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RECENT ADVANCES IN THE DEVELOPMENT OF SIMULATION SOFTWARE

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ABSTRACT

Since the first microcomputer simulation languages became available significant developments have taken place such as major enhancements of existing languages, the availability of animation capabilities, the development of simulation systems specifically designed for microcomputers, domain dependent simulators and powerful user interfaces.

This paper will attempt to identify, analyze and discuss these trends in the development of microcomputer simulation software, the associated changes that are taking place in the application of the simulation modelling approach and the relevant implications for the simulation user.

OPSOMMING

Verskeie betekenisvolle ontwikkelings het plaasgevind sedert die eerste simulasieprogrammatuur vir mikro-rekenaars beskikbaar geraak het. Die belangrikste is waarskynlik omvangryke verbeterings van bestaande programmatuur, die beskikbaarheid van animasiefasiliteite, die ontwikkeling van simulasiestelsels wat spesifiek ontwerp is vir mikro-rekenaars, omgewingafhanklike simulators en kragtige gebruikers-koppelvlakke.

Hierdie artikel sal poog om die genoemde ontwikkelings te identifiseer, te analiseer en te bespreek ten opsigte van die gepaardgaande huidige veranderings in die gebruik van die simulasietegniek en die gevolglike implikasies vir die simulasiegebruiker.

INTRODUCTION

Simulation is not a new technique and general purpose simulation languages have been available for at least three decades. Furthermore, the simulation technique has been placed on a sound theoretical basis [4,9] and has been used extensively for the analysis of complex real world systems [1,11]. However, during 1984 the microcomputer technology reached a state of development which made it possible to run powerful but low-priced simulation software on relatively inexpensive computer equipment [8]. This significant development placed a simulation capability within the reach of most organizations and played a major role in the present widespread interest in and practical application of simulation modelling in South Africa [11]. The majority of simulation software, that became available for microcomputers during 1984 and 1985, was based on software originally developed for mainframe computers which were transferred to the microcomputer environment without necessarily exploiting the special characteristics and capabilities of the available microcomputer hardware [8]. Therefore these software products often lacked the user friendliness and powerful user interface typical of microcomputer software.

Since the first microcomputer simulation software became available significant developments have taken place of which the following may be the most important :

* Enhancements of existing microcomputer simulation software,
* new microcomputer software implementations,
* simulation software developed specifically for microcomputers,
* animation and dynamic graphic capabilities,
* domain dependent high level simulators,
* intelligent front-end processors, and
* support software and interfacing capabilities.

SUMMARY OF THE CHARACTERISTICS OF RECENTLY AVAILABLE SOFTWARE

A number of noteworthy simulation software products for microcomputers became available recently as well as major revisions and/or extensions of existing packages. Tables 1 to 4 provide some information in this regard [2,3,5,6,8,12].

The simulation software packages mentioned in Tables 1 to 4 are all intended for installation on typical microcomputer hardware. These simulation languages are primarily intended for building simulation models using the discrete event approach but some of the languages includes the possibility of incorporating a continuous modelling approach.

GENERAL PURPOSE SIMULATION LANGUAGES		
SOFTWARE	MOST IMPORTANT CHARACTERISTICS	PRICE
CAPS/ECSL *	General purpose simulation language with an intelligent front-end processor.	$3000
GEMS II **	General purpose manufacturing simulation language using a network diagram approach.	$1250
MicroSaint ***	Menu driven general purpose network simulation system.	$995
PC-SOL **	Simulation language specially suited to the modelling of communication systems.	$500
SIMAN PC ***	General purpose simulation language with special manufacturing and materials handling features.	$1500
SIMPLE_1 ***	An integrated simulation modelling environment supporting character animation.	$750
SLAM PC ***	General purpose simulation language using a network approach	$975

TABLE 1 Some characteristics of available simulation languages

MANUFACTURING SIMULATORS		
SOFTWARE	MOST IMPORTANT CHARACTERISTICS	PRICE
MAST/SPAR/BEAM ***	Animated simulation system for simulating flexible manufacturing systems.	$6500
Modelmaster **	Animated general purpose factory simulator.	R12000
SIMFACTORY ***	Animated general purpose factory modelling and planning simulator. (EGA graphics)	$27000

