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SATURS

A. Spalviņš, J. Šlangens, I. Lāce Gruntsūdens režīmu izmaiņu modelēšana, kuras var izsaukt Rīgas transporta tuneļa būvēšana …….....	7
A. Spalviņš, J. Šlangens, I. Lāce Jelgavas pilsētas atkritumu izgāztuves „Kosmoss" teritorijas rekultivācijas pasākumu modelēšana ……....	18
R. Janbickis, K. Krauklis, I. Lāce Hidroģeoloģijas problēmu modelēšanas programmas REMO adaptācija	28
Y. Salicis, T. Juhna, A. Spalviņš Pētījums par iespējām modelēt mangāna transportu gruntsūdens mākslīgās papildināšanas procesā	35
T. Juhna, A. Koliškins, S. Nazarovs, J. Rubulis IMSL bibliotēkas un Epanet-MSX vides pielietojums baktēriju izplatīšanās simulāciju rezultātu salīdzināšanai	42
N. V. Mulyk, O. V. Mul., M. Ye. Fryz Simulation of gas consumption using linear periodical processes ….....	47
T. Nguyen-Ba, H. Hao, H. Jagubs, R. Vajenkurs One-step 9-stage Hermite–Birkhoff–Taylor DAE Solver of order 11	55
T. Nguyen-Ba, H. Jagubs, J. Zuangs, R. Vajenkurs Variable-step variable-order 2-stage Hermite–Birkhoff–Obrechkoff ODE Solver of order 3 to 14 ……....	78
E. Kengne, R. Vajenkurs Divu komponentu Bose-Einšteina kondensātu integrēšanas nosacījumi periodiskos	102
G. Burovs Simbolisks kombinatoriskais modelis paralēlam identifikācijas algoritmam, kas izmanto mazāko kvadrātu metodi ..…….....	111
G. Burovs Skaitliski stabils simbolisks kombinatoriskais polinomiālās aproksimācijas modelis identifikācijas un imitācijas modelēšanas problēmām	120
S. Čerņajeva, I. Eglīte Matemātikas studiju programmas pilnveidošana inženieru izglītībā	129
S. Čerņajeva, I. Eglīte Matemātikas studiju programmas pilnveidošana inženieru izglītībā	134

CONTENT

A. Spalvins, J. Slangens, I. Lace Modelling of groundwater regime changes that may be caused by building of transportation tunnel in Riga, Latvia	7
A. Spalvins, J. Slangens, I. Lace Modelling of recovery measures for waste deposit "Cosmos" area of Jelgava town	18
R. Janbickis, K. Krauklis, I. Lace Adaption of program REMO used for modelling hydrogeological problems …….....	28
Y. Salicis, T. Juhna, A. Spalvins Study about possibilities to model transport of manganese in course of groundwater artificial recharge	35
T. Juhna, A. Kolyshkin, S. Nazarovs, J. Rubulis Application of IMSL library and Epanet-MSX environment for comparison of bacteria growth simulation results	42
N. V. Mulyk, O. V. Mul., M. Ye. Fryz Simulation of gas consumption using linear periodical processes ….....	47
T. Nguyen-Ba, H. Hao, H. Yagoub, R. Vaillancourt One-step 9-stage Hermite–Birkhoff–Taylor DAE Solver of order 11	55
T. Nguyen-Ba, H. Yagoub, Y. Zhuang, R. Vaillancourt Variable-step variable-order 2-stage Hermite–Birkhoff–Obrechkoff ODE Solver of order 3 to 14 …….....	78
E. Kengne, R. Vaillancourt Integrability conditions for two-component Bose-Einstein condensates in periodic potentials **……..**.....	102
G. Burov Symbolical combinatory model of parallel algorithm of identification that uses method of least squares.....	111
G. Burov Numerically stable symbolical combinatory model of polynomial approximation for problems of identification and imitation modelling	120
S. Cernajeva, I. Eglite Improvement of mathematical teaching program in education of engineers	129
S. Čerņajeva, I. Eglīte Matemātikas studiju programmas pilnveidošana inženieru izglītībā	134

