Simulation in Engineering Sciences

J. Burger, Y. Jarny Editors

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Applications to the Automatic Control of Mechanical and Energy Systems

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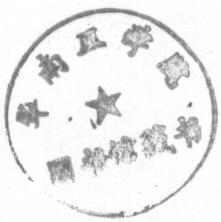

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PREFACE

These Proceedings contain the texts of the papers presented at the IMACS Symposium SIMULATION IN ENGINEERING SCIENCES, which was held in Nantes, France, on 9-11 May 1983.

The International Program Committee accepted about 60 papers among 120 projects that had been presented.

The various chapters of this volume take into account the topics used at the sessions of the Symposium.

The 4 invited survey papers are followed by the contributions related to simulation methods and tools, studied from both the software and the hardware points of view. Then a great number of papers are devoted to technical applications, i.e. to the simulation of actual processes. The contributions concerning mainly modelling are not separated from the others because of the strong connection between modelling and simulation.

The Committee has put particular emphasis on papers related to mechanical systems, vehicles and robots, considering the high interest of a great many people in the subject.

Distributing the communications into the various sessions proved to be rather difficult and this arrangement reflects the editors' personal opinion.

J. Burger – Y. Jarny
May '83

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LIST OF CONTENTS

INVITED PAPERS

I. SIMULATION TOOLS – Software

II. SIMULATION METHODS – NUMERICAL METHODS

X. MECHANICAL SYSTEMS

XI. CHEMICAL SYSTEMS

XII. MANIPULATORS – ROBOTS (1)

XIII. THERMIC SYSTEMS

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XIV. VEHICLES – TRANSPORTATION (2)

XV. MANIPULATORS – ROBOTS (2)

XVI. ELECTRICAL AND ELECTROMECHANICAL SYSTEMS

INVITED PAPERS

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SIMULATION SOFTWARE: TODAY AND TOMORROW

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This paper describes briefly the current situation on the simulation software market. A list of simulation software features is presented which is then graphed in tabular form versus a couple of current simulation languages and packages. In a second part, some of the major shortcomings of current simulation systems are outlined, and some prospectives for development are given.

1. INTRODUCTION

Eight years ago I have been asked already once to survey the numerical techniques used in continuous simulation together with the major software systems which existed at that time for this purpose [8]. When I was now asked once more to repeat this task, I tried to figure out whether our knowledge about simulation techniques has sufficiently advanced over the past eight years to justify a reconsideration. I then came to the conclusion that most of the "prospectives for development" mentioned in that paper had meanwhile become everydays state-of-the-art issues, while most of the software systems considered at that time are meanwhile obsolete. Moreover, I have some new ideas about future development of simulation software which were not present yet in 1975. Therefore, I considered the time come to write another survey now.

In this paper, I shall not review the basic features (such as numerical integration) dealt with in my previous survey [8]. I shall assume that the reader of this article has already acquired a basic knowledge of the functioning of simulation software. Moreover, I shall extend my view to discrete simulation as well, as it was realized in the mean time that the techniques used in these two classes of simulation systems are very much related to each other, and as there exists now a considerable number of software systems capable of performing combined continuous and discrete simulation.

There are meanwhile so many simulation software systems on the market that it has become impossible to review even the major ones within a reasonably limited number of pages. For this reason, the mentioned software systems (which are those that I know best) are meant to be respresentative for many other software systems showing only minor differences.

This paper shall basically consist of three parts. In a first section, I shall try to present a crude clustering of simulation software systems based on a selection of classifying features. In a second part, I shall then list a few simulation systems which are either available on the market now or which are currently under development. The paper shall then be concluded with a list of proposals how some of the more important shortcomings of the available systems might be overcome in the future.

