ ; $\mathbf{n}$ is a vector of oblique cosines of exterior normal to area boundary.

There is obtained the numerical solution of boundary value problem (1)-(15). Displacements, stresses, deformations and field distribution pressures, filtration velocities, concentrations of salt solution and temperatures are found at the body base of soil dam with core. The change of SDS of soil dam base under heat-mass transfer was analyzed.

References

1. Sergienko I.V. Mathematical modelling and the research of processes in non-homogeneous media / I.V. Sergienko, V.V. Skopets'kyi, V.S. Deyneka. – Kyiv: Naukova Dumka, 1991. – 432 p. (in Russian)
2. Vlasjuk A.P. Numerical modelling of heat-mass transfer influence on SDS of multilayer soil dam base / A.P. Vlasjuk, N.A. Fedorchuk // Abstracts of XIX International Conference “Problems of decision making under uncertainties” – Mukachevo, 2012. – Pp. 70-72. (on Ukrainian)

OPTIMIZATION OF DETERMINISTIC POPULATION DYNAMICS MODELS

Vojtová Michaela

Masaryk University, Brno, Czech Republic

michaela.vojtova@mail.muni.cz

The aim of this talk is to apply methods from optimal control theory to the mathematical modeling of biological pest control. We formulate a pest control strategy for nonlinear Kolmogorov system of n interacting populations

$$\dot{x}_i = x_i f_i(x_1, x_2, \dots, x_n) \quad i = 1, 2, \dots, n \quad (1)$$

where $x_i(t)$ is density of population i at the time t , f_i are continuous functions of variables x_i , by introducing natural enemies into (1) as a control function. The sufficient conditions for existence of an optimal feedback control function are based on the fact, that the steady-state solution of the Hamilton-Jacobi-Bellman partial differential equation is a Lyapunov function guaranteeing stability and optimality [2]. We apply those general results to the predator-prey system in modified form

$$\begin{aligned} \dot{x} &= rx \left(1 - \frac{x}{K} \right) - \frac{axy}{1 + axT} \\ \dot{y} &= \frac{caxy}{1 + axT} - dy \end{aligned}$$

to illustrate biological control of pest mite in stored grain *Acarus siro* by predatory mite *Cheyletus eruditus*.

References

- 1 R.G. Van Driesche, T.S. Bellows.: Biological Control. Chapman and Hall. New York (1996). ISBN 0412028611.
- 2 D.S.Bernstein: Nonquadratic cost and nonlinear feedback control. In: International Journal of Robust and Nonlinear Control 3(1993)211–229.

MATHEMATICAL MODELING OF DYNAMICAL SYSTEMS WITH UNCERTAIN INITIAL-BOUNDARY CONDITION

Voloshchuk S.D.

Vadym Hetman Kyiv National Economic University

serg_vls@rambler.ru

The problem of constructing an approximate solution of linear initial-boundary task is reviewed. The ill-posed problem is studied, when some of the initial boundary conditions of the problem is unknown. An approximate solution is constructed as the sum of:

$$y(s) = y_u(s) + y_{0r}(s), s = (x, t) \in S_0^T = S \times [0, T], S \in R^n, \Gamma = \partial S$$

where $y_u(s) = \int_{S_0^T} G(s-s')u(s')ds'$ – the solution of differential equations

of dynamics without taking into account the initial-boundary conditions;

$$y_{0r}(s) = \int_{R^{n+1}} G(s-s')u_{0r}(s')ds'; \quad G(s-s') \text{ – the fundamental solution of}$$

the differential operator of equations; $u(s)$ – the right-hand side of the differential equation; $u_{0r}(s)$ – unknown function that provides the satisfaction of known initial-boundary conditions.

The function $u_{0r}(s)$ belongs to the set Ω_{0r} . Elements of this set minimize the total mean-square error Φ of the initial-boundary conditions of the problem. The set Ω_{0r} can be constructed in two ways.

In the first case, the matrix-integral system was obtained as a result of discretization of initial-boundary conditions and mean-square error Φ with the following pseudoinverse of this matrix [1]. In the second case, the integral representation of the initial-boundary conditions is discretized by variable s' . This procedure allows to replace the integrals by the corresponding sums. As a result we have a matrix-functional system which is ready for pseudoinverse [1].

The problems of observation and control of system, state of which is modeled by this initial-boundary value problem are resolved similarly

References

1 Скопецький В.В., Стоян В.А., Кривonos Ю.Г. Математичне моделювання прямих та обернених задач динаміки систем з розподіленими параметрами. – Київ: Наукова думка, 2002. – 361 с.

ITERATIVE BANDWIDTH SELECTION IN KERNEL DISCRIMINANT ANALYSIS

Kamila Vopatova

University of Defence, Czech Republic

kamila.vopatova@unob.cz

Kernel estimates belong to the most popular non-parametric estimates of a probability density function and they are a useful tool for visualising the distribution of data. Kernel density estimates play an important role in exploratory data analysis as well as in a discriminant analysis. These estimates strongly depend on a bandwidth matrix, which controls smoothness of the estimated density.

We focus on data-driven bandwidth matrices; especially those selected according to a recently proposed iterative method, and compare it to a least square cross-validation method and a normal reference rule. We study the performance of the kernel discriminant analysis with parametric (i.e., linear and quadratic) discriminant rules on simulated and real data.

ABOUT ONE RANDOM SEARCH ALGORITHM OF PARAMETERS IDENTIFICATION FOR ONE MODEL OF DEVELOPING SYSTEM

Yu. Zahorodnii, T. Korobko

Taras Shevchenko National University of Kyiv,

Ukraineyuzagor@ukr.net

Let function $m(\tau, t, \bar{c})$ describes density of age-distribution of biological population, where $\tau \in [0, \tau_{\max}]$ is age of the individual and $t \in [0, T]$ is time, with the definitional domain $\Omega = \{(\tau, t) | 0 \leq \tau \leq \tau_{\max}; 0 \leq t \leq T\}$. This function satisfies differential equations of hyperbolic type and some additional conditions which describe biological laws [1].

Let the function of the population's general biomass has the next view

$$H(t, \bar{c}) = \int_0^{\tau_{\max}} m(\tau, t) d\tau ,$$

That the parameters identification problem is stated as

$$\bar{c}^* = \arg \min_{\bar{c} \in C} J(\bar{c}) = \arg \min_{\bar{c} \in C} \sum_{i=1}^{N_h} \left(H(t_i, \bar{c}) - H_i^h \right)^2 / \left(\sum_{i=1}^{N_h} \left(H_i^h \right)^2 \right), \quad (1)$$

where H_i^h - experimental data at the observations time $t_i \in [0, T]$,

$i = \overline{1, N_h}$, and C - the set of identification parameters.

For solving problem (1) we used adaptive method of random search. Than algorithm of the model parameters identification had the next view.

Step 1. To define the model parameters from the set $\bar{c}_1 \in C$ and $k = 1$.

Step 2. To calculate $r_0 = J(\bar{c}_1)$, using formula (1).

Step 3. To find ξ_k - independent realization of random unit vector ξ , which is even distributed on unit m-measured sphere with center point in origin of coordinates, where m – number of the parameters.

Step 4. If the set $L_k = \{p \mid \bar{c}_k + p\xi_k \in C, p \in R\}$

is not empty, than go to step 5, else increase k on 1 and, if $k \leq N$, than go to step 3, else to stop the algorithm.

Step 5. To select points $p^0 < p^1 < p^n$ from the set L_k and calculate

$p_k = a_0 + a_1 m + a_2 \sqrt{m}$, where m - number of changes (improvements) of vector $\bar{c}_k$ for last $n = 20$ iterations of the

algorithm, $a_0 = p^0$, $a_1 = \frac{\sqrt{n}(p^1 - p^0) - (p^n - p^0)}{\sqrt{n} - n}$,

$$a_2 = \frac{(p^n - p^0) - n(p^1 - p^0)}{\sqrt{n} - n}.$$

Step 6. To calculate $r = J(\bar{c}_k + p_k \xi_k)$.

Step 7. If $r < r_0$, then increase k on 1, $\bar{c}_k = \bar{c}_{k-1} + p_k \xi_k$, $r_0 = r$ and, if $k \leq N$, go to the step 3, else go to the step 11.

Step 8. To calculate $r = J(\bar{c}_k - p_k \xi_k)$.

Step 9. If $r < r_0$, then increase k on 1, $\bar{c}_k = \bar{c}_{k-1} - p_k \xi_k$, $r_0 = r$ and, if $k \leq N$, then go to the step 3, else go to the step 11.

Step 10. To increase k on 1 and, if $k \leq N$, then go the step 3, else go to the step 11.

Step 11. To give out $\bar{c}_k$ as result of the algorithm.

Using this algorithm, it were defined parameters of the model for the hop plants as a developing system.

Reference

1. Akimenko V.V., Zagorodniy Yu.V. Modeling of dynamics of monocycle cells aggregation.// Cybernetics and systems analysis. – 2011. – v.47, №1. - p.34-49.

STOCHASTIC OPTIMIZATION OF A TRANSVERSELY VIBRATING CANTILEVER BEAM

Eva Žampachová

Brno University of Technology
zampachova@fme.vutbr.cz

Many problems from a wide range of applications can be described as optimization problems with constraints in the form of ordinary or partial differential equations (ODEs or PDEs). We are interested especially in the engineering problems where the processes are very often governed by PDEs and uncertainties can be found there. The paper discusses the applicability of stochastic programming approach to the optimization problem of the forced undamped transverse vibrations of a cantilever beam, see e.g. [3] and [4] for another engineering applications. Two-stage PDE constrained stochastic programming problem is formulated as a theoretical model for the selected engineering problem. Scenario-based approach [2] and finite difference method are used to propose a computational scheme for this optimization problem. Estimates of the approximation errors are based on Monte Carlo method and theory of point and interval estimation [1]. The solution quality is determined in terms of these estimates. By means

of derived approximations the mathematical model is implemented and solved in GAMS. Graphical and numerical results are presented and interpreted.

References

1. MAK, W., MORTON, D., WOOD, R. K.: Monte Carlo bounding techniques for determining solution quality in stochastic programs. *Operations Research Letters* 24 (1999), 47-56.
2. RUSZCZYŃSKI, A., SHAPIRO, A. (ed.) *Handbooks in Operations Research and Management Science*, vol. 10: Stochastic Programming. 1st ed. Amsterdam: Elsevier, 2003. 688 p.
3. ŽAMPACHOVÁ, E., POPELA, P., MRÁZEK, M. Optimum beam design via stochastic programming. *Kybernetika* 46, 3 (2010), 571-582.
4. ŽAMPACHOVÁ, E., POPELA, P. Different reformulations of stochastic optimization of the transverse vibrations. *Engineering mechanics* 17, 5/6 (2010), 339-350.

OPTIMIZATION PROBLEMS OF INFRASTRUCTURE FACILITIES ALLOCATION

Olena Zaslavska

Taras Shevchenko National University of Kyiv, Ukraine

zasla@univ.kiev.ua

We consider two optimization problems of infrastructure facilities allocation, which arise in the planning of social infrastructure (primary education, health care, culture, sport and recreation facilities), and roadside infrastructure (maintenance and gas stations, restaurants, camping areas). The first one is to maximize

$$\min_{i \in I} A_i(\gamma_i^1, \gamma_i^2, \dots, \gamma_i^{k^*}, x_i^1, x_i^2, \dots, x_i^{k^*}), \quad (1)$$

subject to:
$$\sum_{i \in I} (c_i^0 \cdot \bigvee_{k \in K} \gamma_i^k) + \sum_{i \in I} \sum_{k \in K} c_i^k \gamma_i^k x_i^k \leq b, \quad (2)$$

$$\sum_{k \in H_s} \gamma_i^k \leq 1 \text{ for all } i \in I, s = 1, 2, \dots, p, \quad (3)$$

$$\bigwedge_{s \in S_j} \bigvee_{k \in H_s} \gamma_i^k = 1 \text{ for all } j = 1, 2, \dots, m, i \in I, \quad (4)$$

$$\gamma_i^k \in \{0, 1\}, \alpha_i^k \leq x_i^k \leq \beta_i^k, x_i^k - \text{integer for all } k \in K, i \in I; \quad (5)$$

where $I = \{1, 2, \dots, n\}$ and $K = \{1, 2, \dots, k^*\}$ are finite sets; $A_i(\cdot)$ - nonlinear function of variables $\gamma_i^k, x_i^k, k \in K, i \in I$; coefficients c_i^0 ,

c_i^k , b are given values from $\mathbb{R}_+$; $H_s \subset K$ are given sets (used to specify compatibility conditions); S_j are given sets (used to specify connectivity conditions), $j=1,2,...,m$; α_i^k , β_i^k are given nonnegative integer values; and the second problem is to maximize

$$\sum_{k \in K} \left(p_k \cdot \sum_{h \in H} \min(\tilde{a}_h^k, \sum_{i \in W_h} \delta_i^k a_i^k x_i^k) \right), \quad (6)$$

subject to:
$$\sum_{i \in I} \left(\bigvee_{k \in K} \delta_i^k C_i^0 + \sum_{k \in K} \delta_i^k C_i^k x_i^k \right) < C, \quad (7)$$

$$\sum_{i \in W_h} a_i^k x_i^k \geq \tilde{a}_h^k \text{ for all } k \in K, h \in H = \{1, 2, \dots, h^*\}, \quad (8)$$

$$\sum_{k \in K} p_k \min(s_i^k, \delta_i^k a_i^k x_i^k) \geq \alpha \left(\bigvee_{k \in K} \delta_i^k C_i^0 + \sum_{k \in K} \delta_i^k C_i^k x_i^k \right) \text{ for all } i \in I, \quad (9)$$

$$\delta_i^k \in \{0, 1\}, \alpha_i^k \leq x_i^k \leq \beta_i^k, x_i^k - \text{integer for all } k \in K, i \in I; \quad (10)$$

where p_k , a_i^k , s_i^k , $\tilde{a}_h^k$, C , $\alpha > 1$ are given values from $\mathbb{R}_+$; $W_h \subset I$ are given subsets of set I .

Described optimization problems (1)-(5) and (6)-(10) characterized by following features: a) fixed and variable costs are considered in constrains (2), (7), (9), b) boolean and integer variables bounded on the interval values are used (5), (10); c) compatibility conditions - (3) and connectivity conditions - (4) are defined for boolean variables; min-operator is used in (6) and (9).

The algorithm for solving (1) - (5) and (6) - (10) problems is based on decomposition approach developed for middleman problem that was proposed in [4]. According to this algorithm to solve the initial problem we should develop the sequence of parameterized subproblems, that can be quickly solved (easily in means of computational complexity) due to use of heuristic rule. Procedure of subproblem formation includes elimination rules to remove subproblems which solution can't improve global solution of the initial problem.

References

1. Zaslavskaya O.V. Decomposition algorithm of middleman profit optimization // Bulletin of Kyiv University. Series: physics and math. Sciences. – 2005. – №4. – pp. 163 – 169.

HYSTERESIS STRATEGY FOR $M^\theta/G/1/m$ QUEUE WITH TWO-SPEED SERVICE AND BLOCKING OF INPUT FLOW

Zhernovyi K.

Ivan Franko National University of Lviv, Ukraine

k.zhernovyi@yahoo.com

In application of queueing systems, the following two problems are of great importance: a) we don't want the queue to be too long; b) It is desirable that the total idle time of the server should be as short as possible. These requirements are in opposition to each other. This situation is readily identified in the following example. Let us consider a standard $M/G/1$ -type queueing system and let ρ be its traffic intensity. It is well known that if $0 < \rho < 1$, then the mean value of the queue length is finite, but it increases towards infinity as $\rho \uparrow 1$. On the other hand, the mean value of total idle time has a tendency to increase as $\rho \downarrow 0$. So, problem a) requires ρ to be close to 0, while problem b) requires ρ to be close to 1. We propose to satisfy both these requirements using a special type of queueing system.

We consider the $M^\theta/G/1/m$ queue with two service modes (basic and postthreshold) with the distribution functions of service time $F(t)$ and $\tilde{F}(t)$ respectively. Postthreshold mode is used in conjunction with blocking of input flow if at the beginning of service of the next customer the number of customers in the system $\xi(t)$ satisfies the condition $\xi(t) > h_2$. Return to the basic mode and stop blocking carried out at the beginning of service of the next customer, if $\xi(t) \leq h_1$, where $h_1 \leq h_2$.