СОДЕРЖАНИЕ

А. Спалвиньш, Я. Шлангенс, И. Лаце Моделирование изменений режима грунтовых вод, которые могут быть вызваны строительством подземного туннеля в г. Риге, Латвия	7
А. Спалвиньш, Я. Шлангенс, И. Лаце Моделирование процесса рекультивации территории свалки «Космос» города Елгава …….....	18
Р. Янбицкий, К. Крауклис, И. Лаце Адаптирование программы моделирования гидрогеологических проблем REMO	28
И. Салицис, Т. Юхна, А. Спалвиньш Исследование возможностей моделирования транспорта мангана для процессов искусственного пополнения запасов подземной воды	35
Т. Юхна, А. Колышкин, С. Назаров, Я. Рубулис Применение IMSL библиотеки и среды Epanet-MSX для моделирования размножения бактерий в водопроводных системах	42
Н. В. Мулык, Е. В. Муль, М. Е. Фрыз Имитационное моделирование газопотребления с использованием линейных периодических процессов	47
Т. Нгуен-Ба, Х. Хао, Х. Ягоуб, Р. Вайенкур One-step 9-stage Hermite–Birkhoff–Taylor DAE Solver of order 11.....	55
Т. Нгуен-Ба, Х. Ягоуб, Я. Жуанг, Р. Вайенкур Variable-step variable-order 2-stage Hermite–Birkhoff–Obrechkoff ODE Solver of order 3 to 14	79
Э. Кенне, Р. Вайенкур Условия интегрируемости для двухкомпонентных конденсатов Боза-Эйнштейна в периодических потенциалах …….....	103
Г. Буров Символьная комбинаторная модель параллельного алгоритма идентификации с использованием метода наименьших квадратов	112
Г. Буров Численная устойчивость символьной комбинаторной модели полиномиальной аппроксимации для задач идентификации и имитационного моделирования …..…….....	120
С. Черняева, И. Эглите Усовершенствование программ обучения математике в образовании инженеров ….....	129
S. Čerņajeva, I. Eglīte Matemātikas studiju programmas pilnveidošana inženieru izglītībā	134

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Redkolēģija
Editorial board

Contents

Abstracts 8
Spalvins A., Slangens J., Lace I. Modelling of groundwater regime changes that may be caused by building of transportation tunnel in Riga, Latvia 8
Spalvins A., Slangens J., Lace I. Modelling of recovery measures for waste deposit "Cosmos" area of Jelgava town 8
Janbickis R., Krauklis K., Lace I. Adaption of program REMO used for modelling hydrogeological problems 9
Y. Salicis, T. Juhna, A. Spalvins. Study about possibilities to model transport of manganese in course of groundwater artificial recharge 10
Juhna T., Kolyshkin A., Nazarovs S., Rubulis J. Application of IMSL library and Epanet-MSX environment for comparison of bacteria growth simulation results 10
Mulyk N.V., Mul O.V., Fryz M.Ye. Simulation of gas consumption using linear periodical processes. 11
Nguyen-Ba T.,, Hao H., Yagoub H., Vaillancourt R. One-step 9-stage Hermite–Birkhoff–Taylor DAE Solver of order 11 11
Nguyen-Ba T., Yagoub H., Zhuang Y., Vaillancourt R. Variable-step variable-order 2-stage Hermite–Birkhoff–Obrechkoff ODE Solver of order 3 to 14 12
Kengne E., Vaillancourt R. Integrability conditions for two-component Bose-Einstein condensates in periodic potentials 13
G. Burov. Symbolical Combinatory Model of Parallel Algorithm of Identification That Uses Method of Least Squares 13
G. Burov. Numerically stable symbolical combinatory model of polynomial approximation for problems of identification and imitation modelling 14
Cernajeva S., Eglite I. Improvement of mathematical teaching program in education of engineers 14
Yagoub H., Nguyen-Ba T., Vaillancourt R. Variable-step 7-stage Hermite–Birkhoff–Taylor DDE solver of order 8 15

