

Poster Book

F. Breitenecker I. Husinsky editors

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Foreword

Developments over the last years show that beside the classical tools theory and experiment simulation becomes more and more the third major tool for problem solving in application and research. Nowadays simulation is found in nearly every application area, research activities result in new methodologies and tools for simulation, and more and more simulation software, simulators, and simulation systems are offered on the market.

The *EUROSIM Congress*, the European Simulation Congress, an international event normally held every three years, aims to be a common forum for presenting European and international recent results and applications in simulation, and to stimulate the exchange of ideas and experiences among scientists and engineers active in simulation.

EUROSIM is the Federation of the European Simulation Societies, acting as a European forum for Simulation Societies and promoting the advancement of system simulation in industry, research, and education.

All these intentions are reflected in the 5th European Simulation Congress *EUROSIM* 95, the 2nd Congress after the formal foundation of EUROSIM. The scientific programme consists of invited and contributed papers to regular sessions and to "Special Interest Sessions", of contributions to the session "Software Tools and Products", and of posters.

The invited and contributed papers to regular sessions and to "Special Interest Sessions" are published in the Congress Proceedings printed by Elsevier Science B.V. and in a Late Paper Volume (ARGESIM Report, ISBN 3-901608-01-X). The Proceedings contain eight invited papers and 212 contributed papers, the Late Paper Volume contains 20 contributed papers. The papers were selected by the International Programme Committee from 459 abstracts received.

The session "Software Tools and Products" presents papers dealing with State-of-the-Art and new features of simulation languages, simulators, and simulation environments. These contributions also passed the review process and are published as ARGESIM Report (Proceedings EUROSIM'95 - Session "Software Tools and Products", ISBN 3-901608-02-8).

The reviewed Poster Session completes the scientific programme. The abstracts of the 111 posters are published as ARGESIM Report (EUROSIM'95 - Poster Book, ISBN 3-901608-03-6).

It is interesting to compare the titles of papers and posters presented at previous European Simulation Congresses with those at the present congress. Even a brief glance through the four volumes of Proceedings and Late Paper Volumes shows that in this twelve year period considerable, remarkable, and sometimes astonishing advances have been made in a number of different areas. For example, developments in parallelism and distributed processing are now not only being seen in simulation applications but are also frequently used. Object-oriented methods are being implemented now, and artificial intelligence and knowledge-based tools appear to be an established part of system modelling and simulation methodology. The availability of improved graphic algorithms and tools is also leading to some very interesting and innovative research and application in terms of man-machine interface and of animation and visualisation, both for discrete-event and continuous-system simulation. New developments in terms of mathematical modelling and simulation techniques as well as in terms of general methodology are of little significance unless they are stimulated by the requirements of the real world in terms of industry, business, agriculture and the sciences. We are very pleased, therefore, that application papers are so well represented. This also applies to papers on parallel and distributed simulation, where beside graphics the fastest development can be observed.

We are also pleased that the idea of "Special Interest Sessions" could be realized. These sessions deal with recent developments in areas where methodology and application are considered together. The results of the closing discussion at the end of these sessions are summarized in manuscripts which will be edited and published in abbreviated form in *EUROSIM - Simulation News Europe* (SNE), the newsletter of the EUROSIM member societies. Some of these papers will be prepared for publication in EUROSIM's scientific journal *SIMULATION PRACTICE AND THEORY*. A separate role is played by the Industry Session on "Model Exchange and Software Independent Modeling" where people mainly from industry report on this topic without necessarily having to publish a paper in the Proceedings. Furthermore, we are pleased, that the contributions to the session "Software Tools and Products" show a very broad spectrum of simulation software, and that the Poster Session presents new ideas under development.

The European Simulation Congress *EUROSIM* 95, held in Vienna (Austria) at the Technical University of Vienna from September 11 through September 15, 1995, is organized by *ASIM* (Arbeitsgemeinschaft Simulation), the German speaking Simulation Society, in co-operation with the other member societies of EUROSIM: *AES* (Asociación Española de Simulación), *CSSS* (Czech & Slovak Simulation Society), *DBSS* (Dutch Benelux Simulation Society), *FRANCOSIM* (Société Francophone de Simulation), *HSTAG* (Hungarian Simulation Tools and Application Group), *ISCS* (Italian Society for Computer Simulation), *SIMS* (Simulation Society of Scandinavia), *SLOSIM* (Slovenian Society for Simulation and Modelling), *UKSS* (United Kingdom Simulation Society).

The moral co-sponsorship of CASS (Chinese Association for System Simulation), CROSSIM (Croatian Society for Simulation Modelling), *IFAC* Advisory Board Austria, *IMACS* (International Association for Mathematics and Computers in Simulation), *JSST* (Japanese Society for Simulation Technology), *LSS* (Latvian Simulation Society), *OCG* (Austrian Computer Society), *PSCS* (Polish Society for Computer Simulation), *ROMSIM* (Romanian Society for Modelling and Simulation), *SCS* (Society for Computer Simulation), *SiE* Esprit Working Group "Simulation in Europe" supports this congress.

A successful conference is always due to the efforts of the many people involved. To this purpose, particular acknowledgement goes to the members of the Scientific Committee for their contributions in the paper selection process, to the members of the Local Organizing Committee, and more especially to the head of this committee, to Mr. Manfred Salzmann. We would like to thank *Unseld* + *Partner* and *CA* (*Creditanstalt*) for sponsoring the printing of this report.

Felix Breitenecker

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Technical University of Vienna

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About ARGESIM

ARGE Simulation News (ARGESIM) is a non-profit working group providing the infra structure for the administration of **EUROSIM** activities and other activities in the area of modelling and simulation.

ARGESIM organizes and provides the infra structure for

- the production of the journal EUROSIM Simulation News Europe
- the comparison of simulation software (EUROSIM Comparisons)
- the organisation of seminars and courses on modelling and simulation
- COMETT Courses on Simulation
- "Seminare über Modellbildung und Simulation"
- development of simulation software, for instance: mosis continuous parallel simulation, D_SIM - discrete simulation with Petri Nets, GOMA - optimization in ACSL
- running a WWW server on EUROSIM activities and on activities of member societies of EUROSIM
- running a FTP-Server with software demos, for instance
 - * demos of continuous simulation software
 - * demos of discrete simulation software
 - * demos of engineering software tools
 - * full versions of tools developed within ARGESIM

At present ARGESIM consists mainly of staff members of the Dept. Simulation Technique and of the Computing Services of the Technical University Vienna.

In 1995 ARGESIM became also a publisher and started the series **ARGESIM Reports**. These reports will publish short monographs on new developments in modelling and simulation, course material for COMETT courses and other simulation courses, Proceedings for simulation conferences, summaries of the EUROSIM comparisons, etc.

Up to now the following reports have been published:

No.	Title	Authors / Editors	ISBN
# 1	Congress EUROSIM'95 - Late Paper Volume	F. Breitenecker, I. Husinsky	3-901608-01-X
#2	Congress EUROSIM'95 - Session Software Products and Tools	F. Breitenecker, I. Husinsky	3-901608-02-8
#3	EUROSIM'95 - Poster Book	F. Breitenecker, I. Husinsky	3-901608-03-6
# 4	Seminar Modellbildung und Simulation - Simulation in der Didaktik	F. Breitenecker, I. Husinsky, M. Salzmann	3-901608-04-4
# 5	Seminar Modellbildung und Simulation - COMETT - Course "Fuzzy Logic"	D. Murray-Smith, D.P.F. Möller, F. Breitenecker	3-901608-05-2
#6	Seminar Modellbildung und Simulation -COMETT - Course "Object-Oriented Discrete Simulation"	N. Kraus, F. Breitenecker	3-901608-06-0
#7	EUROSIM Comparison 1 - Solutions and Results	F. Breitenecker, I. Husinsky	3-901608-07-9
#8	EUROSIM Comparison 2 - Solutions and Results	F. Breitenecker, I. Husinsky	3-901608-08-7
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ARGESIM REPORT NO.3

PROCESSING SPEECH WITH NEURAL NETWORK

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EXTENDED ABSTRACT:

Adaptive quantisers with and without some form of adaptive prediction are becoming increasingly common in speech transimission systems where high quality speech is required with a reduced bitrate. Such memory-based coders contrast with simpler memory-less quantisers whose action is dependent purely on the signal amplitude at a single instant. The characterisation and evaluation of such memory-based coders with a wide variety of input signals presents difficulties due to the dependence on the content of the coder's memory.

The state of any system with memory can be described as a vector in a suitable n-dimensional state space. As the state of the system and the corresponding vector changes, the system can be said to follow a trajectory around the state space. The form of this trajectory may be very simple. For example, if the system has no input, the coder may not change state at all and the trajectory will be a single point. If the coder exhibits small amplitude limit cycle behaviour, the trajectory will make a circuit through a small number of states.

These examples serve to show that the trajectory characterises the speech coder's performance in terms of its internal state. This behaviour is modified by the input signal. It is also modified by any error performance of the coder: e.g. slope overloading effects. The trajectory of the coder with a large amplitude signal, exhibiting some form of limiting behaviour forms an extremely complex figure.

Such figures can be obtained by simulation of coder algorithms, but their interpretation is less than straightforward.

The system is further complicated by the existance of noise on the input signal, or dither signals applied to the adaptive quantiser. The presence of such random purturbations on the signal are reflected in the state space trajectories; making their character less clear. The presence of such signals in coder algorithm simulation is desirable as results are more likely to reflect real applications.

A single memory adaptive quantiser executes a trajectory in a one dimensional state space. When combined with a single tap adaptive predictor, the coder exhibits complex behaviour in a two dimensional space. The figures traced by the states of the coder in response to a given input signal fully describe the internal operation of the coder at any instant. Noise present on the input signal (or dither at the quantiser) creates difficulties in the automated interpretation of the state space trajectories.

The paper describes the use of a neural network to identify aspects of speech coder simulation behaviour where the results are in the form of state space trajectories. The distinction between different modes of behaviour (limit cycle, overloading signal etc) is demonstrated.

EUROSIM CONGRESS '95

TU VIENNA, September 11-15

FUZZY-Control Simulation of Heat Supply by Circular Heat Networks

Balátě, J., Druckmüller, M., Starý, A., Sysala, T.

A Fuzzy-control application was examined for the heat distribution control by circular heat networks. In the large cities with **the centralized heat supply**, the heat is distributed to the consumers through the circular networks, that are suplied by several cooperating heat sources, that means by power and heating plants and heating plants.

The heat supply control lies in the optimal production control of the heat sources (power and heating plants and heating plants) and in the heat distribution control with the aim, to keep required values of hydraulic parameters on the given circular heat network configuration. In this time, this task is carried out by the dispatcher of the heat distribution (main dispatcher in the control point of the heat distribution), according to his knowledge, experince and capability, on the base of the information about hydraulic parameters of the controlled heat network. The dispatcher decides, what heat power output and from which cooperating heat sources it is necessary to supply during the specified day. His decision is used as a message for dispatchers in the cooperating power and heating plants and heating plants. These dispatchers fulfil the instructions and commands of the heat disribution dispatcher and they make their own decisions themselves, how the heat power requirements for their production plants will be provided.

The modern way of control, the Fuzzy-control theory, is offered for the operational control of the circular heat networks in the large systems.

In our case the Fuzzy-control application was examined on the example of miniaturized model of a heat supply network, by using of DEMO-version, as well as for a more extensive model of centralized heat supply system by using of full version of expert system LMPS - Linguistic Model Processing System. LMPS-system was produced on the Technical University in Brno, Faculty of Machinary Engineering.

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MODELING OF CONTROLLED MOTIONS OF HUMAN LOWER EXTREMITY VIA OPTIMAL PROGRAMMING

Victor BERBYUK

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Modelling of biodynamical system, especially human locomotor system or some of its part is very complicated and challenging problem. This problem is interesting and important for different applications in mechatronics, ergonomics, medicine, biomechanics of sport, rehabilitation technologies, etc.

In our report the modeling problem of the controlled motions of human lower extremity via optimal programming is considered.

It's necessary to model of the energy - optimal controlled motion of human leg in swing phase from the initial state to the final state over the given time. The modeling problem of human leg motion is formulated as the energy - optimal control problem for 8-th order nonlinear dynamical system with two point boundary conditions, given time of the control process and some constraints on phase coordinates and controlling forces. These constraints are based upon experimental data of the human locomotion.

From mathematical point of view the optimal control problem in question is very complicated problem with undifferentiable functional and nonlinear restrictions on phase coordinates.

The efficient approach for designing and simulation of the energy-optimal controlled processes of the human leg during swing phase have been proposed.

By means of the Fourier and spline approximations the considered continual optimal control problem have been reduced to some nonlinear programming problem which is solved by a standard algorithm of the constraints optimization.

A number of the energy-optimal controlled processes of human leg for different boundary conditions and restrictions on phase coordinates and controlling forces have been obtained.

The kinematic dynamic and energetic characteristics of the optimal control processes obtained are compared with respective characteristics of human leg swing phase during normal locomotion.

A MODEL: VEGETATION SHIFTS AND CARBON POOLS DYNAMICS UNDER GLOBAL CLIMATE CHANGE

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ABSTRACT

Nowadays, modeling of biospheric response on expected climate change due to anthropogenic influence is intensively developing scientific problem. Within the task, there are a few model approaches for prognosis of long-term global vegetation dynamics. The principles of them have been discussed.

Model approach based on bioclimatic schemes has been chosen for further considerations. The schemes of global bioclimatic classification connect in some manner the climatic variables (such as temperature, precipitation, etc.) and characteristics of vegetation. The model approach could forecast potential vegetation pattern redistribution under climate warming. However such model does not permit to investigate the temporal characteristics of vegetation change.

An approach of time delays has been created to incorporate vegetation dynamics into the modeling (Belotelov et al., 1994). A model, designed within this approach, is based on Holdridge's bioclimatic scheme and completed by a procedure of time delays. The procedure was designed to take into account inertia of vegetation response on climate change. It was based on expert estimates of biome replacements.

Next step was to combine the suggested model and simple submodel of carbon cycle. Dynamics of two basic terrestrial pools (living phytomass and soil) were considered. The fluxes (production, dying off, destruction) are determined by external climatic parameters and by current biome type, defining its coefficients' values. The submodel structure is similar to the typical balance models (e.g. Esser 1984, Moiseev et al.1985). The cardinal difference is change of values of the flux coefficients when original biome is replaced.

A time-dependent climatic scenario for Russia has been designed. It is presented by various power functions of time variable, connecting fixed initial and final states of vector of climatic parameters. We assume that the climate reaches its final state after 100 years. The initial climate was extracted from IIASA database. The final climate corresponds to the "hybrid" scenario for doubled CO_2 in the atmosphere. Three scenarios of general circulation models and three paleo-analogy scenarios have been used for the hybrid scenario.

The designed model was analyzed to examine number of stable states and their stability.

A number of computer experiments has been conducted to estimate vegetation shifts and correspondent dynamics of terrestrial carbon pools. One of the important results was a compensation effect of the vegetation redistribution: the pattern shifts increase absorbing of the atmospheric carbon by terrestrial cover. Thus, long-term accumulation of the carbon by vegetation is bigger in the case of the pattern shifts than in the case of the fixed original state. It is interesting that even experiment, when forest biomes cannot migrate and replace the other biomes, also demonstrates compensation effect. The result shows the important role of non-forest vegetation in absorption of the additional atmospheric CO_2 .

The model would be the basis for further development of suggested approach, including coupled description of processes at different hierarchical levels in vegetation.

Keywords: bioclimatic scheme; model; vegetation shifts; carbon pools; time-dependent response.

Student perception in the use of computational tools for building performance analysis

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<u>Abstract</u>

University teachers must take responsibility for *what* and *how* their students learn and be aware that 'concentrating hard is not necessarily understanding' Teachers should create the conditions in which understanding is possible- the student's responsibility is to take advantage of that situation. To facilitate these aims many different teaching and learning techniques are used nowadays and 'educational technology' is heavily funded, particularly in the Higher Education sector. Unfortunately, vast sums are often made available to facilitate the 'method' but the subject matter taught and student perception in its use are incidental aspects. Teaching strategies are undergoing radical re-appraisal and the focus is on 'presenting the learner with new ways of seeing' and the creation of a different interaction between student and teacher.

The study of building engineering services and environmental science on undergraduate construction management courses requires students to grapple with a wide range of peripheral aspects, particularly in building physics. There is now a plethora of computer software available for analysing the physical processes which affect the performance of occupied buildings and much of this utilises very sophisticated mathematical modelling techniques to examine heat transfer and fluid flow processes.

This paper describes the design of a project currently underway at Leeds Metropolitan University (LMU) which introduces second year undergraduate students, with minimal computer knowledge but having a reasonable building science background, to the use of a sophisticated, commercially -available thermal modelling package (APACHE) for analysing the energy consumption and internal environmental parameters of a building subject to real weather influences (albeit historical). The effects of, for example, architectural changes, material specification modifications and operational parameters can be simulated singly or in combination. To facilitate the use of the software a study guide has been written students being provided with individual copies, the software being accessed via twenty terminals on a Local Area Network (LAN).

There is no attempt to expose students to the mathematical concepts and techniques inherent in the design and operation of the software. The aim is to allow the student rapid access to the power of an excellent analytical tool in order to develop critical and investigative abilities, to stimulate curiosity and to exercise engineering judgement. Initially the student uses written scenarios, "self-building" the model using a step-by -step guide based on the software author's manual but prepared in a more user-friendly format. Model answers and discussion are provided and these lead the student to self-assessment questions about alternative scenarios. The detailed study guide is commercially available from LMU.

Student perceptions have been monitored in tutorial sessions with encouraging results, and overall opinion is that this approach is a genuinely useful alternative to traditional lectures. Feedback from students has suggested that some revisions/improvements are nontheless appropriate and this is to be addressed as the project evolves. Generally there was a marked improvement in understanding as the course progressed, and it is considered worth extending the approach for use with a computational fluid dynamics software package.

Modeling and Optimization of Carbon and Nitrogen Elimination

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On the background of risen costs for nutrient removal from wastewater a new treatment process for carbon and nitrogen elimination has been developed. Using this process the extension or reconstruction of wastewater treatment plants becomes cheaper. The intention of this paper is to present a simulation model of the new process taking into account the activated sludge model (ASM) No.2 from the IAWQ. It will be shown that it is possible to optimize the complex process of carbon and nitrogen elimination.

The process consists of a three-step treatment and corresponds to a post denitrification with respect to the sequence of the unit operations. The first step - a carbon elimination - works as an activated sludge process. Here, an essential property is the carefully directed adsorption of organic carbon compounds by the activated sludge. The adsorption results in accumulation and storage in the bacteria and can be influenced by the aeration rate.

The second treatment step is a nitrification in a packed-bed reactor followed by a denitrification in a stirred tank reactor which represents the third step. The important characteristic of the whole three-step process is a bypass stream of recycle sludge from the first step to the denitrification tank. The adsorbed carbon in this stream is used as a substrate for denitrification so there is no need for an external carbon source. In addition, there exists a recirculation of recycle sludge from the third step to the oxidation/adsorption tank. This exchange of sludge between the first and the third step causes the complexity of the process since nitrification is relatively easy to handle with respect to process engineering.

Besides the regulation of aeration in the oxidation/adsorption step the bypass stream has to be controlled carefully. The main criterion is a minimization of the stream in order to minimize ammonia and COD (chemical oxygen demand) in the effluent. On the other hand sufficient carbon for denitrification has to be provided.

The whole three-step process has been tested in a pilot plant which is equipped extensively with measuring instruments. Observations of the dynamic behaviour of the process were used to develop a simulation model with special regard to adsorption, accumulation and storage of organic compounds in the sludge. This work has been done taking into account ASM No.2 and describing in addition the adsorption and its influence on the denitrification rate.

Based on measurement data from the pilot plant verification and validation of the model have been performed. In particular an accurate determination of the kinetic parameters was necessary. This way a reasonable agreement between predicted and measured data has been obtained. Therefore it is possible to use the model for process optimization and control.

Simulating Multimedia Communication Systems

Poster Summary

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Multimedia and the Internet have been the largest growth areas in the computing arena of the 1990s. The introduction of the WorldWide Web (WWW) saw the first major convergence of the two areas, and web traffic now accounts for some 30% of all Internet traffic, up from around 1% at its introduction. If the current rate of growth continues, multimedia traffic on the Internet will exceed worldwide telephony traffic before the end of 1996 [1].

While the web, with its friendly graphical front end and ability to access a wide variety of information, is a tremendous boon to end users, it places a great strain on networks. The problem which the web poses is twofold:

- firstly it makes it much easier for users to access information which has always been available;
- secondly it makes it easier to access newer multimedia information such as still images, video and audio and even to play these in real-time over the network.

Both of these effects result in a huge increase in the load placed on the network, with a resulting decrease in quality of service. The ability to quantify this quality of service is necessary for network operators to plan network expansion. Unfortunately, theoretical models for networks dealing with multimedia traffic are less mature than those for conventional packet-switched data networks. In addition, few commercially available network simulation packages have the ability to deal with multimedia traffic and new multimedia protocols built in.

This poster examines the possibility of using relatively low-end (and hence inexpensive) simulation packages to model two multimedia communication systems. We first develop traffic models based on some short MPEG clips and published research. We then compare mechanisms for generating traffic according to these models using the relatively simple statistical distribution functions built in to many simulation packages. Finally we use these traffic models to drive simulations of two communication systems: packet video on an Ethernet LAN and multimedia traffic on a newly proposed ATM switch architecture.

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Modelling and Simulation of Power Plants for Stability Studies

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Key words: modelling, simulation, nonlinear analysis, power plants

With respect to process dynamics, boiler-turbine systems are very complex continuous processes, because of different concurrent reasons: structural complexity, strong nonlinearity, interaction among subsystems, relevance of distributed parameter phenomena, considerable uncertainty of process parameters at macroscopic knowledge level (heat transfer constants, friction, flame radiation, two-phase interaction etc.).

In view of their great technical and economical importance in the power industry, the dynamics of boiler–turbine processes has been the object of considerable research effort. Most of the works come from the process control community: for that reason, simple global boiler models suitable for control design were essentially proposed though some papers more widely looked at application of numerical techniques. However, global models are rather convenient to understand the gross behavior of an existing plant than reliable to predict the dynamics of a new plant during the design phase, since such models, incorporating drastic simplifying assumptions, generally need ad hoc tuning.

Analyzing the stability of the first swing of electrical power systems, the power plant can be modelled very simply by an exosystem only, which describes the ability to outstore the stored energy within the plant to stabilize the global system. For long term stability studies, the dynamics of the plants must be modelled more detailed. Compared to the models e.g. boiler manufactures use, they are simple ones with low order. These models are essential to study multimachine power system frequency dynamics, in which case very crude assumptions are made about the boiler while keeping a better representation of turbine and speed governor.

Fossil fired power stations with fixed pressure and modified sliding pressure working conditions are considered essentially. Well known power plant models suitable for dynamic studies of electrical power systems were used, to describe the necessary dynamical behavior from the view of the electrical net. The proposed model is mathematically in such a shape, that the nonlinearities of the plant are approximated by nonlinear functions with analytical properties, were the physical structure of the plant is preserved. Therefore, this model can be used in the future for analytical nonlinear controller design of more sophisticated frequency–power–controllers. Also, due to the smoothness of the nonlinear approximations, it has good numerical properties in simulation studies. The model is incorporated into a matched simulation structure based on MATLAB/SIMULINK and is conceived to be connected with other models of power system elements with respect to boundary conditions.

Further, the derived simulation model can be used as a stand-alone model and is designed to use it for teaching of power plant dynamics with an easy to use control mask for parameters an inputs.

Modelling of falling slurry film absorber applied to flue gas desulphurization process

in combination with heat recovery

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ABSTRACT

Non stationary model of wet limestone desulphurization process for coal fired power stations was developed to study chemical and physical phenomena during operation. Model of SO_2 absorption from flue gas to counter current flow of falling slurry film inside vertical tube(s) was developed. Properties of falling film inside vertical tube were calculated according to literature data about laminar, wavy and turbulent film flow regime:

- From liquid entrance (at the top) to developed waves area, the properties of laminar film area were calculated
- In main area developed film waves were modelled by additional division. Single wave was divided to wave's front, back, trail and substrate. Each mentioned part of wave has specific hydrodynamic properties.
- At film flow regimes with Reynold's number greater than 2000, combined wavy and turbulent film flow was modelled.

Mass transfer of SO_2 across gas/liquid phase boundary was calculated taking into account mass transfer resistance on gas and liquid side, Henry's constant of SO_2 , and absorption enhancement because of further chemical reaction in liquid phase. In addition to mentioned model of falling film and mass transfer also the following chemical reactions were modelled:

- Chemical reactions of absorbed SO₂ including chemical equilibria of sulphates (IV), sulphates (VI) and carbonates. Based on electrical balance of all charged ions, new equilibrium pH value in any modelled liquid element was calculated.
- Oxidation of sulphate (VI) ions to sulphate (VI) ions by forced air introduction to slurry conditioning tank(s).
- Polidisperse dissolution of limestone particles in slurry at given chemical conditions.
- Precipitation of gypsum (CaSO₄·2H₂O)
- Partial precipitation and dissolution of calcium sulphite (CaSO₃·2H₂O)
- Stripping of CO₂ gas liberated from limestone dissolution.

Also heat transfer from liquid film across tube wall to surrounding cooling media was calculated. It was found that all resistance is located on the side of surrounding flow of media. Simultaneous absorption and heat transfer have been verified in laboratory apparatus consisting of concentric tube type absorber heat exchanger. Good agreement between model and experimental data regarding SO_2 removal rate at various operating conditions was found.

Model divides falling film absorber to vertical slices of liquid and gas, which are in contact in appropriate iteration time. In that way, absorber profiles are calculated. Also chemical composition of slurry conditioning tank(s) contents are calculated. Model was implemented as computer program for IBM PC compatible computers.

Results of modelling show that low temperature heat can be recovered from flue gases in absorber/heat exchanger. Depending on flowsheet it has been estimated that 2.3 % of heat produced in the boiler can be reused for boiler air and condensate preheating and for the flue gas re-heating. Part of high-heat value can be recovered by flue gas cooling under dew point.

SIMULATION OF VISUAL CROSS-TRACKING

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The most complex problem which can be considered in the theory of correlation and data association is that of multi-target tracking. Ambiguities arise when targets are closely spaced as in the case of two crossing targets. When two target are crossing each other, it may be very difficult to determine which measurement belongs to which target. In this situation, miscorrelation could occur.

Although developments have been made on the crossing target problem, it remains an area which merits further consideration. The aim of this work is to introduce a new algorithm to deal with the crossing tracks in a multi-target environment. However, to establish some ideas for dealing with the problem and to test the suitability of different methods, the simpler problem of two crossing tracks is first examined.

In the processing procedure, the order of the recorded data is not important. Here, two aircraft with random acceleration perturbing their motions from a straight line are considered. The position of the targets are measured at uniformly spaced intervals T seconds apart, and each observation is noisy. The accuracy of position and velocity estimates depends not only upon the sensor accuracy, but also upon the perturbing acceleration and upon the sensor geometry. The problem is to determine the accuracy with which the aircrafts' trajectories can be estimated.

Three approaches have been investigated for dealing with the problem of two crossing targets. The first approach makes use of a limited batch processing technique to create all possible tracks based on four scans data and then decide on the most likely pair. Two criteria have been used for pruning, one terminating tracks which change slope too rapidly and a second tracks with higher total variances.

Here, the underlying assumptions of the least squares method were applied. The errors were computer generated with Gaussian distribution, zero mean, and constant variance. Then, these errors were added to the ideal data points and the simulation tasks were performed by means of 100 runs in each step. The simulations were carried out for the following three cases:

- 1 Situation in which the errors associated with y-values were dominant. Here, a second degree polynomial fit was applied.
- 2 Case where both x and y-values were subject to errors of about he same order of magnitude. A straight line was chosen to fit the data points. Here, the minimisation of the sum of the squares of the perpendicular distances from the data points to the line was considered as the minimisation function.
- 3 The same as case two except the data points were fitted by a circle.

Our aim in this paper is to make a comparison between the results obtained here with those of our previous approaches to come to a better understanding of the problem and therefore a better solution.

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Professor Norman E. Gough School of Computing and Information Technology University of Wolverhampton, Wulfruna Street, Wolverhampton WV1 1SB Fax: +1902 322680 E-mail cm1822@wlv.ac.uk SIMULATION OF SHAPE CHANGE OF BIOLOGICAL CELLS DUE TO EXTERNAL HIGH FREQUENCY ELECTRIC FIELDS IN THREE DIMENSIONS. Reinhard Grebe, Guido Bartsch and Martin Baumann

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Introduction High-frequency homogenous and inhomogenous electric fields can be used to apply defined anisotropic forces on biological cells or parts of them. Mechanical properties of the cells can be calculated, if the resulting changes in cell geometry are quantified. Typical properties of interest are shear modulus, global elasticity modulus and others. The shape quantification can be done by light microscopy and image analysis. Most of the investigated cells do not show any kind of symmetry. In addition it turned out that it is extremely useful to use inhomogenous electric fields in these experiments. So, we can not compute *analytical* solutions, but use a finite-element method for *mumerical* solutions of the three-dimensional field problems instead.