2. SIMULATION SOFTWARE FEATURES

In the following table, a rather large set of characterizing features of nowadays simulation software systems are listed. Altogether 15 software systems have been analysed with respect to the availability of these features. If a feature is not available in a system, this is indicated by (-). If the feature is available, this is marked by (x). In many cases however, the implementation of a feature being present in several software systems differs with respect to the degree of sophistication (e.g. comfort of usage). In such cases, the better implementation is indicated by (xx). Sometimes, a foot note is added to explain the difference. Please note that a (-) does not necessarily indicate that the respective feature is not programmable in that language. It just means that no particular provision is taken by the language for that purpose. To cite an example: it is of course possible to receive a histogram by use of SIMULA (as SIMULA is a flexible general purpose programming language). Still, the respective box in the table is marked by (-) as no particular provision is taken by SIMULA to relieve the user from writing his own program to collect statistics and get a histogram printed.

Features: \ Languages:	ACSL	DARE-P	SIMNON	DYMOLA	SYSMOD	FORSIM-6	SIMULA	PROSIM	SIMSCRIPT	GPSS-F-2	GPSS-F-3	SLAM-2	GASP-5	GASP-6	COSY
EXPRESSIVENESS OF THE LANGUAGE															
Continuous Systems															
Ordinary Differential Equations	xx	x	x	xx	xx	x	-	x	-	-	x	x	x	x	xx
Partial Differential Equations	x1	x2	-	-	-	xx	-	-	-	-	-	-	x3	xx	xx
Difference Equations	x	-	xx4	-	x	-	x	x	x	x	x	x	x	x	x
Discrete Systems															
Event Handling	x	-	-	-	x	-	x	x	xx	xx	xx	xx	xx	xx	xx
Process Interaction	-	-	-	-	-	-	xx	xx	-	xx	xx	xx	-	xx	xx
Activity Scanning	-	-	-	-	-	-	xx	xx	-	xx	xx	xx	-	xx	xx
Symbolic Library (at Source Level)	xx	-	-	xx	xx	-	-	-	-	-	-	-	-	-	xx
Run-Time Library															
for Continuous Systems	xx	x	x	x	xx	x	-	x	-	-	x	x	xx	xx	xx
for Discrete Systems	-	-	-	-	x	-	x	x	x	xx	xx	xx	xx	xx	xx
Data Handling (Data-Base Management)	-	x	-	-	x	-	-	-	-	-	x	xx5	x	x	x
NUMERICAL BEHAVIOR															
Integration															
Library of Integration Methodes	x	xx	x	x	x	x	-	-	-	-	x	-	x	x	x
Own Integration Method	-	xx	-	-	-	-	-	-	-	-	x	-	x	x	x
Automatic Selection of Method	-	-	-	-	-	-	-	-	-	-	-	-	x6	x6	x6
Partitioning of State-Space															
Manual Partitioning	xx	-	x	x	xx	-	-	-	-	-	x	-	-	-	-
Automatic Partitioning	-	-	-	-	-	xx7	-	-	-	-	-	-	-	-	-
Algebraic Loop Solver	xx	-	-	-	xx	xx	-	-	-	-	-	-	x	x	xx
Root Solver (State Events)	x	-	-	-	xx	x	-	-	-	-	x	x	xx	xx	xx
Steady-State Solver	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tracking Problems	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Integral-Differential Equations	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sparse Linear System Solver	-	-	-	-	-	x	-	-	-	-	-	-	-	x	x
Stiff Systems	xx	xx	x	x	xx	xx	-	-	-	-	x	-	xx	xx	xx
Highly Oscillatory Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Linear Systems (Special Method)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Noisy Systems	x	x	x	-	x	x	-	x	-	-	x	x	x	x	x
Partial Differential Equations (PDE)	x	x	-	-	-	xx	-	-	-	-	-	-	x	xx	xx
Spatial Derivatives Computation															
One-Dimensional Derivatives	-	x	-	-	-	xx	-	-	-	-	-	-	xx	xx	xx
Two-Dimensional Derivatives	-	-	-	-	-	xx	-	-	-	-	-	-	-	xx	xx

1) Formulation through vector-integration and interpretive macros.
2) By use of the REPEAT-operator.
3) As GASP-V is restricted to 100 ODE's, only PDE's in one space dimension can be formulated.
4) Special operator. All other systems treat difference equations by means of time events.
5) By use of a special simulation data language (SDL) which is available through Pritsker & Assoc.
6) Provided to date only in an experimental version which is not yet made available.
7) Not in the public version of FORSIM-VI, but well documented, tested and available from AECL.