Abstracts

Spalvins A., Slangens J., Lace I. Modelling of groundwater regime changes that may be caused by building of transportation tunnel in Riga, Latvia

The publication is devoted to numerical modeling of changes in groundwater regime that may happen during and after building of the 7 km long and 50 metres deep underground transportation model in Riga. There are two kinds of changes: the ones caused by the tunnel impermeable body and by harmful effects that may happen during the process of building, for example, impacts of open deep construction trenches. To estimate possible after effects caused by the tunnel and the trenches, the hydrogeological model has been created. Its plane size is 3500metre□8000metres and the plane approximation step is 10 metres. Model contains twelve grid planes accounting for complex geological structure of the place and the tunnel geometry. By comparing results provided by the undisturbed (no tunnel) and disturbed models, the change of the groundwater regime was found. It contained changes of: groundwater heads and flows; hydraulic gradients; meteoric infiltration. These changes were small and the tunnel itself should cause practically no disturbance of groundwater regime. By modeling possible versions of watertight walls for trenches, it was found that deep wrongly built construction trenches may cause considerable harm by lowering a groundwater table at the trench surroundings. (pp. 7-17)

Spalvins A., Slangens J., Lace I. Modelling of recovery measures for waste deposit "Cosmos" area of Jelgava town

The former waste deposit area "Cosmos" is located in outskirts of the Jelgava town, Latvia. The area has been closed as an active deposit place for about 15 years. However, the process of waste spreading into groundwater continues and the contaminated area is enlarging. The decision has been made that the abandoned waste deposit site should be sanitized. A scenario has been developed for accomplishing the task. Hydrogeological modelling has been applied to simulate the principal stages of the planned sanitation. The groundwater Vistas (version 4) system was used for creating the necessary models and for investigating the waste migration in the groundwater flow. Four hydrogeological models representing the consecutive stages of sanitation have been developed: before sanitation when the contaminated area is still enlarging; after elimination of liquid waste pools and stopping the infiltration flow for the mostly contaminated central area of the site; after enclosing the central area with a drainage

ditch; after enclosing the central area with a watertight wall. The models have the size of 800m×800m and they contain six model layers (planes). The plane approximation step is 2.0 metres. Modelling of the contamination migration for these sanitation stages resulted in the following conclusions: removing of the open waste pools and blocking the infiltration flow is the first necessary action; dissolution of the hard waste bulk ceases and enlargement of the contaminated area stops; appliance of the drainage ditch is the second obligatory sanitation step; due to the ditch the polluted outside area also gets cleaned; effectiveness of installing the watertight wall strongly depends on unknown intensity of an ascending groundwater flow caused by the Devonian aquifer placed beneath the deposit site; a borehole reaching the aquifer should be produced to decide if the wall should be applied. The information provided by the publication may be useful for specialists dealing with cleaning of contaminated places. (pp. 18-27)

Janbickis R., Krauklis K., Lace I. Adaption of program REMO used for modelling hydrogeological problems

In the publication, the recent adaption of the modelling program REMO is considered. It was developed by the Environment Modelling Centre (EMC) of the Riga Technical University. The program is compared with the licensed system GROUNDWATER VISTAS. The REMO program is handy for calibration of hydrogeological models. The program was originated in 1990 when the regional hydrogeological model (REMO) for the central part of Latvia has to be created. REMO modelled hydrogeological processes. It was based on the more universal software OMEN (also developed by EMC). To account for hydrogeological processes, some specific modules were included. Since 1996, many hydrogeological models have been developed for Latvia and abroad by using REMO. The models considered problems of well fields supplying drinking water and migration of contaminants in groundwater. During its exploitation, REMO was updated and many special applications were introduced: interpolation of well rates on the model grid, computing of groundwater balance for polygon areas, modelling elements of drainage systems. Because REMO was originated in 1991, the DOS environment and FORTRAN 77 were applied to create REMO. In order to apply resources of modern software and hardware, partial updating and adaption of REMO has been accomplished: the FORTRAN 90 has been applied in the WINDOWS XP environment; the former maximal grid plane size of 100×100 nodes has been enlarged to 989×989. However,