By using Korolyuk's potential method [1], we obtain Laplace transforms for distributions of the number of customers in the system on the busy period, for the busy time distribution function and formulas for average duration of the busy time, for the stationary distribution of number of customers in the system and for stationary characteristics of queue. The case of $m = \infty$ and problem of optimal choice of parameters h_1 and h_2 are considered.

References

1. Королук В.С. Граничные задачи для сложных пуассоновских процессов / В.С. Королук. – Киев: Наукова думка, 1975. – 139 с.

ITERATIVE MINIMAX OPTICAL FLOW ESTIMATION FROM A SEQUENCE OF SATELLITE IMAGES

**Sergiy Zhuk¹, Jason Frank², Isabelle Herlin³,
Oleksandr G. Nakonechny⁴**

^{1, 2} - CWI P.O. BOX 94079, NL-1090 GB Amsterdam, the Netherlands
{sergiy.zhuk,jason.frank}@cwi.nl

³ - Inria Rocquencourt - BP 105 78153 Le Chesnay Cedex, France
isabelle.herlin@inria.fr

⁴ - Taras Shevchenko National University of Kyiv, 64, Volodymyrska
str., Kyiv, Ukraine
nakonechniy@unicyb.kiev.ua

In geophysics, the atmosphere and ocean satisfy the assumption of incompressibility. Currently, a large number of satellites provide an increasing amount of 2D observations of these systems. The 2D incompressible hypothesis still remains a good approximation for ocean satellite sequences if little or no vertical motion occurs (no upwelling and downwelling). Introducing the divergence-free assumption for motion estimation methods is then a promising issue for such data sequences. During the last two decades, many authors investigated the issue of reconstruction of the fluid velocity (optical flow) from 2D images of the incompressible fluid, assuming that the brightness function of the images is transported by the optical flow. For instance, a 2D brightness transport equation (optical flow constraint) may be derived from the 3D continuity equation in radiography fluid flow imagery. For Sea Surface Temperature (SST) oceanographic images, the 2D optical flow constraint is derived from a 3D model of ocean surface temperature.

In this paper we present an iterative minimax state estimation approach for the following inverse problem: to reconstruct the optical flow given a sequence of 2D images of the flow surface and assuming that the optical flow satisfies incompressible 2D Navier-Stokes equation with uncertain parameters.

METHODS OF DISTRACT ANALYSIS OF TEST TASKS IN REMOTE LEARNING SYSTEM «VITAVA»

Zhyrytskyy V.

Taras Shevchenko National University of Kyiv, Ukraine

v.zhiritskiy@gmail.com

Computer testing is an effective tool of estimating the students' level of knowledge if the test is the reliable measurement tool [2].

One of the methods of estimation of the test reliability is method of distract analysis of test tasks of closed form and verification of uniform distribution of distractors [1].

One of symptoms of successful distractor selection is fact that students, who performed the test task incorrectly, choose the distractors with equal probability [2].

For verification of hypothesis we use the criteria χ^2 .

The further of distractor analysis is to calculate the value of point-biserial correlation coefficient for every distractor using following formula:

$$\rho_{bis} = \frac{\overline{x_1} - \overline{x_0}}{S_x^2} \sqrt{\frac{n_1 n_0}{n(n-1)}},$$

where $\overline{x_1}$ - average value of individual marks of students who have chosen the distractor; $\overline{x_0}$ - average value of individual marks of students who haven't chosen the distractor; S_x^2 - sample variance of individual marks; n_1 - amount of students who have chosen the distractor; n_0 - amount of students who have not chosen the distractor; n - amount of students, $n_1 + n_0$.

Distract analysis allows making conclusions about the quality of developed distractors for test tasks.

References

1. Аванесов В.С. Содержание теста и тестовых заданий. [Электронный ресурс] Режим доступа: - <http://testolog.narod.ru/Theory61.html>
2. Нейман Ю. М. Введение в теорию моделирования и параметризации педагогических тестов / Ю.М.Нейман, В.А.Хлебников – Москва, 2000. – 168 с.
3. Чельщикова М.Б. Теория и практика конструирования педагогических тестов. – М.2002.- 432 с.

МОДЕЛИ С ПРЕЦЕДЕНТНОЙ НАЧАЛЬНОЙ ИНФОРМАЦИЕЙ

Анафиев А.С.

ТНУ им. В.И. Вернадского, Симферополь, Украина

anafiyev@gmail.com

«В экономике как неформализованной науке важна опора на прецеденты, на эмпирические закономерности. Поэтому в ней большое значение имеют методы обучения диагностике и выбора на основе опыта, на материале наблюдений» [1].

В общем случае задачу оптимизации можно сформулировать в следующем виде: $\text{extr} f(x) / x \in \Omega \subseteq X$, где $f: X \rightarrow Y$ – целевая функция, X – множество объектов, Y – множество значений и Ω – множество допустимых решений, из которого выбирается искомое оптимальное значение целевой функции.

Оптимизационные задачи, когда полностью заданы целевая функция и область допустимых решений (обычно в виде ограничений-неравенств), достаточно хорошо изучены. Однако в реальных практических задачах, в частности экономических, когда мы имеем дело с моделированием нестационарных и плохо определенных процессов, тяжело точно выпisać целевую функцию и ограничения. Вследствие чего имеет место неполнота исходных данных. В этом случае трудна даже сама постановка задачи, не говоря уже о выборе адекватной решаемой задаче модели и непосредственного поиска оптимального решения.

В данной работе делается акцент на *задачах оптимизации с прецедентной начальной информацией*, которые слабо изучены и представляют огромный практический интерес в связи с большим объемом имеющейся прецедентной информации. *Актуальными становятся задачи синтеза алгоритмов машинного обучения (алгоритмов обучения по прецедентам) и методов оптимизации.*

Литература

1. Математические методы в экономике / [Еремин И.И., Мазуров Вл.Д., Скарин В.Д., Хачай М.Ю.]. – Под ред. Еремина И.И. и Мазурова Вл.Д. – Екатеринбург: Изд-во «У-Фактория», 2000. – 280 с.

К ВОПРОСУ ОБ УТОЧНЕНИИ МЕТОДИКИ РЕШЕНИЯ ЗАДАЧ ЭКОЛОГИЧЕСКОГО МЕНЕДЖМЕНТА

Анищенко В.А.

Черниговский филиал Европейского университета, г. Чернигов
ocean_soul111@mail.ru

Методика системного анализа для исследований и описания социо-эколого-экономических систем (СЭЭС, в роли которых выступают промышленные предприятия-природопользователи), а также разработки технологии поддержки принятия решений (ППР) на сегодня требует расширения и усовершенствования. На рис. 1 приведена схема организации экологического менеджмента.

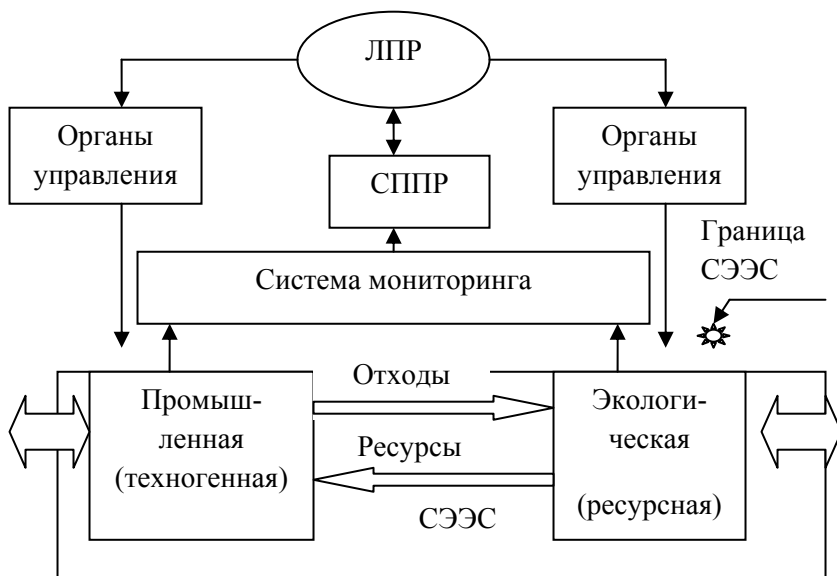


Рис. 1. Система централизованного управления СЭЭС

С нашей точки зрения, с позиций формализованного описания любых систем, мы можем представить СЭЭС следующим образом: $S_{СЭЭС} \subset (X_{П} \cdot X_{Э}) \cdot (Y_{П} \cdot Y_{Э})$, применяя формулу:

$$S_{СЭЭС} = \Omega(S_{П} \circ S_{Э}),$$

где $S_{П}$ та $S_{Э}$ - соответственно промышленная и экологическая подсистемы; $X_{П}, X_{Э}, Y_{П}, Y_{Э}$ - множества их входных и выходных

переменных; $^{\circ}, \Omega$ - знаки операций прямого и обратного соединения подсистем. К характерным особенностям $S_{\text{СЭЭС}}$ мы относим наличие возможных процессов, характерных для подсистемы $S_{\text{Э}}$.

Базируясь на описании данного класса систем мы предлагаем методику их исследования, состоящую из пяти этапов: концептуализация, спецификация, отображение, анализ, реализация. В основу информационного процесса ППР положен ряд принципов, отличающих экоменеджмент от производственного, с учетом которых нами математически были поставлены типовые задачи управления природопользованием и охраной природы. Считаем, что математическая модель, адекватно отображающая процессы в СЭЭС, может быть представлена следующим образом:

$$\begin{aligned} Y_{\Pi} &= F_1(r_{\Pi}, u_{\Pi}, z_{\text{Э}}^A, z_{\text{Э}}^B); \quad Y_{\text{Э}}^A = \Phi_1(r_{\text{Э}}, u_{\text{Э}}, z_{\text{ЭП}}, Y_{\text{Э}}^B); \\ z_{\text{ЭЭ}}^A &= \Phi_3(r_{\text{Э}}, u_{\text{Э}}, z_{\text{ЭП}}, z_{\text{ЭЭ}}^B); \quad z_{\text{ЭП}} = F_2(r_{\Pi}, u_{\Pi}, z_{\text{ЭЭ}}^A, z_{\text{ЭЭ}}^B); \\ z_{\text{ЭЭ}}^B &= \Phi_4(r_{\text{Э}}, u_{\text{Э}}, z_{\text{ЭП}}, z_{\text{ЭЭ}}^A) \quad ; \quad Y_{\text{Э}}^B = \Phi_2(r_{\text{Э}}, u_{\Pi}, z_{\text{ЭП}}, Y_{\text{Э}}^A) \end{aligned}$$

где $u_{\text{Э}} \in U_{\text{Э}}, r_{\text{Э}} \in R_{\text{Э}}$ - соответственно управляемые и наблюдаемые входные переменные в $S_{\text{Э}}$; $u_{\text{Э}} \in U_{\Pi}, r_{\Pi} \in R_{\Pi}$ - управляемые и наблюдаемые входные переменные в S_{Π} ; $Y_{\text{Э}}^A, Y_{\text{Э}}^B$ - соответственно входные абиотические и биотические переменные в $S_{\text{Э}}$; $z_{\text{ЭП}}, Y_{\Pi}$ - выходные переменные в S_{Π} ; $z_{\text{ЭП}}^A, z_{\text{ЭЭ}}^B$ - выходные абио- и биотические переменные в $S_{\text{Э}}$, воздействующие на S_{Π} .

Для решения каждой из задач нами принимались определенные условия, при выполнении которых могут быть решены проблемы управления в области соблюдения статических и динамических законов управления СЭЭС в условиях неопределенности состояний $S_{\text{Э}}$, при наличии сезонных факторов, циклических и структурных изменений, свойственных экологической подсистеме. Все эти постановки задач не только очерчивают круг проблем во время реализации экоменеджмента, но и предусматривают определение особенностей разработки систем поддержки принятия решений.

О РЕКОНСТРУКЦИИ НЕИЗВЕСТНЫХ ХАРАКТЕРИСТИК СИСТЕМ С ПОСЛЕДЕЙСТВИЕМ ПРИ ИЗМЕРЕНИИ ЧАСТИ КООРДИНАТ

М.С.Близорукова, В.И.Максимов

Институт математики и механики УрО РАН, Екатеринбург, Россия

msb@imm.uran.ru,

maksimov@imm.uran.ru

Обсуждается задача устойчивого восстановления переменного входа, а также неизмеримых координат динамической системы с последствием по результатам неточных наблюдений части ее траектории. Цель сообщения – дать некоторый набор алгоритмов решения для ряда типичных ситуаций. Содержание рассматриваемой задачи таково. Имеется динамическая система, описываемая векторным нелинейным дифференциальным уравнением. Траектория системы зависит от меняющегося во времени входного воздействия (входа). Заранее вход и траектория не заданы, но, возможно, известно множество, ограничивающее допустимую реализацию входа. В процессе движения наблюдается часть фазовых состояний системы. Наблюдения, вообще говоря, неточны. Требуется построить алгоритм приближенного восстановления входа и ненаблюдаемой части координат, обладающий свойствами динамичности и устойчивости. Свойство динамичности означает, что текущие значения приближения соответствующих координат и входа вырабатываются в реальном времени, свойство устойчивости – что приближения сколь угодно точны при достаточной точности наблюдения.

Задача относится к классу обратных задач динамики управляемых систем. Представленные в сообщении алгоритмы опираются на конструкции теории устойчивого динамического обращения, сочетающие методы теории некорректных задач и теории позиционного управления. Суть методики состоит в том, что алгоритм восстановления представляется в виде алгоритма управления некоторой искусственной динамической системой, моделью. Управление в модели адаптируется к результатам текущих наблюдений таким образом, что его реализация во времени аппроксимирует неизвестный вход.

ДИФФЕРЕНЦИАЛЬНЫЕ УРАВНЕНИЯ С ЗАПАЗДЫВАЮЩИМ АРГУМЕНТОМ, ОПИСЫВАЮЩИЕ НЕМАРКОВСКИЙ СЛУЧАЙНЫЙ ПРОЦЕСС

К.Г. Валеев, Ю.В. Шушарин

Киевский национальный университет имени Вадима Гетьмана
shusharin@meta.ua

Естественным обобщением системы обыкновенных дифференциальных уравнений являются дифференциальные уравнения с запаздывающим аргументом. Приведем один из результатов в развитии этого важного направления.

Теорема [1]. Пусть система дифференциальных уравнений

$$\frac{dP(t)}{dt} = A(t)P(t) \quad (1)$$

определяет некоторый марковский конечнозначный случайный процесс, $P(t)$ – стохастический вектор.

Пусть $\alpha_k(t) \geq 0, \tau_k(t) \geq 0 \ (k = 1, \dots, N),$

$\Pi_k(t)$ – произвольные стохастические матрицы. Тогда система дифференциальных уравнений с запаздывающим аргументом

$$\frac{dP(t)}{dt} = A(t)P(t) + \sum_{k=0}^N \alpha_k(t) (\Pi_k(t)P(t - \tau_k(t)) - P(t)) \quad (2)$$

определяет некоторый немарковский случайный процесс.

При $\tau_k(t) \equiv 0 \ (k = 0, 1, \dots, N)$ система уравнений (2)

описывает конечнозначный случайный марковский процесс.

Система уравнений (2) позволит исследовать более реальные задачи, связанные со случайными процессами.

Литература

1. Валеев К.Г., Карелова О.Л., Горелов В.И. Оптимизация линейных систем со случайными коэффициентами. –М.: Из-во РУДН, 1996, – 258 с.
2. Тихонов В.И., Миронов М.А. Марковские процессы. –М.: Советское радио, 1977. –488 с.

ИДЕНТИФИКАЦИЯ НЕИЗВЕСТНЫХ ПАРАМЕТРОВ ИСТОЧНИКА ЗАГРЯЗНЕНИЙ В ДВУХМЕРНЫХ НЕСТАЦИОНАРНЫХ ЗАДАЧАХ МАССОПЕРЕНОСА

Власюк А.П., Багнюк О.М.

Национальный университет водного хозяйства и
природопользования, г. Ровно

A.P.Vlasyuk@rambler.ru, olga_bagnyk@ukr.net

Рассматривается задача моделирования переноса загрязнений в ограниченной области $\Omega \in R^2$ от некоторого точечного источника мощности Q , расположенного в точке $M(x_0, y_0) \in \Omega$ [1]. Нужно по известным измерениям концентрации загрязнений $\bar{C}_i, i = \overline{1, N}$ в точках с координатами (x_i, y_i) в моменты времени t_i определить мощность, координаты и время срабатывания мгновенного точечного источника загрязнений, а также подобласть $\Omega_0 \in \Omega$, в которой концентрация $c(x, y, t)$ не превышает заданной величины $\bar{C}_0$.

