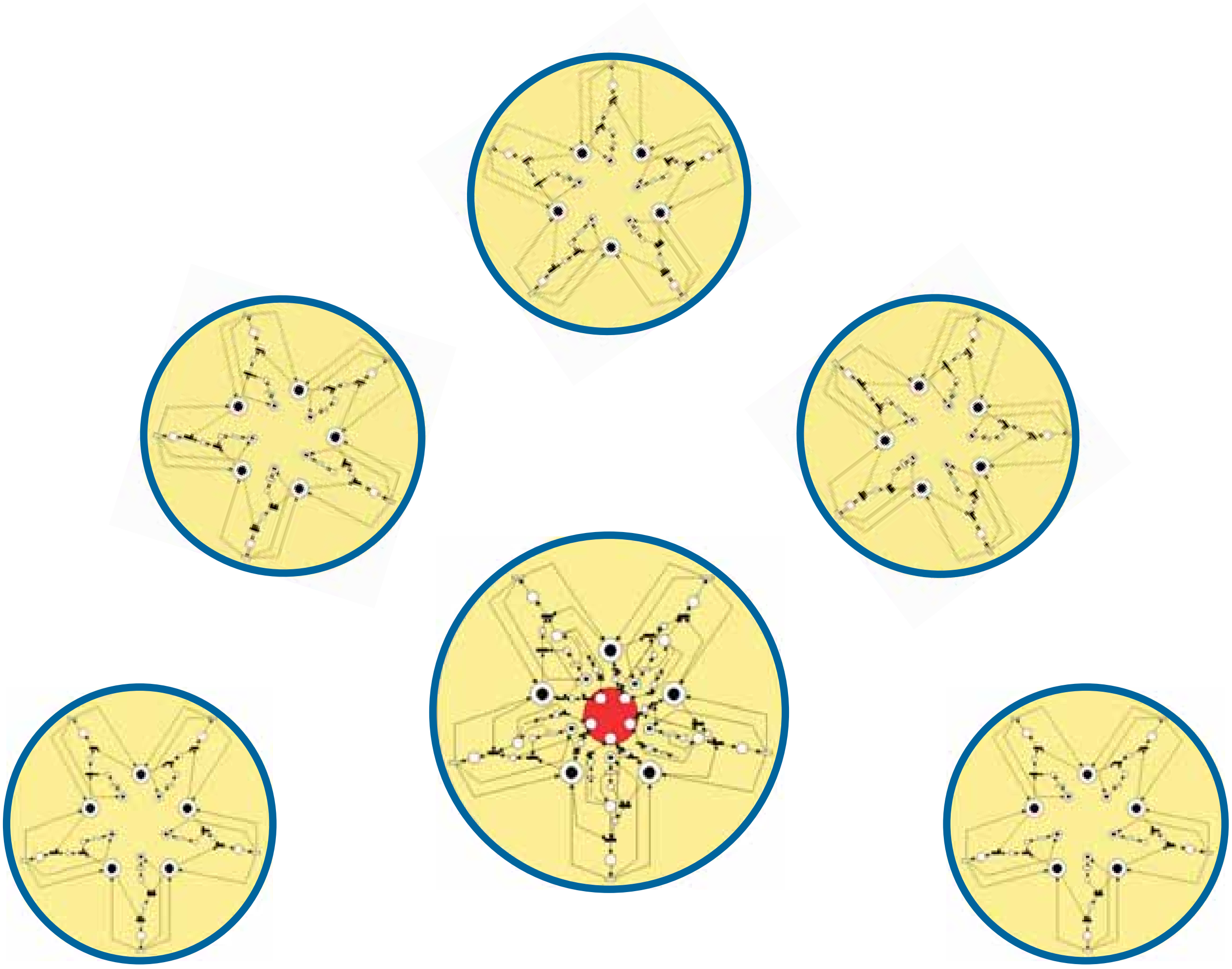
SNE SIMULATION NEWS EUROPE



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Journal on Developments and Trends in Modelling and Simulation

Membership Journal for Simulation Societies in EUROSIM

ARGESIM

Dear readers,

Together with the new SNE layout, also some structural changes and change in SNE's strategy took place. First of all, in 2006 a new numbering with volumes was introduced, which provides for 2007 SNE Volume 17, with a single issue SNE 17/1 in April, a single special issue SNE 17/2 in August, and a double issue SNE 17/3-4 in December.

Second, the SNE Editorial Board is increasing, and it co-operates with IPCs from Simulation Conferences, to suggest conference papers for publication in SNE in extended and revised form. This issue publishes e.g. revised contributions from MATHMOD 2006 Conference (Vienna), and from ASIM 2006 Conference (Hannover). Furthermore, more space is available for Technical Notes, Short Notes and Benchmark Notes. This issue presents three Technical Notes and four Short Notes, from modelling approaches via numerics to applications and software evaluation.

Third, the ARGESIM Comparisons on Simulation Software have evolved to ARGESIM Benchmarks on Modelling and Simulation: new two-page layout for benchmarks solutions - now called Benchmark Notes, starting updates and revisions of 'old' comparisons to 'new' benchmarks, new general benchmarks, and a better embedding into a new ARGESIM / SNE website. This issue publishes a revised and extended definition 'Benchmark C13R Crane and Extended Embedded Control' and a general 'Benchmark on Parallel and Distributed Simulation', and four benchmark solutions show the new layout.

And last but not least, also the News Section shows a better information structure for EUROSIM Societies (information tables). Furthermore, EUROSIM welcomes in this issue PSCS as full member, and LSS - Latvian Simulation Society - and CAE-SMSG - IFAC's Spanish Modelling and Simulation Group - as new observer members.

We hope, readers enjoy al these innovations, and we thank all contributors, members of the editorial boards, and people of our ARGESIM staff for co-operation in producing this SNE issue.

Felix Breitenecker, editor-in-chief; Felix.Breitenecker@tuwien.ac.at

SNE 17/1 in Five Minutes

Content

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TECHNICAL NOTES

Automating the Selection of Numerical Solvers

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Selecting the right numerical solver or the most appropriate numerical package for a particular simulation problem is increasingly difficult for users without an extensive mathematical background and deeper knowledge in numerical analysis. In this paper we propose a model-driven combined decision-simulation framework for automatically selecting a numerical method for a given set of equation system. We also propose a formal paradigm based on domain-specific languages for specification of structural and behavioural aspects of the numerical equation solving process. Starting from a declarative description of the equations, our system is able to detect the nature of the equations, perform symbolic manipulations, and transform them into a domain-specific model. We describe the motivation the a system, its main features, and a prototype environment with a usage example.

Introduction

The German physiologist, philosopher and historian of science, Emil du Bois-Reymond during a lecture delivered in 1872 and later published in 1874 (du Bois-Reymond 1874 [9]) considered that we could predict the future our universe if we could capture its present state in a huge system of mathematical equation:

> *'We may conceive of a degree of natural science wherein the whole process of the universe might be represented by one mathematical formula, by one infinite system of differential equations, which would give the location, the direction of movement, and the velocity of each atom in the universe at each instant'.*

du Bois-Reymond realised the difficulty of these approach and interpreted it as a limitation to our scientific knowledge :

> *'…the impossibility of stating and integrating the differential equations of the universal formula, and discussing the result, is not fundamental, but rests on the impossibility of getting at the necessary fact, and, even where this is possible, of mastering their boundless extension, multiplicity and complexity'.*

While these worries might be significant, they are by no means a hinder to describe many engineering problems with the help of mathematical equations. Problem solving in science and engineering often requires numerical solution of large systems of equations. It is a common practice today to use off-the-shelf software for solving numerical problems. This trend is supported by the availability of large general purpose mathematical subroutine libraries such as NAG library (Ford and Pool 1984 [14]), LAPACK (Anderson et al. 1990 [6]), Harwell Subroutine Library (AEA 1996 [3]), PORT Subroutine Library (Fox et al. 1978 [15]) or the Collected Algorithms published by the journal *ACM Transactions on Mathematical Software* (ACM 2004 [1]) and the *Numerical Recipes* published by Cambridge University Press (Press et al. 1988 [29]), just to name a few of them.

The use of readily available numerical routines poses several difficulties to a normal user:

- Although these standard numerical codes usually offer very high quality if used alone, the integrated use together with other software components seldom leads to optimal solutions. Many numerical packages are nested within each other. Hence, the user of an engineering modelling environment has to fiddle with numerical details he/she is neither interested in nor seldom an expert.
- In order to ensure robustness, the tuning parameters of the individual numerical solvers must be made available to the user. This often leads to a clumsy and hardly intuitive user interface thus seriously interfering with the application problem the user is really interested. Deriving user interface requirements from general purpose numerical packages has been recently addressed by the automated software engineering community (Strelzoff and Petzold 2003 [33]) in an effort to overcome the complexity of graphical user interfaces associated to numerical solvers. Moreover, as Chan et al. 1980 [11] pointed out, the available documentation for mathematical software tends to overwhelm users with a multitude of choices and does not provide much guidance in how to make those choices.
- The efficiency of numerical simulation is strongly influenced by a correct choice of the numerical method. This choice can be only made by a knowledgeable user and selecting a well suited mathematical package require a deep understanding of the problem that need to be solve and a familiarity with the available mathematical packages.

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It is a common practice today to use modelling and simulation environments that help engineers to create models through a graphical user interface or by writing custom modelling source code using a high level mathematical modelling language. However, this approach, adopted by simulation environments such as MATLAB / Simulink (The Math Works Inc. 1992 [35]), VHDL (Frey et al. 1998 [17]) gPROMS (Barton and Pantelides 1993 [7]) or Dymola (Elmqvist et al. 2003 [13]) offers a high flexibility at the model input level but it is not flexible enough at the simulation level. The user is required to specify in advance the choice of a numerical solver that should be used in combination with a certain simulation model. In some cases, this means that the users need to have advanced numerical analysis knowledge as well a good insight into the structural and behavioural properties of the model to be simulated.

Let us summarise the desirable characteristics that a decision framework for selection of numerical solvers should possess, in no particular order of importance:

- *Applicability*: detects and solves a broad range of Ordinary Differential Equations (ODEs), Differential Algebraic Equations (DAEs), Partial Differential Equations (PDEs), linear and nonlinear equation systems automatically or semi-automatically (the user intervention is reduced to a minimum).
- *Efficiency*: The execution time and memory requirements should be close to a minimum.
- *Extensibility*: new algorithms and new numerical packages can be easily adapted to existing ones.
- *Generality*: It is independent on the input modelling language and generates platform independent source code.
- *Debugability*: In case of failure should produce meaningful error messages that help to fix the error.
  It should also identify statically ill-specified problems and provide debugging alternatives.

Developing an efficient backend for simulation environments with the above mentioned characteristics that accommodates various existing numerical packages (often written in various languages) is a challenging and error prone task. modelling and automatic code generation is the most promising way to address this problem.

The *Model-Driven Architecture* (MDA) (Frankel, 2003 [16]) is an initiative by the *Object Management Group* (OMG) to define an approach to software development based on modelling and automated mapping of models to implementations.

We propose to rely on model-driven engineering and meta-modelling to automate the numerical solver selection process for a given equation system or for an equation-based simulation model.

This paper introduces *ModSimPack*, a *Modelling* and *Sim*ulation *Pack*age for automatic selection of numerical solvers for a particular simulation problem. ModSimPack takes as input a simulation model expressed in declarative modelling and simulation language such as Modelica 2002 ([25]). The system is able to detect the types of the equations, perform symbolic manipulations on them and decide which numerical solver is suitable to solve the problem. ModSimPack provides an advanced feedback mechanism if inconsistencies and structural singularities are present in the model (Bunus and Fritzson 2004 [10]). The output is a domain specific model of the equation solving process. An interpreter traverses the generated solving process domain specific model and emits imperative procedural code that can be compiled and executed by a simulation environment

ModSimPack aims to lay out a methodology for diagnosing, simplifying and debugging simulation models expressed by mathematical equations by presenting the act of numerical method and solver selection as a modelling process. In traditional software engineering and mathematical analysis this task is seldom seen as a modelling process.

The remainder of the paper is organised as follows: Section 1 presents the problem formulation and a motivational example. Section 2 gives a detailed description of our decision and simulation framework for selection of numerical solvers. In this context, details about the salient feature of the equation systems that are exploited by our system are also given. Section 3 describes the formal paradigm based on domain specific languages provided by ModSimPack that enables user with limited numerical analysis knowledge to quickly develop backends for simulators. In Section 4 we survey some related work in the field of automatic selection of numerical methods. Finally, Section 5 presents our conclusions and future work.

1 Problem Formulation

Mathematical modelling proceeds by specifying a set of mathematical equations or functional relations denoted $E = \{e_1, ..., e_n\}$ involving a set of variables denoted $V = \{v_1, ..., v_m\}$. In the general case a system of n equation with m variables or unknowns can be described by the following equalities:

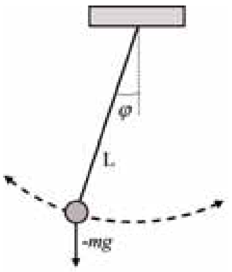
$$e_i(v_1,\dots v_m)=c_i \tag{1.1}$$

where c_i are constants and $i=1\ \dots\ n$. Solving the system of equations from (1.1) is the problem of finding the set of solutions

$$S=\{(s_1,\dots s_m)\in T^m \mid e_i(s_1,\dots s_m)=c_i\}$$

where T is the domain of equations, which fulfils the equalities (1.1).

In our case besides the solution set S we are interested in the set of symbolic and numerical methods $M=\{m_1, \dots, m_k\}$ available to compute the solution set S as well as an implementation $I=(m_k, l_i)$ of an available method in a general purpose programming language l_i.



As an example let us consider the following system of equation that describes the behaviour of a pendulum. The pendulum model is expressed in a Cartesian coordinate system and consists of a heavy body of mass m suspended by a rigid rod of length L.

Applying Newton's second law to the pendulum results in a nonlinear second order differential equation system:

$$m\ddot{x}=-\frac{x}{L}F;\quad m\ddot{y}=-\frac{y}{L}F-mg \tag{1.2}$$

where F is the force in the rod, g is the gravitational acceleration and x, y are the coordinates of the mass m. In order to completely specify the physical system the following geometrical constraint needs to be added:

$$x^2+y^2=L^2 \tag{1.3}$$

At time $t=0$ the pendulum is deformed 90º degrees from the vertical position and released. The initial conditions can be stated as follows:

$$x(0)=L;\quad y(0)=0 \tag{1.4}$$

By combining equations (1.2), (1.3) and the initial conditions (1.4) a system of differential equations is obtained. In order to predict and quantify the features of our pendulum model we need to solve this system of equations. First of all we need to decide if the system of equation is a system of ordinary differential equations (ODE) or is a system of differential algebraic equations (DAE). It is impossible to directly solve this system of equations because the geometric constraint (2.3) does not contain the higher order derivatives $\ddot{x},\ddot{y}$ and F. Since the system cannot be transformed into an explicit form we conclude that the problem is a DAE.

The next obvious question is: Which numerical method should be chosen for solving this type of equation? The answer to this question is extremely difficult task for a non expert. Eventually an expert would indicate that general purpose DAE solver DASSL by Petzold (1983, [28]) should be used for this particular problem. A closer look to the DASSL subroutine reveals that it has 17 arguments that need to be known and set by the user before calling the solver:

```
DDASSL(RES, NEQ, T, Y, YPRIME, TOUT,
        INFO, RTOL, ATOL, IDID, RWORK,
        LRW, IWORK, LIW, RPAR, IPAR, JAC)
```

Some of the arguments are arrays. For example `INFO` is array with a length of 15 and each element sets a separate option for the numerical solver. The system of differential equations needs to be supplied in a separate subroutine of the form:

```
SUBROUTINE RES( T, Y, YPRIME, DELTA, IRES,
                                RPAR, IPAR)
```

DASSL is based on backward differentiation formulas and will not converge for high-index problems (the high index of a DAE is explained in Section 2.4). Our DAE system of equations is an index 3 problem and the index need to be reduced to an index 1 problem in order to solve it with DASSL. The index reduction can be done by differentiating twice the algebraic constraint equation (1.3).

As we have seen solving a simple system of differential equation that describes the behaviour of planar pendulum would require some numerical analysis knowledge. Moreover, the user is also required to have an extensive FORTRAN programming knowledge in order to state the problem and use an available numerical solver.

In the next sections we describe how this process can be automated by requiring only limited numerical analysis knowledge and no prior programming experience from the user. We propose an automatic system called ModSimPack for detection and simulation of differential system of equations. The software is designed for people that need to solve dynamic simulation problems and do not have a numerical background in numerical analysis.

Users that are interested in how to use a numerical library are also potential users of our systems. ModSimPack will generate a source code that calls the selected solvers, transforms the equation into a form that is accepted by the solver and most of the required parameters are automatically determined.

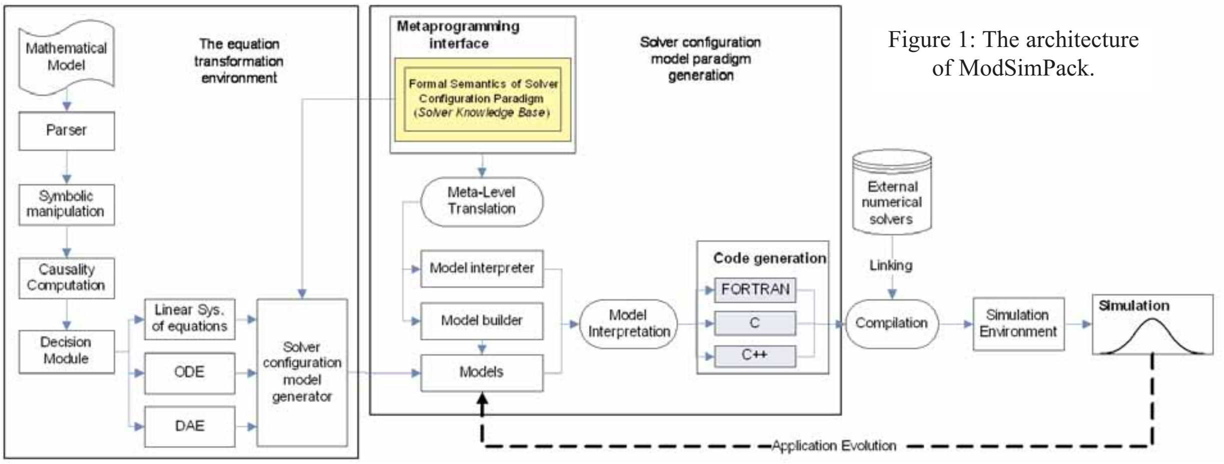


Figure 1: The architecture of ModSimPack.

2. An Overview of ModSimPack

Before delving into technical details it is worth getting an overall feel of the ModSimPack environment. The architecture and organisation of the decision and simulation framework is depicted in Figure 1. The system combines numerical, symbolical and knowledge based modules. ModSimPack has two components: the *Equations Transformation Environment* where the equations are extracted from simulation models and mapped into an internal data structure that permits symbolic manipulation on them and the *Solver Configuration Model Paradigm Generator* where a domain specific paradigm and modelling environment is generated from a meta-model.

The equation transformation environment takes as input a mathematical model representing the problem that need to be solved and output a domain-specific model in which a default numerical solver configuration is proposed to solve the problem. The following subsections describe each transformation step in more detail.

2.1 The Model Input

The user starts by defining the mathematical problem with the help of declarative modelling and simulation language such as Modelica 2002 [26]. In this way the problem to be analysed can be entered in a flexible manner and there are no major restriction imposed on the form of the equations. As an example the Robertson chemical kinetics problem (Robertson 1966 [30]):

$$\begin{cases} \dot{x} = -0.04x + 10^4 yz \\ \dot{y} = 0.04x - 10^4 yz - 3\cdot 10^7 y^2 \\ \dot{z} = 3\cdot 10^7 y^2 \end{cases} \tag{2.1}$$

with the initial conditions $x(0)=1,\ y(0)=0;\ z(0)=0$ can written in Modelica as follows:

```
model Robertson
  Real x(start=1),y(start=0),z(start=0);
  equation
    der(x)  = -0.04x + 10e4*y*z;
    der(y)  =  0.04x - 10e4*y*z - 3*10e7*y*y;
    der(z)  =  3*10e7*y*y;
end Robertson
```

Those interested in more details of the Modelica language may wish to consult the textbooks by Fritzson 2004 ([18]) and by Tiller 2001 ([36]).

2.2 Symbolic Manipulation

After the parsing the input model, the equations are mapped into a special form of abstract syntax tree that permits simple symbolic manipulations such as: common subexpression elimination, algebraic simplifications, constant folding and translation of equations into canonical form. In ModSimPack a symbolic template library called Ginac (Bauer et al. 2002; [8]) has been used for storing the symbolic expressions and variables, and performing trivial symbolic expression simplification. It is even possible to solve some linear system of equation symbolically by this module without being necessary to call a numerical method later.

This stage is extremely efficient in decreasing the complexity of the system of equations and in reducing the number of overall equations especially for models generated by object oriented modelling tools. For large scale process models a reduction in computation time between 20 an 40% have been reported by Schlegel and Marquardt (2003; [31]) due to symbolic simplifications and to removal of redundant algebraic equations.

2.3 Causality Computation

For large-scale models the correct computation order for model variables must first be determined. The overall system of equations needs to be ordered to facilitate the use of numerical solvers for improving efficiency. Partitioning equations into blocks can be achieved by first constructing the incidence matrix associated to the system of equations. Given a system of equations S_E with m equations $\{e_1, e_2, ..., e_m\}$ and n variables $\{v_1, v_2, ..., v_n\}$, the associated *incidence* matrix to S_E is the $m \times n$ matrix whose entries d_{ij} are:

$$d_{ij} = \begin{cases} 1 & \text{if } \quad v_j \text{ is present in } e_i \\ 0 & \text{otherwise} \end{cases} \quad \text{where} \quad \begin{array}{l} 1 \le i \le m \\ 1 \le j \le n \end{array}$$

In the next step, it is desirable to obtain a lower triangular form of the incidence matrix. The lower triangular form guarantees that the equations can be sequentially solved one at a time by a forward substitution process. In general the structure of the incidence matrix extracted from the equations of a physical system simulation model is not lower triangular and in most cases it is not possible to find a permutation to transform it into a strictly lower triangular form. However, efficient algorithms exist to transform matrices to *Block Lower Triangular* form (shortly BLT form) (Duff and Reid 1978; [12]). The advantage of using the BLT decomposition is twofold. First the overall system of equations is decomposed into smaller blocks that can be solved sequentially by forward substitution process. Secondly, solving the blocks sequentially is computationally more efficient in terms of execution time and memory storage than solving the whole system of equations at once.

As an example the following system of equations consisting of 5 equations with 5 unknowns can be decomposed by the causality computation module into 3 smaller systems of equations that can be solved sequentially:

$$\begin{cases} x + y + t = 3 \\ z + 2s = -4 \\ x - 2y = -7 \\ t = z \\ z - s = 5 \end{cases} \quad \leftrightarrow \quad (1) \begin{cases} z + 2s = -4 \\ z - s = 5 \end{cases} \quad (2) \{ t = z \quad (3) \begin{cases} x + y + t = 3 \\ x - 2y = 5 \end{cases}$$

2.4 Decision Modules

Our system is able to automatically detect the type of the input equations. At the current stage of implementation ModSimPack is able to detect and simulate simulation models that are expressed with the help of linear and nonlinear system of equation, ODEs and DAEs. The decision module will attempt to recognise the salient features of the system and matching them with a suitable numerical solver in the Solver Knowledge Base.

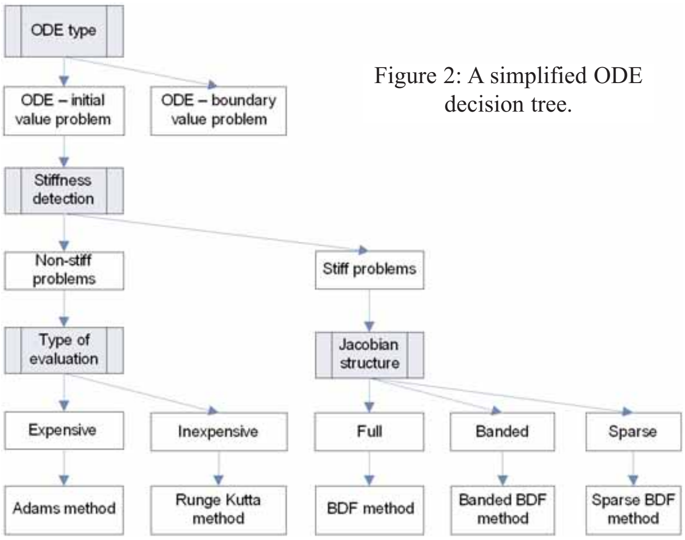


Figure 2: A simplified ODE decision tree.

We have used a decision trees based on the classification tree proposed by Boisvert et al. (1985; [9]) for the GAMS method repository and the decision tree employed by Kamel et al. (1993; [19]) in the ODEXPERT system. The classification of numerical methods used in GAMS has a broad consent in the field of numerical analysis and it was introduced with the purpose of standardising classification of mathematical and statistical software. The decision used by the ODEXPERT system is an extension of the decision tree proposed by Addison et al. (1991; [2]). In Figure 2 a simplified decision tree for ODE systems is shown. Figure 3 shows a corresponding decision tree for selecting a DAE solver.

The choice of a particular numerical solver for a given problem is affected by the following properties:

- Stiffness.
- Type of requested evaluation (accuracy).
- Jacobian structure.
- Differential index for DAE.

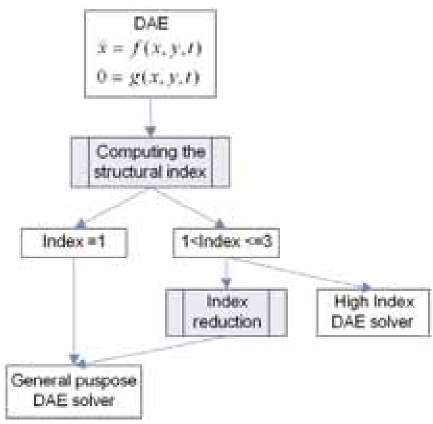


Figure 3: A simplified DAE decision tree.

We give a brief description of some of these properties: A set of ODE is said to be stiff if it involves widely differing times scales for the variables that need to be computed. A numerical solver that tries to compute the solution of a stiff ODE system needs to integrate using very small step to capture the behavior of the rapidly changing variable while integrating for a longer time to capture the behavior of the slowly changing variable. Generally, the integration time step depends on the fastest settling rate. In stiff problems we have both slow and fast behavior and the solution may have an initial transient where the fast modes settle.

The fast mode may be followed by a longer period where the slower mode dominates. In this phase the fast modes are still present in the equation system and are not influencing very much the solution. However they will have an influence on the imposing a small step for the integrator even if it is not necessary. This will cause the solver to slow down and use excessively small time steps for computing slow varying solutions. These situations should be ideally detected and the choice of a specially adapted numerical solver should be offered to the user. ModSimPack insert stiffness tests blocks in the solver configuration domain specific model. If a stiff problem is encountered the equation solving process switches from a non-stiff solver to a stiff solver.

The stiff ODE solvers often executes faster if additional structural information regarding the Jacobian matrix is provided. The Jacobian is computed symbolically by the symbolic engine that was previously used for computing the canonical form of the equations. The sparsity pattern of the Jacobian is extracted and the system will try to classify the structure based on classification proposed by Kamel et al. (1993, [19]; diagonal, tridiagonal. lower triangular, etc). This information is used to choose an adequate numerical solver or eventually supplied to the solver if it is required. If the Jacobian is not explicitly supplied most of the available numerical solvers will approximate it by using finite differences.

The index of a system of differential algebraic equations is one of the measures of solvability for the numerical problems in physical system simulation when solving differential equations. For a DAE given in the fully implicit form $F(dx/dt, x, t) = 0$ the differential index is the minimum number of times that all parts of the system must be differentiated with respect to t to reduce the system to a set of ODEs for the variable x (determine dx/dt as a continuous function of x and t). The index gives a classification of DAEs with respect to their numerical properties and can be seen as a measure of the distance between the DAE and the corresponding ODE. An explicit ODE is an index 0 DAE.

As it can be seen from Figure 3, depending on the computed structural index value, different strategies can be adopted for solving a DAE. If the index is less or equal than 1, a general purpose DAE numerical solver such as DASSL can be used. If the index is greater than 1, a special high index numerical solver can be used. Another option is to lower the index of the DAE with symbolic preprocessing methods and applying a normal index 1 DAE solver for computing the solution.

Since the development of methods for solving high index DAEs is still an active field of research in numerical analysis and there is no general purpose high index solver available, we have chosen to reduce the high index problem to index 1 problems by using symbolical methods such as the dummy derivatives methods proposed by Mattsson and Söderlind (1993; [24]). After the symbolic index reduction, the framework is able to propose the selection of a suitable general purpose numerical solver for computing the solutions of DAE.

2.5 Solver Configuration Model Generator

Based on information coming from the decision modules and from a *Solver Knowledge Base*, the last component from the equation transformation environment generates a domain specific solver configuration model proposed for solving the given input model. The input model expressed initially in a declarative modeling language is transformed now into a model that contains a numerical solver that can compute the solutions. The mathematical equations were extracted from the initial model and transformed into a form that is required by the chosen numerical solver without the user intervention. More details about the generated solver configuration model are given in the following section.

3 The Solver Configuration Formalism

The equation transformation environment, described in the previous section generates a solver configuration model expressed in a domain specific modeling paradigm. The formal semantics of the solver configuration model is given by a meta-model constructed with the help of a meta-programming interface.

We use the *Generic Modeling Environment* (GME) (Ledeczi et al. 2001; [21]) developed at Vanderbilt University to meta-model and derive the domain specific modeling paradigm for selection of the numerical solvers. GME is a generic, configurable modeling environment in which the configuration process is seen as a modeling process (modeling of the modeling process).

A domain expert is required to model in advance the modelling process (meta-modelling). In GME the meta-model is UML-based. With the help of UML entity relationships diagrams the expert defines what types of objects will be used during the modelling process, the visual appearance of these objects and the attributes associated of each object. The constraints that the modelling environment must to enforce on the domain model are expressed with the help *Object Constraint Language* (OCL) rules. The output will be a compiled set of rules, called paradigm that configures the generic environment for a specific application domain. It is worth noting that GME allows the modelling paradigm and the corresponding graphical environment to be modelled by the meta-model. GME closely follows the *model-integrated computing* philosophy proposed by Sztipanovits and Karsai (1997; [34]) in which the requirements, the architecture and the environment of a system is captured by high level models (meta-models).

As discussed earlier, to define a meta-model one has to provide an abstract syntax (denoting entities of the formalism, their attributes and relationships and constraints) as well as a concrete graphical syntax (how the entities and relationships should be rendered in a visual interactive tool) as well as the possible graphical constraints. Figure 4 shows a small section of the solver configuration paradigm meta-modelled in GME.

The 'solver configuration' models are made of linear and nonlinear solvers models, integrators, Jacobian, stiffness detectors, etc. Models are connected together to form a working implementation of a numerical method for a particular input simulation model. Figure 5 shows a generated solver configuration model for solving a simple system of ordinary differential equations with the method of Backward Differentiation formula (BDF). Solving an ODE numerically is to compute the solution step-by-step in discrete increments across a given time of integrations. The BDF method predicts a new solution point by interpolating on multiple previous solution points. Figure 5 shows a fixed leading coefficient (FLC) integrator based on BDF predictor/corrector formulations that uses a modified Newton iteration method for solving the nonlinear corrector equation derived during the solution process. The solution of the nonlinear equation system approximates the solution of the DAE. However the nonlinear system is further converted to a linear system.

The structure of the generated solver configuration model matches closely the structure of a C++ package for solving Differential Algebraic Equations, called DAE-TK (Kees and Miller 1999 [20]). Model interpreters traverse the solver configuration model structure and automatically synthesize a procedural source code implementation of the model. One particular interpreter can generate code for DAE-TK. The generated source code can be compiled and linked to solvers for efficient simulation. A simulation environment is executing the compiled code and the simulation results can be visualised.

The generated solver configuration model can be modified if the simulation results are unsatisfactory or if the user is interested in other solver configurations. In this way, the initial model generated by the equation transformation environment can be evolved. In Figure 1 we indicate the application evolution by a dashed arrow from the simulation block to the solver configuration model.

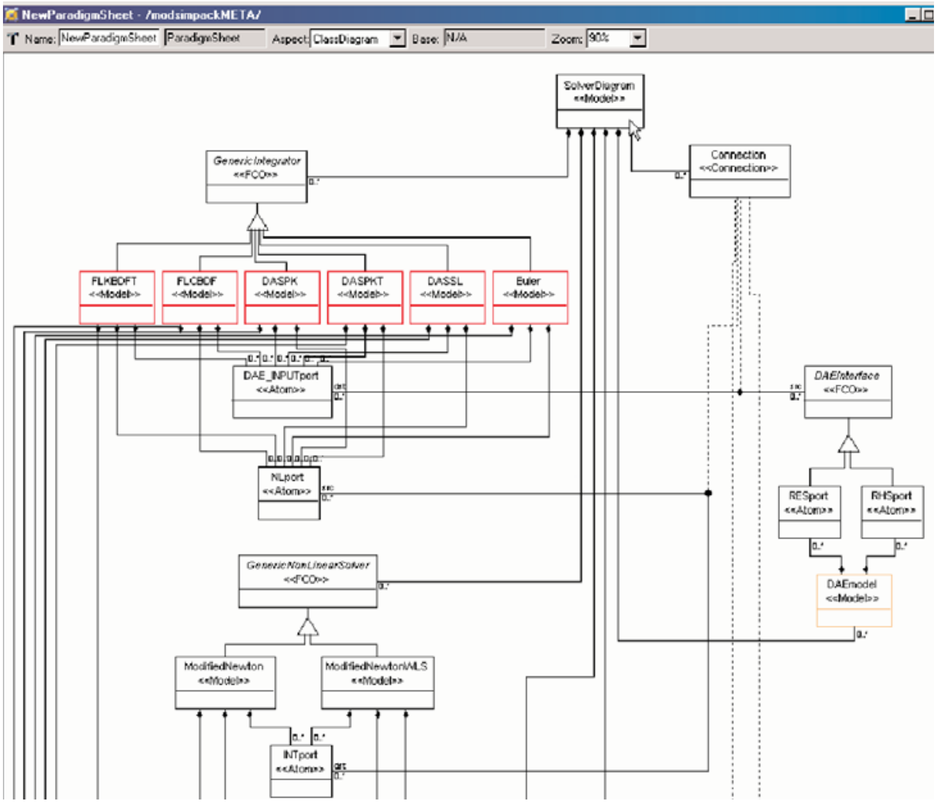


Figure 4: The Solver configuration paradigm meta-modeled in GME.

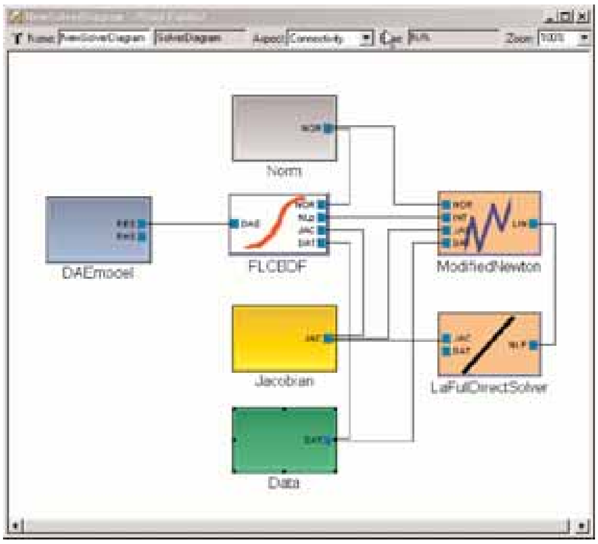


Figure 5: A generated solver configuration model.

For example, a non expert user can easily substitute an integrator with another integrator model without being necessary to write FORTRAN or C code.

Moreover, the modelling environment can be evolved as well. The solver configuration modelling paradigm can be changed by introducing new models such as new integrators or numerical solvers or by specifying new interaction rules among the models. When a change is performed at the meta-model level the model interpreters that generate the simulation source code need to be updated as well. The change of the modelling environment is usually done by numerical analysis domain experts.

4 Related Works

Several expert systems that assist the user in the various aspects of numerical analysis have been reported in the literature. The work most closed related to ours is the knowledge-based system proposed by Kamel et al. (1993; [19]) called ODEXPERT for selecting the appropriate numerical solver for initial value ordinary differential equations. The system is restricted to the returning the name of the selected solver without generating executable code or executing the systems. Another drawback is that the input equations need to be specified in an explicit form. ODEXPERT relies on the external package Maple for computing the Jacobian.

The *EPODE* (*E*x*P*ert system for *O*rdinary *D*ifferential *E*quations) problem solving environment proposed by Petcu and Dragan (2000; [27]) provides automatic detection of problem types, method properties and solving procedure parameters.

Based on the identified problem properties EPODE automatically selects a solving method. Besides this standard functionality, a high level user interface, ways to incorporate novel solution methods, and the facility of testing parallel algorithms are also available in EPODE.

Lucks and Gladwell 1992 [23] propose an automated consultant for evaluating and recommending ODE IVP mathematical software called SAIVS (*Selection Advisor for Initial Value Software*). SAIVS contains an advanced knowledge base of encoded expertise about ODE problems and software. Given an input ODE IVP problem, the system returns a ranked list of numerical codes. The ranked list is computed by taking into account a set of functions expressing knowledge about the effects of problem features on performance. SAIVS is able to analyse competitive tradeoffs between the knowledge functions and therefore has a significantly higher rate of agreement with the opinions of a domain expert. However, the system relies on queries to the user for specifying some of the measurements functions.

PYTHIA (Weerawarana et al., 1996; [38]) is a knowledge based system to assist in the selection of a partial differential equation (PDE) solvers that fulfils the user's expectations with respect to the accuracy and computational cost. PYTHIA uses data mining strategies to select problem or algorithm parameters, based on a database of previous results.

Compared to the above presented expert systems our approach is uniquely by providing a high flexibility when inputting the problem and a domain specific modelling environment for selecting the numerical solvers.
However our system has some architectural similarities with other model-based simulation frameworks. MILAN (Ledeczi et al. 2003, [22]; Agrawal et al. 2001, [4]) is a model-based, extensible simulation framework based also on GME. It provides a unified framework for modelling a large class of embedded systems and application by integrating different widely used simulators such as Matlab, SystemC, ActiveHDL. The models developed in MILAN are primarily graphical, hierarchical and includes multiple aspects.

Our solver configuration paradigm was meta-modelled with the *Generic Modelling Environment* (GME) in the MetaGME formalism. It could have been implemented as well with ATOM3, a multi-paradigm modelling environment proposed by Vangheluwe and Lara ([37]). From a given meta-specification (called *Entity-Relationship* formalism), ATOM3 can generate a tool to visually manipulate models described in the specified formalism.

6 Summary and Conclusion

We have presented a combined simulation-decision framework for the automation of the numerical solver selection for a given mathematical system of equations based on the equation system properties and structure. The selection is performed without relying on the user to supply this information. The system is able to recognise linear equation, ODE and DAE problems and select a suitable solver based on the input problem.We have also presented a paradigm based on domain-specific languages (DSLs) that enables users with limited numerical analysis knowledge to quickly develop solver configuration for a particular simulation problem. In this context we propose a framework that integrates this paradigm into existing simulation environments.

A major limitation of our system is that the 'Solver Knowledge Base' includes only a limited number of numerical solvers. This is due to the fact that the system was originally intended as a symbolic and numeric engine for a Modelica-based simulation environment where a limited number of general purpose DAE solvers are sufficient for providing the required functionality. The long term goal of this research is to provide a more complete decision framework that would involve the extension of the Solver Knowledge Base to include more numerical solvers available in mathematical software repositories. We also intend to extend the framework to include models of the control optimization packages such as COOPT (Serban and Petzold, 2001; [32]). The numerical solver selection process can be further extended by developing model transformations specifications for transforming domain specific platform independent (PIM) solver configuration models into platform specific solver configuration models (PSM). This is usually the case when the input model is intended to be simulated on parallel computers. The numerical solvers developed for parallel computers are mostly platform specific and require extra parameters settings. Architecturally, such a model transformation functionality will require the integration of the model transformation environment GREAT (Agrawal et al., 2003; [5]) into the existing framework.

We believe that the proposed framework can be used to discuss solution of a system of equations in a qualitative way with emphasis on the physical behaviour first and the numerical implementation second.

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A System Dynamics Model for Diabetes Prevalence in Vienna

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In this paper we present a System Dynamics model for the incidence of type-2 diabetes in Vienna based on a model developed by A. Jones, J. Homer et al. for the United States of America. The main influencing factors incorporated in the model are obesity, age and disease management. This model is developed further to better represent the health care organization in Austria as well as a distinction by sex. While the control circles are very similar to the USA model the input parameters differ radically, making an adaptation necessary. This results in large deviations in the disease prevalence relative to the total population. Preliminary results are presented to show the applicability on the real world system and further developments and test runs are suggested.