Methods and Materials Fig. 1 shows the principle design of our software package. The first step is to construct a discrete model using the FAM (Fegs, Cambridge, UK) preprocessor, which allows an efficient tetraeder meshing. Fig. 2 gives, as an example, the model of a spherical thin shell in a homogenous electric field. The first of three interfaces - pre2solv -



Fig 1: Dataflow during construction, meshing, solving, visualization and remeshing.

takes over the FAM ASCII data output containing the geometrical data and the electrical and bounding information and converts it into a matrix. This matrix is solved by our FE solver, a C++ program. This program runs under PVM, which makes it easy portable. The solver itself produces a file containing data needed to calculate forces and corresponding cell shape changes. The complete data set is redirected to the preprocessor for remeshing via the second interface - solv2pre - after the new geometry is computed. Since cell geometry and electric field lines and thereby forces depend on each other the loop described has to be reiterated as long as there are significant changes in any of the magnitudes. As soon as an equilibrium state has been reached, the iteration is stopped and the solver output is converted in the third interface - solv2post - to a FAM postprocessor readable file. This postprocessor performs the visualization of the results. Fig. 3 gives an example, where the calculated equipotential lines of the above mentioned shells are drawn.



Fig. 2: meshing sample



Fig. 3:equipotentlial lines

THE RED BLOOD CELL SIMULATED AS A CLOSED TANK-TREADING FLUID MEMBRANE UNDER NORMAL FLOW CONDITIONS IN TWO DIMENSIONS Reinhard Grebe and Frank Kreuder

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Introduction Nearly half the blood volume in normal healthy human beings consists of cells, mostly red blood cells (RBC). Blood behaves like a suspension of stiff particles in big arteries where mainly small shear forces are to be found. In small capillaries where high shear stress acts on each single RBC, blood is more similar to an emulsion of droplets. Even.a concentrate of up to 90% blood cells is able to flow out of a reaction vessel. In contrast densely packed spheres can to the utmost hold 74% of a volume and will show properties of a solid body. The reason for the described blood dimorphism may be due to the single RBC's ability to undergo a complex cell and membrane movement called 'tanktreading'. Until now tanktreading has only be observed in vitro under the influence of high shear stress [1]. To get a better understanding of the described RBC properties we start here with a two-dimensional simulation to investigate single cell behavior under shear stress in a hydrodynamic field. **Foundations** To simulate a RBC in a hydrodynamic field we model

- the medium as a fluid passing a volume bordered by fix boundaries driven by an arbitrary pressure difference,
- the interior of the cell as a fluid of constant volume and distinct viscosity and
- the cell membrane as a two-dimensional fluid with constant area of surface.

To compute the properties and time dependent changes of each of these fluids we use a set of equations including

- equations for to establish the needed continuities especially of volume,
- specially adapted Navier-Stokes equations and
- boundary conditions for the kinematics and forces of the different fluid regions.

Methods We use a combined method to describe the discretized mesh-elements of the different fluids - *Lagrange* for the external medium with unchanging boundaries and *Euler* for the variable geometry of cell interior and membrane. According to the so-called MAC-scheme [2] there is a shift of half the length of a grid element between the mesh of pressures and of the two vector components of velocity respectively. Furthermore we increase the resolution for the elements of the moving boundaries by 100. The program is written in C and runs under PVM.

Tests To test the algorithms and their implementations we solved some standard problems well documented in literature. We simulated the stationary flow between two plates as establishing after a step functioned rise of pressure. More complex has been the 'driven-cavity' problem where systems of timedependent vortices appear and disappear in a cavity driven by a peripheral flow [3].

Simulations To simulate the RBCs behavior under shear stress, we introduced RBC-models of different viscosity in driven-cavities. Cells with an internal viscosity 10 times higher than the surrounding medium showed the behaviour of a solid, while cells with normal viscosity showed the 'tanktreading' called movement of the membrane around the cell interior. The results have been visualized in a computer animation.

Problems To avoid instabilities during a simulation run, the single time step t should be chosen according the formula $\Delta t_{max} \leq (\Delta x^2) / (4 v)$. A model on the realistic microscopic scale would therefore need in our present implementation a CPU-time of 500 years for 1s of simulation. That is why we have so far performed our simulation only in the macroscopic regime.

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AUTOMATED DEVELOPMENT OF KNOWLEDGE BASE IN FAILURE ANALYSIS OF TECHNICAL SYSTEMS BASED ON STRUCTURAL MODELLING METHOD

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There are many methods and tools for fault diagnosis. A common approach has been to apply techniques, based on structures. A more recent phenomenon is the application of artificial intelligence in this problem domain. In two papers Grundspenkis (1993, 1994) proposed to combine these techniques in methodology of structural modelling for failure analysis of complex technical systems in conditions of incomplete information. The essence of structural modelling method is that an expert's understanding of how a system operates is organized as a representation that reflects the morphological (physical) structure of a system, its functions and parameters of each component. Three kinds of corresponding structural models are used, which are visualized by digraphs.

The development of knowledge base is divided into two phases. The results of these phases are the topological knowledge base (TKB) and the deep knowledge rule base (DKRB), respectively. TKB is developed using a systematic knowledge acquisition process where the main sources of the knowledge are documents about system and human experts. TKB is organized hierarchically and represents the knowledge as structured objects consisting of named slots with attached values. A frame hierarchy as knowledge representation language is used to encode information about systems components, their functions and behavior as well as information about relationships between components. TKB is a passive component of a knowledge-based system for failure analysis.

TKB supports both well-known inferences, namely, forward and backward chaining, because causal event chains allow to generate a tree structure from causal relations represented in that part of TKB that contains knowledge captured in a model of functional structure in a space of parameters (FSM SP). Formal method based on decomposition of FSM SP is used to derive a set of event trees. Each event tree has its root - the final event (symptom to be observed), and leaves represent possible faults of components (primary events). To make inferences effective when implemented, the set of cause-consequence (C-C) rules are used. The decomposition of each event tree is carried out in such way that each obtained subtree contains only one logical operation. Every subtree corresponds to one C-C rule. The set of C-C rules which are derived from all subtrees compiles the deep knowledge rule base (DKRB).

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MONTE CARLO CALCULATION OF ENERGY LOSS DISTRIBUTIONS AT TILTED INCIDENCE OF ACCELERATED ELECTRONS TO SOLIDS

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Abstráct

Monte Carlo simulation (MCS) is a most widely used technique for obtaining the spatial distributions of absorbed electron energy density in resists as applied to electron beam lithography (EBL) due to its advantages over other methods. However, one of these advantages, namely the possibility of modeling the scattering of fast electrons impinging on targets of complex topography is, as to our knowledge, not properly studed and exploited so far in regard to EBL, but it may be of interest in some particular applications. This problem can be brought, as the first approximation, to the simulation of tilted incidence of accelerated electrons to solids. There are several papers addressed to the latter one [1-4] but they consider mainly backscattering of electrons. As far as we know, all results on energy deposition of fast electrons reported hitherto are obtained for normal incidence of primary electrons.

Therefore, the aim of this work is to simulate the scattering of fast electrons impinging at angles different than 90 to the target surface and to obtain spatial distributions of absorbed energy density in the resist, deposited on substrate of the material most widely used in micro-electronics, namely silicon.

Such distributions in 125 nm resist layer on bulk Si substrate are obtained numerically by MCS for angles of incidence 30, 45, and 60 at two beam energies - 25 and 50_keV. The results show strong asymmetry of the distributions. Their peaks, commonly associated with the forward scattered electrons, are of lower values and 50-100 nm shifted and the shapes are different in comparison with those for normal incidence of electrons. These peculiarities of exposure distributions may lead to an enhanced proximity effect in the part of the exposed structure as well as to the absence of the proximity effect in the other part. The latter one can be used for improving the shape of the exposed pattern when a periodic (e.g. comb-shaped) structure is to be created. In all cases, if a tilted incidence of accelerated electrons to any surface occur during EBL it has to be taken into account.

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A NUMERICAL INVESTIGATION OF A REFORMER OPERATING IN FUEL CELL POWER-GENERATION SYSTEMS

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ABSTRACT

Fuel cell systems convert chemical energy derived from a fuel directly into electrical energy. A reformer, which converts the higher hydrocarbons in the natural gas into hydrogen-rich gas that is generally more appropriate fuel for the fuel cells, has often been used in the fuel cell systems. A reformer operating in fuel cell systems differs essentially from its operating in process plant, where continuous full load operation is the rule. A reformer for fuel cell systems is required to operate in such a manner that the production of hydrogen-rich gas to a fuel cell always follows the changes in the demand of power. It is therefore required that the reformer should display rapid responsiveness to load changes and flexible controllability. There are still few investigations on the dynamic performance of a reformer in fuel cell systems. Hence, the dynamic performance of a reformer operating in fuel cell systems is studied here.

The main phenomena in a heat exchange reformer (HER) from Haldor Topsoe are firstly analysed, and then the modelling approach and the evaluation are carried out.

The HER uses a principle with a combination of counter- and co-current heat exchange between the process gas and the flue gas, in order to maximize thermal efficiency and to optimize usage of construction materials. Consequently, the idea of HER is to combine the two heat transfer principles in a two-bed catalyst system. That is, the heat exchange of counter-current flow is used at the low temperature side and co-current flow is used at the high temperature side. In order to reach equilibrium faster, the fuel processing reactions are performed in catalyst beds. The heat passes through the tube walls by conduction and is transferred to the catalyst bed by convection and radiation. At the same time, the chemical reactions create temperature and concentration gradients in the radial direction of the tube and around and within the porous catalyst particles.

The overall performance of a reform is related to the burner duties, the feed stream characteristics, catalyst properties, and reformer geometry and properties. The main processes of HER, are identified as:

- chemical reactions in the process and flue gas
- heat transfer from the flue gas to the process gas
- mass-transport of flue and process gases

Accordingly, a reformer model is developed, which can consider simultaneously the dominant processes of a reformer, such as chemical reactions and heat transfer as well as mass-transport. The present reformer model has been successfully implemented in the SpeedUp code.

To evaluate the reformer model, step change testing is carried out. The processed gas from the reformer determines the fuel cell power-generation. Therefore, the dynamic responses of the product-gas's flow-rate, pressure, temperature and H_2 concentration are demonstrated. Particularly the following three step change cases are used to illustrate the dynamic behaviour of the reformer model:

- flow rate of process gas ± 10%
- temperature of flue gas at inlet ± 10%
- pressure of process gas at outlet 10%

These response results appear to be reasonable and have provided valuable insight into the characteristics of the reformer operating in fuel cell systems.

A Telecontrol Display Simulatiom Which is Composed of Virtual Environment and TV Realistic Image.

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ABSTRACT:

In this paper, a new telecontrol system which is composed of Virtual Reality and TV Realistic image is described.

This system adapts an unmanned vehicle. A camera with a following-up system and a special optical system which can make two TV images, that is one is left image and another is right image is mounted on the vehicle. The TV (left image and right image) images are transmited to head-mounted binocular display system which displies the stereo environment around the vehicle.

The color three-dimensional graphics which are made by a computer display the environment inside steering room. The graphics which are separated into two graphics: one is left graphic and anather is right graphic are transmited into the head-mounted binocular display system too.

Then the virtual reality and the TV image make a truly realistic pictures of telecontrol environment.

In order to develop above system, we must solve the following key techniques :

1: Research on a fast matching algorithm which can complete the match of virtual environment and TV image in real-time.

2: Research on a knowledge-based hidden algorithm whose time-coplerity is so low that it can be finished in real-time.

In order to use this system for simulating driving a car along some road, we can use the special TV camera system and a videorecorder to recorde the sceneries which stand by the side of the road, when we drive a vehicle along the road.

Then using the videorecorder image and the graphics which display the environment inside steering room, we can simulate the full process of drving a vehicle along the road.

Electro-Magnetic Field Simulation of Cable in Metallic Duct

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An accident was reported of parched cable at the bend in the metallic duct for the use of instrumentation of a factory in Japan. The cross sectional area of metallic duct is the closed rectangular form of 250 \times 200 mm where 62-wires are installed. The current is 3.5(DC)+25.5·sin(2 π ft) [A] for each wire, where f=26kHz. The cable was manufactured at 1989. The parched part of the cable was discovered in the part of bend at 1994. The bend is the tansition between horizontal and vertical part where the wires were loosely bound but tightly at the part of bend to fix. Detailed discussion was made[1].

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Here, the useful results are reported by using electro-magnetic field simulation software named "hfss" istalled in HP 9000 series 750 CRX APOLLO. The electro-magnetic fields are observed in consentarion at the part of bends, resulting overheating mainly by resistance of wires. The diagram gives the useful data of current density versus the angle of bend of cable for future installation of cable in the factory. In general, the bridging is the future interesting theme between the electro-magnetic field approach and the heat conduction in some materials.

<u>Reference</u>: [1] Report on the damage of HKPCV cable, Nihon Electric Wire & Cable Co. Ltd. 28, April, 1994.

AN ADAPTIVE USER INTERFACE FOR CONSULTATION OF A MULTIMEDIA DATABASE. APPLICATION IN PRINTED TEXTILES.

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Abstract:

An adaptive man-machine interface requires a dynamic user-model and an adaptation strategy in agreement with the logic of utilization.

The work presented in this paper deals with the consultation of the multimedia environment that we have developed for the $MISE^1$. This environment, with its three software programs, allows us to build and to present the museum's collection of fabric patterns. These 3 million fabric patterns are accompanied by extracts of textual and aural information in several languages.

The users of this environment are from various origins (textile manufacturers, scientists, students, etc....) and have very different objectives. Choosing a pattern can take from a few hours up to a few days. In this context, the interface has to take account of the user's behaviour or help him in his choice, thus minimizing the consultation time. In order to achieve this goal, we are developing a modeller to add to the interface of our environment which defines a model describing the user, according to his tastes and needs. This modeller is based on an annotated knowledge graph and is used to gradually replace the functioning logic of the system by the logic of utilization.

Thus defined, this interface will be capable of following the evolution of the different media used by the environment as well as the user's behaviour.

Keywords:

Consultation, User model, Adaptive user interface, Modeller.

¹ Musée de l'Impression Sur Etoffes (Museum of Printed Textiles - Mulhouse - FRANCE). The MISE has a collection of 3 to 4 million of textile samples dating from the second half of the 18^{th} century.

EXPERT KNOWLEDGE IN THE MODEL DEVELOPMENT PROCEDURE FOR THE NITRENDIPINE SUSTAINED RELEASE DOSAGE FORM DESIGN

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The goal of the present study is to develop the sustained release dosage form for Nitrendipine (only one dose per day) by the aid of pharmacokinetical modelling and computer simulation stressing the points where the inclusion of expert knowledge is crucial for the successful course of the study.

Here the nitrendipine can be introduced as a modern antihipertensive drug being administered via peroral dosage form. It is known that it has linear kinetics with complete absorption to the portal circulation and extensive metabolism, which represents the main route of elimination from the plasma. Very precise analyses with gas chromatography indicates the possibility of deep peripheral compartment existence which maintains pharmacodynamical effects of drug by the slow transportation back to the central compartment-plasma.

Mathematical modelling procedure based on the data of the four dosage forms of nitrendipine namely: intravenous application, oral application of the solution in the capsule, tablet with normal and tablet with sustained release. So by the aid of expert knowledge, the nine compartment model was developed including shallow and deep peripheral compartments which represents the mechanisms of nitrendipine acting. In the procedure of model development the very interesting fact came out. Namely the model responses were matched very well to the measured data (plasma concentrations time profile) only by changing the dissolution rate constant what shows that the dosage form is mainly responsible for the nitrendipine kinetics. Finaly the dissolution rate constant was found, which enables nintrendipine sustained release dosage form design for only one dose per day regimen.

DETERMINING THE CONDITIONS OF RELIABLE OPERATION OF CERMET HEATING ELEMENTS BY MEANS OF SIMULATION

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Abstract.

At the present time the cermet heating elements (CHEs) are widespread. They are used in various devices and apparatuses from household appliances to thermostating systems of spacecrafts.

CHE has the form of a plate in which resistance element is placed. This resistive element is a wolfram-molybdenum conductor. The electric leads are soldered to lands on CHE surface. Such a structure of the CHE possesses the number of valuable properties (possibility to work in aggressive media and with high temperature, satisfaction to ecological standards and conditions of electric safety). However, one of essential lacks is the destruction of ceramic plate at relatively

small temperature gradients $(\operatorname{grad} T)_{crit}$ which cause the appearance of thermal stress. The value of electric current has essential influence on reliable operation of the CHE too. Exceeding the permissible value of current can cause the burning of the resistive track (the wider the track the

grater the permissible value of current I_{perm}). There is also a limitation on the temperature of heater, for example at the zone of attaching the electric leads. Exceeding the temperature at this

zone over a permissible value T_{perm} causes the disconnection of leads.

It is not a success to determine the values of critical thermal stresses and critical temperature gradients with necessary accuracy by direct measuring because of the number of technical and technological difficulties. It is possible to determine only temperature at CHE surfaces and electrical performance by direct measuring.

Temperature gradients, temperature field and the value of electric current depends on voltage U applied to the CHE and intensity of heat removal from its surfaces, which is specified by environment temperature T and heat transfer coefficient h. Therefore the life area of the CHE is determined by three conditions

$$(\operatorname{grad} T)_{orit} \ge f_1(U, h, T),$$

 $I_{perm} \ge f_2(U, h, T),$
 $T_{nerm} \ge f_3(U, h, T).$

Determining the life area of the CHE in accordance with regime parameters allows to reduce experimental-calculating investigations (such performances as fatigue strength and lifetime), number of regime tests and, hence, to reduce the cost of investigations.

The mathematical model of the thermal process taking place in the CHE, the calculating procedures of the determination of its thermal and electric performances, the calculating procedure of determination of its life area in accordance with regime parameters and calculated life areas of several CHEs are presented in the paper. It is also described the experimental-calculating procedure of identifying the intensity of heat removal from the surfaces of CHE with the simultaneous determination of thermal and electric performances on the basis of the temperature measured when thermocyclic tests are carried out. The abovemantioned procedures are realized as software that allows to carry out thermocyclic tests of CHEs at workstation for the investigation of their operation.

MULTILEVEL SIMULATION OF A MILITARY MESSAGING PROTOCOL OVER TACTICAL COMMUNICATIONS NETWORK

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Tactical military communications networks differ in many significant ways from conventional computer and communications networks. Unlike civil radio communications systems that are carefully planned and have well placed antennas, military radio systems have no such advantage and also have to cope with high levels of interference, both deliberate and otherwise. Thus tactical communications links are, and will continue to be, less than ideal. Traditionally, military networks employed purpose-designed protocols and architectures that took the nature of the links into account. Tactical networks also differ from their civil counterparts in that the network topology is not fixed and can be highly dynamic because of failing links and node mobility. In addition, military requirements such as avoidance of single-point failures mandate the use of automatic, distributed network control. Thus gaining an understanding of the performance of military networks is not a simple matter particularly as much of the network modelling and simulation work performed by the civil communications research sector is not entirely applicable. In this paper we discuss our philosophy on how to model tactical links and networks and illustrate it using civilian messaging protocols as our network application.

Messaging protocols comprise a methodology to exchange messages between originators and recipients. Currently the main example of a layered system of protocols is OSI (open systems interconnection) which has been developed by the ISO organisation as a framework for development of protocols. Common protocols are TCP/IP, X25, X400 and all of them satisfy basic requirements in order to provide a message exchange service (the message must not get lost or be changed in transit, the entities handling the message must be able to interpret the message, etc.)

In specific, military tactical environment some additional factors determine the efficiency of message handling protocols. Messaging security issues are of the prime importance, protocol overheads definitely slow down the throughput of information. Confidentiality, integrity (the content of received message is the same as that which was originated), data origin authentication (the message was originated by the user as indicated by sender), access control (messages sent and received must not violate the security policies of either originator or the recipient) are just a few desirable properties of such message handling. Directory service availability is also a slowing factor in the performance of military tactical messaging, as well as the provision of the message retention (maintaining the time traceability of documents exchanged over a network).

Multiple communications architectures that have to be used in tactical situation influence the messaging efficiency. We simulate (using OPNET) messaging architectures where links are established using the HF, satellite, cable, line-of-sight, fibre optics, ATM or other communications media. We explore the effect of additional overheads over a broad range of known protocols, as well as some new ones.

SIMULATION OF THE MECHANICAL BEHAVIOUR OF DENTAL IMPLANTS

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Man's chewing mechanism is a biomechanical system where the different components (mandible, muscles, teeth, etc.) are subjected to various kinds of forces and are shaped in such a way as to bear and resist to such loadings. Loss of the natural teeth brings about the need for a replacement structure which is usually embedded in the jaw bone by means of abutments (osseointegrated prosthesis). The close apposition of bone to implant fixtures results in a stiff connection that transmits chewing forces through the implants directly to the surrounding bone of the mandible, without such natural stress-absorbing elements as the parodontal ligament. This may lead to the bone being overstressed with the likelihood of bone-resorption phenomenon, loosening of the implants and even microfractures occuring. The study the biomechanical interaction of mandibles with endosseous implants becomes then the basis for designing long-lasting and stable prostheses. In recent years quite a few studies have been aimed at determining the major factors of influence on the stress concentration. Among those: the number of implants, their length and the presence of a more or less rigid connecting bar. The object of this study is the stress distribution in a mandible with implants in both cases, with and without connecting superstructure. In particular, different implants' typologies and different load cases were compared in order to quantify the state of stress occuring both in the implant and in the mandible.

Materials and methods

A three-dimensional linearly elastic model with hexahedral elements was built and implemented in a Finite Element Analysis Program. The jaw's cross-section's geometry was surveyed by slicing the chalk mould of a real jaw; afterwards it was meshed into two distinct zones so that the outer cortical bone and the inner spongy bone could be taken into account. This cross-section was then projected into a third direction to form the basic three-dimensional element into which the abutment can be inserted. The three dimensional development of the jaw was described with enough accuracy by a parabola. As a result the basic three dimensional element was copied in a number of point described by this parabola. The last step was simply connecting the three dimensional elements. In total, the model consists of 1272 elements with 1784 nodes. In the model both the tissues, the abutments and the bar were regarded as homogeneous, isotropic, linearly elastic materials. The load cases considered were a 70 kg, static and axial force on the solitary abutment, on the connecting bar and finally on the extension of the bar beyond the abutment (this is an ultimate value for the force). All of them were combined with an horizontal component.

Results

The stress distribution within the elements of the abutments and connecting bar was expressed in terms of Von Mises equivalent stress, whereas for the bone it is important to quantify the tensile stress which leads to biological resorption. It is necessary to point out that among the parameters deemed influent on the stress distribution we disregarded the boundary conditions because the distance from the abutment is such that De Saint Venant's hypothesis are valid and the connecting bar's stiffness which practically the same for a gold (180 HV) or titanium alloy. The results indicate that the largest stress concentration takes place when the cantilever arm of the connecting bar is loaded. The values of Von Mises equivalent stress in the connecting bar are about one and a half times those obtained by loading in between two abutments and twice those obtained by loading the single abutment, reaching the material's failure values. In this case the force is not distributed in the mandible and the failure mechanism will involve the node connecting the bar and the abutment. On the other hand the worst loading condition for the bone is the force distributed on a solitary abutment. The largest compressive stress is located in the upper cortical layer and decreases rapidly into the spongy bone. This result can be explained by the relative (10:1) high Young's modulus of the cortical layer and confirms why the loosening of the implants occurs in the upper portion of the implant stem. Finally, the values of displacements and tension in the other abutments were found in order to understand how the stress is distributed by the superstructure and how, under cyclic loading conditions, this causes the resorption of other abutments.
Simulation of Dynamics and Control of an Electromechanical Robot With Elastic Elements Sergei MIKHAILOV

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The control of rotary motions of the last link of manipulator is considered within the framework of elastic beam model. We consider the lowest elastic vibration mode. In the basis of the assumptions mentioned the equations of motion can be represented in the form :

$$\varepsilon \ddot{\alpha} + \ddot{\alpha} + \dot{\alpha} = U(t) \tag{1}$$

$$\ddot{x} + \omega^2 x = -\ddot{\alpha} \tag{2}$$

Here α is the d.c. motor angle, x is the elastic displacement, U is the voltage in the d.c. motor, ε and ω are pure parameters. Points denote time derivative.

The following control problem is considered for the system (1)-(2): the voltage of electric motor is assumed to be the control function $|U(t)| \leq 1$; at the initial moment of time t=0 the values of state variables are given; the objective is to turn the beam to the preassigned angle α^0 and to reduce elastic displacement; the functional characterizing the control quality is the time of operation $T, T \Rightarrow min$.

The smooth control for the system consisting of vibration link and the electrodrive is constructed. The time optimal control for the rigid link is bang-bang. This means that applying control for the rigid link in the system (2) the large amplitudes of the elastic vibrations will be obtained. We would like therefore to correct bang-bang control to avoid the large elastic deflections on one hand and to reach higher productivity (minimum time of working operation) on the other hand. This can be made by means of the smoothed control. The input of the vibration link is angle acceleration $\ddot{\alpha}$ therefore at the moments of the control switches, large elastic displacements occur. Our aim is to smooth angle acceleration near the points of control switches. The elastic oscillations can be remarkably reduced by means of rational choice of the smooth control functions. In this case low elastic deflections and insignificant increasing the time of operation with respect to bang-bang (timeoptimal) control can be achieved. System of fifth order (1)-(2) have been numerically integrated by Runge-Kutta method with automatical control of step and accuracy.

Conclusions. The outcomes derived by numerical computation are as follows: the amplitudes of elastic vibrations and values of current at the moments of switch during bang-bang control are rather big, which makes difficult the realization of this control; the elastic displacement of the link can be remarkable reduced using smoothed control. As a result the elastic displacement of the link can be practical removed; almost the same time of operation as the bang-bang (time-optimal) control can be reached using the smoothed control. The time of operation slightly increasing (approximately 10%).

SIMULATION ANALYSES OF IRRATIONAL TEMPERATURE STATE IN THE MAIN COMBUSTION CHAMBER OF CFBC BOILER

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ABSTRACT

Presently, irrational temperature state in the main combustion chamber is one of the serious problems which hinder the development of Chinese domestic CFBC boilers. Generally speaking, the temperature is quite high at bottom part and rather low at the top part of the main combustion chamber.

With a view to solving this problem, it is proposed to increase the mass fraction of fine particles in feeding coal. Such a measure is thought to be able to increase the solid entrainment and cause more coal particles to burn at upper part of the chamber.

In order to verify the rightness of this proposal, the general mathematical model of CFBC boiler of Tsinghua University is applied in the simulation of a 50 MW_e CFBC boiler. The model has the capability of considering the broad size distribution of feeding coal and bed inventory. Three operation cases with different size distribution of feeding ash are simulated. It is turn out that, due to the restriction of the characteristics of separator, the temperature state of the main combustion chamber can not be always improved by increasing the mass fraction of fine particles in the feeding ash. This is true only when the mass fraction of those fine particles which are the main body in the circulating ash and could be well separated by the separator increases. Hence, an important understanding is recognized, i.e. the particle mass composition of the dense bed is the ket factor which determines the entrainment rate and moreover the teperature level and profile of the main combustion chamber. At the same time, it is also recognized that the low separator efficiency is responsible for the irrational temperture state and has become one of the primary restraints for the development of domestic CFBC boiler of China.

In order to clarify the effect of separator efficiency on the behavior of CFBC boiler, simulation is carried out with separators with different efficiency. When separator is improved, the following changes take place. Firstly, the mass fraction of fine particles increases in dense bed. Secondly, the solid concentration increases in the upper part of the chamber. Thirdly, the teperature level lowers down and the temperature difference between the bottom and top parts of the main combustion chamber decreases. In other word, when the separator is improved, the behavior of the CFBC boiler is also improved.

Therefore, it can be concluded:

- 1. the particle mass composition of the dense bed is the key factor which determines the entrainment and moreover the teperature level and profile of the main combustion chamber;
- 2. the temperature state of the main combustion chamber could not be surely improved by increasing the mass fraction of fine particles in feeding ash;
- 3. low separator efficiency is responsible for the irrational temperture state and has become one of the primary restraints for the development of domestic CFBC boilers of China.

Controlling Spatio-Temporal Chaos in Two Dimensional Copuled Map Lattice

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Recently many studies of controlling chaos have been done and its application to higher dimensional systems. in which the space structure becomes important, is coming to the attention.

Taking consider of controlling spatio-temporal chaos, all-site control is ideal, but not practical. Therefore, local controlling is thought to be necessary. Hu Gang et_al. suggested a pinning method which is one of the local control methods, and confirmed its effectiveness in the one dimensional Coupled Map Lattice (CML)[1]. However, in experimental systems most of the spatio-temporal chaos is two dimensional. In addition, more complex behavior, probably corresponding to a higher chaotic potential, is expected, so that two dimensional controlling is more realistic and useful, provided that the successful control can be realized.

For this reason, we extended the pinning method into two dimensional CML. With computer simulation of CML, each site of which was described by a chaotic logistic map, we investigated the effect of pinning density and the pinning pattern in the CML. Some of the simulation results are shown in Figure 1.



Figure 1. An example of successful controlling in two dimensional CML. We can change the pattern from (a) spatio-temporal chaos into (c) checker board. In this case pinning density is 0.5.

<u>Referece</u>

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Automatic Configuration of Electronic Circuit

Yuuichi ONO and Nakatomo FURUHASHI

We reported a new electronic circuit simulation program for the investigation of analog and digital circuits. The program was written by use of the C language, so it can be easily implemented on many kinds of computers ranging from personal computers to supercomputers.

If a good idea for a new circuit comes to our mind, the characteristics of the circuit can immediately be checked out by the simulation program. The function of the circuit is determined and can be adapted to design targets.