В ограниченной области $\Omega_1 = \Omega \times (0, T)$ ищется решение сформулированной выше задачи, математическая модель которой в общепринятых обозначениях следующая:

$$Lc \equiv \sigma \frac{\partial c}{\partial t} - \operatorname{div}(D \operatorname{grad} c) + \vec{v} \operatorname{grad} c + \gamma c = Q \delta(x - x_0) \delta(y - y_0) \delta(t - t_0), \quad (1)$$

$$c(x, y, 0) = 0, \quad (2)$$

$$lc|_{\Gamma} = (\vec{v}c - D \operatorname{grad} c)|_{\Gamma} = 0, \quad (3)$$

где (1) – дифференциальное уравнение конвективного диффузионного переноса загрязнений со скоростью $\vec{v} = (V_x, V_y)$,

(3) задает граничные условия на границе Γ области Ω .

Согласно [2] сопряженная задача к (1)-(3) имеет следующий вид:

$$-\frac{\partial c^*}{\partial t} - \vec{v} \operatorname{grad} c^* + \gamma c^* - \operatorname{div}(D \operatorname{grad} c^*) = P_i, \quad (4)$$

$$c^*(x, y, t) = 0 \text{ при } t = T, \quad (5)$$

$$(\vec{v}c^* - D \operatorname{grad} c^*)|_{\Gamma} = 0, \quad (6)$$

где $P_i = \delta(x - x_i)\delta(y - y_i)\delta(t - t_i)$, $i = \overline{1, N}$.

Двоистое представление функционала от концентрации следующее:

$$J_i = \int_0^T dt \int_0^a \int_0^b P_i c dx dy = Q \int_0^T dt \int_0^a \int_0^b c_i^* dx dy. \quad (7)$$

В случае прямоугольной области со сторонами a и b , решение прямой задачи (1)-(3) с постоянными коэффициентами и нулевыми начальными и граничными условиями примет вид

$$c(x, y, t) = \exp \left[\frac{V_x}{2D}(x - x_0) + \frac{V_y}{2D}(y - y_0) - \left(\frac{V_x^2 + V_y^2}{4D\sigma} + \frac{\gamma}{\sigma} \right) (t - t_0) \right] \cdot U(x, y, t),$$

где

$$U(x, y, t) = \frac{4}{ab} \sum_{m=1}^{\infty} \sum_{n=1}^{\infty} F(m, n) \exp \left[-Dt\pi^2 \left(\frac{m^2}{a^2} + \frac{n^2}{b^2} \right) \right] \sin \frac{m\pi x}{a} \sin \frac{n\pi y}{b},$$

$$F(m, n) = Q \sin \frac{n\pi x_0}{a} \sin \frac{m\pi y_0}{b}.$$

Решение сопряженной к ней задачи

$$c_i^*(x, y, \tilde{t}) = \begin{cases} \exp \left[\frac{V_x}{2D}(x - x_i) + \frac{V_y}{2D}(y - y_i) - \left(\frac{V_x^2 + V_y^2}{4D\sigma} + \frac{\gamma}{\sigma} \right) (\tilde{t} - t_i) \right] \cdot U(x, y, \tilde{t}), & \tilde{t} \in [0, \tilde{t}_i), \\ 0, & \tilde{t} \in [\tilde{t}_i, T], \quad i = \overline{1, N} \end{cases}$$

Тогда неизвестные параметры источника загрязнений x_0, y_0, t_0, Q на основе двойственного представления функционала с учетом решения сопряженной задачи, находим из решения следующей системы:

$$J_i = \overline{C_i} = Q_0 c_i^*(t_0, x_0, y_0), \quad i = \overline{1, N}.$$

Литература

- 1 Власюк А.П. Локализация местонахождения источника загрязнений в двумерных нестационарных задачах массопереноса / А.П. Власюк, О.М. Багнюк // Тез. доп. XIX междунар. конф. «Проблемы принятия решений в условиях неопределенности», Тез. док. – Киев, 2012. – С.67-68.
- 2 Марчук Г.И. Математическое моделирование в проблеме окружающей среды. – М.: Наука, 1982. – 320 с.

МАТЕМАТИЧЕСКОЕ МОДЕЛИРОВАНИЕ ИЗМЕНЕНИЯ НАПРЯЖЕННО-ДЕФОРМИРОВАННОГО СОСТОЯНИЯ ГРУНТА ПРИ НАГНЕТАНИИ В НЕГО ВЯЖУЩЕГО РАСТВОРА

А.П. Власюк, Т.А. Дроздовский

Национальный университет водного хозяйства и природопользования, Украина

A.P.Vlasyuk@rambler.ru, coldion@gmail.com

Рассматривается задача изменения напряженно-деформированного состояния (НДС) грунтовой основы гидротехнического объекта (ГТО) (рис. 1) при нагнетании вяжущего раствора в его основание, которая заключается в расчете НДС как в области нагнетания Ω_1 так и в грунтовом массиве Ω_2 .

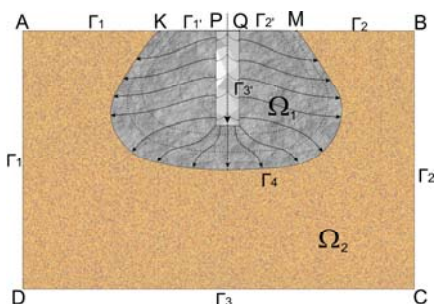


Рис.1. Грунтовое основание ГТО

Математическая модель данной задачи в изотермических условиях в общепринятых обозначениях описывается следующей краевой задачей[1,2]:

- уравнениями НДС для компонент вектора смещений $\vec{u} = (U, V)$

$$\mu_i \cdot \Delta U + (\lambda_i + \mu_i) \frac{\partial}{\partial x} \left(\frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} \right) = X_i, \quad (1)$$

$$\mu_i \cdot \Delta V + (\lambda_i + \mu_i) \frac{\partial}{\partial y} \left(\frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} \right) = Y_i, \quad i = 1, 2$$

- стационарными уравнениями для напоров ньютоновской жидкости в деформирующемся скелете грунта области нагнетания

$$\frac{\partial}{\partial x} \left(k(\varepsilon) \frac{\partial h}{\partial x} \right) + \frac{\partial}{\partial y} \left(k(\varepsilon) \frac{\partial h}{\partial y} \right) = 0 \quad (2)$$

при следующих краевых условиях:

- а) для компонент вектора смещений

$$U = V = 0, \quad (x, y) \in \Gamma_3 \cup \Gamma_4 \cup \Gamma_1' \cup \Gamma_3',$$

$$\begin{aligned}
& [U] = [V] = 0, \quad (x, y) \in \Gamma_{44'}, \\
& \begin{cases} (\lambda_i + 2\mu_i) \frac{\partial U}{\partial x} + \lambda_i \frac{\partial V}{\partial y} = 0, \\ \frac{\partial U}{\partial y} + \frac{\partial V}{\partial x} = 0, \end{cases} \quad (x, y) \in \tilde{A}_1 \cup \tilde{A}_2 \cup \tilde{A}_{2'};
\end{aligned}$$

б) для напоров на границе области нагнетания

$$\left. \frac{\partial h}{\partial \vec{n}} \right|_{\Gamma_1} = 0, \quad h|_{\Gamma_2} = \frac{p_0}{\rho_0 g}, \quad \left. \frac{\partial h}{\partial \vec{n}} \right|_{\Gamma_3} = 0, \quad h|_{\Gamma_4} = y;$$

в) для точек фронта нагнетания (свободной границы Γ_4)

$$(v, \vec{n}) = \sigma \frac{d\varphi}{dt}.$$

Здесь: λ_i, μ_i – коэффициенты Ламе, X_i, Y_i – компоненты массовой силы, h – напор области нагнетания, $k(\varepsilon)$ – коэффициент фильтрации, $\varepsilon = f(\sigma)$, σ – коэффициент пористости, $\varphi = y - h$, $\vec{n}$ – вектор направляющих косинусов внешней нормали к границе.

Произведено конформное и квазиконформное преобразование задачи математической модели к переменным ξ, η параметрического прямоугольника. Численное решение задачи получено методом конечных разностей с использованием численных конформных отображений областей со свободными границами и применением метода последовательной верхней релаксации. Разработано вычислительный алгоритм решения соответствующей краевой задачи и необходимое программное обеспечение.

Проведенное математическое и компьютерное моделирование предоставляет возможность делать количественную и качественную оценку величины зоны нагнетания для расчета напряженно-деформированного состояния грунтовых оснований гидротехнических объектов, их несущей способности, стойкости и надежности сооружений.

Литература

1. Сергиенко И.В., Скопецкий В.В., Дейнека В.С. Математическое моделирование и исследование процессов в неоднородных средах.- Киев: Наук.думка, 1991.- 432 с.
2. Власюк А.П., Дроздовський Т.А. Математичне моделювання зміни НДС ґрунтового масиву при наявності еволюційуючих каверн/ Тез.

МАТЕМАТИЧЕСКОЕ МОДЕЛИРОВАНИЕ МАССОПЕРЕНОСА ПРИ ФИЛЬТРАЦИИ И ВЛАГОПЕРЕНОСЕ В НАСЫЩЕННО-НЕНАСЫЩЕННЫХ СЛОИСТЫХ ГРУНТАХ

Власюк А.П., Цветкова Т.П.

Национальный университет водного хозяйства и
природоиспользования, г. Ровно

A.P.Vlasyuk@rambler.ru, Tsvetkova@ukr.net

Исследуется массоперенос солевых растворов при фильтрации подземных вод и влаги в насыщенно-ненасыщенных слоистых грунтах.

Математическую модель данной задачи в слоях $i = \overline{1, s}$ области полного насыщения в общепринятых обозначениях на основании работ [1, 2] можна описать следующей краевой задачей:

$$\frac{\partial \left(D_1(c_1^i) \frac{\partial c_1^i}{\partial x} \right)}{\partial x} - v_1 \frac{\partial c_1^i}{\partial x} - \gamma_1(c_1^i - C_1^*) = \sigma_1 \frac{\partial c_1^i}{\partial t}, \quad (1)$$

$$\frac{\partial}{\partial x} (k_1(c_1^i, h_1^i) \frac{\partial h_1^i}{\partial x}) - v_1(c_1^i) \frac{\partial c_1^i}{\partial x} = 0, \quad (2)$$

$$v_1 = -k_1(c_1^i, h_1^i) \frac{\partial h_1^i}{\partial x} + v_1(c_1^i) \frac{\partial c_1^i}{\partial x}, \quad (3)$$

$$c_1^i(x, 0) = \tilde{C}_0^i(x), \quad c_1^i(0, t) = \tilde{C}_1^i(t), \quad c_1^i(l_i, t) = c_2^i(l_i, t), \quad (4)$$

$$h_1^i(x, 0) = \tilde{H}_0^i(x), \quad h_1^i(0, t) = \tilde{H}_1^i(t), \quad h_1^i(l_i, t) = \tilde{H}_2^i(t). \quad (5)$$

Математическую модель задачи в слоях $i = \overline{s+1, N}$ области неполного насыщения в общепринятых обозначениях можна описать следующей краевой задачей [1, 2]:

$$\frac{\partial \left(D_2(c_2^i) \frac{\partial c_2^i}{\partial x} \right)}{\partial x} - v_2 \frac{\partial c_2^i}{\partial x} - \gamma_2(c_2^i - C_2^*) = \sigma_2 \frac{\partial c_2^i}{\partial t}, \quad (6)$$

$$\mu(h_2^i) \frac{\partial h_2^i}{\partial t} = \frac{\partial}{\partial x} (k_2(c_2^i, h_2^i) \frac{\partial h_2^i}{\partial x}) - \nu_2(c_2^i) \frac{\partial c_2^i}{\partial x}, \quad (7)$$

$$\nu_2 = -k_2(c_2^i, h_2^i) \frac{\partial h_2^i}{\partial x} + \nu_2(c_2^i) \frac{\partial c_2^i}{\partial x}, \quad (8)$$

$$c_2^i(x, 0) = \tilde{C}_0^i(x), \quad c_2^i(l_i, t) = \tilde{C}_2^i(t), \quad c_1^i(l_i, t) = c_2^i(l_i, t), \quad (9)$$

$$h_2^i(x, 0) = \tilde{H}_0^i(x), \quad h_2^i(0, t) = \tilde{H}_1^i(x), \quad h_2^i(l_i, t) = \tilde{H}_2^i(x). \quad (10)$$

Условия сопряжения для напора и концентрации заданные на границах слоев грунта соответственно

$$[h]_{|x=l_i} = [c]_{|x=l_i} = \left[c\tilde{\nu} - D(c) \frac{\partial c}{\partial x} \right]_{|x=l_i} = 0. \quad (11)$$

где $D_1(c_1^i)$, $D_2(c_2^i)$ – коэффициенты конвективной диффузии в слоях областей, $k_1(c_1^i, h_1^i)$, $k_2(c_2^i, h_2^i)$ – коэффициенты водопроницаемости, $\nu_1(c_1^i)$, $\nu_2(c_2^i)$ – коэффициенты химического осмоса, $[h]_{|l_i} = [c]_{|l_i}$ – прыжки функции относительно напоров и концентрации солей, заданные на границах слоев грунта.

Для краевой задачи (1)-(11) построена монотонная разностная схема, найдено ее численное решение и выполнено программную реализацию. На основе проведенных численных экспериментов получено распределение поля влаги в слоях области неполного насыщения, поле напоров в слоях области полного насыщения, поля концентрации в слоях областей полного и неполного насыщения почвы. Учтено влияние массопереноса солей и осмотических явлений на процесс влагопереноса в слоях области неполного насыщения.

Литература

1. Власюк А.П., Цветкова Т.П. Математическое моделирование массопереноса солей при совместной фильтрации и влагопереносе в насыщенно-ненасыщенных грунтах в нелинейной постановке // Тез. XVII Межд. конф. „Прогнозирования и принятия решений в условиях неопределенности”, Сходница, 2011. – С. 48-50
2. Развитие исследований по теории фильтрации в СССР (1917-1967). – Москва:Наука, 1969. – 542 с.

ОПТИМИЗАЦИОННАЯ МОДЕЛЬ БИПОЛЯРНОГО РЫНКА КВОТ НА ВЫБРОСЫ ПАРНИКОВЫХ ГАЗОВ

Дигас Б.В., Розенберг В.Л.

Институт математики и механики УрО РАН,

г. Екатеринбург, Россия

digas@imm.uran.ru, rozen@imm.uran.ru

Глобальное изменение климата является одной из наиболее обсуждаемых и неоднозначных проблем в современном мире. При изучении различных ее аспектов нередко используются результаты применения математических моделей. В работе, продолжающей исследования [1], обсуждается модельно-ориентированный подход к построению оптимальной стратегии поведения стран на международном рынке квот на выбросы парниковых газов, который является одним из механизмов реализации природоохранных соглашений. Специфика модели состоит в рассмотрении двух продавцов, преследующих общую цель и имеющих возможности резервирования квот и оптимизации времени их продажи. Предполагается, что при условии принятия инициатив по сокращению выбросов развитыми странами по типу Киотского протокола Россия и Украина могут согласованно действовать на рынке квот. Модель использует функцию спроса на квоты со стороны потенциальных покупателей, функцию предельных затрат на снижение выбросов продавцами и прогноз динамики «горячего воздуха» (разности между текущими выбросами и гипотетическими обязательствами). Алгоритм решения задачи основан на процедурах, предложенных в работе [2].

Работа выполнена при поддержке программы Президиума РАН «Перспективы скоординированного социально-экономического развития России и Украины в общеевропейском контексте», проект 12-П-1-1038.

Литература

1. Кадиев А.М., Максимов В.И., Розенберг В.Л. . Об одной оптимизационной модели международного рынка квот на выбросы парниковых газов. Мат. моделирование, т. 21, № 5, с. 103–113, 2009.
2. Kryazhimskii A.V., Maksimov V.I. A solution algorithm for problems of optimal control in Hilbert spaces. Journal of Mathematical Sciences, Vol. 121, no. 2, pp. 2226–2247, 2004.