the graphical interface of software module has not been recovered yet, because about 15 its original programme texts are not found. The number of grid planes remains limited n≤9. (pp. 28-34)

Y. Salicis, T. Juhna, A. Spalvins. Study about possibilities to model transport of manganese in course of groundwater artificial recharge

To study possibilities of modelling the transport of manganese during artificial groundwater recharge (AGR), water samples were taken from 40 wells of Baltezers water supply site, Latvia. The samples were analyzed for temperature, pH, Redox potential, electro conductivity, total organic carbon and manganese concentration. The manganese concentration has been found to be in the range of 0.01 to 0.75 mg/L. The principal Component Analyze method showed that the manganese concentration was mainly dependent on the Redox potential. This observation could be used for development of a semi-empirical model for prediction of manganese concentrations in AGR plant abstraction wells. (pp. 35-41)

Juhna T., Kolyshkin A., Nazarovs S., Rubulis J. Application of IMSL library and Epanet-MSX environment for comparison of bacteria growth simulation results

The issue of bacteria proliferation in water distribution networks has been addressed by several authors. Attempts have been made to develop a comprehensive model that would allow simulating growth of bacteria in drinking water distribution networks and determining how different factors are influencing bacteria growth. There are some difficulties, however, that one developing a bacteria growth model has to overcome. Bacteria development is influenced by many factors and it is virtually impossible to take them all into account.

Nevertheless there are models available that in one hand consider all the significant factors and in other hand are not too bulky enabling quick calculations with the computing power available in most labs. However additional efforts are needed to compare models and check reproducibility of results obtained with different models and various packages of simulation software. The present paper makes an attempt to compare results obtained with the help of Fortran IMSL library and Epanet-MSX software.

A mathematical model describing growth of bacteria in water distribution pipes has been proposed by Zhang et al (2004). In the present paper the equations of the model were solved by means of Fortran IMSL library for a straight pipe. The same model excluding the dispersion term was used in Epanet-MSX environment. The results were compared.

It has been found that the results obtained with IMSL library agree well with the results of Epanet-MSX software. The results indicate that the dispersion term may not be significant in some cases. (pp. 42-46)

Mulyk N.V., Mul O.V., Fryz M.Ye. Simulation of gas consumption using linear periodical processes.

In the given paper the problem of the construction of the gas consumption simulation model is set, for which the mathematical model is justified in the form of a linear periodical process with some stationary pieces.

The simulation is carried out with the help of the separation of the stationary pieces at one period and the following simulation of linear stationary sequences at the corresponding pieces. In this paper the well-known methods of stationary linear sequences modeling are applied. The simulation of the linear sequences after the period of the process is carried out with the same coefficients of autoregression. The correctness of the simulation model is verified by the adequacy of peculiar properties of the simulated signal and the real signal as well as by the adequacy of those characteristics.