Introduction

Diabetes mellitus (DM) and its complications are one of the most challenging topics in public health care. Consequent diseases include neuropathy along with the risk of gangrene and a later amputation, nephropathy that can lead to obligatory dialysis as well as to the necessity of a kidney transplant and retinopathy with the danger of premature blindness. With a prevalence of 25 million people in the European Union and 60 million people at risk of developing prediabetes, diabetes is a major chronic disease responsible for 5 to 10 percent of the total health care costs. The WHO expects a rise in diabetes prevalence of 37 percent from the year 2000 to the year 2025.

The question is how to best manage this serious threat to public health. One way to find an answer is to employ *System Dynamics* (SD) with it's a very broad range of applications in natural, economical, technical and social sciences. SD models are perfectly suited to test different policies of intervention in simulations and therefore are a powerful tool to help finding the best strategies.

We adopt a SD model, commissioned by the Center for Disease Control and Prevention (CDC) in the USA and developed by A. Jones, J. Homer et al. [1], which has been successfully applied to reproduce the historical available data of the last two decades. The structure of the model arises not only from the progression of DM as a chronic disease but also from the available data. We adopt the model to the Austrian data set and enhance it to include a distinction by sex since different policies may become necessary.

The structure of this paper is as follows: In section 1 we try to answer the question why using SD to develop a model for the diabetes prevalence makes sense. The main stocks and flows in this model are described in section 2. Ssection 3 discusses the available input data and methods to handle them.

Section 4 deals with the main influence factors: obesity as a function of caloric intake and consumption, age and disease prevention and control. Some results for Vienna, Austria, are given in section 5. The last section will summarize our findings and propose testing schemes and further future work.

1 Modeling Motivation

Chronic diseases are widespread above all in our aging affluent society. Approximately one third of the total population suffers from chronic diseases and with increasing age the percentage is rising steeply. Already more than one half of the people above 60 suffer from at least one chronic disease. Therefore these afflictions are responsible for a great part of the health care costs, outstripping the costs of accidents and acute diseases combined. According to all estimates chronic diseases are going to increase further.

Besides the socioeconomic importance, chronic diseases sport several features which suggest a SD treatment: Firstly all health care officials, including doctors, politicians, patient associations and other medical staff, recognize the threat and agree that measures on an ecological, system-wide level have to be taken to reduce chronic diseases and their consequences.

But most programs sport conventional analytical methods by which each aspect of a complicated disease control strategy is addressed and evaluated separately. The advantage of SD here is that one gets a global picture where all influencing factors are incorporated and act together.

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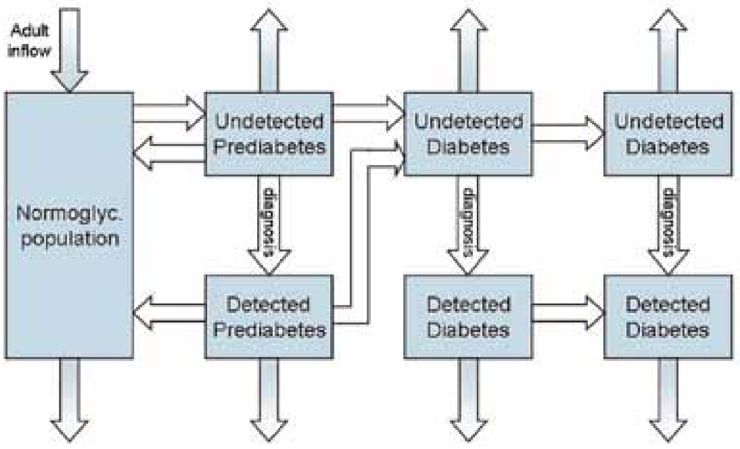

Figure 1: The main stocks and flows of the core model.

Secondly chronic diseases involve long time scales. There are long delays between causes and health consequences making short term analysis methods unsuitable. Three prevention levels, of which each can require dozens of years of treatment, are distinguished: primary prevention to avoid the onset of an affliction, secondary prevention to avoid chronic development and harmful consequences and tertiary prevention to avoid the loss of functions.

This leads to the third argument why SD is suitable: for every prevention level many different policies are available. Primary prevention includes behavioral and socioeconomic measures like improving lifestyle, working and living conditions, information, education and many more. Secondary prevention focuses on precaution and early detection. And finally elements of the tertiary prevention are accessibility to the medical treatment, improvement of compliance and empowerment.

All these measures together with quality control are elements of a process-based disease management approach. SD now gives the opportunity to test different approaches and policies simultaneously and observe the respective outcome.

Finally diabetes mellitus is the prime example of a chronic disease. It is researched well enough so that the main risk factors are known and that much input data is available.

2 The Core Model

Of diabetes mellitus only the risk for type-2 diabetes, which is responsible for 85 to 95 percent of all cases, is reasonably influenceable. Since type-2 DM is still very seldom for juveniles we restrict ourselves to the adult population. The steep rise of people with DM from 1995 to 2000 is not only due to a higher prevalence but also due to better and earlier diagnosis.

This has also consequences for the model structure: In Figure 1 we present the population stocks and flows in our model. We distinguish seven different population stocks arranged in four groups. The first group consists only of one stock: the healthy adults who have a normal blood-glucose level. The other groups each consist of two levels, the diagnoses and the undiagnosed ones.

The second group is the population with pre-diabetes. These are people with an increased blood glucose level but not yet having developed full diabetes, which constitute the third group. In the last group are people who not only have diabetes but are also stricken by consequent diseases.

Let us now examine the flows more closely: There is only one inflow of healthy adults into the fist level, while people may die out of every level. This inflow is given as a time series input by statistical predictions. The different death rates are affected by the fraction of obese people of every stock, which is calculated in our model, as well as by the fraction of elderly people, which is again given as a time series. The basic assumption is that the relative rates of people with a risk factor compared to people without it remains constant in the respective group. Written explicitly,

$$\frac{\mathbf{P}(\text{death} \mid \text{elderly})}{\mathbf{P}(\text{death} \mid \neg\text{elderly})} = const.$$

$$\frac{\mathbf{P}(\text{death} \mid \text{obese})}{\mathbf{P}(\text{death} \mid \neg\text{obese})} = const.$$

holds true for every group. If DM is already detected than also the control of the disease, the *disease management*, is influencing the death rates. With suitable initial values the dynamic death rates can be calculated.

The flows between the different stocks are characterised by the following assumptions: While people with pre-diabetes can still recover, there is no way to cure DM after its onset. DM is a chronic disease after all and once complications occur the damage is dealt and cannot be undone.

The onset of pre-diabetes and DM occur unobserved, while complications can also arise even if under medical supervision. All transition rates are affected by the elderly and the obese fractions of the respective populations.

The progression rates (the horizontal untitled ones) of the detected populations can be influenced by the clinical management, like prevention measures and compliance. The detection rates (the vertical ones) are more difficult to describe: they are first order exponentially delayed functions of the progression rates as well as the testing frequency and the sensitivity of the tests. Time dependent input data enters in several places of DM detection and control incorporating different possible health policies.

3 Data Basis

The original model is very complex, allowing for nonlinear behavior. There are over 134 different input parameters and not all of them can be measured directly. It is therefore necessary to estimate some of the unmeasured input parameters so that the output reproduces available historical data. This is the reason why we start the simulation in 1980 and continue it till 2050. The US model incorporates qualitative statements in their parameter estimation and use a *partial-model-tuning approach*. In short the tuning of uncertain parameters is done manually but applied to the smallest possible piece of structure and the smallest possible cluster of parameters given the configuration of available time series data.

Since the available data is very different in Austria compared to the US we will look at some points in detail now. Where data is available we of course use it directly or use it to calculate the necessary input parameters. Examples are the future population for every year as describes below and the initial death rates from the life expectancy.

Another point is that the available data originates from different years, like data recorded only since a certain starting date or the progression of classification standards. For the parameters which remain constant over time, like the ratio of the death rates above, this constitutes no problem. Where appropriate data is available the assumption that they stay constant is tested. In the other cases we have reason to believe in the validity of this assumption since the model worked for the US.

Where no data from Austria is available, we use data from nearby countries, like Germany or the United Kingdom, or input parameters from the US model. This is justified since all these countries belong to the same western industrial culture area. Therefore it is expected that the parameters are almost the same as in Austria. Additional confidence is provided by the fact that parameters for the US model have already been verified.

And finally the specific situation in Austria makes some parameters unnecessary or completely different. One difference to the USA model arises from the fact that everyone in Austria has access to health care and can afford the necessary medicaments and treatments thanks to the compulsory insurance system and free social healthcare. The second difference is that the costs of DM and consequent diseases are simply not comparable.

One major difficulty encountered when modeling diseases in general is the estimated number of unreported cases. Several studies are available on this topic (c.f. [4] and references therein). Our findings are in fairly good agreement to the WHO estimates of a current DM prevalence of 5 to 7 percent. The exact number of cases is not to be taken intimately, but this isn't our goal anyway. In the application we want to compare different policies of health care management against each other.

For the analysis in this paper we use data for Vienna, since the quality of the data is very good and many input parameters are available, especially with respect to the distinction by sex. This distinction is made by running the model twice with different input parameters and then adding up the respective results.

4 Main Factors of Influence

We have already identified the most important influencing factors: age, clinical management and obesity. The age enters through the fraction of elderly people. The adult population, that is age 20 and above, is given by a time series calculated from the demographic development taken from [2]. The fraction of elderly people is calculated as the fraction of people aged 65 and above compared to the total population and can be seen together with the total population in Figure 2.

The calculation of the values for each year is done by a spline interpolation of order 2 of the available data. Note that the results do change less than one percent if we use linear interpolation instead.

The disease management allows to adjust the following time dependent input parameters: the testing of high-risk patients, the testing for and the monitoring of pre-diabetes, the ability to self-monitor the blood

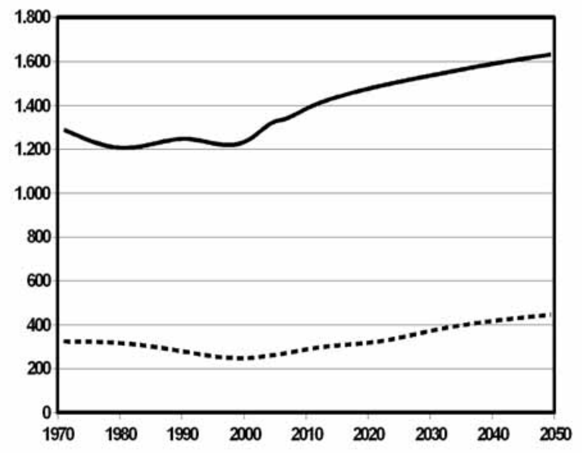

Figure 2: Adult (solid line) and elderly (dotted line) population in Vienna from 1971 to 2006 (data) and prognosis till 2050.

glucose level and the ability to adopt a healthy lifestyle. For the present calculation the historical values of these input parameters are taken from [2,3,4,5] and are assumed to stay constant after 2005.

Finally the obese fraction of the population is calculated dynamically in our model. Figure 3 presents the controlling feedback loop which governs the body-mass-index (BMI) in dependence of the calorie intake and consumption. Here lies a difference to the original model: While the physical activity calories were given directly as a time dependent input variable in the US model we don't have this data available for Vienna. Instead we use the physical activity level, which is a multiple of the basal metabolic rate, as given in [3]. And at last, this control cycle is also a reason why we only study adults: The formulas used are valid only for adults and we automatically exclude adolescence effects on the BMI.

5 Results for Vienna

In this section we give the results for the development of DM in Vienna till 2050. We also test different scenarios for the management of DM against the null hypothesis that every parameter remains constant after 2005.

In Figure 4 we see the fraction of detected and undetected pre-diabetes and diabetes, where all input parameters except the adult population inflow and the fraction of elderly people remain constant after 2005.

We see that the diabetes fraction of the adult population continues to grow until around 2025 and then becomes slowly saturated. The pre-diabetes fraction of the adult population stops to grow almost immediately. A detailed analysis shows that almost all cases of DM with complications are detected. The same is true only for 70 percent of the uncomplicated DM population.

As an example for a possible policy testing we give the results of the same test run with the difference that people spend an additional 200 kcal per day. In Figure 5 we see the same data as in Figure 4 with the difference that people are going for a walk at moderate speed for approximately an hour per day from 2005 onwards. We see that the growth of the DM percentage stops almost immediately and the pre-diabetes fraction exhibits a sharp drop. The total numbers however are still increasing and only due to a faster increase in the adult population we get a slow decline in the DM rate. This example is somewhat academically since it may not be incorporated in reality. However it shows very nicely that a step-like change in the entry produces a delayed output. While the fraction of the pre-diabetes population is already falling, the fraction of the people with diabetes continues growing for a few more years.

5 Summary and Outlook

In this paper we have shown how a SD model for the DM prevalence in the US can be modified to fit the specific requirements and the available data in Vienna. Further work is on the way to extend the model to whole Austria and to include a health care cost analysis. A throughout stability analysis of the adopted model is on the way and will be reported elsewhere [6].

From the applied side of SD the following case studies can be made: We can also simulate different regions of health care to analyse the west-east gradient of life expectancy and life style in Austria.

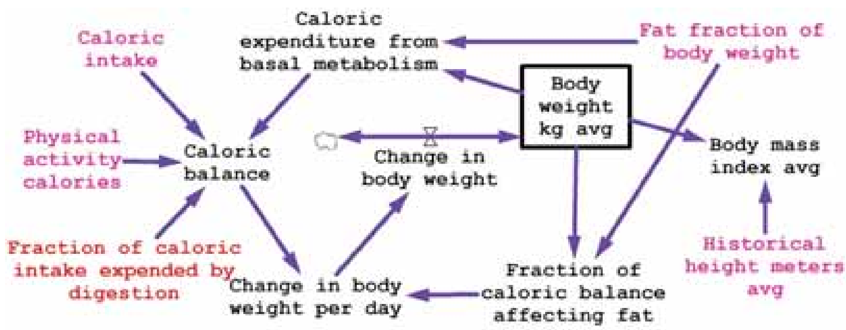

Figure 3: BMI-feedback cycle, detail are found in [1].

Together with the Hauptverband der Sozialversicherungsträger and other public decision makers responsible for health care various policies may be tested. Especially interesting is whether different policies for men and women are useful. Ongoing studies to examine the disease management from prevention and early detection over lifestyle adjustment to compliance are suited to validate the predictions made by the SD model.

Future work may include a hybrid-modeling approach, where individual agents are getting older but are moving through the different levels. Also a combination with SD models for obesity

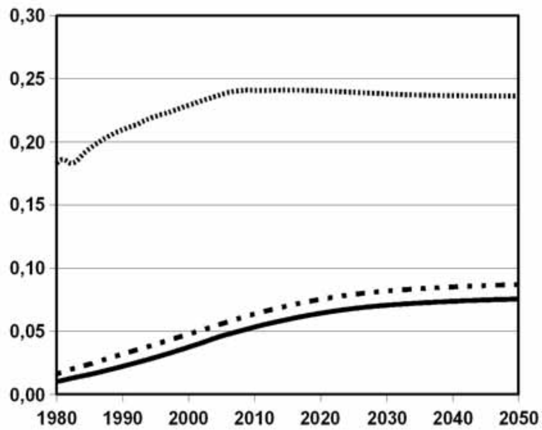

Figure 4: Pre-diabetes (dotted line), diabetes (slash-dotted line) and detected diabetes (solid line) fractions of the adult population in Vienna.

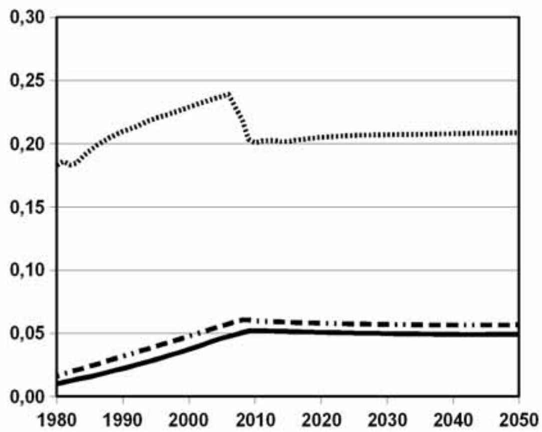

Figure 4: Pre-diabetes (dotted line), diabetes (slash-dotted line) and detected diabetes (solid line) fractions of the adult population in Vienna, with spending additional 200 kcal per day after 2005.

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Linear-logarithmic Kinetics - a Framework for Modeling Kinetics of Metabolic Reaction Networks

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Mathematical modelling of metabolic reaction networks and their regulation is crucial to obtain a better understanding of the (dis)functioning of living cells. Mathematical models that describe the metabolic reaction network include kinetic information on the involved enzymatic reactions. For many enzymes, the kinetic mechanisms are known and the kinetic parameters have been determined under non-physiological conditions in test tubes. However, the validity of these parameters under in vivo conditions (i.e. inside the living cell) is questionable. Furthermore the mechanistic rate equations are often highly complex and contain a large number of parameters. For these reasons approximative rate equations have been proposed as alternative for the mechanistic kinetic expressions. The main advantages of applying approximative equations are that they in some cases allow analytical solutions to express network fluxes and metabolite concentrations as a function of enzyme levels; they have a limited number of parameters and uniform format, which makes them mathematically more tractable, whilst still giving a satisfactory description of in vivo dynamic and steady state behaviour. Among the approximative kinetic formats described in the literature, linear logarithmic (linlog) kinetics has been proposed for modelling of in vivo kinetics and for metabolic redesign, and shown to have a good approximation quality, standardised format and relatively few parameters. The parameters in linlog kinetics are the scaled local sensitivities of reaction rates towards metabolite concentrations which happen to be identical to the elasticities as these are defined within the framework of Metabolic Control Analysis. This paper will focus on several problems which can be fruitfully addressed using linlog approximation. The proposed methodologies will be illustrated with examples.

Introduction

The goal of *Metabolic Engineering* is primarily to improve the performance of cells towards product formation. For rational improvement, the construction of mathematical models of metabolic reaction systems is one of the crucial steps in the abstraction of the underlying biological processes. These models help not only the structural understanding and interpretation of the data (i.e. description of the complex kinetic behavior of metabolic reaction networks that feature metabolite-enzyme interactions (allosteric feedback or feed forward, intercompartmental transport, and cofactor coupling), but also allow performing exploratory simulations, prediction, design and optimization of such systems.

According to their time characteristics there are two main classes of models that are considered for modeling metabolic reaction networks:

- steady state models, and
- dynamic models.

Steady State Models

One of the initial steps in the modeling of metabolic reaction networks is to determine the structure and steady state characteristics of a given network. Steady state models describe time independent data, gathered from steady state experiments; hence they reflect the structural characteristics of the system. *Metabolic Flux Analysis* (MFA) and *Metabolic Network Analysis* (MNA) were developed as a powerful tool to analyse such data.

At steady state, the mass balances over the metabolites in the metabolic network yield a set of linear relations between the metabolic fluxes which can be expressed as:

$$\mathbf{S} \cdot \mathbf{v} = \mathbf{0} \tag{1a}$$

where **S** is the stoichiometric matrix and **v** is the vector of metabolic fluxes.

Using steady state mass balances alone, some identifiability problems remain, such as identification of fluxes in parallel pathways and bidirectional fluxes. ^{13}C-labeling based metabolic flux analysis has been shown to offer a solution to this [1].

Dynamic Models

In contrast to steady state models, dynamic models describe time dependent data obtained from biological systems. These types of models consist of sets of differential equations instead of algebraic relations:

$$\frac{d\mathbf{X}}{dt} = \mathbf{S} \cdot \mathbf{v}(\mathbf{e}, \mathbf{x}, \mathbf{p}) \tag{1b}$$

Here the individual reaction rates are a function of the enzyme activities **e**, the metabolite concentration **x**, and the enzyme kinetic parameters **p**. In setting up the mass balances, the stoichiometric matrix can be formed from steady state experiments. The kinetics of an enzyme-catalyzed reaction is usually based on information obtained from kinetic studies on purified enzymes in test tubes (*in vitro* conditions).

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The resulting rate equations are usually non-linear, contain many parameters and reflect the true mechanism under non-physiological conditions. However, inside living cells, enzyme catalyzed reactions are subject to many different effects, e.g. presence of molecular crowding, buffering conditions, many other enzymes, modulators, different intracellular pH etc.

Therefore the applicability of models based on *in vitro* determined parameters, to represent *in vivo* conditions is doubtful ([2-5]) and it is preferable to base the kinetic analysis of metabolic networks on studies of enzyme kinetics in intact cellular networks. In these so called *in vivo* studies, steady state and/or dynamic perturbations are applied to estimate the kinetic parameters of any suitable modeling framework. Such a modeling framework can be a collection of the published mechanistic equations for each of the enzymes in the network, thus basing the presence or absence of specific metabolite-enzyme interactions (but not their strength, i.e. the exact parameter values) on *in vitro* experimental data ([6]). In this approach, *in vivo* data are used; on the other hand, the relatively high number of parameters, due to the use of mechanistic rate equations, still imposes challenges in the parameter estimation from the available data.

As an alternative to mechanistic rate equations, approximative kinetics has been proposed to overcome the estimation problem. Moreover, it resolves situations where the mechanism of the reaction is unknown. This can be done by approximating the true function v, following an expansion of the Taylor's polynomial such that:

$$v = v(e, x, p) \tag{2a}$$

$$v = v_0 + \left.\frac{\partial v}{\partial x}\right|_0 (x - x_0) + \ldots + \frac{1}{n!}\left.\frac{\partial^n v}{\partial x^n}\right|_0 (x - x_0)^t \tag{2b}$$

where $\boldsymbol{v}$ is the kinetic expression for the corresponding rate, $\boldsymbol{e}$ is the enzyme level, $\boldsymbol{x}$ is the vector of metabolites, and $\boldsymbol{p}$ is the vector of parameters. Note that for the sake of simplicity, only derivatives with respect to one variable (x) are shown. In contrast to mechanistic equations, approximative formats generally contain fewer parameters and provide a unified approach, hence mathematical tractability.

The desired properties of these approximative kinetic formats are:

- The conversion rate is proportional to the corresponding enzyme level.
- Saturation behavior towards metabolites is depicted through a downward concave behavior.
- Minimum number of parameters.
- Analytical solutions of steady state mass balances exist.

The consideration of only the first derivative term of both e and x in the above Taylor's polynomial leads to the well-known *Metabolic Control Analysis* (MCA; [7-8]). For a review of MCA see also [9] and the references therein. The usefulness and problems of MCA stimulated initiatives to generate alternative approximative kinetic formats to provide satisfactory description of the system, with still a moderate number of parameters. Alternative formats which have been proposed are: linear kinetics in x only ([10-11]), loglinear kinetics ([12]), and two variants of Biochemical Systems Theory (*Generalized Mass Action* (GMA) and *S-System*), studied by Savageau ([13]) and Voit ([14]). More recently, a new approximative kinetic format, *linlog kinetics*, was proposed by Visser and Heijnen for modeling of *in vivo* kinetics and for metabolic redesign ([15]). A recent general review and comparison of the various approximative kinetic formats is given in [16].

In this work, we will review the published theory and applications of *linlog kinetics* to address some challenges in the field of Metabolic Engineering, such as modeling in vivo systems, parameter estimation, metabolic redesign and functional genomics.

2 Theory

In the *linlog kinetic* format, all the rate equations have the same mathematical structure: proportionality of the rate to the enzyme level, non-linearity in metabolites and linearity in the parameters (elasticities, ε_x^v) as represented in equation 3a:

$$\frac{v_i}{J_i^0} = \left[\frac{e_i}{e_i^0}\right] \cdot \left(1 + \varepsilon_{x_j}^{v_i} \ln\left(\frac{x_j}{x_j^0}\right) + \varepsilon_{c_k}^{v_i} \ln\left(\frac{c_k}{c_k^0}\right)\right) \tag{3a}$$

where v_i / J_i^0 is the rate of the reaction i relative to its reference flux, e_i / e_i^0 represents the relative enzyme activities, x_j / x_j^0 and c_k / c_k^0 represent the relative concentrations of the jth intracellular and kth extracellular metabolites which influence the kinetics of reaction i. The superscript '°' indicates the reference state values to which the flux, enzyme activities and metabolite concentrations are normalized. The parameters are the scaled local sensitivities, i.e. elasticities, as they were introduced in the MCA ([7-8]). They are defined as:

$$\varepsilon_x^v = \frac{x_0}{v_0} \cdot \left.\frac{\partial v}{\partial x}\right|_{x_0} \tag{3b}$$

Structural Properties

The linlog format possesses the above stated desired properties of general approximative kinetics. The proportionality to the enzyme level is already clear from equation 3a. The saturation behavior can easily be detected via the analysis of the derivatives of the rate equation with respect to the substrate. Considering only intracellular metabolites:

$$v = J^0 \left[\frac{e}{e^0}\right] \cdot \left(1 + \varepsilon^0 \ln\left(\frac{x}{x^0}\right)\right) \tag{4a}$$

$$\frac{\partial v}{\partial x} = J^0 \, e/e^0 \, \frac{\varepsilon^0}{x} \qquad \lim_{x \to \infty} \frac{\partial v}{\partial x} = 0 \tag{4b}$$

$$\frac{\partial^2 v}{\partial x^2} = -J^0 \, e/e^0 \, \frac{\varepsilon^0}{x^2} \tag{4c}$$

The first derivative is approaching to zero, with increasing metabolite concentrations, which indicates a plateau at high x levels. The downward concavity is obvious, with the constant negative sign of the second derivative in equation 4c (assuming a positive sign for the elasticity ε, hence activation of the rate v with metabolite x). The preferred property of a minimum number of parameters is provided by the use of elasticities as parameters in the linlog kinetic model. In this format, there is always only one elasticity per metabolite per reaction. This is an advantage when compared to e.g. *Hill type kinetics*, where there are two parameters (affinity constant and the Hill coefficient) per regulatory effect. Finally, the existence of an analytical solution of the steady state mass balances is obvious due to the linearity property of the linlog kinetic format towards the log-transformed concentrations. This property also allows providing a solution to the metabolic redesign problem that will be addressed below.

One general limitation of the approximative kinetic formats is that, they are typically monotonous. In some cases, like for the enzyme phosphofructokinase, the true enzymatic behavior is non-monotonous, i.e. at low ATP levels the enzyme is activated by the substrate ATP. However, above a certain ATP level, the enzyme does not show saturation behavior, instead, substrate inhibition, resulting in a decrease of the reaction rate at a further increase in the ATP level. In these specific situations, a second order term can be included in the model to describe this non-monotonous behavior. Note that in this case, the descriptive power of the system is improved at the expense of an increase in the number of parameters. When the second order term is included, we obtain:

$$v = v_0 + \left.\frac{\partial v}{\partial x}\right|_0 (x - x_0) + \frac{1}{2} \left.\frac{\partial^2 v}{\partial x^2}\right|_0 (x - x_0)^2 \tag{5a}$$

after rearrangement

$$\frac{v}{v_0} = 1 + \varepsilon_{x_0}^0 \ln(x/x_0) + \delta_{x_0}^0 \left(\ln(x/x_0)\right)^2 \tag{5b}$$

$$\text{with} \quad \varepsilon_{x_0}^0 = \frac{x_0}{v_0} \cdot \left.\frac{\partial v}{\partial x}\right|_0 \quad \text{and} \quad \delta_{x_0}^0 = \frac{1}{2} \frac{x_0^2}{v_0} \left.\frac{\partial^2 v}{\partial x^2}\right|_0$$

Notice that the incorporation of second order terms to improve the approximation has been introduced previously by Höfer and Heinrich ([17]) as second order MCA. The coefficients satisfy the summation theorems similar to those in linear theory.

A comparison of a non-monotonous hyperbolic Michaelis Menten type rate equation kinetics with inhibition term,

$$v = v^m \cdot \left(x/(K_1 + x)\right) \cdot \left(K_2/(K_2 + x)\right)$$

with the corresponding linlog and bilinear-logarithmic (bi-linlog) approximations is shown in Figure 1.

The monotonous behavior of the linlog approximation is inadequate for this case (for $x/x_0 > 2$), but incorporation of the second order term clearly improves the approximation. For this example, the following parameter values are used for the mechanistic equation: $v^m = K_1 = x_0 = 1$, $K_2 = 8$. The parameters of the bi-linlog equation can be estimated to fit the description of the mechanistic equation using simple linear regression. The fitted parameters are found to be $\delta = -0.19$ and $\varepsilon = 0.39$.

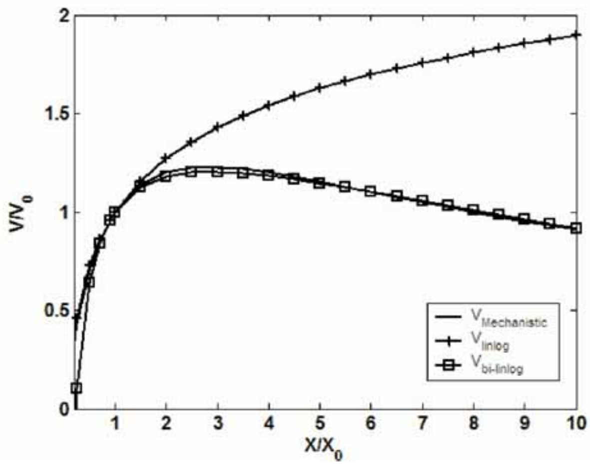


Figure 1: Comparison of the non-monotonous mechanistic hyperbolic kinetics (—) with the linlog kinetics (-+-) and bi-linlog kinetics (-□-).

One additional advantage of the proposed linlog kinetics is in the description of the numerous equilibrium interactions between species (metabolites, proteins, DNA or mRNA). These equilibria are described by linear sums of the log-mass ratios of the participating molecules: no parameters need to be known, as is shown in the following example:

$$aX_1 + bX_2 \longrightarrow cX_3$$

$$\frac{(X_3)^c}{(X_1)^a \cdot (X_2)^b} = K$$

at reference conditions $\dfrac{(X_3^0)^c}{(X_1^0)^a \cdot (X_2^0)^b} = K$

hence $\left(\dfrac{X_3}{X_3^0}\right)^c = \left(\dfrac{X_1}{X_1^0}\right)^a \cdot \left(\dfrac{X_2}{X_2^0}\right)^b$, log transform yields

$$[-a \quad -b \quad c] \cdot \left[\ln\left(\frac{X_1}{X_1^0}\right) \quad \ln\left(\frac{X_2}{X_2^0}\right) \quad \ln\left(\frac{X_3}{X_3^0}\right) \right]^T = 0 \qquad (6)$$

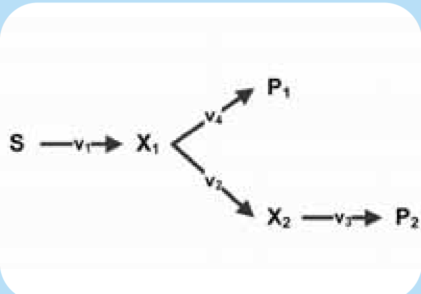
The linear form of equation 6 allows for straightforward removal of equilibrium pools from dynamic models of reaction networks.

3 Linlog as Unifying Kinetic Format for Modeling of Metabolic Reaction Networks

A first use of linlog kinetics is for the modeling metabolic systems under transient conditions. Since the structure of the equation is the same for all reactions, linlog kinetics serves as a mean to unify different types of kinetics (Michaelis–Menten, Hill type, etc). The parameters (elasticities) can be calculated from the available mechanistic rate equations through equation (3b). In this way, both the number of parameters will be decreased, and the mathematical tractability of the corresponding biological system will be increased. An additional advantage is that the elasticities are dimensionless.

As an example, consider the system in Box 1 where four reactions are considered. The rates are described with various types of kinetics. The same network can be translated into unified linlog kinetics using the reference steady state and the elasticity matrix. When the pathway is simulated under transient conditions, the dynamic performance of linlog kinetics is in very good agreement with the time trends of the metabolites simulated using mechanistic rate equations.

Box 1: Transformation of the Mechanistic Rate Equations to linlog Format



$$v_1 = 2 \cdot \frac{S}{S+1}$$

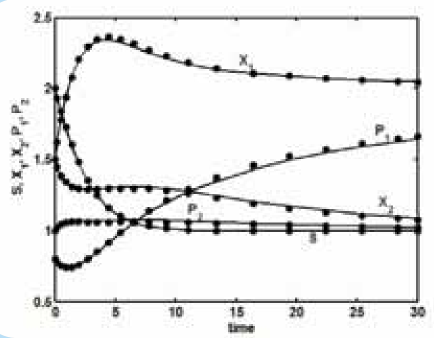
$$v_2 = 1.867 \cdot \frac{X_1}{X_1+2} \cdot \frac{3}{3+X_2}$$

$$v_3 = 4 \cdot \frac{X_2}{X_2+1} \cdot (1 - 0.65 \cdot P_2)$$

$$v_4 = 0.6 \cdot \frac{X_1^3}{X_1^3 + 2^3}$$

Reference conditions

$$\begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \end{bmatrix}_0 = \begin{bmatrix} 1 \\ 0.7 \\ 0.7 \\ 0.3 \end{bmatrix} \qquad \begin{bmatrix} S \\ X_1 \\ X_2 \\ P_1 \\ P_2 \end{bmatrix}_0 = \begin{bmatrix} 1 \\ 2 \\ 1 \\ 1 \\ 1 \end{bmatrix}$$



$E^{X,C}$	S	X_1	X_2	P_1	P_2
v_1	0.50	0	0	0	0
v_2	0	0.50	–0.25	0	0
v_3	0	0	0.50	0	–1.86
v_4	0	1.50	0	0	0

Upper left: the network considered; upper middle: the nonlinear set of equations representing the depicted network; and upper right: the reference conditions. Lower right, elasticities, calculated by differentiation and normalization (eq. 3b) of the rate equations, and lower left: the comparison of the time performance of the two models (continuous lines linlog simulation, filled circles original system). For all simulations, the initial conditions were: $S = 2$, X_1=1.5, X_2 =1.5, P_1 = 0.8, P_2 = 1.

4 Estimating the Elasticities of linlog Kinetics from *in vivo* Data

As described in the introduction, the estimation of kinetic parameters of metabolic models is a great challenge due to the high number of parameters, lack of analytical solutions of non-linear equations and the fact that kinetic parameters determined *in vitro* do not necessarily apply *in vivo*. These classical problems of parameter estimation for non-linear kinetic models are relieved by the use of linlog kinetics.

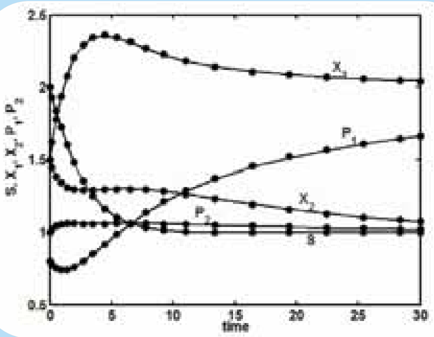
Since we consider living cells as dynamic systems, the parameters of any dynamic model representing this system need to be determined from perturbation experiments.

Box 2: Estimation of the Elasticities directly from Data

Using equations in [20], $\frac{d\mathbf{x}}{dt}=\mathbf{S}\cdot\mathbf{J}^0\cdot\left(\mathbf{i}+\mathbf{E}^x\cdot\ln\left(\mathbf{x}/\mathbf{x}^0\right)+\mathbf{E}^c\cdot\ln\left(\mathbf{c}/\mathbf{c}^0\right)\right)-\mathbf{D}\cdot\mathbf{c}$, where **D** is a vector that has zero as entry for intracellular metabolites and equals Φ / V for extracellular metabolites. The term Φ / V represents the dilution rate of the chemostat system (unit h^{-1}).

Integrating with $\mathbf{S}\,\mathbf{J}^0\,\mathbf{i}=\mathbf{D}\cdot\mathbf{c}$: $\Delta\mathbf{x}=\mathbf{S}\cdot\mathbf{J}^0\cdot\mathbf{E}^x\cdot\int_{t_i}^{t_{i+1}}\begin{bmatrix}\ln\left(\mathbf{x}/\mathbf{x}^0\right)\\ \ln\left(\mathbf{c}/\mathbf{c}^0\right)\end{bmatrix}dt$, rearranged ; $\Delta\mathbf{x}=\mathbf{Y}\cdot\mathbf{b}$ and $\mathbf{b}=\left(\mathbf{Y}^T\mathbf{Y}\right)^{-1}\mathbf{Y}^T\Delta\mathbf{x}$

The vector **b** contains only the elasticities and $\mathbf{Y}=\mathbf{Y}\left(\mathbf{S},\mathbf{J}^0,\int\ln\left(\mathbf{x}/\mathbf{x}^0\right),\int\ln\left(\mathbf{c}/\mathbf{c}^0\right)\right)$. Here, the integrals are calculated using numerical integration and linear interpolation between the measurements.



$E^{X,C}$	S	X_1	X_2	P_1	P_2
v_1	0.49	0	0	0	0
v_2	0	0.47	−0.26	0	0
v_3	0	0	0.40	0	−1.68
v_4	0	1.47	0	0	0

Using the transient metabolite data given in Box 1, the elasticities are estimated. The data used and the simulation of the system with linlog kinetics using the estimated elasticities are shown in the above figure (continuous lines linlog simulation, filled circles original data). The estimated elasticities are also given (upper right). They are in very good agreement with the theoretical elasticities, calculated in Box 1.
Note here that the extension to the bilinear-logarithmic kinetics is straight forward, given the rate is linear to both parameters ε and δ in linlog kinetics.

Starting from $\frac{d\mathbf{x}}{dt}=\mathbf{S}\cdot\mathbf{v}-\mathbf{D}\cdot\mathbf{c}$ and $\frac{d\mathbf{x}}{dt}=\mathbf{S}\cdot\mathbf{J}^0\cdot\left(\mathbf{i}+\mathbf{E}^x\cdot\ln\left(\mathbf{x}/\mathbf{x}^0\right)+\mathbf{D}^x\cdot\left(\ln\left(\mathbf{x}/\mathbf{x}^0\right)\right)^2\right)-\mathbf{D}\cdot\mathbf{c}$,

rearranging and integrating, with $\mathbf{S}\,\mathbf{J}^0\,\mathbf{i}=\mathbf{D}\cdot\mathbf{c}$: $\Delta\mathbf{x}=\mathbf{S}\cdot\mathbf{J}^0\cdot\begin{bmatrix}\mathbf{E}^x\\ \mathbf{D}^x\end{bmatrix}\cdot\int\begin{bmatrix}\ln\left(\mathbf{x}/\mathbf{x}^0\right)\\ \left(\ln\left(\mathbf{x}/\mathbf{x}^0\right)\right)^2\end{bmatrix}dt$

Further rearrangement yields $\Delta\mathbf{x}=\mathbf{Y}\cdot\mathbf{b}$ and $\mathbf{b}=\left(\mathbf{Y}^T\mathbf{Y}\right)^{-1}\mathbf{Y}^T\Delta\mathbf{x}$

Again, the vector **b** contains only the elasticities and $\mathbf{Y}=\mathbf{Y}\left(\mathbf{S},\mathbf{J}^0,\int\ln\left(\mathbf{x}/\mathbf{x}^0\right),\int\left(\ln\left(\mathbf{x}/\mathbf{x}^0\right)\right)^2\right)$.

The integrals are calculated using numerical integration and linear interpolation between the measurements. Note that incorporation of the second order terms is only needed if the dynamic ranges of effectors include the region where the first derivative changes sign, hence non-monotonous behavior occurs. In this example, the second order derivatives are not calculated, because these are not needed, i.e. all the rates were in monotonous range with respect to the metabolites.

There are two main types of perturbation experiments that can be applied namely steady–state and dynamic perturbations. Heijnen et al. ([18]) addressed the question of the minimum number of steady state perturbations needed in order to estimate the concentration control coefficients around a branch point. Kresnowati et al. and Nikerel et al. described how to employ data from dynamic perturbation experiments to extract elasticities ([19-20]). Nikerel et al. estimated the elasticities of the yeast glycolytic pathway from *in silico* generated data. They used steady state perturbations in addition to dynamic perturbations in order to resolve identifiability problems ([20]).

As an illustration of the above, let us assume, for the example system of Box 1 that we have only the concentration-time curves in a perturbation experiment, reference conditions ($\mathbf{J}^0$, $\mathbf{X}^0$ and $\mathbf{C}^0$), stoichiometric matrix and we know which entries of the elasticity matrix are zero, but the set of mechanistic rate equations are unknown, so calculation of the elasticities using equation 3b is not possible. Using the methods outlined in [19] and [20], one can easily estimate the elasticities from this data using simple linear regression. The estimation procedure is summarized and the estimated elasticities are given in Box 2.

5 Model-based Redesign of the Metabolism using linlog Kinetics

One of the main goals in metabolic engineering is to redesign the organism to achieve desired product formation rates. Model based redesign of the organism provides a rational first step towards this goal.