МОДЕЛИРОВАНИЕ ТИПИЧНЫХ ЗАВИСИМОСТЕЙ ОБЪЕМОВ ЭКСПОРТА УКРАИНЫ В ЕВРОПЕЙСКИЕ СТРАНЫ

Дидковская Б.В., Навродский В.А.

Киевский национальный университет культуры и искусства,
Украина

navrodskiy@ukr.net

Рассматривается задача эконометрического анализа показателей экспорта Украины на основе моделей, которые позволяли бы получать качественный прогноз экономических характеристик, описывающих структуру украинского экспорта в Европейские страны. Исследуются следующие типичные зависимости:

- 1) для моделирования объемов экспорта Украины в группу стран ЕС: $x_k = F(x_n, m_r, m_p, t, kv_s, curs)$;
- 2) для моделирования объемов экспорта Украины в конкретные страны ЕС: $x_t = F(x_n, x_k, m_q, m_r, m_p, t, kv_s, curs)$;
- 3) для моделирования объемов экспорта Украины в ЕС по товарным группам: $x_n = F(x_k, m_r, t, kv_s, curs)$;

где x_k – объемы экспорта Украины в группу стран ЕС, x_t – объемы экспорта Украины в страны ЕС, x_n – объемы экспорта Украины в ЕС по товарным группам, m_p – объемы импорта в Украину из групп стран ЕС, m_q – объемы импорта в Украину из стран ЕС, m_r – объемы импорта из ЕС по товарным группам, t – экзогенная переменная тренда, kv_s – фиктивная переменная, $curs$ – показатель изменения курса гривны к доллару.

ЭКОЛОГИЧЕСКИЕ МОДЕЛИ ДИНАМИКИ. ДИСКРЕТНАЯ МОДЕЛЬ ЛЕСЛИ С ПОСЛЕДЕЙСТВИЕМ

Гаркуша Н.И.

Киевский национальный университет им. Тараса Шевченко

В докладе рассматриваются различные модификации моделей динамики популяций Лесли. Особенностью модели Лесли является учет возрастной структуры популяции.

Таким образом, математическая модель динамики в векторно-матричном виде записывается в форме системы разностных уравнений

$$x(k+1) = Lx(k), \quad x(k) = (x_1(k), x_2(k), \dots, x_n(k)), \quad k = 1, 2, \dots,$$

где квадратная матрица L размерности $n \times n$ имеет вид

$$L = \begin{bmatrix} f_1 & f_2 & \dots & f_{n-1} & f_n \\ p_1 & 0 & \dots & 0 & 0 \\ 0 & p_2 & \dots & 0 & 0 \\ \vdots & \vdots & \dots & \vdots & \vdots \\ 0 & 0 & \dots & p_{n-1} & 0 \end{bmatrix}$$

и называется матрицей Лесли.

Динамика развития популяции может быть описана квазилинейной системой разностных уравнений

$$x(k+1) = L[w(x(k))], \quad k = 0, 1, 2, \dots$$

Наконец, учитывая время полового созревания, рассматривается линейная систем Лесли с запаздыванием

$$x(k+1) = L_1 x(k) + L_2 x(k-m),$$

$$L_1 = \begin{bmatrix} 0 & 0 & \dots & 0 & 0 \\ p_1 & 0 & \dots & 0 & 0 \\ 0 & p_2 & \dots & 0 & 0 \\ \vdots & \vdots & \dots & \vdots & \vdots \\ 0 & 0 & \dots & p_{n-1} & 0 \end{bmatrix}, \quad L_2 = \begin{bmatrix} f_1 & f_2 & \dots & f_{n-1} & f_n \\ 0 & 0 & \dots & 0 & 0 \\ 0 & 0 & \dots & 0 & 0 \\ \vdots & \vdots & \dots & \vdots & \vdots \\ 0 & 0 & \dots & 0 & 0 \end{bmatrix}.$$

Проведено исследование поведения решений системы. Найдены особые решения, исследована их устойчивость.

ПАРЕТО-ОПТИМАЛЬНЫЙ ПОДХОД К ЗАДАЧЕ ВОССТАНОВЛЕНИЯ ФУНКЦИОНАЛЬНЫХ ЗАВИСИМОСТЕЙ В УСЛОВИЯХ НЕЧЕТКОСТИ

Заворотный А.Л., Касьянюк В.С.

Киевский национальный университет им. Тараса Шевченко

zal_ua@inbox.ru

Рассматривается задача восстановления значений функции $f(x)$ из класса $L_2[D]$ на произвольном заданном наборе значений аргумента $x_1, \dots, x_m$ из области D . При этом считается, что сами значения функции в данных точках $f(x_1), \dots, f(x_m)$ неизвестны. Вместо этого известны нечетко искаженные значения функционала $y_i = \int_D g_i(x)f(x)dx + \mu_i$, $i = \overline{1, n}$. Тут $g_i(x) \in L_2[D]$ - известные ядра функционала, μ_i - нечеткие погрешности в известных значениях функционала y_i . Для нечетких ошибок известны их распределения, являющиеся монотонно убывающими функциями от модуля аргумента. Эти распределения равны 1, если ошибки нет, и равны 0, если ошибка бесконечно велика. Таким образом реализуется принцип: чем больше ошибка, тем меньше ее возможность.

Предложено искать оценки $\hat{f}(x)$, решая задачу оптимизации по Парето. Первым критерием оптимальности является приближение $f(x)$ к ее усредненному значению в некоторой окрестности заданных точек. Т.е. приближение $f(x_j)$, $j = \overline{1, m}$ к

$$\int_D I_j^\varepsilon(x)f(x)dx, \text{ где } I_j^\varepsilon(x) = \begin{cases} 1/2\varepsilon_j, & |x - x_j| \leq \varepsilon_j \\ 0, & |x - x_j| > \varepsilon_j \end{cases}, \quad \varepsilon_j - \text{ заданная}$$

окрестность усреднения для точки x_j . Второй критерий оптимальности - минимизация необходимости ошибки в построенной оценке [1]. Найденные оценки $\hat{f}(x)$ далее можно использовать для построения в аналитическом виде функции в заданном классе.

Литература

1.Пытьев Ю.П. Возможность. Элементы теории и применения. – М.: Эдиториал УРСС, 2000. – 192 с.

СРАВНИТЕЛЬНЫЙ АНАЛИЗ МЕТОДОВ ПРОГНОЗИРОВАНИЯ МАКРОЭКОНОМИЧЕСКИХ ПОКАЗАТЕЛЕЙ УКРАИНЫ

Зайченко Ю.П., Гасанов А.С.

Национальный технический университет Украины
"Киевский политехнический институт"

zaychenko@gmail.com

Необходимо на основе информации о месячных показателях процента изменения индекса потребительских цен (% ИПЦ) и национального внутреннего валового продукта (НВВП), а также данных о других макроэкономических показателях Украины построить прогнозирующие модели (ПМ) экспоненциального сглаживания (ЭЗ), авторегрессии (АР), авторегрессии со скользящим средним (АРСС), и модели с использованием полиномиального МГУА (ПМГУА) на основе линейных и квадратичных описаний. Приведены результаты и дан сравнительный анализ точности ПМ для разных соотношений, обучающей (Nоб) проверочной выборок (Nпр). Этап предварительной обработки и анализа ряда состоял в восстановлении отсутствующих значений с помощью ЭЗ с рассчитанным начальным приближением, нормировании и удалении первых и вторых разностей ряда. В результате исследований варьировались соотношения между объемом Nоб и Nпр выборок. Приведены статистические характеристики, полученные для построенных моделей и реальные значения ряда (% ИПЦ) при делении выборки на Nоб и Nпр в таком взаимоотношении Nобуч=20 и Nпрров=19 (Nнавч=04/Nпрров=06). При этом в модели ЭЗ в качестве начального приближения выбрано среднее значение ряда 1,095, параметр сглаживания $\alpha=0,1$ выбрано по сетке значений, в модели порядок АР и СС были выбраны 3 соответственно, т.е. АРСС(3,3). Как следует из приведенных результатов при Nобуч=16 и Nпрров=23 (Nнавч=04/Nпрров=06) наилучшей по всем прогнозным характеристикам является модель четкого ПМГУА на основе квадратичных частных описаний (ЧО). Модель четкого ПМГУА на основе линейных частных описаний находится на другом месте.

Полученные результаты позволяют сделать следующие выводы: с увеличением объема обучающей выборки значения

статистических характеристик R квадрат и DW для всех моделей приближается к своим идеальным значениям; по статистическим характеристикам в большинстве случаев лучшей оказалась ПМ АРСС; по прогнозным характеристикам для всех соотношений обучающей и проверочной выборки минимальные значения по показателям RMSE и MARE при прогнозировании ИПЦ и НВВП достигаются для модели четкого полиномиального МГУА на основе квадратичных частных описаний. Во всех экспериментах модель четкого ПМГУА с линейными ЧО занимает второе место. Таким образом, проведенный анализ показал, что модели ПМГУА на основе линейных и квадратичных ЧО являются наилучшими по сравнению с классическими статистическими методами (АР, АРСС, ЭЗ) при прогнозировании макроэкономических показателей (ИПЦ и НВВП) экономики Украины.

ИСПОЛЬЗОВАНИЕ НЕЙРОННЫХ СЕТЕЙ ДЛЯ ПРОГНОЗИРОВАНИЯ НЕЧЕТКИХ ДАННЫХ

Ивохин Е.В., Адзубей Л.Т., Харченко И.И.

Киевский национальный университет имени Тараса Шевченко

`ivohin@univ.kiev.ua`

Традиционно задача прогнозирования данных, полученных в результате наблюдений, формулируется следующим образом [1]. Известен некоторый набор входных данных, описывающих определенные характеристики динамических процессов, которые считаются образцовыми. Нейронная сеть из произвольного неидеального сигнала, поданного на ее вход, должна выделить соответствующий образец (при его наличии) или дать заключение о его отсутствии. В общем случае, сигнал описывается вектором $\mathbf{X} = \{x_i: i=0, \dots, n-1\}$, где n – число нейронов в сети и размерность входных и выходных векторов. Если сеть распознает образец на основании предъявленных ей данных, ее выход содержит вектор выходных значений сети $\mathbf{Y}$, совпадающий с найденным образцом. В противном случае, выходной вектор не совпадет ни с одним из имеющихся образцов.

Задача существенно усложняется в случае представления входных данных в виде вектора элементов некоторого нечеткого множества, построенного на основе совокупности наблюдений в условиях неопределенности.

Предлагается использовать нейронную сеть Хопфилда для поиска выходных значений сети для разных уровней принадлежности нечетких элементов входного вектора и векторов-образцов. Предложена процедура агрегации полученных выходов в виде нечеткого вектора, анализ значений которого позволяет определить тенденцию изменения данных в дальнейшем.

Рассмотрена задача наблюдения при условии неточности входных данных, представленных в виде набора нечетких множеств. Получены условия совместимости исходных данных с рассчитанным в сети выходом.

Предложенный подход апробирован при обработке экономических данных (стоимость курса акций), полученных в результате наблюдений за динамикой соответствующих показателей.

Литература

1. Круглов В.В. Нейронные сети. Теория и практика/ В.В. Круглов, В.В.Борисов. – М: Горячая линия-Телеком, 2002. – 382 с.

ЗАДАЧА ИДЕНТИФИКАЦИИ ДЛЯ НЕЛИНЕЙНОГО НЕСТАЦИОНАРНОГО УРАВНЕНИЯ ШРЕДИНГЕРА ПО НАБЛЮДЕНИЮ НА ВСЕЙ ОБЛАСТИ

А.Д.Искендеров¹, Г.Я.Ягубов², Н.С.Ибрагимов³, М.А.Мусаева¹

¹Ленкоранский государственный университет, Азербайджан

²Кавказский университет, Турция

³Бакинский государственный университет, Азербайджан

¹office@lsu.edu.az , ²gabilya@mail.ru ,

³natiq_ibrahimov@mail.ru

Рассмотрим волновой процесс, в котором комплексная амплитуда волны описывается следующей начально-краевой задачей для одномерного нелинейного уравнения Шредингера [1]:

$$i \frac{\partial \psi_k}{\partial t} + \frac{\partial}{\partial x} \left(v_0(x) \frac{\partial \psi_k}{\partial x} \right) - v_1(x) \psi_k + a_1 |\psi_k|^2 \psi_k = f_k(x, t), (x, t) \in \Omega, k=1,2, \quad (1)$$

$$\psi_k(x, 0) = \varphi_k(x), x \in (0, l), k=1,2, \quad (2)$$

$$\psi_1(0, t) = \psi_1(l, t) = 0, t \in (0, T), \quad (3)$$

$$\frac{\partial \psi_2(0, t)}{\partial x} = \frac{\partial \psi_2(l, t)}{\partial x} = 0, t \in (0, T), \quad (4)$$

где $i = \sqrt{-1}$ – мнимая единица, $l > 0, T > 0$ – заданные числа, $0 \leq x \leq l, 0 \leq t \leq T, \Omega_t = (0, l) \times (0, t), \Omega = \Omega_T$, a_1 – любое вещественное число, $\varphi_k(x), f_k(x, t), k = 1, 2$ – измеримые функции, удовлетворяющие условиям:

$$\varphi_1 \in \overset{0}{W}_2^2(0, l), \varphi_2 \in \overset{0}{W}_2^2(0, l), \frac{d\varphi_2(0)}{dx} = \frac{d\varphi_2(l)}{dx} = 0, \\ f_k \in W_2^{0,1}(\Omega), k = 1, 2. \quad (5)$$

$v_0(x), v_1(x)$ – неизвестные вещественнозначные коэффициенты, описывающие неоднородность среды распространения волны.

Наша цель заключается в определении тройки $\{v_0(x), v_1(x), \psi(x, t)\}$ на основе дополнительной информации:

$$\psi_1(x, t) = \psi_2(x, t), (x, t) \in \Omega, \quad (6)$$

то есть по наблюдению по всей области Ω .

Вектор-функция $v = v(x) = (v_0(x), v_1(x))$ будет найдена на множестве:

$$V \equiv \left\{ v = (v_0, v_1) : v_0 \in W_2^1(0, l), v_1 \in L_2(0, l), \right. \\ \left. 0 < b_0 \leq v_0(x) \leq b_1, \left| \frac{dv_0(x)}{dx} \right| \leq b_2, 0 < b_4 \leq v_1(x) \leq b_3, \overset{0}{\forall} x \in (0, l) \right\}, \quad (7)$$

где $b_j > 0, j = \overline{0, 4}$ – заданные положительные числа, символ $\overset{0}{\forall}$ означает «при почти всех». Это множество будем называть множеством допустимых элементов.

Определение $v = (v_0, v_1)$ из множества V при условиях (1)-(4), (6) является обратной задачей для уравнений Шредингера вида (1). Вариационный метод решения обратной задачи об определении $\{v(x), \psi(x, t)\}$ из условий (1)-(4), (6) основывается на вариационной постановке этой задачи, которая заключается в минимизации функционала:

$$J_\alpha(v) = \|\psi_1 - \psi_2\|_{L_2(\Omega)}^2 + \alpha \|v - \omega\|_H^2 \quad (8)$$

на множестве V при условиях (1)-(4), где $\alpha \geq 0$ – заданное число, $H \equiv W_2^1(0, l) \times L_2(0, l)$, $\omega = (\omega_0, \omega_1) \in H$ – заданный элемент. Эту

задачу в дальнейшем будем называть вариационной задачей или задачей идентификации (1)-(4), (8).

В этой работе сначала доказаны:

Теорема 1. Пусть функции $\varphi_k(x)$, $f_k(x, t)$, $k = 1, 2$ удовлетворяют условиям (5) и $\omega \in H$ – заданный элемент. Тогда задача идентификации (1)-(4), (8) при $\alpha \geq 0$ имеет хотя бы одно решение.

Теорема 2. Пусть выполнены условия теоремы 1. Тогда существует плотное подмножество G пространства H такое, что для любого $\omega \in G$ и при $\alpha > 0$ задача идентификации (1)-(4), (8) имеет единственное решение.

Далее в этой работе установлено необходимое условие для решения задачи идентификации (1)-(4), (8) в виде вариационного неравенства.

Литература

1. Журавлев В.М. Нелинейные волны в многокомпонентных системах с дисперсией и диффузией. Ульяновск: УлГУ, 2001. – 200 с.