But, in case of no circuit diagram, the design of the circuit cannot start. Present electronics circuit simulation system is forming by bottom up, namely electronics circuit constructed by small functions. In an analog circuit, the design of an excellent circuit needs high experience and long learning time. Our development aim is to get easy design methods for electronic circuits.

On the other hand, various electronics circuits are made in IC. These ICs are used not only in the electrical and the electronic field, but also in the mechanic field, e.g. for robots, machine tools, motorcars and so on. Engineers except from the electrical and electronic field are easily trained in the use of the simulation program for electronic circuits.

COMPUTER AIDED ANALYSIS AND SYNTHESIS

OF THE CONTROLLABLE VEHICLE SUSPENSION

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Vehicle suspensions must satisfy several conflicting purposes. Besides supporting the vehicle weight, the suspension should isolate the body from vibrations resulting from road unevenness and maintain firm contact between the tires and the road. Moreover, these tasks must be accomplished under a number of constraints. Suspension systems built to perform these tasks can be roughly divided into passive, semiactive and active [1].

Passive suspensions are those found on most conventional vehicles. Roughly, they are characterized by the absence of external power sources, whereas the active suspensions require additional sources such as compressors and pumps, to achieve superior ride and handling performance. The semiactive suspensions then fill the gap between their passive and active counterparts, since they essentially act as time varying dampers and, thus, offer potentially significant performance improvements, while requiring relatively small external power sources. The advantages of semiactive suspensions are low cost and good reliability. The active and semiactive suspensions allow adaptation to changing road surface quality and driving situations and they are now under development at nearly any major car manufacturer. The semiactive and active suspensions are named here "controllable".

Paper deals with the next problems of computer aided analysis and synthesis of the controllable vehicle suspensions: building of the mathematical vehicle, road models and their computer representation; task formulation for optimal control law synthesis and it design; working out of the methodics for closed loop system quality analysis; using of the advanced investigations during training for students.

The paper presents a structural approach, used for creation of the base with car suspension models, which is integrated with MATLAB (The Math Works Inc.).Base consisting of the next car model classes [2] :lumped parameters, space (a full-car), plane (a half-car, a quarter-car, etc.), one mass, many-mass, nonlinear, linear, passive, semi-active, active. It was used four levels during base creation: structural level I, structural level II, analytical level and software level. The base is open. It is planned to add distributed parameters vibration isolation models.

As an simulation example a lecture presents investigation results of isolation effectiveness roll, pitch and bounce motion at independent active car suspension. The vehicle model presented in the research work comprises six bodies: a driver seat, a sprung mass and four wheel-axle assemblies (unsprung masses). The car is assumed to travel at a constant velocity. The driver seat has vertical degree of freedom, the sprung mass is modeled with three degrees: roll, pitch and bounce, and the unsprung masses each has a vertical degree.

The results of this investigation make it possible to give recommendations for application control vibration isolation to a car. It are used during training for students at the courses: "Simulation and Optimization of Dynamical Systems", "Modern control theory".

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SIMULATION OF POWER ELECTRONIC CIRCUITS BASED ON HOMOGENOUS STATE SPACE REPRESENTATIONS Adriana Pastravanu

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1. Introduction

Power electronics circuits are usually represented as cyclically switched systems, each *cycle* being modeled by a sequence of *modes* governed by the commutation of the switching devices (diodes, thyristors, GTO's etc) presuming they operate as ideal switches. The commutations have two distinct natures : *controlled commutations* (which occur as a result of external commands, representing the actual control function of the circuit) and *uncontrolled commutations* (which occur as a result of the circuit dynamics). Each mode lasts between two successive commutations, regardless of their nature and is charactenzed by a unique topology. In computer-aided design of power converters with complex structure, the simulation of the circuit behavior in the vicinity of a steady state plays an important role.

The usage of a general purpose differential equation solver for reaching the steady state exhibits many disadvantages due to the a prion unknown commutation times. Some approaches are exploiting the fact that the topology corresponding to any mode can be described by a linear and time invariant state space model, but the manipulation of these models becomes cumbersome for high order systems when many circuit topologies are sequenced within a cycle.

2. Basic Results

Assume that N_k modes are sequenced within the k-th cycle and the commutation times are given by $\tau_1^k < ... < \tau_l^k < \tau_{l+1}^k < ... < \tau_{N_k}^k < \tau_1^{k+1}$. Consider the normal form of the state equation corresponding to the topology of the l-th mode which lasts between τ_l^k and τ_{l+1}^k

$$\dot{x}_{l}^{k}(t) = A_{l}^{k}x_{l}^{k}(t) + B_{l}^{k}e(t)$$
, (1)

with A_t^k nonsingular and its spectrum located in Re s ≤ 0 . Since e(t) has a particular form, e(t) can be expressed as

$$\dot{u}(t) = Eu(t)$$
, $\theta(t) = Du(t)$, $u(0) = u_0$ (2)

Consequently, (1) may be transformed into a homogenous state space representation:

$$\bar{\mathbf{x}}_{1}^{k} = \bar{\mathbf{A}}_{1}^{k} \cdot \bar{\mathbf{x}}_{1}^{k} \tag{3}$$

Denote by Φ_l^k , Γ and $\bar{\Phi}_l^k$ the *transition matrices* of (1), (2) and (3) respectively, corresponding to an arbitrary time interval $t_0 < t_1$, with $\tau_l^k < t_0 < t_1 \le \tau_{l+1}^k$. Denote by $\bar{\mathbf{S}}_l^k$ the commutation matrix at τ_l^k which ensures the link $\bar{\mathbf{x}}_l^k(\tau_l^k+\mathbf{0}) = \bar{\mathbf{S}}_l^k \, \bar{\mathbf{x}}_{l+1}^k(\tau_l^k)$.

The following two propositions will be further exploited :

(P1) : $\boldsymbol{\tilde{\Phi}}_{l}^{k}$ can be expressed in terms of $\boldsymbol{-\Phi}_{l}^{k}$ and $\boldsymbol{\Gamma}$.

(P2) : Between two arbitrary points of the state space trajectory there exists a linear mapping expressed in terms of an appropriate product of transition $(\tilde{\Phi}_{i}^{k})$ and commutation (\tilde{S}_{i}^{k}) matrices.

3. Case of A Priori Known Sequence of Modes

Denote by N the total number of commutations within a period of a steady state; introduce the vector of controlled commutation times, $\theta^{T} = [\theta_{1} \dots \theta_{M}]$, M<N, and the vector of uncontrolled commutation times $\sigma^{T} = [\sigma_{1} \dots \sigma_{N-M}]$. The steady state value of the normal state vector at $\theta_{1} = 0$, denoted by $x_{n} \in \mathbb{R}^{n}$, satisfies the matrix equality

$$\mathbf{x} = [\mathbf{I}_{n} \ \mathbf{0}] \tilde{\boldsymbol{\Psi}}(\sigma, \boldsymbol{\theta}) [\mathbf{x} \ \mathbf{u}_{0}]^{\mathsf{T}} , \qquad (4)$$

where the structure of $\tilde{\Psi}(\sigma, \theta)$ results from (P2). On the other hand, the uncontrolled commutation conditions :

$$\mathbf{c}_{\mathbf{j}}(\mathbf{x},\sigma,\theta) = \mathbf{0} \quad , \quad \mathbf{j} = \mathbf{1}..\mathbf{N} - \mathbf{M}$$
 (5)

can be also expressed in terms of (P2). The values of x and σ can be determined as solutions of the algebraic system (4) and (5), since θ and u_0 are known. In practice, spurious solutions may be avoided regarding (4) as a nonlinear optimization problem:

$$\min_{X,\sigma} \left[\mathbf{x} - \left[\mathbf{I}_{\mathsf{n}} \mathbf{0} \right] \tilde{\Psi}(\sigma, \theta) \left[\begin{array}{c} \mathbf{x} \\ \mathbf{u}_{\mathsf{0}} \end{array} \right] \right]_{2}, \quad (6)$$

with equality constraints (5) and range-type constraints for x and σ (resulted from a priori knowledge of circuit operation). From (P2) the analytic derivatives are available.

4. Case of A Priori Unknown Sequence of Modes

The uncontrolled commutation conditions must be checked permanently until the steady state is reached. The proposed method relies on (P2); for a given time step h, the simulation advances through left multiplication by $\tilde{\Phi}(h)$. If h satisfies the condition $h\cdot ||\lambda j|| << 1$ for all the eigenvalues λ_j of the homogenous state-space representation (3) of the current mode,

then $\tilde{\Phi}(h)$ has an accurate linear approximation for $t \in (0,h)$. Therefore any commutation condition may be approximated for $t \in (0,h)$ by a linear scalar function whose coefficients are modified at each simulation step. Thus, once a change of sign of a commutation condition is detected, a fast estimation of the corresponding commutation time is given by the unique solution of the linear approximation.

5. Behavior in Vicinity of a Steady State.

In the vicinity of a steady state, characterized by x, σ and θ , the sequence of modes is preserved. Therefore a small signal model can be derived in terms of perturbations $\delta x,\ \delta \theta$ for two successive cycles :

$$\delta \mathbf{x}(\mathbf{k}+1) = \mathbf{F} \, \delta \mathbf{x}(\mathbf{k}) + \mathbf{G} \, \delta \boldsymbol{\theta}(\mathbf{k}) \tag{7}$$

(P2) is extremely useful for the computation of F and G directly by the linearization of (4) and (5) around x, σ and θ . The asymptotic stability of linear sampled system (7) with $\delta\theta(k) = 0$ represents an important criterion for rejecting the spurious solutions to steady state. Time and frequency domain analysis of (7) give a deeper insight into the role played by controlled commutation times in achieving the desired steady state performances.

7. Concluding Remarks

Exploiting the basic properties of the state space homogenous representations, the simulation method and the procedures for steady state, analysis have been successfully applied to power electronic circuits with complex structure (e.g. the PWM AC/DC converter presented in [1]). It is worth noticing that the framework developed in this paper increases the flexibility and applicability of some concepts and results in [2] which, in their initial form, are not suitable for higher order systems and many topologies sequenced within a cycle. The algorithms can be simply implemented in MATLAB and allow a detailed analysis of the influence of different modes upon the global behavior, problem that usually cannot be addressed using dedicated circuit simulators.

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MATHEMATICAL MODELING OF HYDRAULIC SERVOMECHANISMS: ROBUST SYNTHESIS AND SIMULATION

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ABSTRACT

The electro-hydraulic servomechanisms of the control chains of modern aircraft have to cope with ever increasing requirements of stability, response time, band-pass width, damping of the transient regime. There are paper belonging to the specific technical literature: H.V.Panasian-"Reduced order observers applied to state and parameter estimation of hydro-mechanical servo actuators" Journal of Guidance, Control and Dynamics 2/1986; S.A.Ermakov s.a."Proektirovanie ustroistv korrektii elektroghidravliceskih slediascih privodov na osnove nabliudateliu sostojanija" Pneumatica I ghidravlika, 12/1986, Moskva, Masinostroenie, which have already refereed to the application of the modern theoretical methods of the optimal and robust control to electro-hydraulic servomechanisms. These methods generally improve the performances of the servomechanisms acting as automatic tracking systems in the presence of the perturbations transmitted in the input and output, as well as, of the modelling incertitude. The numerical applications of this paper are an example of these assumptions. Starting from some requirements regarding the frequency response of the servomechanism we can design an optimal full-state knowledge LQG regulator that will have good qualities concerning the robustness (gain margin infinite and phase margin more than 60°). These qualities are lost when we use observers. They would be recovered asymptotically using the LTR method that results from the assumption that the intensity of measurement noise tends towards zero. The computational method elaborated on "MATLAB-ROBUST TOOLBOX" was completed as a design stage to derive the LQG/LTR compensator. The behaviour of the electro-hydraulic servomechanism model together with the optimal LQG/LTR regulator is simulated both for the linear and the non-linear models in order to validate the theoretical results. We made a comparison between the behaviour of the electro-hydraulic servomechanism with LQG/LTR controller and a servomechanism with mechanical displacement feedback loop designed by Dowty Boulton Paul Ltd. (having the same design frequency domain requirements) to be used as an actuator of the stabiliser of the IAR 93/ORAO fighting plane.



Risk Analysis in Crop Production

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Crop production in Hungary is highly dependent on climatic conditions. Local ecological conditions and proper agrotechnology can reduce the risk, associated with the production.

Crop growth simulation models have been widely used for prediction of the yield, depending on environmental conditions and agrotechnology. Our model combines the "traditional" growth models with a stochastic "weather generator".

The "weather generator" in one run produces a multidimensional time series, whose components are the most important daily weather parameters. The set of time series, received in several runs, is statistically close to the data at a given meteorological station, measured for several decades.

The weather generator of course must be identified for the given data set prior to its application.

The set of pseudo random time series provides a tool for constructing a probability distribution of a deterministic crop growth simulation model.

The presentation demonstrates the main parts of the crop growth, and the weather generator model, and also probability distributions, derived from the model.

MATLAB-BASED SIMULATION OF OPTICAL SOLITON PROPAGATION

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Adopting the nonlinear regime in the optical communication instead of the linear regime aims at overcoming the effects of dispersion and loss on the transmitted bit rate. Hasegawa and Tappert [1] were the first who proposed the utilization of the nonlinear Kerr effect to compensate the negative group velocity dispersion (GVD) in the single mode (SM) optical fibers. The optical pulse which carries out such balance between the GVD and the fiber nonlinearity was shown to form an envelope soliton. The dimensionless nonlinear Schrödinger equation (NLSE) which describes the optical soliton propagation through a lossless fiber is:

$$i\frac{\partial u}{\partial \zeta} + \frac{1}{2}\frac{\partial^2 u}{\partial s^2} + |u|^2 u = 0 \quad (1)$$

where ζ , and *s* are the normalized quantities corresponding to *z* (axial distance), and *t* (time) respectively. *u* is the dimensionless wave amplitude. The dimensionless variables are related to the real world quantities by:

$$\zeta = z/z_c$$
 and $s = [t-(\partial k/\partial \omega)z]/t_c$ (2)

where $z_c = 0.322 \frac{2\pi c}{\lambda^2} \frac{\tau^2}{D}$, and $t_c = 0.567\tau$. *c* is the light speed in vacuum, τ is the intensity full width half maximum, λ is the wavelength, and *D* is the group velocity dispersion. *k* is the wave number, and ω is the wave frequency. We note also that the soliton period, which is the distance over which

higher order solitons repeat their shapes, is defined as $z_0 = (\pi /2)z_c$.

We demonstrate the use of Matlab [2] functions and environment to simulate the soliton pulse propagation through the optical fibers. We have solved the NLSE by using the split-step fast Fourier transform numerical method [3]. The algorithm splits the fiber length into small segments, each of length $\Delta~\zeta$, the pulse is first propagated with the GVD effect only till the end of the first half of the segment where the nonlinear effect is added, and then repropagated again through the second half with the GVD effect only.

The propagation of different orders of solitons through SM fibers has been analyzed. The analysis has been done on the basis of the evolution of the pulse shape, the pulse amplitude, and the pulse width. The source code was written inside the Matlab environment to make use of its efficient functions and graphical output.

The graphical output of the program is dedicated to monitor the change in soliton shape during propagation by dividing the screen into several figures, each shows the pulse at certain distance. Our results have shown a good agreement with the theory and the published literature. A comparison of the main pulse characteristics calculated by our algorithm and the analytical solution of Eq.(1) for some soliton orders was also made to confirm the accuracy of the Matlab functions.

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Simulation models of plants for grain primary processing

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Simulation models may offer an effective remedy while designing plants of grain primary processing.

These models are created for the grain reception section, for the grain preliminary storage section, for the dryer as well as for the whole plant.

Two technological schemes were used in the models - the first scheme provides for the reception of only one grain flow simultaneously; the second one - for three grain flows simultaneously.

The assumption is that the grain delivery consists of separate portions which remain unchanged during the further processing, only their parameters varies.

The mass, temperature and volume weight of a grain portion are simulated with a normal probability distribution, but the moisture and cleanness of grain by Weibull's distribution. These parameters of grain portions simulated are recorded in its certificate as variables. The certificate has also to contain the codes of crop, variety and reproduction, as well as codes of its use and the owner.

The cleaning, sorting and drying time are calculated for each grain portion according to different empirical formulas.

The machinery safety is estimated by taking into consideration the elapsed time between the breakdown of the machines and by the time of repair, both of them are simulated with the normal probability distribution.

All simulation models, except the numerical outlet date, receive also histograms, e.g., the histogram of the number of ventilation bins, the histogram of the relationship between the dryer productivity and the grain daily thrashing etc.

The simulation models are most of all susceptible to the changes of the arrive rate and of the grain moisture as well as to the machinery safety.

All simulation models are created by making use of the programming and modelling system SITA/C, designed by the Institute of Mathematics and Informatics, at Latvia University.

Stochastic Simulation of Ligand-Receptor Interactions

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The interaction of radioligands with binding sites on biological and analytic material may involve a variety of different mechanisms, which can not be observed directly. Detailed kinetic studies show a summary of the underlying processes.

Previous studies with simulation experiments based on differential equations indicated, that a stochastic simulation approach could get more realistic models. Here we present the development of a stochastic simulation tool, which allows easy generation of different scenarios and a subsequent analysis of the obtained data.

We have chosen a population of 10000 fictitious binding sites, which can exist in up to four different stages. The transitions between the states are driven randomly, gauged by freely selected probability constraints. By varying these constraints in a systematic way a series of results was obtained and analyzed with classical (exponential, bi-exponential) fitting algorithms. The comparison of these simulation results with true experimental data and predicted values derived from classical diffential equations demonstrates the validity of the model.

The main advantages of our approach are the flexibility to model new scenarios and more realistic appearance of results including random noise.

Numerical Simulation for IR-Fiber Optic Sensor Development

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Today the main application of ray-tracing is to be found in film- and entertainment industry engaging high performance computers to satisfy the computational efforts. In contrast, scientific applications require versatile and flexible software packages capable of wavelength dependent calculations for applications such as designing optical arrangements for spectroscopic experiments.

During this work a new software for numerical simulation of optical sensing schemes is being developed with the aim to provide a flexible tool for the optimization of the IR fiber optic sensor developed in our research group during the last years¹. The most outstanding feature of the program is the possibility of wavelength dependent calculating with respect to the spectral behavior of the used materials of complex optical arrangements such as IR transparent optical fibers coupled to a FTIR spectrometer in three dimensions. IR spectra can be calculated from bulk substances or from layer-stacks of different materials. The optical properties of different media are calculated from the real and imaginary parts of their dielectric function (DF). Layer-stacks are treated as one single material after folding the DF of each layer into one resulting DF. The new software SPORT (by M. Sengeis) is based upon the software SPRAY (by W. Theiß) which has successfully been used for simulating IR-microscopic experiments^{2.3}.

The software SPORT is written in C++ and uses a command-line interface handling all input and output data in ASCII format. Hence, SPORT can be used on any computer that is equipped with a C++ compiler (PCs, Macintosh, workstations or supercomputers) providing a flexible simulation tool. The calculation procedure is based upon simulating optical components such as mirrors, stops, detectors, virtual screens, light-sources and bulky objects coated with layers of dielectric materials using a Monte-Carlo like wavelength-dependent simulation procedure and Fresnel's equations to calculate the amount of radiation absorbed, reflected or redirected. Various fiber geometries such as fibers with integrated microlenses, coiled fibers or tapered fibers can be calculated and optimized. The virtual screens do not effect the path of the radiation and can be used to visualize the intensity of radiation at any place in an optical setup. Due to the modular program structure a wide variety of objects can be simulated by combination of these objects.

It is of considerable interest for the development of fiber optical evanescent field sensors to be able to optimize the optical sensor configuration such as fiber/fiber interfaces with numerical simulation procedures in order to avoid time consuming experiments.

Hence, this work demonstrates that wavelength-dependent numerical simulation is a valuable tool for scientific research and commercial product development to verify experimentally obtained results and to reduce experimental efforts in IR fiber optic sensor design.

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SHIP HULL CONSTRUCTION OF A CONCEPTUAL MODEL OF SHIP HULL CONSTRUCTION MATERIALS PRODUCTION PREPARATION DESIGN.

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When presented on a high memantic level. large shipbuilding systems assume rather identical organizational structure. In suchpresentations, the shipbuilding systems structures have been featured as "connected concepts groups". These groups may be further divided into subgroups. Such systems oscillate in their ekvelopment and entropy in accordance with new situations arising within a system. Co-ential differences in situations within particular systems of our, primarily, in relation to whether connected concept groups have been built of open or closed structural elements. Another essential problem consists in how to recognize where the limits of the groups, as concepts, commence. Should the clue be sought within reciprocal dependence of the groups?

Existence of subgroups as concepts may be unrecognizable or their existence may be taken as a "formal" one. In cases when particulars of these subgroups even to be insufficiently recognizable. Hereinafter, complexity of recognition requirements in the ship hull structure materials production preparation design system has been dealt with

The production preparation design system related to preparation of ship hull structural elements materials, as isolated connected concepts units, has been given the assignment of enabling the connected concepts groups to function in a process-like manner within the domain of the production preparation activities. Fundamental particulars of the subject system are a result of the following elements: a development of activities within a time span, a need for overlapping actions - procedures through which the same are being monitored, a requirement for the ship properties to be copied, and a requirement as to the dynamics of the group to be controlled These premises/ requirements have been accompanied by both spiral and intermittent flow of product tion preparation and construction of a ship within an open system context. Opinal method of conducting the ship construction proc e.s has been generated by activities cycles procedure. Proce duree development cycles are, however, the missing chain links in to analysis of the system. Integrating concept for this connected concepts unit is based on an organization which learns from and ends within the informatic technologies

Within this study, postulations as to existence of ship hull structure materials production proparation design system have been elaborated, as well as the structure of the system proper, with a presentation of the dynamicm of connected concepts groups paralel action. Monitoting of work dynamicm employs symbols con tained within the activities cycles graphic presentation

Analysis of some biodegradation processes using a mathematical model

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In order to represent the bacterial growth, the substrate removal and the oxigen consumption kinetics in the biological oxidation of wastewaters, we consider the following equations :

$$\frac{dX}{dt} = -a \cdot \frac{dS}{dt} - k_d \cdot (X - X_{\min})$$

$$\frac{dS}{dt} = -\mu_{\max} \cdot \frac{S - S_{\min}}{K S_0 + \beta \cdot (S - S_{\min})} \cdot (X - X_{\min})$$

$$\frac{dO}{dt} = k_0 \cdot \frac{dS}{dt} - k_e \cdot (X - X_{\min})$$

where the basic variables are biomass concentration (X), substrate concentration (S) and disolved oxigen concentration (O) and the parameters are time (t), cell yield coefficient (a), cell decay coefficient (\mathbf{k}_{d}), minimal level of biomass concentration needed for starting the biological oxidation process (\mathbf{X}_{\min}), substrate removal rate coefficient ($\boldsymbol{\mu}_{\max}$), remanent substrate concentration (\mathbf{S}_{\min}), constant $\boldsymbol{\beta}$ having two values 0 or 1, constant \mathbf{Ks}_0 representing Michaelis-Menten constant for $\beta=1$, $\mathbf{S}_{\min}=0$ and $\mathbf{X}_{\min}=0$, oxigen requirement per substrate utilized (\mathbf{k}_0) and oxigen consumption per biomass for endogeneous respiration (\mathbf{k}_e).

The above mentioned equations define two types of mathematical models, one type for $\beta=1$ (nondegenerated) and another type for $\beta=0$ (degenerated). For $\beta=1$, $S_{\min}=0$ and $X_{\min}=0$ one obtains also the well known Monod-Heukelekian-Eckenfelder & O'Connors differential model. In this paper we propose a new method for the evaluation of the kinetic coefficients a, k_d , μ_{\max} , Ks_0 , k_0 and k_e together with values X_{\min} and S_{\min} .

Many computer numerical simulation experiments have been realised. We conclude that the mathematical model considered here is in accordance with experimental data in batch reactors and the proposed parameter identification method is very useful in study of biological degradation of organic substrate and elaboration of kinetic coefficients of some processes (e.g. biodegradation processes of phenolic wastewaters or domestic wastewaters).

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Cryosurface Frostdeposit Dynamic Model & Simulation

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The fundamental research on cryosurface frostdeposit has been carried out from long ago. And the main subjects have been: (1)the types of structure of the cryosurface frostdeposit; (2) the frost growth and deposit velocity during frost formation; (3) the decrease of heat transferred; (4) the decrease of air flow rate, etc. All these are important in frost formation. In 1980, the authors of this paper initiated the investigation of " The Effect of Cryosurface Coated with a Hydrophobic Film on Frost Formation" in the P.R.China. And after that, some similar papers have been published abroad. Nowadays, there are some physical and mathematic models established of " The Cryosurface Frostdeposit Dynamic Processes". The effectiveness has been proved both in theory and in practice to prevent the frostdeposit on a cryosurface coated with a high hydrophobic film. The models are presented in two aspects in this paper. They are: first, the frost is formed on the surface itself, that is the phenomenon on the initial stage of frost formation; second, particles being suspended in the air stream change into ice crystals, which will then deposit on the surface at random. These models refer to the dynamic process on an intermediate stage before the frost layer is formed on the surface. And according to the theory of critical supersaturation depending on $\cos \theta$ for desublimation (where θ is the contact angle between the new phase and the substrate), nucleation and interface energy, etc., the frost on the substrate is formed in a dynamic process, in which, ice crystals grow or disappear, and the ice embryos in the air stream grow or disappear when they collide with the substrate. According to the models, computer simulation has been carried out to find out the relationships among the parameters. The results of this simulation are as follow: (1)The cryosurface covered with a hydrophobic film will prevent the frost formation on the substrate; (2)The ice embryos on the cryosurface grow or sublimate when the surrounding parameters are different; (3)Suspended particles in the air stream may play an important role in the frost formation; etc. The computing results show as the figure bellow, in the figure , I is the nucleation rate in the unit area (volume) per minutes, cure 1 is 0=110°, Cure 2 is 0=83°, Cure 3 is some big particles suspended in air. To summarize on the frostdeposit on the cryosurfaces, the following conclusion can be drawn: (1) The initial stage of frostdeposit depends upon the local, different surface properties; (2) The phenomenon of supercooled water on an intermediate stage of frostdeposit can be explained

by the conventional and contemporary theory of heterogeneous nucleation;



(3) The interfering interface energies play an role.

Conclusion: if some conditions are satisfied, the cryosurface would not have frostdeposit. It is industrial available.

Computer Simulation Methods for Treating Instationary Excitations of Building Load Carrying Structures

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Summary of the poster

Linear viscoelastic buildings with composite structures are investigated by new time-history method in case of horizontal earthquake ground motion excitation, which is an instationary generally Gaussian stochastic process. Ground water effects are excluded here from the scope regarding load carrying structure-foundation-soil interaction. Instead of Monte Carlo approach a new simulation method: extended version of the the realizations weighted with its probabilities is used. Here one realization is a stochastic solution itself with fixed circular in frequency of excitation, to which a probability value can be associated. Solution for one realization is performed on multi-degree-of-freedom model of the composite structure with the aid of modal matrix method and direct statistical evaluation of stochastic processes of response second moments. Light till elastoviscous material damping is assumed. The stochastic input here an earthquake ground motion is excitation family, in horizontal direction, which is assumed as sum of doubly stochastic sinusoid Computer program was functions. worked out for analysis of multistoreyed buildings for mainframe computers. Numerical results for horizontal absolute and relative displacements of floor-levels show significant effects of horizontal of structure-subgrade stiffness

contact and of viscous linear damping coefficient. Effect of increasing mass at the first level of storeys above the foundation proved to be advantageous. Own experiences on site of 5. 6. 1994 South-Middle Csepel (Budapest) earthquake on panel buildings (3 floors) negate opposite opinions for similar buildings. earthquake <u>Keywords:</u> modelling, high-rise buildings, instationary ground soil motion (horizontal).

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System Dynamics Simulation for Regional Planning in Bavaria

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In this paper we report on a system dynamics simulation model for regional planning in Bavaria which has been developed by Klatt, Kopf, and Kulla [3]. We have implemented this model in UNIX-MATLAB and carried out different experiments with them and compared the simulated data to actual. To support the experimentation with the model a user interface was also written in MATLAB. Moreover we have applied a method which has been elaborated by Vester [4] to classify the model variables.

Why system dynamics simulation for regional planning?

For regional planers it is important to have informations about the distribution of population, economy, infrastructure, land use, housing market, the changes that are occuring, and the proportions of such changes. Such information is, of course, important to governmental officials at various levels, as well as to legislators involved in the determination of the regional planning policy. For understanding the dynamics of change in a region we have to regard the region - with their population structure, economy structure, land use structure, etc. - as a coherent system, as a kind of whole that cannot be really understood from its separate components only.

By applying the system dynamics established by Jay W. Forrester [1,2] we can develop a simulation model that interconnects different sectors of a region and reflects their crosslinkage, interfacing in reality, and their feedback behaviour.

Structure of the Bavaria Model

Based on system dynamics Klatt, Kopf, and Kulla [3] developed a complex simulation model for planning in Bavaria and programed in DYNAMO (a computer language for simulating models).

The model consists of six model sectors: land use, population, economy, infrastructure, housing, and government (national budget). Objectives of the simulation model are

- studying the system behaviour of the Bavarian region,
- forecasting land requirements for agriculture, industry, manufacture, infrastructure and housing, and
- investigating the dynamics of population, economy, and housing market.