The proposed simulation model gives a possibility to carry out testing of the developed statistical analysis methods for solving on-line control problems. (pp. 47-54)

Nguyen-Ba T.,, Hao H., Yagoub H., Vaillancourt R. One-step 9-stage Hermite–Birkhoff–Taylor DAE Solver of order 11

A necessary structural pre-analysis is sketched for solving DAEs. A one-step 9-stage Hermite–Birkhoff–Taylor method of order 11, denoted by HBT(11)9, is constructed for solving nonstiff to moderately stiff systems of fully implicit differential algebraic equations of arbitrarily high fixed index. The method uses $y^{(1)}$ and the higher derivatives $y^{(2)}$ to $y^{(5)}$ as in Taylor methods and is combined with a 9-stage Runge–Kutta method. Forcing an expansion of the numerical solution to agree with the Taylor expansion of the true solution up to order 11 leads to Taylor- and Runge–Kutta-type order conditions which are reorganized into

Vandermonde-type linear systems whose solutions are the coefficients of the method. The new method has larger scaled interval of absolute stability than Dormand–Prince DP(8,7)13M. The step size is controlled by a local error estimator. HBT(11)9 is equivalent to Taylor method of order 11 and is superior to Dormand–Prince DP(8,7)13M in solving several problems used to test DAE solvers, including high-index DAE problems, on the basis of the number of steps, CPU time, and maximum global error. HBT methods with five high derivatives $y^{(1)}$ to $y^{(5)}$ appear to be promising for DAEs in the light of the numerical results since methods of high order can be derived and implemented efficiently. Furthermore, since these methods use a small number of derivatives, they may be useful for high dimensional problems. (pp. 55-77)

Nguyen-Ba T., Yagoub H., Zhuang Y., Vaillancourt R. Variable-step variable-order 2-stage Hermite–Birkhoff–Obrechkoff ODE Solver of order 3 to 14

Variable-step variable-order 2-stage Hermite–Birkhoff–Obrechkoff methods of order 3 to 14, denoted by HBO(3-14)2, are constructed for solving expensive non-stiff systems of first-order differential equations of the form $y^{(1)} = f(x, y)$, $y(x_0) = y_0$. These methods use $y^{(1)}$ and $y^{(2)}$ as in Obrechkoff methods. Forcing an expansion of the numerical solution to agree with a Taylor expansion of the true solution leads to multistep-type order conditions which are reorganized into linear Vandermonde-type systems. Fast algorithms are developed for solving these systems to obtain Hermite–Birkhoff interpolation polynomials in terms of generalized Lagrange basis functions. Generally, the new methods have larger regions of absolute stability than Adams–Bashforth–Moulton methods of comparable orders in PECE mode. The order and stepsize of these methods are controlled by four local error estimators. In the numerical tests the lower order was changed from 3 to 4. In Matlab, HBO(4-14)2 is found to be superior to Matlab's ode113 in solving several problems often used to test higher order ODE solvers on the basis the number of steps, CPU time, and maximum global error. In C++, HBO(4-14)2 compares well with Dormand–Prince DP(8,7)13M in solving several expensive problems. (pp. 78-101)

Kengne E., Vaillancourt R. Integrability conditions for two-component Bose-Einstein condensates in periodic potentials

We have shown that Hirota's bilinear method is one of the simplest methods to identify the integrability of a binary Bose-Einstein condensates (BEC) described by a coupled nonlinear Schrödinger equations with many parameters. The bilinear method used in this work is very simple when compared with the Painlevé analysis. We consider a set of coupled Gross-Pitaevskii equations as a model for a two-component Bose-Einstein condensate. No assumption is made on the signs or magnitudes of the relevant parameters like the scattering lengths and the coupling coefficients. The formalism is therefore valid for asymmetric as well as symmetric coupled condensate wave states. The question of integrability is then addressed. We explicitly show that Hirota's bilinear method is one of the simplest analyses to obtain the integrability conditions of the coupled Gross-Pitaevskii equations. In the obtained region of integrability, we generate analytical soliton solutions and, in a special case, we decouple the Gross-Pitaevskii equations under consideration. This allows us to identify a large class of solutions in terms of Jacobian elliptic functions. The general bilinear integrability conditions obtained through a bilinear form may be useful for the experimental generation of solitons in a binary BEC with zero potential. Our results can be tested, and can hopefully be confirmed by designed experiments. (pp. 102-110)