ОБ ИСПОЛЬЗОВАНИИ ТЕОРЕТИКО-ВОЗМОЖНОСТНОГО ПОДХОДА К ЗАДАЧЕ ОБРАБОТКИ И ИНТЕРПРЕТАЦИИ ИЗМЕРЕНИЙ

Касьянюк В.С.

Киевский национальный университет им. Тараса Шевченко
veda.sia@mail.ru

Работа посвящена развитию математических методов обработки, анализа и интерпретации косвенных измерений при условии, когда ошибки в данных являются нечеткими величинами. Рассматривается случай, когда модель измерений описывается системой линейных интегральных уравнений Фредгольма I рода вида

$$y = Gu + v, G = \int_D g(t) \bullet dt : L_2[D] \rightarrow C^m, g(t) = (g_1(t), \dots, g_m(t))^T.$$

Оценка измеряемого сигнала - функции $u(t) \in L_2[D]$ - находится с использованием теоретико-возможностных методов [1] из условия минимизации необходимости ошибки; при этом для построения оценки максимальной возможности $\hat{u}$ приходим к условию

$\varphi^v(y - G\hat{u}) = \max_u \varphi^v(y - Gu)$, где $\varphi^v(x)$ - функция распределения нечеткой величины v . Ввиду монотонного убывания функции $\varphi^v(x)$ получаем, что $\hat{u}$ следует искать как решение системы интегральных уравнений Фредгольма I рода $y = Gu$. Данная задача является некорректной и нуждается в регуляризации. Для ее решения предлагается рассмотреть следующую задачу двукритериальной минимизации по Парето

$$\begin{cases} \|Gu - y\|^2 \rightarrow \min_u \\ \|u\|^2 \rightarrow \min_u \end{cases},$$

параметрическое семейство решений которой назовем парето-нормальными оценками. Доказывается, что искомой оценкой максимальной возможности является парето-нормальная оценка, соответствующая значению параметра $\alpha = +0$.

Литература

1. Пытьев Ю.П. Возможность. Элементы теории и применения. – М.: Эдиториал УРСС, 2000. – 192 с.

ARIMA-LI ПРОГНОЗ КАЧЕСТВА КРЕДИТНОГО ПОРТФЕЛЯ БАНКА

Квасний М. Н., Голубец В. В.

Львовский институт банковского дела Университета банковского дела Национального банка Украины (г. Киев), Украина
mkvasniym@lbi.wubn.net

Имеющиеся инструменты анализа качества кредитного портфеля касаются ретроспективы, а современная финансовая среда - нестабильная. Поэтому для обеспечения эффективности принятия решений возникает необходимость перспективного анализа. С этой целью предложено для оценки качества кредитного портфеля на краткосрочную перспективу интеграцию метода ARIMA и опережающих индикаторов (ARIMA-LI). В рамках данного исследования для проведения анализа использовано временной ряд коэффициентов удельного веса проблемных кредитов, который рассчитывается как отношение между суммой задолженности по кредитам и суммой предоставленных кредитов

нефинансовому сектору экономики в период январь 2009 - июль 2011 (Рис. 1).

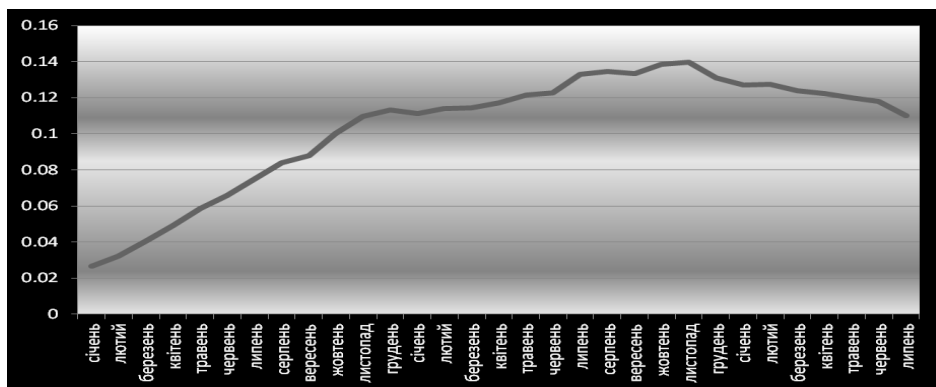


Рис. 1. Динамика коэффициентов удельного веса проблемных кредитов [3]

С помощью статистического пакета STATISTICA 8.0 построены модели ARIMA, которые являются важным классом параметрических моделей, описывающих нестационарные ряды [1, с.435]. Данный пакет позволяет идентифицировать модель, то есть, определить параметры p - порядок авторегрессии, q - порядок скользящего среднего, d - порядок разности [1, с.443]. Основным критерий идентификации поведение автокорреляционной и частичной автокорреляционной функции. Если она не имеет тенденции к затуханию, то можно говорить о нестационарности ряда [1, с.444]. Рассмотрим рисунок 2.

Как видим, она не имеет тенденции к затуханию, данный ряд-нестационарный. Поэтому необходимо брать разности ряда до тех пор, пока данная функция не станет стационарной [1, с.445]. Проведя итерацию взятия разности дважды, получаем стационарный ряд при $d = 2$ (Рис. 3).

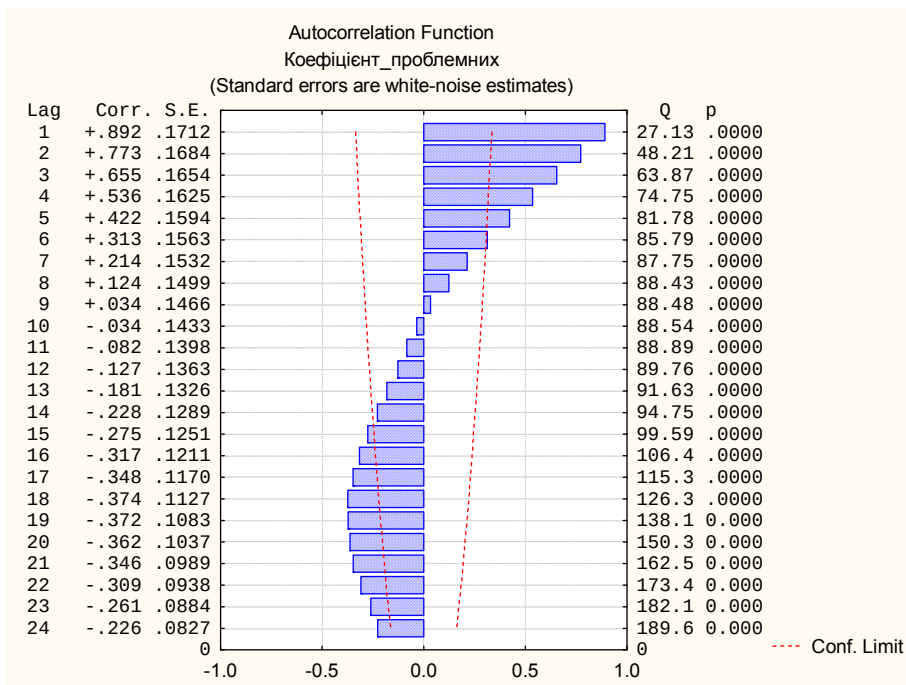


Рис. 2. Автокорреляционная функция временного ряда

Следующим этапом нужно определить параметры p и q . Анализируя поведение автокорреляционной и частичной автокорреляционной функций, приходим к выводу, что достаточно точно данный ряд может быть описан классом моделей, для которых $p = 2$, $q = 0$. Параметр p статистически значимый (Рис.4).

С помощью модели ARIMA (2,2,0) сделаем прогноз на 2 периода (Рис. 5).

Как видно, использование моделей ARIMA позволяет спрогнозировать довольно большой интервал доверия. Поэтому для уточнения прогноза следует определить тенденцию, чтобы можно было выбрать только одну часть интервала доверия. Для этого предлагается использовать

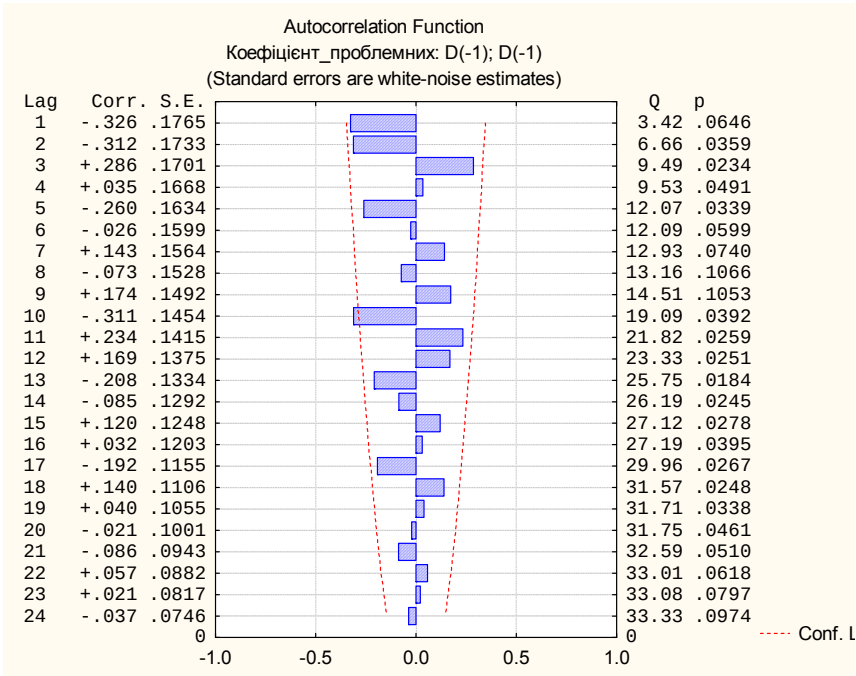


Рис. 3. Автокорреляционная функция при d = 2

Input: Коефіцієнт_проблемних (Spreadsheet6)						
Transformations: 2*D(2)						
Model: (2,2,0) MS Residual= .00005						
Paramet.	Param.	Asympt. Std.Err.	Asympt. t(25)	p	Lower 95% Conf	Upper 95% Conf
p(1)	0.357297	0.185887	1.92211	0.066059	-0.025545	0.740139
p(2)	-0.447604	0.185920	-2.40751	0.023769	-0.830513	-0.064694

Рис. 4. Оценка параметров модели ARIMA (2,2,0)

Forecasts; Model: (2,2,0) Seasonal lag: 12 (Spreadsheet6)				
Input: Коефіцієнт_проблемних				
Start of origin: 1 End of origin: 31				
CaseNo.	Forecast	Lower 90.0000%	Upper 90.0000%	Std.Err.
32	0.110767	0.098990	0.122543	0.006894
33	0.101611	0.089105	0.114117	0.007321

Рис. 5. Таблица прогнозных значений для модели ARIMA (2,2,0)

метод опережающих индикаторов, т.е. показателей для предсказания пиков и дна экономических циклов [2, с.132]. В нашем случае таким индикатором является курс доллара США к гривне. Следовательно, учитывая его динамику, можно с некоторой вероятностью утверждать, что в краткосрочном периоде сохранится тенденция к уменьшению удельного веса проблемных кредитов. Поэтому можно учитывать только нижнюю часть интервалов доверия, которые мы получили с помощью ARIMA модели. Прогнозный интервал будет составлять (0.098990; 0.110767) для первого прогнозируемого периода и (0.089105; 0.101611) для второго. Таким образом, объединив несколько методов прогнозирования, нам удалось получить значительно более точные прогнозные значения по сравнению с прогнозами, которые были получены каждым методом отдельно.

Литература

1. Халафян А.А. Статистический анализ данных. 3-е изд. Учебник— М.: ООО«Бином— Пресс», 2007.- 512с.
2. Холден К., Піл Д.А., Томпсон Дж. Л. Економічне прогнозування : вступ— К.: Інформтехніка — ЕМЦ, 1996. — 216с.
3. http://www.bank.gov.ua/control/uk/publish/category?cat_id=71195.

НЕМАНИПУЛИРУЕМЫЙ МЕХАНИЗМ ВЫБОРА С СЕПАРАБЕЛЬНОЙ ЦЕЛЕВОЙ ФУНКЦИЕЙ

И.В.Козин

Запорожский национальный университет, Украина

ains@commint.net

Рассматривается задача принятия кооперативного решения для n агентов на множестве допустимых решений $X \subseteq R^n$. Будем предполагать, что решение ищется в критериальном пространстве, то есть величина полезности агента с номером i является i -й координатой решения $x = (x_1, x_2, \dots, x_n) \in X$. Каждый агент преследует цель максимизировать собственную полезность $x_i \rightarrow \max$. Для выбора кооперативного решения используется

целевая функция, построенная на основании вектора $x' = (x_1', x_2', \dots, x_n')$ сообщений агентов:

$$F(x') = \sum_{i=1}^n g_i(x_i') \rightarrow \max ,$$

где $g_i(x_i')$, $i=1,2,\dots,n$ -возрастающие функции соответствующих переменных, а сами переменные x_i' - информация о значениях собственной полезности, переданная соответствующими агентами.

Коалиции агентов запрещены, то есть каждый агент формирует свое сообщение независимо от сообщений других агентов. В таких условиях каждый агент заинтересован передать искаженную информацию о значении своей полезности с целью обеспечить принятие наиболее выгодного для себя решения.

Для каждого агента определяется величина штрафа $s_i \geq 0$, $i=1,2,\dots,n$. Причем штраф вычисляется на основе тех же сообщений агентов и правило расчета величины штрафа, как и правило принятия кооперативного решения, известно каждому агенту. Предполагается, что каждый агент преследует цель максимизации собственной полезности за вычетом величины штрафа $x_i - s_i \rightarrow \max$. Задача найти такую систему штрафов, которая при некооперативном поведении агентов позволяет гарантировать сообщение правдивой информации агентами о своей полезности.

Показано, что такая система штрафов существует и может быть найдена как седловая точка игры многих агентов, в которой допустимые стратегии заключаются в сообщении информации о значении собственной полезности.

ОБ УСТОЙЧИВОСТИ В СРЕДНЕМ КВАДРАТИЧЕСКОМ В ЦЕЛОМ УПРАВЛЯЕМЫХ СТОХАСТИЧЕСКИХ ДИНАМИЧЕСКИХ СИСТЕМ СЛУЧАЙНОЙ СТРУКТУРЫ С ПУАССОНОВЫМИ ВОЗМУЩЕНИЯМИ

Лукашив Т.О., Никитин А.В.

Черновицкий национальный университет имени Юрия Федьковича

На вероятностном базисе $(\Omega, \mathcal{F}, \mathbf{P}, \mathbf{F} \equiv \{\mathcal{F}_t \subset \mathcal{F}, t \geq 0\})$ [1] рассмотрим уравнение возмущенного движения, под которым будем подразумевать динамическую систему случайной структуры с конечным последствием

$$dx(t) = a(t, \xi(t), x(t), u)dt + b(t, \xi(t), x(t), u)dw(t) + \int_Z c(t, \xi(t), z, x(t), u)\tilde{v}(dz, dt), \quad (1)$$

с внешними марковскими переключениями

$$\Delta x(t)\big|_{t=t_k} \equiv x(t_k) - x(t_k -) = g(t_k -, \xi(t_k -), \eta_k, x(t_k -)), \\ t_k \in S \equiv \{t_n \uparrow, n \in \mathbf{N}\}, \quad \lim_{n \rightarrow \infty} t_n = +\infty \quad (2)$$

и начальными условиями

$$\xi(t_0) = y \in \mathbf{Y}, \quad x(t_0) = x_0 \in \mathbf{R}^m, \quad \eta_{k_0} = h \in \mathbf{H}. \quad (3)$$

Здесь $\{\xi(t), t \geq 0\}$ – марковский процесс со значениями в метрическом пространстве $\mathbf{Y}$ с переходной вероятностью $\mathbf{P}(s, y, t)$ [1]; $(\eta_k, k \geq 0)$ – цепь Маркова со значениями в метрическом пространстве $\mathbf{H}$ с переходной вероятностью на k -ом шаге $\mathbf{P}_k(h, G)$ [1]; $x(t) = x(t, \omega) : [0, \infty) \times \Omega \rightarrow \mathbf{R}^m$; $w(t)$ – одномерный стандартный винеров процесс; $\tilde{v}(dz, dt)$ – центрованная пуассоновая мера; $u \in \mathbf{U} \subset \mathbf{R}^r$ – управление.