For the model construction the four sectors land use, population, economy, and infrastructure have been divided into further level variables. We have to integrate 19 level equations (e.g. the model has 19 level variables). Moreover the model has 38 table functions, and about 200 flow variables, auxiliary variables, external factors, and parameters. The level variables have been calculated by the following formula:

New level = Old level +
$$\int_{t_0}^{t}$$
 (Inflow rate - Outflow rate) dt

With this pattern of interactions, one can adapt the inflow and outflow rates by using of table fuctions - the non-linear interdependencies that result from the cybernetik interpretation - to reality at any time and thus to the changeswhich have taken place within the system as a whole.

Two simulation results shall be presented now.







Figure 2: Housing stock of Bavaria

The source of actual data is [5].

Conclusions

As shown in figures 1 and 2, the simulation model can make good forecast. Regional development requires a system-oriented treatment. With the help of this systems simulation we can investigate the dynamics of a region such as Bavaria under systemtheoretical and holistic aspects. Therefore systems simulation is a good method to assist in regional planning.

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SIMULATION CONDENSATE TRANSPORT SYSTEMS

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One of the most important requirements to pipeline transportation of natural gas condensate is to provide a single-phase liquid state of carried mixture along the entire trunk lines. Failure to meet this requirement may cause pipes to be locked with gas bubbles and essentially decreases the efficiency of pipeline operations due to the additional power consumption on pump stations that maintain the flow of two-phase gas-liquid mixture. The solution of this problem can be achieved by pipeline operation control based on mathematical simulation of condensed gas flow.

Presented mathematical model and computation algorithm for computer simulation of condensate pipelines can be partitioned as follows.

- Model and algorithm for vapor-liquid balance computation based on Peng-Robinson equation. It permits to calculate mole fractions of mixture components in vapor and liquid phases for given mixture composition, temperatures and pressure.

- Model and algorithm for computation of temperature distribution along the condensate pipelines.

- Model and algorithm for hydraulic computation of condensate flow in a single-phase (gas or liquid) mode and two-phase (vapor-liquid) mode with gas bubbles in liquid or gas/liquid layers separated.

Program package based on the described model provides computation of condensate flow variables (pressure, flow rate, temperature and phase composition) along the pipelines for given initial conditions on the main field pump station. Calculations on each pipe section are completed through implicit iteration procedure with temperature and pressure as independent variables. To increase simulation speed express-algorithm for temperature calculations is also implemented. This algorithm utilizes Shuhov formula for temperature calculations and allows to separate hydraulic and thermal computations for each pipeline section. The overall gain in express simulation time is about 4-to-1 with some deterioration of accuracy.

The suggested condensate flow model and its program implementation enables condensate pipeline operation based on simulation results. Specific application examples are also considered.

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"DYNAMIC SHIP STABILITY MODEL UNDER BORA AND JUGO WIND EFFECTS ON THE ADRIATIC SEA".

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ABSTRACT

System dynamic modeling of dynamic ship stability with the help of digital computers has special meaning because system dynamic method gives a real knowledge about behaving of dynamic ship stability in continued time area.

In this paper the author shows a model of ship dynamic behavior under wind effect during a navigation in the Adriatic Sea. Bora and jugo are characteristic winds in the Adriatic Sea that can be dangerous for ships' navigation, especially bora. Bora which blows over east shore of the Adriatic is a gusty wind, whose gusts can achieve a hurricane force in a short time.

Dynamic stability happens during heeling of the ship under effect of external forces, in other words heeling moments on the ship, wind and waves, or they are a result of ship loading by cargo or by water overrunning.

The model shows wind speed changes by level based on known legitimacy, wind moments as a result of course change, heeling amplitude (including capsizing angle) and rolling period, all in time period.

Dynamic ship stability modeling was executed by using the system dynamic method which defines:

1. mental, 2. verbal, 3. structural, 4. mathematical, and 5. dynamic ship stability model.

Modeling was made on digital computer using Powersim higher program language.

Parallel results of calculation weather criterion according to the recommended method of International Maritime Organization - when the moments of steady and gust winds do not change for the whole period of ship heeling and according to the method when these moments do change in time, are shown in this paper.

COMPUTER SIMULATION OF INDUSTRIAL DUST MIGRATION

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Analytical and simulational model of wind dust transport of contaminations (radioactive fractions, chemical desperive contaminations etc.) in the air surfase layer is suggested. The model was developed and tested on bases of long-time forecast of radionuclide migration in the radioacontamination areas due to Chernobyl catastrophe. The above model is a part of program complex modelling different kind of ridionuclide migration in the air and in the aqueus medium.

A computer program has been developed illustrating on a display the dynamics of contamination spread. It can be used as a visual aid in teaching ecologists as well as in studying transport equations in the mathematical physics course.

Two-dimensional difference diagram of transport equation is analyzed. There are used the following parameters: the concentration of suspension in air, the intensity of distributed source of dust formation, the intensity of distributed dust absorbtion, the wind velocity field, the earth ability of dust formation, vegetation cover of the area and its relief, the presense of reservoirs, constructions as well as weather conditions. Statistical data collected during several years by hidrometeorological center were used in computer simulation. Time modelling step is equal to a calendar week. Wind rose determining averaged wind directions for every month is used for imitation modelling of wind direction which is calculated using random-number generator. The choice of element recalculation sequence in difference diagram is made considering this wind direction. The random-number generator is also used for imitation of wind velocity characteristics of one or another week of simulation.

This work was supported, in part, by the International Soros Sciense Education Program (ISSEP) through grant N GSU 041015.

SIMULATION OF TURBOMACHINE BLADING VIBRATIONS

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Vibrations present the main hazard to the steam and gas turbine blading.

The requirements to turbomachine blading mathematical models are complex and contradictory. They must represent the system vibrational properties as fully as possible at the same time contributing to the development of efficient methods of casculation. Therefore, it is advisable to adopt an hierarchic system of models: rod, two-dimensional and three-dimensional. The turbomachine blades have the most complex structural shape.

In a number of cases rod models of blades can be used for complex blading system, and particulary for systems with mistuning. The mathematical model of blade is constructed on the basis of classical or the refined engineering theory of pretwisted rods, which takes into account the inertial and deformational relationship of vibrations due to the initial pretwisting and non-symmetry of the cross-section, shear, turning inertia, deplanation of the cross-section and the influence of rotation.

However, blades of complex geometry with flanges, roots and often internal cooling channels are used in the-state-of-the-art turbomachines. For such blades, it is necessary to use three-dimensional models in combinations with the method of finite elements. In this case, one can take into account the matherial non-uniformity due to temperature fields with high gradieents and non-uniformity of the object.

Extensive work has been carried out in comparing the results of systematic numerical analysis based on models of different levels with experimental investigations. As a result, we have built the boundaries of the domains of applicability of different models of turbomachine blades depending on the dimensionless parameters presenting their geometric forms.

The principle of system calculation by parts (diacoptic) can be used to reduce the complex problem dimensionality. At calculating the rod models the variational methods using the diacoptic idea turned out to be efficient. Typical partial problems with considerably lower order of the system of equations are selected. The results of solving partial problems are used for constructing basis functions meet all boundary conditions orthogonal to the partial problems operator and have the property of strong minimality. This makes it possible to bring down the order of equations solved at consequtive growth of the system complexity.

For three-dimensional finite element models the methods of condensation, multilevel superelement approach are widely used. Of special importance are the convenience of specifying the input data and the full visualization of results.

For turbomachine impellers possessing rotating symmetry, an approach is used which is based on reducing the order of resolving equation by considering one period of symmetry, viz. the sector of the disk or rotor with one blade and sections of bonds.

A comparison of simulation results and the data of the experimental studies shows the high efficiency of the technique developed.

XMosis: X-Environment for the Simulation System mosis

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1. Introduction

XMosis was developed at the Technical University of Vienna, Department of Simulation Technique as Unix X-Window based frontend to mosis¹. The *XMosis*-project has now reached a stable beta stadium.

2. Features

XMosis offers the user a full configurable interface to mosis, that means the user can define his own menu and dialogs. A global configuration-keeps all necessary settings for *XMosis* to work properly and the user can add with his private configuration file his modifications and extensions.

Menus with userdefined Icons [6] to send commands to mosis or to popup userdefined dialogs can be setup by the user. Dialogs can be used to enter parameters and variables and to pass this information to mosis by the user without typing everytime a long command. All entered commands are stored so the user can scroll through this history and save this commands to a file for later reloading. *XMosis* provides up to 32 windows to display graphics. In this window the user can zoom, resize and save the graphic in Postscript or Gif-format for later use. Online help is also implemented using a WWW-client to browse through a HTMLmanual.

XMosis communicates with mosis via PVM [4], because *XMosis* is launched from mosis and is therefore a child process to the main-mosis task. Due to this technology and the client-server-concept of X-Window it is not necessary to run *XMosis* and mosis on the same workstation.

3. Future Plans

To get the optimum in parallelizing models the next release of *XMosis* will include a task tracer to allow the user to watch the progress of his parallel-model and to optimize his algorithm.

To setup up a PVM-Cluster a cluster manager will be added also to allow dynamic adding and deleting of workstations.

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Simulation Analysis of the Job-shop Priority Rules: Under Three Different Processing Time Distributions and Exponential Job-Arrival Time.

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ABSTRACT

This paper identifies the simulation of the job-shop priority rules. Priority rules are used to assign the next job to be processed on a specific machine. The paper has the following objective: To evaluate the effectiveness of the seven priority rule on the five well-used criteria as follows: - The priority rules under study are: 1- First Come First Service (FCFS). 2- Last Come First Service (LCFS). 3- Shortest Processing Time (SPT). 4- Longest Processing Time (LPT). 5- Last Arrived At Shop First Service (FASFS). 6- Earliest Due Date (EDD). 7- Static Slack (StS). - The criteria used are: 1- Minimize job lateness. 2- Minimize mean flow time. 3- Minimize idle time. 4- Minimize work-in-process. 5- Minimize completion jobs or production rate. This evaluation will be under the dynamic conditions of the job arrival times which behaves the exponential pattern. The job processing times are exponential, uniform and normal patterns. The objective tested were under the steady state period of the observations collected using SIMAN simulation technique. Finally, the experimental results and plots show that the shortest processing time (SPT) rule was the dominant rule with respect to the most criteria tested under the most the last come first service job-shop conditions. But, rule (LCFS) tends to give the best rule than other with respect to the flow-time criterion when the normal processing time pattern is applied.

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Simulating and optimising stochastic inventory Models

An objective of inventory management is the provision of material in the right quantity at the right time. Inventory levels should reflect the level of demand and supply conditions. The level and duration of demand and delivery time are usually unpredictable stochastic variables. As strategy control variables, maximum and minimum inventory levels can be computed with optimising techniques. The objective function is a cost function comprising the costs of re-ordering, inventory holding and inventory shortages.

Both continuous and discrete-event models are appropriate procedures for simulating inventory systems. The continuous model gives effect to a control theory approach. Both approaches make use of familiar simulation languages, namely, SIMAN / ARENA and VisSim respectively.

Simple interfaces facilitate the interaction between the simulators and appropriate optimising programmes.

The slightly uneven surface of the objective function has hitherto revealed a clear global cost minimum. Modified for this application, the familiar GAUSS-SEIDEL method, a simple optimisation procedure, yielded reliable results. Genetic algorithms are also successful optimising techniques. The VisSim integrated optimising procedure are not always suitable for these models.

Analysing Traffic Flow by a Cellular Automaton

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Further expansion of individual road traffic will lead sooner or later to a traffic collapse at least in conurbations. It is hoped that this collapse can be avoided by intelligent traffic control systems. Those systems will heavily depend on simulation tools for a detailed prediction of critical traffic situations. In our contribution we will extend an approach which was first presented by Nagel and Schreckenberg in 1992 [1] and which uses a cellular automaton as a microscopic traffic flow model.

The poster introduces the concept of cellular automata for simulation of discrete dynamical systems. It explains the basic microscopic model being capable of reproducing so-called "stop-and-go" waves which characterize traffic flow on a freeway without further external impacts. These waves can be visualised by displaying the density of cars on a road versus time. The new component of our model [2] is that it is not only capable of simulating undisturbed traffic flow but also flow in case of additional road obstructions. As an example we consider a discretized road corresponding to about 30 km on a real road. In our model – due to some given hindrance – drivers are forced to reduce their velocity on parts of the segment to only half of its original value. Investigation of this model results in hysteresis loops which display two qualitatively different kinds of traffic behaviour.

So our approach makes a step towards new perspectives in dealing with problematic road situations. One future field of application is the support of variable driving instructors. The model can also be understood as a guidance for traffic planers dealing with routing. It predicts the critical density which in case of existing hindrances has to guide shut down of a road rather than the value obtained for undisturbed traffic so far.

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STOCHASTIC MODELING OF MODERN COMPUTER SYSTEMS

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The paper is concerned with appropriate methods for computer system's performance evaluation, based on the queueing and graph theory. Some of problems are solved on the stage of designing, other arise by the operation, when non-satisfactive characteristics become clear. That is why preliminary estimations and recommendations are of great importance. In many cases these estimations are obtained by means of stochastic modeling and simulation.

It should be stressed that performance evaluation for parallel computing is on the stage of development, because the interest on mathematical tractability of modern architectures has almost always led to an oversimplified models.

As the title implies the paper describes new techniques for modeling some kinds of computer systems, to be exact, the Dataflow machines. The distinctive feature of all methods to be proposed is linear dependency of model size on the number of system's components. This fact makes possible their practical using.

Report consists of two parts. Simulation of two alternative approaches to Dataflow computations, such as data-driven (or eager) and demand-driven (or lazy) are considered in these parts respectively. In the first part method of performance analysis of static data-driven machine has been proposed. It is shown that taking into account assumption about fully dynamic assignments of PEs to knodes of data-flow graph and provided programming languages with one-assignment rule operation of data-driven machine is plausibly described by Markovian chain. Special queueing system for data-driven simulation is proposed.

Concept of stationary in such systems is introduced and condition of it's existence is proved, that is following: the average arity of program instructions must be exceeded by the average number of instruction results propagation. This condition wonderably remindes in appearance the basic condition RO < 1 for the simplest M/M/1. It is specially noted that Dataflow algorithms, taken for example, satisfy it. Model of data-driven computation by non-stationary conditions is also implemented as the system of ordinary non-linear differential equations. The results of digital experiments are presented and discussed. They were aimed to reveal influence of some input parameters on performance and, as conclusion, to give recommendations for their choice. The second part is devoted to the simulations of demand-driven computation. The main subject of research is the mixed directed demand / data flow graph. Special class of such graphs is defined. It is shown that this class is the subclass of skew-symmetric Berg's graphs and corresponds to the coarse-grain granularity of parallel algorithm. Two disciplines of demands service in the knodes are considered: switching to the firable state with demand of any consumer and of all consumers. Simulation techniques of moving demands/data are implemented. The optimal rule of demand choice from the queue is proposed, which is the further development and expansion of famous Hu's strategy. Theory of logical determinants is applied to the performance analysis. Effectiveness of methods is illustrated by some real examples, such as direct and inverse Gauss elimination and function's plot construction.

The first part of the report is fulfilled by I.Trub, the second part - by O.Shcherbakova and I.Trub. Prof. L.Feldman has carried out the general guidance of the investigations as a whole.

ON GRAMMAR OF QUACOL - LANGUAGE FOR PROCESS MODELLING

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ABSTRACT

Modelling has been always a method for better product control. Many approaches have been used toward efficient model building. The primal controversy in model building is the relation of quantitative data expressed through process variables and qualitative product data expressed through product features.

The language for process modeling QUACOL (Qualitative Correlation Language) is described based on the extended creative possibilities of qualitative relations.

Grammar G(X, V, S,P) of the QUACOL is proposed with the set of grammar productions P in general iterative form.

 $S\RightarrowS_1, S_1\Rightarrow$ If C then S, $S_1\Rightarrow$ IfD then S_2 else S_3 $S_2\RightarrowR, S_3\RightarrowT, R\Rightarrow$ SUCCESS, T \Rightarrow FAILURE, C \Rightarrow INPUT EXPRESSION, D \Rightarrow INPUT EXPRESSION SIMILAR TO OUTPUT EXPRESSION

Derivation tree enabling parallel processing is given in the structural form:

if C then if D then R else T.

The qualitative relations are obtained from quantitative process data by means of a quantitative/qualitative transformation. Particular transformation is described enabling the application of QUACOL to the case of a thermoelectric power plant with "input" and "output" expressions

 $a + b v_1 + c v_2 / (d + e v_3) :: f v_4 + g v_5 v_6 / v_7$

where: v_1 - feedwater intake, v_2 - fuel intake, v_3 - fuel temperature,

- v_4 superheated steam flow, v_5 temperature of exhaust gases
- v₆ burner air intake, v₇ differential pressure of air for burners, and a, b, c, d, e, f, and g are model constants.

Results

The repetitive procedures in QUACOL enable for up to 97% of the process determination coefficient and less than 3000 ppm error in stohastic process prediction for traffic accidents in elderly people.

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Combining structural and behavioral views for modeling discrete event systems

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Research in discrete event systems has resulted in the development of computer based tools that aid modelers in many parts of the modeling and simulation process. Modeling is intended for an abstract representation of a real world system, that describes the static structure and the dynamic characteristics of the system. Such description is then used for simulation in order to carry out the performance evaluation of the system. This work advocates that when modeling discrete event systems, the modeler must consider two views. The structural view describes the system components and the relationships between them. The behavioral view focuses on the state change of the system in response to the occurrence of discrete events. Several approaches have been proposed to model these two views. The object oriented or entity relationship approaches seem to be better to model the structural view, while finite state automata or Petri nets are widely used to model the behavioral one.

We feel that a better understanding of the link between the structural and behavioral models and its relationship to the modeling process is needed. We have developed some practical tips to fulfill that need. In particular, the problem encountered by modeler is the lack of guidelines to show the traceability between the two models. For example, the abstraction paradigms used in the structural model such as generalization and aggregation relationships have not their equivalent in the behavioral model based on the classical finite state automata or Petri-nets. To deal with these deficiencies, we provide a high level behavioral abstraction mechanisms that show how to specify explicitly the generalization and aggregation relationships in the behavioral model. This is accomplished by using the hierarchical modeling property of Statecharts; a graphical formalism that extends the finite state automata by concurrency and hierarchical constructions. This property augmented by the extension we propose, leads to a more structured and hierarchical behavior modeling and allows a system to be simulated at different level of abstraction.

Fuzzy Logic as Decision Strategy in Discrete Simulation

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INTRODUCTION

The approach of Fuzzy Logic, developed by Zadeh in 1965, provides a tool for modelling most human thinking processes which are the decisive point in a lot of real world systems. This theory has helped to solve a lot of standard problems in the fields of control engineering, pattern recognition, operation research and so on in a better way than classical methodology could have. Simulation on the other hand gives us a possibility to visualise such a real world process on the computer for better understanding, planning, and experimentation. It is precisely the problem of vague rules and facts that often appears during the development of a discrete event simulation model. The main question is now how you can use the advantages of Fuzzy Logic and Approximate Reasoning in Discrete Event Simulation and also how it is possible to implement this theory so that the expanded Simulation Programme can be used for numerous new tasks.

THE DECISION CLASS OF FUZZY LOGIC IN DISCRETE EVENT SIMULATION

The uncertainties in a real world process can come from various sources. There is the possibility that parameters of a process can vary in a indefinable way during the operation. In most industrial processes human operators are integrated into the system and so the possibility to describe every decision in a precise way is no longer as possible as in a "purely technical" process. A third point is that, as the complexity of a system increases, the possibility to make precise statements decreases. All these uncertainties have to be considered during the planning phase of such an industrial process and so you have to implement them into your simulation model as well. The point I want to focus on is the possibility to replace complex crisp priority strategies which are a central point in most manufacturing plants by fuzzy decision rules. It is normal that in such a plant the crisp strategies implemented in the computer system are often overruled by the human operator, who is influenced by experience and feeling. By using a Discrete Event Simulation programme expanded by the decision class of Fuzzy Logic, it is possible to optimise such processes, implementing not only the crisp information but also the vague human decisions. The major purpose of using fuzzy decisions in simulation is to handle crisp and fuzzy information in the same model and to change between the different decision classes (stochastic, fuzzy, deterministic) in a short time.

IMPLEMENTATION

The main point of the fuzzy modelling technique is the idea of a linguistic variable. In order to use Fuzzy Operators, Modificators and Relations on such linguistic variables, you have to define a related Fuzzy Set for every variable. The concept for working with these linguistic variables is the concept of approximate reasoning. A linguistic variable is defined by its name, the universe of discourse, and the names of the labels of the variable. Each label is defined as a Fuzzy Set with a left *zero point*, one or two *max points*, a right *zero point*, and a type of Fuzzy Set. Approximate Reasoning means that you draw approximate conclusions from uncertain preconditions. In a statement using quantitative logic, a dependence between two numerically valued variables x and y is usually characterised by a table which may be expressed as a set of conditional statements such as "if x is 5 then y is 10". The same technique can be used for a qualitative approach, in which a sequence of instructions may contain fuzzy assignments and conditional statements. So, instead of using the IF-THEN-ELSE decision with crisp parameters, it is possible to call the Master Fuzzy Method and to pass the crisp parameters to it. The Master Fuzzy Method controls the other Fuzzy Method for further operations. Using C or C++ for handling the necessary data and calculations, you can use the Fuzzy Methods with all discrete simulators, which provide you with a C-Interface.

CONCLUSION

A lot of different simulation programmes have been developed in the last years and each of them has its advantages and disadvantages compared to the others. But all of them have one thing in common, decisions can be programmed either deterministically or stochastically. These methods were developed for modelling mechanical systems and are highly suitable for modelling processes in which human thinking does not play a central role. But viewed in the perspective of new challenges in the future, the traditional techniques of system analysing are not well suited for dealing with systems directly influenced by people because they fail to deal with the reality of the fuzziness of human thinking and behaviour. So Fuzzy Logic provides a method to reduce as well as explain system complexities. So the benefits of Fuzzy Logic for Discrete Event Simulation can be summarised as follows: The amount of computer power that is needed can be reduced by decreasing the complexity of the model, the system is made more intelligible by integrating linguistic rules and human thinking is encoded more directly and exactly than by using standard mathematical techniques. Fuzzy Logic can expand the deterministic and stochastic decision classes used in simulation and so create the possibility of more efficient solving of new and specific questions in the fields of traffic, business, finance and others, in which human thinking plays a major role. The goal is to implement fuzzy decisions as a third decision strategy in between poor deterministic decisions and poor stochastic ones.

Knowledge acquisition for discrete event systems using machine learning

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Knowledge acquisition for an understanding of discrete event simulation systems is a difficult task. Machine Learning has been investigated to help in the knowledge acquisition process. Our approach involves consultation with a domain expert, and the use of discrete event simulation models and machine learning as tools for the intelligent analysis of simulated systems. Current methods for the analysis and interpretation of such systems are restricted to statistical techniques that say much about the reliability of an output, but little about the output inter connectivity. The objective of our work is to improve the ability to interpret the model to the level of explanation that might loosely be described as "How the simulated system works". The new interpretation techniques are based on knowledge acquisition concerning the system using machine learning tools. "How the simulated system works" is important for a decision maker's understanding of the system in terms of relationships between the various parameters, the utilisation of resources and the location of (potential) bottlenecks. This sort of understanding is important when managing queuing problems in production systems, or when planning a new system. It should be emphasised that the goal of the presented work is not a prediction nor an optimisation. The main goal here is to find interpretations of the simulation

Discrete event simulation produces example situations that can be used as input data for machine learning tools. In the presented research, three simple and commonly used discrete event simulators were interpreted using different machine learning tools. The attribute based learning systems RETIS and ASSISTANT were chosen as appropriate for learning in noisy, real-world domains. The interpretation obtained by these systems was intuitive but obviously expressed in a complicated way. To enable a more powerful knowledge representation, the Inductive Logic Programming (ILP) system MARKUS was used. In addition to compact knowledge representation, MARKUS also highlighted some attribute combinations that could be useful in the attribute based learning.

The knowledge gained from the machine learning tools was evaluated by the domain expert, who considered that this knowledge contributed to an understanding of the system, and how it might profitably be modified. This is important because the success of the present study should not be measured in terms of prediction accuracy, but in terms of the interpretative ability of the induced descriptions.

A methodological point of interest is the combination of ILP learning with attribute-based learning, and "chaining" of classification trees. (1) The ILP system MARKUS, could not really cope well with the noise in the learning data, but made important contribution as a generator for new attribute combinations. These were then beneficially applied in the subsequent attribute-based learning. (2) The knowledge provided by classification trees generated for the target problem (waste in steelworks) was analysed by domain expert and decided to be helpful but not enough detailed. Thus, depending on the already generated classification tree, a new target problem was formulated and the experiments repeated. This approach enables a more flexible analysis of the simulator from different, dynamically chosen, views and was considered by domain expert to be very beneficial for the simulated system understanding.

MATLAB Simulation of Idempotent Structures for Discrete Event Manufacturing Systems

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Key Words: Max/plus algebra, flexible manufacturing, discrete event systems, MATLAB simulation

1. Introduction

In [1] a modern systems theory point of view is offered for the design of sequencing controllers for flexible manufacturing systems (FMS), whereby the controller is considered as separate from the workcell. In [2] the equations of the closed-loop system can be used to derive the max/plus representation for performance analysis. Starting from this matrix framework, MATLAB capabilities are extended to accommodate max/plus models.

2. Max/plus models for FMS

According to [2], for a given FMS (whose controller, if necessary, incorporates a conflict resolution mechanism) a max/plus model can be directly derived in terms of the task sequencing matrix, resource requirement matrix and duration of activities (processing times, transportation times, setup times etc.). System input u(k) represents the arrival times of input parts and system output y(k) represents the delivery times of the final products, where k denotes the iteration index. The maximum order of the delay operator is given by the multiple resources (pallets, buffers slots etc). **3. MATLAB functions for idempotent calculus in the semiring (R** \cup {- ∞ },max,+)

3. MAILAB functions for idempotent calculus in the semiring $(\mathbf{R} \cup \{-\infty\}, \max, +)$

The semiring $(\mathbf{R} \cup \{-\infty\}, \max, +)$ involves non-standard operations which are not available in MATLAB. However the existence of the built-in function *Inf* (which returns the IEEE arithmetic representation for positive infinity) allows developing new routines for matrix addition and multiplication. These new matrix functions are further exploited to approach the complex max/plus models associated to various FMS structures.

4. FMS simulation and performance evaluation

The main objective of the simulator is to create a relevant picture of the workcell dynamics, including both transient and periodical steady state. Thus the analysis of the role played by the arrival times of the input parts becomes a straightforward task. Moreover, comprehensive tests can be performed to underscore the influence of the duration of various activities on the FMS performance. Changes in processing sequences and/or resource availability are simple to handle. A graphical interface based on MATLAB plotting functions is provided. Well designed simulation experiments are extremely useful for the optimization of the machine utilization.

5. Illustrative example

Consider the workcell in fig.1 [3], where both machines are automatically loaded; four pallets are available and the buffer has two slots. Fig. 2 depicts the workcell dynamics, in the case of a non-uniform sequence of arrival times.

6. Conclusion

The paper aims to enlarge the application area of MATLAB, by developing new modules devoted to the simulation of FMS described by max/plus models.

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Fig.1 Sketch of the workcell

Fig.2 Graphical plots of input and output

EXPERT DECISION SUPPORT BASED ON THE GENERALIZED NETWORK MODEL : AN APPLICATION TO TRANSPORTATION PLANNING

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ABSTRACT: An expert (knowledge-based) decision support system (KBDSS) is presented which is then specialized to the Generalized Network (GN) domain. The resulting KBDSS developed by the authors and called GENETEXP is actually useful for decision making in all real problems that can be put in the GN form and need additional higher level expertise. Practical results in the Optimized Transportation planning area have been obtained that illustrate the functioning and usufulness of the KBDSS.

THE GENETEXP TOOL : GENETEXP is a tool for analysing GN problems within a generalized decision making environment. With this package, any problem that has the GN mathematical formulation can be modeled and analyzed. Actually, the problems to be treated with GENETEXP cover a wide range of applications since it can deal with boundary condition constraints of inequality type, i.e. the nonzero supply for a given node can be specified either as a resource to be compulsorily conveyed through the network, or as the available quantity of the resource considered. In the same way, the value of a demand can be considered either as a specific requirement to be met, or as a minimum of the required quantity.

GENETEXP is the outcome of the integration of GENET OPTIMIZER (a previous pure numeric GN-DSS package developed by the authors) with an expert system shell developed at NTUA and used extensively for Engine Fault Diagnosis (ENGEXP) and Medical Therapeutic Treatment (BIOEXP). The package was developed in PASCAL under DOS on an IBM-PC compatible with sufficient memory to support the model's data and knowledge structure. A number of experiential rules have been accomodated to the knowledge-base for heuristic (expert-based) post optimization analysis. Work is under development by the authors to incorporate in the knowledge-base subsystem fully heuristic models accompanied by user/decision maker preferential rules. This is done in cooperation with a European-level supply-distribution chain. The system will then be capable of evaluating the solutions and using the one that satisfies not only numerical but also experiential preferential requirements.