G. Burov. Symbolical Combinatory Model of Parallel Algorithm of Identification That Uses Method of Least Squares

The problem of development of parallel algorithms for the method of the least squares (MLS), used in the identification of analog dynamic objects, is considered. With the help of symbolical combinatory models, the analytical expression of the inverse matrix of the system of normal equations is found. It has allowed to apply non-conventional methods of regularization and to reveal the factors that influence the numerical stability of the MLS algorithm. The reduction of the distances between the discrete poles of the object can lead to degeneration of the algorithm. The increase in the linear dependence between the vectors of the matrix of initial system of equations leads to the same results. The developed theoretical model of the method of least squares (MLS) shows, that the improvement in solving the problem of approximation is achieved due to the reduction of the stability of computing algorithm. In the inverse matrix of the system of normal equations, as a matrix factor, there arises a matrix constructed from fragments of the products of mutual distances between

discrete poles with absolute value less than one. The determinant of this matrix depends on the number of equations in the system of conditional equations. It decreases in a nonlinear way with the increase in the number of the determined parameters and the amount of processed information. The use of symbolical combinatory models allows, to some extent, to overcome the computation difficulties. (pp. 111-119)

G. Burov. Numerically stable symbolical combinatory model of polynomial approximation for problems of identification and imitation modelling

The problem of the approximation of experimental data for identification of analog objects with the help of polynomial functions of any kind is considered. The application of symbolical combinatory models has allowed creating an algorithm for inverting the matrices of the equation systems made of such functions, in the analytical form. It allows to apply non-conventional methods of algorithm regularization and to increase their noise tolerance. The theoretical results, allowing allocating, in the direct form, the factors leading to degenerate situations, are developed. It allows to make computing process observable and to correct its properties. The problem was solved, taking into account the application of algorithms in modern computers working in the modes of parallel calculation. The validity of the algorithm has been verified by a numerical experiment and its efficiency is proved. Hilbert's inverse 20th order matrix, used for polynomial approximations has been calculated with the 100% accuracy. It is believed, that obtaining such result for the matrices with the order greater than 10th is impossible. (pp. 120-128)

Cernajeva S., Eglite I. Improvement of mathematical teaching program in education of engineers

The steady tendency of decline for quality of mathematical preparation of graduating students of schools, lacks of ability them well-off to work, upgrading teaching it is possible to attain only due to new forms and methods of organization of educational process. It is necessary concretely formulate the aims of the programs for courses of higher mathematics, taking into account the different level of preparedness of students, to diversify teaching methods and accent connection of the mastered theoretical material with his practical application. Further perfection of teaching of mathematics in engineering education is related to integration in the Bologna process: passing to the multilevel departmental teaching,

individualization of the teaching programs. The programs of the mathematical teaching and didactics need to be perfected, leaning on information and communication technologies, creating materials using new technologies and providing access to them in the internet. Development of e-teaching, as well as the use of modern application packages with mathematical components in the educational process, is planned. (pp. 129-133)

Yagoub H., Nguyen-Ba T., Vaillancourt R. Variable-step 7-stage Hermite–Birkhoff–Taylor DDE solver of order 8

This article presents a new solver for delay differential equations (DDEs) called HBT8DDE. It is based on a hybrid variable-step 7-stage Hermite–Birkhoff–Taylor ODE solver of order 8. The current version of our method solves DDEs with state dependent, non-vanishing, small, vanishing and asymptotically vanishing delays except neutral type and initial value DDEs. Delayed values are computed using Hermite interpolation, small delays are dealt with using extrapolation, and discontinuities are located by a bisection method. HBT8DDE was tested on a set of problems and results were compared with those of known solvers like SYSDEL and the recent Matlab DDE solver ddesd and statistics show that it gives, most of the time, a smaller relative error than the other solvers for the same number of function evaluations at stringent tolerance. (pp. 134-148)