Пусть измеримые за совокупностью переменных отображения

$a : \mathbf{R}_+ \times \mathbf{Y} \times \mathbf{R}^m \times \mathbf{U} \rightarrow \mathbf{R}^m,$

$b : \mathbf{R}_+ \times \mathbf{Y} \times \mathbf{R}^m \times \mathbf{U} \rightarrow \mathbf{R}^m, \quad c : \mathbf{R}_+ \times \mathbf{Y} \times \mathbf{Z} \times \mathbf{R}^m \times \mathbf{U} \rightarrow \mathbf{R}^m$ и

$g : \mathbf{R}_+ \times \mathbf{Y} \times \mathbf{H} \times \mathbf{R}^m \rightarrow \mathbf{R}^m$ удовлетворяют по последнему аргументу условию Липшица

$$\begin{aligned}
& \left| a(t, y, x_1, u) - a(t, y, x_2, u) \right|^2 + \left| b(t, y, x_1, u) - b(t, y, x_2, u) \right|^2 + \\
& + \int_Z \left| c(t, y, z, x_1, u) - c(t, y, z, x_2, u) \right| \Pi(dz) + \\
& + \left| g(t, y, h, x_1) - g(t, y, h, x_2) \right|^2 \leq L \left| x_1 - x_2 \right|^2, \quad L > 0,
\end{aligned} \tag{4}$$

при $\forall t \geq 0, y \in \mathbf{Y}, h \in \mathbf{H}$, и условие

$$|a(t, y, 0, u)| + |b(t, y, 0, u)| + |g(t, y, h, 0)| = c < \infty. \tag{5}$$

Дискретный оператор Ляпунова $(lv_k)(y, h, x)$ на последовательности измеримых скалярных функций $v_k(y, h, x) : \mathbf{Y} \times \mathbf{H} \times \mathbf{R}^m \rightarrow \mathbf{R}^1, k \in N \cup \{0\}$ для уравнения (1) с импульсным действием (2) определяется равенством

$$(lv_k)(y, h, x) \equiv \int_{\mathbf{Y} \times \mathbf{H} \times \mathbf{D}} \mathbf{P}_k(y, h, x)(du \times dz \times dl) v_{k+1}(u, z, l) - v_k(y, h, x).$$

Справедлива **теорема**.

Пусть:

$$1) 0 < |t_{k+1} - t_k| \leq \Delta, \quad k \geq 0, \quad \Delta > 0;$$

2) выполняется условие Липшица (4) и условие равномерной ограниченности (5);

3) существуют последовательности функций Ляпунова $v_k(y, h, x)$ и $a_k(y, h, x), k \geq 0$ такие, что в силу системы справедливо неравенство $lv_k(y, h, x) \leq -a_k(y, h, x)$ и выполняются неравенства $c_1 |x|^2 \leq v_k(y, h, x) \leq c_2 |x|^2, c_3 |x|^2 \leq a_k(y, h, x) \leq c_4 |x|^2$ при некоторых $c_i > 0, i = \overline{1, 4}$ для всех $k \geq 0, y \in \mathbf{Y}, x \in \mathbf{R}^m, h \in \mathbf{H}$.

Тогда сильное решение системы случайной структуры (1)-(3) асимптотически устойчиво в среднем квадратическом в целом.

Литература

1. Дынкин Е.Б. Марковские процессы. – М.: Физматгиз, 1969. – 859с.

ОПТИМАЛЬНОЕ УПРАВЛЕНИЕ ИНВЕСТИЦИЯМИ В ПРОИЗВОДСТВЕННЫЕ ФОНДЫ, ИНТЕЛЛЕКТУАЛЬНЫЙ КАПИТАЛ, ОХРАНУ ОКРУЖАЮЩЕЙ СРЕДЫ

Ляшенко И.Н., Тадеев Ю.П.

Киевский национальный университет имени Тараса Шевченко

lyashenko@univ.kiev.ua, ytadeyev@gmail.com

Рассматривается модель оптимального управления

$$w = \int_0^T u(c(t), p(t)) e^{-\delta t} dt \rightarrow \max,$$

$$\dot{K} = (1 - \alpha - \beta)F(K, L) - \mu K,$$

$$\dot{L} = \beta F(K, L) - \nu(L - L_0),$$

$$\dot{p} = (\varepsilon - r\gamma)F(K, L) - \varphi p,$$

$$c = \alpha F(K, L),$$

где $0 \leq \alpha(t) \leq 1, 0 \leq \beta(t) \leq 1, 0 \leq \gamma(t) \leq 1, 0 \leq \alpha(t) + \beta(t) + \gamma(t) \leq 1$.

Здесь $u(c, p)$ – функция полезности, c – потребление, p – загрязнение, K – производственные фонды, L – труд, $L - L_0$ – интеллектуальная часть трудовых ресурсов, $F(K, L)$ – производственная функция, δ – коэффициент дисконтирования, μ – норма амортизации производственных фондов, ν – норма амортизации интеллектуального капитала, $\varepsilon < 1$ – коэффициент загрязнения, $r > 1$ – коэффициент уменьшения загрязнения при очистке, φ – темп ассимиляции загрязнения. В задаче речь идет об оптимальном выборе управлений $\alpha(t), \beta(t), \gamma(t)$.

К исследованию модели применён принцип максимума Понтрягина. Построен гамильтониан, система сопряжённых дифференциальных уравнений для двойственных переменных.

Детально исследованы точки равновесия, удовлетворяющие необходимым условиям оптимальности.

О РЕАЛИЗАЦИИ ЗАДАННОГО КАЧЕСТВА ПРОЦЕССА УПРАВЛЯЕМОЙ СИСТЕМЫ В УСЛОВИЯХ НЕОПРЕДЕЛЕННОСТИ

Максимов В.И.

Институт математики и механики УрО РАН,
Уральский федеральный университет, г. Екатеринбург, Россия
maksimov@imm.uran.ru

Возникающие в приложениях динамические управляемые системы часто подвержены воздействию переменных входов (возмущений), законы изменения которых слабо предсказуемы и практически не наблюдаемы. Это является причиной дефицита информации. В последнее время дефицит информации по причине ограниченной скорости в каналах передачи данных, дискретизации и квантования сигналов сформировал важную область исследований. Теория управления в условиях неполной и меняющейся информации посвящена изучению таких случаев. Целью этой теории, в частности, является удержание системы в предписанном диапазоне допустимых траекторий при любых возмущениях неизвестных входов. Одним из типичных примеров задач указанной теории является задача реализации предписанного движения, суть которой состоит в построении алгоритмов формирования законов управления некоторой системой, обеспечивающих заданное качество управляемого динамического процесса. В ситуациях, когда система не является полностью наблюдаемой, ключевой шаг в создании желаемых контроллеров — это онлайн-реконструкция ненаблюдаемых компонент фазового вектора и/или входов [1]. Типичная задача, о которой идет речь в настоящем сообщении, характеризуется двумя особенностями. Во-первых, мы полагаем, что состояния системы (все или их часть) измеряются неточно. Поэтому точное решение задачи невозможно, вследствие чего мы допускаем приближенное решение. Во-вторых, мы требуем, чтобы управления, необходимые для решения точной и приближенной задач управления, «мало» отличались. Для того чтобы этого добиться, мы используем стабилизирующее управление с обратной связью, использующее сглаживающий функционал. При этом мы опираемся на технику динамического обращения. Последняя основана на сочетании метода экстремального сдвига из теории позиционных дифференциальных

игр и методов регуляризации из теории некорректных задач (типа метода сглаживающего функционала или метода невязки).

В качестве объекта исследований, на примере которого реализована описанная выше идеология, взята динамическая модель, связывающая основные экономические и экологические показатели, предложенная в монографии [2]. Если от дискретной динамической системы, предлагаемой автором монографии, перейти к «непрерывной», то модель будет описываться системой нелинейных обыкновенных дифференциальных уравнений четвертого порядка:

$$\begin{aligned}\dot{T}(t) &= c_1 T(t) + c_2 T_1(t) + c_5 \log_2 \left(1 + \frac{M_1(t)}{590} \right) + c_3 O(t), \quad t \in [0, 9], \\ \dot{T}_1(t) &= c_4 (T - T_1), \\ \dot{M}_1(t) &= E(t)(1 - \mu(t)) - \delta_M M_1(t), \\ \dot{K}(t) &= -\delta_K K(t) + I(t).\end{aligned}\tag{1}$$

Здесь $O(t)$ — влияние внешних парниковых газов, $\mu(t)$ — снижение эмиссии по отношению к неконтролируемой эмиссии, $M_1(t)$ — избыток массы парниковых газов в атмосфере по сравнению с доиндустриальным периодом; $T(t)$ — средняя температура на поверхности Земли; $T_1(t)$ — средняя температура в глубине океана; $I(t)$ — глобальные инвестиции; $K(t)$ — запас капитала. Роль управляющих параметров, законы формирования которых следует построить, играют функции $\mu(t)$ и $I(t)$.

Работа выполнена при поддержке программы приоритетных исследований Президиума РАН «Перспективы скоординированного социально-экономического развития России и Украины в общеевропейском контексте», проект 12-П-1-1038.

Литература

1. Осипов Ю.С., Кряжковский А.В., Максимов В.И. Методы динамического восстановления входов управляемых систем. Екатеринбург, 2011.
2. Nordhaus W.D. Managing the Global Commons. The Economics of Climate Change. MIT Press, 1994.

ОБ ОПТИМАЛЬНОМ УПРАВЛЕНИИ ПОТОКАМИ В СЕТЯХ ЭРЛАНГА

Мензатов Л.Ш., Лебедев Е.А.

Киевский национальный университет имени Тараса Шевченко
leb@unicyb.kiev.ua

При работе сотовых сетей связи часто возникает задача управления общим потоком вызовов. В связи с этим рассмотрим две соседние соты, функционирование которых будем моделировать системами Эрланга S_1 и S_2 . Через n_i, μ_i , $i=1,2$, будем обозначать число каналов связи и интенсивность обслуживания вызовов в i -ой системе. На системы S_1, S_2 поступает общий рекуррентный поток вызовов ([1], стр. 134), $F(t)$ - функция распределения интервала времени между моментами поступления вызовов. В момент прихода вызов с вероятностью q_1 направляется на обслуживание в первую систему и с вероятностью $q_2 = 1 - q_1$ - во вторую систему. Если все каналы связи в системе заняты, то вызов теряется.

На практике наличие общего потока обусловлено тем, что зоны обслуживания соседних сот пересекаются. Абоненты из пересечения и генерируют вызовы общего потока.

Обозначим через $S_i(t)$, $i=1,2$ - число вызовов, обслуживание которых завершилось в i -ой системе за время t . Если существуют пределы $\lim_{t \rightarrow \infty} t^{-1} E S_i(t)$, то будем обозначать их через m_i , $i=1,2$. Очевидно, m_i , $i=1,2$ зависят от параметров: $q' = (q_1, q_2)$, $F(t)$, n_i, μ_i , $i=1,2$. В дальнейшем будем считать, что $F(t)$, n_i, μ_i заданы, а выбор вектора q находится в нашем распоряжении. Таким образом $m_i = m_i(q)$, $i=1,2$.

Аналогично, если существуют пределы $\lim_{t \rightarrow \infty} t^{-1} \text{cov}(S_i(t), S_j(t))$, то будем обозначать их через $V_{ij} = V_{ij}(q)$, $i, j=1,2$.

Перейдем к постановке оптимизационных задач.

Пусть C_i , $i=1,2$ - прибыль от обслуживания одного вызова в i -ой системе. Тогда важное значение имеет следующая задача:

$$C_1 m_1(q) + C_2 m_2(q) \rightarrow \max, \quad (1)$$

$$q_1 + q_2 = 1, \quad q_1, q_2 \geq 0. \quad (2)$$

Решение $q^{*'} = (q_1^*, q_2^*)$ задачи (1), (2) представляет собой такое управление общим входным потоком, которое максимизирует среднюю прибыль.

Очевидно, что $\sum C_i V_{ij}(q) C_j$ является величиной риска.

Учитывая это, мы приходим к оптимизационной задаче вида

$$\sum_{i,j=1}^2 C_i V_{ij}(q) C_j \rightarrow \min, \quad (3)$$

$$C_1 m_1(q) + C_2 m_2(q) = M_0, \quad (4)$$

$$q_1 + q_2 = 1, \quad q_1, q_2 \geq 0. \quad (5)$$

Приоритетность задач (1) - (2), (3) - (5) зависит от цели управления системами S_1, S_2 . Подобные постановки для многоканальных стохастических сетей исследовались в [2]. В предлагаемой работе решение оптимизационных задач основано на эффективных алгоритмах расчета функционалов $m_i(q)$, $V_{ij}(q)$, $i, j=1,2$. Случай пуассоновского входного потока изучен в работе [3].

Литература

1. Гнеденко Б.В., Коваленко И.Н. Введение в теорию массового обслуживания. – М: КомКнига, 2005. – 400 с.
2. Лебедев Е.А., Макушенко И.А. Оптимизация риска для многоканальных стохастических сетей. – К: НБУВ, 2007, 65 с.
3. Мензатов Л.Ш., Лебедев Е.А. Максимизация прибыли и минимизация риска для сетей Эрланга // Вестник Киевского университета. Серия: физико-математические науки. – 2010. - № 2. – С. 130-135.

ОБ ОДНОМ ПОДХОДЕ К НАХОЖДЕНИЮ ТЕМПА НАУЧНО-ТЕХНИЧЕСКОГО ПРОГРЕССА

Назарага И.М.

Киевский национальный университет имени Тараса Шевченко

inna_na@ukr.net

В докладе рассмотрены проблемы нахождения темпа эндогенного научно-технического прогресса [1-5], а также предложен подход к его нахождению, базирующийся на использовании математической модели экономических процессов [6]. Модель является развитием модели "Альфа" [7], в которой учитывается взаимодействие факторов совокупного спроса и совокупного предложения с эндогенным нахождением уровня инфляции. Принципиальным предположением для нахождения темпа эндогенного научно-технического прогресса есть предположение о изменяемости его во времени, а также то, что прогресс по экономической сути является «потокowym» показателем, а не показателем «запаса».

Вычисленный предложенным образом темп научно-технического прогресса можно использовать для прогнозирования значений основных макроэкономических показателей в условиях переходной экономики.

Литература

1. Денисюк В. Теоретико-методологічні підходи до визначення внеску науково-технічного прогресу в моделі економічного зростання / В. Денисюк, Ю. Харазішвілі // Банківська справа – 2010. – № 6 – с. 6 – 21.
2. Griliches Z. Issues in growth accounting: a reply to Edward F. Denison / Z. Griliches, D. Jorgenson// The Survey of Current Business.- 1972. – V. 52. - № 5. – P. 65–94.
3. Oliner D. The Resurgence of growth in the Late 1990s: Is Information technology the Story? / Oliner D., Sichel D. // The Journal of Economic Perspectives. – 2000. – V. 14. – P. 3-22.
4. Оппенлендер К. Технический прогресс. Воздействие. Оценки. Результаты / К. Оппенлендер. – Мюнхен. – 1980. – 119 с.
5. Назруллаева Е. Оценивание уровня технологического прогресса в российской экономике / Е. Назруллаева // Квантиль. – 2008. - № 5. – С. 59–82.
6. Донченко В.С. Програмне забезпечення для прогнозування основних макроекономічних показників економіки України /

В.С. Донченко, І.М. Назарага // Вісник КНУ ім. Тараса Шевченка. Серія: фіз.-мат. науки. – 2010. – № 4. – С. 118 – 123.

7. Харазішвілі Ю.М. Теоретичні основи системного моделювання соціально-економічного розвитку України: Моногр. / Ю.М. Харазішвілі. – К.: ПоліграфКонсалтинг, 2007. – 324 с.