Simulation in the planning of Construction Operations

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Construction Operations have characteristics that make them suitable for simulation. For example they are resource intensive and the resource flow between operations often leads to a queuing behavior. Due to the uniqueness of a facility, construction tends to be like prototyping. When a project is completed, the production is ended and the prototype is hopefully built according to the specifications. Although facilities themselves are unique, the construction methods used during the project are often repetitive and cyclic. Construction operations are regularly-vulnerable to external factors, e.g. weather conditions, that are difficult to predict and control.

All these conditions make simulation very applicable as a planning tool for construction operations. Simulation's ability to test and evaluate systems and plans before the actual implementation ought to attract construction engineers and managers. Despite these factors, simulation has not yet gained the expected success in the construction industry.

There are of course several reasons for the limited use of simulation in construction planning: the flow based structuring approach in most simulation tools, developed for simulation of manufacturing processes, is not suitable for modeling of construction operations. There is a also lack of useful input data, and the limited knowledge about modeling, statistics and how to interpret simulation results among construction professionals also effect the usage.

Models are often developed in the construction planning stage and later transferred to the construction site. The models must therefore be easy to communicate to members of the construction team and the modeling approach should be able to capture the cyclic flow of resources in construction processes.

To make the modeling quick, the tool ought to be integrated with other planning software and use available equipment data, previous captured production data and saved models. The interface should be based on a graphical modeling approach, in which the models can be visualized both during design and run.

Based on the requirements above, a prototype tool for discrete-event simulation of construction operations, called TOWERS, have been developed. Some of the suggested requirements, have been successfully exemplified and tested with TOWERS.

TOWERS is capable of modeling complex resource flows and contributes new capabilities in visual model building. A simulation model is conceptualized and built by drawing an activity cycle diagram. The activity cycle diagrams can capture the cyclic flow of resources at the construction site. The diagram is formed by simple symbols, but can also contain pictures and digital video. This enhances the visualization capability and improves the understanding for the model among occasional users. The usage of templates provides quick and easy model building combined with the usage of captured data.

It is too early to draw any far reaching conclusions, but initial field tests indicate promising results for the visual modeling and structuring approach suggested. The simulation technique can, in the future, be naturally integrated with other computer based tools for planning and controlling construction projects.

Discrete Event Simulation of a Real Assembly System A Tool to Double Throughput

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This poster describes the use of event-simulation for optimizing highly configurable manufacturing facilities for large-scale production. Within a research project carried out at the Institute of Flexible Automation, TU Vienna and Profactor, Steyr, event simulation was successfully used to demonstrate that the substantial benefits of configurable automation can also be achieved in areas traditionally relying on rigid production lines.

Problem Formulation

Traditional production lines frequently rely on a transportation system rigid with constant processing times between a sequence of simple pick and place work stations. In such an assembly line, disturbances will inevitably prevent the achievement of the planned production volume and result in inefficient operation. Indeed, it is known that the overall availability of a rigid production line equals the product of the availability of the individual stations. In a sequence of 20 stations with 97% availability each, for example, the overall availability sinks to as low as 50%.

Strategies aimed at improving the productivity, must observe the following typical constraints: highly variable disturbance frequencies, large variations in repair times, a wide spread in product variation and quantities, high product volume and large variations in processing times.

To investigate these phenomena, the influence of various disturbances on both loosely coupled and rigid production lines with short repair times were simulated and compared. The long-term objective of the study is to highlight the importance of flexibility in large scale productions and to establish generic strategies for increasing productivity.

Solution Strategies

To obtain quantifiable results, potential manufacturing facility layouts were described by parametric models. The following optimization was based on the sum of invested and running costs divided by productivity as measured by units manufactured per hour. An iterative algorithm was then used to estimate the optimal processing times, buffer capacities, supply rates of assembly parts, number of pallets and workforce size.

Further effects modeled in the optimization included various product distributions, as well as different disturbance frequencies and durations. Finally, the economic feasibility of "chaotic manufacturing" was evaluated.

Results

The above optimization study shows convincingly that the flexible manufacturing paradigm holds substantial benefits for large scale productions subject to disturbances with short repair times. In particular, by introducing and optimizing buffer capacities and variable processing times it was possible to double productivity and drastically down-size the working force in spite of uncertain production and failure data. The cost of introducing these upgrades was evaluated to be an investment increase of 15% and running cost increase of 20%. It was also shown that a rigid production line with the same nominal throughput (no failures assumed) would require similar investment and running costs.

Thus, there were only minor additional costs associated by introducing the advantageous flexible automation.

SIMULATION OF MANUFACTURING SYSTEMS

Simeon Simeonov

Dynamic characteristics of Manufacturing System are represented by using a computer simulation model. This model allows to find out lacks of simulated system before his realization in nature. A model shows the behavior of the system and impact of changes of parameters and conditions. FACTOR/AIM (Pritsker-Corporation) is used for evaluating the simulation model of FMS (Flexible Manufacturing System). This FMS consist with six technological workstations which provide milling and drilling operations. The simulation model is utilized in process of FMS projection. Therefore, numbers of workstation and other devices are an object of simulation experiments. Flow of technological pallets ensures the automatic transporter with linear transportation path. The transporter takes workpieces from the fixture workstation and carries to technological workstations under process plans. When a technological workstations is busy, a workpieces is put on the linear storage area. The speed of transporter and number of cells of the linear storage area are an object of simulation experiments, too. Input/Output storage situated before fixturing workstation creates a boundary - line between FMS and other production facilities. Two workers are used for fixturing of workpieces in fixturing workstation. For representing of production requirements of FMS such as technological workstation, storage areas, workers etc. AIM has prepared four modelling components: Resources, Resources group, Pools and Materials. The FMS model used both resources and resource groups. To model linear storage area and Input/Output storage are selected two approaches. Input/Output storage was modeled as WIP (Work-In-Process) because this storage has small capacity and its behavior is like as a conveyor. For quick modelling of the linear storage area is used WIP again. But, this approach for modelling of large storage area with transporter is not precise. Therefore, the following approach is used: each storage location (cell) is modelled as a resource. The transport system has a control point at each location. For traveling between storage location are defined appropriate segments. The resources are all in a resource group. This group and control points are tied together through AIM Control point Group structure. For releasing one or more orders into the FMS are used several DEMANDs. The demand limits the number of orders released and time between releases. Time between releases (Interarrival Time) is generated by using Normal distribution. FMS produces 22 different types of workpieces (parts). Technological process, witch routes flow of parts through FMS is described using process plans and jobsteps. Each operation is defined by using one or more jobsteps. The FMS model includes a transporter system which is setting with transporter vehicle, transporter segments and transporter control points. Each technological workstation, fixturing workstation and each storage area cell has own transporter control point. The FMS simulation model is used to perform several simulation experiments. The experiments carry out to determine characteristics and the operation of FMS.

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THE VALUATION OF A ROBUSTNESS OF A MULTIPROCESSOR COMPUTING SYSTEM

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We consider the model of the multiprocessor computing system on the base of transputers (CT) which permits to resolve the question of valuation of a structural robustness (viability, survivability) of CT.

For research we chose a class of managing computing systems. This class is simulated by a communication network. As a main component of CT for this class its fragment FCT is considered. FCT is a microstructure connecting the output into external environment with data processing unit or one point of entering in the microstructure with other point of entering. The difference FCT from other components of CT is insignificant.

At simulation FCT by a communication network, the transputer is considered as a complex element, consisting from four simple communication elements, possessing one common point, in which concentrates a computing element (data processing unit). An idea of a rank is suggested. The rank is a quantitative characteristic, determining the minimum quantity of faults of simple elements, causing to fault of a communication network between first and second points of entering.

The quantitative expression for calculation of the structural robustness of FCT (microstructure) is suggested:

$$J_{F_k}(N, S, f^{in1}, f^{in2}, R, P^{sr}) = (r + P^{sr}),$$

where F_k - is the chosen FCT, N - is a set of elements of the FCT, S - is a structure of FCT, f^{in1} - is the first point of entering into the FCT, f^{in2} - is the second point of entering into the FCT, R - is a set of the ranks of branches (sections of a way), P^{sr} - is a structural probability of keeping the rank of FCT, r - is the rank of FCT.

The result of calculation under this formula is a real number, the entire part of which is the rank of a microstructure, the fractional part is the probability of keeping this rank at the first single fault. The probability of keeping a rank for a particular microstructure is determined as a fault probability sum of some elements of this microstructure. These elements are selected so that each element fault in of separateness does not lower the rank of the microstructure.

By use of the given expression, the structural robustness of any structure of CT of a type of FCT can be evaluated, if its structure can be represented as a set of different level microstructures, and if for each of microstructure a way of calculation of this expression is known. The examples of some typical microstructures and ways of account for them of the structural robustness are submitted.
Optimal state save insertion for parallel simulation based on Time Warp approach

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The Time Warp is a method of asynchronous parallel simulation with an optimistic approach and is collocated among methods that explain the intrinsic parallelism of real systems through an opportune decomposition of relative models in subsystems which are exclusively interagent by means of messages: this is referred to as object-oriented simulation. Any object can interact at any time with any other object each one of which has three queues: one queue, in which incoming messages from other objects are inserted, is called the input-queue; another queue, in which messages sent to other objects are memorised, is called the output-queue; the third queue, in which a certain number of evolution states passed through by the object during simulation is memorised, is called the state-queue. None of these objects undergoes constraints in order to carry out the computation relative to a new message but can continue to go ahead, unless the input-queue is empty. Therefore, with respect to non optimistic methods, the approach to the problem of the consistency of the simulation changes completely. Rather than synchronisation mechanisms, if a situation of incorrectness occurs, a rollback mechanism is predicted which takes the simulation back to a correct state relative to a previous virtual time from which the computation can start again. It is necessary to memorise a fraction of the states which have been passed through during the simulation just in order to enable the handling of this eventual rollback procedure.

The saving of the state of the objects is a procedure which costs in terms of execution time and therefore saving the state of the object less frequently results in economy of the time spent on this procedure. On the other hand, however, having only a fraction of the states passed through during simulation available increases, on the occurrence of rollback, the probability of restoring a state, which sends the simulation further back than is really necessary for the elaboration of the message which generated the error. This makes the object in rollback go through a series of elaborations which have already previously been carried out correctly. This last phase of rollback is referred to as coasting-forward and its mean cost is proportional to the distance, measured in terms of the number of computations, that separates two consecutive saved states.

Our goal is therefore to determine the optimal distance between two consecutive saved states, for which the increasing cost of the coasting-forward is balanced by the decreasing cost obtained by avoiding saving all the states passed through the simulation.

The Algebraic Programming of Parallel Symbolic Computation for Modeling and Simulation

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Increasing size and complexity of computer simulation systems especially in their parallel implementations evokes a need for their high-level, declarative description and prototyping. Symbolic computation gives good opportunities for research and making knowledge-based decisions. Algebraic programming is a kind of symbolic rewriting based computation that integrates four main paradigms of programming: procedural, functional, algebraic and logical. Its main distinction consists in considering rewriting activity together with a strategy of rewriting usually defined in procedural form. It gives advantages of flexibility, high-level rapid prototyping, low cost simulation and evolutionary development of efficient parallel software from declarative to procedural programs.

The poster displays an approach to symbolic simulation developed in our algebraic programming system APS framework [2] and basic facilities of the APLAN language [3] that provide creating, completioning and interpreting algebraic modules. Simulation algorithms follows eventdriven approach in running modules being simulated. Our methodology is demonstrated with an example of parallel program development and simulation for the known computer algebra problem of Gröbner basis construction [1]. We have developed rewriting style parallelization of Buchberger's algorithm. It gives opportunities to construct highly adaptable parallel version of the algorithm that was realised as a multimodule algebraic program with message passing. Experiments on benchmarks for Gröbner basis known from literature show good efficiency of simulated parallelism that can be achieved from our declarative presentation of the algorithm. Current version of the APS system is implemented on IBM PC 486 computer and the experiments on the local net of PCs is now under preparation.

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EUROSIM '95 - POSTER BOOK

DISTRIBUTED SIMULATION OF HIGH LEVEL TIME PETRI NETS

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High Level Time Petri Nets (HLTPN) are a formalism commonly used for systems specification and development, because they represent both functional and time behaviour. Distributed simulation, where a net is divided into a number of subnets which are executed on different processors is a mean to cope with complexity of large designs, increases the modularization in the specification/design process, can make use of remote resources in the simulation, and makes its animation geographically distributed. We have applied this technique to HLTPN.

The simulation scenario is composed by submodels with shared places, the simulator or logical processor for each submodel, the physical processors and the communication system. Distributed simulation of HLPTN is event-driven, pessimistic and asynchronous.

This approach gives maximum freedom to compose subnets in order to create larger models, being the only restriction to join them by places. As a consequence of that, there are some restrictions to the concurrency degree of the simulation, because the marking of a shared place can be modified by the sharing subnets at unpredictable times. The general condition to be met to ensure time correctness is that a transition t can fire at time τ only if no other subnet can insert a token with a timestamp lower or equal to τ in any of its input places.

To ensure this general principle, the algorithm uses several protocols:

- for transition firing. To ensure the coherence between local copies of shared places, to fire transitions in an atomic way and to solve effective conflicts found.
- time management. To explore the time of next events in each subnet to perform firings in a safe way.
- **deadlock detection.** To detect and break communication deadlocks by chosing the time of the lowest event in the whole system.

A toolset for distributed simulation/animation of HTLPN models has been built in the ESPRIT IPTES project. It has been used for distributed animation of SA/RT models on top of the HLTPN executor.

Parallel Simulation of Large Office Workflow Models

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Abstract

Modeling and analysis of business organizations is required for the purpose of redesigning an enterprise's business process to make the organization more efficient (Business Process Reengineering), as well as for the purpose of establishing advanced coordination technology in the organization, i.e. provide automated support for the management of dependencies among the interacting agents (humans, machines) responsible for executing a business process by using e.g. distributed, networked environments. We consider a (business) process to be a set of partially ordered steps to reach a (business) goal. Any component of a process is called a process element, which is an atomic action with no internal substructures. An agent is an actor (human or machine) who performs one or more process elements. A coherent set of process elements to be assigned to an agent as a unit of functional responsibility is called a role, and the a product created or modified by the enactment of a processes element is referred to as "work". A process model now is an abstract description of an actual or proposed process constituted by a set of selected process elements. Typically, these process steps either produce some work, or coordinate the dependencies with other agents involved in the same or a related process. Due to the migration of work from agent to agent we refer to the dynamics of the execution of process models as "workflow models". A workflow model must appropriately describe the input and output relation of work for every process element, and above that, the assignment of process elements to the responsibility of agents. The latter necessitates the preservation of causal (flow) relationships defined in processes, but also the work scheduling and management strategy applied by an agent to execute the assigned process elements. This is essential especially for agents acting in several roles (involved in more than one process).

An important aspect of a real system of business processes is its *temporal behavior*. For a model to be adequate in this respect, it must reflect delays and durations of process element executions. As a consequence, the modeling formalism has to provide sufficient expressive power to characterize the time dynamics of the system. We have developed an abstracted framework of business process systems in the domain of Generalized Stochastic Petri Nets (GSPNs), and have shown how those systems are modeled and analyzed *quantitatively* and *qualitatively* using GSPNs [1]. Preliminarily we have choosen discrete event simulation as the means for the quantitative evaluation of GSPN workflow models, but encountered that with the increasing complexity of business process systems, traditional simulation techniques become practically intractable.

In this work, we present the use of parallel simulation methods to accelerate the workflow model evaluation. Our approach is to automatically decompose a timed Petri net model based on the structural properties obtained from a preanalysis of the model. Submodels are executed by *logical processes* allocated to different nodes on a multiprocessor [2], such that the overall elapsed CPU time can be reduced considerably. We present GSPN model partitioning heuristics as applied to models coming from a real business organization, and the respective parallel execution performance on the CM-5 and a cluster of RS6000 workstations.

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Sensitivity Analysis of Simulation Time in Time Warp Parallel Simulation

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Abstract

In the last few years, much efforts have been devoted to obtain efficient implementations of parallel discrete event simulation.

Among the different approaches, time warp is a method based on the rollback mechanism, to perform simulation on a distributed environment. This paradigm states a strategy to synchronize the logical processes involved in the simulation.

Parallel simulation consists of two basic components: the normal forward execution time, and the rollback mechanism time-overhead. It is convenient to parallelize a simulation until the latter component is not predominant with respect to the former one.

The goal of this work is the sensitivity analysis of simulation time versus variables as number of processors, checkpoint interval, rollback rate and lenght.

To this purpose the time warp mechanism is first analyzed by use of an execution graph, whose nodes describe various procedures the mechanism executes to deal with event sequencing and parallelization.

Total simulation time is the by-product of the mean time spent in the execution graph and the average number of events processed by each processor, given a certain simulation length.

For each node in the graph, the time necessary to execute its operation is introduced. Such time depends on the execution environment and the time warp kernel. An expression is also introduced for various branching probabilities among nodes in the graph. A further expression is obtained to evaluate the number of events processed by each processor, for the forward execution and for the rollback overhead.

On the basis of quantities above, the complete expression is obtained for the total simulation time as a function of number of processors, checkpoint interval, rollback rate and length.

Two out of four variables (i.e. number of processors and checkpoint interval) are user-controllable to tune the execution for optimal speedup, while the remaining two (rollback rate and length) are partly model-dependent and partly dependent on the processor number, and strongly affect the simulation overhead.

Various curves are introduced that illustrate the effect of such variables on time warp parallel simulation time.

Parallel simulation of charge transfer in semiconductor devices.

M. Jadzhak

Two-dimensional mathematical model of semiconductor devices represented by two continuity equations and one Poisson equation is considered. Having as the goal determination of concentrating fields of charge carrier and the field of electric potential we use the following new technique: approximation of output system of nonlinear differential equations is realized by the Galorkin form of finite elements method, and the obtained large-dimension system of nonlinear algebraic equations is linearized further by modificated Newton-Rafson method.

Basing on the technique proposed and on the employment of high-level language means for the introducing of parallelism a parallel algorithm for numerical modeling of charge transfer in semiconductor devices is constructed by the following way:

- the sections having explicit inner parallelism are discovered;

- the algorithmic complexity analysis and parallelism degree estimations for every from the sections discovered and for every possible parallel form are effected;
- using the primitives "fork", "join" and program loops of the types AUTON (autonomous), SIM (simultaneous), SYNCH (synchronous) parallel implementation of these sections is prescribed;
- the implementation of program loops is prescribed in the pipeline manner by using type of parallelism PIPE.

The results concerning adequacy of this model, semiconductor devices and parallel algorithms constructed are proved.

Numerical Solutions of Ordinary Differential Equations in a Transputer System

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The paper deals with numerical solutions of ordinary differential equations. The Modern Taylor Series Method is used.

It is known that the Taylor series method is a parallel one and therefore attempts at a parallel interpretation in a transputer network can be expected. Transputers are high performance microprocessors that support parallel processing. They can be connected together in any configuration and they can form a building block for complex parallel processing systems.

The block notations and block diagrams (used in analogue and hybrid computers) represent a very convenient tool for describing parallel tasks in a transputer network.

The integrators, summers, multipliers, dividers, ..., are taken as procedures in OCCAM, the corresponding calculations are viewed as processes. The integrators and summers are interconnected by channels in OCCAM.

As in the OCCAM programs only very simple communication with the operator in the form of a "running column of numbers" is possible and as a debugging a program in OCCAM is complicated, the TKSL/TRANSP has been created.

TKSL/TRANSP created for simulating dynamic systems makes it possible to automatically write a program for a transputer or a network of transputers from a textual description. In fact, the only interconnection of analogue elements must be described in the textual description. Thus, when simulating, it is no longer necessary to debug a program in OCCAM.

Moreover, a repeated start of the calculation is possible in TKSL/TRANSP without having to load a new program into the transputer.

When using a transputer network, any element of the state diagram can be placed practically in any transputer of the network. The problem is, however, the serial communication. The reason is that the serial communication may be almost as time consuming as the calculation itself.

The system elements must then be placed in the network in such a way that the transputers communicate with one another as little as possible.

A TRANSPUTER NETWORK HOST LOAD SIMULATION.

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In the organization of parallel computations in transputer networks much attention is paid to load algorithms. Here we are concerned with the algorithms of a transputer system's host work control in the stationary mode. Upon that, as an effective technique of the load simulation and that of the examination of such algorithms use is made of a queueing theoretical model.

It is assumed that the Poisson arrival task stream have been split on any number r of the homogeneous task classes called the priority classes. It is known that the first step in the transputer network load [1] is the network dumping, after that the processors in the network pass into the load mode on one of its network line. Therefore, as it is further believed, on a host, besides the service process, there is another random process, with the help of which the time losses on , so called, "switchings" of the priority classes or their "orientations" will be simulated. The expenditures on a "switching" within a priority class are equal to zero. Following Kendall such a queueing model with the priority and orientation is noted by $M_r/G_r/1$.

The class of host load control algorithms has been built on the basis of the analytic correlations describing the busy period behavior within a network host. Each algorithm of the class depends on the parameters of the arrival streams, time losses for the priority "switchigs", the tasks' service time distributions and other. Each algorithm involves the fast-algorithms for the solution of the recurrent equations and the calculating methods to inverse Laplace and Laplace-Stiltjes transformations, as well as the object-oriented approach to programming.

The operation mode analysis is made by the object-oriented programming technique for common goals of priority systems simulation [2]. By means of the programming language Turbo-Pascal 6.0 the system of the objective types describing a queueing system with priority and orientation have been developed. Also, in order to evaluate the set of the work mode characteristics of a system with r priorities as well as to "evaluate" the possibility or the impossibility of such a system to be functioned in the stationary mode the procedures using the above collection of means and elaborations have been constructed. Constructively, on the each step $k \geq 1$ the characteristic ρ_k is calculated by using the procedures of the packet in force and then the condition of stationarity $\rho_k < 1$ is checked. If the condition is true for each k up to r then it means that the host load can function in the stationary mode under given parameters. Simultaneously with that the characteristics of the stationary mode are evaluated. Numerical results of the simulation under various specific parameters have been obtained.

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SCHEDULING AND METASCHEDULING IN MULTIPROCESSORS: EVOLUTIONARY COMPUTATION APPROACH

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In this paper a variant of the job-shop problem related to the area of parallel processing is considered. The problem concerns scheduling tasks of a parallel program on multiprocessors. An approach to solve the problem based on application of evolutionary computation methodology is proposed.

It is assumed that a parallel program is represented by a directed and weighted graph called a *precedence task graph*. Nodes of the graph represent elementary tasks which are indivisible computational units. Weights of the nodes describe the processing time needed to execute a given task on any processor of a given multiprocessor system. Edges of the precedence task graph describe the communication pattern between the tasks. Weights of the edges describe a communication time between pairs of tasks k and l, when they are located in neighbour processors.

A multiprocessor system is represented by an undirected graph called a *system graph*. Nodes of the system graph represent processors of a parallel computer of MIMD architecture. Edges represent bidirectional links between processors and define a topology of a communication system of the multiprocessor system.

The objective of the scheduling problem studied in this work is to find an assignment of tasks into processors to *minimise the total execution time* of a parallel program. Since this optimization problem is know to be NP-hard, to solve the problem with a realistic size of the precedence task graph some effective heuristic methods should be applied. In this paper, the evolutionary computation methodology based on *genetic algorithms* (GAs) and *genetic programming* (GP) is applied.

A chromosome representation for a scheduler describing the scheduling task is proposed. A number of specialized genetic operators supporting the chromosome representation has been designed. During a life cycle of each scheduler-chromosome genetic operators are applied to produce new legal solutions of the problem. A population of schedulers evolves in the evolutionary process to search optimal or suboptimal solutions.

The evolutionary system has been implemented on a sequential computer. Results of conducted experiments show that the system is able to discover very effectively a solution, improving sometimes solutions presented in the literature.

While the problem of scheduling tasks it closely related to the area of parallel computing, we face a more general problem deriving a solution of the problem. Our simulation system is described by a set of parametres, and by a set of genetic operators. What are the right values of these parameters, and what is the best order of applying operators to use the most effectively the simulator? To solve these problems we introduce a second level of schedulig, which we call *metascheduling*. We show that introducing the metascheduling implemented also with use of the evolutionary computation methodology, particularly using GP and GAs techniques, increases the efficiency of use of the simulator and quality of obtained solutions.

Parallel simulation programs optimum partitioning

Uljanov Alexander

Optimum partitioning of data is very important for speed-up in SPMD (single program multiple data) parallel simulation. Formally the problem consists of following: there is a graph G = (X, U) with functions of weights of edges: $\rho_{\mu}: U \to R^*$ and functions of weights of vertexes

 $\rho_{u}: X \to R^{+}$. We have to calculate a partitioning X of set X with limitation

 $\sum_{X''} \sum_{X',x_l \in X''} \rho_x(x_l) \leq V^x \text{ and a criterion } J = \sum_{U, P_U} \rho_U(x_l, x_l) \text{ must be minimum,}$ where $U_r = \{(x_1, x_1) \mid (x_1, x_1) \in U \land (\exists X'' \in X') [(x_1 \in X'' \land x_1 \notin X'') \land (x_1 \in X'' \land x_1 \notin X'']\}.$ To solv this problem the Floyd-matrix of the shortest chains $R^i = \|r_u^i\|$ is used, where $R^i = \|r_u^i\|, i, j = 1, 2, ..., n, r_u^i = \rho_u(x_1, x_1), \text{ when } (x_1, x_1) \in U \text{ and } r_u^i = \infty, \text{ when } (x_1, x_1) \notin U.$ Let us accept, then vertex subsets $x_{I_{n-2}}^{(i)}$ for the vertex x^i . $d(x^i, x_{I_n}^{(i)}) \leq V^x$ and a shortest chain $C_{I_1} = x^i, x_{I_1}^{(i)}, x_{I_2}^{(i)}, ..., x_{I_n}^{(i)} \text{ exist. We have a net with the source } x_{I_{k_1-1}}^{(i)} \in X_1^{(i)} \text{ and flow-off } x_{I_{k_1}}^{(i)}, or in the opposition direction }.$ The maximal flow in this net $U_1^{(i)} = \min_{\sigma \in U} \sum_{(x_l, x_l) \in \sigma} \rho_u(x_l, x_l).$

can be calculated with the Ford-Fulkerson algorithm.

The cut σ^{l} determines the partitioning of set X in two sets $X_{1}^{(0)}$ and $\overline{X}_{1}^{(0)}$, where

$$\boldsymbol{\chi}_{l\boldsymbol{k}_{1}}^{(i)} \in \overline{\boldsymbol{X}}_{1}^{(i)}, \boldsymbol{\chi}_{1}^{(i)} \wedge \overline{\boldsymbol{X}}_{1}^{(i)} = \{\emptyset\}, \ \boldsymbol{\chi}_{1}^{(i)} \cup \overline{\boldsymbol{X}}_{1}^{(i)} = \boldsymbol{X}.$$

We will get a value $V_1^{(1)} = \sum_{\chi_i \in X_1^{(1)}} \rho_{\chi}(\chi_i)$ then let us accept, the vertex $\chi_{I_{h-2}}^{(1)}$ is a source and the

vertex $\chi_{(k-1)}^{(0)}$ is a flow-off. Now the maximal flow is to get according to formula:

$$U_{2}^{(0)} = \min_{\sigma^{2} \in U} \sum_{(\mathbf{x}_{1}, \mathbf{x}_{2}) \in \sigma^{2}} \rho_{v}(\mathbf{x}_{1}, \mathbf{x}_{2}), V_{2}^{(0)} = \sum_{\mathbf{x}_{1} \in X_{2}^{(0)}} \rho_{x}(\mathbf{x}_{1}), \mathbf{x}_{1k_{1}-2}^{(0)} \in \overline{X}_{2}^{(0)} \land \overline{X}_{2}^{(0)} \land \overline{X}_{2}^{(0)} \land \overline{X}_{2}^{(0)} \land \overline{X}_{2}^{(0)} = X...$$

and so on, until we get the maximal flow between χ^i and $\chi_{l_1}^{(0)}$. The k_i minimal partitionings and k_i variants $\chi_{1}^{(0)}, \chi_{2}^{(0)}, \dots, \chi_{k_i}^{(0)}, \chi_{i}^{(0)} \subset X, i = 1, 2, \dots, k_i$ will be calculated using the chain C_{l_i} . Further the following three components will be got for all the chains:

$$V = \{V_1^{(1)}, V_2^{(1)}, \dots, V_{k_1}^{(1)}, V_1^{(2)}, \dots, V_{k_2}^{(2)}, \dots, V_1^{(n)}, \dots, V_{k_n}^{(n)}\}$$

$$X' = \{X_1^{(1)}, X_2^{(1)}, \dots, X_{k_1}^{(1)}, X_1^{(2)}, \dots, X_{k_2}^{(2)}, \dots, X_1^{(n)}, \dots, X_{k_n}^{(n)}\}$$

$$U' = \{U_1^{(1)}, U_2^{(1)}, \dots, U_{k_1}^{(1)}, U_1^{(2)}, \dots, U_{k_2}^{(2)}, \dots, U_1^{(n)}, \dots, U_{k_n}^{(n)}\}.$$

where

$$|V| = |X'| = |U'| = \sum_{i=1}^{n} k_i \ (\exists i, j, m, l) \{ [V_{k}^{(i)} = V_{km}^{(l)}] [X_{k}^{(i)} = X_{km}^{(l)}] [U_{k}^{(i)} = U_{km}^{(l)}], U_{k}^{(i)} \ge \rho_0, X_{k}^{(i)} \subset X.$$

Then the optimal partitioning $X_{k}^{(q)} \in X'$ is to calculate with function

$$f = \min_{i \in \mathbf{I}, n} \min_{i \in \mathbf{I}, k_{i}} \{ [V^{\mathbf{x}} - \sum_{\mathbf{x}_{i} \in X_{i}^{(i)}} P_{\tau}(\mathbf{x}_{k})] + l_{2} * \frac{\sum_{(\mathbf{x}_{i}, \mathbf{x}_{u}) \in U_{i}^{(i)}} P_{U}(\mathbf{x}_{P}, \mathbf{x}_{u}) - P_{0}}{\sum_{(\mathbf{x}_{u}, \mathbf{x}_{u}) \in U_{i}^{(i)}} P_{U}(\mathbf{x}_{P}, \mathbf{x}_{u}) - P_{0}} \}.$$

where minimum is to calculate for all i,j:

$$C_{i}^{(i)} = \sum_{\boldsymbol{x}_{k} \in \boldsymbol{x}_{i}^{(i)}} \boldsymbol{\rho}_{x}(\boldsymbol{x}_{k}) \leq V$$

The alternation of the values $l_1 l_2$ gives the variants with the minimum of parts (machines, blocks) or minimum value of the cut (interfaces). This method is effective when the value of

$$|V| = |X'| = |U'| = \sum_{i=1}^{n} k_i$$
 is enough great.