By providing an analytical solution of the steady state mass balances, linlog kinetics offers a general equation for metabolic redesign, relating enzyme levels needed to achieve desired steady state fluxes and metabolite levels ([15]). The metabolic redesign equation is given as:

$$\frac{\mathbf{e}^0}{\mathbf{e}} = \frac{\mathbf{J}^0}{\mathbf{J}} \cdot \begin{bmatrix} \mathbf{C}^{J0} \\ \mathbf{C}^{X0} \end{bmatrix}^{-1} \cdot \left(\begin{pmatrix} \mathbf{i} \\ -\ln\left(\frac{\mathbf{x}}{\mathbf{x}^0}\right) \end{pmatrix} + \begin{bmatrix} \mathbf{R}^{J0} \\ \mathbf{R}^{X0} \end{bmatrix} \cdot \ln\left(\frac{\mathbf{c}}{\mathbf{c}^0}\right) \right) \qquad (7a)$$

Here, all the dependencies between the metabolites and fluxes (due to conserved moiety and mass balance constraints) must be eliminated using link matrices $\mathbf{L}^\mathbf{X}$ and $\mathbf{L}^\mathbf{J}$ ([9]). The concentration and flux control response coefficients can be calculated from the estimated elasticities using well known connectivity and summation theorems ([7-8]). For a recent review, see [9] and the references therein.

Box 3: Model-based Metabolic Redesign

Desired relative flux levels: $\begin{bmatrix} J_1/J_1^0 & J_2/J_2^0 & J_3/J_3^0 & J_4/J_4^0 \end{bmatrix} = \begin{bmatrix} 1 & 0.57 & 0.57 & 2 \end{bmatrix}$

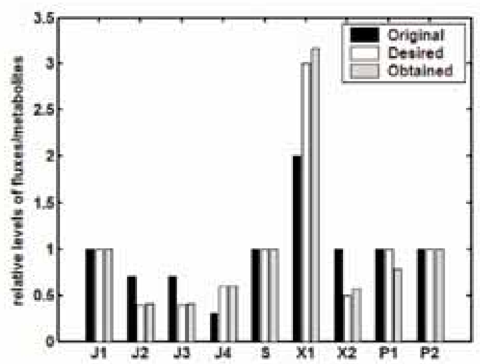
Desired relative metabolites levels: $\begin{bmatrix} S/S^0 & x_1/x_1^0 & x_2/x_2^0 & P_1/P_1^0 & P_2/P_2^0 \end{bmatrix} = [1 \quad 1.5 \quad 0.5 \quad 1$

This design corresponds to a redirection of the flux, without making any change in the substrate level. Using equation 7a-7e, the corresponding relative enzyme levels are calculated to be:

$$\begin{bmatrix} e_1/e_1^0 & e_2/e_2^0 & e_3/e_3^0 & e_4/e_4^0 \end{bmatrix} = \begin{bmatrix} 1 & 0.42 & 0.79 & 1.25 \end{bmatrix}$$

To check the validity of the prediction, we have manipulated the corresponding V^{max} terms of the original system, simulated until the system reached the new steady state, and compared the results with the desired ones (figure at right).

It is noteworthy that the metabolic redesign recipe provided by equation 7a holds well in terms of providing the desired metabolite and flux levels.



$$\mathbf{C}^{\mathbf{x}0} = -\left(\mathbf{S}\cdot\left[\mathbf{J}^{0}\right]\cdot\mathbf{E}^{\mathbf{x}0}\right)^{-1}\cdot\mathbf{S}\cdot\left[\mathbf{J}^{0}\right] \tag{7b}$$

$$\mathbf{C}^{\mathbf{J}0} = \mathbf{I} + \mathbf{E}^{\mathbf{x}0}\cdot\mathbf{C}^{\mathbf{x}0} \tag{7c}$$

$$\mathbf{R}^{\mathbf{J}0} = \mathbf{C}^{\mathbf{J}0}\cdot\mathbf{E}^{\mathbf{C}0} \tag{7d}$$

$$\mathbf{R}^{\mathbf{x}0} = \mathbf{C}^{\mathbf{x}0}\cdot\mathbf{E}^{\mathbf{C}0} \tag{7e}$$

As an illustration, consider again the example system in Box 1, and assume that P_1 is a valuable product of which we want to increase the production rate. This can be accomplished by redirecting the flux from $\mathbf{J}_2$ towards $\mathbf{J}_4$, and also increasing the level of x_1 and decreasing the level of x_2. This can be done using the equation above given that the elasticities have been estimated. The steps taken and the results of the metabolic redesign are given in Box 3.

6 Unraveling Silent Mutations using linlog Kinetics: a Functional Genomics Approach

Functional genomics is the area of genetics that focuses on determining the function of genetic information present in a cell i.e. which gene regulates which enzyme or transcription factor. Given a full kinetic model including previously estimated elasticities, linlog kinetics can be used to understand the functions of (silent) mutations, by making use of measured metabolite and flux profiles. Such a method was proposed by Wu et al. ([21]). Starting from equation 3a, after rearrangement

$$\frac{e'}{e^{0}} = \frac{J'}{J^{0}}\cdot \mathrm{diag}\left(\mathbf{i} + \mathbf{E}^{x}\cdot \ln\left(\mathbf{x}'/\mathbf{x}^{0}\right)\right)^{-1} \tag{8}$$

Here, the superscripts ' ′ ' and ' ° ' denote the perturbed (mutant) and the reference (wild type) state respectively, where it clearly holds that $e' \neq e^{0}$ for one or more enzymes due to the mutation in a gene. Note that using only metabolite and flux profiles, the changes in the enzymes can be calculated, even in case of a silent mutation, i.e. in a case of no phenotypic flux changes.

In this sense, this method is advantageous compared to the constraint-based analysis of reconstructed metabolic networks, in which only phenotypic properties can be used, through steady state FBA models. The problem of the latter is that it can describe neither silent mutations nor quantification of gene dosage. The approach proposed by Wu et al., is similar to the FANCY approach proposed by Raamsdonk et al. ([22]), in terms of using metabolite profiles. On the other hand, a non-linear kinetic model is central for this approach, in contrast to the linear approximation of co-response coefficients and the assumption of mono-functional units; hence this approach is valid over wider ranges of metabolite concentrations. The proposed methodology is illustrated in Box 4.

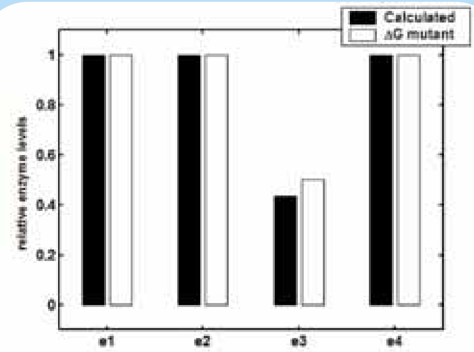
7 Conclusion and Outlook

Traditionally, mathematical models developed to describe the dynamic behavior of metabolic reaction networks have been based on mechanistic rate equations. Typically these models are highly non-linear and therefore the estimation of the model parameter and their error margin is not straightforward.

Box 4: Functional Genomics Study using Metabolome Data and linlog Kinetics

From the original system (Box 1), let us assume that there is a gene G which regulates the activity of one reaction v_3. In a mutant strain ΔG, due to a point mutation, the enzymatic activity of v_3 decreases by 50%. When grown in chemostat conditions, this strain yields certain steady-state, the relative levels of the metabolites and the fluxes are presented below. The fluxes J_2 and J_4 follow from the mass balances. $S/S^0 = 1, x_1/x_1^0 = 1, x_2/x_2^0 = 1, P_1/P_1^0 = 1.539, P_2/P_2^0 = 0.461, J_1/J_1^0 = 1, J_3/J_3^0 = 1$

This is a silent mutation since the flux to the product (J_3) did not change. From the change in metabolite levels, it is not obvious which reaction is affected. Using equation 8, and the elasticities estimated from Box 2, the enzyme levels can be calculated. The figure below compares the calculated enzyme levels with the enzyme levels of the original mutation (ΔG). The calculated levels of all the enzymes reflect well the original situation: the expression of the e_3 is estimated to be decreased by 54% and the enzyme levels of the other enzymes did not change.



Linlog kinetics is a promising format for describing the dynamics of such systems. In this kinetic format, all reaction rates are completely specified by:

- the reference steady-state flux values,
- the metabolite vector (dependent X_i and independent C_j) and their values in the reference state,
- the stoichiometric matrix S, and by
- the elasticity matrices for dependent and independent metabolites (Box 1).

This matrix based formulation allows easy transfer of the model between researchers. Linlog approximative kinetics offers significant advantages in modeling metabolic systems like mathematical tractability, minimum number of parameters, easy parameter estimation from *in vivo* steady-state and dynamic perturbation data. In this communication, we described alternative applications of linlog kinetics, for the modeling of metabolic reaction networks. In the end, redesigning cells requires dynamic model of the complete cell, including the regulation of the levels of mRNA and protein. It will be of great interest to investigate extension of the application of the linlog kinetic format for that purpose.

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System Dynamics – a Tool for Designing and Analysing Complex Processes

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In recent times there has been a lot of interest on system dynamics modelling, a concept first introduced by MIT professor J. W. Forrester in the 1950s. The increase of computing power and advance of computers has enabled the analysis and simulation of many large scale systems. There are several commercial tools with easy-to-use graphical user interfaces available in the field of system dynamics. These commercial tools are briefly discussed in this paper. In addition to describing the tools, this paper gives a short introduction to system dynamics models and their capabilities with simple examples.of research results and future plans.

Introduction

The concept of *System Dynamics* (SD) was introduced by J. W. Forrester in the 1950s. Forrester started the System Dynamics Group at the Sloan School (MIT) in 1956 and with it, the field of system dynamics. The main body of his ideas is collected in his three famous books: *Industrial Dynamics* in 1961 (explains how managers' actions shape the dynamic characteristics of their organisations), *Urban Dynamics* in 1969 (exploration of the life cycles of cities) and World Dynamics in 1971 (exploration of human beings' place in the world ecology). The development of system dynamics coincides with the development of control and system theory and, in fact, professor Forrester's background was in control engineering.

In the early years, the lack of computing power limited many approaches but the recent advances in computers and simulation technology as well as in the large scale and nonlinear system theory has enabled the development of system dynamics theory and a large number of successful practical applications. The development of easy-to-use software packages with graphical user interfaces and with complex mathematics hidden to the background has further widened the system dynamics community.

1 What is System Dynamics?

In effect, system dynamics is merely the art of applying dynamic models to practical systems, e.g., decision making and production processes. Systems described by system dynamics models are typically large, complex, nonlinear sets of differential equations. Theoretical system analysis usually fails in these cases, mainly because linear approximations cannot be used. Top-line structural analysis can be performed (such as analysis of dominating positive and negative feedback loops and their interactions) but theoretical analysis is beyond the grasp of the modeller.

This lack of theoretical analysis tools leaves the theoretical modeller somewhat running on empty; the main methods left are simulation and experimental analysis of data. Nevertheless, the theoretical analysis of structure gives important insight to the potential behavioural patterns of the system, may they be desired or unwanted (e.g., exponential growth, death spiral, rise and collapse, oscillation, balancing buffer and inertia, to name but a few).

Structural analysis is a crude tool and without any information of parameter values, the analysis can only suggest a possibility of this behaviour (fictional, planned systems with no real data) or give a plausible explanation to a detected behaviour (real systems with available data). Typical results of this analysis might be something in line of 'There is a danger of a death spiral if the subcontractor supplier chain is not secured' or 'The detected oscillation in the stocks and orders is probably due to the time delay on the negative feedback loop of order processing'.

The models are used for system optimisation, prediction and control. The optimisation of different policies and structures of an organisation can be done when the system contains suboptimal elements, which can be changed at political will. Typical example is a minimisation of labour supply cycle oscillations (hiring-layoffs) by the introduction of a flexible workweek.

Prediction, on the other hand, is useful when one organisation's actions cannot affect the outcome but the organisation can benefit from reacting quickly to changing circumstances (such as predicting the raw material market price and reacting to it). The pulp and paper prices contain three different oscillations: production, inventory and prices oscillate with 3 – 5 year cycle and capacity oscillates with a 12 – 20 year cycle. Overall economy oscillates with a 60 year cycle time (the long wave of economy). The model captures the reasons for oscillation, adjusts the historical data to the model and gives best predictions on, e.g., 1, 5 and 10 year scale. The model can, for instance, detect a turning point in pulp prices half a year ahead, and this prediction can be used for aiding decision making.

Model-based control design concentrates on finding the best strategy on managing the system under various conditions. Let us consider a case in which the industry demand of engineers on a certain field increases rapidly. However, it takes 4 – 6 years to graduate and a conventional strategy for increasing the number of graduates quickly causes significant oscillations in the system (not to mention lower graduate quality, motivational problems, etc.). A *Smith predictor type* of control design combined with feed-forward compensators would perform much better under the same conditions.

2 Basic Structures of System Dynamic Models

The structure of the system dynamics model is a loop diagram, which consists of simple positive and negative feedback loops. A typical positive feedback loop is a population growth: larger population generates more births, which results even larger population and even more births, etc. This is shown in a simple loop diagram in Figure 1.

It is just as easy to find a simple negative feedback loop limiting the population explosion. Let us consider that there is limited amount of food available. The carrying capacity of that area limits the population growth. Large population consumes a lot of food leaving less food per capita, this causes starvation, deceases and death, which makes the population smaller and then there is again more food per capita, etc. (see Figure 2).

The entire system is now limited by these two feedback loops (in a very simplified model with no aging chains, no predator-prey structure, or such). In this kind of models a flow and stock structure is usually much more intuitive than mere information loops. The population is described with a stock and the net increase of the population as a flow variable (see Figure 3).

This simple model structure can generate instability, goal seeking balance, rise and collapse as well as oscillation – depending on the parameters of the model.

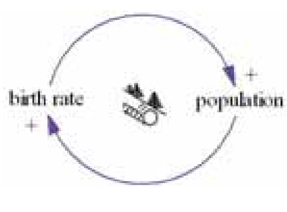

Figure 1: A simple positive feedback loop.

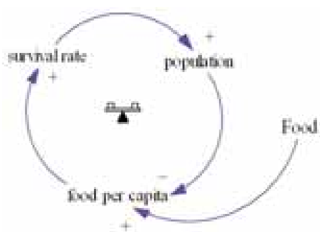

Figure 2: A simple negative feedback loop.

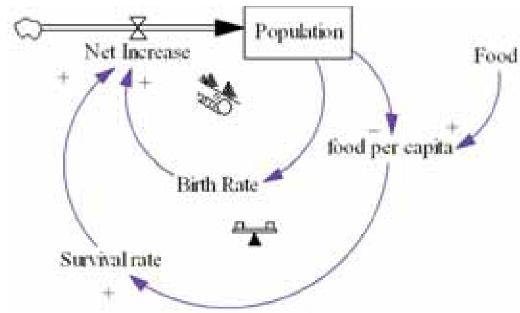

Figure 3: The combined model.

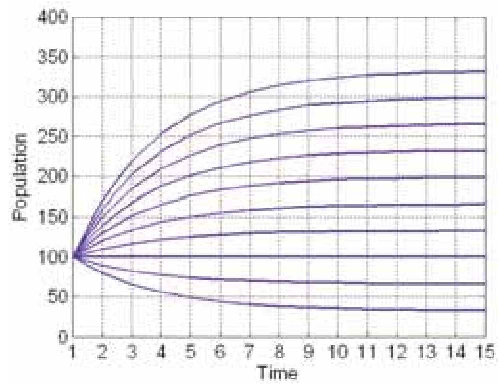

Figure 4: Population vs. food available.

To illustrate, assume that in the case shown in Figure 3 birth rate is proportional to the size of the population with a fixed coefficient and the survival rate is the inverse of food per capita. When an initial value of 100 individuals is given to the population and the variable food is given values ranging from 10 to 100, the results in Figure 4 are obtained. In each case the population stabilises after a while to a level depending on the amount of available food.

3 Supply Chain Example

Let us take a simple example from a simple supply chain. Customers order products, the orders are filled, and inventory and production react accordingly, which means that new production is started (limited by the production capacity). The inventory coverage affects the price of the product, which, together with unit variable costs, has an effect on the profitability of the operation – and on the capacity utilisation. There is obviously a balancing loop involved, but at this model resolution the individual variables are somewhat obscure and the overall behaviour in not intuitive (see Figure 5).

A more detailed model of the supply chain gives much more insight to the system. The polarities of the effects (whether a positive change in input variable causes a positive or negative change in the output variable) are more clear, the effects can be pinpointed to the correct variable and the entire model is more intuitive. The larger resolution model is presented in Figure 6.

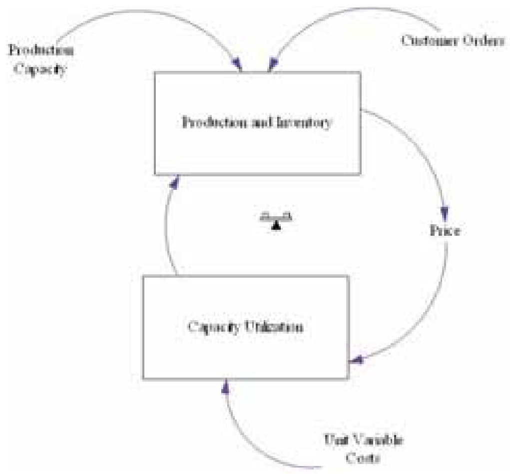

Figure 5: The top line model of the supply chain.

The raw material – product flow and the inventories are described with stocks and flows, whereas all the management strategies and modification of information are conceptualised with information arrows. The intuitive balancing loop of production and capacity utilisation is now much more apparent: production start rate affects the production rate and indirectly the product inventory, production start rate is limited by the production capacity and the decision to utilise capacity, which in turn depends on the expected markup (depends on the prices and the costs). The price depends on the inventory coverage (among other things) affected by the inventory. Another balancing loop deals with order fulfilment. The inventory and order processing time limit the order fulfilment which affects the shipment rate.

The individual models are typically as follows: The individual models are either static or dynamic but the overall loop always contains dynamic elements so that the model is dynamic and it can be simulated without algebraic loops. The model for *Expected Markup Ratio* is a simple static ratio and the model for the *Short-Run Expected Price* is simply a first order dynamic filtering of the actual price (with time constant *Time to Adjust Short-Run Price Expectations*).

$$(\text{Expected Markup Ratio})(t) = \frac{(\text{Short-Run Expected Price})(t)}{(\text{Expected Variable Costs})(t)}$$

$$(\text{Time to Adjust Short-Run Price Expectations}) \cdot \frac{d(\text{Short-Run Expected Price})(t)}{dt} = -(\text{Short-Run Expected Price})(t) + (\text{Price})(t)$$

Even the detailed model is not actually very realistic. The assumptions that that price is affected only by the inventory coverage and that the price has no effect on the customer orders is rather naïve as well as the assumption that production is not limited by raw materials and their supply problems. The acquisition of capacity is also omitted from the model.

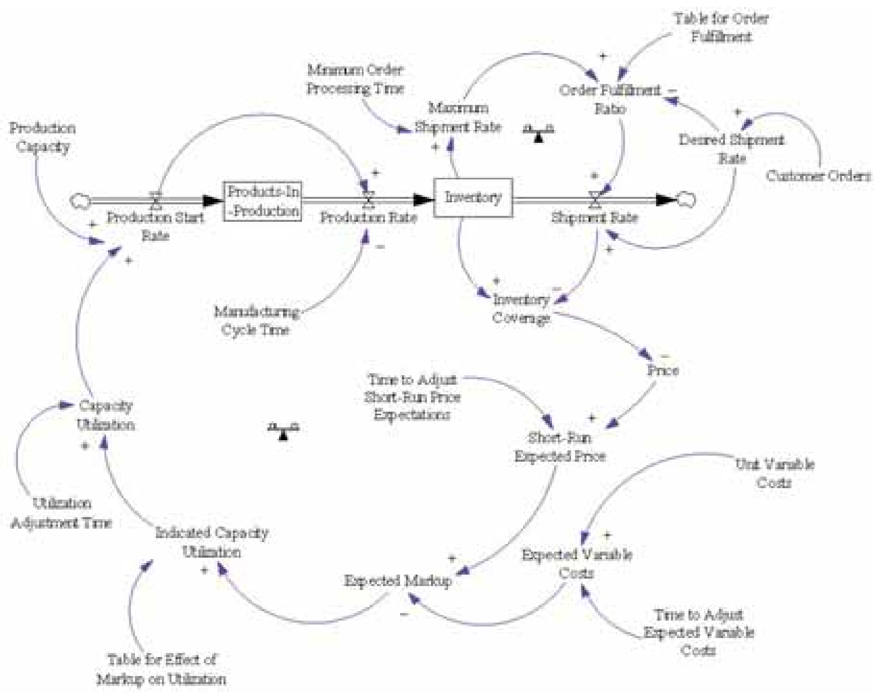

Figure 6: A more detailed view of the supply chain.

A much more detailed treatment of the supply chain problem can be found in the Sterman book *Business Dynamics, Systems Thinking and Modeling for a Complex World*, from where is the simulation of the supply chain presented in Figure 7.

In this simulation the customer orders contain small random variation in a two company model (one company is a supplier to the other company).

The amplitude of the variations is significantly increased when they travel through two companies.

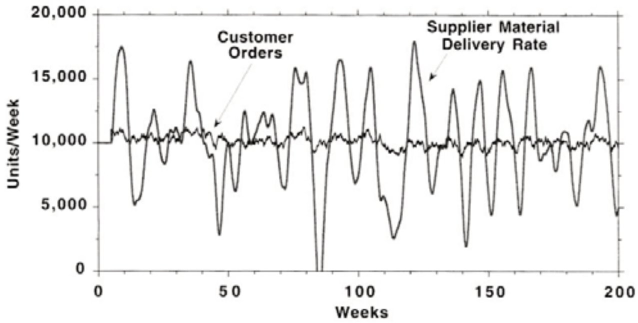

Figure 7: Simulation of a manufacturing supply chain (Sterman 2000).

4 Modelling Procedure

The system dynamics modelling begins always in the problem definition. The models are usually very large and the selection of variables, the definition of model borders and the selection of time horizon all depend on the problem to be solved. As a rule, it is unwise to make a model just for the sake of modelling.

The dynamic systems operate on the basis of causality. The causal chain of effects create the dynamic hypothesis, which the basis of the modelling procedure. The formulation of dynamic hypothesis is a difficult and laborious task for novice modellers with static modelling background. It is even more difficult to formulate dynamic hypothesis with endogenous focus, when human nature is more adept to exogenous focus. If the modeller has grasped the endogenous focus, the model structure will create the actual behaviour without a large number of independent, exogenous variables.

When the dynamic hypothesis is sound, the actual model building becomes much simpler. The initial model can be very rough (Figure 5) and in the course of model building, the resolution of the model can be increased (Figure 6), new structures can be added and individual submodels identified. The parameters of the model have to be estimated based on historical data, laws of physics or common sense.

It is usually advantageous to decompose a large model to simple submodels which can be evaluated and identified separately. In large models there are usually far too many free parameters and it is difficult to pinpoint which free parameters should be estimated with which data set. Iterative parameter searches do not converge with large models or they might converge to a group of values which is not physically sound. Furthermore, the feedback loops may weaken or destroy entirely the identifiability of the system. Numerical parameter estimation is a powerful tool, but only when used correctly.

The model testing and validation contains a great number of different tests varying from consistency tests and fit to historical data to robustness and sensitivity tests. The outputs under different extreme conditions have to be plausible and the uncertainty of various parameter and structures has to be addressed.

As a whole, the modelling is a very iterative procedure – in the course of modelling the modeller may have to return back to the beginning, create better dynamic hypothesis or define the problem differently. The customer has to be included in the modelling procedure, he/she has to be committed and have trust on the model. After all, if the customer does not believe in the model, the results will have no effect on their policies and actions. Also, it would be arrogant and unwise not to use their knowledge on their own system – in many cases the dynamic hypothesis and individual submodels can be generated based on interviews with the customer.

Once a satisfactory model has been reached, there is a number of things that can be done with it. Depending on the problem to be solved, it can be used for instance for evaluating different scenarios, designing advanced policies and control structures, trying various 'what if' situations, etc.

5 Tools

The system dynamic models can be simulated with any simulation tool, but there are a couple of software tools specifically designed for system dynamic applications. They have a library of typical models, a number of analysis tools, such as, dominant loop analysis and sensitivity analysis and the results are presented in an easily digestible format. Currently, there are three major tools at the market: *Vensim*, *Powersim* and *ithink*.

5.1 Vensim

Ventana Systems, Inc. of Harvard, Massachusetts was formed in 1985. It develops and markets the *Vensim* software (WWW.VENSIM.COM) which can integrate both managerial and technical elements to solve difficult problems. Vensim is used for constructing models of business, scientific, environmental, and social systems. Ventana Systems also provides strategic management consulting using dynamic simulation models. Vensim 5 was released in February of 2002 and the latest update is the Version 5.4 which was released in July of 2004. There is also a free version Vensim PLE for educational and teaching purposes. This version can be freely downloaded from their website.

5.2 Powersim

A Norwegian company Powersim Software AS develops and markets *Powersim* (WWW.POWERSIM.COM) which was designed for helping organisations on how they should make strategic choices in challenging situations. In 1988 Powersim launched *SimTek*, its first generation simulation software and in 2004 *Powersim Studio 2005*, the latest version of the simulation software, was released.

5.3 ithink

Barry Richmond, then a Professor at Dartmouth College, founded HPS in 1984. Later, the company changed its name to isee systems (WWW.ISEESYSTEMS.COM). In 1987, the company was awarded the Jay Forrester prize when it was the first to introduce an icon-based model building and simulation tool (*STELLA*). In 1990, the company introduced *ithink* for business simulation and the next year they created the first Management Flight Simulator. Their software aims to provide a framework and associated tool for assembling a 'collective intelligence' and then bringing it to bear on the issues facing an organisation. Their simulation language describes processes, markets, customers, and competitors so that the knowledge can be integrated into a coherent, operational picture.

5.4 Differences of System Dynamics Software

There are no significant differences in the main structure of the programs. They are all graphical modelling interfaces and they all are based on simulating dynamic differential or difference equations. The selection of integration routines differs somewhat; some of the products handle stiff differential equations or discontinuities in derivatives better than the others. The basic elements are very similar in different tools (such as, first order dynamics, flows and stocks, table functions, etc.).

There are some differences in advanced model components, e.g. in the blocks for decision making or prediction, but the largest variations are in the design and analysis tools. For instance, how easy it is to optimise given criteria or estimate parameters numerically, can the sensitivity analysis or the extreme condition check be automated and with what kind of effort. The recent developments in these products concentrate among others on these issues and the potential buyer of there products should check the capabilities of the latest versions before making the decision to purchase the product – based on his or her needs.

Conclusions - Acknowledgement

This paper gives a short introduction to the field of system dynamics and it serves as a compendium to the other survey paper by the same authors. The basic structures and capabilities of system dynamics are shortly discussed and the major commercial products on the field are introduced.

There is active research going on and the number of industrial applications is increasing rapidly. The commercial tools are improving and different analysis and design tools within these commercial products are developing significantly. As a result the amount of tedious hand work needed for system dynamics modelling is decreasing.

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SHORT NOTES

A Shortlist of the Most ‘Popular’ Discrete Simulation Tools

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This paper documents a work on simulation tools evaluation. Rather than making specific judgements of the tools, we tried to measure the intensity of usage or presence in different sources, which we called the *popularity*. We did it in several ways, like occurrences on the web and scientific publications. It is obvious that more popularity does not necessarily mean more quality or better simulation tool, nevertheless there is a probable positive correlation between popularity and quality associated. The result of this work is a short list of twenty simulation tools

Introduction

Most scientific works related to simulation tools analysis only focus on a small set of tools, usually evaluate independent parameters/criteria, and always escape to make final judgements due to the subjective nature of such a task. High market prices of simulation tools in the past decades, relatively low effort for constructing a simulation tool, the emergence of graphics facilities, the different fields of possible applications and the absence of strong standards (or languages), lead to a large - may be too large - offer of simulation tools ([2]).

Thus, for instance, in the *Industrial Engineering Magazine* of 1993 ([10]), there is a list of 45 commercial simulation software products. The sixth biannual edition of simulation software compiled by James J. Swain in 2003 identifies about 60 commercial simulation products, and 55 in 2005 ([8]). Furthermore, the annual 2004 SCS edition *M&S Resource Directory* lists 60 simulation products ([6]). In the *Simulation Education Homepage* ([14]; simulation tools list by William Yurcik) there are more than 200 simulation products, including non commercial tools.

1 Motivation – why *Popularity* ?

In this scenario of such a large simulation tools offer it is unfeasible to experiment them all consistently. The comparison, based on features or characteristics is also very difficult or non conclusive, mainly due to great similarity of features.

This work uses a measure called *popularity*, as to identify the most used simulation tools and thus the potentially better simulation tools.

A popular simulation tool offers two advantages:

- For a company, it is easier to find out simulation specialists with know-how on that tool;
- and for a simulation expert, it is easier to find out companies working with the tool.

There the second advantage applies to educational purposes once students may be future simulation specialists.

Popularity, however, should never be used as the unique measure for simulation tools evaluation, as new arriving tools would never get the market place they may deserve. So, *popularity* may be seen as a dangerous ‘blind’ factor and should be used together with direct evaluation mechanisms like features comparison and experimentation.

2 Development – *Popularity* Evaluation

Our evaluation method, in order to identify a small set containing the most popular or important tools, was based essentially on:

- Level of presence in the web (Internet)
- Level of presence in the Winter Simulation Conference scientific publications
- Level of presence on a selected set of scientific surveys and Conferences Sponsorship

About 20 parameters were used for evaluating each simulation tool. In the parameter explanation below we refer to the tool using the following two labels:

- *Tools* represents the string containing the name of the simulation tool (for more than one tool, we summed the occurrences for each of them separately).
- *Vendor* represents the string containing the name of the simulation tool vendor.

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Each parameter corresponds to a column in the table (in appendix), and is described as follows:

a) Number of occurrences of *Tools* in WWW.INFORMS-SIM.ORG
INFORMS is the Institute for Operations Research and Management Science - Simulation Society; this source includes all Winter Simulation Conference (WSC) scientific papers between 1997 and 2004)
b) Number of occurrences of *Tools* + *Vendor* in WWW.INFORMS-SIM.ORG; same source as a)
c) Number of web pages pointing with a link to the *Site* of the *Vendor* (in Google)
d) Number of web pages with *Tools* + *simulation*; the *simulation* string was used to count only the internet pages in the simulation field
e) Number of web pages with *Tools* + *Vendor* + *simulation*
f) Google *PageRank*; Google automatic evaluation about page importance
g) Weighted *Total* of parameters:

$$g = Total_{a,\dots,f} = \sum_{i \in \{a,\dots,f\}} F_i \cdot \log_{10} P_i$$

with P_i parameter level and F_i parameter factor; factors considerations in t)
h) *ORMS* Simulation tools *list* ([8], [12])
i) Simulation software: *survey* of academic and industrial users ([5])
j) *Brooks homepage* (Simul8) identification of *concurrency*; WWW.SIMUL8.COM/products/webdemo.htm
k) Tools systematic evaluation based on *experimentation; Valentin*, 2002 WWW.TBM.TUDELFT.NL/webstaf/edwinv/SimulationSoftware/index.htm
l) *Sim-Serv* organization *white paper* about simulation tools; WWW.SIM-SERV.COM/wg_doc/WG1_White_Paper_discussion.pdf
m) List of the simulation tools where the *PMC* Company have *competency*; WWW.PMCORP.COM/sim_services.shtm
n) Paper about *simulation tools* ([7])
o) *Sponsors* of the conference '*Solution Simulation* 2004' ([9])
p) Recent *sponsors* of the *IIE Conference* ([10])
q) *Sponsors* with a stand in the *WSC* 2005 ([11])
r) Weighted *Total* of parameters *h*, …, *q*

$$r = Total_{h,\dots,q} = \sum_{i \in \{h,\dots,q\}} F_i \cdot \log_{10} P_i$$

t) *FinalTotal t* is a weighted sum of the partial *Total g* and of the partial *Total r* :

$$t = FinalTotal = \mathrm{int}(10 \cdot \log_6 (g + \frac{4}{5} r)$$

In the formula for *FinalTotal* the logarithm basis (6) and the factor (10), were adjusted by successive experimentation in order to define a measure that do not differ too much between tools. As the method and parameters weights were defined empirically and are subjective, the final measure is subjective in the same way but introduces less relative differences.

Factors Considerations

We gave different weights to each parameter based on what we feel to be more important or significant in the tools evaluation. The used factors are given in Table 1.

3 Results – The Top List of *Popularity*

Table 2 lists the names of the most popular commercial tools for discrete simulation based on our method and criteria, summarising the results given in Table 3, Evaluation Table.

This list was created based on subjective evaluation of a parameters set. Different parameters may be used alternatively with different weights producing different results. Anyway, even with subjectivity, we believe that the top 10 most 'popular' simulation commercial tools are included in this list. We also believe that this list includes the top 10 'most used' and 'better' contemporary simulation tools.

4 Future Work

This work should be complemented with other simulation tools including non-commercial tools, should analyse consistency of results over time and understand the influence of emerging tools. The systematic testing of a wide variety of simulation tools, together with critical analysis on the ease of modelling and parameters critical evaluation using tools experimentation is also planned.

Parameter	a	b	c	d	e	f	h	i	j	k	l	m	n	o	p	q
Factor	2	3	2	0,5	1	0,5	2	2	0,5	1	0,5	0,5	0,5	1,5	1	2

Table 1: Weighting factors for evaluation parameters.

Arena	ProModel	Automod
Simprocess	WITNESS	Extend
Simul8	QUEST	Crystal Ball
Flexsim	GPSS/H + SLX	ProcessModel
iGrafx	Micro Saint	AnyLogic
E.D.	eM-Plant	GPSS World for Windows
Task Resource SIM	V.S.E.	

Table 2: Shortlist of the most popular commercial tools for discrete simulation, summary from Table 3 (Evaluation Table)

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Tool(s) - Vendor	Website	Tools in WSC	Tools+Vendors WSC	WWW links to site	Tools+Sim WWW	Tools+Sim+Vend WWW	Google page ranking	**Total WSC + WWW**	ORMS List	Survey Hlupic	Brooks homepage	Evaluation Velentin	SimServ white paper	PMC list	Papers Law,McComas	Spons. Sim.Sol.Conf.	Sponsors IEE Conf.	Sponsors WSC 2005	**Total Sources**	**Final Total**	Price in K$ Swain, 2000		
	parameter ››	***a***	***b***	***c***	***d***	***e***	***f***	***g***	***h***	***i***	***j***	***k***	***l***	***m***	***n***	***o***	***p***	***q***	***r***	***t***			
	factor ››	*2*	*3*	*2*	*0.5*	*1*	*0.5*		*2.0*	*2.0*	*0.5*	*1.0*	*0.5*	*0.5*	*0.5*	*1.5*	*1.0*	*2.0*			<	~	>
Arena - Rockwell Software	WWW.ARENASIMULATION.COM	382	55	67	1M	45K	6	**22.1**	x	x	x	x	x	x	x	x	x	x	**13**	***19***	0,5		25
Promodel (MedModel) - ProModel Solutions	WWW.PROMODEL.COM	181	181	60	60K	50K	6	**22.3**	x	x	x		x	x			x	x	**11**	***19***	1		19
Automod (Simul8) - Brooks Automation	WWW.AUTOSIM.COM	146	40	35	20K	0.7K	6	**17.6**	x		x	x	x	x		x	x	x	**11**	***18***		24	
SIMPROCESS, SIMSCRIPT CACI Products	WWW.SIMPROCESS.COM	79	26	96	50K	20K	5	**10.0**	x	x	x		x				x		**9**	***18***	0,8		10
WITNESS - Lanner Group	WWW.LANNER.COM	108	36	106	900K	10K	6	**20.2**		x	x	x	x	x			x		**7**	***18***			
Extend - Imagine That, Inc.	WWW.IMAGINETHATINC.COM	150	38	68	1M	0.7K	6	**19.0**	x		x		x				x	x	**7**	***18***	1		4
Simul8 (Automod) - Brooks Automation	WWW.SIMUL8.COM	48	6	96	30K	0.4K	6	**14.8**	x	x			x	x		x	x	x	**11**	***18***	1,5		4
QUEST; DPM ROBOTIC - Delmia	WWW.DELMIA.COM	104	19	105	20K	10K	6	**18.5**			x		x	x		x	x		**5**	***17***			
Crystal Ball - Decisioneering, Inc.	WWW.CRYSTALBALL.COM	30	8	300	100K	20K	6	**17.8**	x									x	**4**	***17***		1,5	
Flexsim (TaylorII,até 2002) Flexsim Software	WWW.FLEXSIM.COM	12	3	47	20K	1K	6	**12.5**	x	x			x			x	x	x	**10**	***17***		20	
GPSS/H + SLX - Wolverine Software	WWW.WOLVERINESOFTWARE.COM	103	44	16	15K	1.7K	5	**17.0**					x					x	**4**	***17***			5
ProcessModel - ProcessModel, Inc.	WWW.PROCESSMODEL.COM	11	11	44	10K	10K	6	**14.9**	x		x								**4**	***16***		2,5	
iGrafx (2005) - iGrafx	WWW.IGRAFX.COM	4	4	400	25K	25K	7	**15.2**			x		x			x			**3**	***16***			
Micro Saint - Micro Analysis & Design, Inc.	WWW.MAAD.COM	40	1	49	15K	0.6K	6	**11.8**	x				x				x	x	**7**	***16***	9		
AnyLogic - XJ Technologies	WWW.XJTEK.COM	4	1	115	10K	0.5K	6	**10.4**	x							x	x	x	**7**	***15***	4		13
Enterprise Dynamics (Taylor ED) - Incontrol	WWW.INCONTROL.NL	17	5	2	1k	0.4K	3	**9.5**	x		x	x	x	x				x	**7**	***15***	3,5		
eM-Plant (SIMPLE++) - Tecnomatix / UGS	WWW.EMPLANT.DE	46	2	3	15K	0.1K	4	**9.0**	x			x	x			x			**6**	***15***		20	30
GPSS World - Minuteman Software	WWW.MINUTEMANSOFTWARE.COM	3	3	11	10K	0,3K	4	**9.2**	x	x	x								**6**	***15***	4,5		
TaskResourceSIM - Simulation Dynamics	WWW.SIMULATIONDYNAMICS.COM	11	10	16	0.2K	0.2K	5	**11.1**	x								x		**3**	***15***		1,5	
Visual Simulation Env. - Orca Computer, Inc.	WWW.ORCACOMPUTER.COM	14	8	6	0.7K	0.2K	4	**10.5**	x			x							**3**	***14***		2	

Table 3: Evaluation Table for discrete simulation software (commercial products) - based on *popularity* measure.

The Distributed and Unified Numerics Environment (DUNE)

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Most finite element or finite volume software is built around a fixed mesh data structure. Therefore, each software package can only be used efficiently for a relatively narrow class of applications. For example, implementations supporting unstructured meshes allow the approximation of complex geometries but are in general much slower and require more memory than implementations using structured meshes. In this paper we show how a generic mesh interface can be defined such that one algorithm, e. g. a finite element discretisation scheme, can work efficiently on different mesh implementations. These ideas have also been extended to vectors and sparse matrices where iterative solvers can be written in a generic way using the interface. These components are available within the 'Distributed Unified Numerics Environment' (DUNE).

Introduction

Finite element or finite volume software packages differ mainly in the kind of meshes they support: (block) structured meshes, unstructured meshes, simplicial meshes, multi-element type meshes, hierarchical meshes, bisection and red-green type refinement, conforming or non-conforming meshes, sequential or parallel mesh data structures are possible.

Using one particular code it may be impossible to have a particular feature (e. g. local mesh refinement in a structured mesh code) or a feature may be very inefficient to use (e. g. structured mesh in unstructured mesh code). If efficiency matters, there will never be one optimal code because the goals are conflicting. Extension of the set of features of a code is often very hard. The reason for this is that most codes are built upon a particular mesh data structure.

A solution to this problem is to separate data structures and algorithms by an abstract interface. Realizing interface and implementation using generic programming and static polymorphism one is able to write algorithms based on an abstract interface. At compile-time exactly the data structure that fits best to the problem is chosen allowing the application of all compiler optimisations.

Figure 1(a) shows how this concept is applied in the case of a discretisation scheme accessing the mesh data structure and an algebraic multigrid method accessing a sparse matrix data structure by means of an abstract interface. The interfaces can be implemented in different ways, each offering a different set of features efficiently.

Of course, this principle also has its implications: The set of supported features is built into the abstract interface. Again, it is in general very difficult to change the interface. However, not all implementations need to support the whole interface (efficiently). Therefore, the interface can be made very general. At runtime the user pays only for functionality needed in the particular application.