TABLE 2 Some characteristics of available manufacturing simulators

ANIMATION SYSTEMS		
SOFTWARE	MOST IMPORTANT CHARACTERISTICS	PRICE
CINEMA/EGA ***	Animation and graphics generator for use with the SIMAN simulation language. (EGA graphics)	$14000
SLAM Animation ***	Animation and graphics generator for use with the SLAM simulation language. (EGA graphics)	$9500

TABLE 3 Some characteristics of available animation systems

SIMULATION SUPPORT SOFTWARE		
SOFTWARE	MOST IMPORTANT CHARACTERISTICS	PRICE
BLOCKS/ ELEMENTS ***	Menu driven editors for generating SIMAN block models and experimental frames.	$200
CONTEX/CODER ***	Context sensitive and menu driven editors for generating SLAM network models.	R100
SIMCON ***	Simulation model development and control environment for SIMAN	R100
UNIFIT *	Statistical support software for the fitting of probability distributions to observed data.	$900

TABLE 4 Some characteristics of available support software

*** Additional information available from the author.**
**** Demonstration version installed at the University of Pretoria.**
***** Installed at the University of Pretoria.**

IMPORTANT RECENT DEVELOPMENTS IN MICROCOMPUTER SIMULATION SOFTWARE

Enhancements of existing microcomputer simulation software

The existing microcomputer simulation software are subjected to a continuous process of enhancement and further development both in terms of the languages features and other modelling support capabilities. The purpose of these enhancements is often to exploit the special characteristics and capabilities of the microcomputer hardware such as inexpensive graphics and interactive operation. For example the most recent version of SIMAN PC includes new features such as an interactive debugger, extensive graphics capabilities using standard microcomputer hardware facilities, comprehensive statistical analysis of simulation output and additional modelling constructs for modelling manufacturing systems.

New microcomputer software implementations

The established trend of transporting and adapting existing mainframe simulation software to the microcomputer environment is continuing. GEMS II and PC-SOL are recent examples of this process since both have been available as mainframe languages for some time.

Simulation software developed specifically for microcomputers

Numerous mainframe simulation languages have been successfully transported to the microcomputer environment (for example GPSS, Simscript, SLAM and GEMS). However, these microcomputer implementations often did suffer from various defects. These defects are primarily caused by the limitations of the inherent mainframe software design philosophy which may be difficult to get rid of or circumvent. In an effort to alleviate these problems a number of simulation software products specifically designed for the microcomputer environment have recently appeared on the market with MicroSaint and SIMPLE_1 being typical examples. Both of these software products provide a self contained integrated simulation environment including for example file managers, editors, graphics and on-line help facilities.

Animation and dynamic graphic capabilities

Animation and dynamic graphics of simulation model results are available in various forms and may make an important contribution to both the acceptance of simulation as a valid modelling tool and the effective debugging of a simulation model. Previous systems based on microcomputer technology and supporting animation suffered from some serious disadvantages such as slow execution speed, low screen display resolution, expensive hardware requirements and were often based on a low level and unsophisticated simulation language. However, recent developments have resulted in the availability of software products such as CINEMA/EGA and SLAM Animation which provide high resolution screen animation, based on a powerful simulation language and which require relatively inexpensive hardware. A number of other presently available,

relatively powerful simulation languages (for example SIMPLE_1), also provide animation features but these are often not as sophisticated as is the case with for example CINEMA/EGA, but are at the same time usually less expensive and easier to use.

Domain dependent high level simulators

A number of domain dependent high level simulators have become available recently. The main purpose of these simulators is to provide the user with a simulation environment for easier development of simulation models within a specific and constraint application domain. These simulators may often be used without necessarily requiring extensive knowledge and/or experience of either the simulation modelling technique or computer programming. Typical examples are MAST/SPAR/BEAM for the modelling of flexible manufacturing systems and SIMFACTORY for general manufacturing and materials handling simulation modelling. If applicable in a specific situation these simulators may have various significant advantages such as fast and easy model development but may also have some serious disadvantages in terms of insufficient modelling flexibility and the inherent danger of inadvertently developing and using a totally inappropriate model.

Intelligent front-end processors

The complex nature of the simulation technique, the resultant complexity of general purpose and powerful simulation languages and the accompanying discipline and detail knowledge necessary when developing a simulation model is often a strong deterrent when the use of the simulation approach is contemplated. Various intelligent front-end processors have become available in an effort to reduce the modelling and coding difficulties encountered by the simulation user.

