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Integration of web based environment for learning discrete simulation in e-learning system

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ABSTRACT

This paper proposes a new web-based environment for learning discrete simulation. FONWebGPSS is an application that provides a web-based interface for creating, storing and executing discrete system simulation models in the GPSS language. The primary goal of the paper is to improve the process of learning simulation by integration of the FONWebGPSS in the existing e-learning system, Moodle. Evaluation of the developed integrated solution for learning simulation has been performed within an undergraduate course, Simulation and simulation languages, at the Faculty of Organizational Sciences, University of Belgrade on a testing sample of 208 students divided into an experimental and a control groups. The research results show that students achieve better results on the final test when using the FONWebGPSS application integrated into the e-learning system in comparison with the standard desktop version of the GPSS.

1. Introduction

The area of computer simulation has been successfully applied to the study and modelling of processes, applications and real-world objects. A discrete system is one in which the state variables change only at a discrete set of time points, while in a continuous system the state variables change continuously over time [15,36]. Discrete event simulation has been successfully applied in the analysis of complex systems with discrete changes in the system's state, such as: airports, hospitals, factories, banks, and supply chain management systems [2,15]. Discrete simulation enables conducting analyses of various types of systems, investigating relations and interactions among system's components, project designing and implementation of a system, verifying different solutions and environments, testing capabilities and technical characteristics. Particularly, these tasks are very important for students in the area of management and business information systems, as they can learn how to make decisions, manage business processes, design complex information systems and applications that include a wide range of requirements [20]. Knowledge gained from simulation courses helps them understand, analyze and design systems, business processes, develop software components, test software solutions, and improve final outcomes of their work [10].

The major idea of this paper is to improve learning and teaching discrete simulation within e-learning courses through developing a new web-based simulation tool. Further, the simulation tool should be integrated with other components of the e-learning system. The subject of the research is to introduce the implemented simulation tool into the e-learning system of the Faculty of Organizational Sciences, University of Belgrade, where computer simulation has been studied in the scope of management and business information systems study programmes.

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2. Related work

Courses that teach discrete event simulation are usually conducted by using a specific simulation language [10]. The key issue is to find the language for simulation with appropriate simulation performance and adequate for students in the specific area of study. Also, a simulation language should be able to adapt to the up-to-date directions in the science of simulation and to enable an efficient simulation execution on modern computers [6,10,11].

The first generation of general purpose simulation languages included [10,25,31]: GPSS, HOCUS, ECSL, SIMULA, SIMCRIPT. They were followed by a specific implementation and new versions with improved features (GPSS/H, SIMSCRIPT II, etc.) [9,25,31,32]. The next phase was directed towards the development of visual interactive modelling packages such as: WITNESS, ProModel, and Automodel [10,31]. These visual simulation software solutions provided users with a variety of powerful multimedia tools and enabled model creating by simple selecting adequate visual elements, without a need for a writing code.

However, the quality of a simulation tool cannot be evaluated meaningfully based on the presence or absence of a single characteristic [28]. It is determined by the combination of general characteristics and specific features that are frequently used in model development. The first generations of simulation languages were block-based contrary to visual animated oriented simulation software [31]. Since many problems of interest in the study of business systems, resources and information flows are characterized by clearly different times for movement and contain invisible processes, animated simulation is not appropriate [10]. At the same time, graphical modelling tools can force their users to make the model fit within a rigid framework bound by the available menus and forms [10,28]. Complex visual models can become very cumbersome to view, edit, and document [19,28].

The GPSS (General Purpose Simulation System) is a language interpreter for executing a simulation of discrete, stochastic systems [9]. It defines the model's structure based on language commands [4,9,31,35,36]. A program in the GPSS is composed as a collection of processes descriptions, specifying sequences of activities and operations that will be executed on the attribute of the object model [4]. The best known versions of the GPSS language for personal computers are: GPSS/PC [12], GPSS/H [28,36], GPSS World [34]. It is one of the languages for discrete event system simulation proven to be adequate for educational purposes [10].

The GPSS/FON [3,4] is an implementation of the GPSS created in the Laboratory for simulation, at the Faculty of Organizational Sciences, University of Belgrade, during the 1990s. The main difference between the original versions of the GPSS and the GPSS/FON can be noticed in lower number of block types in our solution. Because of its simplicity and accessibility, a quick and easy model debugging, the GPSS/FON language has been successfully used within courses in the area of simulation, at the University of Belgrade [4,21,23]. The main reasons for using the GPSS language for teaching and learning purposes can be described through the following:

Educational purposes: Since its creation, the GPSS was the most common language used for learning simulation in both graduate and undergraduate studies [2,10]. In some extent, the GPSS requires a programming-style effort, but does so within a natural modelling framework that can be readily used without extensive programming experience [28,35]. It is based on a clear and simple syntax, commands that illustrate basic discrete event simulation concepts: queues, event scheduling, activities scheduling, etc. Over a period of 30 years in our teaching practice the GPSS has proved to be suitable for educational purposes [3,22].

Process interaction paradigm: The GPSS uses the intuitive and natural process interaction approach to modelling. The modeller specifies a sequence of events, separated by lapses in time, which describes the manner in which "entities" flow through a system [28]. This approach helps students analyze business systems through processes and services, which is fully in accordance with current directions in the information system design. On the contrary, Simula [25,31], one of the most used general purpose languages, is object-oriented and it forces students to focus on objects, classes, inheritance, but not on processes.

Flexibility: A key feature of the GPSS is the conceptual flexibility to model a wide range of different types of systems: any system that can be described as a process flow, with objects and resources acting upon each other [35]. Mapping between real-life world problems and objects can be seamlessly realized with the GPSS/FON. On the other side, the SIMSCRIPT features are not wide enough to cover all requirements in the area of discrete simulation and syntax tends to be more complex [32]. Another aspect of flexibility is related to the possibilities of integration with other components of the e-learning system. Since we have implemented our own version of the GPSS language, the source code is available and can be reused to implement simulator functionalities in other applications and components of the e-learning system.

Costs: Another reason for implementing our own version of the GPSS simulator was related to costs of licenses for commercial GPSS implementations. Licenses would have to be provided for more than 100 computers at the Faculty of Organizational Sciences and for more than 300 students each year. The GPSS/FON application is free and both installation and source code can be downloaded from our website.

2.1. Web-based simulation

A rapid development and ubiquity of the Internet and Internet technologies have had an impact upon the field of simulation, as they provide numerous ideas on how simulation can be improved. Since Fishwick [26] introduced a web based simulation (WBS) as a new issue, there was much research related to this area in the industrial, scientific and education community.