1 The DUNE Library

Writing algorithms based on abstract interfaces is not a new concept. In object oriented languages abstract base classes and inheritance are often used to implement polymorphism. E. g. C++ offers virtual functions to implement dynamic polymorphism. The function call itself poses a serious performance penalty in the case where the function in the interface consists only of a few instructions.

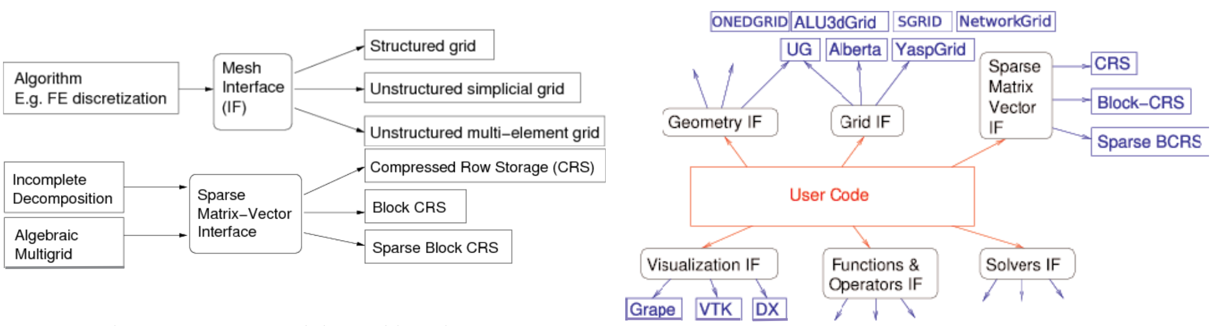

Figure 1: DUNE modules and interface
(a) Encapsulation of data structures with abstract interfaces.
(b) DUNE module structure.

Therefore, function calls and virtual methods can only be used efficiently for interfaces with sufficiently coarse granularity.

However, to utilise the concept of abstract interfaces to it's full extend one needs interfaces with fine granularity. E. g., in the mesh one needs to access the coordinates of nodes, normals of faces or evaluate element transformations at individual quadrature points. Generic programming, implemented in the C++ programming language via templates, offers the possibility to implement interfaces without performance penalty.

The abstract algorithm is parametrized by a concrete implementation of the interface at compile-time allowing the compiler to inline small functions and employ all code optimisations. Basically the interface is removed completely at compile time. This technique is called static polymorphism and is extensively used in the standard template library STL, see [6]. Many C++ programming techniques we use are described in [4] and [8].

DUNE is supposed to be a template library for all software components required for the numerical solution of partial differential equations. Figure 1(b) shows the high level design. User code will access geometries, grids, sparse linear solvers, etc. through the abstract interfaces. Many specialised implementations of one interface are possible and particular implementations are selected at compile time. This concept allows easy incorporation of existing codes as well as coupling of different codes.

1.1 The Grid Interface

The abstract mesh interface supports finite element grids with the following properties:

- Grids with elements of arbitrary dimension embedded in a space with the same or higher dimension can be described.
- Grids may have elements of arbitrary shape (there is a way to define reference elements) and arbitrary transformation from the reference element to the actual element.
- Grids may be nonconforming, i. e. the intersection of two elements need not be a common vertex, edge or face.
- Local refinement is always nested. I. e. every fine grid element results from subdivision of exactly one coarse grid element.
- Grids may be partitioned into overlapping sub grids for parallel processing.

A grid in the DUNE interface is viewed as a read only container of entities (i. e. vertices, faces, elements, etc.). The only way to modify a mesh once it is created is through mesh refinement. Access to the entities is only possible via iterators allowing on-the-fly implementations of simple (e. g. structured) meshes.

Several mesh objects of different type can be instantiated in one executable in order to couple problems on different grids. Each grid provides mappings of classes of entities onto consecutive indices. This allows the storage of user data outside of the mesh in contiguous memory location (e. g. arrays or ISTL vectors), e. g. for efficient usage of the cache in the fast linear algebra. See Table 1 for a list of available implementations of the DUNE grid interface.

1.2 Iterative Solver Template Library

Sparse matrices obtained from finite element discretisations exhibit a lot of structure that is usually not exploited in available sparse matrix packages.

OneDGrid	A 1D grid with local mesh refinement.
Network-Grid	A grid representing networks of 1D elements in an arbitrary dimensional world capable of local mesh refinement.
SGrid	Equidistant structured grid, on-the-fly generation, parallel with arbitrary overlap, n-dimensional with only co-dimension 0 and n.
YaspGrid	A structured parallel grid in n space dimensions.
Alberta-Grid	Unstructured simplicial mesh in 1, 2 and 3 space dimensions, local refinement using bisection, adaptation of the finite element toolbox Alberta ([SS05]).
UGGrid	Unstructured multi-element meshes in 2 and 3 space dimensions, red-green type local mesh refinement, non-overlapping decomposition for parallel processing, adaptation of the finite element toolbox UG [BBL+97].
ALU 3DGrid	Unstructured tetrahedral and hexahedral meshes, local mesh refinement with hanging nodes, non-overlapping parallel data decomposition, adaptation of the finite element toolbox ALU3d [DRSW04].

Table 1: Available grid implementations.

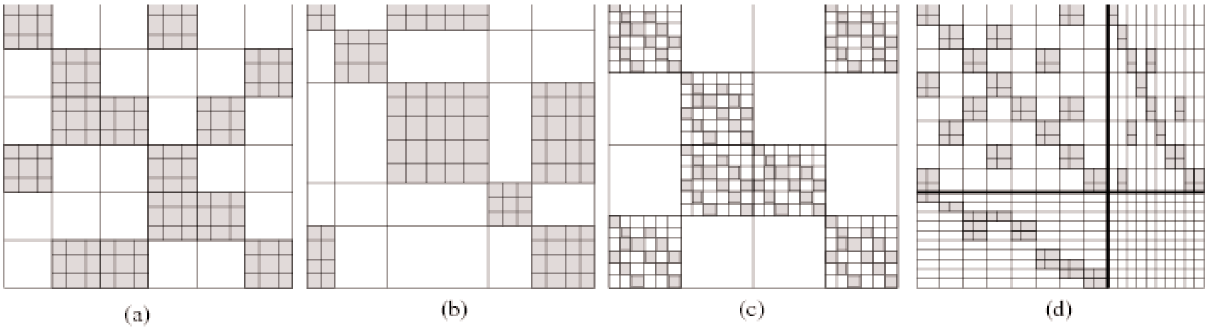

Figure 2: Block structure of matrices arising in the finite element method.

N	500	5000	50000	500000	5000000
MFLOPS	936	910	108	103	107

Table 2: MFLOPS for daxpy operation: $y = y + \alpha\, x$, 1200 MB/s transfer rate for large N.

N, b	100,1	10000,1	1000000,1	1000000,2	1000000,3
MFLOPS	388	140	136	230	260

Table 3: MFLOPS for matrix vector product (BCRSMatrix, 5-point stencil, b: block size of dense small matrix blocks).

In Figure 2 several examples are shown:

(a) discretisation of three-component system with linear finite elements and point-wise ordering,
(b) p-adaptive discontinuous Galerkin method,
(c) system of reactiondiffusion equations, and
(d) discretisation of Stokes' equation with equation-wise ordering.

The *Iterative Solver Template Library* (ISTL), see [1] and [2], the linear algebra and solver interface of DUNE, allows the definition of recursively block-structured vectors and matrices at compile-time via the usage of templates.

Vectors and matrices are viewed as one- and two-dimensional containers, respectively, and provide a similar functionality as the sparse BLAS standard. On top of this interface a variety of Krylov methods (Gradient method, CG, BiCGStab) and preconditioners ranging from simple Jacobi, Gauß-Seidel and incomplete decompositions to overlapping Schwarz and algebraic multigrid methods have been implemented. For parallel computations arbitrary data decompositions are supported in a generic way.

The MFLOP rates achieved with ISTL compiled with GNU C++ 4.0 on a Pentium 4 Mobile 2.4 GHz (see Tables 2 and 3) show nearly optimal performance.

The stream benchmark achieved 1024 MB/s transfer rate for large numbers of unknowns N on this machine. As expected one can see in Table 3 that for matrices with non scalar dense blocks (block size $b > 1$) better MFLOP rates are achieved due to the better usage of the cache. Here the structure is like in Figure 2a.

2 Sample Application

We consider the second order elliptic model problem

$$-\Delta u = f \text{ in } \Omega = (-\frac{1}{2},\frac{1}{2})\times(0,1)\times(0,1) \tag{1}$$

$$-\nabla u\cdot n = 0 \text{ on } \Gamma_N = \{(x,0,z) \mid -\frac{1}{2} < x < 0, 0 < z < 1\} \tag{2}$$

$$u = g \text{ on } \delta\Omega \setminus \Gamma_N \tag{3}$$

where the right hand side f and Dirichlet boundary conditions g have been chosen such that the solution u is given in cylindrical coordinates by

$$u(r,\varphi,z) = r^{\frac{1}{2}} \sin\left(\frac{\varphi}{2}\right) 4z\,(1-z)$$

This solution u has a singularity along the line (½, 0, z). The solution is depicted graphically in Figure 3.

Equations (1)-(3) are solved numerically using standard conforming P_1 finite elements on adaptively refined grids using a residual based error estimator with local estimators:

$$\|u-u_h\|_1 \le C\sqrt{\sum_{e\in E^0} \eta_e}$$

$$\eta_e = h_e^2 \int_{\omega_e} f^2 dx + \frac{1}{2} \sum_{\substack{\lambda=(e,e',\ldots)\in I \\ \omega_\lambda \not\subset \delta\Omega}} h_\lambda \int_{\omega_\lambda} [\nabla u\cdot n]^2 ds +$$

$$+\frac{1}{2} \sum_{\substack{\lambda=(e,e',\ldots)\in I \\ \omega_\lambda \subset \Gamma_N}} h_\lambda \int_{\omega_\lambda} [\nabla u\cdot n]^2 ds$$

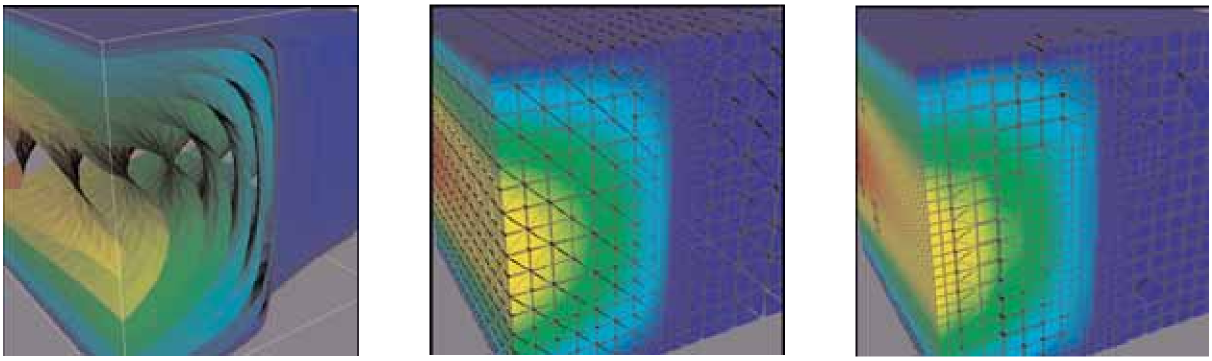

Figure 3: Grid function of the exact solution for the elliptic model problem and adaptively refined grids generated with AlbertaGrid and UGGrid.

The generic implementation of the adaptive finite element method works on grids of all element types, space dimension, as well as with conforming and nonconforming refinement (hanging nodes).

Table 4 shows timings for different parts of the adaptive algorithm on the different grids. In the first column (GRID) *s* and *c* identify grids using simplices and cubes, respectively. The other columns give the number of degrees of freedom (*N*), the time for setting up the nonzero structure of the sparse matrix in block compressed row storage from the grid (MAT), the time for assembling the matrix entries (ASS), the time for solving the linear system with conjugate gradients preconditioned with symmetric Gauß-Seidel (residual norm reduction 10^{-3}) (SLV), the time to evaluate the error estimator (EST), the total time for grid adaptation including vector reorganization (ADP), the time for grid refinement only (REF), the relative speed computed as sum of columns MAT through ADP divided by *N* and normalising that number relative to ALBERTA (RS), the L_2 error multiplied with 10^5 on the given mesh (ERR).

All times are given in seconds and have been measured on a Laptop-PC with an Intel T2500 Core Duo processor with 2.0 GHz, 667 MHz FSB and 2 MB L2 cache using the GNU C++ Compiler in version 4.0 and -O3 optimisation.

GRID	*N*	MAT	ASS	SLV	EST	ADP	REF	RS	ERR
Alberta *s*	496304	12.7	16.2	5.6	46.2	37.1	9.4	1.00	7.7
ALU3d *s*	537515	31.7	32.8	8.3	37.9	24.1	5.3	1.06	12.7
UG *c*	365891	8.5	15.0	5.0	15.6	15.5	13.2	0.69	13.3
ALU3d *c*	360118	11.0	12.6	4.2	9.2	5.2	1.0	0.49	14.7

Table 4: Timing for various components of the adaptive algorithm.

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Modeling and Simulation of Falling Dominoes: A Fertile Example for Simulation Education

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Modeling and simulation education needs examples that, on the one hand, are simple enough to be worked out in a reasonably short time and, on the other hand, exemplarily demonstrate typical problems. In particular, the example should bear some intrinsic difficulties that provoke the students to experience characteristic pitfalls of simulation. The falling domino problem is such an example as will be shown in this contribution. The problem is significantly more complex than the classical bouncing ball example because it includes different possible modeling concepts, handling of nonlinear state events, variable model structure, DAE formulation and numerical stiffness problems. Thus, the falling dominoes can show many facets of modeling and simulation, at the cost of needing some time in the classroom.

1 Falling Domino Example

Examples play an important role in modeling and simulation education because practical experience is much more important than just the theoretical knowledge of various concepts and methods ([1]). On the other hand, examples should not be too complex to be suitable for typical simulation courses. In this context, the falling domino problem is one of the rather complex examples which takes about one day for a classroom exercise. The reward is given by a broad variety of concepts and problems that can be understood in detail.

Generally, the falling domino problem is characterized by the following features:

- Both (stiff and non stiff) ODEs and DAEs can be used to model the problem.
- The formulation of model equations is not trivial but manageable with a computer algebra system.
- State events occur that must be properly handled. After a state event the system changes its structure and/or dimension.

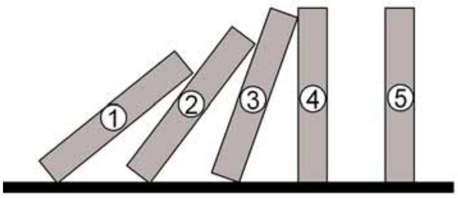
The problem is illustrated in Figure 1 (left). Initially, the dominoes 2, 3, … are standing upright and the first one is given a push (i.e. an angular momentum). The task is to model and simulate the dynamics of this system for any number of dominoes by using different approaches.

Project Aims

Clearly, it is easy to configure and run such a simulation by using a multi body simulation tool or a modern DAE based tool like Modelica ([2]). However, the user of these software systems is not aware of the intrinsic algorithms used to formulate and solve the model equations.

In fact, quite different approaches are possible having their specific advantages and disadvantages (see below). These different variants, finally, have to be judged by the students with respect to criteria like elegancy, generality, model formulation effort, ease of implementation, computing time, numerical errors and reproduction of the real system. For all these aspects, practical experiences can be made, i.e. this is a very fruitful example for education. It shows that a naive use of black box simulation systems can produce wrong or at least biased results.

The extensive classroom exercise described in the following has been developed to teach the application of basic methods and algorithms in the context of a nontrivial example. For this reason MATLAB is used for implementation and MAPLE for term manipulation. A total time of about one day should be reserved for the exercise if it guided by a skilled advisor.



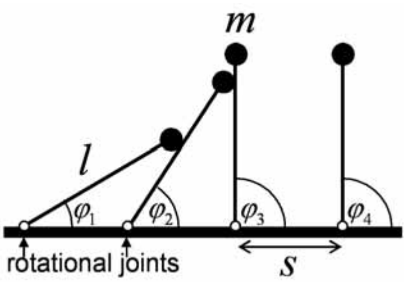


Figure 1: The falling domino problem; left: illustration of the physical experiment; right: abstraction by a simplified model.

Afterwards, the achievements of modern simulation tools will be really appreciated by the students. On the other hand, it will become clear where the algorithmic and numerical problems of these tools are hidden. Some basic knowledge of mechanics is needed, particularly the Lagrangian formalism ([3]).

2 Problem Simplification and Geometry

The falling domino problem is a typical mechanical multi body problem with state dependent contacts. The state events are given by the first contact times of neighbored dominoes. At these times the dynamics of one more rigid body has to be described. In order to reduce the problem to a manageable complexity the dominoes are modeled by weight-less rods with a rotational degree of freedom at the bottom and a point mass at the top (Figure 1, right).

In particular, this means that the dominoes cannot glide over the bottom surface and that their upright position (unlike for real dominoes as in Figure 1, left) is unstable. Likewise, the gliding friction between two contacting dominoes is neglected.

A comparable physical experiment, consequently, must be performed on a high friction surface (e.g. rubber) with a sufficiently strong initial push. However, these restrictions have no consequences on the basic modeling and simulation problems that are demonstrated with the example.

State events and their detection play a central role in this example. In contrast to the classical bouncing ball problem ([4]) the collision function of the domino problem is nontrivial and nonlinear in the state variables. The events are determined by a function d that computes the distance of the i^{th} mass to the $(i+1)^{\text{st}}$ domino surface.

Doubtlessly, the angles φ_i between dominoes and ground (Figure 1, right) are suitable state variables which will are used throughout the exercise.

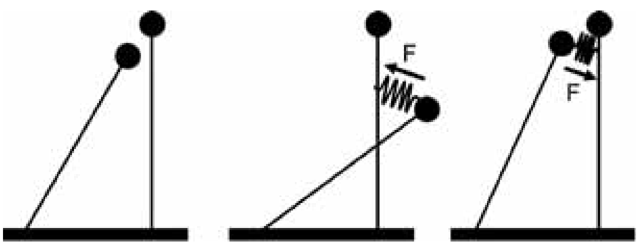


Figure 2: Modeling contacts with springs;
left: No force before the first collision of two dominoes;
middle: Imaginary one sided spring keeps penetration depth low.;
right: Two sided spring keeps the dominoes in contact.

Based on these angles the function

$$d(\varphi_i,\varphi_{i+1}) = (x_i - x_{i+1} + l\cdot\cos\varphi_i)\cdot\sin\varphi_{i+1} - (y_i - y_{i+1} + l\cdot\sin\varphi_i)\cdot\cos\varphi_{i+1}$$

is computed from the orthogonal distance of the point

$$(x_i + l\cdot\cos\varphi_i,\, y_i + l\cdot\sin\varphi_i)$$

to the line $(x - x_{i+1})\cdot\sin\varphi_{i+1} - (y - y_{i+1})\cdot\cos\varphi_{i+1} = 0$

It becomes positive if the i^{th} domino penetrates the $(i+1)^{\text{st}}$ domino. Particularly, in the contact case the condition $d(\varphi_i, \varphi_{i+1}) = 0$ yields an equation for φ_{i+1} as a function of φ_i:

$$\tan\varphi_{i+1} = \frac{y_i - y_{i+1} + l\cdot\sin\varphi_i}{x_i - x_{i+1} + l\cdot\cos\varphi_i} \tag{1}$$

Consequently, all contacting dominoes may be described by one single kinematic degree of freedom represented by φ_1 (cf. Section 4.1).

A visualization component for the dominoes as a function of the angles (looking similar to Figure 1, left) is prepared and supplied to the students. It can be used for checking the correctness of the implemented equations and for animating the simulation results.

3 Modeling Contacts with Springs

A primitive but still commonly used approach taken to model contacts is the introduction of springs that become active when one body penetrates the other (Figure 2, left and middle). In a first approach 'one-sided' springs are used which are only active when $d(\varphi_i, \varphi_{i+1}) > 0$ (penetration). Using the corresponding energy functions (potential, kinetic and spring energy)

$$U_i = mgl\cdot\cos\varphi_i, \qquad T_i = \frac{1}{2}ml^2\dot{\varphi}_i^2,$$
$$S_i = \frac{c}{2}\cdot\begin{cases} d^2(\varphi_i,\varphi_{i+1}) & \text{if } d \geq 0 \\ 0 & \text{if } d \leq 0 \end{cases} \tag{2}$$

the corresponding model equations are quickly derived by using the Lagrangian formalism. m is the total number of dominos (not necessarily contacting):

$$L(\varphi_1,\varphi_2,\ldots,\dot{\varphi}_1,\dot{\varphi}_2,\ldots) = \sum_{i=1}^{m} T_i - \sum_{i=1}^{m} U_i - \sum_{i=1}^{m-1} S_i$$
$$\Rightarrow \frac{d}{dt}\left(\frac{dL}{d\dot{\varphi}_i}\right) = \frac{dL}{d\varphi_1},\ i = 1,\ldots,m$$

Clearly, a large spring constant c must be chosen to prevent deep penetrations. Consequently, the well known problem of state dependent stiffness occurs in the simulation. The step size control of an integration algorithm has difficulties to locate the contact (Figure 3, left), resulting in long computing times. Moreover, due to the one-sided unsteady spring model, the contact is lost from time to time which does not look very realistic. Introducing additional dampers reduces the effect at the cost of a high stiffness. If more than two dominoes are considered this effect even prohibits any efficient simulation.

3.2 Two-sided Springs

To prevent the effect of loosing contact the spring model is altered in a non physical way such that after the first contact two dominoes attract each other when they are loosing touch (Figure 2, right). This means that the case distinction in Equation (2) is omitted. The structure of the model equations now changes after each initial contact of two successive dominoes.

As a consequence, a precise contact localization must be introduced by supplying the distance function d to the MATLAB integrator. When the contact happens, the model is changed by switching on the spring force term. From the first contact on two dominoes will permanently keep touch. Integration is slower now, because strong spring oscillations during contact occur (Figure 3, middle)). If a damper is introduced explicit and implicit integration schemes behave very different in this case but none is really efficient.

3.3 Elastic Collisions

As a third version of modeling the domino contacts an elastic collision model can be implemented. In this model, the contact of two dominoes is precisely detected. Then the collision model is applied to compute the domino velocities after the elastic collision from the velocities before the collision.

The advantage of this approach, clearly, is that the stiffnes due to spring forces is completely avoided at the cost of a high number of collisions to be detected.

The governing law of the elastic collision can be derived from the momentum and energy conservation of the two involved dominoes before and after the collision. However, a reduced mass which is active at the point of collision must be introduced to get a correct result. This needs some more mechanical background and is not described here in detail. The result (Figure 3, right) looks quite similar to the one sided spring solution but the computational speed and stability is much higher.

4 Modeling Contacts with Constraints

4.1 One Degree of Freedom

The next model has a fixed number of ODEs but a variable structure. It is based on the assumption that once the contact between two dominoes takes place it will remain for the rest of the falling time (gliding condition). This introduces a geometrical constraint given by $d(\varphi_i, \varphi_{i+1}) = 0$ for the i^{th} domino pair. When the dominoes $1, 2, \ldots, n$ are currently in contact this means that the whole system is described by just one state variable φ_1 from which $\varphi_{2,\ldots,}\varphi_n$ can be successively computed.

Consequently, the whole system has only one geometric degree of freedom at each time and the (unconstrained) Lagrangian formalism can be applied in each contact phase. The formalism directly yields a non stiff ODE system with only two equations for φ_1 and $\dot{\varphi}_1$.

However, when doing this, it quickly turns out that equation (1) has to be used iteratively yielding more and more complex terms for $\varphi_{2,} \varphi_2, \ldots, \varphi_n$ as a function of φ_1.

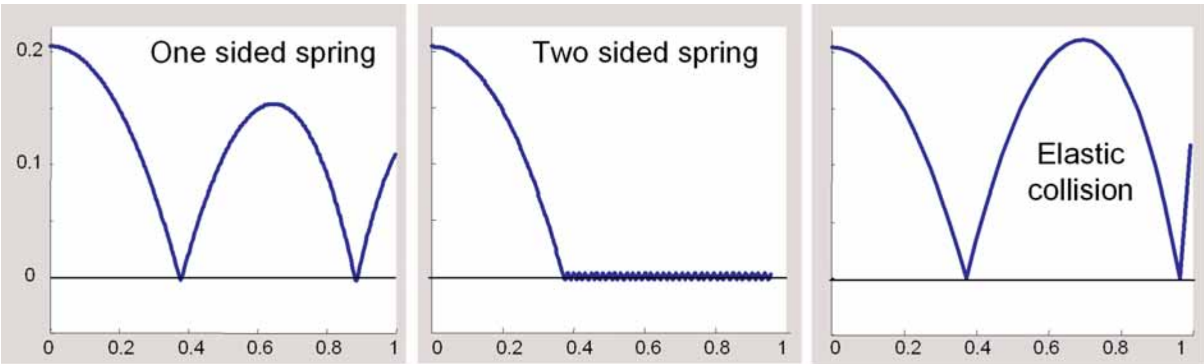


Figure 3: Distance function and detected contacts for three different models.

This holds even more for the terms U_i, T_i as a function of φ_1. Consequently, the effort of manual term manipulation for more than two dominoes becomes extremely high and a complex case distinction must be implemented in the program. For this reason a computer algebra system must be used for term generation.

At least for two dominoes the simulation (with contact detection and model switching) is implemented and runs fine. Notice that after each detected contact the structure of this system changes. The result looks very similar to the two sided spring solution (Figure 3, middle).

4.2 Many Degrees of Freedom

From the experiences with the unconstrained Lagrangian formalism, it becomes obvious that the reduction to one degree of freedom is complicated and inflexible. Thus the general constrained Lagrangian formalism is now applied to the whole system with contact constraints $d(\varphi_i, \varphi_{i+1}) = 0$, $i = 1, \ldots, n\text{-}1$ leading to a DAE system with a growing dimension after each new contact. Nevertheless, the arising equations for each domino pair now have the same structure and, thus, no dimension limitation is necessary:

$$L(\varphi_1, \varphi_2, \ldots, \dot{\varphi}_1, \dot{\varphi}_2, \ldots) = \sum_{i=1}^{n} T_i - \sum_{i=1}^{n} U_i - \sum_{i=1}^{n-1} \lambda_i \cdot d(\varphi_i, \varphi_{i+1})$$

$$\Rightarrow \quad \frac{d}{dt}\left(\frac{dL}{d\dot{\varphi}_i}\right) = \frac{dL}{d\varphi_i}, \; i = 1, \ldots, n$$

$$d(\varphi_i, \varphi_{i+1}) = 0, \; i = 1, \ldots, n-1$$

The implementation makes use of the MATLAB integrators for stiff systems which can deal with algebraic equations by introducing singular mass matrices. However, an index 1 DAE system is needed for this purpose.

The equations can be reduced to an index 1 DAE which is conceptionally not limited by the dimension because the terms have the same structure in every dimension. The necessary derivatives can be safely computed with a computer algebra system.

Consistent initial conditions can be easily derived from the system state at the moment of first contact between two dominoes. Clearly, the total number of equations needed to describe the system now is much higher than for the unconstrained formalism.

5 Evaluation of the Experiences with the Example

After working through the different approaches to model the falling dominoes the experiences can be reported by the students by judging all five variants with respect to six criteria, see Table 1.

As a general result, the only method that really works is the last one. This approach in turn cannot be managed by purely manual term manipulation. Thus, computer algebraic methods are definitively necessary. A final comparison with a Modelica implementation of the model at the equation level shows that almost no effort for term manipulation remains since Modelica automates the task of DAE index reduction. This finding should at last lead to a proper judgment of the achievements of modern simulation tools.

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Approach	Criteria
A One sided springs B Two sided springs C Elastic collisions D One degree of freedom E Many degrees of freedom	1 Effort for deriving model equations 2 Implementation effort 3 General applicability 4 Simulation runtime 5 Numerical stability 6 Reproduction of reality

Table 1: Evaluation of five variants with six criteria.

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Accepted: February 25, 2007

BOOK REVIEWS - JOURNAL REVIEWS

Book Reviews

Contemporary Cryptology
Advanced Courses in Mathematics CRM Barcelona
Dario Catalano, Ronald Cramer, Ivan Damgård,
Giovanni Di Crescenzo, David Pointcheval,
Tsuyoshi Takagi
Birkhäuser, Basel - Boston - Berlin, 2005
ISBN 3-7643-7294-X

The aim of this text is to treat selected topics of the subject of contemporary cryptology, based on the material presented in the lectures of 'Advanced Course on Contemporary Cryptology' in February 2004 at the Universitat Politècnica de Catalunya.

The Text is structured in five quite independent but related themes:

- Efficient distributed computation modulo a shared secret
- Multiparty computation
- Modern cryptography
- Provable security for public key schemes
- Efficient and secure puplic-key cryptosystems

Efficient distributed computation modulo a shared secret: In this lecture some efficient algorithms are described, that allow a set of players to generate shared RSA keys without assuming the existence of a trusted dealer. Specifically a 'modular' approach to the problem is presented.

Multiparty computation: In this lectures some concepts necessary to define what it means for a multiparty protocol to be secure are introduced, and some known general results are surveyed that describe when secure multiparty computation is possible. Then some general techniques for building secure multiparty protocols are discussed.

Modern cryptography: Here some basic topics in the foundation of modern crytography are presented; specifically: one-way functions, pseudo-random generators, pseudo-random functions and zero-knowledge protocols.

Provable security for public key schemes: In this section more about exact security proofs are explained, and the notation of the weaker security analyses are introduced. Then the formalism of the most important asymmetric primitives are reviewed: signatures and public-key encryption schemes.

Efficient and secure public-key cryptosystems: In this chapter an overview of efficient algorithms applied to RSA cryptosystems and EC cryptosystems are discriebed. On the other hand, novel attacks in the efficient implementation have been proposed, namley timing attack, side channel attacks, fault attack, ect.

Beginner	Intermediate	Expert
		●
Theory	Mixed	Practice
	●	
Lecture Note	Monograph	Proceedings
●		

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Textbook Teaching and Exercising Numerical Mathematics, with Software Support (in German)
Lehr- und Übungsbuch Numerische Mathematik, mit Softwareunterstützung
Wolfgang Preuß, Günter Wenisch
Fachbuchverlag Leipzig, 2001
350 pages, ISBN 3 44 6213759

The book gives a compact overview of numerical mathematic. It covers the most important methods for numerical solutions. The book covers

- Finding roots
- Linear and non linear equations
- Eigenvalue problems
- Problems of interpolation and approximation
- Numerical differentiation and integration
- Initial value and boundary value problems of ordinary differential equations
- Numerical libraries

An overview on existing numerical libraries is given and a software package *Mathe-Demo* is provided on the book's website. Many examples are given in the book encouraging the students to find solutions.

The software Mathe-Demo is sufficient to do the numerical calculations and graphical representations needed for the examples. Further solutions to the examples can be found on the website.

The book can be good to study basic concepts of numerical mathematics because it provides many examples and tasks. For a reference book its content is too compact.

Beginner	Intermediate	Expert
●		
Theory	**Mixed**	**Practice**
	●	
Lecture Note	**Monograph**	**Proceedings**
	●	

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The Active Modeler: Mathematical Modeling with Microsoft Excell
Erich Neuwirth, Deane Arganbright
Duxbury, 2003
ISBN-10: 0534420850, ISBN-13: 978-0534420857

Microsoft excel is the world's most well-known computer programme for calculating spreadsheets. It's commonly used for calculating costs, for managing storage, collecting ideas for X-mas presents for family and friends, whereas excel is not the first named programme for mathematical modelling, like e.g. MATLAB.

Nevertheless, the authors, Erich Neuwirth and Deane Arganbright describe in this book, that excel is able to do much more than some kind of calculating. Contrariwise, they demonstrate that it is possible to handle small to medium complicated mathematical models also by Microsoft excel. They also show that a wide variety of applications can be modelled and solved by a simple excel-spreadsheet.

Starting by introducing the Fibonacci Numbers for growth-problems the authors describe in detail how a problem is 'implemented' in excel, each example they demonstrate is supplemented by related exercises.

Going further to dynamical models and difference equation, the authors give clear advise how they can be described in excel, it is even recorded how chaotic behaviour can be modelled in excel, e.g. by Feigenbaum diagrams.

The following chapter describe how science application can be processed in excel (e.g. projectile motion, heat propagation), followed by a chapter concerning number theory and their applications.

Almost 80 pages are reserved for the effective graphic facilities that excel spreadsheet possess. Displaying polar and parametric equations are as well described as using Bezier Curves, like Newton and Secant, methods .

The last chapters demonstrate how mathematical 'everyday-problems' can be implemented effective, by showing how the world famous problems, like 'game of Life' or 'The golden Ratio' are doing in an excel-spreadsheet. Even problems of probability and combinatorial analysis are discussed e.g. by geometric distribution and simulations. The last chapters describe how an optimal solution to an existing problem can be found.

Mathematical Modelling with Microsoft excel makes clear, that it is not necessary to buy an expensive computer software to model small or medium complicated problems.

Far from is, there exists a large amount of modelling challenges that can be solved quite simply by a spreadsheet. How this can be done is described excellent in this book and I suggest: it's worth reading!

Beginner	Intermediate	Expert
●		
Theory	**Mixed**	**Practice**
●		
Lecture Note	**Monograph**	**Proceedings**
●		

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BOOK AND JOURNAL ANNOUNCEMENTS

Journal Announcements

SNE Special Issues

The new *SNE Special Issue Series* has been introduced as an extension of the regular SNE. The idea for special issues was born in ASIM, the German Simulation Society. As there has been still is a need for state-of-the-art publications in topics of modelling and simulation, ASIM first tried to publish monographs on this subject, but stopped due too high costs. ASIM, seeking for alternatives, contacted ARGESIM with the idea of SNE Special Issues - while ARGESIM itself thought on Special Issues, because of lack in publication space in the regular SNE issues. In September 2006, one year after the first contact, the first SNE Special Issue *Parallel and Distributed Simulation Methods and Environments* could be presented. It is planned to publish one SNE Special Issue each year, but also extra issues are possible.

The editorial policy of *SNE Special Issues* is to publish high quality scientific and technical papers concentrating on state-of-the-art and state-of-research in specific modelling and simulation oriented topics in Europe, and interesting papers from the world wide modelling and simulation community. The special issues are open to every society, group or person, who wants to publish a state-of-the-art summary emphasising on a certain topic in modelling and simulation.

SNE Special Issue *Distributed Simulation Methods and Environments* - SNE 16/2

The first special issue of SNE was edited by the ASIM Working Group *Methods of Modelling and Simulation*. The editors, Thorsten and Sven Pawletta from University Wismar, Germany collected very interesting papers due to the special issue's subject:

Overview about the High Level Architecture for Modelling and Simulation and Recent Developments; *S. Straßburger*

Lookahead Computation in G-DEVS/HLA Environment; *G. Zacharewicz, C. Frydman, N. Giambiasi*

Parallel Simulation Techniques for DEVS/Cell-DEVS Models and the CD++ Toolkit; *G. Wainer, E. Glinsky*

SCE based Parallel Processing and Applications in Simulation; *R. Fink, S. Pawletta, T. Pawletta, B. Lampe*

HLA Applied to Military Ship Design Process; *C. Stenzel, S. Pawletta, R. Ems, P. Bünning*

Co-simulation of Matlab/Simulink with AMS Designer in System-on-Chip Design; *U. Eichler, U. Knöchel, S. Altmann, W. Hartong, J. Hartung*

Parallel Computation in Blood Flow Simulation using the Lattice Boltzmann Method; *S. Wassertheurer, D. Leitner, F. Breitenecker,M.Hessinger, A. Holzinger*

ARGESIM Benchmark on Parallel and Distributed Simulation; *F. Breitenecker, G. Höfinger, R. Fink, S. Pawletta, T. Paletta*

The issue was sent to all ASIM members, and sample copies were sent to other European Simulation Societies. Due to the demand, a second edition will be printed end of 2007. Furthermore, for regular and special SNE issue in 2007, a new system for individual SNE subscriptions will be set up, including subscription of electronic copies.

SNE 17/2 Special Issue *Verification and Validation*

Building high-quality simulation models and using the right input data are pre-conditions for achieving significant and usable simulation results. For this purpose, a simulation model has to be well-defined, consistent, accurate, comprehensive and applicable. The quality criteria can be proved by verification (*building a model in the right way*) and validation (*building the right model*) - topics for the second Special Issue of SNE (edited by the ASIM Working Group *Simulation in Production and Logistics)*.

The guest editors Sigrid Wenzel (University Kassel), Markus Rabe (Fraunhofer Institut IPK, Berlin), und Sven Spieckermann (SimPlan AG, Maintal) invite for submitting a contribution to the following topics:

- Procedure Models for Verification and Validation
- Methods for Verification and Validation
- Certification and Accreditation
- Information and Data Acquisition for Simulation Models and their Verification and Validation
- Verification and Validation - Documentation Aspects
- Credibility
- Automatic Verification and Validation
- Case Studies and Practical Experiences

Contributions should not exceed 8 pages (template) and should be mailed directly to Sigrid Wenzel not later than August 31, 2007 (contributions will be peer reviewed; templates for preparing a contribution ASIM website, WWW.ASIM-GI.ORG, menu *International - SNE - Templates*, template for Technical Notes).

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ARGESIM BENCHMARKS ON MODELLING AND SIMULATION

From ARGESIM Comparisons of Simulation Software to ARGESIM Benchmarks on Modelling and Simulation

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ARGESIM started in 1990 the series *Comparison of Simulation Software* in the journal *Simulation News Europe* (**SNE**). The ARGESIM Comparisons are based on relatively simple, easily comprehensible processes. Different modelling techniques and their implementation as well as features of modelling and experimentation within simulators, also with respect to application area, are compared.

Development of Comparisons. Since that time there have taken place new developments in software, algorithms, and modelling. Consequently also the comparisons developed further on, from comparisons of simulation software towards comparisons of modelling and simulation techniques and tools. This development can be seen in definitions and solutions published from 1990 to 2006 in 44 SNE issues: 20 definitions, and 298 comparison solutions (~ 7 / SNE issue). The list of comparisons and benchmarks shows also the broad variety of the applications.

Re- organisation towards Benchmarks. In 2006, a re-organisation of the comparisons has been started, based aspects of content, and on aspects of documentation. First, the comparisons developed more towards benchmarks for modelling approaches, underlined by more content on modelling in solutions, and by more emphasis on modelling in the newer definitions C16 - C19 - called now benchmarks. Second, it turned out, that some comparisons should be updated, because of changing challenges and misleading definitions. And third, the stronger emphasis on modelling needs more than one page SNE for documentation of the solution, so that now two pages SNE are provided.

Two-page Layout for Solution. The last issue already introduced the new two-page layout of the solutions, used as well for 'old' comparisons and 'new' benchmarks, providing the following structure:

Simulator. Features and advantages of the simulator used should be sketched within 1/4 page SNE.

Modelling. Strong emphasis should be put on the modelling approach, so that about 1 page SNE is reserved for this important subject.

A-C **Tasks.** For experiment documentation and results of the three tasks (A-C) also about 1 page SNE is reserved.

Résumé. And finally a resume should summarise the important facts of the solution.

Revised Comparison Definitions. In the last issue, SNE 16/3, December 2006, two updated benchmark definitions already were published:

- C9R Extended Fuzzy Control of a Two-Tank System
- C19R Pollution in Groundwater Flow

This issue again publishes a revised benchmark definition, and the definition of a new 'parallel' benchmark:

- Crane with Complex Embedded Control – ARGESIM Benchmark C13R with Implicit Modelling, Digital Control and Sensor Action
- ARGESIM Benchmark on Parallel and Distributed Simulation (CP2)

New Benchmarks Solutions. SNE 17/1 continues the new solution series with four solutions on 'old' comparisons and 'new' benchmarks:

- C4 Dining Philosophers I with HPSim
- C6 Dining Emergency Department with WebGPSS
- C9R Extended Fuzzy Control of a Two-Tank using Modelica/Dymola
- C13R Crane with Complex Embedded Control using Modelica/Dymola

Future Development. For the next issues, revisions of 'old' comparisons/benchmarks are planned (C17R and C18R because of misleading and too narrow formulation, and C1R and C7R for update). A new comparison in the area of flexible manufacturing will continue the discrete benchmark series (C20), and a general benchmark for structural dynamic systems (CSS) will be introduced.