Performance Analysis of Prioritized HMPMB Multiprocessor Systems

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Abstract

The principal characteristic of a multiprocessor system lies in the capability that all processors share a single main memory. This sharing capability is provided through an interconnected network between the processor and the memory module. A few interconnection networks(INS) have been proposed by many research groups for interconnecting multiple processors, including crossbar and multiple bus, etc.. However, the complexity of these INS is prohibitive for large scale multiprocessor systems.

Recently, hierarchical systems are designed and analyzed to reduced the network complexity by in incorporating hierarchies of interconnection networks. Nevertheless, their cost and complexity are still higher when the number of processors and memory modules is greater. In order to reduce the cost and complexity of the system without significantly reducing the performance, we present an improved m-level hierarchical memory-oriented partial multiple bus(HMPMB) multiprocessor system.

The m-level HMPMB architecture consists of a global interconnection network(GIN), a cluster interconnection network(CIN), or called local level, and a nonlocal interconnection network (NLIN). It is assumed that $N = n \times k_1 \times k_2 \times \cdots \times k_{m-2} \times k(\text{let } N \text{ be the number of processors or memory modules})$. In the CIN, it consists of N/n clusters of processors and memory modules. Each cluster consists of n processors and n memory modules interconnected by means of a CIN, which is a memory-oriented partial multiple bus(MPMB) IN of size n × n × b_c/g_c. In a cluster, n memory modules are divided into g_c groups with each group of n / g_c outputs fully connected to a set of b_c / g_c buses, whereas all n processors are connected to all buses.

The GIN is a MPMB IN of size $k \times k \times b_g / g_g$. In this network, k outputs are divided into g_g groups with each group of k / g_g outputs fully connected to a set of b_g / g_g buses, whereas all k inputs are connected to all buses. Between the local and global levels there exist m-2 nonlocals(NL). NL_j is a MPMB IN of size $k_j \times (k_j+1) \times b_{nj} / g_{nj}$. In this network, k_j outputs are divided into g_{nj} groups with each group of k_j / g_{nj} outputs fully connected to a set of b_{nj} / g_{nj} buses. Each output of the GIN is connected through a hierarchy of m-1 buses. Each output of the NL_jIN is connected through a hierarchy of j-1 memory bus.

The performance of multiprocessor systems has been studied extensively in a number of papers, but processor priorities were not considered in most of the published literature. In an actual systems, simultaneous requests to the same memory module can be resolved on a priority basis. Thus, we analyze the bandwidth performance of a prioritized HMPMB system in detail. This bandwidth model is useful not only to quantify a set of parameters for a given configuration, but also to investigate the effect of different parameters on system performance.

In order to validate the modeling technique, the system was simulated. Every simulation-run was repeated 10 times with different seed values to determine the 95% confidence interval of the results. Requests are generated randomly by each processor. A blocked processor will reissue the same memory request in the next cycle.

The motivation of the work of this paper is to develop analytical models for prioritized hierarchical multiprocessor systems for the favorite case so that the performance of such systems can be accurately predicted using analytical models.

Parallel simulation of hierarchical digital systems

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Topics: Applications (VLSI-CAD), Simulation of VLSI circuits, Distributed Processing

Abstract

With this paper, a strategy is explained which allows to map the hierarchy of a model onto a network of parallel computing nodes for simulation purposes. It is shown that exploiting hierarchy can support the solution of many computational tasks, especially the devide and conquer approach of partitioning a given problem before solving it. Demonstrated results were gained in the field of logic and fault simulation of digital circuits as well as in the test generation for electronoc devices; the parallel computer used is a transputer net with 40 nodes. The developed approach shows general strategies for a broad class of applications in discret event simulation.

1. Hierarchical Modelling

This principal is explained by way of the design of digital circuits. All CAD tools provide the user with some basic primitives, out of which he can construct a first set of subdevices (e.g. adder, multiplexer, and decoder may be constructed using basic gates). In a second step, more complex modules will be constructed, e.g. an arithmetic unit consisting of several adders and multiplexers. The designer takes advantage in the high degree of equality of the instances in the sense that he constructs each module only once, on the next higher level of design he will only refer to the memorized design of subcircuits, i.e. he uses the subcircuit in many instances. Most CAD tools flatten such a hierarchical design and work on a representation which describes all instances in the same detailed way every time the subcircuit is used.

Due to the fact, that such flattened descriptions of large designs are workloads difficult to handle sometimes even for powerful workstations, the simulator TESI (TEst and SImulation) has been developed. Exceptional feature of this simulator is that the hierarchy of the design is not only used for model description but also during run time of the simulator. For this purpuse, a substructure of a circuit which is used in multiple areas of the model is stored only once; only a reference to its unique definiton is stored at the places where the substructure is used. This fact results in very compact internal data structures. As a consequence, the required space for working memory as well as CPU time for loading and storing the net list are dramatically reduced. /1/.

2. Parallel simulation

This technique has been developed for an ordinary sequential simulator. In addition, it turned out that it can be exploited as a basic strategy for parallel simulation. Reasons are:

- The simulation of a large circuit can easily be broken into the simulation of substructures given by design hierarchy. No time consuming cutting algorithms have to be used to create artifical subcircuits.

- Due to the fact that many substructures are identical (i.e. instances of the some basic type), the number of different substructures is significantly smaller than the number of sub-structures of similar sizes gained from a cutting algorithm. Therefore this partitioning will map on a net with fewer computing nodes.
- Due to the very compact internal data structures of these models it is possible to load many different instances (sometimes the entire model) on each and every computing node of the parallel computing net. As a consequence mechanisms can be constructed which allow easy and fast load ballancing when the simulation of some instances requires significantly more or less computing time than the average of all nodes of the net.

Based on these considerations a parallel version of the simulator TESI has been implemented on a transputer net with 40 nodes. The described devide and conquer method revealed to be efficient although frequent communication between nodes is obviously the drawback of this approach. Alternative experiments using different strategies (e.g. partitioning of the fault list) showed that hierarchy can be used as a reasonable way of problem partitioning. Together with the advantages in memory requirement and load time it may be especially worthwhile to use it for the simulation of large circuits /2/.

- /1/ Hunger, A., Papathanasiou, A.: Acceleration of simulation time by hierarchical modelling. In: Silvester, P.P.: Software Applications in Elelectrical Engineering, Computational Mechanics Publications, Southampton, 1993
- /2/ Müller, F.: Methodische Analyse der digitalen Fehlersimulation als Grundlage für die Entwicklung effizienter Parallelisierungsansätze. Dissertation im Fachbereich Elektrotechnik der Gerhard Mercator Universität Duisburg - GH, 1994.

SDL Integrated Tool Environment - SITE

DESCRIPTION

The Tool Set provides an open environment for SDL'92 development and analysis tools. All tools are single stand-alone components, which communicate via the Common Representation. This allows an independent development of new tools as well as the integration of third-party products.

Currently available are the *Parser* (according to Z.100 with tool dependent ASN.1 extension as well as according to Z.105), the *Semantical Analysis*, the *Simulation* (SIM-Lib, SDL-Lib), the *Petri-Net-Analyser* (dedicated to SDL-Time-Nets), the *Syntax-Oriented Editor for SDL/ PR*, the *Pretty Printer for SDL/PR* and the *C++-Generator*. The work on the *Petri-Net-Generator*, the *Graphical Editor*, and the *Result Presentation* is under progress. A *runtime library* to generate prototype software is part of a third party project and not public available.

All tools are developed in C resp. C++ and are portable to different platforms. To keep the expenditure for the development process low, metatools were extensively utelized. The major metatools are

- yacc and lex (resp. Bison and Flex) for the lexical and syntactical analysis
- *Kimwitu* for all CR-operations (CR-construction and semantical analysis)
- Gnu tools like awk, perl, rcs...
- own developments, e.g. the Scanner-Parser Generator for incremental analysis.

ENVIRONMENT

SITE was developed on SUN work stations with SunOS/Solaris. Graphical applications are X-based. Adaptations to other UNIX platform are possible. For the tool demonstration the preferred environment is:

- Sun (compatible) SPARC station 5,10, or 20, colour monitor
- SunOS 4.1.x with X or Openwin
- Gnu development kit if any problems occurs

CONTACT

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AVAILABILITY

Not commercially available, research licence necessary

ESPRIT-III-Project

INSYDE

Integrated Methods for Evolving System Design

Project Objectives:

The main objective of the INSYDE Project is to define, implement, validate and demonstrate a comprehensive methodology for hybrid hardware/software system design. The result of the project will be a prototype methodology and a toolset, exploiting and combining the advantages of object-orientation and formal description techniques (both for hardware and software design), which covers the full development cycle from system requirements analysis to system architectural design and validation. The INSYDE Methodology will be used in selected application domains (telecommunications and microelectronics hardware/software systems).

Project Partners:

- Verilog SA (France)
- Intracom SA (Greece)
- Alcatel Bell Telephone (Belgium)
- Humboldt-Universität zu Berlin (Germany)
- Dublin City University (Ireland)
- Vrije Universiteit Brussel (Belgium)

Duration: March 1994 - March 1996

Project Description - The INSYDE Methodology:

In the INSYDE Methodology a hybrid system is modelled at different levels of abstraction:

1. Conceptual Level:

The Conceptual Level describes the WHAT. The Conceptual Model is the result of a rigorous analysis of the functional aspects of a system. Non-functional aspects, such as performance, reliability, cost, etc. are outside the scope of the project. Analysis is done using the object-oriented modelling technique OMT.

2. Architectural Level:

The Architectural Level describes the *HOW*. Although the Conceptual Model provides enough information to describe the required architecture and functionality of a system, it is not formal enough to provide a basis for code generation or to allow simulation. Therefore, a more formal model – the Architectural Model – is constructed using the formal description techniques SDL (for the software components) and VHDL (for the hardware components). The transition from the OMT description to the SDL/VHDL specification is supported by software-tools.

3. Validation Level:

The Validation Model is an executable simulation model (realized by execution of e.g. generated C or C++ code). It is the result of an automatic transformation of the Architectural Model. In the INSYDE Methodology the validation is realized by co-simulation of the hybrid system specification: An SDL simulator and a VHDL simulator are used to simulate the SDL and VHDL part of the system specification; the interaction and synchronization between both parts is realized by a coupling module, which connects the simulators.

Performance Prediction System PEPSY for Parallel Programs *

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Abstract

Parallel programs, generated by the supercompiler, VFCS (Vienna Fortran Compilation System), are an application area for the tool, PEPSY, which we have developed recently. The initial sequential version of the program, written in Fortran'77 or Vienna Fortran programming language, is parallelized by VFCS, which translates a Fortran program into an explicit parallel program with message-passing statements, for the parallel computer Intel iPSC/860. Performance prediction should be done before generating the final code for the target compiler, i.e., before a real run is executed on the parallel computer. Performance results should be used for the comparison of several variants of the parallel program, and for recognition of the most critical parts in the program, so as to find the optimal parallelization strategy for VFCS.

PEPSY (PErformance Prediction SYstem) is a tool based on automatic modeling of parallel programs and performance analysis based on discrete-event simulation. The tool consists of two modules, viz. MOGEN and PROGAN. The automatic modeling technique is implemented in the functional module MOGEN (MOdel GENerator), which is integrated with the internal representation of the parallel program in VFCS. The modeling is based on the **Process Graph** (PG), which we have defined for the abstract representation of the sequential and parallel Fortran programs. PG model of the program is analyzed by the performance analyzer PROGAN (PROcess Graph ANalyzer), based on the discreteevent simulation technique evaluating a set of static and dynamic **performance parameters**. *Static parameters* characterize the size and structure of the modeled system, i.e., parallel program. We have defined nine parameters characterizing the size of the model and interconnections among nodes of the model. *Dynamic parameters* characterize the behavior of the model for steady or transient states. PEPSY evaluates about ten basic and several derived dynamic indices, e.g., execution time, computation time, communication time, parallelism degree, utilization, communication volume, etc. Comparing different versions of the parallel program, PEPSY allows to evaluate the *scalability parameters*, e.g., execution signature, speed-up, efficiency, and efficacy.

Monitoring facilities of PEPSY evaluate the performance indices for the whole execution period of the parallel program or for the detailed dynamic behavior, evaluating the values by an optional sampling period. The performance results are provided, in a hierarchy, for the global or *program level*, as an average values for all parallel processors, for the *processor level* comparing all parallel processes, e.g., for the load balancing analysis, and for the intraprocess level, i.e., the *statement level* of the parallel program. Using different monitoring facilities, PEPSY produces a large spectrum of performance characteristics for the parallel program. These information enable the user to find the critical parts and variants of the program, to be modified for the optimal parallelization strategy. A practical performance prediction for parallel programs, using PEPSY, is presented by examples.

^{*}The work described in this paper is being carried out as a part of the research project "Performance Prediction and Expert Adviser for Parallel Programming Environment", funded by the FWF, Vienna, Austria, under the grant number P9205-PHY.

Sensor based Simulation System for Planning and Programming of Manufacturing Processes in One-of-a-kind Manufacturing

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A major approach to improve quality and cost relation in one-of-a-kind production is the introduction of automation technology with a high degree of flexibility. Existing planning and programming systems (e.g. IGRIP, ROBCAD, GRASP) cover only standard off-line programming features, therefore real workpiece or tool geometries have to be implemented by manual teach-in or similar procedures in the shop-floor area. This reduces the productivity of the manufacturing facilities, and thus the cost/benefit relation is poor. To improve this situation we have developed and realised a sensor based simulation environment for planning and programming of manufacturing processes involving industrial robots.

The new technological approach is the connection of active vision with robot simulation and off-line programming systems. So necessary geometrical data can be acquired from topometric measurement and integrated in the planning and programming task. With this technology not only the described gap in off-line programming can be decreased, but also functions like geometrical inspection during/after manufacturing sequences or calibration of robot cell devices can be demonstrated. To prove the claimed functionality under real manufacturing conditions, an experimental environment has been realised which consists of three main items:

- Graphical simulation, visualisation and off-line programming system (IGRIP). A new feature is an advanced interface for rapid integration of topometric data, CAD-product data, manufacturing cell models or peripheral devices. The system enables the planning, layout design and simulation of robot based manufacturing of one-of-akind products.
- 2. Sensoric system based on coded light approach and phase shifting techniques. Realised by a sensoric head mounted on a spherical positioning system to cover various product shapes. To modify scenery information into 3D-clusters, preselect, extract and calibrate object data and transfer it to the simulation system, a unique communication process has been developed. As a result, the amount of input data for the simulation is reduced substantially.
- 3. Flexible manufacturing cell, based on a joint-coordinate industrial robot with rapid tool changing facilities and positioning devices for sensor and workpiece handling.

Field test experiments using arc-welding, spherical flame-cutting and assembly show the overall function of the described technology. Further exploration in view of manufacturing of free from surfaces is under development. The research work has been carried out in the ESPRIT project "NEUROBOT".

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Simulation Language TKSL/TRANSP and Partial Differential Equations

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The paper deals with parallel solutions of parabolic, hyperbolic and eliptic partial differential equations (PDE) in a transputer network. The method of lines is applied. Three-point-approximations and five-point-approximations are used for numerical solutions of PDE.

An original numerical method has been worked out based on the use of analogue functional blocks and on the use of analogue schemes. For this method procedures have been created describing the activities of the basic functional blocks (integrators, invertors, multipliers, dividers etc.). The functional blocks are interconnected via channels in OCCAM. The efficiency of the numerical solutions of systems of differential equations in transputer networks is improving with the number of differential equations solved (with the number of functional blocks used), and thus the proposed method is suitable for large systems of differential equations. The paper demonstrates a comparison of computations in a one-transputer and a two-transputer network. To stress the effect of the extreme speed and accuracy of the computation the paper is complemented by an analysis of the effect of the order of numerical integration.

TKSL/TRANSP created for simulating dynamic systems makes it possible to automatically write a program for a transputer or a network of transputers from a textual description. The textual description is based on analogue diagrams.

The paper demonstrates an application of transputer networks to the numerical solution of partial differential equations. The worked out method can be used for arbitrary systems of differential equations. For its illustrative power the method has already been used in teaching Parallel Architectures at the Technical University of Brno.

The worked out method of applying transputer networks has been successfully tested in solving special parabolic, hyperbolic and eliptic partial differential equations (and corresponding large systems of ordinary differential equations - a problem of 3,000 differential equations and a system of 8,000 differential equations has been solved).

Comparison between Ptolemy, SynDEx and TOPModèle shells

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<u>Abstract</u>: (KEYWORDS : Parallel simulation - Modelling - Development of Simulators - Prototyping)

The purpose of this paper is to propose a simulation tool called TOPModèle and to compare it with several development shells (DS) as SynDEx of INRIA Rocquencourt in FRANCE, Ptolemy of the University of California at Berkeley, USA. In many scientific areas, applications involve a large amount of computation suggesting the use of multiprocessors in order to speed up processing. Given an application and a set of architectural restrictions, the goal is the application partitioning so that every part will be processed by a different processor, but the research of the tasks allocation that minimize execution time is not easy since we know that the task allocation problem is a NP-complete one. Nevertheless, a lot of heuristics have been developed and implemented on DS in order to find sub-optimal solutions. Obtaining of optimal performances is a problem where it should be considered at once the potential parallelisms of the studied application, the available parallelisms of the computer and the allocation strategy.

First, study of parallel implementation methods used on DS emphasizes the problem of the granularity tasks application when modelized by means of a graph. The task granularity is defined as the ratio of the mean task execution time to the total application processing time. Exploiting the whole potential parallelism requires fine grain but leads to combinatorial explosion when the size of the application increases. Usually, this explosion could be reduced by increasing granularity, but potential parallelisms are decreased. Ptolemy and SynDEx use a task granularity depending on the application size. Simulations with TOPModèle show that parallel performances depend on this granularity and that DS should take into account the CCR (communication computation ratio) parameter for choosing an assignment strategy (mapping/scheduling, clustering and duplication heuristics) and the granularity of modelling in order to exploit potential parallelisms and raise parallel performances to a maximum.

Secondly, An analysis of some existing multiprocessors shows a large number of differences. Parallel machines contain many processing units of various powers calculating simultaneously. An internal network is used for exchanging intermediate data in parallel. Various natures, topologies and methods for communication have been proposed and achieved yet. An universal model is difficult to find because of the diversity of these architectures. Therefore, DS like Ptolemy or SynDEx modelize a particular machine hardening the research of an adapted architecture to the considered application. The target multiprocessor system considered is often a MIMD (Multiple Intructions Multiple Data) with homogeneous processors connected in a fixed topology. Each processor has a CPU and communication units that share a local memory and work concurrently. On Ptolemy, topology is fully connected or a shared bus with a variable number of homogeneous MIMD processors. Communications are executed through a DPM (Dual Port Memory). There are divided in two similar parts : the transmitter processor writing on DPM and the receiver processor reading on the same DPM. SynDEx is dedicated to T800 transputers or TMS320C40 DSP.

On TOPModèle, the set of processing units and communication links is described by an oriented graph. The vertices are the processors. They include one or more modelized functions : processing, memorizing, routing and sequencing. Then, the machine could be homogeneous or heterogeneous, the memory shared or distributed. The vertices may be partitionned to specify the multiSIMD mode. Therefore, a set of Instruction Registers (IR) is defined. Every class is associated one IR and every processing unit in the class executing the operation registered in that IR. An edge leaving a vertex specifies a physical unidirectional communication link towards a neighbour processor. One wants to stipulate that an input/output port in the machine is shared between several links. Therefore, links are grouped in parallel ways i.e. set of links able to transfer simultaneously and ways are grouped in communication channels, in which may are switched successively by the model during communication. Actual machines propose various parallel modes for processing the delivered informations. They differ by control and synchronization in particular the start, stop and load conditions for processing. Three modes are implemented in TOPModèle. Informations are not actually processed, only the ressource activity is simulated. In SIMD mode, the constraint is that parallel resources are whether idling or running the same operation. The starting condition is the availability of all the processing resources. Already delivered informations are reviewed and if they are associated with a common operation, an occupation delay is deducted for every involved ressource. The occupation indicators are initialized with the calculated load. They will be decremented during the simulation until the availability of all ressources. The SPMD mode starts with the same condition but simultaneous execution of different operations is allowed. In MIMD mode, synchronization is local. Activating a processor is independant of the other processors activity. The arrival of information in a processor initiates processing with the specified operator as soon as this processor is free. For all these modes, it is possible to specify that transfer and processing overlap or the whole transfer occurs first and then only processing.

After the application and machine modelling, TOPModèle delivers the results of execution timings with the instantaneous utilization of all the machine resources (links, memomies and processing units), the execution time of the application on a target multiprocessor in number of clock cycles, speedup for processing and exchanges, load repartition obtained with a given mapping. TOPModèle is a prototyping assistance for parallel applications design. This prototyper determines some minimum sizes requires for the parallel resources, i.e. memory, registers, FIFOs and I/O ports... Given CCR, this prototyper allows to choose the assignment strategy and task granularity and to change architectural constraint in order to research the best parallel performances.

SIMULATING LANDSCAPE SUSTAINABILITY WITH "MELAS" (MEditerranean LAndscape Sustainability Simulation System)

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Abstract

MELAS is an expert system designated to allow the user to simulate the behaviour of Mediterranean landscapes in time with respect to the concepts and principles of sustainability.

MELAS performs five different tasks.

1. Assessment of Mediterranean landscape sustainability on the basis of land use change.

2. Assessment of Mediterranean landscape sustainability on the basis of soil data.

3. Assessment of Mediterranean landscape (land use or soil) sustainability on the basis of land management and disturbance.

4. Sustainable land and soil use optimization.

5. Sensitivity analysis of the solutions.

The data the user imports are the following.

a) Land Use / Land Cover (area or biomass percentage), from time "1" to time "10". (forests, agriculture, shrublands - grazeland, bare ground)

b) Land Use / Land Cover Transitions (16 transition types), which are constant for the time interval from time "1" to time "10".

c) Land Use Sustainability thresholds.

d) Soil features (units as appropriate), for one or more time points, from time "1" to time "10" (soil depth, soil productivity)

e) Soil Sustainability thresholds

Items c and e are constant through time.

The main sustainability condition is that a landscape is sustainable if the soil erosion rate is minimum, the degraded land cover is also minimum and the soil productivity is maximum.

A SIMULATION SYSTEM FOR FORECASTING THE IMPACT OF CLIMATE CHANGE ON MEDITERRANEAN VEGETATION

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Abstract

The simulation system "MEDCLIVE" is designed to give for every place (φ, λ) within the boundary of the Mediterranean and time (year from 1990 until 2030) the response of the vegetation type (natural, seminatural and cultivation) to climate change for any climate change scenario. It can also show the sensitivity of the vegetation type to changing climatic parameters for the place and time these parameters are considered.

The grid resolution covering the Mediterranean is 2 by 1 degrees longitude and latitude respectively. Thus, it is possible to calculate the dominant vegetation type corresponding to the given climatic parameters on each one of the resulting grid cells for any year (until 2030).

MEDCLIVE is an simulation system suitable for research, as well as for training purposes. It serves the user by allowing to make rapid estimations of the impact of possible climate change on vegetation in the Mediterranean. In this context, the term "vegetation" describes both agricultural crops and natural vegetation. The most appropriate climatic parameters and the most representative vegetation types were selected for inclusion in the system's database.

$C_E_D_L_x$ a tool for modeling of chemical kinetics

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I. Introduction

In applied chemistry the factors, which determine the run of a chemical reaction, has to be examined. Due to the knowledge of these factors the chemical reaction can be influenced in an optimal way, and it is possible to answer questions about the chemical process without experiments.

The mechanism of a chemical reaction therefore is determined by the kind and number of elementary reactions. The fundamental task of reaction kinetics is to find out the reaction mechanism. Therefore this tool is implemented to support the modeling of chemical systems and the most important experiments applied on the chemical systems.

II. Description of the facilities of the system

The system provides several means of describing a chemical reaction.

- It is possible to write the equations of the chemical reaction with an editor and simulate the system. So a chemical equations' description language is implemented, which uses special keywords as matter, reaction, constant, step, time, temp and beside the normal expressions the two special arrow operators (order, constant_expression> and <order, constant_expression/ order, constant_expression>. Each reaction(input_list; output_list; parameter_list) can be part of a larger model - So libraries of often used submodels can be built. It is also allowed to nest the model descriptions to gain a fine local structure of the model.
- On the other hand the scientist can use the graphical possibilities of the UNIX X-Window based system and to draw the reaction with the mouse.

This method uses several basic objects to model the chemical equations: The participating matters are linked together with "arrows" of variable types (reaction in one or two directions (reversible reactions), catalytic reactions).

The participating matters are the sum of the compounds of one side of the chemical equation. These compounds are linked together by the arrows characterizing the kind of the reaction between the participating matters.

The attributes of the arrows are the order of the reaction and an expressions characterizing the constant of the speed of the chemical reaction.

- The chemical model results in a mathematical system of differential equations. Special algorithms have to be used because this system is stiff the algorithm for the solution of differential algebraic systems DASSL also fulfills the necessities of an algorithm to solve stiff systems.
- The experiments are variation of parameters and steady state analysis.
- If further experiments have to be made, the model also can be translated in the most popular simulation-languages like ACSL, MOSIS, SIMUL_R.

III. Steps of Realization

The realization of this project is organized in several phases:

- Implementation of the extended C_E_D_L_x Compiler using LEX and YACC.
- Implementation of a character based User Interface for the solution of the chemical systems.
- Implementation of the Graphical User Interface using the script language TcL/Tk to enable a graphical way to input the model using the basic graphical object types.
- Generation of the code of the description language based on the graphical description.
- Implementation of algorithms for experiments and algorithms for the solution of the differential equations.

An Object-Oriented Graphical Environment for Modelling and Simulation of Complex Process Units

J. Schmuhl, K.-P. Kniess

The modelling of process units in chemical engineering is realized mostly by the generation of complex models describing the basic processes. The complex model usually consists of variety of basic processes like reaction, adsorption, heat exchange, etc. Therefore it is possible to combine their basic models in a complex model.

We present an object-oriented graphical environment under UNIX system for modelling and simulation of complex process units. By using the mouse it is possible to select all required basic processes and to generate the complex model. After that one can simulate the steady state or dynamic condition of this process unit.

The following basic models are available recently:

several types of reactions tatic and dynamic heat exchange adsorption, desorption cooling and heating mixing compression and expansion

For simulation purpose we developed interfaces to static and dynamic simulators like AspenPlus and SpeedUp.

Several examples of using this graphical environment in order to generate final complex models for number of columns and reactors are presented in the paper.

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Bond Graph Modeler

1 Introduction

The program **bgm** is a project to interpret bond graph descriptions and create output for the **mosis** simulation system which was developed at the Technical University of Vienna.

The current state of the project is a processor that can handle linear bond graphs and output **mosis** model descriptions.

Further developments concern nonlinearities, fitting the model output to make use of the parallelization features of **mosis** and object orientation.

2 Bond Graphs

Bond graphs are a powerful tool for modeling physical systems, especially when they are interdisciplinary. The idea of bond graph modeling is that the power flow in a system is represented by two power variables, namely effort and flow, in any physical discipline.

The bond graph itself is a directed graph, where the different kinds of vertices ("elements") describe the relations between the two power states and the directed edges ("bonds") represent the power flow through the system. The elements can be divided active (sources), passive (consumers and storages), forwarding (transformers and gyrators) and distributing (parallel and serial junctions) elements.

The advantages of bond graph modeling are the fact that the graph still represents the structure of the physical system and that the generation of the corresponding equations from the bond graph can be done automatically. Moreover the elements of bond graphs can be expanded nearly as you like.

3 Equation Generation

As already mentioned each element of the bond graph represents a relation between the power states bound up with the attaching bonds. These relations are acausal, i.e. there is no information about cause and effect being at work at this node. An *acausal* bond graph represents a DAE^2 of the form

$$f(\dot{x}, x, t, u) = 0,$$

where x is a vector of states, t is the independent time and u is a vector of input variables. The fact, that most simulators³ need the system equations represented by an ODE of the form

$$\dot{x} = f(x, t, u)$$

necessitates the assignment of causality, which in fact corresponds the transformation of a DAE to an ODE⁴.

This step is done automatically by **bgm** based on the state transition table method described in [2].