One of the most significant contributions in this respect have been provided by CAPS (Computer Aided Programming of Simulations) which may be seen as an intelligent front-end processor for the simulation language ECSL. CAPS uses the concept of an activity cycle diagram and through an inter-active question and answer dialogue with the user a simulation model is constructed in the ECSL language. This approach represents one of the first attempts to use artificial intelligence concepts to provide a user-friendly modelling interface.

MicroSaint provides a different approach since it is almost completely menu-driven thus eliminating the necessity for the coding of language commands to a large extent. A MicroSaint model consists of a hierarchical system of networks where each sub-network may be seen as an interrelated network of tasks. The characteristics of each task, for example release condition, starting/ending effect, time duration and branching control, are specified by using a menu approach. This approach results in a relatively friendly user-interface but may also limit the modelling flexibility of MicroSaint while large models may become unwieldy.

In a similar fashion BLOCKS/ELEMENTS and CODER/CONTEX provides context sensitive editors for the coding of simulation models based on the

simulation languages SIMAN and SLAM respectively. SIMCON provides a simulation modelling and control environment for SIMAN and includes a build-in text editor.

Support software and interfacing capabilities

Performing a simulation modelling exercise often requires statistical analysis and data manipulation of both simulation input and output data. Software specifically designed for this purpose are available, for example UNIFIT, while general purpose software such as Statgraphics may also be used for this purpose.

Convenient interfacing of simulation models with the rest of the software environment, for example a data base, is often worthwhile and necessary but few simulation software packages provide such facilities at the moment. In those instances where interfacing is possible it is usually effected by using the development language of the simulation package, for example FORTRAN, to create intermediate files for data transfer between the simulation model and the rest of the software environment. This approach is often laboriously slow and may require intimate knowledge of the relevant file structures of the software packages involved. However, it may be expected that the development of such interfacing capabilities will take place in the near future.

TRENDS IN THE APPLICATION OF THE SIMULATION APPROACH

Significant changes have taken place in the application of the simulation approach and these changes are at least partly due to the availability of inexpensive software running on inexpensive microcomputer hardware. The most important changes may be summarized as follows :

* The use of simulation modelling as a decision tool has been expanding significantly both in terms of frequency and application base [11]. Furthermore, the technique is no longer being used just for once only long term strategic and planning purposes but also for solving operational decision problems of a repetitive kind [6,7,9].

* As a consequence of the increased availability of powerful simulation software, simulation modelling is being attempted by users who may be less sophisticated in terms of knowledge and/or experience of simulation theory and computer programming [5,6,7,10]. This development has resulted in a user need for easier to use, interactive and self contained simulation systems supporting both model development and the execution of simulation experiments. Software development has responded to this need but most of the presently available simulation software is, in this respect, still a long way behind typical microcomputer software [2,3,12].

* A large number and variety of simulation software products are available and although most simulation languages are at least conceptually the same or similar, significant differences exist between these products from a user point of view. Furthermore, there is a tendency for simulation languages to become, to some extent, more dedicated toward modelling systems within a specific domain. Selection of an appropriate simulation software product has become a difficult problem and the extent to which this problem is solved successfully may have a significant influence on the success of the particular application [6].

* Presently, most of the simulation software development is taking place in the microcomputer environment and microcomputer equipment has become the preferred hardware for the development of simulation models [2,3,5,6]. The previous generation of microcomputer hardware and system software may present some problems in terms of execution speed and capacity. However, the present generation, based on a 32-bit architecture, supporting a multi-tasking, multi-user environment and which has execution speeds and memory capacities comparable to main frame machines of less than a decade ago, may be capable of handling most of the requirements of the simulation user.

SUMMARY AND CONCLUSIONS

There has been a dramatic increase in the use of simulation modelling as a decision support tool in a variety of application areas. Consequently a large number of similar but nevertheless different simulation software products have become available providing a variety of powerful modelling features. These developments have made it easier for the inexperienced user to start using simulation. Features such as animation and interactive operation have made it easier to develop valid models and to obtain acceptance of such models. However, at the same time, choosing the appropriate simulation software product for a specific project has become an important but difficult and often recurring problem.

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