We invite readers to send in solutions for all type of comparisons and benchmarks, whereby also solutions to 'old' (non-revised) comparisons are accepted. For a template, please visit the ARGESIM or the ASIM website:

WWW.ARGESIM.ORG, menue SNE
WWW.ASIM-GI.ORG, menu *International*, *SNE*

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Crane with Complex Embedded Control – ARGESIM Benchmark C13R with Implicit Modelling, Digital Control and Sensor Action

Alexander Schiftner, Felix Breitenecker, Horst Ecker, Vienna University of Technology
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The ARGESIM Bencmark C13R 'Crane with Complex Embedded Control' is based on modelling and digital control of a crane crab. The discrete control is designed by means of a state space observer, and by state space control. On modelling level, setup and handling of implicit nonlinear model descriptions are investigated, and nonlinear model and linear model (linearised model) are compared. Thus, the benchmark addresses as well graphical model description of standard input/output type and of a-causal element type, as well as textual descriptions given by DAEs or implicit laws. Furthermore, graphical or textual modelling features for discrete control are investigated, together with additional sensor action modelling. On simulation level, simulation results for nonlinear and linear dynamics without feedback control are to be compared, and two time-domain scenarios with changing set points and with disturbances are investigated of the fully controlled nonlinear system are to be investigated. Thereby, the synchronisation of digital control, DAE or ODE solvers and isolated disturbance events is of importance.

Introduction

This benchmark originates from a publication of E. Moser and W. Nebel ([2]), where the authors set up a first benchmark mainly for testing the VHDL-AMS model description in a case study for digitally controlled crane crab. This first benchmark addressed mainly modelling and simulation of discrete control with complex sensor actions (a standard task for VHDL) in combination with modelling and simulation of the continuous mechanical dynamics of the crane crab (a task, which VHDL-*AMS*, the extension of VHDL for *A*nalog and *M*ixed *S*ignals, is designed for).

In 2003, the definition of the ARGESIM Comparison C13 *Crane and Embedded Control* extended the previous VHDL-AMS benchmark for simulators of any kind, keeping the control structure and sensor structure given, and adding nonlinear dynamics, DAE modelling, and complex scenarios to be simulated. Experiences with the few solutions sent in showed, that the design of the control was not really adequate, was leading to mis-interpretations, as well as the comparison of linear and nonlinear dynamics was not representative.

Consequently, this new revised definition as ARGESIM Benchmark C13R *Crane with Complex Embedded Control* presents a more precise nonlinear and linear model for the crane dynamics, a new designed controller with much more stable behaviour, well-defined rules for sensor actions, and for simulation purposes, a representative scenario for comparing linear and nonlinear model, and two scenarios for investigating the time domain behaviour of the fully controlled nonlinear model with sensor actions.

1 Model for Crane Dynamics

The crane crab consists of a horizontal track, a car moving along this track, and a load that is connected to the car via a cable of length r as shown in Figure 1. The car is driven by the force f_c , which is exerted by a motor controlled by a digital controller. A disturbance is modelled as the disturbing force f_d accelerating the load in horizontal direction. Three sensors provide information about the current state of the system: current position, left stop signal and right stop signal. The actuators for steering the crane are the motor for the car, and a brake acting in case the car has reached a steady state at set point, or in case of emergency.

The nonlinear model can be derived by Lagrange approach, resulting in two nonlinear coupled 2nd order ODEs for car position x_c and for angle α, respectively; the position of the load x_l follows from x_c and α. It is to be noted, that the nonlinear model is of implicit type, and can be expressed with mass matrix $\mathbf{M}_{nl}$, general coordinates $\mathbf{p}$, and generalised forces $\mathbf{g}$:

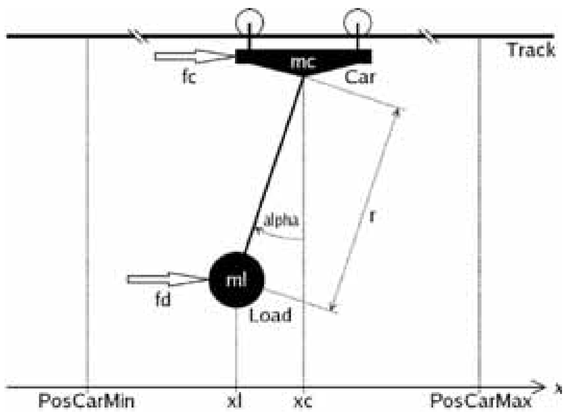

Figure 1: Schematic overview of crane model.

$$\ddot{x}_c = [m_c + m_l \sin^2(\alpha)] = -d_c\dot{x}_c + f_c + f_d \sin^2(\alpha) + \\ + m_l \sin(\alpha)[r\dot{\alpha}^2 + g\cos(\alpha)] - d_l\dot{x}_c \sin^2(\alpha)$$

$$r^2\ddot{\alpha}[m_c + m_l \sin^2(\alpha)] = \left[f_d \frac{m_c}{m_l} - f_c + d_c\dot{x}_c \right] r\cos(\alpha) - \\ -[g(m_c + m_l) + m_l r\dot{\alpha}^2 \cos(\alpha)] r\sin(\alpha) - \\ -d_l \left[\frac{m_c}{m_l}(\dot{x}_c r\cos(\alpha) + r^2\dot{\alpha}) + r^2\dot{\alpha}\sin^2(\alpha) \right]$$

$$x_l = x_c + r \cdot \sin(\alpha); \mathbf{M}_{nl}(\mathbf{p}) \cdot \ddot{\mathbf{p}} = \mathbf{g}(\mathbf{p}, \dot{\mathbf{p}}, \mathbf{g}), \ \mathbf{p} = (x_c, \alpha)^T$$

The basic model parameters can be found in Table 1. The linear model (details in [2]; identical to model above linearised at zero states) is given by two coupled explicit 2nd order linear ODEs for car position x_c and for angle α, resp. (linear state space of 4th order):

$$\ddot{x}_c = \frac{f_c}{m_c} + g\frac{m_l}{m_c}\alpha - \frac{d_c}{m_c}\dot{x}_c$$

$$r\ddot{\alpha} = -g(1 + \frac{m_l}{m_c})\alpha + (\frac{d_c}{m_c} - \frac{d_l}{m_l})\dot{x}_c - \\ -r\frac{d_l}{m_l}\dot{\alpha} - \frac{f_c}{m_c} + \frac{f_d}{m_l}, \quad x_l = x_c + r\alpha$$

$$\dot{\mathbf{x}}_L = \mathbf{A}_L \cdot \mathbf{x}_L + \mathbf{b}_c f_c + \mathbf{b}_d f_d, \quad \mathbf{x}_L = (x_c, \dot{x}_c, \alpha, \dot{\alpha})^T$$

2 Specification of the Control

The control includes the sensors, the actuators, the digital controller and the diagnosis. The variable *PosDesired* is used as input to the controller (set point) and controls the position of the car *PosCar*, being x_c, the only measured state of the crane.

Actuators. The car is driven by a motor which exerts the force f_c on the car. As a model for the motor, including a specific controller for it, a first-order

Description	Name	Value
mass of car	m_c	10 kg
mass of load	m_c	100kg
length of cable	r	5 m
gravity	g	9.81 m/s^2
friction coefficient of car	d_c	0.5 kg/s
friction coefficient of car with activated brake	d_c^{Brake}	10^5 kg/s
friction coefficient of car	d_l	0.001 kg/s
maximum position of car	*PosCarMax*	5 m
minimum position of car	*PosCarMin*	-5 m

Table 1: Basic model parameters.

transfer function is used (the digital control variable computed in the digital controller is $f_c^{Desired}$):

$$\dot{f}_c = -4\,(f_c - f_c^{Desired})$$

As second actuator, a brake becomes active either in case of emergence, or in case the car has reached a steady state or a set point resp.

This second case is given by a control variable $f_c^{Desired}$ being for more than *TimeSteady* seconds less than a minimal control force *BrakeCondition*:

if $|\,(f_c^{Desired})\,| < $ *BrakeCondition*
for more then *TimeSteady* seconds
then activate the brake

Activation of the brake is given by the following actions (setting control variable to zero, and setting the friction coefficient of the car to a maximal value):

$$f_c^{Desired} := 0, \quad d_c := d_c^{Brake}$$

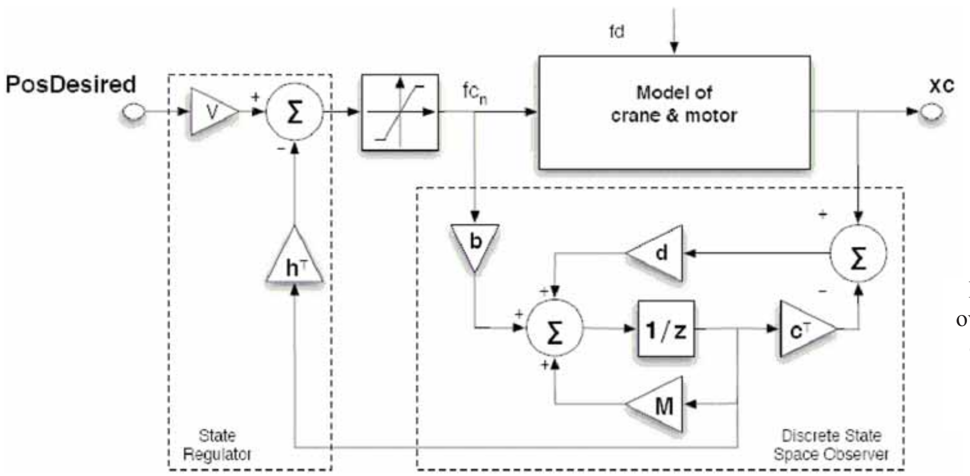

Figure 2: Schematic overview of the digital controller with state space observer.

Sensors. Three sensors give information about the status of the system, one measuring the position of the car (*PosCar*) and the other ones (*SwPosCarMax*, *SwPosCarMin*) signaling that the car has reached the outmost left or outmost right position (Table 2).

Definition of the digital controller

The digital controller (schematic overview given in Figure 2) is implemented as a cycle based controller using a fixed cycle time of *SampleTime* ms. A discrete state space observer calculates the 'fictive' states **q**, $\mathbf{q} = (\tilde{f}_c, \tilde{x}_c, \dot{\tilde{x}}_c, \tilde{\alpha}, \dot{\tilde{\alpha}})^T$ based only on observation of *PosCar*.

The vector **q** is then fed into a state regulator. The discrete control algorithm calculates the new control variable $f_c^{Desired}{}_{n+1}$ based on the system output value $PosCar_n$ and control variable $f_c^{Desired}{}_n$ from the previous control cycle (n numbers the controlling cycles; graphical presentation given in Figure 2):

$$\mathbf{q}_{n+1} := (\mathbf{M} - \mathbf{d}\,\mathbf{c}^T)\,\mathbf{q}_n + PosCar_n\,\mathbf{d} + f_c^{Desired}{}_n\,\mathbf{b}$$
$$u_{n+1} := V\ PosDesired - \mathbf{h}^T\mathbf{q}_{n+1}$$
$$f_c^{Desired}{}_{n+1} := \max\{\min\{u_{n+1}, ForceMax\}, -ForceMax\}$$

The discrete state space observer was derived from the linear model equations for crane and motor, combining the linear state space $\mathbf{x}_L$ for the crane with the first order transfer function for the control force f_c without disturbance input f_d, giving a linear system of 5th order:

$$\dot{\mathbf{x}} = \mathbf{A}\cdot\mathbf{x} + \mathbf{b}_m\,f_c^{Desired}, \quad x_c = \mathbf{c}^T\mathbf{x}$$
$$\mathbf{x} = (f_c, x_c, \dot{x}_c, \alpha, \dot{\alpha})^T, \mathbf{b}_m = (4,0,0,0,0)^T$$

As the above linear system is observable and controllable, the state regulator and the state space observer could be treated independently. For a detailed description of how to choose **d** refer to [3].

The resulting continuous state space observer was discretised using an explicit Euler integration scheme using the fixed cycle time *SampleTime*, which results in the following parameter vectors:

Name	Type	Description
PosCar	Real	reports the position of the car (x_c)
SwPosCarMin	Boolean	*true* if $x_c < PosCarMin$ else *false*
SwPosCarMax	Boolean	*true* if $x_c > PosCarMax$ else *false*

Table 2: Sensor variables.

Description	Name	Value
sample time of discrete controller	*SampleTime*	0.1 s
gain	*V*	109.5 N/m
minimal control force	*BrakeCondition*	0.01 N
recognition interval for *BrakeCondition*	*TimeSteady*	3.0 s
maximal control force	*ForceMax*	160 N

Table 3: Controller parameters.

$$\mathbf{M} = \begin{pmatrix} 0.96 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0.01 & 0 & 0 \\ 0.001 & 0 & 0.9995 & 0.981 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ -0.0002 & 0 & 0.0001 & -0.2158 & 1 \end{pmatrix}$$

$$\mathbf{c} = \begin{pmatrix} 0 \\ 1 \\ 0 \\ 0 \\ 0 \end{pmatrix}, \mathbf{d} = \begin{pmatrix} 34.5724 \\ 0.2395 \\ 2.0322 \\ 0.0164 \\ -0.1979 \end{pmatrix}, \mathbf{b} = \begin{pmatrix} 0.04 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}, \mathbf{h} = \begin{pmatrix} 2.9 \\ 109.5 \\ 286.0 \\ 1790.6 \\ 44.5 \end{pmatrix}$$

There, the state regulator, represented by **h**, was chosen as a Ricatti-type regulator using an error metric emphasising the state variables in favour of the controlling variable (given the linear system as before, MATLAB's function `lqr` was used to calculate the control vector **h**). Further parameters for the control are given in Table 3.

Diagnosis. The diagnosis runs concurrently to the digital controller. It is used to ensure the car stays within the given soft limits *PosCarMin* and *PosCarMax*. Therefore a boolean value *EmergencyMode* is introduced, which defaults to *false* and will not be reset once set to *true*. In parallel, the condition for activating the brake while the car is standing still, can be observed.

In each cycle of the controller, the following conditions have to be checked:

- if *PosCar* > *PosCarMax*
  then set *EmergenceMode* = *true*
- if *PosCar* < *PosCarMin*
  then set *EmergenceMode* = *true*
- if *EmergencyMode*
  or if for more than *TimeSteady* seconds
  (| ($f_c^{Desired}$) | < *BrakeCondition*)
  then activate the brake

3 Tasks - Experiments

The classical ARGESIM Comparisons required three tasks to be performed with the defined dynamic system, mostly addressing investigations and analysis in the time domain; furthermore information on the simulator used and a short description of the model implementation should be given - both to be presented within one page SNE. The new or revised ARGESIM Benchmarks extend the three tasks - Task **A**, Task **B**, Task **C** - and the simulator description - Task **S**imulator Description - by requesting a detailed description of the model implementation, whereby also different modelling approaches may be presented - Task **M**odelling, and by a short summary for the benchmark solution - Task **R**ésumé, trying also a classification of the approach. For documentation of all tasks two pages SNE may be used, (Task **M**odelling more than ½ page, and tasks **A**, **B**, and **C** about 1 page). Furthermore, model source files should be sent in. More details at ARGESIM website WWW.ARGESIM.ORG, menu *SNE*.

Modelling. First present the general approach, the implementation idea in the simulation system used. Especially, make clear how the implicit nonlinear model was handled, and how the digital controller was implemented. Was the DAE model used directly, or must it be made explicitly by analytical or by numerical means ? Furthermore it is of interest, how the synchronisation of digital control, DAE or ODE solvers and isolated disturbance events are performed, and how the scenarios in the tasks were managed.

A - Task: Nonlinear vs Linear Model. Implement the model (crane and motor) once using the linear equations for the crane dynamics and once using the nonlinear equations. Give details about implementation of both models in parallel. Compare linear and nonlinear model without controller and without brake, with following scenario:

- Initial state: all states zero, $f_d = 0$
- At time $t = 0$: set $f_c^{Desired} = 160$ for 15s, then $f_c^{Desired} = 0$
- At time $t = 4$: set $f_d = Dest$ for 3s, then set $f_d = 0$

Print a table showing the steady-state difference (reached after about 2.000 s) in the position of the load (x_l) for three values of *Dest*, *Dest* = -750, -800, -850.

B - Task: Controlled System. Show implementation of controller with brake and of brake action in the nonlinear equations for the crane dynamics.

Give comments on work of discrete model parts and simulate the following scenario:

- Initial position: zero states, $f_d = 0$
- At time $t = 0$: *PosDesired* = 3
- At time $t = 16$: *PosDesired* = -0.5
- At time $t = 36$: *PosDesired* = 3.8
- At time $t = 42$: $f_d = -200$ for 1s, then $f_d = 0$
- At time $t = 60$: stop simulation

Results should be displayed as graph of position of car position x_c, load x_l, angle α, and of the status of the brake over time.

C - Task: Controlled System with Diagnosis. Add the diagnosis to the controller. State how the *EmergencyStop* event is handled within the controller, and simulate the following scenario:

- Initial position: zero states, , $f_d = 0$
- At time $t = 0$: *PosDesired* = 3
- At time $t = 16$: *PosDesired* = -0.5
- At time $t = 36$: *PosDesired* = 3.8
- At time $t = 42$: $f_d = -200$ for 1s, then $f_d = 0$
- At time $t = 46$: $f_d = 200$ for 1s, then $f_d = 0$
- At time $t = 60$: stop simulation

Results should be displayed as graph of position of car position x_c, load x_l, angle α, status of the brake and status of *EmergencyStop* over time.

For a solution, please follow the guidelines at the ARGESIM website WWW.ARGESIM.ORG and include your model source code files with the solution sent in.

References

[1] O. Foellinger: *Regelungstechnik*. Huethig, 5. Auflage, 1985

[2] E. Moser, W. Nebel. *Case Study: System Model of Crane and Embedded Controller*. Proc. DATE'99, pages 721-724, 1999.

[3] J. Scheikl, F. Breitenecker, I. Bausch-Gall: Comparison C13 *Crane and Embedded Control – Definition*. SNE 35/36, Dec. 2002; 69 – 71.

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ARGESIM Benchmark on Parallel and Distributed Simulation

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This ASIM / ARGESIM Benchmark on Parallel and Distributed Simulation addresses benefits of parallel and distributed computing in the area of continuous, discrete, and hybrid simulation and in related areas. This new benchmark may be of interest for users of all types of parallel and distributed facilities. The spectrum may range from parallelisation strategies and strategies for distributing tasks, via general purpose programming languages to simulation languages, and from networks of workstations, via special parallel computers, to very high performance computers. The problems considered are a Monte-Carlo study for parameters in a dynamic mass-spring system, a case study for Lattice-Boltzmann simulation for fluid flow (famous cavity flow problem published by Hou et al.), and solution of the PDE for the swinging string with different approaches.

Introduction

In 1994, ARGESIM has set up the *ARGESIM Comparison on Parallel Simulation Techniques* (CP1). There, three test examples have been chosen to investigate the types of parallelisation techniques best suited to particular types of simulation tasks ([1]). The new *ARGESIM Benchmark on Parallel and Distributed Simulation* (CP2) extends the previous comparison, addressing not only simulation software and predefined given algorithms, but also allowing use of different algorithms for solving the tasks and comparing different strategies for parallelisation or distribution of the tasks.

1 Contribution to Benchmark CP2

The *ARGESIM Benchmark on Parallel and Distributed Simulation* test benefits of parallel and distributed simulation with three case studies:

- Monte-Carlo study for parameters in a dynamic mass-spring system
- Case study for Lattice-Boltzmann simulation for fluid flow (famous cavity flow problem published by Hou et al.)
- Solution of the PDE for the swinging string with different approaches

Participation at this benchmark requires:

- Documentation of the algorithms for solving the case studies (one or more algorithms)
- Documentation of the strategy for parallelising or distributing the case studies (one or more strategies)
- Serial solution of the case studies
- Parallel / distributed solutions of the case studies
- Determination and documentation of efficiency of parallelisation

In detail, a contribution to this benchmark should for each case study describe first the approach or the algorithms for calculating solutions, followed by information about the method of parallelisation or distribution of tasks and subtasks. It is highly appreciated, if more than one solution for a particular case study is given, either using different parallelisation strategies or strategies for distribution, or by using different hardware environments, or by using different algorithms for calculating solutions.

In the following results of the case studies should be presented, based on a comparison of a serial solution and the parallel / distributed simulation of each case study.

For quantitative comparison of serial solution and parallel or distributed solutions, performance should be assessed in terms of the relative speed-up factor, a numerical value found by dividing the time for serial solution by the time for the parallel solutions (speed-up factor f).

Measurements of time, whenever necessary, should be in terms of the total elapsed time for running the task. Furthermore, a rough indication should be provided for the (time) effort for implementing a parallel / distributed simulation (at best compared with implementing the serial solution).

Contributions to this benchmark will be published in the journal SNE – Simulation News Europe. Solutions sent in should not exceed four SNE pages and will be reviewed by the editorial board and by authors of the benchmark. Whenever possible, also model files and code should be provided, or linked.

SNE 17/1, April 2007

C1 Case Study 1 Monte Carlo Study

The first case study is a Monte Carlo study. In a damped dynamic mass – spring system the damping factor is randomly disturbed, and the mean of a sample of dynamic outputs is to be calculated. The second order mass-spring system is described by the following ODE, where the damping factor d should be chosen as a random quantity uniformly distributed in [800, 1200]:

$$m\,\ddot{x}(t) + d\,\dot{x}(t) + k\,x(t) = 0$$

$$x(0) = 0,\ \dot{x}(0) = 0.1,\ k = 9000,\ m = 450$$

The task is to calculate a sample of r = 1000 results $x(t, d_i)$ of the motion (Figure 1 shows $x(t, 1000)$) and to calculate the mean motion $x_{mean}(t)$ over the time interval [0, 2] with a resolution (stepsize) of 0.01 (n = 200 steps):

$$x_i(t) = x(t, d_i), \quad i = 1, \ldots, r$$

$$x_{mean}(t) = \frac{1}{r}\sum_{i=1}^{r} x_i(t) = \frac{1}{r}\sum_{i=1}^{r} x(t, d_i)$$

As the model is a linear one, the solution can be provided also analytically, not only by using an ODE solver:

$$x(t,d) = Ke^{-\alpha t}\sin(\omega t)$$

$$\alpha = \frac{d}{2m},\ \omega^2 = \frac{k}{m} - \alpha^2,\ K = \frac{\dot{x}(0)}{\omega}$$

$$x_{mean}(t_j) = \frac{1}{r}K\sin(\omega t_j)\cdot\sum_{i=1}^{r} e^{-\frac{d_i}{m}t_j},\ j = 1, \ldots, n$$

While the ODE may be basis for a parallelisation of the varying damping factor, the analytical formula may be a basis for parallelisation of the 201 time instants, where a solution is to be calculated.

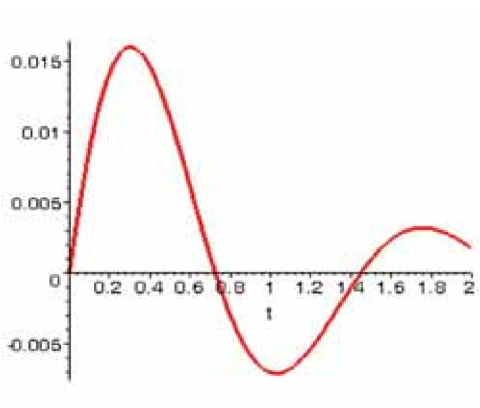

Figure 1: Plot of the analytical solution of the second order mass – spring system with d = 1000.

For documentation, we ask for a precise description of the parallelisation strategy used, and for comparison of the solutions we ask for a plot of the mean motion $x_{mean}(t)$ and of values for the speed-up factors $\boldsymbol{f}$.

C2 Case Study 2 Lattice Boltzmann Simulation

The second case study addresses the *Lattice Boltzmann Method* (LBM) for fluid flows, which is widespread in parallel simulation domains today. The purpose of the Lattice Boltzmann Method is to simulate fluid behaviours in complex geometries efficiently in parallel. Traditional fluid simulations, which are based on numerical solutions of the Navier Stokes equations have limited parallel potential and can hardly handle complex. geometries.

The Lattice Boltzmann Method ([2]) is derived from the *Lattice Gas* (*Cellular*) *Automata* (LGA), a cellular automata approach which considers single particles on lattice nodes. In contrast to LGA, LBM deals with distribution function values instead of single particles. The exact denomination for the Lattice Boltzmann Method is *Lattice Boltzmann BGK Method* (LBGK), caused by the special collision operator being introduced by Bhatnager, Gross and Krook in 1954.

In lattice gas cellular automata, space, time, particle velocity, and particle occupation state are all discrete. In LBM and LBGK, particle occupation state on nodes is replaced by single-particle distribution functions (real valued).

In 2D square LBM, a square lattice with unit spacing is used. Each node has eight nearest neighbours being connected by eight links (see Figure 2). Particles on nodes move along the axes and along the diagonals with discrete speed, furthermore, non moving particles with speed zero are allowed. The occupation of particles is represented by a single-particle distribution function. The distribution function represents the probability to find a particle at a certain node.

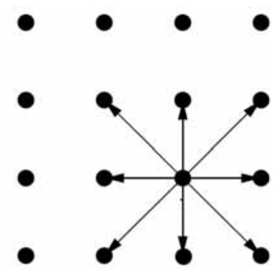

Figure 2: Nearest neighbour links of a lattice node.

The Lattice-Boltzmann BGK equation equals particle propagation terms and particle collision terms. In simulation, in each time step, two operations have to be performed: collision and propagation due to the equations ([3]).

The case study is based on on a special problem in fluid dynamics, the famous cavity flow problem published by Hou et al. in J. Comput. Physics ([4]), where the behaviour of an incompressible fluid in a square enclosure, driven by a constant stream on the top boundary is examined (see Figure 3).

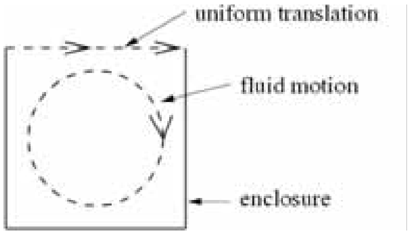

Figure 3: Lid-driven cavity flow.

For a description of the geometry matrix g, cell types are divided into wall cells (W), driving cells (D) and fluid cells (F). For a lattice size of 2×2, the matrix g is given in the following:

$$g_{2,2} = \begin{pmatrix} D & D & D & D \\ W & F & F & W \\ W & F & F & W \\ W & W & W & W \end{pmatrix}$$

The uniform translation on top of the cavity is given as $u_{0x} = 0.1$, $u_{0y} = 0$, where the Reynolds number is $Re = 1000$. At any grid point, the initial macroscopic velocity is $u_x = 0$, $u_y = 0$ and the initial density is $\rho = 1$.

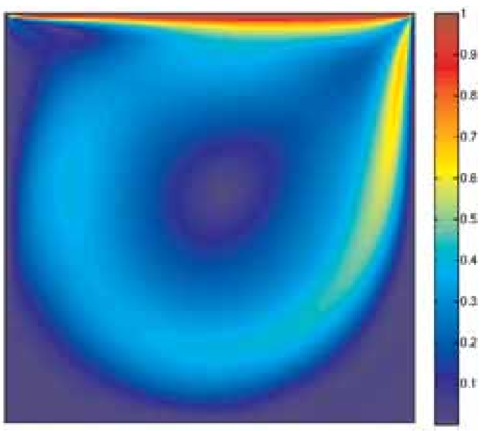

Figure 4: Relative macroscopic velocity magnitude (u/u_0) in cavity flow after 350000 iterations on a 257x257 grid.

The task is, to simulate the cavity flow with lattice size 257×257 for a number of 350.000 iterations. After this number of iterations, steady state is reached. Simulation results are shown in Figure 3.

For documentation, we ask for a precise description of the parallelisation strategy used, and for comparison of the solutions we ask for a plot of relative macroscopic velocity magnitudes (u/u_0) at steady state and for values of the speed-up factors f (please note, that also a serial solution is necessary for this purpose).

A problem discussion in detail and links to sequential reference implementations as well as to introductory materials for the lattice Boltzmann method are provided at WWW.MB.HS-WISMAR.DE/CEA/LBM.

C3 Case Study 3 – Solution of a Partial Differential Equation

The third case study is based on a second order partial differential equation describing a swinging string with length L fixed at both ends, excited at the beginning

$$u_{xx}(t,x) = \frac{1}{v^2} u_{tt}(t,x)$$

One approach for solving this PDE is the method of lines, using discretisation of space. Discretising the space into N equidistant intervals and replacing the differential quotient $u_{xx}(t,x)$ by a central difference quotient, a set of weakly coupled ODEs replaces the PDE:

$$u(0,t) = u(L,t) = 0, \quad u_t(x,0) = 0$$
$$u(0 \le x \le \frac{L}{2}, 0) = 2\frac{h}{L}x, \quad v = 0.6, \quad L = 0.5, \quad h = 0.05$$
$$u(\frac{L}{2} \le x \le L, 0) = 2h(1 - \frac{1}{L}x)$$

$$\frac{k^2}{v^2}\ddot{u}_i(t) = u_{i-1}(t) - 2u_i(t) + u_{i+1}(t), \quad i = 1, N-1$$
$$u_i(0) = 2\frac{h}{N}i, \quad i = 0, \ldots, \frac{N}{2},$$
$$u_i(0) = 2h(1 - \frac{i}{N}), \; i = \frac{N}{2}, \ldots, N, \quad \dot{u}_i(0) = 0$$

Also an analytical solution (approximation) can be calculated because of linearity. A classical separation approach $u(t,x) = X(x) \cdot T(t)$ can be used for calculating the solution.

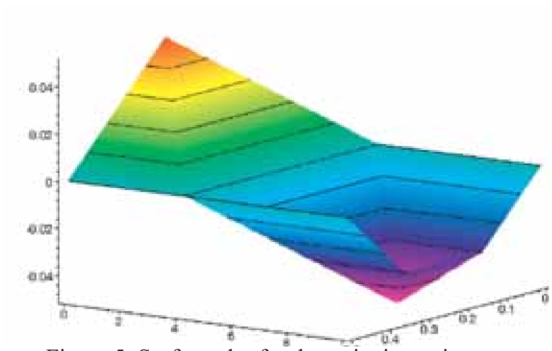

Figure 5: Surface plot for the swinging string – excitation in dependency of space and time.

This yields with given initial and boundary conditions a solution with a Fourier series ([5]):

$$u(x,t) = \frac{8h}{\pi^2}\sum_{j=0}^{\infty}\frac{(-1)^j}{(2j+1)^2}\sin\left(\frac{(2j+1)\pi x}{L}\right)\cos\left(\frac{(2j+1)\pi v t}{L}\right)$$

Figure 5 shows a surface plot of the solution, Figure 6 and Figure 7 show solution lines in x and t, calculated with Fourier series (series cut at 100 summands).

In principle, also discretisation of space and time may be suitable. For instance, using for space discretisation a central difference quotient as in method of lines, and using for time backwards difference quotients (as well for PDE and for initial condition) yields a linear system for $u(t_k, x_i)$, which may be parallelised for solution. Of course, other algorithms for solving the PDE may be used, with varying grids etc, which can be parallelised or distributed appropriately.

In general, the system is to be solved with a spatial discretisation of $N = 500$ lines at the interval [0, 10] with time discretisation of 0.01s (m = 1000 steps).

For documentation, we ask for a precise description of the parallelisation strategy used, and for comparison of solutions we ask for plots of the lines

$$u(x = 3L/4,\ t),\quad u(x = L/2,\ t)$$
$$u(x,\ t = 15),\quad u(x, t = 30),$$

and of a surface plot (excitation versus space and time). Furthermore, give values for the speed-up factors $\boldsymbol{f}$.

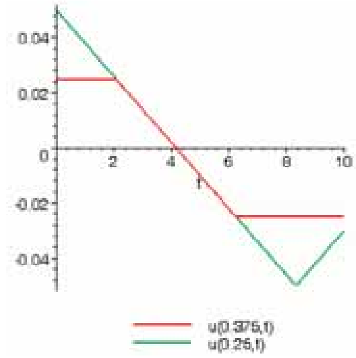

Figure 5: Solution of the PDE, excitation over time at x = 0.375 and x = 0.25.

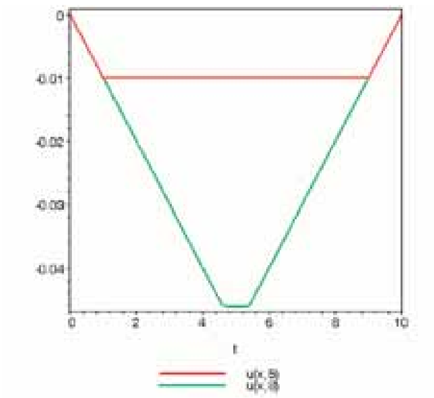

Figure 7: Solution of the PDE, excitation over space at t = 5 and t = 8.

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Petri Net Modelling of Different Strategies in ARGESIM Comparison C4 'Dining Philosophers' with HPSim

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Simulator: *HPSim* is a simple Petri Net Simulator developed by Henryk Anschuetz in the context of a study. It has a graphical editor which provides basic editing and simulation of Petri Nets, and is useful for beginners - such as students - in order to get familiar with Petri Nets. The program is a win32 application developed in C++; it can be downloaded for non-commercial purposes at WWW.WINPESIM.DE free of charge.

HPSim provides an editor, a simulator offering token game animation and CSV file outputs, and is capable to simulate non-coloured place-transition networks with different kinds of edges and transitions (including means to stochastic simulation). Time units are given in milliseconds.

Modelling. The classic *Dining Philosophers Problem* describes a group of five philosophers sitting around a dining table, competing for food. There are five chopsticks on the table, each one between two philosophers.

When a philosopher gets ready to eat after some time of meditation, he first takes the chopstick on his right side, then the left chopstick, and begins to eat. Once finished, the chopsticks are laid back to their original places and the philosopher falls back into meditation. Since there exist only five chopsticks for five philosophers, conflicts are to be expected. This model serves as an analogy for competing computer processes and as the standard example for deadlock.

Figure 1 shows this basic model implemented in HPSim's model editor.

Simulation of Classic Model. For simulation, the classic model (Figure 1) has to be parametrised.

Meditation spans are implemented via stochastic transitions (hollow rectangles), all uniformly distributed with a range from 0 to 4 ms. Every philosopher takes 1 ms to eat; all other transitions are of type *Immediate* (black rectangles).

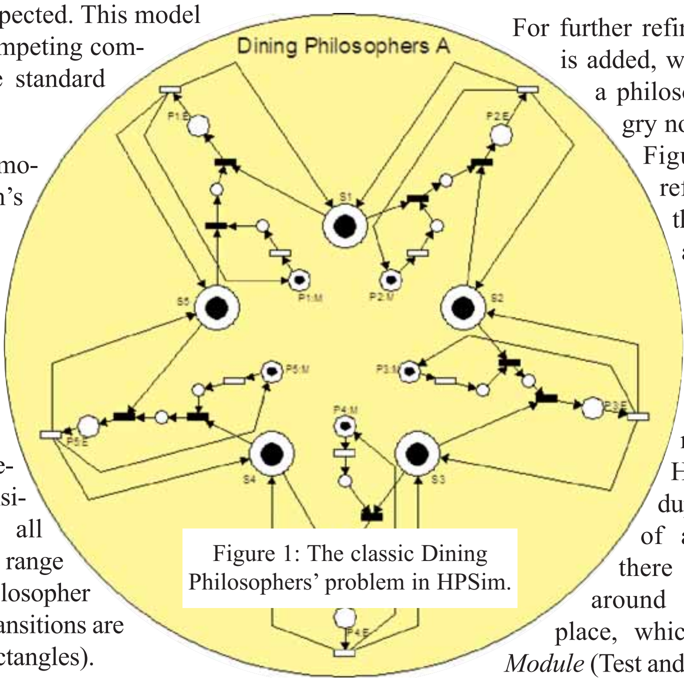

Figure 1: The classic Dining Philosophers' problem in HPSim.

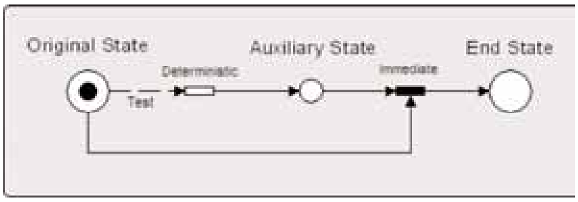

Figure 2: TF Module (for Test and Firing).

As is well known, sooner or later a deadlock situation takes place, where all five philosophers grab the sticks to their rights at the same time and wait for the left ones to become available - forever. At this time, HPSim stops the simulation with the exception 'Error: Deadlock at Time:'. The deadlock is detected when it occurs, but HPSim does not provide means to preemptive deadlock prevention or alge-braic analysis - it is a rather simple tool, well suited for relatively simple problems and great for visualisa-tion through its flow-animation eye candy.

Hunger and Death. For a first refinement, the state *hungry* is introduced. Whenever a philosopher stops meditating, an additional token is fired onto a *hungry* place. Once he has snatched both sticks, the hungry state releases the token. So now, a philosopher is always in one of these three main states: *meditating*, *hungry*, or *eating*.

For further refinement, a *dead* state is added, which gets filled once a philosopher has been hungry non-stop for 150 ms. Figure 3 shows these refinements displaying the *dead* states inside a red circle.

Implementing the test for 150 milliseconds together with a firing in one place is not possible in HPSim, since *Test* arcs duplicate tokens in case of a match. However, there is a simple workaround using an auxiliary place, which we will call *TF Module* (Test and Firing), see Figure 2.

Cleaning the Chopsticks. In this variation, chopsticks get dirty after use. The dirty sticks are laid back on the table, and have to be cleaned by the next person who grabs them. This process is realised by changing the *Immediate* transitions to *Deterministic*. To gather more interesting results, three philosophers need 6 ms for the cleaning process, while the other two only require 2 ms. This inequality leads to starvation and three dead philosophers at the end of the simulation.

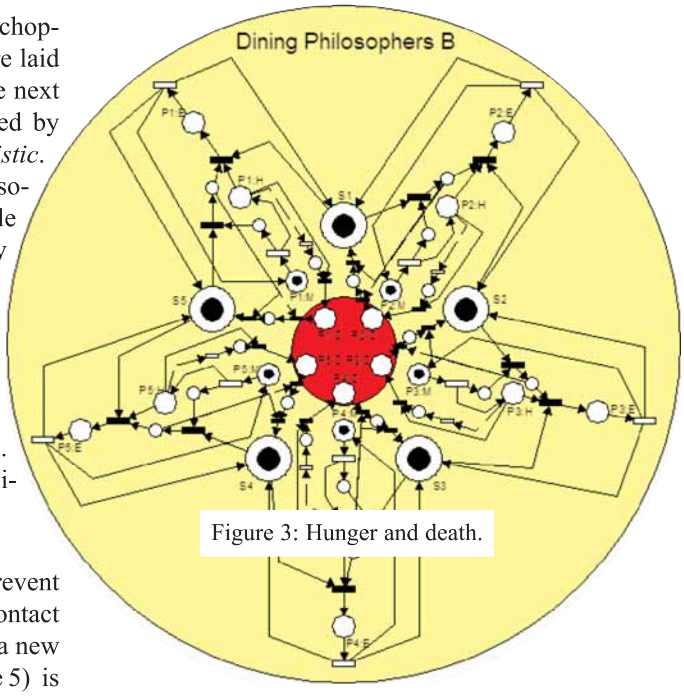

Figure 3: Hunger and death.

Conspiracy. Here, all philosophers need 2 ms for cleaning, but two decide to conspire against the one sitting between them. HPSim provides *Inhibito*r arcs, enabling inhibition of transitions.

Big Hunger and Communication. To prevent starvation, philosophers are now able to contact their neighbours in case of big hunger. For this, a new state - *very hungry* - (orange circles in Figure 5) is introduced, which is getting filled after 30 ms of hunger.

A very hungry philosopher takes the right chopstick immediately after his right neighbour has dined; the left chopstick is given to him by his left neighbour right after cleaning. This strategy prevents starvation and death.

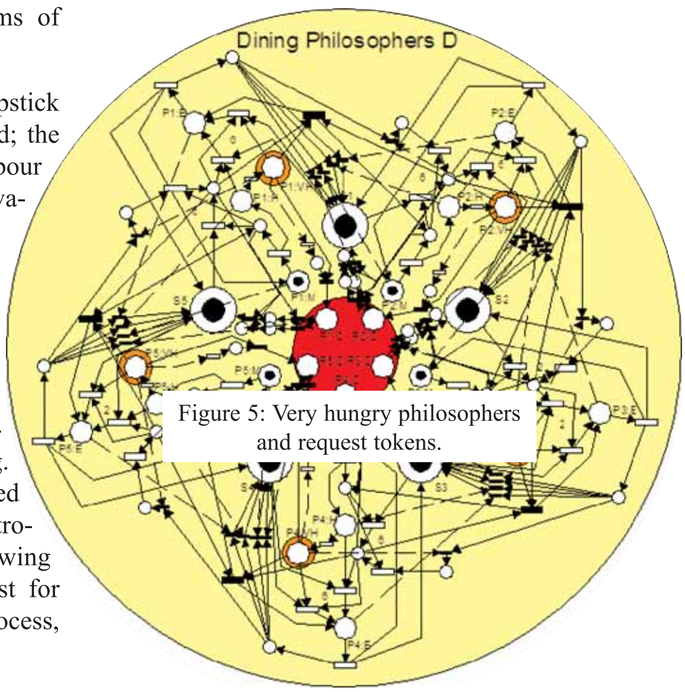

Figure 5: Very hungry philosophers and request tokens.