4 Features

The following is a brief description of the features of **bgm**:

- Simple and succinct c-like bond graph description language with elements for the use of modular development of simulation models "graphs" and "subgraphs".
- Automatic causality assignment with the possibility of user preferences.
- Full solving of the system equations in order to get pure ODEs.
- Optionally implicit model descriptions.
- Modeling of non-linear systems.
- Definitions of "new" bond graph elements through realization as subgraphs.

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1. The Modular Simulation System, developed by G. Schuster at the TU Vienna; see [1].

2. Differential Algebraic Equation (DAE), in contrast to Ordinary Differential Equation (ODE).

3. Further releases of mosis can also solve DAEs.

4. In the case of the presence of algebraic loops the transformation is not unambiguous. Strategies for causal completion of bond graphs are given in [2] or [3].

APPLICATION OF SIMULATION SYSTEM SOL/PC FOR EDUCATION

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The universality of the simulation method makes it an irreplaceable tool when studying a great number of disciplines connected with projection, maintenance and all-round estimation and reconstruction of complex, hardly formalized systems. Among these are: automated management systems, multiservice theory and operations research. The system for simulation training provides a professor with the following possibilities: adapted to the modern user interface, simulation models description, debugging and running, simulation models development dynamics visualization, editing and the work with the base of models and use of the type models from the base.

Let us consider the capabilities of our system, which are oriented toward the educational use.

1. Model description language. Simulation oriented language (SOL) originated by Knuth&McNelly was implemented and supplemented by us. Its simplicity and easy interpretation will allow the user to run fast in the language and to highlight the simulation methods being studied.

2. Interface. Systems for computer simulation in general must satisfy the same demands for computer systems. In spite of that they have a number of peculiarities, that can influence interface organization: from simulation process time to the great volume of information received as a result of simulation. Thus, the main problem in interface design is harmonious combination of the simulation tools and results analysis; and of the visualization of the results and simulation process.

3. Editor and the models base maintenance. For the creation of new model and the editing those which have been created earlier the integrated texts editor was worked out; it contains a large number of editing commands: create, save and edit models and data files, move cursor; insert, choice, copy and text delete. When editing the user can call up the list of edit options using F1. Contextual help on SOL for any language construction is called up using CtrlF1. There are information files about type models of certain courses in the models base. There are also means for the private user model base creation and addition. All information files and contextual help are written in three languages: Russian, Romanian and English (the languages used in Moldova High Schools).

4. Display and processing of results. The simulation results are displayed as statistics of observations for different model objects states changes. Usually they are represented in a standard form used in the statistics theory. The volume of data received as a result of simulation requires further processing to extract information which is sufficient for researcher work. We offer the following types of processing: united tables, graphical representation of the results, multicriteria graphical analysis and diagram of the model dynamic development. Simulation experiment visualization is a valuable teaching tool, allowing the user to find flaws arising between the model and the real world.

Using this system in the education process offers the students with parallelism and simulation logic which prepare them for later application of these methods in real system research. On the other hand, joining together the means of translation, analysis and visualization the system helps to explain quickly and clearly how these methods are applied.

EUROSIM CONGRSS '95 K. Fischer, V. Hrdliczka Institute for Industrial Engineering and Management Swiss Federal Institute of Technology Zurich

POSTER SESSION:

Simulation in Production - new tools enter education of students at the Institute for Industrial Engineering and Management at the Swiss Federal Institute of Technology Zurich

Industrial companies are increasingly faced with new technologies and markets, rapid changes in the environment and significant sociopolitical developments. In this changing environment enterprises are forced to respond to these challenges quickly and in a flexible way.

Under an increasing time pressure it is necessary, to redesign or to adapt the structures of manufacturing systems. Decisions, which may have far-reaching consequences, have to be taken as fast as possible.

Operational procedures can be defined as processes, which are characterized by complexity and dynamics.

Discrete event-driven simulation is a powerful method to analyze and understand these processes and to solve dynamic problems.

For three years, the faculty for Industrial Engineering and Production Management at the Swiss Federal Institute of Technology Zurich has been offering a lecture in "Simulation in Production" to students and persons from industry, who are interested in these problems.

The participants are taught in theory and practice of modelling and in the application of simulation-software packages. The course has a special focus on simulation methodology i.e. project management in simulation or the theory of design, execution und evaluation of experiments.

With the aid of a case study, based on a real project in a large international company, the importance and efficiency of simulation is demonstrated to the students. It ist shown, that without simulation it was impossible to get control of the inherent dynamic of the system and to fulfil the demands of the management. There was an extrem exceeding of the planned costs, that had could be avoided by using simulation from the very beginning.

The case study shows, that the application of simulation as early as possible may be essential to the success of a project. This will be demonstrated and discussed at the poster-session.

SPICE : The Ultimate Tool for Teaching Electrical Circuits ?

When it was introduced in the 1970's, SPICE ran on minicomputers and was intended as an aid in advanced circuit design. However, when it migrated onto desktop microcomputers such as IBM compatibles and MAC's, it effectively became available to every professional engineer. It is therefore important that, during an undergraduate course in Electronics and Electrical Engineering, students should learn the capabilities of SPICE, and appreciate how they can use it during their subsequent career.

Additionally, in the transfer to the desktop microcomputer, SPICE acquired a usefulness as a teaching tool, which it is probable that the originators of the software never envisaged. The key feature here is the graphical packages such as PROBE, which effectively allow the user to investigate the circuit under study with a software oscilloscope. SPICE with PROBE now provides facilities which make it a superb teaching tool at all levels throughout a student's course of study.

- Student can learn how to analyse a circuit before they have the ability to carry out the complex number algebra required for a.c. circuit analysis. The expected behaviour can be predicted from simple approximations - a capacitor blocks d.c. and passes high frequencies - and compared with the output of SPICE.
- While they are learning the complex number algebra, SPICE can be used to give practice in evaluating numerical values from algebraic expressions.
- After they have acquired the ability to carry out the mathematical work and SPICE simulation for simple circuits, they can progress to more complicated circuits. In most cases, the tedium of wading through a morass of complicated algebra is rendered unnecessary. The vital skill which should be inculcated here is that of continual questioning : does the output of SPICE agree with the simple approximations at e.g. high and low frequencies?

Once students have thoroughly mastered SPICE and the main algebraic techniques for analysing circuits, it is an invaluable tool in circumstances where there are difficulties either with the theoretical analysis or with the experimental observations.

- SPICE provides numerical solutions where exact algebraic analysis would not normally be attempted e.g. in diode circuits and in transistor circuits.
- The study of power in typical industrial (predominantly R,L) loads is an area where it can be difficult to make experimental measurements. With PROBE it is possible to examine the overall power consumption and compare this with the power dissipated in the resistive components of the load and the energy storage and release from the inductive components.
- The observation of transients (a.c. or d.c.) traditionally requires a digital storage scope, which can be prohibitively expensive. A desktop P.C. with an analog I/O interface provides a cost-effective way to look at transients. SPICE and PROBE on the same PC allow instant comparison between theoretical predictions and experimental measurements.

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SIMULATION TRAINERS ON THE BASIS OF CAI SYSTEMS

The present poster is devoted to the problem of the development of Computer - Based Simulation Trainers for preparation of the operative personnel of automatic equipment.

Developed Simulation Trainers are based on the combination of calculating and expert models and the possibilities of Computer - Aided Instruction (CAI) systems.

- A lot of functions are realized by Simulation Trainers:
- modelling the processes of controlled object;
- control of teaching dialogue;
- developing the individual skills to make a correct decisions for prevention the emergency situations appeared;
- analysis of learning process statistics etc.

The variety of functions requires to use the uniformed model for knowledges representation in Simulation Trainers. Cercone-Rieger semantic networks have been chosen for this aim.

The Simulation Trainers described in the poster realize the following key models:

- static modelling;
- dynamic modelling;
- dialogue based on the trees of situations estimation;
- checking of knowledge and developed skills.

Conclusions.

1. Simulation Trainers have been developed for preparation of operative personnel of atomic and power stations based on CAI systems.

2. The direction of the advanced Trainers evaluation is the automatization of the simulation models development and the creation of the convenient instrumentation for integration teaching and simulation models.

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INVERSE NONLINEAR SYSTEM NOISE COMPENSATION

ABSTRACT:

The objective of this research work deals with resolving the inherent noise factor involved in nonlinear systems. Specifically the motivation is to reduce the noise embedded in signal outputs of nonlinear systems. As what will be termed as the sandwiched Hammerstein nonlinear model is employed so as to initially identify the linear and nonlinear subcomponents of the system. An optimal realizable Wiener filter is utilized to initiate an inverse filter at the input and output. Simulation of the developed algorithms provide a comparison of results using a noise reduction ratio measure.

In this problem only the noisey input and output data are known without aprior knowledge of the noise-free data. Furthermore, the assumption that both noise sources are uncorrelated is not a strict constraint. Within this framework, the nonlinear subsystem is the Hammerstein model represented in polynomial form as:

 $y_n = p_1 x_n + p_2 x_n^2 + \ldots + p_m x_n^m$ where x = input, y = output; n = 1, 2, ..., N; m = 1, 2, ..., M.

Once the nonlinear parameters p and linear input and output subsystems are identified, inverse filtering is utilized by applying an optimal realizable Wiener filter at the input and output linear subsystems.

Simulation of this research is accomplished with the aid of the noise reduction ratio. This ratio is given in general form as:

 $\frac{\sigma_y^2}{\sigma_x^2} = \sum_n h_n$, where h is a subsystem impulse response. Results indicate the development in this work

show promising achievement of noise reduction.

SOLVING THE INVERSE CAUCHY PROBLEM OF ELECTROCARDIOLOGY

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In the paper the problems concerning the appointing of epicardial maps (i.e. maps of distribution of potentials on a heart surface) by means of computer simulation have been presented. In the investigated case a source of data are Body Surface Potential Maps (BSPM) taken from human chest. The problem leads to solving the inverse boundary problem of Cauchy type. For the electrical field generated by myocardium the mathematical description is formulated as the partial differential equation of elliptical type with boundary conditions of the first and second kind. To solve this problem the new iterative algorithm based on the unitary distribution with weight parameter has been elaborated.

The numerical experiment has been carried on, in which 3D model has been applied. The examined model contains the region between the heart surface and human torso surface. The parameters concerning the shapes and locations of body organs inside the considered region have been taken from the anatomical atlas obtained by Computer Tomography (CT) method [1]. The respective conductivity parameters have been taken from Rush tables. The model obtained such a way is a subject of computer simulation.

The source of the data to the researched problem are the BSPM measured in non-invasive way on a human chest. To perform these measurements the system HP-7100 of Fukuda Denshi has been used. This system allows to measure the potentials in 87 points of a torso surface at the same time. The distances between the successive moments of measurements of BSPM's are of 1 ms during the whole cycle of the heart beat.

As it was mentioned above, to solve the discussed problem the unitary distribution method with weight parameter [2] has been applied. The examined region has been divided into 273 elements. To find, how the electrical heart field changes, the calculations have been made for BSPM measured in 50 most important moments of ECG cycle.

The results of a performed computer simulation are the epicardial maps, i.e. the maps of the distribution of potentials on a heart surface. They help to find e.g. the superconductivity paths on a myocardium - it is an important information for a surgeon before the operation. These epicardial maps are presented numerically as well as graphically. The graphical presentation in a form of respective isopotential lines is being performed according to the rules discussed e.g. in [3].

The analysis of the errors of epicardial potentials, concerning the applied method, is included in [4]. The present elaboration contains the conclusions concerning the quality of construction of human chest model and accuracy of measurements of BSPM. On the basis of the obtained results of carried simulation there has been made the evaluation, how much the usefulness of applied method depends on accuracy of measurements of geometrical and conductivity parameters of chest and body organs.

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Object-Oriented Modelling and Simulation of Multipurpose Batch Plants

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Multipurpose batch plants are used for the economic production of chemical products in small quantities. Different products can be made at the same plant, even in parallel, at the same time. Flexible batch production, formerly mainly used in certain specialized branches of the chemical industry, e. g. the production of pharmaceutics or paints, is extended to other products like polymers and replaces continuous production processes as production to order becomes more and more important.

The versatility of such plants imposes special requirements for their control, because at the same time optimal usage of resources, safe operation of the plant and high product quality are desired. Recipe-driven production makes it possible to master these complex systems by describing the chemical and physical operations for the production of a specific product in a basic recipe, independent of any particular plant. For the actual production, the equiment of the plant has to be assigned to the operations described in the recipe and the control sequence for the execution of the production has to be generated.

This task is hardly achievable without computer support. A need exists for tools to simulate the production process and to support production planning.

From a system-theoretic point of view, batch plants have elements of both discrete-event and continuous-time systems (such systems are called hybrid systems). Simulation of flexible batch plants with (potentially) multifunctional equipment is a task which is different from — and in a sense more demanding than — the simulation of continuous-flow plants, and thus specific solutions have to be developed.

Such a tool, called BaSiP, is currently developed at the Process Control Group of the University of Dortmund. It enables the simulation of recipe-driven processes. The simulation models contain all relevant aspects of the plant and the recipe, i. e. the continuous dynamics of the equipment and the material as well as the sequential and parallel execution of operations in the recipe.

Plant and recipes can be modeled by the user with full graphics-oriented editors. By using an object-oriented approach in modelling, an extensible and configurable library of model blocks can be provided.

The tool supports various tasks in the operation and design of batch plants:

- Finding errors in recipes by simulating them on a given plant,
- checking for resource bottlenecks by simulating several recipes in parallel,
- supporting production planning by determining the execution time of operations and the usage of resources, and
- calculating the necessary capacities when designing or resizing plants.

A New Method of Multivariate Orthogonal Random Process Simulation

J. Figwer *

The problem of simulating multivariate orthogonal random processes (MORP) defined by its power spectral density matrix has been effectively solved for rational power spectral densities. Presently, multivariate time-series are simulated as outputs of discrete-time linear filters excited by white noise. This filter has to be identified using one of many spectral factorization approaches [3]. However, very often the power spectral density matrix of the time-series to be simulated is given only by a nonparametric representation as tables or diagrams.

The main idea of the proposed approach is to simulate the MORP by a multivariate multisine random series (MMRS) with a periodogram matrix coinciding with the power spectral density matrix of the MORP for a given number of equally spaced frequencies from the range $[0, 2\pi)$. The periodogram matrix is next factorized to get the Fourier transform matrix, which is via any FFT algorithm transformed into the time-domain, resulting in the simulated time-series.

The MMRS is defined in the time-domain by the *p*-dimensional multivariate series $\mathbf{u}^{N}(i)$ where the *r*-th (r = 1, 2, ..., p) MMRS element is given by:

$$u_r^N(i) = \sum_{\Omega n \in N_r} A_n \sin(\Omega n i + \phi_n),$$

where: $\Omega = \frac{2\pi}{N}$ denotes the fundamental relative frequency, $n = 0, 1, \ldots, \frac{N}{2}$ denotes consecutive harmonics of this frequency in the range $[0, \pi]$, *i* denotes consecutive discrete time instants, ϕ_n are the phase shifts of which ϕ_0 is deterministic and the remaining phase shifts are random, independent, uniformly distributed on $[0, 2\pi)$ for $n = 1, 2, \ldots, \frac{N}{2} - 1$ and Bernoulli distributed with parameter $\frac{1}{2} \in \{\alpha, \pi + \alpha\}$ for $n = \frac{N}{2}$. N_r is the set of all frequencies Ωn present in the *r*-th MMRS component $u_r(i)$. The sets N_r for $r = 1, 2, \ldots, p$ are pairwise disjoint and their sum gives all frequency lines up to the Nyquist frequency $\{0, \Omega, \ldots, \Omega \frac{N}{2}\}$.

When this approach is applied to the power spectral density matrix of true white noise, the corresponding MMRS is turned into a white MMRS. For p = 1, 2 constant bin spacings can be kept throughout the entire frequency range $[0, 2\pi)$ and whiteness holds for finite *N*-sample series [1], [2]. This property can't be unfortunately extended for MMRS having dimension larger than 2 or non-white MORP.

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IMPACT MODELLING USING DELTAFUNCTION

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We consider the direct central impact of two masses m_1 und m_2 , hitting each other with speeds v_1 , v_2 at the collision time point $t = t_c$. For a short period these bodies exert big forces on each other. This results in time-dependent deformations in the environment of the contact area, which complicates dealing with the matter. Changing the state of motion during the collision can be described by means of the following idealisations:

- a) The collision time Δt is so short that the change of position of the bodies involved during Δt can be neglected.
- b) The forces being exerted at the area of contact are so big that all other forces can be neglected during Δt .
- c) The deformations of the bodies are so small that they can be neglected with respect to the motion of the bodies as a whole (i.e. the bodies are considered as rigid due to the laws of motion).

After passing the limit $\Delta t \rightarrow 0$ the impact can be simulated as a state event, happening at the very moment. A computer-oriented, alternative approach is presented and compared with the conventional method, according to the classical solution in physics.

Conventional, piecewise modelling

The contact forces F(t) do not appear in the two equations of motion. The periods of time are connected by two fitting conditions for the speeds at $t_c - 0$ and $t_c + 0$:

 v_1 , v_2 are the speeds just before and v_1' , v_2' the speeds just after the impact. The coefficient of restitution e can have the values $0 \le e \le 1$ (e = 0 plastic, e = 1 elastic). For multiple collisions these fitting conditions are to be repeatedly applied.

Computer-oriented, closed description

The impact forces F(t) are involved in the equations of motion by means of Deltafunctions $\delta(t)$. During the collision time the impulse of force

$$\hat{F} = \hat{F}(v_1, v_2, m_1, m_2, \theta)$$
 (2)

is exerted on both masses in opposite directions.

Finite impact forces, acting after $t = t_c$ for a short period $\Delta t = \varepsilon$, can be described by the δ_{ε} -Function:

$$F(t) = \hat{F} \cdot \delta_{t} (t - t_{c}), \qquad (3)$$

compression and restitution phases being differenciated, dependent on the restitution coefficient e.

Passing the limit $\varepsilon \to 0$, resulting in the abstraction of the immediate impact, can be carried out after integrating the equations of motion. Here, the δ -Function (more precisely, δ -Distribution) is replaced by the discontinuous Thetafunction $\theta(t)$ with values of 0 and 1, which can be presented without any problems. For multiple collisions, the impulses of forces are to be added.

Using the SCHEDULE-Operator and a DISCRETE-Section, the modelling of an impact is given in the allpurpose simulation system ACSL.

Symbolic Computation in Industrial Simulation Applications

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Computer simulation is a growing discipline which is widely applicable to fairly complex systems. However, potential application area is much wider, and futher extensions can be achieved by integrating simulation with other related fields. Understanding of real-world systems becomes more and more important when the size of applications grows. Since restrictions of simulation tools become apparent, conjoint numeric, symbolic and neural computing will be very important. Symbolic computing provides methods for connecting applications and making them easier to access for nonspecialist users. There is a wide selection of these methodologies which should be adapted to appropriate levels in simulation applications.

Rule-based programming. Rule-based programming is commonly used in the development of expert systems but leads to serious maintenance and testing problems in practical applications where rule bases become really massive. Using declarative languages on relation level can reduce amount of rules to some extent. However, these simulations are still too slow for complex systems, and linking the rule-based systems to more efficient modelling methods is essential for operability of the practical systems.

Fuzzy set systems. Fuzzy set systems provide a practical way of handling qualitative information in simulation and integrating different applications on an appropriate level. Nonlinearities can easily taken into account. Fuzzy logic together with other AI methods can be used in diagnostical applications which are very valuable in improving the resemblance between the simulation models and the real-world systems. Although building small systems is quite easy, acquiring the knowledge from human experts is a tedious and time-consuming task for complex systems.

Neural networks. Neural networks (NN) have been used as a behavioural model to map a systems input to its output regardless of the nature of the system. NN models are difficult to connect to other models of the system. Another drawback is that extremely long training periods are required for complex systems. Connecting NNs to other modelling techniques is vitally important: a solution might be neurofuzzy approach which makes the model more understandable.

In this framework, neural computing provides an suitable identification method for working point adaptation.

Genetic algorithms. Genetic algorithms (GA) can be considered as an experimenting tool which produces a satisfactory solution which is not necessarily optimal for complex systems where all the models are not known, search space is very large, and data is noisy. The algorithm is a reasonable way for processing populations of alternatives. The crucial point is that fitness functions measure the right thing, i.e. they should be application dependent. Massive parallel processing is required in real applications.

Linguistic equations. Linguistic equation approach is a new method for developing and tuning adaptive expert systems by combining different approaches and modelling methods. A wide variety of applications is based on this methodology, although, some of these applications are implemented by conventional techniques. A set of linguistic relations can be changed into a compact equation, AX = 0, where linguistic values are replaced by integer numbers, e.g. very_low, low, normal, high, and very_high by numbers -2, -1, 0, 1 and 2. The direction of the interaction is represented by coefficients $A_{ij} \in \{-1, 0, 1\}$. This presentation is easily generalized for finer fuzzy partitions and transfered between the programming systems. Adaptive systems can be built if the structure of the system and the data specifying the working point conditions are separated, i.e. for fuzzy simulation rules belong to the knowledge base and membership functions to the database.

Description language. For small systems, a structural description language for symbolic computing could be based on rules since they are widely used in present systems. For complex systems, better standards for component model exchange are linguistic relations which can be used either as a list of facts corresponding linguistic relations for a Prolog program or as a database of alternatives for simulation programs with embedded SQL commands. Finally, linguistic equations provide an even more universal gateway since this framework can be implemented easily on any programming language.

Mathematical Modelling and Simulation of The Singularities in Contact Mechanics.

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The investigation of contact interaction of beams, plates and shells with rigid bodies is very important for technical applications. Analysis of exact solutions for such problems in the simplest cases testifies that the contact reaction may include concentrated forces and bending moments along the boundary.

The kind of the singularity of reaction depends on the used theory of shells. For classical theory the solutions is possible only in class of the generalized functions and the structure of contact pressure includes δ -function.

At the employment of the shell theories with allowance for the deformations of shear, the exact solution can obtain in class of the functions having discontinuity of the first type. More complicated shell theories which describe deformation of normal to the median surface permit to realize physical smoothing and to obtain the correct mathematical problem. However such theories have not wide propagation in practice.

The contact problems for real construction are solved mainly by numerical methods. This paper deals with the investigation of numerical results in the domains of the singularity of contact reaction. Discretezation of the continuous contact problems has been carried out by the quadratic-differential approximation. The problem of non linear programming has been solved by relaxation method with projection.

Manifestation of the singularity and discontinuity in discrete models of contact problems have been determined as a result of numerical experiments.

K-CHARAKTER DIFFERENTIAL EQUATIONS IN PRIVATE DERIVATIVES AND THEIR USE FOR SIMULATION DIGITAL DEVICES

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Simulation with the help of K-character ordinary differential equations gives more total information about transitional processes in devices in comparison with boolean simulation and at the same time does not require the excessive volume of calculations. The description device of computer facilities with the help of ordinary K-character differential equations enables to conduct its detailed researches, however, when the studied object contains the large number of the same type components of computer facilities, such close mathematical model hinders investigations. Especially sharply this question stands at simulation of various systolical structures for processing of digital and logic data. It forces to improve known and to develop the new approaches to exact and simplified simulation.

The repeated repeatability of separate groups elements of known digital technics devices, as well as in one-, two- and threedimensional systolical matrixes and analogy in distribution information in these computing structures with distribution of heat or diffusion accordingly to uniform rods, plates or volumes induce on idea that the considered objects can be described by discrete differential equations in private derivatives of parabolic type.

The methodology of models construction and serviceability of numerical methods are checked during the research of oneand twodimension periodic computing structures, which were described by K-character analogues of heatconductivity and diffusion equations. So new theory of K-character differential equations in private derivatives which help to receive in the main new mathematical models were worked out.

Aspects of the Dominance Analysis for Model Simplification

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A simplification of mathematical system models can be helpful for the system analysis, simulation and controller design. Different approaches are known which all aim to find a model that approximates the behaviour of the most important (dominant) variables of the original complex model. Depending on the simplification approach these dominant variables may be identified intuitively or by technical considerations. In many cases, however, a **systematic dominance analysis** is required by which important and unimportant system variables can be distinguished and judged by dominance size values. This contribution presents a general approach. It is useful in different fields of system modelling and has been applied successfully to technical systems in the context of model order reduction [2-4].

Different approaches to the simplification of dynamic systems are known and used frequently: (1) linearisation, (2) neglecting unimportant factors, terms, or part systems, (3) approximation of distributed parameter systems by ordinary differential equations, (4) approximation of dead time systems by ordinary differential equations, (5) model order reduction. Whatever method is applied, the designer should be in a position to decide which system variables are dominant and which are "contained" in the behaviour of the other variables. The required dominance analysis of system variables can be done based on a time history analysis by a singular value decomposition (which has proven to be helpful in linear model simplification also, [1]).

Figure 1 illustrates the main idea: The time paths $x_1(t)$ and $x_2(t)$ represent the behaviour of two system variables, gained by measurement or simulation. Neither x_1 nor x_2 can be classified to be dominant. For a rough description the approximation $z_1(t) \approx x_1(t) = x_2(t)$ may be sufficient. With a second function $z_2(t)$ it is possible to describe $x_1(t)$ and $x_2(t)$ precisely: in the example we have $x_2 = z_1 + z_2$ and $x_1 = z_1 - z_2$. Figure 2 illustrates the transformed coordinates and the trajectory. In the description of the dynamic system in terms of z_1 and z_2 , the dominant variable is identified easily: z_1 is dominant, since the original variables x_1 and x_2 both can be approximated from z_1 . z_2 is non-dominant. A systematic approach to finding the transformation, the dominance size values and the dominant system variables is presented in the poster session and is also described in [2-4] together with application results.



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IDENTIFYING AN OBSERVABLE SYSTEM WITH ONE OF SEVERAL SIMULATION MODELS

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One of the most important steps in the development of a simulation model is recognition of the simulation model which is an accurate representation of the system being studied. It is natural for model users to devise rules so as to identify an observable system with one of several distinct models, collected for simulation, which accurately represents the system, especially when decisions involving expensive resources are made on the basis of the results of the model.

This paper deals with the problem of how to identify a sample of independent observations obtained from a real system with one of several samples of observations obtained from distinct models collected for simulation, respectively. The problem considered represents, ma-thematically, the problem of classifying a system data sample as coming from one of several populations. Some of the information about the alternative distributions of populations has been obtained from model data samples collected for simulation. Each sample is declared to be realization of a specific stochastic process. By this step each sample is attached to just one out of a set of possible models with distinct characteristics. We are dealing with the case when the alternative distributions of populations are multivariate normal with dif-ferent mean vectors and covariance matrices. It is assumed that all parameters are unknown. If it is known explicitly that a system data sample belongs to one of populations from a set of possible populations of data of models, but to which of them it belongs is unknown, the problem is to identify this sample with the proper model data popula-tion. The decision rule should be in the form of associating the system data sample with one of the model data samples and declaring that this sample came from the same population as the model data sample with which it is associated. When there is the possibility that the system data sample does not belong to one of the specified model data populations, it is desirable to determine if the assumption that this sample belongs to one of the above populations is feasible. In the present paper, for solving the above problem, we propose to

In the present paper, for solving the above problem, we propose to use the tests of homogeneity or normality of several independent samples in order to construct separation rules for distinguishing between model data populations into which a system data sample may be classified. This idea is new in the literature and it is due to the author. It is shown that certain tests of homogeneity or normality of several independent samples of data can be used to transform a set of model data samples into some statistic that measures distance from homogeneity or normality of these samples, respectively. Its distribution will be parameter-free or distribution-free. This statistic is then used to construct a sample based discriminant rule maximizing a distance from homogeneity or minimizing a distance from normality of several model data samples, respectively, with respect to sample data of a real, observable system.

The sample based discriminant rules, mentioned above, are applied to obtain the new procedures of identifying an observable system with one of several simulation models. These procedures are relatively simple to carry out and can be recommended in those situations when we deal with small samples of the data.

Illustration of the new procedures suggested herein is given by using a numerical example.

HYBRID MODELLING OF COMPLEX SYSTEMS AND ITS APPLICATIONS

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Abstract Poster Session

The paper describes a system designated for handling compound models based on various types of formalisms. The architecture of the system is also presented. Different submodels sharing some state variables or parameters are coupled. More precisely, the paper addresses issues related with continuous time/discrete time submodels, discrete event submodels, fuzzy submodels, knowledge-based submodels. To describe a complex process, several types of formalisms are nedeed, as for instance developing applications based on expert systems and numerical simulation, fuzzy systems and numerical simulation , continuous time systems and discrete event systems. Given the difference between the models, coupling formalisms in implementation proves rather difficult. The hybrid model describing the behaviour of a complex system, useful in both simulation and predictive control, is presented. To make such a model operational, the following problems have been solved:

. Standard formalisms of the four mentioned models, i.e. a discrete time nonlinear equations set including interval constraints for state variables, a Boolean differential equations set, a set of fuzzy functions and a set of heuristic rules (behaviour, control and decision rules, derived from expert knowledge).

. Solving of each model problem, by using adequate computer programs: Mathcad 3.0, Matlab 4.0 for the two first models, a special program for solving fuzzy models, and an expert system shell (Clips 6.0) for solving knowledge-based models.

. Solving of the problem of interactions between various kinds of models, including their synchronization, using a special blackboard module and a hybrid algorithm of computation. To account for the efficiency and portability of our systems, i.e. hybrid modelling, simulation, and predictive control of complex systems, an application has been proposed: a complex hydro-

logical system of the Danube Delta, more precisely a complex network of 10 great lakes, interconnected by canals and channels.