ПРОГНОЗНЫЕ ОЦЕНКИ РЕШЕНИЙ НАЧАЛЬНО-КРАЕВЫХ ЗАДАЧ ДЛЯ УРАВНЕНИЙ ПАРАБОЛИЧЕСКОГО ТИПА В УСЛОВИЯХ НЕОПРЕДЕЛЕННОСТИ

А. Г. Наконечный

Киевский национальный университет имени Тараса Шевченко

a.nakonechniy@gmail.com

Пусть Ω - ограниченная область в пространстве R^n с кусочно гладкой границей Γ . В цилиндре $D_T = \Omega \times (t_0, T)$ функция $\varphi(x, t)$ является слабым решением уравнения

$$L\varphi = \frac{\partial \varphi}{\partial t} - A\varphi = f(x, t) \quad (1)$$

с начальными и краевыми условиями вида

$$\varphi(x, t_0) = f_0(x), \quad \varphi|_{\Gamma_T} = 0. \quad (2)$$

Предполагается, что функции $f(x, t), f_0(x)$ интегрируемые с квадратом в соответствующих областях. При некоторых неизвестных функциях $f(x, t), f_0(x)$ задается вектор y из гильбертового пространства H вида $y = C\varphi + f_2$, где C - линейный непрерывный оператор, определенный в пространстве $L_2(D_{T_1}), T_1 < T$, f_2 - неизвестный вектор. Пусть также известно, что вектор (f_0, f_1, f_2) принадлежит некоторой области G , а через $G_y(f)$ обозначим множество вида

$$G_y(f) = \{(f_0, f_1) : (f_0, f_1, y - C\varphi) \in G\}.$$

Определение. Назовем множество решений начально краевой задачи (1), (2), для которой функции f_0, f_1 принадлежат множеству $G_y(f)$ множеством прогнозных оценок функции $\varphi(T, x)$.

Исследуемые задачи состоят в конструктивном описании множества $G_y(f)$, а также в определении оптимальных в некотором смысле прогнозных оценок.

Изучаются также вопросы о построении линейных прогнозных оценок, когда функции f_0, f_1 - случайные с неизвестными средними и корреляционными функциями.

ГАРАНТИРОВАННЫЕ ОЦЕНКИ ИНТЕНСИВНОСТИ ИСТОЧНИКОВ В ЗАДАЧАХ ПЕРЕНОСА И ДИФFUЗИИ

Наконечный А.Г., Демиденко С.В.

Киевский национальный университет имени Тараса Шевченко
s.demidenko@gmail.com

Пусть задана последовательность функций $y_k(t)$, $k = \overline{1, N}$ вида

$$y_k(t) = (g_k, \varphi(t)) + \eta_k(t), 0 \leq t \leq T, k = \overline{1, N}, \quad (1)$$

где $\varphi(t) = \varphi(t, x)$, $x \in R^n$ - решение задачи

$$\begin{aligned} \frac{\partial \varphi}{\partial t} &= L\varphi + g(x)f(t), \\ \varphi(0, x) &= \varphi(T, x), \end{aligned} \quad (2)$$

$$L\varphi = \sum_{i,j=1}^n a_{ij} \frac{\partial^2 \varphi}{\partial x_i \partial x_j} + \sum_{j=1}^n v_j \frac{\partial \varphi}{\partial x_j} + \sigma \varphi.$$

Матрица $A = (a_{ij})$, $i, j = \overline{1, n}$ - положительно определена,

$$v_j, j = \overline{1, n}, \sigma - \text{некоторые числа, } (g_k, \varphi(t)) = \int_{R^n} g_k(x) \varphi(t, x) dx,$$

$\eta_k(t)$ - реализации непрерывных в среднем квадратическом процессов с нулевым средним и матрицей корреляций $R(t, s) = (r_{ij}(t, s))$, $i, j = \overline{1, n}$, $r_{ij}(t, s) = E\eta_i(t)\eta_j(s)$.

Оценки функции $f(t)$ ищутся в виде

$$\hat{f}(t) = \sum_{k=1}^N \int_0^T u_k(t) y_k(t) dt + c, \quad (3)$$

где функции $u_k(t)$ интегрируемые с квадратом на интервале $(0, T)$, c - некоторая константа.

Предполагается, что неизвестная функция $f(t)$ принадлежит множеству G пространства $L_2(0, T)$, а корреляционная функция $R(t, s)$ - также неизвестна и принадлежит множеству V .

Гарантированная оценка $\hat{\hat{f}}(t)$ ищется из условия

$$\min_{u,c} \sup_{G,F} \int_0^T E(f(t) - \hat{\hat{f}}(t))^2 dt = \sup_{G,F} \int_0^T E(f(t) - \hat{\hat{f}}(t))^2 dt. \quad (4)$$

Наблюдения (1) записываются в виде

$$y_k(t) = \int_{R^n} \tilde{g}_k(\lambda) \tilde{\varphi}(t, \lambda) d\lambda + \eta_k(t), \quad (5)$$

где функция $\tilde{\varphi}(t, \lambda)$ есть решение уравнения

$$\begin{aligned} \frac{\partial \tilde{\varphi}}{\partial t} &= P(\lambda) \tilde{\varphi} + \tilde{g}(\lambda) f(t), \\ \tilde{\varphi}(0, \lambda) &= \tilde{\varphi}(T, \lambda). \end{aligned} \quad (6)$$

$$P(\lambda) = \sum_{k,j=1}^n a_{kj} \lambda_k \lambda_j + \sigma - i \sum_{k=1}^n v_k \lambda_k, \quad \text{где}$$

$$\tilde{g}_k(\lambda) = (2\pi)^{-\frac{n}{2}} \int_{R^n} g_k(x) \exp i(\lambda, x) dx.$$

Далее исследуется задача оценки функции $f(t)$ для уравнения (6) при наблюдениях (5). При некоторых множествах G и F предлагаются конструктивные гарантированные оценки.

Литература

1. *Наконечний О.Г.* Оцінювання параметрів в умовах невизначеності // Наукові записки КНУ ім.Т.Г.Шевченка.- 2004,- Том 7: факультет кібернетики.- С.102-112.
2. *Подлипенко Ю.К.* Минимаксное оценивание правых частей неётеровых уравнений в гильбертовом пространстве в условиях неопределенности // Доповіді НАНУ.- 2005,- №12.- С.36-44.
3. *Демиденко С., Жук С., Наконечний О.* До проблеми мінімаксного оцінювання розв'язків одновимірних крайових задач // Тавр. вісн. інформ. і мат.- 2007,- №1.- С.7-24.

ОБ УСТОЙЧИВОСТИ НА КОНЕЧНОМ ИНТЕРВАЛЕ ВРЕМЕНИ РЕШЕНИЙ СТОХАСТИЧЕСКИХ ДИФФЕРЕНЦИАЛЬНЫХ УРАВНЕНИЙ.

Наконечный А.Г., Шушарин Ю.В.

Киевский национальный университет имени Тараса Шевченко

nakonechniy@unicyb.kiev.ua

Пусть $x(t) \in R^n$ есть решение стохастического дифференциального уравнения

$$dx(t) = f(x(t), t)dt + \sigma(x(t), t)dw(t), \quad x(t_0) = x_0, \quad (1)$$

где $w(t) \in R^m$ – стандартный винеровский процесс, векторная функция f , и матричная функция σ – таковы, что существует единственное решение уравнения (1), причем $f(0, t) = 0$, $\sigma(0, t) = 0$.

Пусть также f, σ такие функции, что выполнено условие

$$f(\lambda x, t) = \lambda f(x, t), \quad \sigma(\lambda x, t) = \lambda \sigma(x, t) \text{ при } \lambda > 0.$$

G_λ – семейство множеств из R^n , что $G_{\lambda_1} \leq G_{\lambda_2}$ при $\lambda_1 \leq \lambda_2$.

Исследуется задача о нахождении множества начальных условий таких, что при всех $x_0 \in G_1$ выполняются неравенства:

$$P_k(x_0) = \int_0^T E f_k(x(t), t)dt + E \Phi_k(x(t), t) \leq 1, \quad k = \overline{1, N}, \quad (2)$$

где $f_k(x, t)$, $\Phi_k(x, t)$ – непрерывные функции по совокупности переменных таких, что существуют соответствующие средние значения и для всех λ выполняются условия

$$f_k(\lambda x, t) = \lambda^{2r} f_k(x, t),$$

$$\Phi_k(\lambda x) = \lambda^{2r} \Phi_k(x)$$

Показано, что имеет место теорема.

Теорема. Для того чтобы выполнялось неравенство (2) при всех $x_0 \in G_\lambda$, необходимо и достаточно, чтобы λ удовлетворяло

соотношению $\lambda \leq \left\{ \max_{1 \leq k \leq N} \max_{x_0 \in G_1} V_k(x_0, t_0) \right\}^{1/2r}$, где функция

$V_k(x, t)$ – решение уравнения с частичными производными вида

$$\frac{\partial V_k}{\partial t} = (V'_k(x, t), f(x, t)) + \frac{1}{2} sp \sigma(x, t) \sigma^T(x, t) V''_k(x, t) + f_k(x, t),$$

$V_k(x, T) = \Phi_k(x, T)$, V'_k – градиент функции, V''_k – матрица вторых производных.

Литература

1. Наконечный О.Г. К устойчивости на конечном интервале решений стохастических уравнений / О.Г. Наконечный, А.М. Мередов // Вестник КДУ "Моделирование и оптимизация сложных систем". Киев, N7. 1988 г.

СХЕМА ПОЛНОГО УСРЕДНЕНИЯ ДИНАМИЧЕСКИХ СИСТЕМ НА ВРЕМЕННЫХ ШКАЛАХ

А.П. Огуленко¹, О.Д. Кичмаренко²

Одесский национальный университет имени И.И. Мечникова

¹ ogulenko.a.p@onu.edu.ua, ² olga.kichmarenko@gmail.com

В работе представлено обоснование метода усреднения для систем уравнений на временных шкалах, которые моделируют процессы, происходящие то в непрерывном, то в дискретном режиме. Теория динамических уравнений на временных шкалах активно развивается в последнее десятилетие, основополагающими являются работы Bohner M., Peterson A. [1, 2].

Пусть T - временная шкала – непустое замкнутое подмножество из R , $t \in T$ - время, $\varepsilon > 0$ - малый параметр. Для системы

$$\begin{cases} x^\Delta = \varepsilon X(t, x) \\ x(t_0) = x_0, \end{cases} \quad (1)$$

где $x \in R^n$, $X(t, x)$ - n -мерная вектор-функция, нами доказана возможность применения схемы полного усреднения при естественных условиях, гарантирующих существование решения исходной (1) и усредненной (2) систем, а также при равномерной сходимости относительно ε предела (3) и, если потребовать, чтобы существовало такое значение $\mu_0 > 0$ функции «зернистости» временной шкалы $\mu(t)$, что для любого $t \in T$ либо $\mu(t) = 0$, либо $\mu(t) > \mu_0$.

$$\begin{cases} \xi^\Delta = \varepsilon \bar{X}(\xi) \\ \xi(t_0) = x_0 \end{cases} \quad (2) \quad \bar{X}(x) = \lim_{\substack{\tau \rightarrow \infty \\ \tau \in T}} \frac{1}{\tau} \int_{t_0}^{\tau} X(t, x) dt \quad (3)$$

Аналогичные результаты для непрерывного и дискретного времени получены давно и хорошо изучены [3, 4], в [5] представлены оценки близости решений исходной и усредненной

систем при сложно проверяемых ограничениях на правую часть уравнений и при ограничениях на свойства временной шкалы.

Литература

1. Bohner M., Peterson A. *Dynamic Equations on Time Scales: An Introduction with Applications*. Boston: Birkhauser, 2001
2. Bohner M., Peterson A. *Advances in Dynamic Equations on Time Scales*. Boston: Birkhauser, 2003
3. Боголюбов Н.Н., Митропольский Ю.А. Асимптотические методы в теории нелинейных колебаний. – М.:Наука, 1974. – 503 с.
4. Плотников В.А., Плотникова Л.И., Яровой А.Т. Метод усреднения дискретных систем и его приложение к задачам управления. // Нелинейные колебания. - 2004. - Т.7, No. 2. - С. 241 - 254.
5. Slavik A. Averaging dynamic equations on time scales. // Journal of Mathematical Analysis and Applications 388 (2012), 996–1012 (preprint)

АНАЛИЗ ЧУВСТВИТЕЛЬНОСТИ РЕШЕНИЙ ЗАДАЧ ГЕТЕРОДИФфуЗИИ ПРИМЕСНОГО ВЕЩЕСТВА ОТНОСИТЕЛЬНО ИЗМЕНЕНИЙ ПАРАМЕТРОВ СРЕДЫ

Савула Я., Щербата Г., Щербатый М.

Львовский национальный университет имени Ивана Франко

savula@lnu.edu.ua, shcherbatyy@gmail.com,

shhelenka@gmail.com

Вследствие загрязнения почвы радионуклидами, вредными химическими веществами и их перенесения подземными водами, актуальными являются проблемы компьютерного моделирования процессов диффузии и массопереноса примесей в почве. Перенесение примесного вещества в неоднородной многокомпонентной среде (гетеродиффузия) в работе моделируется системой уравнений параболического типа. При исследовании процессов гетеродиффузии существенными являются вопросы анализа чувствительности (АЧ) - определение влияния малых изменений параметров процесса (начального состояния, внутренних и внешних параметров) на динамику процесса и его характеристики. Полученные в результате АЧ коэффициенты чувствительности (полные производные некоторой характеристики процесса относительно выбранного параметра) предоставляют важную информацию о влиянии выбранного параметра на динамику процесса. Данная информация указывает на

необходимость задания (измерения) параметров реального процесса с определенной точностью с целью прогнозирования его поведения с требуемой точностью. Коэффициенты чувствительности являются необходимой составляющей при решении обратных задач, задач идентификации параметров, задач оптимизации.

В данной работе анализируется чувствительность решений задач гетеродиффузии примесного вещества в одномерных и двумерных телах относительно изменений параметров среды. С использованием полудискретных аппроксимаций Галёркина и метода конечных элементов начально-краевая задача гетеродиффузии сводится к задаче Коши для системы обыкновенных дифференциальных уравнений относительно узловых значений концентраций примеси. Получены уравнения чувствительности в дифференциальной, вариационной и конечно-элементной постановках. Приведены результаты численных экспериментов для задач анализа чувствительности и идентификации параметров для процесса гетеродиффузии в слое почвы. Проанализировано влияние малых изменений параметров модели на распределение концентраций примесного вещества.

МЕЖРЕГИОНАЛЬНОЕ ВЫРАВНИВАНИЕ В СИСТЕМЕ МЕЖБЮДЖЕТНЫХ ТРАНСФЕРТОВ УКРАИНЫ

Семенов В.В.

Институт демографии и социальных исследований имени

М.В. Птухи НАН Украины

semenovsr@meta.ua

Предположение относительно выравнивающего характера системы межбюджетных трансфертов проверяется с помощью построения и оценивания модели, устанавливающей зависимость между объемом трансферта и доходами (бюджетными поступлениями) регионов на человека. При этом используем понятие прогрессивности, которое определяется аналогично прогрессивности налоговой системы. Система межбюджетных трансфертов является прогрессивной, если эффективная ставка трансферта, т.е., отношение объема трансферта на человека к показателю, который выравнивается (собственные поступления в региональный бюджет, валовой региональный продукт и т.п.)

уменьшается с ростом этого показателя. Это также означает, что предельная ставка трансферта меньше средней, или, в терминах эластичности, эластичность трансферта по региональным доходам должна быть меньше единицы. В работе получены оценки редистрибутивной способности системы межбюджетных трансфертов Украины относительно выравнивания имеющихся ресурсов регионов. Исследованы перераспределительные свойства системы межбюджетных трансфертов Украины за период 1999-2010 года. Полученные результаты свидетельствуют о том, что в 1999-2005 годах правительство в большей мере ориентировалось на выделение общецелевых безусловных грантов. В период 2006-2009 годов влияние грантов софинансирования становится доминирующим, образуя положительные стимулы к увеличению собственных налоговых поступлений регионов.

Анализ результатов исследования позволил оценить влияние собственных ресурсов регионов и межбюджетных трансфертов на объемы и стабильность финансирования образования, здравоохранения и социальной защиты а также сформулировать ряд предложений для использования преимуществ системы межбюджетных трансфертов и усиления ее влияния на развитие социальной инфраструктуры за счет доходов местных бюджетов.