Resume: The Dining Philiospers problem is analysed by a classical Petri modelling approach using HPSIM, a simulator for simple Petri net modelling and simulation a introductory level. Time is introduced by means of holding transitions which consume time until firing. Simulation of the basic model shows the expected deadlock occurence. The model is refined by introducing additional states *(very) hungry*, allowing deadlock prevention and strategies like request for chopsticks, and by implementing a cleaning process, allowing control for starvation and conspiracy.

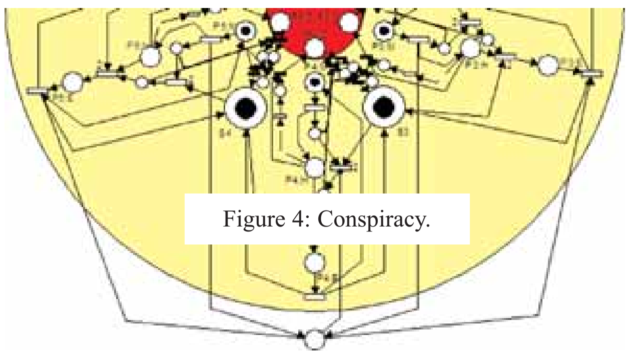
Figure 4: Conspiracy.

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A Process-oriented Solution to ARGESIM Comparison C6 'Emergency Department' using WebGPSS

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Simulator: *GPSS* (General Purpose Simulation System) introduced the transaction-flow modelling paradigm. Under this paradigm, active *consumer* objects, called transactions, travel through a block diagram representing a system, competing for the use of passive *server* objects. This modelling paradigm is extremely general and has been adopted in a large number of simulation languages. At the Stockholm School of Economics, a simulation tool called *micro-GPSS* has been used by almost all students during more than a decade. Micro-GPSS is a streamlined version of GPSS, which, seen over time, is the package for discrete-event simulation that has been most widely used. Micro-GPSS has been focussed on being very easy to learn and use. Micro-GPSS has been developed by Professor Ingolf Ståhl on the basis of feedback from over 5000 students.

A new version presented here, *WebGPSS*, uses a web-based GUI for the very simple input of programs. The main idea behind WebGPSS was that it should be so simple that it could also be used in high schools. For this purpose, it has also been regarded as important to provide this tool freely available on the Web.

Modelling. An emergency department is modelled, where four kinds of causalities are admitted. Their way trough *Causality Ward*, *X-ray* and *Plaster Room* depends on the severity of their wounds. Figure 1 shows a screenshot of the WebGPSS GUI. Here the user can build simulation models by adding blocks and changing different parameters. There are 16 buttons, corresponding to the 16 different blocks, and a button to start the simulation.

A WebGPSS program has two types of representations: the graphic one as a block diagram, and a textual one, which is the 'classic' way of representing a GPSS program. Figure 1 also shows the so called *block diagram* of the model. The different treatment points are implemented as blocks and the patients (the processes) are represented through the so called *transactions* which are generated in the GENERATE Blocks. Depending on several conditions the transactions are finding their way through the system.

In this model special values are assigned to the generated transactions, telling which kind of patient the transaction represents. Depending on these values, the transaction makes its way trough the system. Every time a patient transaction exits a treatment point new routing values are assigned.

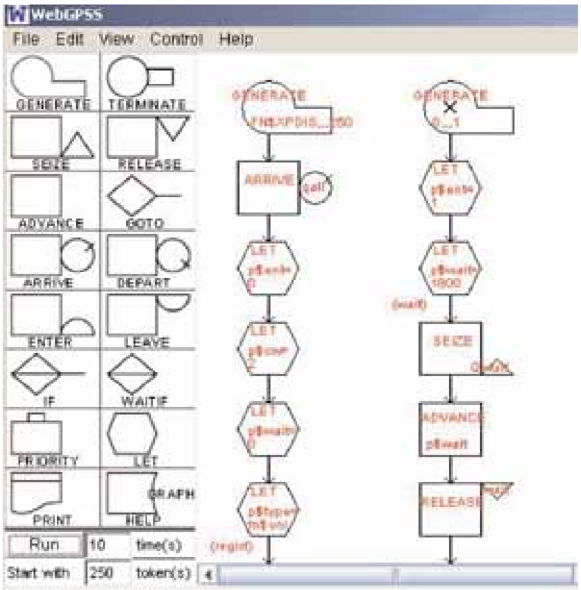

Figure 1: Screenshot of part of WebGPSS model for causality ward system.

Unfortunately, WebGPSS offers only five built-in statistical functions which are not really programmed in a general way. Thus, the necessary distributions are realised through discrete probability density functions provided in WebGPSS. Figure 3 shows the triangular distribution for the treatment time of casualty ward 1.

Another disadvantage of WebGPSS is the limitation of the possible program lines. Only 500 rows of code are accepted for modelling. Otherwise the following error occurs: *Program has too many statements*.

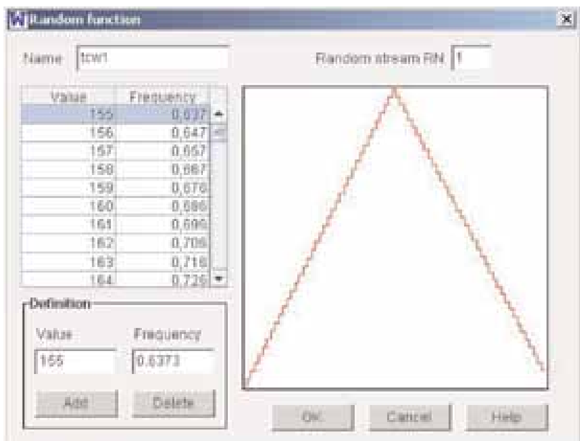

Figure 2: Discrete random density function of WebPPSS used for triangular distribution.

For the purpose and the aim of WebGPSS itself the restriction of lines is not really a problem because the user can build very easily big models using the built-in functions of the program.

A very tricky part of modelling was the implementation of the doctor's starting time. Patients start arriving at 7.30 a.m. and queue for registration. Doctors start work at 8.00 a.m. All patient transactions get a value 'wait' which is set to zero. One extra transaction is created at the beginning with value 'wait' equal to 1800 seconds. All patient transactions have to wait in the queue QWAIT of the SEIZE Block until the extra transaction leaves the FACILITY Block. Now the doctors start their work and the patient transactions can pass the FACILITY Block without loosing time.

Figure 3: Model part for doctors' delay at begin.

The statistical evaluation is automatically performed by WebGPSS and shown in the *results window* after the simulation.

A-Task: Simulation – Average Treatment Times. In WebGPSS, a single simulation run is started within the GUI by pressing the 'Run' button. At the end of the simulation the *results window* is opened where all needed results are generated automatically. Depending on the type of patient the treatment time takes between 94 and 220 minutes (results Table 1).

B - Task: Doctors' Exchange Strategy. The model has to be extended by several IF and GOTO blocks, see Figure 5, to model the check points for testing the queue lengths of the causality wards and to route the transactions to the correct doctor block. The difficulty is to implement each doctor as FACILITY Block instead of two STORAGE blocks to realise the exchange of the two doctors. As soon as the queue before causality ward 2 contains more than 20 patients the more experienced doctor takes over.

This strategy yields an increase of treatment times for all types of patients, for the standard deviation and also for the overall treatment time (see Table 1).

C - Task: Priority Ranking. Priority ranking is a standard feature of WebGPSS. PRIORITY blocks can be used to give entities (transactions) a priority, which can be used as ranking order in queues or in front of other blocks. Priorities are set after leaving the causality wards after treatment (Figure 5).

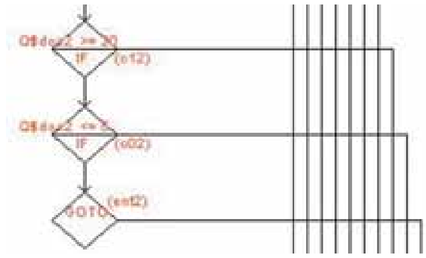

Figure 6: Doctors' exchange strategy modelled by IF and GOTO blocks.

The transaction PRIORITY is used for ranking in front of the causality ward blocks to prioritise patients of type 1 and type 3 if they are visiting the causality wards a second time. Results (Table 1) show a decrease in treatment time for patients of type 1 and type 3, an increase for the others. Standard deviation and the overall treatment time decrease.

Figure 5: Block for priority modelling

Mean time	**Task A**	**Task B**	**Task C**
patient 1	192	195	122
patient 2	96	119	118
patient 3	220	233	134
patient 4	94	94	122
Std. dev.	88	91	87
ov.treat.time	343	363	342
close hour	13:43	14:03	13:42

Table 1: Results for Task a -c: mean of treatment times, standard deviation and closing time.

Resume: This solution is based on classical process-oriented modelling using the WebGPSS, a simplified version of GPSS mainly for educational purposes. As special features for parametrisation of model blocks are not available, given input distributions and the doctors's delay have to be implemented additionally (GUI for random distributions, DELAY submodel). Doctors' exchange stategy requires a nontrivial model extension by using coupled single resources for each doctor, instead of using multiple resources for the ward. However, modelling of priority is a standard feature.

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A Dymola-Implementation of Benchmark C9R 'Extended Fuzzy Control of a Two-Tank System' with Directly Programmed Fuzzy Control

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Simulator: *Dymola* 5.3d, Dynamic Modeling Laboratory, is an object oriented simulation environment for acausal modeling, simulation and visualisation of continuous, hybrid and discrete models. Dymola is able to understand Modelica, a unified textual and graphical modelling language offering many libraries for applications (WWW.DYNASIM.COM).

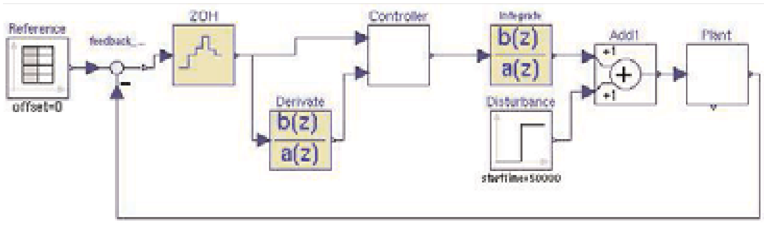

Figure 1: Dymola / Modelica model of the overall system.

Modelling. The model of the whole system was build by using standard blocks from the Modelica Standard Library, except model of the fuzzy controller. The model is composed of the *Controller* model, the *Plant* model, and standard blocks from the Modelica Block Library (zero-order-hold, discrete transfer function, and sources; Figure 1). The plant model is described textually by the system governing ODEs using Dymola notation, put into a graphical block.

No tool for fuzzy control is supplied in Dymola (5.3d), neither in the standard Modelica library (2.2). The fuzzy control has to be programmed directly in Dymola, using the `algorithm` section. The fuzzy controller model is hierarchically comprised from simpler blocks, integrated into a graphical block (Figure 2).

The input fuzzification block is made up of blocks which represent single fuzzy set and linearly interpolate input provided by parameters in a table:

```
parameter Real values[2];
parameter FuzzySetMembership membership[2];
algorithm
  if u <= values[1] then y := membership[1];
  elseif u <= values[2] then
      y := interpolate(values,membership,u);
  else y := membership[2];
end if;
```

Inputs and outputs are routed to input and output of the parent block respectively. The same holds in case of output blocks where two outputs, center and surface must me provided by each block:

```
 parameter FuzzySetMembership height = 1.0;
 parameter Real points[3];
protected
 parameter Real C =
        points[2]+points[3]+points[1])/3
 parameter Real S =
          height*(points[3]-points[1])/2;
algorithm
 center := C;
 surface := membership * S;
```

All outputs are then routed to a block which calculates the output by center of gravity formula, and finally, the interface engine block is implemented as an explicit set of rules due to only four simple rules:

```
   y = sum(vars*weights) / sum(weights);
 algorithm
   y[1] := set_h[1]; y[4] := set_h[3];
   y[2] := set_h[2] * set_v[2];
   y[3] := set_h[2] * set_v[1];
```

All components (input/output blocks and interface engine) are then connected to the controller model `ProcessModelFC1` as depicted in Figure 2. As the control is programmed directly, I-FC1 and I-FC2 are implemented very similar. The controller model is a discrete Dymola model, which can be used standalone or in combination with other Dymola models.

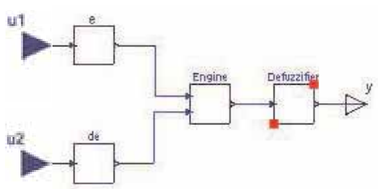

Figure 2: Controller, Dymola blocks.

A-Task: Controller Surfaces. The stand-alone con-troller model, with a discrete ramp signal on both inputs of the fuzzy controller, calculates the controller surface (control calculated at 2.500 points). For plotting the results, due to lack of any 2-D plotting abilities of Dymola, MATLAB was used. Data from MATLAB's file `SurfaceFC1.mat` that Dymola produces were extracted with help of `dymload.m` and `dymget.m`. The vectors need to be reshaped into a 2D matrix, which is suitable for surface plotting in MATLAB. Figure 3 shows the control surfaces: after rescaling, the shapes for I-FC1 (max. 5) and I-FC2 (max. 2) look very similar, but I-FC2 calculates significantly lower control values (slower control action).

B- Task: Transient Response. The sources (Figure 1) are defined as table (`Reference`) and as step function (`Disturbance`). Simulation is done in the Dymola menu-driven environment, which also produces the result plots (Figure 4 for I-FC1). For simulation of I-FC2, in the controller model the output defuzzifier of the control was redeclared and replaced by singleton defuzzifier:

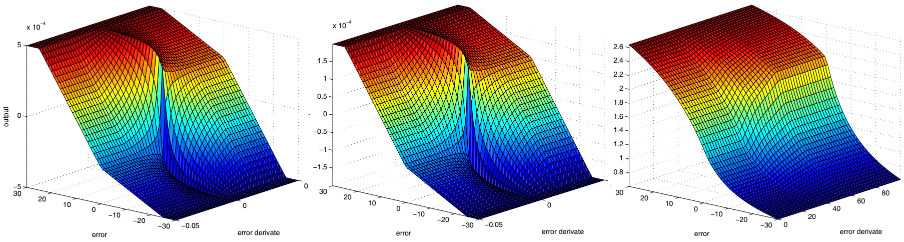

Figure 3: Control surfaces for I-FC1 (a - left), I-FC2 (b - midst) and P-FC (c - right)

```
model ProcessModelFC2
extends ProcessModelFC1(Controller(redeclare
        Components.FuzzyOutput_Singleton
        Defuzzifier));
end ProcessModelFC2;
```

Results for I-FC2 in Figure 5 show, that due to lower gain the response is slower and that also the overshot is smaller, compared with I-FC1.

C-Task: Comparison with Proportional Fuzzy Controller. To model the proportional fuzzy controller P-FC, input and output fuzzy block and the interface engine need to be rebuild (different membership functions, different rule base), but the base input (and output) fuzzy set blocks can be reused and almost no code needs to be written additionally.

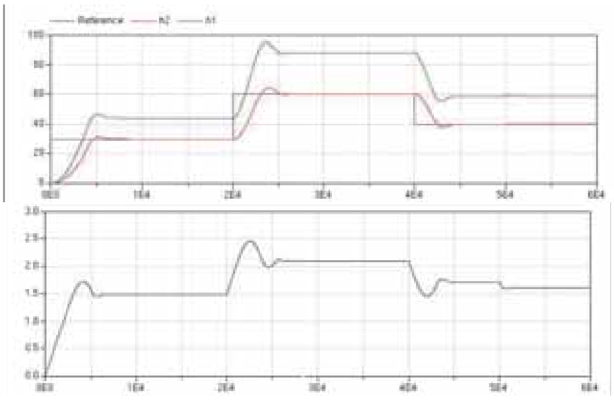

Figure 4: State variables h_1, h_2 and reference signal (upper) and control signal (lower) over time for I-FC1.

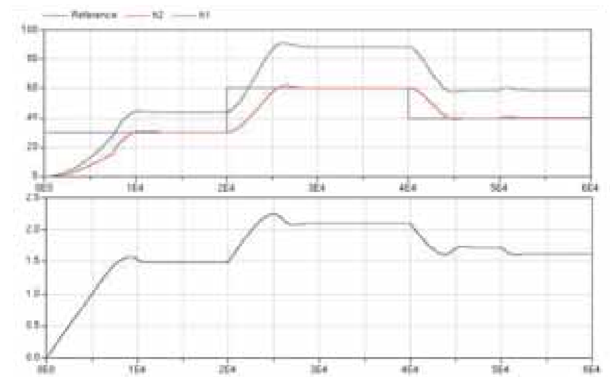

Figure 5: State variables h_1, h_2 and reference signal (upper) and control signal (lower) over time for I-FC1.

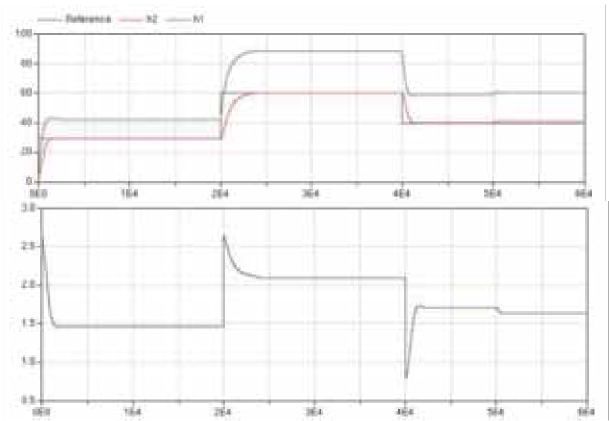

Figure 6: State variables h_1, h_2 and reference signal (upper) and control signal (lower) over time for P-FC.

The overall model becomes simpler, because the discrete transfer functions can be omitted, whereby the controller input has to be changed to $e(t)$ and $h_2(t)$.

The control surface (Figure 3c) is calculated by the modified stand-alone P-FC controller model and plotted in MATLAB. Figure 6 shows the results for time domain. While the control surface for P-FC is smoother (max. control 2.6), the control itself is discontinuous and the disturbance cannot be compensated because of the missing integral action. As advantage, this controller reacts faster.

Résumé: In this Dymola / Modelica solution, for plant model and for the discrete control structure standard Modelica blocks are used. Fuzzy control has to be programmed directly in textual Modelica code, making use of table function features and of very similar structure for all controller types. The Dymola fuzzy control model can be used standalone, computing control values for arbitrary input values directly. Experiments are controlled by table functions.

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A Modelica Approach to ARGESIM Benchmark 'Crane and Complex Embedded Control' (C13R) using the Simulator Dymola

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Simulator: *Modelica* is a new modern standard for defining dynamic models in an a-causal manner. *Dymola* is an simulator being able to process Modelica model descriptions. Modelica's textual frame offers constructs for defining models in an object-oriented language, whereby implicit structures may be used. Basic models for typical dynamic behaviour may be embedded into graphical blocks and compiled as Modelica Library (some freely available; WWW.MODELICA.ORG). The simulator *Dymola* comes with comprehensive Modelica application libraries and offers advanced features for time domain analysis (index reduction methods, solvers for DAEs, sophisticated state event handling, etc.). At experiment level, Dymola comes with limited features - here a MATLAB interface may be used.

Model. The nonlinear crane was modelled using the *Multi-Body Library* of Modelica 2.2. Only graphical blocks representing mechanical devices have to be connected following the physical relations (Figure 1): a prismatic joint, in parallel with a damping element are coupled with the mass element Car - defining the car movement; the car mass is coupled via a swiwel joint and a bar element with the mass Load - defining the swinging load. Dymola translates this graphical model by symbolic transformations into an implicit model (DAE model). The resulting nonlinear equations are mathematically equivalent to the given nonlinear implicit model (different states).

It is not necessary to transform this implicit model to an explicit one, or to add terms for braking the implicit equations, because Dymola does time domain analysis with DAE solvers.

The linear crane model and the motor model were implemented using the *Modelica Block Library* (transfer functions and blocks like in SIMULINK for causal modelling; Figure 2). All digital controller actions and sensor actions were modelled textually and embedded into an Controller and Diagnosis block (Figure 3), to be linked with inputs, with motor model and with nonlinear crane model (Figure 4).

Fig. 3: Selfdefined block, embedded textual control

Modelica's function `sample` and the `pre(.)` function (giving the previous sampled value of the argument) were used for modelling the digital controller with a fixed `sample_time` of 10 ms:

```
algorithm
  when sample(0, sample_time) then
    q := (M - d*c)*pre(q) +
        + b*pre(fcDesired) + d*pre(PosCar);
    y := h*q; u := k*PosDesired - y[1,1];
    fcDesired := max(min(u, ForceMax),
                        -ForceMax);
  end when;
```

A - Task: Nonlinear vs. Linear Model. Linear and nonlinear model were simulated independently until $t = 2.000$ s (steady state), the inputs were modelled as table functions for $f_c^{Desired}$ and f_d. Final values for x_l (Table 1) show very small differences.

Dest	x_l nonlinear	x_l linear	difference
-750	294.041	294.075	-0.034
-800	0.008	-0.005	0.013
-850	-294.112	-294.096	-0.016

Table 1: Steady state differences of nonlinear and linear calculated positions of load.

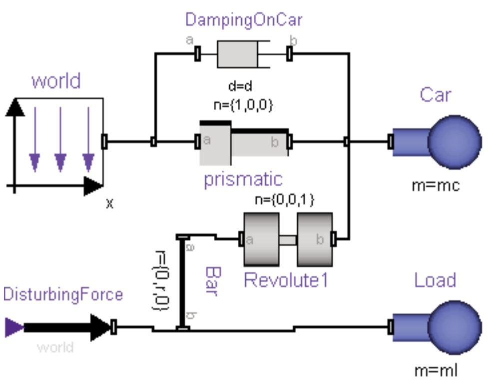

Figure 1: Nonlinear crane model implemented with Modelica MultiBody Library.

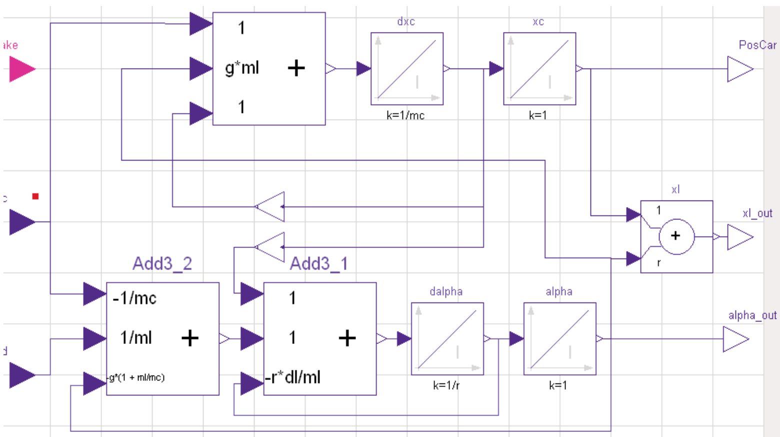

Figure 2: Linear crane model implemented with Modelica Block Library.

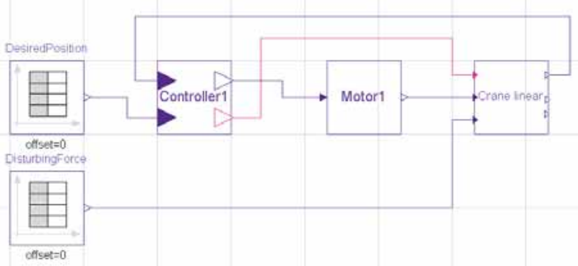

Figure 4: Inputs, controller model, motor model and nonlinear crane model connected to overall control model.

B - Task: Controlled System. Digital control is extended by brake condition, to be checked in every cycle of the digital control. A variable `ts`, representing the time since the brake condition holds, is updated accordingly and used for controlling the brake:

```
when sample(0, sample_time) then
  q := (M - d*c)*pre(q) + b*pre(fcDesired)
                        + d*pre(PosCar);
  y := h*q; u := k*PosDesired - y[1,1];
  ts := if (abs(vc) < BrakeCondition) then
            pre(ts) + sample_time else 0;
  Brake := if(ts>=3) then true else false;
  fcDesired := if Brake then 0 else
          max(min(u, ForceMax), -ForceMax);
```

Brake action is implemented by defining a conditional friction coefficient in the nonlinear crane model:

```
dc_var = if Brake then dc_Brake else dc;
```

Change of set point `PosDesired` and 1s - disturbances `fd` were modelled by table functions (Figure 4). Simulation results for the given scenario in Figure 5 show:

i) reliable control action (x_c and x_l close together),
ii) fast deflection of angle α at set point changes,
iii) brake action at $t = 35$ s caused by control treshold, followed by immediate break release caused by new setpoint at $t = 36$ s, and
v) significant deflection of angle α caused by disturbance on load at $t = 42$ s, and as consequence a bigger deviation of x_c and x_l ,
vi) but return to steady state (reached at t = 50 s).

C - Task: Controlled System with Diagnosis. A separate `when`-clause in the digital controller handles the emergency stop:

```
algorithm
 when ((PosCar>PosCarMax) or (PosCar<PosCarMin))
      then EmergencyStop := true; end when;
 when sample(0, sample_time) then .......
  ts := .......;
  Brake := if (EmergencyStop or (ts >= 3))
           then true else false;
  fcDesired := .....;
 end when;
```

Results for the diagnosis scenario in Figure 6 show:

i) - v) until $t = 46$ s same behaviour as in Task B,
vi) second disturbance at $t = 46$ s in opposite direction causes fast increase of angle α, followed by dropout of x_l and x_c, and consequently
vii) emergency stop as x_c reaches `PosCarMax` - the break fixes the car, but angle α and x_l oscillate

Resume: This Modelica / Dymola solutions makes use of different modelling paradigms. The linear dynamics are modelled by Modelica's causal Simulink-like library, nonlinear dynamics by Modelicas a-causal mechanical library. Digital control and sensor actions are implemented textually into Dymola blocks using dicrete features, and graphically composed to digital control. The nonlinear implicit equations are solved by Dymola's implicit solver, and the complex scenarios are modelled by input table functions, simulating different set points and disturbances over time.

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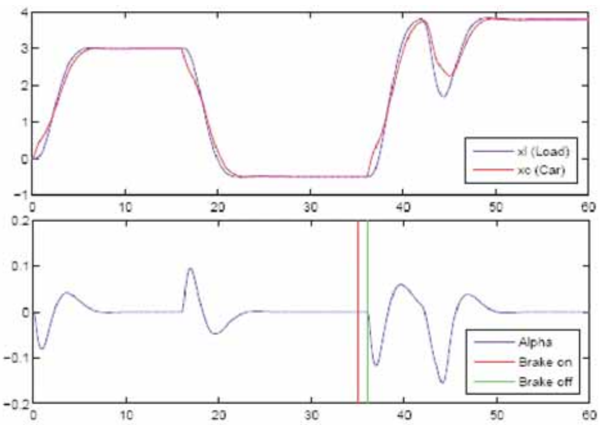


Figure 5: Time domain results for controlled model, with brake action.

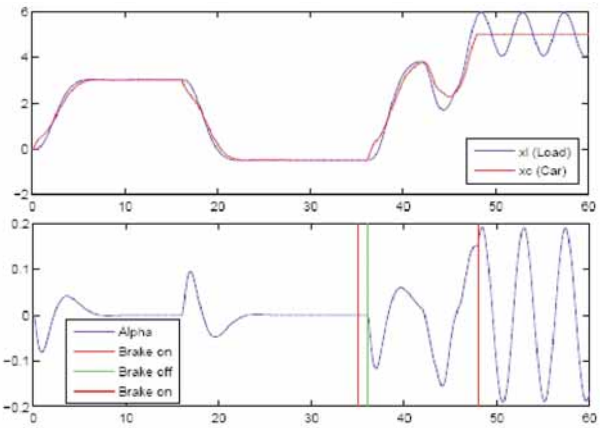


Figure 6: Results for diagnosis experiment (the second brake-on event is due to an emergency stop).

SNE NEWS SECTION

CONTENT

SNE - Simulation News Europe is the official journal of EUROSIM and sent to most members of the EUROSIM Societies as part of the membership benefits. Furthermore **SNE** is distributed to other societies and to individuals active in the area of modelling and simulation. SNE consist of a *Notes Section* with peer reviewed contributions, supervised by an international editorial board (*SNE Editorial Board*) and a *News Section* with news from EUROSIM Societies and other societies dealing with modelling and simulation, and with industry news. Contributions to the *News Section* are provided by the members of the *SNE News Editorial Board*. SNE is registered with ISSN 1015-8685. Circulation of printed version is 3.000 copies.

SNE at Web – recent issues of SNE are also available via internet at WWW.ARGESIM.ORG. Members of EUROSIM Societies may access to the SNE Archive.

SNE NEWS EDITORIAL BOARD

If you have any information, announcement, etc. you want to see published, please contact a member of the editorial board in your country or *sne@argesim.org*.

Editorial Information / Impressum - see front cover, inside

EUROSIM and EUROSIM Societies

EUROSIM - Federation of European Simulation Societies

General Information. *EUROSIM*, the Federation of European Simulation Societies, was set up in 1989. The purpose of EUROSIM is to provide a European forum for regional and national simulation societies to promote the advancement of modelling and simulation in industry, research, and development.

- WWW info EUROSIM: www.eurosim.info

Member Societies. EUROSIM members may be national simulation societies and regional or international societies and groups dealing with modelling and simulation. At present EUROSIM has eleven full members and three observer members:

- ASIM - Arbeitsgemeinschaft Simulation (Austria, Germany, Switzerland)
- CROSSIM - Croatian Society for Simulation Modelling (Croatia)
- CSSS - Czech & Slovak Simulation Society (Czech Republic, Slovak Republic)
- DBSS - Dutch Benelux Simulation Society (Belgium, The Netherlands)
- FRANCOSIM - Société Francophone de Simulation (Belgium, France)
- HSS - Hungarian Simulation Society (Hungary)
- ISCS - Italian Society for Computer Simulation (Italy)
- PSCS - Polish Society for Computer Simulation (Poland)
- SIMS - Simulation Society of Scandinavia (Denmark, Finland, Norway, Sweden)
- SLOSIM - Slovenian Simulation Society (Slovenia)
- UKSIM - United Kingdom Simulation Society (UK, Ireland)
- CEA-SMGS - Spanish Modelling and Simulation Group (Spain; Observer Member)
- LSS - Latvian Simulation Society (Latvia; Observer Member)
- ROMSIM - Romanian Society for Modelling and Simulation (Romania; Observer Member)

Contact addresses, weblinks and officers of the societies may be found in the information part of the societies.

EUROSIM Board / EUROSIM Officers. *EUROSIM* is governed by a board consisting of one representative of each member society, president and past president, and representatives for SNE and SIMPRA. The president is nominated by the society organising the next EUROSIM Congress. Secretary and treasurer are elected out of members of the Board:

- President: Borut Zupančič (SLOSIM); *borut.zupancic@fe.uni-lj.si*
- Past President: Yskander Hamam (FRANCOSIM); *y.hamam@esiee.fr*
- Secretary: Peter Fritzson (SIMS); *petfr(@ida.liu.se*
- Treasurer: Felix Breitenecker (ASIM); *Felix.Breitenecker@tuwien.ac.at*
- SIMPRA Representative: Jürgen Halin, *halin@iet.mavt.ethz.ch*
- SNE Representative: Felix Breitenecker; *Felix.Breitenecker@tuwien.ac.at*

SNE - Simulation News Europe. EUROSIM societies are offered to distribute to their members the journal *Simulation News Europe* (**SNE**) as official membership journal. SNE is a scientific journal with reviewed contributions in the *Notes Section* as well as a membership newsletter for EUROSIM with information from the societies in the *News Section*. Publishers are EUROSIM, ARGESIM and ASIM.

- Editor-in-Chief SNE: Felix Breitenecker; *Felix.Breitenecker@tuwien.ac.at*
- WWW SNE: www.argesim.org; www.asim-gi.org, menu *International*

SIMPRA. Members of EUROSIM societies can subscribe the official EUROSIM scientific journal *Simulation Modelling Practice and Theory* (SIMPRA) at a significantly reduced price.

- Editor-in-Chief SIMPRA: Jürgen Halin, *halin@iet.mavt.ethz.ch*
- WWW info SIMPRA: ees.elsevier.com/simpat/

EUROSIM Congress. EUROSIM is running the triennial conference series *EUROSIM Congress*. The congress is organised by one of the EUROSIM societies. EUROSIM 2007 will be organised by SLOSIM in Ljubljana, September 9-13, 2007; EUROSIM 2010 will be organised by CSSS in Prague, September 2010.

- WWW Info EUROSIM 2007: www.eurosim2007.org
- Chair OC EUROSIM 2007: Borut Zupančič (SLOSIM); *borut.zupancic@fe.uni-lj.si*
- Chair IPC EUROSIM 2007: Rihard Karba (SLOSIM); *rihard.karba@fe.uni-lj.si*
- Info EUROSIM 2010: Mikuláš Alexík (CSSS); *alexik@frtk.utc.sk*

Reports of the EUROSIM President

Visit 13th PSCS 2006 Conference

13th PSCS 2006 Conference in Kazimierz Dolny, Sept. 31-Nov.2. 2006

I was invited from the PSCS president Leon Bobrowski. During the conference I presented a keynote lecture but the main aim was for me to obtain more information about PSCS activities and to see whether polish society is interested to fulfil the conditions and to become the full member of EUROSIM. I discussed with many members of PSCS organisation. I obtained a very good impression about PSCS activities and about the conference. There were more than 50 participants, 2 parallel sessions, 4 keynote lectures. The abstracts were published; later selected papers will be published in proceedings – as all previous years from the foundation of the PSCS in 1992. I expressed the EUROSIM intention to accept PSCS as a full member as soon as possible.

In the discussion with prof. Leon Bobrovski it came out that the polish society is highly interested to become the EUROSIM full member. It seems that there are no problems in the sense of fulfilling the mentioned conditions. With regard to financial means - for SNE, PSCS will investigate whether it is possible to obtain some money from the Ministry. The discussion about it will be continued also during the EUROSIM board meeting in Bratislava in Dec. 2006.

Roman Bogacz, Borut Zupančič, Leon Bobrowski (President of PSCS), and Andrzej Tylikowski.

Borut Zupančič, EUROSIM president
borut.zupancic@fe.uni-lj.si

Discussions at Asian Simulation Conference 2006

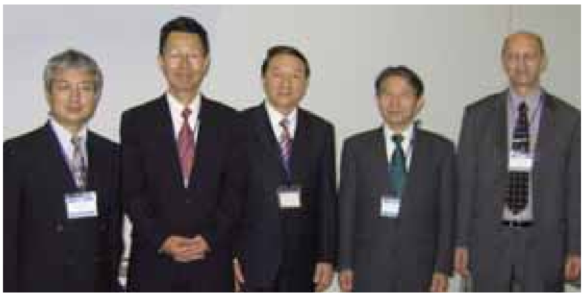
Discussion about the cooperation between EUROSIM, JSST, CASS and KSS

During the Asian simulation conference ASC 2006 held in Tokyo on October 30 – November 1, 2006 four presidents: Prof. Genki Yagawa, the president of JSST - Japan Society for Simulation Technology, Prof. Bo Hu Li, the president of CASS - Chinese Association for System Simulation, Prof. Tag Gon Kim, president of KSS - Korea Society for Simulation and Prof. Borut Zupancic, the president of EUROSIM had a rare opportunity to discuss in such formation about the possibilities for future co-operation. During the opening session each of us had the possibility to present his society and to propose also possibilities for future co-operation. Later we had also a nice opportunity to discuss with some other members of the mentioned societies exploring the possibilities for better cooperation.

We agreed that instead of general cooperation agreement it is better to propose few small but concrete actions which can be realised. Some of the discussed possible actions are:

- Websites: It was proposed that societies would have at list a part of its information in English.
- Links to other societies will be included.
- Websites would have Calendars of events: important events of all cooperative societies can be included. These calendars can enable appropriate coordination of events which is in interest of all organisations.
- Mutual cosponsoring on mayor societies' events – more informal, without any financial obligations from either side – this will enable better coordination and better promotion.
- Societies can cooperate also in international program committees.
- Societies can cooperate with organisation of special sessions.
- Important information in official publications of societies can be exchanged. EUROSIM offers cooperative societies some place in Simulation News Europe – regular corners with brief, actual information.
- The number of participants from Europe is rather small in ASC events and vice versa: in former EUROSIM congresses the number of people from Asia was also very small. Societies will try to motivate people to participate on overseas events.

Four presidents - Genki Yagawa (JSST), Bo Hu Li (CASS), Tag Gon Kim (KSS) and Borut Zupančič (EUROSIM) during the opening session.



Participants during ASC 2005 in Tokyo.

- Some of the proposed items are already in life. EUROSIM web page has appropriate links. It has also the calendar of events in which Asian simulation conference is announced. (Seoul 2007). Mutual cosponsoring and cooperation in IPCs was already realised in ASC 2006 conference in Tokyo and is planned also for EUROSIM 2007 Congress in Ljubljana.

Recently Asian Simulation Societies started informal discussion about the need for Asian-Pacific Association for Simulation Technology, similar to EUROSIM.

Tokyo, October 30, 2006

Borut Zupančič, the president of EUROSIM
Genki Yagawa, the president of JSST
Bo Hu Li, the president of CASS
Tag Gon Kim, the president of KSS

EUROSIM Board Meeting Bratislava

Report from the 28th EUROSIM Board Meeting, 11 Dec. 2006, Bratislava

Report of the President

- Promotion and cooperation. The president visited ECMS 2006 (Sankt Augustin, Bonn, April 2006), PSCS 2006 (Kazimierz Dolny, Poland, Sept. 2006), ASC 2006 (Asian Simulation Conference, Tokyo, Nov. 2006).
- Motivation for membership: PSCS (Poland), LSS (Latvia), CEA-SMSG (SPAIN).
- Working on EUROSIM website: presidents activities, Calendar of events, links, …and stimulation of EUROSIM member societies. See details: http://www.eurosim.info/?id=118

EUROSIM WEB. Societies must immediately update their part at EUROSIM website. They must nominate the responsible person for WEB (can be the person who is responsible for SNE reports). Zupančič and Breitenecker demonstrated the EUROSIM web page. New – NEWS can be put in from the front end. Ideas for other subjects and information for Calendar of events, EUROSIM links; please send to the president. Help of the EUROSIM officers welcome. Breitenecker and Halin will send some text with regard to SNE and SIMPRA. Societies can expand the minimal structure and prepare also pages in national languages.

EUROSIM Membership

- PSCS - Polish Society for Computer Simulation, was accepted for the full membership.
- CEA-SMSG Spanish Modelling and Simulation group was accepted for the observer membership instead of no more existing AES group.
- LSS Latvian Simulation Society was accepted for the observer membership of EUROSIM.
- More societies from one country: More than one organisation from a country can be observer and member of EUROSIM.

Report of the Editor-in-Chief SIMPRA

EUROSIM societies were asked to propose new reviewers. In current situation some areas are not covered adequately which causes too big delays.

Board members at Bratislava meeting, December 2006.

Leon Bobrowski, president of PSCS - Polish Society for Computer Simulation was accepted for full membership.

Report of the Editor-in-Chief SNE.

More emphasise will be given to technical papers and short notes. With regard to the news section the editor-in-chief appeals not to send old information but only new one. There is enough place on the WEB to document old activities. Some special issues will be published for ASIM and offered to other societies. As there is no participant fee for EUROSIM Societies it is expected that societies buy SNE for all members. In future fixed schedule for SNE, and new numbering: single issue in March/April, special issue in July/August, double isssue in November. For 2007 the following Issue are planned: SNE 16/3 (delayed 2006 Issue), SNE 17/1 (single issue), SNE 17/2 (single issue; special issue), SNE 17/3-4 /double issue).

More EUROSIM Events

EUROSIM board supports the idea of more EUROSIM events originating in current societies events. The official language of such event is English. In all materials of such events the EUROSIM co-organisation or co-sponsorship must be clearly presented and appropriate logo should be used. Expressed and approved candidates: UKSIM 2008 and MATHMOD 2009.

EUROSIM Congress 2007 in Ljubljana

Many activities have been undertaken. IPC nominated, website arranged WWW.EUROSIM2007.ORG, invited lectures selected. What do organisers expect in near future from the EUROSIM societies: support in promotion, session organisation, proposals for sponsors, exhibitors, tutorials. A student competition is planned: each society should find at least some students. If societies will be active then we can expect a good event. Best papers will be published in the special issue of SIMPRA.

EUROSIM Congress 2010

Application - from CSSS. They would organise the congress in Prague. General chair prof. Miroslav Šnorek, close cooperation with Mikulás Alexík. They propose Mikulás Alexík for the future EUROSIM president. Decision: The 7th EUROSIM Congress will be organised by CSSS in Sept. 2010 in Prague.