Features \ Languages	ACSL	DARE-P	SIMNON	DYMOLA	SYSMOD	FORSIM-6	SIMULA	PROSIM	SIMSCRIPT	GPSS-F-2	GPSS-F-3	SLAM-2	GASP-5	GASP-6	COSY
Three-Dimensional Derivatives	-	-	-	-	-	xx	-	-	-	-	-	-	-	xx	xx
Library of Methods	-	-	-	-	-	xx	-	-	-	-	-	-	x	xx	xx
Spline Interpolation	-	-	-	-	-	x	-	-	-	-	-	-	-	x	x
Up-wind Interpolation	-	-	-	-	-	x	-	-	-	-	-	-	-	x	x
Own Interpolation Method	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Automatic Selection of Method	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Variable Grid Width	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Automatic Grid Width Control	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Error Estimation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parabolic PDE's	x	x	-	-	-	xx	-	-	-	-	-	-	x	xx	xx
Hyperbolic PDE's	x	x	-	-	-	x	-	-	-	-	-	-	x	x	x
Ellyptic PDE's	x	-	-	-	-	x	-	-	-	-	-	-	-	x	x
Shock Waves	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mixed PDE's and ODE's	x	x	-	-	-	xx	-	-	-	-	-	-	xx	xx	xx
Statistical Analysis															
Random Number Generation	x	x	-	-	x	-	x	x	xx	x	xx	xx	xx	xx	xx
Distribution Function Library	-	-	-	-	-	-	x	-	xx	x	x	xx	xx	xx	xx
Tabular Distribution Functions	-	-	-	-	-	-	-	-	x	x	x	x	x	x	x
Distr. Funct. Parameter Fitting	-	-	-	-	-	-	-	-	-	-	-	xx[1]	-	-	-
Statistical Report Generation															
Sampling Statistics	-	-	-	-	-	-	-	x	xx	xx	xx	xx	xx	xx	xx
Time-Persistant Statistics	-	-	-	-	-	-	-	-	xx	xx	xx	xx	xx	xx	xx
Histograms	-	-	-	-	-	-	-	xx	-	xx	xx	xx	xx	xx	xx
Confidence Intervals	-	-	-	-	-	-	-	-	-	x	x	xx[1]	-	-	-
Variance Estimation															
Variance of the Mean	-	-	-	-	-	-	-	-	-	x	x	x	x	x	x
Run-Length Determination	-	-	-	-	-	-	-	-	-	x	x	-	-	-	-
Transient Period Duration	-	-	-	-	-	-	-	-	-	x	x	-	-	-	-
Significance Tests	-	-	-	-	-	-	-	-	-	x	x	xx[1]	-	-	-
Variance Reduction															
Replication and Batch	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Subinterval Analysis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sensitivity Analysis															
Linear Approximation (Metamodel)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Replication	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Table Look-up															
Two-Dimensional Tables	x	x	-	-	x	x	-	-	-	-	-	x	x	x	x
Three-Dimensional Tables	x	x	-	-	-	x	-	-	-	-	-	-	-	x	x
Linear Interpolation	x	x	-	-	x	x	-	-	-	-	-	x	x	x	x
Non-linear Interpolation	-	-	-	-	x	-	-	-	-	-	-	-	-	x	x
Spline Interpolation	-	-	-	-	x	-	-	-	-	-	-	-	-	x	x
Dynamic Table Load	-	-	-	-	-	-	-	-	-	-	-	x	x	x	x
Sequential Interpolation	-	-	-	-	x	-	-	-	-	-	-	-	-	x	x
Mass-Storage Interpolation	-	-	-	-	x	-	-	-	-	-	-	-	-	x	x

1) By use of a separate program (AID) also provided by Pritsker & Assoc.

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