РЕШЕНИЕ ОБРАТНОЙ ЗАДАЧИ ПЕРЕНОСА ЗАГРЯЗНЕНИЙ РЕЧНЫМ ПОТОКОМ

Стеля О.Б., Стеля И.О.

oleg.stelya@gmail.com

Рассматривается обратная задача для нестационарного уравнения адвекции-диффузии, описывающего процесс переноса консервативных загрязнений русловым потоком. Конвективный член уравнения содержит расходную характеристику русла, которая определяется из системы уравнений Сен-Венана. Наблюдения за концентрацией загрязнений осуществляется на границе области ниже по течению. В задаче необходимо установить объем сбросов в реку, при котором концентрация загрязнений в месте наблюдения не будет превышать допустимой величины. Задача сводится к минимизации функционала, для нахождения минимума которого используется метод проекции градиента. Для решения уравнений Сен-Венана используется схема

Прейсмана. Линеаризация нелинейной системы разностных уравнений осуществляется методом Ньютона. Полученная в результате система линейных уравнений на каждом шаге метода Ньютона решается итерационным методом. Найденная в результате моделирования дискретная функция расхода используется для решения обратной задачи. Для нахождения компонентов градиента функционала используется сопряженная задача для уравнения адвекции-диффузии. Решение прямой и сопряженной задачи осуществляется с помощью разностной схемы, основанной на параболическом сплайне. В соответствии с приведенным алгоритмом разработано программное обеспечение. Рассматриваемая задача имеет прикладную направленность и может быть использована для создания графика плановых сбросов загрязненных стоков в реки. Результаты численных расчетов свидетельствуют о высокой вычислительной эффективности разработанных алгоритмов и программного обеспечения. Дальнейшим развитием работы может быть создание программного комплекса с удобным пользовательским интерфейсом.

ОБ ОСНОВНЫХ ПОДХОДАХ К МОДЕЛИРОВАНИЮ МЕДИАПОКАЗАТЕЛЕЙ

Тарасова О.В.

Киевский национальный университет имени Тараса Шевченко,
Украина

`olga_ta@bigmir.net`

Регулярное социологическое исследование измерения телевизионной аудитории является источником единой телевизионной «валюты» - телевизионных рейтингов. Для различных медийных задач, в том числе, для задачи медиапланирования, возникает необходимость в моделировании поведения телевизионной аудитории, а соответственно и телевизионного рейтинга с целью прогнозирования [1,2].

В докладе рассмотрены основные подходы к моделированию функции рейтинга телевизионной аудитории с целью прогнозирования [2,3,4]. Предложено использование RTF-преобразований [5,6] для конструирования прогнозных средств решения медийных задач, в том числе, задачи медиапланирования.

Литература

1. Тарасова О.В. Задача розміщення ефірних подій/ О.В.Тарасова// Вісник Київського національного університету імені Тараса Шевченка. – 2012. - №1. – С.231-234.
2. Теория и практика медиарекламных исследований / [отв. ред. В.П.Коломиец] – М: ООО «НИПКЦ Восход – А», 2011. – 420 с.
3. Meyer D. The accuracy of television network rating forecasts/ D.Meyer, R J Hyndman - Model Assisted Statistics and Applications, 2005/2006. – №1 – 147-155 p.
4. Prediction strategies in a TV recommender system – method and experiments / M Setten, M Veenstra, A Nijholt [and others] // International Conference WWW/Internet – 2003. – 203-210 p.
5. Кириченко Н.Ф. Нелинейные рекурсивные регрессионные преобразователи: динамические системы и оптимизация / Н.Ф. Кириченко, В.С. Донченко, Д.П. Сербаяев // Кибернетика и системный анализ. – 2005. - №3. – С. 58-68.
6. Кириченко Н.Ф. Аналитическое представление возмущений псевдообратных матриц / Н.Ф. Кириченко // Кибернетика и системный анализ. – 1997. - №2. – С. 98-106.

ОБОБЩЕНИЕ МЕТОДА СТРУКТУРНО-АЛФАВИТНОГО ПОИСКА

Тимофеева Н.К.

Международный научно-учебный центр информационных технологий и систем НАН и МОН Украины
tymnad@gmail.com

Известными универсальными методами решение задач комбинаторной оптимизации различных классов требует для каждого из них разработки дополнительных правил, которые отличаются между собой. Универсальный метод структурно-алфавитного поиска основан на распознавании структуры входных данных и определенном упорядочении комбинаторных конфигураций. В нем использован известный разрешимый случай, заданный двумя системами перестановок (a) и (b) , на которых введена целевая функция $\sum ab$. Для этих систем определены перестановки, для которых $\sum ab$ принимает наибольшее или наименьшее значения. Если элементы перестановки из системы (a) упорядочены от большего элемента к меньшему, а из (b)

упорядочены от меньшего элемента к большему, то значение $\sum ab$ является глобальным минимумом. Если элементы обоих перестановок упорядочены от меньшего элемента к большему, то значение $\sum ab$ является глобальным максимумом.

Для различных классов задач комбинаторной оптимизации отличаются как правила нахождения оптимального решения этим методом так и разрешимый случай. По способу вычисления целевой функции выделим стационарные и динамические задачи. Для стационарных задач на множестве перестановок и подмножестве изоморфных комбинаторных конфигураций справедливый оговоренный выше разрешимый случай. Но для разных классов задач нахождение этим методом оптимального решения требует разработки отдельных правил. Для динамических задач в процессе их решения генерируется текущая информация, изменяющаяся в зависимости от аргумента. Поэтому входные данные задаются одной конечной последовательностью, которая является функцией комбинаторной конфигурации, а разрешимый случай, для которого аналитически вычисляются глобальные минимум и максимум, отличается от описанного выше.

МИНИМАКСНОЕ ОЦЕНИВАНИЕ В ГИПЕРБОЛИЧЕСКИХ УРАВНЕНИЯХ С РАЗРЫВНЫМИ КОЭФФИЦИЕНТАМИ ПРИ НЕПОЛНЫХ НАБЛЮДЕНИЯХ

Л.В. Чухрай, В.С. Чухрай

Львовский национальный аграрный университет, Украина

I.chukhrai@gmail.com

В $\Omega_t = \{(x, t) : 0 < x < 1, t_1 < t < t_3\}$ рассмотрим гиперболическую краевую задачу

$$a(t) \frac{\partial^2 \varphi(x, t)}{\partial t^2} = \frac{\partial}{\partial x} \left(k(x) \frac{\partial \varphi(x, t)}{\partial x} \right) + b(x) \varphi(x, t) + B(x, t) f(x, t) \quad (1)$$

с краевыми условиями

$$\varphi(0, t) = 0, t \in (t_1, t_3), \quad \varphi(h, t) = 0, t \in (t_1, t_3) \quad (2)$$

и начальными условиями

$$\varphi(x, t_1) = f_0(x), \varphi'(x, t_1) = w_0(x), x \in (0, 1), \quad (3)$$

где $f(x, t) \in L_2(\Omega_t)$, $f_0(x) \in L_2(0, 1)$, $w_0(x) \in L_2(0, 1)$, $B(x, t) \in C(\Omega_t)$,

$k(x) \in C^1(0,1), b(x) \in C(0,1)$, причем $\exists \alpha > 0, c > 0$ такое, что $k(x) \geq \alpha > 0, k(x) \leq c$ почти везде на $(0,1)$, а коэффициент $a(t)$ удовлетворяет условие

$$a(t) = \begin{cases} a_1, t_1 < t < s, \\ 0, t = t_2, \\ a_3, t_2 < t < t_3, \end{cases} \quad (4)$$

где $a_1(t) \in L_2(t_1, s), t_1 < s < t_2, a_3(t) \in L_2(t_2, t_3), a_1(t) > 0, a_3(t) > 0$.

Предполагается, что наблюдается реализация случайного процесса $y = (y_1(t), y_3(t))$ с гильбертово пространства H в виде

$$\begin{cases} y_{1k}(t) = \int_0^1 h_{1k}(x) \varphi_1(x, t) dx + \eta_{1k}(t), t_1 < t < s, k = \overline{1, N_1} \\ y_{3k}(t) = \int_0^1 h_{3k}(x) \varphi_3(x, t) dx + \eta_{3k}(t), t_2 < t < t_3, k = \overline{1, N_3} \end{cases} \quad (5)$$

где $\varphi(x, t) = (\varphi_1(x, t), \varphi_2(x, t), \varphi_3(x, t))$ - обобщенные решения системы уравнений (1)-(4), $h_{ik}(x) \in L_2(0,1), i = 1, 3$, $\eta_{1k}(t), \eta_{3k}(t)$ - выборочные значения случайных процессов, которые попарно некоррелированы, с нулевыми математическими ожиданиями

$M\eta_{1k}(t) = M\eta_{3k}(t) = 0, M\eta_{1k}^2(t) < \infty, M\eta_{3k}^2(t) < \infty$. Будем считать, что $f_0(x), w_0(x), f(x), \eta_{1k}(t), \eta_{3k}(t)$ не определены точно, а известно, что они принадлежат множеству

$$\begin{aligned} & \int_0^1 (f_0^{(n)}(x))^2 q_0^2(x) dx + \int_0^1 (w_0^{(n)}(x))^2 q_{00}^2(x) dx + \int_{t_1}^s \int_0^1 f_1^2(x, t) q_1^2(x, t) dx dt + \\ & \int_0^1 f_2^2(x) q_2^2(x) dx + \int_{t_2}^{t_3} \int_0^1 f_3^2(x, t) q_3^2(x, t) dx dt \leq 1. \end{aligned}$$

Найдено минимаксную оценку функционала $l(\varphi)$

$$l(\varphi) = \int_{t_1}^s \int_0^1 l_1(x, t) \varphi_1(x, t) dx dt + \int_0^1 l_2(x) \varphi_2(x) dx + \int_{t_2}^{t_3} \int_0^1 l_3(x, t) \varphi_3(x, t) dx dt \quad \text{за}$$

неполными наблюдениями (5) по состоянию системы, которое описывается системой уравнений (1)-(4) в следующем виде

$$\hat{l}(\varphi) = \int_{t_1}^s \hat{u}_1(t) y_1(t) dt + \int_{t_2}^{t_3} \hat{u}_3(t) y_3(t) dt = l(\hat{\varphi}),$$

при этом погрешность оценивания равняется

$$\sigma^2 = \sup_{G_0} M[l(\varphi) - \hat{l}(\varphi)]^2 = l(p),$$

$$\text{а } \hat{u}(t) = \left(\int_0^1 r_1^2(t) h_1(x) p_1(x, t) dx, \int_0^1 r_3^2(t) h_3(x) p_3(x, t) dx \right).$$

Функция $p(x, t)$ однозначно определяется как решение системы интегрально-дифференциальных уравнений.

Література

1. Наконечний О.Г. Оцінювання параметрів в умовах невизначеності // Наукові записки КНУ ім.Т.Г.Шевченка. — 2004.- Том 7:факультет кібернетики. — С.102-112.
2. Наконечний О.Г. Оптимальне керування та оцінювання в рівняннях із частинними похідними. Навчальний посібник – ВПЦ «Київський університет», 2004.

СТАТИСТИЧЕСКАЯ ОБРАБОТКА РЕЗУЛЬТАТОВ ТЕСТИРОВАНИЯ ПРОГРАММОЙ INDEX

Шарапов М.М., Обруч Татьяна, Маренец Олеся

Киевский национальный университет имени Тараса Шевченко
sharapov@unicyb.kiev.ua

В Киевском национальном университете имени Тараса Шевченко на факультете кибернетики кафедрой прикладной статистики разработана онлайн программа Index проверки практических знаний студентов по теории вероятностей и математической статистике. Уникальность этой программы заключается в том, что, во-первых, она предусматривает возможность использования задач и вопросов широкого спектра (с фиксированным ответом, с выбором варианта ответа, с использованием в качестве ответа числа, функции действительного аргумента, логической функции, вербального ответа, подмножества действительных чисел); во-вторых, для каждого испытуемого задачи могут отличаться в той или иной мере (от полной идентичности, до изменения численных или качественных составляющих условия); в-третьих, в тренировочном режиме

можно пройти тестирование без регистрации; в-четвертых, ведется статистика участников проекта на нескольких уровнях (от общедоступного, до индивидуальной статистики и статистики, доступной только преподавателю); в-пятых, программа легко может быть модифицирована для использования в других учебных дисциплинах.

Самым интересным с научно-педагогической точки зрения является корреляционный анализ, позволяющий выявить связь между весом каждой задачи, который заранее определяется преподавателем, и количеством неверных попыток решения задачи испытуемыми. Результаты анализа применимы как для коррекции весов задач, так и для коррекции соответствующих теоретических разделов, преподаваемых студентам.

В настоящий момент программа Index функционирует и доступна в интернете по адресу <http://databa.com.ua/sharapov/ukr/index>

РЕАЛИЗАЦИЯ ОТНОШЕНИЯ ПРЕДПОЧТЕНИЯ В УСЛОВИЯХ НЕОПРЕДЕЛЕННОСТИ

Шарапов Михаил Михайлович, Пархомец Артём Дмитриевич

Киевский национальный университет имени Тараса Шевченко

parhomets_art@mail.ru

Задача прогнозирования выигрыша одного из двух игроков согласно результатам игр между ними и другими игроками возникает довольно часто. Простейшими примерами могут служить спортивные соревнования. Выигрыш в таких ситуациях имеет объективно случайную природу, а соответствующие задачи не имеют единого решения, поскольку точно неизвестен способ количественного представления отношения предпочтения. Поэтому возникают вопросы о построении различных математических моделей, исследования связи между ними и их обобщения, что будет дополнительным свидетельством их адекватности.

В данной работе анализируются два подхода к задаче нахождения вероятности реализации отношения предпочтения между объектами А и В с известными вероятностями реализации отношения предпочтения между ними и другим объектом. Проводится обобщение одного из подходов на большее количество

объектов, а именно на случай, в котором они образуют цепь, и случай, в котором они образуют дерево.

Приводится анализ обобщений. В частности, обобщение остаются справедливыми при замене функции количественной оценки отношения предпочтения на другую неубывающую функцию.

Литература

1. Шарапов М.М. *Оцінювання ймовірності реалізації відношення переваги в умовах невизначеності*. 3-я международная школа-семинар "Теория принятия решений", Ужгород, 2006.

УСЛОВИЯ СХОДИМОСТИ ДВУХПАРАМЕТРИЧЕСКОГО МЕТОДА ТИПА ХОРД ДЛЯ РЕШЕНИЯ НЕЛИНЕЙНЫХ УРАВНЕНИЙ С УЧЕТОМ ПОГРЕШНОСТЕЙ ОКРУГЛЕНИЙ

Шахно С.М., Ярмола Г.П.

Львовский национальный университет имени Ивана Франко

s_shakhno@franko.lviv.ua

Пусть задано нелинейное уравнение

$$F(x) = 0, \quad (1)$$

где F – непрерывный оператор, определенный на выпуклом множестве D банахового пространства X со значениями в банаховом пространстве Y . Для решения (1) рассмотрим итерационный метод типа хорд с двумя действительными параметрами [1]

$$x_{n+1} = x_n - [F(u_n, v_n)]^{-1} F(x_n), \quad n \geq 0, \quad (2)$$

где $u_n = x_n + \alpha_n(x_{n-1} - x_n)$, $v_n = x_n + \beta_n(x_{n-1} - x_n)$, $\alpha_n \in [0; 1]$, $\beta_n \in [-1; 1]$; $F(u, v)$ – разделенная разность первого порядка оператора F за точками u и v , x_{-1}, x_0 – заданные начальные приближения.

Частными случаями процесса (2) при $\alpha_n = 0$, $\beta_n = 1$ являются метод хорд [2], при $\alpha_n = 0$, $\beta_n = 0$ – классический метод Ньютона, при $\alpha_n = 1$, $\beta_n = -1$ – метод Курчатова и при $\alpha_n = 0$, $\beta_n \in [0; 1]$ – метод типа хорд [3].

В данном докладе исследуются условия сходимости процесса (2) с учетом погрешностей округлений и его полная погрешность.

Литература

1. Шахно С. Двопараметричні методи типу хорд для розв'язування нелінійних рівнянь / С. Шахно, С. Граб, Г. Ярмола // Вісник Львівського університету. Сер. прикл. матем. та інф. – 2009. – Вип. 15. – С. 117–127.
2. Argyros I.K. On an iterative algorithm for solving nonlinear operator equations // Zeitschrift für Analysis und ihre Anwendungen, – Vol. 10. – 1991. – pp. 83–92.
3. Chen J., Shen Z. Convergence analysis of the secant type methods // Appl. Math. Comp. – Vol. 188. – 2007. – pp. 514–524.

Наукове видавництво ТВіМС
Свідоцтво ДК 110 від 5.07.2000 р.
у Державному реєстрі видавців, виготовників
і розповсюджувачів видавничої продукції
03127, м.Київ, пр. Глушкова, 2