EUROSIM Award

EUROSIM gives *EUROSIM Award* for individuals, groups or societies for long standing exceptional service to the simulation community. Candidates are normally proposed by EUROSIM societies, EUROSIM board members or the EUROSIM president. The final decision is made by EUROSIM board.

Code of Professional Ethics

EUROSIM board proposes member societies to discuss about the Code of Professional Ethics for Simulationists: .
WWW.SITE.UOTTAWA.CA/~oren/SCS_Ethics/ethics.htm

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borut.zupancic@fe.uni-lj.si

EUROSIM Congress.

The EUROSIM Congress is arranged every three years by a member society of EUROSIM. EUROSIM'04, the *5th EUROSIM Congress*, took place in Noisy-le-Grand, near Paris, France in Sept. 2004. The *6th EUROSIM Congress* will be organised by the Slovene Society for Simulation and Modelling SLOSIM in close cooperation with German speaking modelling and simulation society ASIM and other simulation societies.

EUROSIM 2007

6th EUROSIM Congress
September 9-13, 2007, Ljubljana, Slovenia

WWW.EUROSIM2007.ORG

Ljubljana - Your Host City. Ljubljana, the capital of Slovenia which is the member of the European Union, is the heart of the political, economic, cultural and scientific life of Slovene nation. It was build on the place of a Roman city Emona. Numerous churches, theatres, museums, galleries, the Medieval castle, give Ljubljana a reputation of being a modern and one of the most beautiful towns in Europe. Especially impressive are some works of the famous architect Jože Plecnik.

For more information about EUROSIM'07, please contact:

Prof. Borut Zupancic, chair of the congress
borut.zupancic@fe.uni-lj.si
Prof. Rihard Karba, chair of the IPC
rihard.karba@fe.uni-lj.si

ASIM - Buchreihen / ASIM Book Series

Fortschritte in der Simulationstechnik (FS) / Series Frontiers in Simulation (FS) - Monographs, Proceedings:

W. Borutzky: *Bond Graphs Methodology for Modelling Multidisciplinary Dynamic Systems*. FS 14, ISBN 3-936150-33-8, 2005.

M. Becker, H. Szczerbicka (eds.): *19th Symposium Simulation Techniques*. Proceedings Tagung ASIM 2006, Hannover; FS 16, ISBN 3-936150-49-4, 2006.

S. Wenzel (Hrsg.): *12. Fachtagung Simulation in Produktion und Logistik*. Proceedings Tagung ASIM SPL 2006; ISBN 3-936150-48-6, 2006.

F. Hülsemann, M. Kowarschik; U. Rüde: *18th Symposium Simulation Techniques*. Proceedings Tagung ASIM 2005 Erlangen; FS 15, ISBN 3-936150-41-, 2005.

Available / Verfügbar: SCS Publishing House e.V., Erlangen, WWW.SCS-PUBLISHINGHOUSE.DE
Download ASIM Website WWW.ASIM-GI.ORG (partly; for ASIM members)

Fortschrittsberichte Simulation (FB) / Advances Simulation (AS) / ASIM Mitteilung (AM) ARGESIM Reports (AR) - Special Monographs, PhD Theses, Workshop Proceedings

C. Deatcu, S. Pawletta, T. Pawletta (eds.): *Modelling, Control and Simulation in Automotive and Process Automation*. Proceedings ASIM Workshop Wismar 2006, ARGESIM Report 31, AM 101; ISBN 3-901-608-31-1, 2006.

H. Ecker: *Suppression of Self-excited Vibrations in Mechanical Systems by Parametric Stiffness Excitation*. ARGESIM Report FB 11, ISBN 3-901-608-61-3, 2006.

M. Gyimesi: *Simulation Service Providing als Webservice zur Simulation Diskreter Prozesse*. ARGESIM Report FB 13, ISBN 3-901-608-63-X, 2006.

J. Wöckl: *Hybrider Modellbildungszugang für biologische Abwasserreinigungsprozesse*. ARGESIM Report FB 14, ISBN 3-901608-64-8, 2006.

Th. Löscher: *Optimisation of Scheduling Problems Based on Timed Petri Nets*. ARGESIM Report Vol. 15, ASIM / ARGESIM Vienna, 2007; ISBN 978-3-901608-65-0.

Available / Verfügbar: ARGESIM/ASIM Publisher, TU Vienna, WWW.ARGESIM.ORG
Download / Bestellung zum Mitgliederpreis € 10.- ASIM Website WWW.ASIM-GI.ORG

Reihen der ASIM-Fachgruppen / Series of ASIM Working Groups

S. Collisi-Böhmer, O. Rose, K. Weiß, S. Wenzel (Hrsg.): *Qualitätskriterien für die Simulation in Produktion und Logistik*. AMB 102, Springer, Heidelberg, 2006; ISBN 3-540-35272-4.

M. Rabe, S. Spiekermann, S. Wenzel (Hrsg.): *Verifikation und Validierung für die Simulation in Produktion und Logistik*. AMB 103, Springer, Heidelberg, 2006; ISBN 3-540-35281-3.

J. Wittmann, M. Müller (Hrsg.): *Simulation in Umwelt- und Geowissenschaften - Workshop Leipzig 2006*. Shaker Verlag, Aachen 2006, AM 106; ISBN 978-3-8322-5132-1.

A. Gnauck (Hrsg.): *Modellierung und Simulation von Ökosystemen - Workshop Kölpinsee 2006*. Shaker Verlag, Aachen 2007, AM 107; ISBN 978-3-8322-6058-3.

Available / Verfügbar: Bookstore / Buchhandlung, ermäßigter Bezug für ASIM Mitglieder
Info at ASIM webite WWW.ASIM-GI.ORG

ASIM - German Simulation Society
Arbeitsgemeinschaft Simulation

ASIM (Arbeitsgemeinschaft Simulation) is the association for simulation in the German speaking area, servicing mainly Germany, Switzerland and Austria. ASIM was founded in 1981 and has now about 700 individual members, and 30 institutional or industrial members. Furthermore, ASIM counts about 300 affiliated members.

ASIM Structure - ASIM Working Groups. ASIM, part of GI - Gesellschaft für Informatik, is organised in *Working Groups*, dealing with applications and comprehensive subjects:

- **GMMS** Methods in Modelling and Simulation
  Info: Peter Schwarz, *schwarz@eas.iis.fhg.de*
- **SUGMBB** Simulation in Environmental Systems
  Info: J. Wittmann, *wittmann@informatik.uni-hamburg.de*
- **STS** Simulation of Technical Systems
  Info: H.-T. Mammen, *Heinz-Theo.Mammen@hella.com*
- **SPL** Simulation in Production and Logistics
  Info: Sigrid Wenzel, *s.wenzel@uni-kassel.de*
- **SVS** Simulation of Transport Systems
  Info: U. Brannolte, *Brannolte@bauing.uni-weimar.de*
- **SBW** Simulation in OR
  Info: C. Böhnlein, *boehnlein@wiinf.uni-wuerzburg.de*
- **EDU** Simulation in Education/Education in Simulation
  Info: W. Wiechert, *wiechert@simtec.mb.uni-siegen.de*

In these working groups most of ASIM's activities are organised: workshops, publications, standardising groups, industrial relations, etc. Each ASIM member may assign to working groups he is interested in, and chooses one primary working group, from which he gets additional information and additional benefits.

Membership, Information, Address

ASIM offers a personal membership (€ 35.-), an institutional membership (€ 80.-) and an industrial membership (€ 150.-). ASIM members get three times a year the journal **SNE** - *Simulation News Europe* (including SNE Special Issues) and they receive four times a year the *ASIM Newsletter* via email. Additionally, ASIM members get personal access to the members' area of the ASIM website WWW.ASIM-GI.ORG. In the members' area of the ASIM website downloads of all SNE issues are provided, as well as downloads of Proceedings of ASIM Conferences, of ASIM Working Group Conferences, of ASIM Workshops, and of additional documentations from workshops (slides, publications, etc.).

Members may update their personal data directly at the website (with access to member register for limited use).

The ASIM website also invites to become an ASIM member, either registering directly via web, or by downloading applications forms, to be sent to the ASIM administration in Vienna. ASIM administration is done in two offices: the Vienna office handles all membership affairs and organises the website, the Munich office takes care on industrial relations and mailing (addresses see below). For personal information on ASIM and ASIM membership, as well members and as well as people in interested in a membership are invited to contact a regional ASIM officer for membership affairs.

- WWW info EUROSIM: WWW.ASIM-GI.ORG
  with members' area (downloads, etc.)
- Email contacts: *info@asim-gi.org, admin@asim-gi.org*
- Address: ASIM - Arbeitsgemeinschaft Simulation
  Inst.f. Analysis and Scientific Computing
  Prof. Dr. F. Breitenecker, Vienna Univ. of Technology
  Wiedner Haupstrasse 8-10, 1040 Vienna, AUSTRIA

  ASIM - Arbeitsgemeinschaft Simulation
  BAUSCH-GALL GmbH, Dr. Ingrid Bausch-Gall
  Wohlfartstrasse 21b, 80939 Munich, GERMANY

Function	Name and Email
President	Felix Breitenecker, *Felix Breitenecker@tuwien.ac.at*
Vice-President	Sigrid Wenzel, *s.wenzel@uni-kassel.de*
Vice-President	Th. Pawletta, *pawel@mb.hs-wismar.de*
Secretary	Claus-Burkhard Böhnlein, *boehnlein@wiinf.uni-wuerzburg.de*
Treasurer	Ingrid Bausch-Gall, *Ingrid@Bausch-Gall.de*
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Repr. EUROSIM	Felix Breitenecker, *Felix Breitenecker@tuwien.ac.at*
Deputy	W.Wiechert, *wiechert@simtec.mb.uni-siegen.de*
Edit. Board SNE	Th. Pawletta, *pawel@mb.hs-wismar.de* + all Heads of ASIM Working Groups
Web EUROSIM	Johannes Kropf, *jkropf@osiis.tuwien.ac.at*

ASIM Board and Officers: The *ASIM Executive Board* consists of elected officers (elected all three years), of the chairpersons of the ASIM Working Groups, and of co-opted specialists. Independently, the *Executive Boards* of the working groups also is elected all three years.

ASIM Publications

SNE - Simulation News Europe. ASIM is publishing together with ARGESIM the journal SNE, which is regularly published and sent to all ASIM members (as part of their membership; 900 issues) and for promotion purposes (300 issues). Since 2006, the ASIM Working Groups publish *SNE Special Issues* with state-on-the-art reports on modelling and simulation in their workscope.

ASIM News. In December 2005, printed *ASIM Nachrichten* have been replaced by an electronic news-letter - *ASIM Newsletter.* Editors are Th. Pawletta and C. Deatcu, Univ. Wismar, *pawel@mb.hs-wismar.de*.

ASIM Notes - ASIM Mitteilungen. The trademark *ASIM Mitteilungen* (*ASIM Note*) stands for all publications of ASIM and of the the ASIM Working Groups. Each publication gets an identification as *ASIM Mitteilung,* independent of the publisher, and independent of the publication medium (printed book, CD, Web). ASIM Notes range from printed books (with CDs) published by Springer, via workshop publications published in SNE by ARGESIM, to compiled abstracts published at the ASIM webserver.

ASIM Books. ASIM co-operates with the SCS Publishing House e.V., with ARGESIM (Vienna University of Technology), and with Shaker Verlag Aachen in publication of book series (*Fortschritte in der Simulationstechnik - Frontiers in Simulation* and *Fortschrittsberichte Simulation - Advances in Simulation)* and in publication of Proceedings. Publications in these series range from monographs via proceedings to PhD theses.

ASIM News

From the ASIM Executive Board

ASIM Conference. At the last board meeting in Berlin, December 2006, discussions about the structure of ASIM conferences were continued. It can be observed, that the annual *ASIM Conference* attracts less people, while the application oriented conferences and workshops of the ASIM working groups show an increasing number of participants. Suggestions were e.g. to organise the *ASIM Conference* only bi-annual - as the successful conference series *Simulation in Production and Logstics,* organised by the homonymous working group, or to set a special topic for the conference. As a first consequence, it was decided to skip the ASIM Conference in 2008, and to start 2009 anew with one of the strategies mentioned. The board warmly welcomed Albrecht Gnauck (*Albrecht.Gnauck@tu-Cottbus.de*), who will organise the *ASIM Conference ASIM 2009* at Brandenburgische Technische Universität Cottbus in September 2009.

ASIM website. After three years development, testing and experiences the ASIM website WWW.ASIM-GI.ORG has reached an almost stable status. Reactions from members show an increasing acceptance, and requests for extensions. Furthermore, the website supports and partly executes administrative affairs, where also extensions are meaningful. It was decided to implement more functionality into the website:

- organisation of downloads via a database, in order to have structural access to free download, to member download, to download for workshop participants, and to download for the board;
- implementation of a small ordering system for printed books, which forwards orders to the respective publisher (taking care on reduction for ASIM members);
- increasing information in English for international affairs (international ASIM conferences, SNE, EUROSIM congress, co-operation with European simulation societies, etc);
- for administration, extending the functionality of the mailing system for the boards, including attachments and sending of the newsletter;
- extending the members' database with addresses for special invoicing;
- and especially for working groups, implementing frontend editing of static information.

ASIM Award. The board decided to continue the *ASIM Award* on a yearly base. This award will be given to members, who have done excellent work in research and development of modelling and simulation, as well as in education for modelling and simulation and in organisational work for the simulation community. If necessary, the award may be split to two or more persons.

EUROSIM 2007 Congress. Within international relations, it was again underlined to support strongly the *EUROSIM Congress 2007* in Ljubljana by special sessions in various areas (see later), and by organising at EUROSIM 2007 not only an ASIM Executive Board Meeting, but also an ASIM General Meeting for ASIM members and people interested in ASIM (see invitation).

Recent ASIM Publications

SNE - Special Issue. Since 2006 the ASIM working groups publish *SNE Special Issues* with state-on-the-art reports on modelling and simulation in their workscope. These series was started in November 2006 by the working group *Methods in Modelling and Simulation* with a special issue on *Parallel and Distributed Simulation Methods and Environments*. The special issue was presented at the board meeting in Berlin (December 2006), and mailed to members in begin of 2007. The working group *Simulation in Production and Logistics* will continue in 2007 with a special issue on *Verification and Validation* (more details see elsewhere in this SNE issue), in 2008 the working group *Simulation of Technical Systems* will take care on a special issue.

Recent ASIM Books (ASIM Mitteilungen - ASIM-Notes). In 2006 and 2007 new books (monographs, Proceedings) have been published by various publishers under the trademark *ASIM Note*. Members may download some of the books freely, or at least summaries of the books, and/or they may order some of the books for a reduced price. The new books, published at Springer, Shaker Verlag Aachen, SCS Publishing House Erlangen, or ARGESIM Vienna, are:

M. Becker, H. Szczerbicka (eds.): *Proc. 19th Symposium Simulation Technique Hannover 2006*. Frontiers in Simulation FS 16, ASIM / SCS Publishing House e.V., ISBN 3-936150-49-4.

S. Wenzel (Hrsg.): *Simulation in Produktion und Logistik 2006*; Tagungsband 12. Fachtagung Kassel Sept. 2006. AMB 104, SCS Publ. House e.V, ISBN 3-936150-48-6.

H. Ecker: *Suppression of Self-excited Vibrations in Mechanical Systems by Parametric StiffnessExcitation*. Advances in Simulation, ARGESIM Report Vol. 11, ASIM / ARGESIM Vienna, 2006; ISBN 3-901608-61-3.

M. Gyimesi: *Simulation Service Providing unter Verwendung von Web Service Technologie*. Fortschrittsberichte Simulation, ARGESIM Report Vol. 13, ASIM / ARGESIM Vienna, 2006; ISBN 3-901608-63-X.

J. Wöckl: *Hybrider Modellbildungszugang für biologische Abwasserreinigungsprozesse*. Fortschrittsberichte Simulation, ARGESIM Report Vol. 14, ASIM / ARGESIM Vienna, 2006; ISBN 3-901608-64-8.

S. Collisi-Böhmer, O. Rose, K. Weiß, S. Wenzel (Hrsg.): *Qualitätskriterien für die Simulation in Produktion und Logistik*. AM 102, Springer Heidelberg, 2006; ISBN 3-540-35272-4.

M. Rabe, S. Spiekermann, S. Wenzel (Hrsg.): *Verifikation und Validierung für die Simulation in Produktion und Logistik*. AM 103, Springer Heidelberg, 2006; ISBN 3-540-35281-3.

A. Gnauck (Hrsg.): *Modellierung und Simulation von Ökosystemen - Workshop Kölpinsee 2005*; Shaker Verlag, Aachen 2006, AM 98; ISBN 978-3-8322-5477-3.

C. Deatcu, S. Pawletta, T. Pawletta (eds.): *Modelling, Control and Simulation in Automotive and Process Automation*. Proc. ASIM Workshop Wismar 2006, ARGESIM Report no.31, AM 101; ISBN 978-3-901608-31-5.

J. Wittmann, M. Müller (Hrsg.): *Simulation in Umwelt- und Geowissenschaften - Workshop Leipzig 2006*; Shaker Verlag, Aachen 2006, AM 106; ISBN 978-3-8322-5132-1.

A. Gnauck (Hrsg.): *Modellierung und Simulation von Ökosystemen - Workshop Kölpinsee 2006*; Shaker Verlag, Aachen 2007, AM 107; ISBN 978-3-8322-6058-3.

Th. Löscher: *Optimisation of Scheduling Problems Based on Timed Petri Nets.* Advances in Simulation, ARGESIM Report Vol. 15, ASIM / ARGESIM Vienna, 2007; ISBN 978-3-901608-65-0.

Books may be ordered via the ASIM website from end of 2007 on (price reduction for ASIM members, downloads partly available; WWW.ASIM-GI.ORG).

ASIM Working Groups

Working Group Structure. ASIM is part of GI - *Gesellschaft für Informatik (Society for Informatics)* and is itself structured into working groups (WG), which address various areas of modelling and simulation.

WG Methods in Modelling and Simulation (GMMS) The ASIM working group *Methods in Modelling and Simulation* (GMMS) held two meetings in February 2007. The first meeting was a joint meeting with the working group *Simulation of Technical Systems* (STS) on February 26-27, 2007 at University Bremen (report see later). The second meeting was the 4th ASIM GMMS Workshop *Survey on Methods and Application in Modelling*, Februar 28 - March 2, 2007, at RWTH Aachen, which focussed also on education by organising a poster session for master students and PhD students (report in the following).

ASIM GMMS Workshop 2008
Survey on Methods and Application in Modelling
February 18 - 20, 2008, Erlangen

In 2008, the these series will be continued by 5th ASIM GMMS Workshop *Survey on Methods and Application in Modelling*, Februar 18 - 20, 2008, at University Erlangen, hosted by Ulrich Rüde, Dept. System Simulation (*Ulrich.Ruede@informatik.uni-erlangen.de*).

Education - Simulation. The working group will intensify work on *Education in Simulation / Simulation in Education* (EDU/SIM), underlined by separate section at the ASIM website (organised by Wolfgang Wiechert, University Siegen, *wiechert@simtec.mb.uni-siegen.de*).

Report Workshop ASIM GMMS 2007, Aachen

The ASIM workshop on *Methods of Modeling and Simulation* is different from typical scientific conferences because it is dedicated to the dissemination of new ideas and methods in modeling and simulation on a moderate level of specialisation. In contrast to typical conference sessions it is not dedicated to the presentation of the newest and most sophisticated results in a very specific application field but to tutorial surveys for a broad audience. Today, even a simulation specialist is not able to survey this extremely broad field, although many concepts from one application domain might be well suited for another one. For this reason the workshop is conceived as a 'higher education' seminar for simulationists. In particular, it is a forum for graduate or PhD students students and researchers working in one of the various application fields of simulation.

In a series of carefully chosen invited talks tutorial surveys are given, both with respect to methodology and new application fields. Each talk has 45 minutes followed by an extensive plenary discussion of 15 minutes. Additionally, the workshop gives plenty of time to intensify the discussion in the half hour coffee breaks. The talks are complemented by a poster session taking one full afternoon. It gives graduate and PhD students the opportunity to present and discuss their work with experienced simulationists. Thus, for the young people the workshop has a double profit: Learning more about simulation, getting new ideas for their own work, and meeting new colleagues.

This year's ASIM workshop took place at RWTH Aachen University. The workshop was hosted by Prof. Bischof and Dr. Bücker.

Prof. Clauser talking on geothermic energy.

It was the 4th workshop with educational focus after its successful predecessors in Siegen, Wuppertal and Munich.

The Aachen workshop had around 60 participants.

The fascinating talks dealt with such different problems as

- scheduling problems in public transportation
- automatic mesh generation from 3D-geometries
- meshfree methods for PDEs

Audience at Invited Lectures; at right Wolfgang Wiechert, organiser of the workshop series.

- simulation of electromagnetic fields
- geothermal reservoir characterisation
- optical molecular imaging
- hypergraphs in scientific computing
- simulation of electromagnetically excited noise
- analysis of multi-phase reaction systems
- modeling of cellular networks
- data warehousing in practice
- numerical simulation of casting processes
- modeling and simulation of two-phase flows

The crowded Thursday afternoon poster session had 22 posters from various application fields.

Lively discussions at the poster session.

In the first evening the conference guests could discuss their experiences (and more) in the pubs of the beautiful town centre of Aachen. At the second day the famous Aachen cathedral with the 1200 years old throne of emperor Carolus Magnus was visited, followed by the conference dinner.

Once more the workshop was a full success. All talks had a high presentation standard. The highly communicative atmosphere of the conference stimulated scientific exchange between graduate students, PhD students and established researchers.

More information is available at the conference web page WWW.SC.RWTH-AACHEN.DE/Events/ASIM07/. The presentations as well as the posters will soon be made available on the the ASIM server (WWW.ASIM-GI.ORG). These workshop series will be continued at the Universities of Erlangen (2008) and Siegen (2009).

WG Simulation in Environmental Systems and Medicine, Biology and Biophysics (SUGMBB)

The ASIM working group *Simulation in Environmental Systems and Medicine, Biology and Biophysics* (SUMGBB) co-operates since many years with other working groups of GI (*Gesellschaft für Informatik*) in the area of environmental simulation. The working group is running two annual workshop series, the one on *Simulation in Environmental Systems* (SES) - organised in spring at different locations, and the other one on *Modelling and Simulation of Ecosystems* (MSE) - organised in October in Kölpinsee at island of Usedom.

In 2006, the workshop of the SES series took place in Leipzig, March 22 -24; Proceedings have been published at Shaker Verlag, *ASIM Note* 106. The 2006 workshop in the MES series was organised October 25 - 27, 2006 at Usedom; Proceedings have alreadybeen published at Shaker Verlag, *ASIM Note* 107. The foreword of both Proceedings (in German language) can be downloaded from the ASIM website, giving scientific and social reports of the workshop.

Recently the 2007 workshop of the SES series took place in Berlin, march 21-23, 2007; Proceedings are in preparation (Shaker Verlag); a report will be given in the next SNE. The next workshop in the SES series is planned for March 2008 in Switzerland, to be held at EAWAG/ETH in Dübendorf/Zürich.

ASIM SUGMBB Workshop SES 2008
Simulation of Environmental Systems
March 2008, ETH Zürich/Dubendorf, Switzerland

The next workshop in the MSE series is organised in Kölpinsee at island of Usedom, October 22-24, 2007. Information can be obtained from Albrecht Gnauck, Brandenburgische Technische Universität Cottbus, *umweltinformatik@tu-cottbus.de,* WWW.TU-COTTBUS.DE /umweltinformatik/.

ASIM SUGMBB Workshop MSE 2007
Modelling and Simulation of Ecosystems
October 22 - 24, 2007; Kölpinsee, Usedom

WG Simulation of Technical Systems

The ASIM working group *Simulation of Technical Systems* (STS) held its annual meeting on on February 26-27, 2007 at University Bremen, together with the working group *Methods in Modelling and Simulation* (report see later). On this occasion elections for the Executive Board of the working group took place. The new elected officers are:

- Heinz-Theo Mammen, Hella; Speaker
  Hella Heinz-Theo.Mammen@hella.com
- Walter Commerell, T-Systems GEI; Vice Speaker
  walter.commerell@t-systems.com
- Joachim Haase, Fraunhofer-Inst. IIS; Vice Speaker
  Joachim.Haase@eas.iis.fraunhofer.de
- Klaus Panreck, Hella; Vice Speaker
  klaus.panreck@hella.com

4th ASIM Wismar Workshop
Modeling, Control and Simulation in Automotive and Process Automation

ASIM STS Workshop 2007
May 29-30, 2008; University Wismar, Germany

In 2008 the meeting of the working group will be organised together with the 4th ASIM Workshop *Modeling, Control and Simulation in Automotive and Process Automation* in Wismar, May 29-30, 2008. These successful workshop series is co-organised by ASIM STS, University Wismar, University Rostock, and IAV GmbH Gifhorn (detailed information can be found at WWW.MB.HS-WISMAR.DE/cea/asim08/).

Report Workshop ASIM STS/GMMS 2007

The ASIM working groups *Simulation of Technical Systems* (STS) and *Methods in Modelling and Simulation* (GMMS) held there annual workshop together in Bremen on February 26-27, 2007. About 120 engineers and scientists from industry, research labs and university met for a common meeting at University of Bremen. Two plenary papers introduced into the main topics:

- Computational Material Sciences
  Prof. Th. Frauenheim, University of Bremen
- Simulation techniques as Basis for the Development Process of Car Electronics
  Dr. Ch. Ameling, VW Wolfsburg

Furthermore two tutorials were held about the topics:

- VHDL-AMS – Basic principles and model libraries
- Dymola / Modelica

Part of exhibition area (11 exhibitors).

Speaker and his representatives of the ASIM working group Simulation of Technical System; from left to right Dr. Haase, Dr. Commerell, Dr. Mammen, Dr. Panreck, and Dr. Wohnhaas (previous Speaker).

Eleven exhibitors showed their software and their services. About 50 presentations introduced to intense discussions of the following subjects:

- VHDL-AMS in practice
- Simulation of thermal systems
- Model-based Testing
- Modelling and simulation in automotive, aeronautics and astronautics
- Modelling of mechatronical systems
- Education
- General simulation applications
- Automated model generation

At the end of the first day, the meeting of the working group members took place. During this meeting a new speaker of the group and also his representatives were elected. The former speaker, Dr. Wohnhaas from T-Systems, wasn't again available for this job due to professional reasons. Instead Dr. Mammen from Hella was elected to this position. His representatives are Dr. Commerell from T-Systems, Dr. Haase from Fraunhofer IIS/EAS and Dr. Panreck from Hella.

The evening of the first day was spent with a traditional 'Kohlfahrt' and a cabbage-food meal in the restaurant 'Haus am Walde'. The meeting was closed with two excursions – Daimler Chrysler visiting a car production line and Rheinmetall Defence Electronic, where flight and car simulators were demonstrated.
The participants had much time for discussion and the chance to make new contacts and also to meet old friends. The meeting was organised by the University of Bremen (Prof. Laur), the Microsystems Center Bremen and by ASIM.

In 2008, the working group will organise the annual workshop at Hochschule Wismar (organiser Prof. Thorsten Pawletta), together with 4th ASIM Wismar Workshop on 'Modellierung, Regelung und Simulation in Automotive und Prozessautomation'.

WG Simulation in Production and Logistics

Meetings / Workshops. The ASIM working group *Simulation in Production and Logistics* (SPL) organises the very successful bi-annual conference series *Simulation in Production and Logistics*. These conference series was continued with the *12th Conference* in Kassel, September 26 -27 2006 (report see later). The Proceedings of this conference were be published at SCS Publishing House e.V. ASIM members can order the Proceedings at a reduced price.

ASIM SPL Conference 2008
13th ASIM SPL Conference
Simulation in Production and Logistics
October 1 - 2, 2008, Berlin, Germany

The working group organises also one-day meetings in industry, at research centres or at fairs. The last meeting took place at March 1, 2007, hosted by Fraunhofer Institute IML in Dortmund. Among other topics, the candidature of Fraunhofer Institute IPK in Berlin (represented by Markus Rabe) for organising the next conference *Simulation in Production and Logistic* in October 2008 was warmly accepted. The next one-day meeting will take place at May 17, 2007 in Dresden, hosted by Dualis IT Solutions. For more details of these meetings, see ASIM website, entry WWW.ASIM-GI.ORG/index.php?id=32.

ASIM SPL Meeting
One-day Working Session
May 17, 2007; DUALIS IT Solution, Dresden

For autumn 2007 Sigrid Wenzel, speaker of the working group, invites together with Birgit Vogel-Heuser from Dept. Electrical Engineering/Computer Engineering, Univ. Kassel, to a workshop at Informatik 2007.

The workshop *Modellbildung und Simulation in der Logistik - von der Logistikplanung bis zur Steuerungsrealisierung* is embedded into the Congress *Informatik 2007 - Informatik trifft Logistik*, the annual congress of the GI - Gesellschaft für Informatik, to be held September 24 - 27, 2007, at University Bremen. For details see websites WWW.INFORMATIK2007.DE and WWW.UNI-KASSEL.DE/fb15/ipl/pfp/workshop/.

ASIM SPL Workshop at Informatik 2007
Modellbildung und Simulation in der Logistik - von der Logistikplanung bis zur Steuerungsrealisierung
September 24 - 27, 2007, Univ. Bremen, Germany

Books. The working group has compiled two books, which appeared in end of 2006 (details before in section on ASIM books):

- Qualitätskriterien für die Simulation in Produktion und Logistik
- Verifikation und Validierung für die Simulation in Produktion und Logistik

Report ASIM SPL Conference 2006

During September 26 - 27, 2006 the 12th ASIM Conference *Simulation in Production and Logistics* took place at the University of Kassel organised by Prof. Dr. Sigrid Wenzel in cooperation with Prof. Adi Reinhardt and Univ.-Prof. Dr. Jens Hesselbach.

Every two years the conference of the ASIM working group *Simulation in Production and Logistics* presents recent developments and interesting applications of simulation. This largest European conference for simulation in production and logistics is well balanced between research, development and industrial application. Scientific innovation is discussed as well as the successful application in day-to-day business. Thus, companies, which have not used simulation before, receive a first impression of different ways of using simulation. Furthermore, they are enabled to choose their own way of using simulation and to estimate the potential asset to their own enterprises. For simulation users the conference is an adequate panel for the exchange of experiences.

This time more than 170 participants (40 percent industry) visited the conference at the University of Kassel. Three plenary lectures reflected the current development trends of simulation in production and logistics.

Invited Speaker:
Dirk Steinhauer
(Germany) –
Supporting Shipyard Planning, Production Planning and Product Development.

Invited Speaker:
Simaan M. AbouRizk
(USA)
Modeling Construction Operations Using Cyclone-Based Systems.

Invited Speaker:
Ulrich Brannolte
(Germany)
Simulation of Road Traffic: State of the Art and Further Perspectives.

In more than sixty contributions (fifteen sessions and three workshops) the following topics were discussed:

- Supply Chain Simulation
- Simulation in Production Planning and Control
- Simulation of Organisational Structures and Business Processes
- Traffic and Transport Logistics Simulation
- Simulation in Semiconductor Manufacturing
- Digital Factory
- Quality Aspects in Simulation
- Simulation and Visualisation
- Modelling Approaches and Algorithms
- Simulation Methods and Tools
- Emulation (Workshop)
- Simulation in Construction Industry (Workshop)
- Quality in Simulation (Workshop)

The traditional associated exhibition of simulation tools gave an opportunity to evaluate the recent developments and services. Additionally, the Enterprise Dynamics User Group was organised at the second conference day.

Exhibition at ASIM SPL 2007 Conference.

The event was kindly supported by ASIM, Daimler Chrysler AG Kassel, DUALIS GmbH IT Solution, Fraunhofer-Institute for Material Flow and Logistics, Fraunhofer-Institute for Production Systems and Design Technology, Incontrol Enterprise Dynamics GmbH, MLP AG, Palgrave Macmillan, SimPlan AG, SDZ GmbH, TTN Hessen, UGS Unigraphics Solutions GmbH, University Duisburg-Essen, University Kassel and University KasselTransfer as well as by the GI e. V. and the Association of Engineers Society for Materials Handling, Materials Flow and Logistics Engineering (VDI-FML Germany). The Project was funded by the European Social Fund (ESF).

The social event took place at in the historical Congress Palais Kassel and was opened by the speech of the day presented by Prof. Dr. Dr. Dr. med. habil. Hans Hatt (University of Bochum, Germany).

Hans Hatt (Germany)
The Human Sense of Smell: Molecular Mechanisms and Functional Role.

Subsequently, Adi Reinhardt was awarded for his activities in ASIM by Univ.-Prof. Dr. Felix Breitenecker (details in next SNE). Afterwards the buffet and wine-tasting themed 'Wine and Chocolate' gave an opportunity for individual talks and professional discussions.

Exhibition at ASIM SPL 2007 Conference.

The written versions of all contributions are collected in the proceedings (ISBN 3-936150-48-6), edited by Sigrid Wenzel and published by SCS Publishing House e. V., Erlangen.

The proceedings are available through book stores, the SCS European Publishing House or the University Kassel (s.wenzel@uni-kassel.de) at the regular price of 75 € (for ASIM-, GI- and EUROSIM-Members 50 €).

The next ASIM-Conference *Simulation in Production and Logistics* will be organised by Dr. Markus Rabe, Fraunhofer-Institute for Production Systems and Design Technology, Berlin, October 1-2, 2008. Detailled information you will find under WWW.ASIM.IPK.FRAUNHOFER.DE/de/fachtagung.htm

Sigrid Wenzel, *s.wenzel@uni-kassel.de*

WG Simulation in Business Administration

The working group *Simulation in Business Administration* (SBW) held its bi-annual conference *Simulation as Operational Decision Support* on March 13 - 15, 2006, in Braunlage, Harz. A report in German language can be found at ASIM website at WWW.ASIM-GI.ORG/uploads/media/SimSymp2006_Bericht.pdf.

ASIM SBW Symposium 2008
Simulation as Operational Decision Support
March 2008; Braunlage, Harz, Germany

The working group is in process of restructuring, and the executive board will form anew, so that the continuation of the successful conference series *Simulation as Operational Decision Support* can be guaranteed. The next Braunlage Symposium will be held in March 2008, infos provided at the ASIM website intime.

WG Simulation of Traffic Systems

The working group *Simulation of Traffic Systems* (SVS) is in process of restructuring. For 2007, the working group has organised two actions, a workshop in Weimar, and a Special Session at the EUROSIM Congress (contributions in the session on education). After the successful workshop at Bauhaus University Weimar in February 2007, a similar workshop is planned for 2008.

Report Workshop ASIM SVS 2007

At the 8th of February 2007 the ASIM working group *Simulation of Traffic Systems* met at the Bauhaus University in Weimar to hold a workshop. The group represents the interests and activities in terms of development and appliance in problems of traffic- and transport simulations. The workshop *Current traffic analysis by dint of simulations models – achieved state of technologies and future perspective* was arranged by the Bauhaus University and especially by the professorship traffic planning and traffic engineering (VPT) of this university.

The ambition of the workshop were an intensive exchange of ideas between researchers, developers and users of simulation models and software. In the centre of attention stood the experiences to generate and visualise the data from actually situations on roads. The acquisition of data is based on a multiplicity of detectionssystems which are transmit their collected data to a traffic control centre. In current research projects this method occupy a central position in modern traffic analysis. In addition to this, the data will be supplemented by manual generated data as well as by floating cars.

For the preparation of complete traffic analysis the operator needs access to simulations models. These models could be differentiated in macroscopic and microscopic levels. Newer appendages try to combine the vantages of both models. The traffic analysis is the base for modern and effective traffic management systems which could give information to the user and as well to the operator.

The event were started with short presentations (10 min.) about the specific problems in this area of responsibility. Below is a list of the different topics.

- Conceptual conceivabilities for the integration of different forecast models for the duties in a traffic control centre ; Iotislav Kountchev (SBUV Bremen), K. Konz (VMZ Bremen)
- Detection of the traffic situation in Dmotion – Datafusion with DINO; Daniel Schmidt (ivh - Uni Hannover)
- Estimate of the traffic situation and short time prognosis with VISUM Online; Peter Vortisch (PTV Karlsruhe)
- SOCCER Trafficforecast for the town Colongne; G.. Krajzewicz (DLR)
- GPS –based measurement for the calibration of simulation models; Thomas Riedel (vsplus – Winterhur)
- Tracing of routes and targets by a multiagent-trafficsimulation; Gunnar Flötteröd (TU Berlin)
- Requirements for modelling and simulation for the compilation of trafficmodels in the Projekt MOSAIQUE; Uwe Plank-Wiedenbeck (Leipzig)

Finally the 30 participants had a lively discussion which were conducted by Professor Brannolte. All concerned persons were satisfied with the results and labelled the workshop as prolific.

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WWW.VPT-WEIMAR.DE

Snapshot of a presentation.

ASIM Conferences

ASIM organises the up to now annual *ASIM Conference*, the ASIM working groups organise annual workshops (up to 150 participants) and bi-annual conferences (more than 150 participants. ASIM cooperates in organising the tri-annual *EUROSIM Congress*. Furthermore, ASIM co-organises local conferences, e.g. the *ASIM Wismar Workshop*. A special co-operation was established with the annual conference series SIMVIS - *Simulation and Visualisation* in Magdeburg and with the three-annual conference series MATHMOD - *Mathematical Modelling* in Vienna .

ASIM Annual Conference. In 2006, the annual *ASIM Conference* takes place in Hannover. The conference is organised by at University Hannover by Helena Szczerbicka and Rainer Rimane, September 6 - 11, 2006. A detailed report will be given in the next issue.

It can be observed, that the annual *ASIM Conference* attracts less people, while the application oriented conferences and workshops of the ASIM working groups show an increasing number of participants. Suggestions were e.g. to organise the *ASIM Conference* only bi-annual - as the successful conference series *Simulation in Production and Logistics,* organised by the homonymous working group, or to set a special topic for the conference. As a first consequence, it was decided to skip the ASIM conference in 2008, and to start 2009 anew with one of the strategies mentioned.

ASIM - Conference 2009
20th Symposium Simulation Technique
September 2009, Cottbus, Germany

The *ASIM 2009 Conference* will be organised by Albrecht Gnauck (*Albrecht.Gnauck@tu-Cottbus.de*), at Brandenburgische Technische Universität Cottbus in September 2009. Information will be provided at both websites WWW.TU-COTTBUS.DE/umweltinformatik and WWW.ASIM-GI.ORG intime.

EUROSIM Congress. SLOSIM, the Slovenian Simulation Society will organise *EUROSIM 2007*. ASIM will not only co-sponsor, but also co-organise this event, so that in this year the annual ASIM Conference is part of EUROSIM 2007. Details see later.

SimVis. ASIM is co-organiser of the annual international conference *Simulation and Visualisation* (SIMVIS) in Magdeburg. The Conference Series *Simulation and Visualization* is open to everyone with interest in the fields of simulation, modelling and visualization (SimVis).

The goal of this conference is the presentation of new research and innovative applications in visualisation and mainly discrete simulation. More information about SIMVIS can be found at WWW.SIMVIS.ORG.

MATHMOD Conference Series. ASIM is co-organiser of the tri-annual conference series MATHMOD in Vienna. The 5th MATHMOD Conference took place at Vienna University of Technology on February 7 - 10, 2006 and was a big success.

MATHMOD 2009 Vienna
6th Symposium on Mathematical Modelling
February 11 - 13, 2009, Vienna, Austria

The 6th MATHMOD Conference will take place February 11 -13, 2009 (info at WWW.MATHMOD.AT). It will be hosted by Vienna University of Technology, organised by Inge Troch (*Inge.Troch@tuwien.ac.at*) and Felix Breitenecker (*Felix.Breitenecker @tuwien.ac.at*).

Wismar Workshop. At University Wismar the workshop series *Modelling, Control and Simulation in Automotive and Process Automation*. The *3rd ASIM Wismar Workshop* took place from 18th to 19th May in Wismar, Germany. The 4th ASIM Workshop *Modelling, Control and Simulation in Automotive and Process Automation* will take place in Wismar, May 29-30, 2008, together with a meeting of the ASIM Working Group *Simulation of Technical Systems*. These successful workshop series is co-organised by ASIM STS, University Wismar, University Rostock, and IAV GmbH Gifhorn (detailed information can be found at WWW.MB.HS-WISMAR.DE/cea/asim08/).

ASIM at EUROSIM 2007

ASIM invites its members to come to Slovenia in September 2007 and to participate at the EUROSIM 2007 Congress in Special Sessions, Work Groups and to attend the ASIM General Assembly.