Such problems as simulation and predictive control of (some) state variables (e.g. inflow and outflow of water, the level and the depth of water, the accumulated volume of water in the lakes, the water refreshment factor, the biomass of some species) are being solved. For example, the water refreshment factor (ecologically the most important factor) is to be found in the so-called suboptimality intervals, established by an expert A simulation experiment offers the so-lution to the problem of matching water refreshment factors (of all lakes) with suboptimality intervals, by predictive control. Ecologists are to pronounce as regards the results and to make their own decisions.

Finally, we emphasize that the paper develops a new approach to modelling of complex systems, using different kinds of interconnected models, and an application based on simulation experiments and predictive control.

AN INTELLIGENT MODELLING AND SIMULATION ENVIRONMENT FOR DECISION SUPPORT

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The development of decision support (DS) technologies is related to the integrated use of approaches, methods and tools of modelling, simulation and artificial intelligence field, aiming at the design of intelligent DS systems. In the paper are summarized the results of the development and the implementation of an intelligent modelling & simulation environment for complex problem solving support.

A framework of procedures for development of DS environment is suggested. The main phases of the DS cycle are as follows: A. Problem Definition Phase. B. Model Development Phase. C. Model Assessment Phase. D. Decision Support Phase.

The Model Development Phase requires the design of a general model of the problem stated and identification of sets of model variables.

The Model Assessment Phase consists in multimeasure cross-validation, assessment and selection of the set of modelled alternatives. The stages of this phase are as follows: a) simulation of the set of modelled alternatives; b) 1st validation: screening procedure; c) 2nd validation: sensitivity analysis 1; d) 3rd validation: sensitivity analysis 11 (metamodelling).

The *Decision Support Phase* consists in analysis of a set of feasible alternatives, via hypothesing future decision states of the problem modelled, and a choice of the "best feasible" alternative for implementation.

For supporting all modelling, simulation and assessment functions required by the framework for DS a Generalized Software System (GSS) has been developed. The architecture of the GSS embodies *Data Base*, *Model Base*, *Knowledge Base* and interfacing modules.

Following the GSS architecture a problem-dependent software system SIMOS PAM has been developed.

The concepts, procedures and systems developed have been implemented in a number of policy analysis applications, in particular, in the design of DS environments for resource assignment and allocation problems.

Duplication of Mental Representation for Visional Illusion in the Rotating Space

Takeshi SETA and Ryoichi TAKAHASHI

This paper proposes the human like vision model which reconstructs three-dimensional shape from impossible figures (i.e. M.C.Escher's nonexisting world, Penrose's triangle and so on). The intuitive notion of an impossible figure seems to be summarized as follows: An impossible figure is a flat drawing that gives an impression of threedimensional object such that the object suggested by our spatial interpretation of the drawing can not exist in the Euclidean space, that an attempt to construct it leads to geometical contradictions clearly visible to the observer. Paying attention to that human beings perceive three-dimensional objects from the impossible figure. his mental representation for visional illusion should be mathematically described. This paper indicates that three-dimensional shape of the impossible figure can exist in three-dimensional rotating space with periodic axis of depth. The rotating space is threedimensional distance space and does not contain the time axis, from the viewpoint that human mental representation possesses whole parts of the figure concurrently. The shape can be reconstructed from the impossible figure, in spite of the constraints that one vertex on the two-dimensional image uniquely corresponds to one vertex in the threedimensional object, and that every edges connecting vertexes is reconstructed as a geodesic representing the shortest distance in the rotating space. In the rotating space value in depth of one point on the figure is smaller than that of another point and the former is larger than the latter at the same time. Though the description "One value in depth is smaller and larger than another" is logically incorrect, it accurately expresses property of the rotating space and is mathematically correct. This property enables human mental representation for visonal illusion to be duplicated. The curvature of this space is defined as a function of difference between two values in depth found from one line by recovering the shape.

Shape recovery method is as follows. First, three-dimensional-shape of edges is reconstructed. The threedimensional direction of an edge is formulated as a function of the inclination of the edge in the two-dimensional images. A norm is defined to evaluate the error from the correct value of the direction of edges. An assumed energy function is utilized to evaluate the orthogonality of the two edges. This function represents the deviation from right angles of the above-mentioned picture. Minimization of the weighted summation of the energy function and the norm enables us to reconstruct the three-dimensional shape of edges from two-dimensional drawings by means of the modified Powell method. Second, three-dimensional shape of faces is reconstructed with considering influence of shading on image. Authors deal with Poisson equation representing the membrane in the three-dimensional object to reconstruct the shape of faces. Furthermore, in order to allow for the influence of shade on the faces, the imageirradiate equation will be introduced. A measurement of image brightness restricts the possible face orientations. This constraint is expressed by the image-irradiate equation. The shape of the faces is recovered to minimize summation of potential energy of the Poisson equation and error norm of image-irradiate equation simultaneously by means of the Gauss-Seidel method. Boundary condition of faces is specified by position in depth determined by the reconstructed edges. Several experimental results demonstrate that the present method yields human like interpretation.

The method and language of simulation of systems for management, designing and training

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Diversity of approaches to formations of structure and contents of tasks of management by technical objects, set of proposals of special packs of programs of acceptance of decisions, including on the basis of expert systems, make necessary the development of method of reliable simulation of control systems.

The necessity of maintenance of reliability of management has caused the construction of control systems, as man-machine systems. The new conditions of activity of staff of power-generating objects have required development of special systems of training and retraining of staff.

Thus was generated the wide circle of problems, on first sight poorly connected among themselves, however incorporated units of increase of reliability, controlliability and survivability of control systems is extraordinary.

The purpose of work to develop the method of structuralfunctional simulation of technical objects for uses of it at designing of control systems, designing and training.

For achievement of delivered purpose in work the following tasks are resolved:

- the way of coordination of various methods - from algorithm to heuristic - optimization for various levels of management in frameworks of technology of expert systems is found;

- the unified description of control system is created;

- the way of representation of knowledge about technical objects, enabling to describe the object with of given by degree detailing is found;

- the technique of automated training of experts, ensuring formal substantation of decisions on each step of their acceptance is developed.

- the software of automation structural- functional simulation of technical systems and designing information and software of management in technology of expert systems are developed.

CHAOTIC SIMULATION - A NEW KIND OF SIMULATION

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We have known that the three greatest revolutions in the world-view of science in the twentieth century are Quantum Mechanics, Relativity, and Chaos. For physicists and philosophers, Quantum Mechanics and Relativity must rank above Chaos for their impact on the way we view the world, but they have less appreciable effect whatever on medicine, biology, or geology. Yet Chaos is having an important impact in all of these fields, as well as many others, including chemistry, physics, mathematics, engineering, social science, even philosophy.

In recent two decades, the scientific community has witnessed the birth and initial development of Chaos for understanding complicated and seemingly unpredictable behavior. During the same period, as computers had permeated society, computer simulation has achieved greatest development. So it is the time for us to combine Chaos and Computer Simulation together and create a new research field: Chaotic Simulation.

1. Chaos and Chaotic System

We often say observations are chaotic when there is no discernible regularity or order. A system exhibiting chaotic behaviors evolves in a deterministic way, but measurements made on the system do not allow the prediction of the state of the system even moderately far into the future.

A chaotic system possesses following distinguished features. First, it is sensitive dependence on initial conditions on invariant set. Thus, in a very real sense, chaotic systems are unpredictable. Second, it is topologic transition on invariant set. As a result, a chaotic system can not be resolved into two invariant and uncrossed open sets. Third, periodic orbits are dense on invariant set. Thus, there is a regularity in the seemingly irregularly chaotic map. The regularity is that it has the densely periodic solution.

There are many chaotic systems, such as turbulence, thermal convection in fluids, weather system, etc.

2. Simulations about Chaos

There are two kinds of simulations about chaos. The first one is Chaotic Simulation and the other one is Chaotic System Simulation.

2.1 Chaotic System Simulation

Chaotic system simulation pays more attentions to simulating natural phenomena or system's behavior. Generally speaking, we should decide whether a system is chaotic first, then study what kind of simulation model can be built up and how to simulate system's behavior. Chaotic system simulation's purpose is on application. Some chaotic system simulations are non-linear dynamic system simulations, fractal simulation, dissipation system simulation, and other chaotic system simulations.

2.2 Chaotic Simulation

Chaotic simulation focuses on simulation itself, i.e., on common properties shared by chaotic systems, on suitable simulating methods or tools, etc. Chaotic simulation also deals with integration and iteration that are common problems in simulations.

There are some methods to measure and characterize chaos, such as strange attractors, bifurcation diagrams, Poincare maps, manifolds, Lyapunov exponents, fractal dimension, power spectrum analysis, etc. They are powerful tools and useful methods for the chaotic simulations.

3. New Classification of Simulations

There are many kinds of classifications about system simulations. Now we proposed a new kind of classification in which simulations are classified from the viewpoint of mathematics.

The new classification of simulations includes deterministic simulation, probability and statistic simulation, fuzzy simulation, chaotic simulation, fractal simulation, gray simulation, etc.

Object oriented approach for modelizing discrete event systems

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Simulation provides a significant aid for the design of new systems or the analysis of already existing ones. However, before running any simulation, it is necessary to work out an abstraction of the system being studied. This modelization is all the more difficult as there is no improved methodology to assist the designer in his job.

After having briefly recalled the main steps of any simulation process, we expose a method based on the object oriented approach for modelizing discrete event systems. The main objectives of our method are : (1) a logical description of the real-world, (2) a description adapted to the simulation goals, (3) a high-level of abstraction and independence of effective simulation tool, (4) a description which leads to an almost automatic elaboration of the "simulable" model.

The specifications which describe the system and clearly identify the goals of the simulation must be available before starting the modelization process. The later is performed in four steps : (1) elaboration of a structural object oriented model which is a static, structured and hierarchical description of the system, (2) working out of a dynamic model which expresses the global temporal behavior of the system, the temporal behavior of each class being a state machine (statechart diagrams), (3) construction of a communication model synthesizing the interactions between its different components and (4) elaboration of a "simulable model" which corresponds to a description from which object code can be generated and executed; here we recommend VHDL (Very high speed integrated circuits Hardware Description Language) which allows easy implementation of the concepts described above (classes, hierarchy, concurrency).

Using this approach, we describe and simulate an asynchronous numerical clock having two functions : time counting and time setting. With this example, we exhibit : (1) a top-down **analysis** process which determines the components, structure and behavior of the system in accordance with the simulation objectives and (2) a buttom-up **design** process leading to the definition of generic behaviors.

The method exposed integrates the results obtained in software engineering in order to achieve reliable, coherent and possible advanced models.

Generic Features of an Artificial Neural Network Pultrusion Process Model Developed Using Object Oriented Qualitative Analysis

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ABSTRACT

Previous extensive laboratory pultrusion trials using Derakane 440/40 thermosetting resin system and materials analysis yielded a rich data set. This poster shows the application of previous pultrusion Artificial Neural Networks (ANN's) structures with a new very different set of pultrusion data using a polyester thermoplastic resin system to create new ANN's which perform well. Within this context the authors examine the generic features and effectiveness of both sets of ANN process models. Further, a methodology linking Object Oriented and Qualitative Analysis (OOQA) techniques in relation to the collection of appropriate data and development of successful ANN structures is discussed. Further insight into process genericness was gained through mathematical deconstruction of the ANN's.

CONCLUSIONS

The main conclusions include:

* OOQA proved useful for determining data to be collected, and in structuring ANN's.

* The thermoplastic and thermosetting data was very different, but could be used to successfully create ANN models.

* The best ANN models were similar in structure for both thermoplastic and thermosetting data.

* Comparison was made in a deconstructed ANN math model and existing pultrusion math models.

* Some elements of genericness are present, and development of further ANN models for similar manufacturing processes is underway.

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Modelling of combustion of coal particle in gas flow

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A modelling of dynamics of particles of dust solid fuel is an actual problem. In general case a combustion process has three basic steps: drying, pyrolysis and homogeneous heterogeneous combustion reactions and gasification reactions of flying substances and carbon mass. A mathematical modell and calculation results of dynamics of combustion process as a totality of named steps are given in the article.

Physic model. A particles of solid fuel of different dimensions (up to 5 fractions has been considered) and humidity are brought into the moving higt temperature gas stream. During acceleration of particles the following processes occur: a heating of solid phase, a cooling of gas phase, reactions of combution and gasification, drying, output of flying. Besides, a possibility of particle destruction is accounted. Mathematical model. A model of processes of heat- and mass exchange inside the porous particle hase diffusion character. Mathematical description includes a change of temperature and density of water steam and flying substances in time and on particle radius. For the gas phase the kinetic model includes an equations of chemical kinetics of conservation of basic components: $CO, O_2, CO_2, CH_4, H_2, NH_3, NO, H_2O$, HCN. For the numerical solution of diffusion-kinetic model an integration methods for stiff systems and integro-interpolation method were used.

Calculation results. The original parameters and physical and chemical conditions of process corresponds to real characteristics of installations of fuel preparing. For the various variants of poly-fractional composition of coal and its humidity a periods of drying and pyrolysis are calculated. The calculation results of reaction kinetics in gas phase allow to estimate an ecological danger of products of pyrolysis and combustion.

Modelling of bifurcations for some basic combustion theory models

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A number of basic models of combustion theory, corresponding to oxidation reactions in CSTR are considered. In classic case one the models (Zeldovich-Semenov's model) is of the form:

$$\dot{x} = f(x)e^{y/(1+\beta y)} - x/Da$$

$$\gamma \dot{y} = f(x)e^{y/(1+\beta y)} - y/Se,$$
(1)

where x, y are concentration and temperature; $f(x) = 1 - x, Da, \gamma, Se, \beta$ are dimensionless parameters. The model corresponds to one reaction $A \rightarrow B$. The models of the type (1) corresponding to different reactions

 $nA \rightarrow B; A + O_2 \rightarrow B; A_1 \rightarrow B, A_2 \rightarrow B$

are considered in the study.

A parametric analysis of dynamic model (1) with dimensionless and real parameters and other forms of dimensionless models (Amundson-Aris, Volter-Salnikov) is carried out.

The parametric analysis of dynamic model (1) includes: analysis of steady state number; construction of dependencies on parameters; stability analysis: construction of bifurcation curves (the steady state multiplicity and neutrality curves), phase portraits and time dependencies. On the basis of specificity of the model the bifurcation curves are constructed in explicit form for the various planes of dimensionless parameters. A parametric portrait allows to estimate conditions of ignition where the system pass from one steady state to another one with high temperature. On the basis of known parametric portrait of dimensionless model a procedure for construction of ignition diagram for real conditions of process is proposed.

Modelling of utilization processes of rocket fuel components

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Complex solution of the problem of the rocket-cosmos technique utilization, including fluid rocket fuel components, is an actual problem [1]. It has an important value as ecological as economic. A storage and tendency of rocket fuel accumulation require a development of new effective multi-tonnage and ecologically pure technologies of utilization. Technological lines of heptile, amile and melanges processing are projected and installated in present. A researches carried out allow to suggest methods for obtaining from the fluid rocket fuel components a wide series of products of industrial-technique purpose: thinners, extractors, inhibitors, plasticizers, hardeners and so on.

A problems of ecological control and fire-and-explosion hazard of named components utilization technology, which are toxic substances, are solved at the same time.

The mathematical modelling in rocket fuel conversion include following problems:

— mathematical modelling of chemical-technological processes of utilization;

- disign of chemical reactors for utilization;
- optimization and optimal control;
- automatization of technology for rocket fuel conversion;
- disign of complex chemical-technological schemes;

- computer monitoring of ecological restrictions and control of fire-and-explosion hazard.

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1. V.N. Podvezennyi, Y.G. Veselov, V.I. Bykov // Iut. Aerospace Congress. Moscow: MGU, 1994, p. 78. Dr. Tomislav Grladinović Zagreb University, Faculty of Forestry Production organisation in wood industry Svetosimunska 25, Zagreb, Croatia

Continuous Computer Simulation - A Support in Managing and Decision-Making in the Production and Business of Furniture Industry of Furniture Industry

The paper is a research on the method of predicting and optimisation of business regime and furniture production management. The method used has been the System Dynamics, a relatively young scientific discipline with its own scientific methodology of investigating the behaviour dynamics, modelling, simulation and optimisation of primarily the most complex dynamic systems that have been scientifically studied and determined by real continued models, i.e. by a group of linear and non-linear differential equations. It is also an actual application of the "System Thinking" to the processes of management of complex, dynamic, natural, technical and organization systems. This paper demonstrates the Philosophy of the System Dynamics Continuos Computer Simulation of the behaviour dynamics in the production and business management of furniture manufactures. The System-dynamic models are not based on any mass data processing but on the least number data that yield the most information on the studied laws of behaviour dynamics in the organizational business systems. Having made a model of a furniture company, we have identified, by simulating its performance, the factors influencing decision-making and management/production processes. The simulation model has been validated through twenty different operation regimes and varying demands for the company's products. We have compared results of the simulations with the original data, showing the dynamics of a real system in the past. This comparison has shown that the model is valid, because the differences between the simulation results and the original data were small. A simulation of future management and performance of the company has shown that furniture industry would pass through the following three periods: 1. A period with high oscillations in material flows, causing a high oscillations in financial flows; 2. A period of a decreased demand for the company's products, causing a drop in the values of other elements in the material and financial flows subsystems, and 3. A period of stabilisation, with decreased oscillations in material flows and, consequently, positive effect on financial flows. Through the simulation a number of factors significantly influencing decision-making and management processes have been determined. The obtained results enabled a determination of the factors that will advance the processes of predicting and optimisations if the business regime in furniture production. The model has been successfully applied to decision-making and management processes in furniture industry. The simulation language was DYNAMO. The programming and computer simulation was made in BASIC version using the SYSDYNS software package of system dynamics, the DYNAMO language compiler in the BASIC language, enabling simulation on personal computers. The processing was carried out on the computer. The presented conclusions are an attempt of a scientific approach to prediction and a system-dynamic optimization of business regimes for improvement of this important field in furniture production and other both industrial and nonindustrial activities.

Modelling by Thermal Resistances of Asynchronous Machine Heating

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The paper presents an original method for the determination of the thermal field in the asynchronous machines. The method is based on the modelling through linear or/and non-linear thermal resistances of the heating of the asynchronous machines which are outside ventilated.

The analysis of the equivalent non-linear resistive circuit associated to the asynchronous machine heating is done by using the modified nodal analysis. This method is associated to the original algorithm based on the node tearing, in which the subcircuits are torn apart along appropriate nodes. Node tearing method leads to a bordered block diagonal structure of the circuit matrix. The development of parallel processing systems for solving a number of subcircuits simultaneously leads to a reduction computation time and to an increase of the accuracy.

Corresponding to the ways of the heat transfer, the thermal resistances corresponding to the heat transfer by conduction are linear thermal resistances and the ones corresponding to the heat transfer by convection and by radiation are non-linear thermal resistances.

For computing of the thermal resistances corresponding to the heat transfer by conduction we are considered that the thermal conductivities of the materials are constants and the thermal conductivity of the stator winding presents the different values for the three directions corresponding to the three dimensional space, because the isolation and the copper have different structures in these directions.

For computing of the thermal resistances corresponding to the heat transfer by convection we are considered the following formula for the computing of the coefficient of heat transfer by radiation and convection:

$$\alpha = \alpha_0 \left(1 + 1, 3\sqrt{v} \right), \tag{1}$$

where: $\alpha_0 = 3,49 + 0,093 \Delta T$ in $Wm^{-2}K^{-1}$, v - is the velocity of air in ms^{-1} , and $\Delta T = T - T_{\star}$ is the difference of the temperatures between the connective wall and the coolant fluid.

Numerical results obtained on the mathematical model are compared with the experimental results which were obtained on the physical model. The good agreement between the numerical values by the proposed method and the experimental ones confirm the validity of the proposed method.

The our method allows the testing of the great number of alternatives being useful instrument in the design and testing of the asynchronous machines.

Modified nodal analysis associated to the original node tearing, used for the analysis of the equivalent non-linear resistive circuit corresponding to the asynchronous machine heating has the advantage that the elements of the equation matrix which depend only on linear circuit element parameters remain unchangeable in the time of the iteration procedure. Novák, Vladimír⁺, Schmidt, Jan^{*}

The Model of Stochastic Activity of a Neuron at Some Types of Gaussian's Entrance Processes.

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Contemporary approach to the modelling of neuron dynamic properties, following both aspects of informatics and physiological aspects, have above all concentrated on the mathematical problem formulation and its corresponding solution (1,2). This approach has a series of limiting assumptions more or less removing the problem formulation, and the solution resulting from it, from experimentally found and by physiology presented behaviour of a living nervous cell. Methods of experimental physiology make possible a relatively acceptable study of the dynamic behaviour at the output of a living nervous cell enabling only a very limited study of corresponding input processes. Consequently, the principle question arises, when monitoring a dynamic behaviour of the neuron, consisting in the description of the input stochastic processes transformation, coming in the form of the input action potentials at the input neuron synapsis on the output stochastic process.

It is possible to assume that these transformation to a great degree depend not only on the properties of input stochastic processes but on the values of physiological parameters, too, examples of which are the threshold level, absolute refracter-phase duration, input synapses, weights and types and number of synapses.

In principle proposed simulation methodics is supported by already once realized stochastic neuron activity model implemented on a hybrid computer EAI 680. Applicability of at that time obtained results (3,4) leads to the forming of a new model realized on PC and bringing a much broader spectrum of the possible experimentation. This model in contrary to a previous one has increased freedom degrees number, enabling the study of stochastic transformations between input and output point stochastic processes in dependence on the following physiologically significant parameters: types and stochastic properties of input stochastic processes, input excitation and inhibition synapses number, their weights, threshold level and absolute refracter-phase duration. These properties to a great degree draw nearer the model behaviour to that of a living neuron.

Flexible Robots Modelling

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Abstract: For the purpose of better efficiency and better productivity, the efforts are made to make robot construction lighter and to increase its speed. Consequences are significant vibration of robot links. Due to that, important performance of precise positioning, repeatability and precise trajectory tracking of the robot tip are deteriorated. When robot links elasticity have significant effects on the robot characteristics and performances, then also mathematical model of robot dynamics has to include robot links elasticity. I.e. the elasticity of robot links can not be neglected any more, and the links can not be assumed as absolute rigid bodies without serious consequences on the robot performances.

This paper will present a finite element - Lagrange approach to mathematical modelling of dynamics of lightweight flexible robots. Obtained mathematical model can be used for numerical simulation of flexible robot motion, or it can be base for robot control algorithm design as well. Differently of their rigid counterparts, flexible robots are, mathematically speaking, systems with parameters distributed in space, and consequently they are described with partial differential equations (PDE) with infinite model order. For the majority of engineering purposes, mathematical model order reduction is required, i.e. model should be of finite order. Moreover it should be of as small order as possible and yet it has to describe process dynamics good enough. Therefore, finite element method (FEM) for process discretization will be used in this paper. Flexibility and facility to manipulate with various constructions are main advantages of the FEM compared with other methods which are used frequently in flexible robots modelling (for instance assumed-modes method). So, different discontinuance of the robot link's shape or material discontinuity are solved easier with FEM.

MSD A FUZZY MODEL FOR MEDICAL SIMULATION AND DIAGNOSIS

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MSD - presents an original manner of treating a fuzzy model for simulation and medical diagnosis. The modelling is realized by means of a new conceived fuzzy technique and practicioner - physician reasoning, namely by fuzzy modelling the influence over them and over the final diagnosis.

MSD is a general-purpose software based on fuzzy techniques, for medical simulation and diagnosis hint.

MSD comes to assist general practitioners in offering them medical simulation possibilities and diagnosis hints.

The MSD system architecture covers:

Hardware : IBM PC compatible personal computers Operating system: DOS 6.0

MSD is a software product developed by the Research Institute for Informatics, Bucharest.

MSD is under testing at Children's Hospital in Bucharest. It helps in simulating and diagnosing syndroms in children's pathology.

The system is available at Research Institute for Informatics - Bucharest, ROMANIA

Evaluation of queuing allocation strategies by simulation

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In this research a simulation model was developed in GPSS/H and used to test the impact of a variety of allocation-location strategies on system throughput and service levels, without the constraints which we need to impose in mathematical analysis of this problem. The model simulates arrival and service process for any system in which two or more centers supply services to a larger number of demand points and where significant time is consumed in travel from any one demand point to any one center.

The type of system represented has a structure in which demands from some points have limited choices, between two adjacent service centers, while others have no choice. The model tests the comparative effectiveness of five control strategies with respect to assigned behavior for demands. These strategies are:

- 1. random assignment for demands which have a choice
- 2. selection of the shorter queue for demands which have a choice
- 3. cycling for demands which have a choice
- 4. selection of shortest queue in entire system for all demands
- 5. selection of shortest combined travel and estimated delay time in entire system for all demands.

System characteristics which were varied in 1600 random configurations of the model were:

- 1. interarrival time distribution -- exponential, normal, deterministic
- 2. service time distribution -- same alternatives
- 3. number of servers -- 1,2,3
- 4. rate of utilization -- 50%, 70%, 80%
- 5. ratio between travel time an service mean -- 50%, 100%, 200%
- 6. number of service centers (with corresponding number of demand points) -- 2,4,9,16

What is particulary exciting about results is that a regression analysis of the comparative effectiveness of the five strategies yielded a very high correlation invariant of the configuration of system characteristics, implying a high level of generalizability of the results. Strategy 5, which is sometimes considered to benefit the invidual but to penalize the overall system, was indeed more effective. However, the regression analysis shows this effectiveness to be only a 4.14% improvement over strategy 2, which would presumably be an inexpensive strategy to implement. Therefore, if the cost of implementing the more complex strategy 5 would exceed by more than this percent that of strategy 2, it would not be recommended.

Telecommunications systems constitute one example of area of application, although we would need to add the event of the signal for a service request being part of the volume of service provided in order to accomodate this application within the model.

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The paper presents a distributed software system -"Furnace"-, written on a UNIX machine, for blast-furnace charging supervision and control.

This system offers the opportunity for various kinds of equipments such as programmable logic controllers (which can be linked in a PLC-network), microprocessor controlled weighing/dosage equipments, a UNIX machine and others used in blast-furnace charging supervision and control to work together in an integrated system, taking into account the general and specific demands of the application.

The distributed software system is composed of a configuration module, a set of modules for PLC controlling - "AP-MASTER" -, a set of modules for controlling microprocessor weighing/dosage equipments DD-Master, a real-time database, a set of modules for operator-system interface, based on windows (OSF/Motif) (there are many sorts of windows: windows for alarms, for graphical representation of the evolution of the process values, for synoptical representation, etc), a report generator for reports on any measurements or important data of the process, a security module, that based on a hierarchy of passwords ensures the access to windows or database elements.

A PLC-simulator and a blast-furnace simulator have been used for testing the Furnace system off-line.

Object-oriented "fill-in-the-blank" tables permit blast-furnace charging applications to be configured without any programming and without the limitations imposed by predefined menus.

The Furnace system has a library of graphical symbols specific to blast-furnace charging process. Based on them a series of synoptical representations can be presented. The system has also a set of routines for on-line updating of synoptical representations from user program.

The Furnace system optimizes blast-furnace charging, raw-materiales use, reduces equipments non-functioning period and offers higher reliability of technological devices operation. It will be implemented in several metallurgical platforms in Romania: Calarasi, Hunedoara, Resita.

The Furnace system is an open system, other functions can be easily added, application programs can be expanded, enhanced, replaced, duplicated without affecting other programs or current application.

Extending the Use of Simulation: A Manufacturing Case Study

Máire Kerrin and Andrew Greasley School of Business, University of Derby

This paper aims to provide a practically based insight into a case study manufacturing organisation in the UK which used simulation as part of an overall change programme. The organisation manufactures a range of bogies - the supporting frame and wheel sets for rail vehicles. The approach taken is in response to calls for case study material which, rather than focusing on the tool of simulation, focuses on the problem, solutions and business benefits related to the use of the technique (Simulation Study Group 1991).

The first part of the paper will focus on the change process brought about by the need to improve performance in response to changing market conditions. Low demand in the UK market had led the company to enter new markets in Europe and the Far East. This need to compete on a global basis led the company to re-evaluate its manufacturing facility with particular emphasis on the need to increase output, reduce lead times and increase flexibility. To meet these demands, management had identified areas where substantial investment in new machinery was required. Simulation was used as part of the planning process in order to maximise the potential of the investment before implementation. The focus of the simulation study was on the technique of line-balancing which would help to ensure this was achieved. A 'balanced' system would provide one of the necessary steps in an implementation strategy for the proposed Just-In-Time (JIT) system (Schniederjans 1993, p.96). The results of the simulation study will be presented, highlighting the business benefits of using this tool within the above context.

The second part of the paper will examine how the simulation technique can be developed within the organization beyond its use as a 'one-off' tool. In addition to its traditional role as a top-down management aid, the paper will explore ways of using simulation to facilitate shop-floor involvement in the overall change process. Areas highlighted in which simulation could be utilised include training, communication and learning. Recommendations will be put forward for the future use of simulation within the UK manufacturing industry. They will be considered within the context of the move towards the 'Japanese model' of manufacturing (Schonberger 1986), which requires a greater understanding of the overall business from shop-floor workers (Womack et al. 1990). The aim of the paper is to provide practitioners with ways in which they can adapt and use simulation to better effect within their organisation.

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