ASIM has organised / co-organised the following Special Sessions:

- Education in Simulation / Simulation in Education Simulation Models for Education in Transport an Mobility; Wolfgang Wiechert, Univ. Siegen, Germany; *wiechert@simtec.mb.uni-siegen.de*; Ulrich Brannolte, Univ. Weimar, Germany;
- Digital Factory/ Simulation and Optimization of Industrial Processes; Peggy Näser, Cottbus, Germany; *peggy.naeser@mb.tu-chemnitz.de,* L. März , VResearch Dornbirn; *Lothar.Maerz@v-research.at;* János Josvai, Hungar; W. Krug, H. Krug, Dresden
- Modelling and Simulation in the Vehicle Thermal Management System; Wolfgang Puntigam, Virtual Vehicle Competence centre, Graz, Austria; *Wolfgang.Puntigam@virtuellesfahrzeug.at*

- Modelling of Structural Dynamic Systems – Model Reduction Methods
  Peter Schwarz, Fraunhofer Fraunhofer IIS Dresden; *Peter.Schwarz@eas.iis.fraunhofer.de*,
  Felix Breitenecker, Vienna Univ. of Technology
- Alternative Modelling and Comparisons and Benchmarking in Modelling and Simulation
  Felix Breitenecker, Vienna Univ. of Technology, *Felix.Breitenecker@tuwien.ac.at*
  Wolfgang Wiechert, Univ. Siegen, Germany
- Agent-based and Dynamic Approaches to Modelling in Economics;
  Jürgen Wöckl, Vienna Univ. of Economics and Business Administration, *juergen.woeckl@wu-wien.ac.at*

Furthermore, about fifty contributions from Germany, Austria and Switzerland have been submitted to regular session. In sum, there will be about hundred contributions, many of them by ASIM members.

ASIM General Assembly at EUROSIM 2007
September 11, 2007, 12.00 - 13.30
University Ljubljana

Consequently it was decided, to organise during the EUROSIM Congress an ASIM General Assembly. ASIM invites all members and simulationists interested in ASIM to attend this meeting, where reports on ASIM are given, and new books and features of the ASIM website are presented. Furthermore ASIM invites for snacks and wine tasting.

ASIM Conference Calendar

ASIM SPL Meeting
One-day Working Session
May 17, 2007; DUALIS IT Solution, Dresden

6th EUROSIM Congress
EUROSIM 2007
ASIM Special Sessions / ASIM General Assembly
Sept. 10-14, 2007, Ljubljana, Slovenia
WWW.EUROSIM2007.ORG, WWW.ASIM-GI.ORG

Informatik 2007 - Informatik trifft Logistik
37. Jahrestagung der GI Gesellschaft für Informatik
September 24 - 27, 2007, Univ. Bremen, Germany
WWW.INFORMATIK2007.DE

ASIM SPL Workshop at Informatik 2007
Modellbilldung und Simulation in der Logistik - von der Logistikplanung bis zur Steuerungsrealisierung
September 24 - 27, 2007, Univ. Bremen, Germany
WWW.UNI-KASSEL.DE/fb15/ipl/pfp/workshop/

ASIM SUGMBB Workshop MSE 2007
Modelling and Simulation of Ecosystems
October 22 - 24, 2007; Kölpinsee, Usedom
WWW.TU-COTTBUS.DE/umweltinformatik/

ASIM - GMMS Workshop 2008
Survey on Methods and Application in Modelling
February 18 - 20, 2007, Erlangen
WWW.ASIM-GI.ORG

ASIM SBW Symposium 2008
Simulation as Operational Decision Support
March 2008; Braunlage, Harz, Germany
WWW.ASIM-GI.ORG

SIMVIS 2008
18th Simulation and Visualization Conference
March 2008, Magdeburg, Germany
WWW.SIMVIS.ORG

ASIM SUGMBB Workshop SES 2008
Simulation of Environmental Systems
March 2008, ETH Zürich/Dubendorf, Switzerland
WWW.ASIM-GI.ORG

4th ASIM Wismar Workshop
Modeling, Control and Simulation in Automotive and Process Automation
ASIM STS Workshop 2007
May 29-30, 2008; University Wismar, Germany
WWW.MB.HS-WISMAR.DE/cea/asim08/

ASIM SPL Conference 2008
13th ASIM SPL Conference
Simulation in Production and Logistics
October 1 - 2, 2008, Berlin, Germany
WWW.ASIM.IPK.FRAUNHOFER.DE/de/fachtagung.htm

MATHMOD 2009 Vienna
6th Symposium on Mathematical Modelling
February 11 - 13, 2009, Vienna, Austria
WWW.MATHMOD.AT

ASIM - Conference 2009
20th Symposium Simulation Technique
September 2009, Cottbus, Germany
WWW.ASIM-GI.ORG

HSS - Hungarian Simulation Society

General Information. The Hungarian Member Society of EUROSIM was established in 1981 as an association promoting the exchange of information within the community of people involved in research, development, application and education of simulation in Hungary and also contributing to the enhancement of exchanging information between the Hungarian simulation community and the simulation communities abroad. HSS deals with the organization of lectures, exhibitions, demonstrations, and conferences.

Membership Information, Contact Address

• Web info: WWW.EUROSIM.INFO

• Address: HSS- Hungarian Simulation Society
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Activities At the Department of *Information and Knowledge Management* at the Faculty of Economic and Social Sciences of the Budapest University of Technology and Economics classes *Simulation and Modeling in Economy* and an other *Decision Making and Man-agement using Simulation* as well as simulation laboratory practices are held for graduate and post-graduate students studying economy, informatics and electrical engineering. PhD students participate in various simulation research projects aimed at methodological basic research as well as applications of simulation mainly in the fields of traffic, economic and interdisciplinary problems.

In the town of Györ at the Széchenyi István University the discipline of simulation is also taught. Here the class *Simulation Methodology and Applications* is studied by undergraduate students of informatics, electrical and traffic engineering. Lately a new specialization called *Compter Science in Economy* was started, where simulation is also taught as a basic subject.

Our efforts mentioned are intended to contribute to the dissemination of the various aspects of the methodology and application of simulation. We have participated at EUROSIM and SCS conferences and presented our simulation results. Our members have been and are successfully participating in national and EU simulation projects.

Publications. Beyond publications at conferences a volume in a series Alma Mater published at the Budapest University of Technology and Economics in 2006 revealed certain aspects of our results in simulation. The volume contains the following papers:

András Jávor: *Model Identification using Intelligent Agents*
Gábor Szűcs: *The Simulation of Rare Events using the RESTART Method*
Gergely Mészáros-Komáromy: *Simulation of the Choice of Bank Offices using a High Level Petri Net*
András Varga: *Simulation of Voice Traffic on a Liberalized TELECOM Market using a High Level Petri Net*
László Wágner: *Portfolio Management to Help Decision Making in Investment in Information Technology*
Éva Szabó Bonifert: *Tax System and Simulation*
Attila Fűr – Ákos Tóth: *Vision Modeling by Knowledge Attributed Petri Nets and Synthesized Symbolic Descriptions*
Miklós Szegedi: *Building an Agent-Based Manufacturing Model*

András Jávor, *javor@eik.bme.hu*

ISCS - Italian Society for Computer Simulation

The Italian Society for Computer Simulation (ISCS) is a scientific non-profit association of members from industry, university, education and several public and research institutions with common interest in all fields of computer simulation.

• Web info: WWW.EUROSIM.INFO

• Address: ISCS / Mario Savastano,
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Treasurer	Pasquale Arpaia
Repr. EUROSIM	F. Maceri, *Franco.Maceri@uniroma2.it*
Deputy	-
Edit. Board SNE	Mario Savastano, *mario.savastano@unina.it*

CROSSIM - Croatian Society for Simulation Modelling

General Information.

CROSSIM - *CROatian Society for SIMulation Modelling* was founded in 1992 as a non-profit society with the goal to promote knowledge and use of simulation methods and techniques and development of education and training in the field of simulation modelling. CROSSIM is a full member of EUROSIM since 1997.

Information, Contact Address

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Activities.

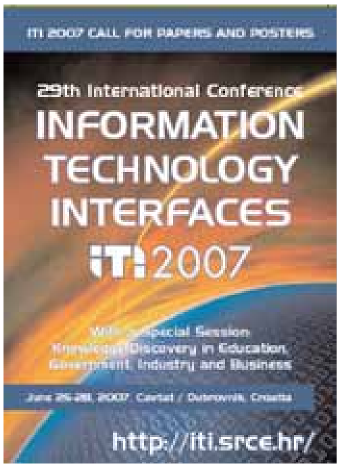
The Society is engaged in dissemination of information on simulation as well as in organization of meetings, courses and workshops. CROSSIM co-operates with the University Computing Centre, Zagreb, in organization of an international conference *Information Technology Interfaces* (ITI) and in publishing of the *Journal of Computing and Information Technology* (CIT). All information concerning CIT is available at CIT.SRCE.HR.

Coming Events

The 29th Internatonal Conference *Information Technology Interfaces* ITI2007 will be held in Cavtat near Dubrovnik on June 25-28, 2007.

ITI 2007
28th Conference
Information Technology Interfaces
June 25 - 28, 2007
Cavtat near Dubrovnik, Croatia
ITI.SRCE.HR

with BIOSTAT 2007
14th Meeting of Researchers of Biometrics/Statistics
and 12th School of Biometrics



The Conference has a long tradition (since 1974) of creating an inspiring, productive and pleasurable atmosphere for interdisciplinary communication among researchers, scholars and professionals from various subfields of ICT arena. ARGESIM and CROSSIM are among Conference co-operating institutions.

ITI Conference is scientific, multidisciplinary conference, but each year there is a special topic for the conference. In 2007 this special topic is *Knowledge Discovery in Education, Government, Industry and Business*.

The *14th Meeting of Researchers of Biometrics/Statistics* BIOSTAT 2007 and *12th School of Biometrics* co-organised by Croatian Biometric Society will be held in parallel with the Conference.

The Conference is organized by Zagreb University Computing Centre (SRCE) and held under the auspicies of Croatian Academy of Sciencies and Arts. ARGESIM and CROSSIM are among Conference co-operating institutions. The official language of the Conference is English, Conference registration, paper submission and hotel reservation can be done through Internet at: ITI.SRCE.HR.

Best student paper competition is envisaged and opened to undergraduate and graduate students. Student paper must be prepared according to the ITI guidelines. Co-authorship with other students and/or faculty advisers is permitted, but the competing student must be identified as the leading and corresponding author. A special certificate will be awarded to the student authors of the winning papers, and prizes will be given to the lead student authors of the winning papers in two categories: undergraduate and graduate students.

Jadranka Bozikov
jbozikov@snz.hr

CSSS - Czech and Slovak Simulation Society

General Information

CSSS -The *Czech and Slovak Simulation Society* has about 150 members working in Czech and Slovak national scientific and technical societies (*Czech Society for Applied Cybernetics and Informatics*, *Slovak Society for Applied Cybernetics and Informatics* -SSAKI). The main objectives of the society are: development of education and training in the field of modelling and simulation, organising professional workshops and conferences, disseminating information about modelling and simulation activities in Europe to its members, informing the members about publishing in the field of modelling and simulation. Since 1992 CSSS is a full member of EUROSIM.

Information, Contact Address

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  CSSS / Mikuláš Alexík, University of Zilina
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Past Events

ASIS'2006. The 28th *International Workshop Advancements in Simulation Systems ASIS'2006* took place on September 18-20 in Hostýn, Czech Republic. About 35 participants from Czech and Slovak republics attended the conference.

MOSMIC'2006. The 8th International Workshop *Modelling and Simulation in Management Informatics and Control MOSMIC'2006* took place on October 23-26, 2006 in Zilina, Slovak Republic. The event was organised by the Faculty of Management Informatics and Control, University of Zilina, in cooperation with Slovak Society for Applied Cybernetics and Informatics, Bratislava and CSSS. The workshop was co-sponsored by EUROSIM. Some 20 participants from Czech and Slovak Republics attended the conference.

EUROSIM Board Meeting. CSSS in cooperation with SSAKI (Slovak Society for Applied Cybernetics and Informatics) was hosting the 28th EUROSIM Board meeting in Bratislava, Slovak Republic (see picture) on December 11th, 2006. Prof. Mikulas Alexik was proposed there for the future EUROSIM president.

CSSS Assembly. On January 23rd, 2007, the assembly of CSSS committee was held in Brno, Czech Republic. The reports about the previous election period were presented and accepted and a new CSSS board for the next period has been elected:

M. Šnorek – president,
M. Alexík – vice-president,
A. Kavička – scientific secretary,
E. Kindler – treasurer.

Coming Events

MOSIS'2007
41th Spring International Conference on
Modelling and Simulation of Systems
April 24 - 26, 2007
Rožnov pod Rad-hoštěm, Czech republic

The 41st Spring International Conference on Modelling and Simulation of Systems MOSIS' 2007, will take place in the Moravian spa town Rožnov pod Radhoštěm, Czech Republic on April 24-26, 2007. The chairman of the international organising committee is Dr. Ing. Jan Stefan. The conference is organized by the Faculty of Information Technology, Brno University of Technology and the Department of Computer Science, FEI VŠB-Technical University of Ostrava in co-operation with CSSS, MARQ and with the kind co-sponsorship of EUROSIM.

Miroslav Šnorek, *snorek@fel.cvut.cz*

SIMS - Scandinavian Simulation Society

General Information

SIMS is the *Scandinavian Simulation Society* with members from the four Nordic countries Denmark, Finland, Norway and Sweden. The SIMS history goes back to 1959. SIMS practical matters are taken care of by the SIMS board consisting of two representatives from each Nordic country. Iceland will be represented by one board member. The SIMS annual meeting takes place at the annual SIMS conference or in connection to international simulation conferences arranged in the Nordic countries.

SIMS Structure. SIMS is organised as federation of regional societies. There are FinSim (*Finnish Simulation Forum*), DKSIM (*Dansk Simuleringsforening*) and NFA (*Norsk Forening for Automatisering*).

Information, Contact Address

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Deputy	-
Edit. Board SNE	Esko Juuso, *esko.juuso@oulu.fi*
Web EUROSIM	Vadim Engelson, *vaden@ida.liu.se*

To become a member of SIMS you should join one of the SIMS member organizations, as specified on the SIMS web page WWW.SCANSIMS.ORG.

Past Events

SIMS Conference 2006. The *47th SIMS Conference* was held at The House of Sciences and Letters in Helsinki, Finland in September 27 – 29, 2006. The conference was arranged by the *Finnish Automation Forum* (FinSim) which is a section of the *Finnish Society of Automation* (FSA).

The call for papers gained numerous submissions reflecting current trends in developments in modelling and simulation. The papers were based on abstracts selected by the International Programme Committee (IPC). Thereafter, the successful contributors were invited to submit a complete draft paper. These papers were evaluated by the IPC. The review comments were taken into account in preparing the final manuscripts. The selection process resulted in an excellent two-day programme comprising 45 papers organised into 10 sessions. Totally there were 50 pressentations. More than 70 participants attended the conference.

The contributed papers were organized into two tracks: methodology and applications, both with five sessions. Two methodology sessions were devoted on simulation in control and decision making. Numerical methods for distributed parameter systems concentrated on computational fluid dynamics. Simulation in training and education dealed with new programming tools, mobile and remote technology and distributed interactive simulation. The session on modelling and simulation tools and technology ranges from ontology to software development. The application oriented sessions covered various industrial sectors. Simulation in energy sector had two sessions dealing with boilers, cogeneration systems, solar energy, power plant design and oil and gas processes. Simulation in ecosystems and biotechnology had various topics, ranging from drug dosage and pot plants to brewing and ecosystems. Simulation in pulp and paper industry covered paper machines and several types of pulp processes. Simulation in process and manufacturing industry combined multi-phase process models with analysis of chemical and metallurgical processes and manufacturing. Methodology papers and application papers had a considerable overlap since the methodologies were tested in some applications and the applications use new methodologies.

In addition to the contributed papers, two prominent researchers were invited to give keynote lectures in their respective fields of competence. Professor Rihard Karba from University of Ljubjana, Slovenia, presents a view on the role of modelling and simulation in biopharmacy through case studies. Dr. Leif Hammarström from Nestle Jacobs presented requirements and viewpoints on simulators in the chemical process industry.

Modelling and simulation software was focused in tutorials, vendor presentations and exhibition. Tutorials are given by Adept Scientific Nordic, Comsol, The MathWorks and the Modelica Association. Adept Scientific Nordic, Comsol, The MathWorks, Medeso and Process Flow presented their products in vendor sessions. The sponsors, including also Numerola and VTT, present their products also in the exhibition. Further information is available on the web page NTSAT.OULU.FI

IFAC ALSIS'06 Workshop. The *1st IFAC Workshop on Applications of Large Scale Industrial Systems - ALSIS'06 Workshop* was arranged as a cruise between two Scandinavian capitals, Helsinki and Stockholm in August 30-31, 2006.

The Applications of Large Scale Industrial Sys-tems, the first workshop of its kind in IFAC, covered such systems as mill- and company-wide systems, communication systems, environmental systems, intelligent manufacturing systems, and so on. Large scale system theory provides methodologies to deal with complexity in modelling, control, and design of such systems. The special emphasis was on industrial applications (chemical and petrochemical industries, metallurgical industries and pulp and paper) and development tools and methods applicable in industrial environment.

Selected papers have been published in International Journal of Computers, Communications & Control, IJCCC, see JOURNAL.UNIVAGORA.RO. Further information is available on the web page NTSAT.OULU.FI.

Workshop New Trends in Automation 2006. The Workshop on New Trends in Automation was organised by Malardalen University in Vasterås, Sweden, September 4-5, 2006. The workshop contained keynote presentations, peer reviewed papers and discussion workshops. The program included 5 speeches of well knows researchers and authorities in different areas in the field of automation.

The workshop discussed on various future trends, combining experience and competence different areas, Robotics and possibilities of new advanced controls in process industries and power plants. 70 participants attended the conference.Further information is available on the SIMS web page WWW.SCANSIMS.ORG.

Modelica Conference 2006. The International Modelica Conference was held at Arsenal Research in Vienna, Austria on September 4-5, 2006. The conference was organized by the Modelica Association and Arsenal Research. Further information is available from WWW.MODELICA.ORG.

SIMsafe2006. The SIMsafe2006 – Systems for improving public safety was held in Karlskoga, Sweden on September 7, 2006. The conference addressed the impact on society of using modern technology such as modelling and simulation to improve public safety. Further information is available on the SIMS web page WWW.SCANSIMS.ORG.

Future Events

SIMS 2007. The 48th Scandinavian Conference on Simulation and Modelling, will be organized by MoSIS in Göteborg, Sweden, October 29-31, 2007.

SIMS 2007
48th SIMS Annual Conference
October 29-31, 2007
Göteborg, Sweden

The purpose of SIMS 2007 is to cover broad aspects of modeling and simulation and scientific computation. Every year a special topic will be considered, this year mutibody dynamics. The conference will be of interest for model builders, simulator personnel, scientists, engineers, vendors, etc. The scientific program consists of technical sessions with submitted and invited papers, and vendor demonstrations. There will be a tutorial day in conjuction with the conference.

The Proceedings of the conference will be published electronically by Linköping University Electronic press. Selected papers will be considered for publication in the EUROSIM scientific journal *Simulation and Modelling - Practise and Theory* (SIMPRA) published by Elsevier Science.

The annual meeting of SIMS will be held during the conference. Further information is available on the SIMS web page WWW.SCANSIMS.ORG and on the conference web page WWW.IDA.LIU.SE/~petbu/conferences/sim2007/.

Trends in Automation 2007. The *Workshop on Trends in Automation* will be organised by Malardalen University in Vasterås, Sweden, June 18, 2007 in conjunction with the *3rd International Green Energy Conference*.

Workshop on
Trends in Automation 2007
June 18, 2007
Vesterås, Sweden

The workshop will contain keynote presentations, peer reviewed papers and discussion workshops. Further information will be available on the SIMS web page WWW.SCANSIMS. ORG.

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CEA-SMSG - Spanish Modelling and Simulation Group

General Information. CEA is the *Spanish Society on Automation and Control* and it is the national member of IFAC in Spain. Since 1968 CEA-IFAC looks after the development of the automation in Spain, in its different issues: automatic control, robotics, Simulation, etc. In order to improve the efficiency and to deep into the different fields of Automation, the association is divided into thematic groups, concretely eight groups at present, one of them is named *Modelling and Simulation*, constituting then the CEA-SMSG. This group works basically about all the issues concerning the use of Modelling and Simulation techniques as essential engineering tools for decision-making.

Information, Address

- Web info: WWW.CEA-IFAC.ES/wwwgrupos/simulacion
- Address: CEA-SMSG / María Jesús de la Fuente, System Engineering and Automatic Control department, University of Valladolid, Real de Burgos s/n., 47011 Valladolid, SPAIN

Function	Name and Email
President	María J. la Fuente, *maria@autom.uva.es*
Repr. EUROSIM	María J. la Fuente, *maria@autom.uva.es*

Activities. The main usual activities of the group can be summarized as an annual meeting about modelling and simulation, inside CEA meeting on automation, specialized courses, a distribution list, a periodic electronic report, technical books, a journal (translated as *Latin American journal of Automation and Industrial Computing*), a trade agreement with Pearson Inc. for a collection of books, an award for the scientific contribution in automation and a specific award for modelling and simulation, sponsorship of events, etc.

Recent Events. As most interesting recent activities could be selected:

- Course on Distributed simulation and high level architecture for modeling and simulation (UAB, Barcelona 2005)
- Course on Metamodelling and analysis based on simulation of supply nets (UAB, Barcelona 2006)
- Workshop on Decision-making (UPC, Madrid 2006)
- Collaboration in the 17th European Simulation Symposium and Exhibition, ISS05, co-located with the 2005 International Mediterranean Modelling Multiconference, I3M05 (Marseille, 2005).
- Organisation (by the then coordinator of the group, Dr. Miquel Àngel Piera) of two conferences co-located within the I3M06: The European Modeling and Simulation Symposium (EMSS06) and the Harbour, Maritime & Multimodal Logistics Modelling and Simulation (HMS06), (Barcelona 2006).

Coming Events

XXVIII Jornadas de Automática by CEA-IFAC
4-7 Sept. 2007, Huelva, Spain
with annual meeting of the CEA-SMSG

CEDI-SIMOSI2007
Symposium on Modelling and Simulation
on occasion of the Spanish Congress of Computing
11-14 Sept. 2007, Zaragoza, Spain

María J. la Fuente, *maria@autom.uva.es*

LSS - Latvian Simulation Society

General Information. The Latvian Simulation Society (LSS, has been found in 1990 as the first professional simulation organisation in the field of Modelling and simulation in the post-Soviet area. Its members represent the main simulation centres in Latvia, including both academic and industrial sectors, in particular, operating at Riga Technical University, Latvian University, the Latvian University of Agriculture, Transport and Telecommunication Institute, as well as at industrial companies DATI Exigen Group and Solvers, Ltd.

- Web info: BRIEDIS.ITL.RTU.LV/imb/
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Function	Name and Email
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Repr. EUROSIM	Yuri Merkuryev, *merkur@itl.rtu.lv*

Activities. The society performs regular activities at both national and international levels. It holds a seminar, where current research activities at involved organizations in the area of modelling and simulation are discussed. LSS is regularly involved into organization of international events. For instance, it hosted international conferences *Simulation, Gaming, Training and Business Process Reengineering in Operations* (1996, 2000) *Harbour, Maritime & Multimodal Logistics Modelling and Simulation* in 1998 and 2003 , as well as the *European Conference on Modelling and Simulation ECMS 2007*.For detailed information see website.

Yuri Merkuryev, *merkur@itl.rtu.lv*

DBSS Dutch Benelux Simulation Society

General Information. The Dutch Benelux Simulation Society (DBSS) was founded in July 1986 in order to create an organisation of simulation professionals within the Dutch language area. DBSS has actively promoted creation of similar organisations in other language areas. DBSS is a member of EUROSIM and works in close cooperation with its members and is further affiliated with SCS International, IMACS, and the Chinese Association for System Simulation and the Japanese Society for Simulation Technology.

Membership Information, Contact Address

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Secretary	Th. L. van Stijn
Repr. EUROSIM	A.W. Heemink, *a.w.heemink@its.tudelft.nl*
- Deputy	W. Smit, *smitnet@wxs.nl*
Edit. Board SNE	A.W. Heemink, *a.w.heemink@its.tudelft.nl*

Both corporate entities (companies, institutes, etc.) and individuals are welcome to join DBSS as full corporate or individual member. The contribution is divided in two options:

- Euro 34,- individual member or Euro 68,- institutional member, which means that you will receive the newsletter Simulation News Europe two times a year.
- Euro 68,- individual member or Euro 114,- institutional member, which means that you will receive the Journal Simulation Practice and Theory eight times a year, and Simulation News Europe two times a year.

Becoming member of DBSS includes automatically being member of EUROSIM, the overall organisation of European Simulation Societies. DBSS members enjoy reduction of the fees attending the 'EUROSIM Events' which include congresses, conferences, symposia, workshops etc. For institutional members counts that they can join national *DBSS events* with three persons against the reduced fee. Please mention your name, affiliation and address (including email, fax and telephone), and indicate whether you are interested in the personal or institutional membership and contact DBSS:

Arnold W. Heemink, *a.w.heemink@its.tudelft.nl*

PSCS - Polish Society for Computer Simulation

General. PSCS was founded in 1993 in Warsaw. PSCS is a scientific, non-profit association of members from universities, research institutes and industry in Poland with common interests in variety of methods of computer simulations and its applications. At present PSCS counts 264 members.

Information, Contact Address

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Deputy	Andrzej Chudzikiewicz, *ach@it.pw.edu.pl*
Edit. Board SNE	Zenon Sosnowski, *zenon@ii.pb.bialystok.pl*

Activities. The main activity of the Polish Society for Computer Simulation are annual conferences known as PSCS *Workshops on Simulation in Research and Development*. The last PSCS Workshops were organized in Zakopane (2003), Bialystok/Augustow (2004), Sarbinowo Morskie (2005), and Kazimierz Dolny (2006).

Past Events. On December 11, 2006 the PSCS became the full member of EUROSIM. The annual PSCS Workshop *Simulation in Research and Development* took place on August 31 - September 2, 2006 in Kazimierz Dolny, Poland. The workshop was visited by EUROSIM President Prof. Borut Zupancic. The papers of the workshop covered the following areas: simulation in mechanical engineeringand in mathematical problems, artificial intelligence and simulation, simulation in transportation, neural nets, and others.

Publications. Proc.12th PSCS Workshop *Simulation in Research and Development*, M.Nader, A.Tylikowski (Eds.), Warszawa, 2006, (Polish; 30.- PLN).

Coming Events. A. Grzyb organises the 14th PSCS Workshop *Simulation in Research and Development* on September 26-29, 2007 in Krynica Zdroj, Poland; E-mail: *agrzyb@mech.pk.edu.pl.*

14th PSCS Workshop
Simulation in Research and Development
September 26 - 29, 2007; Krynica Zdroj, Poland

Zenon Sosnowski, *zenon@ii.pb.bialystok.pl*

SLOSIM - Slovenian Society for Simulation and Modelling

General Information. SLOSIM - *Slovenian Society for Simulation and Modelling* - was established in 1994 and became the full member of EUROSIM in 1996. Currently it has 74 members from both slovenian universities, institutes, and industry. It promotes modelling and simulation approach to problem solving in industrial as well as in academic environments by establishing communication and cooperation among the corresponding teams.

Information, Contact Address

- Web info: MSC.FE.UNI-LJ.SI/SLOSIM
- Address: SLOSIM - Slovenian Simulation Society
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Edit. Board SNE	Rihard Karba, *rihard.karba@fe.uni-lj.si*
Web EUROSIM	Aleš Belič, *ales.belic@fe.uni-lj.si*

Activities

General Assembly. On November, 30th, 2006, the general and election assembly was held at the Faulty of Electrical Engineering in Ljubljana. The reports about the previous election period and plans for the future were presented by the president and treasurer. SLOSIM board for the next four-year period has been elected with the following members:

R. Karba – president,
L. Žlajpah – vice-president,
A. Belič – secretary,
M. Simčič – treasurer,

and five members from different institutions.

Lecture. Before the general assembly, the lecture about industrial and military simulations in Slovenia, given by the representatives of two slovenian SMEs of the area, was organised for the members of SLOSIM

.ERK 06. On the 15th slovenian ERK conference SLOSIM was involved with the following activities:

- organisation of the invited lecture: *On the many Roles of Simulation along Developments and Projects*, given by Jose Maria Giron-Sierra from Spain,
- organisation of modelling and simulation session with eight participants,
- several SLOSIM members participated with lectures also in other sessions.

EUROSIM 2007. The main efforts are put into EUROSIM 2007 congress organisation. Here the actions for exhibitors and sponsors attraction were undertaken, as well as discussion of details for social events organisation were done. The progress in gathering special sessions and tutorials is most directly visible on the congress web site WWW.EUROSIM2007.ORG, where also other news are promptly accessible. The conference management system is also working, enabling registration, submission, and reviewing of papers.

Coming Events. See WWW.EUROSIM2007.ORG for latest information on EUROSIM 2007 congress.

Rihard Karba, *rihard.karba@fe.uni-lj.si*

FRANCOSIM - Société Francophone de Simulation

FRANCOSIM was founded in 1991 and aims to the promotion of simulation and research, in industry and academic fields. Francosim operates two poles.

- Pole Modelling and simulation of discrete event systems; contact: Henri Pierreval, *pierreva@ifma.fr*
- Pole Modelling and simulation of continuous systems; Pole contact: Yskandar Hamam, *y.hamam@esiee.fr*, WWW.ESIEE.FR/~HAMAMY

- Web info: WWW.EUROSIM.INFO
- Address: FRANCOSIM / Yskandar Hamam
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Vice president	-
Treasurer	François Rocaries, *f.rocaries@esiee.fr*
Repr. EUROSIM	Yskandar Hamam, *y.hamam@esiee.fr*
Deputy	-
Edit. Board SNE	Yskandar Hamam, *y.hamam@esiee.fr*

UKSim - United Kingdom Simulation Society

General Information. The UK Simulation Society (UKSim) has more than 100 members throughout the UK from universities and industry. It is active in all areas of simulation and it holds a biennial conference as well as regular meet-ings and workshops.

Information, Address, Membership

- Web info: WWW.UKSIM.ORG.UK
- Address: UKSIM - United kingdom Simulation Society
  Alessandra Orsoni, Kingston Business
  School, Kingston Hill, Kingston-Upon-Thames,
  Surrey, KT2 7LB, UNITED KINGDOM

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Secretary	Alessandra Orsoni, *A.Orsoni@kingston.ac.uk*
Treasurer	B. Thompson, *barry@bjtcon.ndo.co.uk*
Membership Chair	K. Al-Begain, *kbegain@glam.ac.uk*
Univ. Liaison Chair	R. Cheng, *rchc@maths.soton.ac.uk*
Ind. Liaison Chair	Richard Zobel, *r.zobel@ntworld.com*
Conf. Venue Chair	John Pollard, *j.pollard@ee.ucl.ac.uk*
Repr. EUROSIM	A. Orsoni, *A.Orsoni@kingston.ac.uk*
Edit. Board SNE	A. Orsoni, *A.Orsoni@kingston.ac.uk*

Membership is very good value at only £20 per year including an online subscription to Simulation News Europe. For information about the Membership please contact the Membership Secretary Alessandra Orsoni.

Activites.

European Modelling Symposium. In September 2006 the Society launched the first of a new series of meetings under the title of *European Modelling Symposium*. Dr. John Pollard from University College London, was appointed by UKSim as Director for the series which is especially aimed at attracting new researchers, post-graduates and post-doctoral fellows, with the benefits of fully credited papers, rigorously reviewed to international standards and published in the Symposium proceedings. A selection of papers from each meeting have been chosen for extension and publication in a special issue of the International Journal of Simulation Systems Science and Technology.

EMS2006. The first edition of this series, EMS2006, was hosted by University College London on 11-12 September 2006. Further information may be found at WWW.EURO-MODELLING-SYMP.INFO.

EMS2007. The second edition of the Symposium will also be hosted by University College London and will be held on 13-14 September 2007.

UKSim Committee Meeting. In December 2006, UKSim Committee held its annual review meeting at St John's College, Oxford. The meeting covered the Society's activities in 2006 and reviewed plans of upcoming events. These include UKSim first major international event outside of the UK, the Asia Modelling Symposium in Phuket, Thailand, March 2007, and a one day workshop at Oswestry Hopsital in Shropshire, UK, which concentrates on the interaction between medicine and simulation, MedSim 2007 workshop.

Conferences

AMS2007 - UKSim 2007. On the occasion of the 10th anniversary of the UKSim series of conferences, the society will hold its 2007 meetings in Thailand as the *Asian Modelling Symposium 2007*, at the Prince of Songkla University, Phuket Campus, from 27 to 30 March 2007, in conjunction with Thailand's *Annual National Symposium for Computational Science and Engineering* (ANSCSE-11).

AMS 2007
Asian Modelling Symposium 2007
Prince of Songkla University, Phuket Camps
March 27-30, 2007, Phuket, Thailand

The event has attracted numerous papers on the multiple aspects of modelling and simulation for intelligent systems. These include intelligent and adaptive design methods, new paradigms in computational intelligence, hybrid networks, connectionist systems, as well as the design and implementation of evolutionary algorithms and fuzzy systems to support all stages of the life cycle in application areas such as industry, business, energy, transport and the environment

UKSim - MedSim 2007. The Society is concurrently organising a one day workshop, the first in the UK Simulation Society series of meetings to focus exclusively on the interaction between modelling and simulation on the one hand and medicine and biology on the other with particular reference to Orthopaedics. The workshop represents the outcome of newly established links by Dr Gillian Pearce from the University of Wolverhampton, who has recently become a member of the UKSim committee, with the Robert Jones & Agnes Hunt (RJAH) Orthopedic hospital at Oswestry. The UKSim-MedSim 2007 workshop will be hosted by RJAH Orthopaedic hospital on 12 April 2007. Further details on the event may be found in the Conferences/Events section of UKSIM website.

ECMS Conference Series. The society is significantly involved in the organization of the *European Conference on Modelling and Simulation* (ECMS) series. The new President of ECMS is Prof. Khalid Al-Begain from the University of Glamorgan, who has been a key member of the UKSim committee for several years. The current treasurer of ECMS is prof David Al-Dabass from Nottingham Trent University, who currently serves as chairman of UKSim. Other members of the UKSim committee regularly contribute to the organisation of ECMS with conference and track chairing roles. The next ECMS meeting will be held in Prague, Czech Republic, on 4-6 June 2007.

Publications - Journal IJSSST.

A leading publication of UKSIM is the Journal of Simulation Systems, Science & Technology (IJSSST) which has recently received the IEE accreditation and the IEEE (UK and RI Chapter) technical co-sponsorship. All the special issues are listed in the Inspec Database. Due to the large number of special issues of the journal devoted to the best papers from conferences supported by UKSim, a new role of Special Issues Editor has recently been established. UKSim is proud to have appointed Dr Alessandra Orsoni, University of Kingston, UK, to this role and wish Dr Orsoni every success in this endeavour.

Eight special issues of the journal have been published in 2006. Three of them, including selected papers from the 2005 and 2006 European Conference on Modelling and Simulation and one including selected papers from the 2006 UKSim Conference, as well as papers focusing on topics of special interest such as Performance Evaluation of Computer Systems, Performance Engineering, Vision & Visualisation, Modelling Simulation and Decision Support, Technology Processes and Operations Research, Simulation in Industry, Business and Services, Mechatronics Technology, Simulation in Engineering, Science, and Technology. All issues are available online (UKSIM website, with samples.)

ROMSIM - Romanian Modelling and Simulation Society

ROMSIM has been founded in 1990 as a non-profit society, devoted to both theoretical and applied aspects of modelling and simulation of systems. ROMSIM currently has about 100 members from both Romania and Republic of Moldavia.

- Web info: INFODOC.ICI.RO/romsim
- Address: ROMSIM / Florin Stanciulescu
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ROMSIM has developed in the last time a lot of activities in both scientific and information field, as for instance: organisation of scientific conferences and seminaries in modelling and simulation of systems, etc - see EUROSIM website WWW.EUROSIM.INFO.

Present and Coming Events

EUROSIM 2007. ROMSIM is involved in organization of the EUROSIM Congress 2007 in Liubliana. Four members of ROMSIM are members of the IPC of the Congress. ROMSIM encouraged members to submit papers at this Congress.

MATHMOD 2006. Two ROMSIM members attended the MATHMOD Conference, Vienna, Feb. 2006.

Seminars. ROMSIM is involved in organisation of the periodic scientific seminary on *Systems Modelling and Simulation*, attended by 15 to 20 specialists. The seminary present and discuss both theoretical and applied contributions of participants, in the field of systems modelling and simulation.

Workshop Bucharest. Members of ROMSIM participated at the Workshop Principles of Modelling of Complex Ecological Systems, organised by the Faculty of Biology from University of Bucharest.

Series / Articles. Some monographs are to be published in a new Series titled *Technologies of Information*, of Technical Publishing House, Bucharest and articles will be published in the Romanian journals *SIC-Studies in Information and Control* and *RRIA-Romanian Journals of Informatics and Automatics*. ROMSIM members ensure the reviewing of articles submitted. Members of ROMSIM have published articles in *Romania Journal for Informatics and Automatics*, as dr. Florin Hartescu, math. Zoe Radulescu and other. Some PhD thesis ,elaborated on these subjects by some members of the seminar, are in progress.

Books. An important book has been published out from ROMSIM: *Modelling of High Complexity Systems with Applications* (including a CD with 12 MathCAD applications and a Readme), by dr. Florin Stanciulescu, WIT Press, Southampton, Boston. A review of this book has been published in SNE 16-1.

Florin Stanciulescu, *sflorin@ici.ro*

INDUSTRY NEWS

COMSOL Conference 2007 in Grenoble

COMSOL is running a world-wide conference series on COMSOL Multphysics (FEMLAB) applications. The European conference in 2007 will be organised in Grenoble, October 23 - 24, 2007. The Call for Papers invites any kind of application in industry, research or university environment; application areas range from acoustics, bioscience and bioengineering, via optimization & numerical methods to quantum mechanics, and structural mechanics, including any kind of engineering application.

Abstracts with 200 - 400 words without formula should be submitted to *conference@comsol.eu*, to be forwarded to an international program committee.

Contact: FEMLAB GmbH
Berliner Strasse 4, 37073 Göttingen
Tel.: +49(0)551-99721–0, Fax: –29
info@femlab.de
WWW.FEMLAB.DE, WWW.COMSOL.COM

Incontrol: ED 7.1 – German User Group

In this first update to Enterprise Dynamics 7.1 a lot of small issues have been solved. The issues are related to 4DScript (e.g. full cursor control), to the Engine (e.g. improved search functionality), to general atoms (mainly GUI functionality), and to logistics suite atoms (mainly application atoms.). Registered users may download the maintenance pack from the website of Incontrol WWW.INCONTROL.NL.

In Germany an ED User Group has been setup. The User Group is supervised by Harald Apel, Magdeburg Univ. of Applied Sciences, (*harald.apelhs-magdeburg.de*) and offers a webserver with forum, chat, file sharing, etc.: WWW.DBED.DMT.DE.

Contact: Enterprise Dynamics, Planetenbaan 21
3606 AK Maarssen, The Netherlands
Tel +31-346-552500, Fax – 552451
WWW.ENTERPRISEDYNAMICS.COM

Scientific Computers: Maple Webinars Maple for Vista -

Maplesoft, developer of Maple, provides so-called webinars for Maple users. Webinars may either be followed online, or recorded webinars may be downloaded. Webinars provide in-depth information and demonstrations of Maplesoft products:

- Introduction to Maple 11
- Derive to Deploy: Five Ways to Accelerate your Engineering Design Process
- Clickable Calculus: Pre-Calculus, and Calculus of one and Several Variables
- Prototype and Simulate Vehicle Systems using Maplesoft's Design Engineering Tools
- Maple Connectivity Tools for Simulink®/MATLAB®
- From Theory to Practice: Maple to Increase Insight and Efficiency in Engineering Education and Research

The *Windows Vista* version of *Maple 11* is available at no charge users with valid license. Software may be downloaded from WWW.MAPLESOFT.COM, or may be obtained from Scientific Computers.

Contact: Scientific Computers GmbH
Friedlandstrasse 18, D-52064 Aachen,
Tel + 49 (0241) 40008 - 0, Fax – 13
info@scientific.de, WWW.SCIENTIFIC.DE

Upgrade MATLAB Toolboxes / Blocksets SimEvents

The MathWorks announced major upgrades to toolboxes and blocksets. Among them, SimEvents® 2.0, a major release to the SimEvent Blockset is found (for immediate download). SimEvents extends Simulink with a discrete-event simulation (DES) model of computation. The new features are:

- Vector and matrix support for modelling dense payloads via attributes
- Entity combining feature for bundling entities and attributes
- Time-out feature for modelling point-to-point timing constraints
- New application demos in communications, video processing, and architecture modelling

Contact: The Mathworks GmbH,
Friedlandstr. 18, D- 52064 Aachen
Tel +49 -241-47075-0, Fax – 12
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