On-line Model-Based Atlas of Pathophysiology: Glimpse into Technological Background

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Introduction: Currently, our team approaches the final year of the project "The Internet Multimedia Atlas of the Selected Chapters of Human Physiology and Pathophysiology". The goal of the project is to develop an original and effective teaching tool, while using interactive multimedia and simulation games. With an interactive simulation model, we can demonstrate the dynamic behaviour of a real object interactively - student can play with it and understand their features more easily than using classical educational methods. In this paper, we want to briefly speak about technological background of our project's product and notice its didactical impact. The project development involves a large number of professions, not only the graphic designers and physiology teachers.

Methods: Just as the reception of a text-book by students depends on the author's ability to explain complex material in an illustrative and comprehensive way, the key to success of multimedia educational software is a good scenario. Thus the design cycle of our programs begins with the creation of scenarios. A scenario comprises not only a textual material, but also of cartoon strips of the "storyboard" which will later help the graphic designers to create graphics and animations. The behaviour of interactive educational programs is not linear – it depends on the user's interaction, on evaluation of user's actions and on the results of the simulation games involved.

The construction of a simulation model is indeed a domain of science. It is a theoretical work by itself, one based on formalization of physiological relations. The cooperation among system engineers (skilled in mathematical modelling), physiologists and eventually physicians (if the model is supposed to be applied in clinical medicine) has to be established at this level. A specialized tool for the simulations and the mathematical modelling, Matlab/Simulink by MathWorks, was used by our development team. We have adopted the concept of ***simulation chips*** that represent the building blocks of our simulation models [1] by taking advantage of the features of Simulink. A simulation model comprises of subsystems represented by simulation chips. The main advantage of this methodology is its comprehensibility for many professionals. The physiologists can look at the chip as a black box with some physiological functions inside and programmers can understand it as a subprogram or algorithm that is a part of more complex system.

The next level of an educational software elaboration is more like an industrial work. It is necessary to "wrap" the simulation models into nice and understandable graphical user interface according to the scenario. This is done by application programmers and web designers. We have used the Microsoft .NET platform for hosting the multimedia simulators. The simulation models' ability to communicate with the objects of the user interface (created in Microsoft Visual Studio .NET) enhances greatly their didactic value. We wanted then to do this often. Thus, we have developed a specialized tool, which would automate the conversion of a Simulink model to the .NET environment. It is a good idea to use interactive animated pictures connected to the simulation model for the visualization of simulation games**.** The Macromedia Flash offers the creation of interactive, scripted graphical components that can be placed into the Microsoft .NET environment and controlled by our simulation models. Thus, the interactive graphics created in Flash are used to visualize the behaviour of the simulation models, e.g. a picture of a vein can dilate or constrict, an alveolus can "breathe" more or less deeply etc.

As the next step, we use the Macromedia Breeze platform for the distribution of our multimedia e-learning content. The use of the environment of Macromedia Breeze is of advantage chiefly because of its capacity for rapid e-learning course creation and in-built wide e-learning management (LMS - Learning Management System). Nevertheless, it was still necessary to solve the problem of joining the e-learning web based application with the simulation model. Due to the small size of our simulation models and the continuous stream of input/output data generated by the model, it seems better to run the simulation model on the client's side. Thus, we have developed a special client application - "the simulation models dispatcher". This application executes (in the .NET environment) the simulation models, which are automatically downloaded from the server by the e-learning presentation. The "dispatcher" behaves like a common picture viewer, it only executes a simulation model instead of viewing a picture.

And last, but not least: The software then enters the testing phase in the education process. Further refinements can be made, if required by the teachers.

Results: The results of our work lie in elaboration of multimedia educational software, which uses computationally demanding simulation models distributed via Internet. Simulation models run on the computer of an on-line client, who just needs to have installed one particular control program to assure their correct operation. The download of a particular model goes on during the e-learning explanations, and is thereafter ready to be launched by one single click. The use of the .NET environment on the side of clients and ASP .NET on the side of server is assumed.

We have designed an internet accessible multimedia e-learning tool, which utilizes various simulation games. Experiments with the simulation model provide a virtual world where one can play harmlessly with a virtual organism, offering a new range of possibilities for exploring complex relationships. When explaining complex regulatory bonds in physiology, students can explore the behaviour of individual physiological subsystems being separated from their environment. The subsystems then can be interconnected again; temporarily broken regulatory loops can be closed, so that one can study their role and influence in various pathological disorders and therapy. Multimedia simulation games therefore becomes a visual learning aid for better understanding of the nature of physiological regulations and the manifestation of their malfunctions.

Discussion: The time of small groups of educational software enthusiasts as the only developer of the educational software is over. The process of working on the multimedia educational software is getting closer to an industrial procedure. The elaboration of modern educational programmes is challenging and complicated and it requires team cooperation of various professionals: skilled teacher, e.g. physiologist, system analyst, graphic designer, application programmer, web designer and others [2]. To keep the whole interdisciplinary design cycle fast and efficient, it is necessary to use specialized development tools with sufficient technical support at every stage of the work. One thing is clear: Convenient developer tools and a sound design methodology save time and money.

References:

[1] Kofránek, J., Andrlík, M., Kripner, T., Mašek, J.: From Simulation chips to biomedical simulator. *Modelling and Simulation 2002* (Amborski K, Meuth H, (Eds.)), *Proc. of 16th European Simulation Multiconference*, Germany, Darmstadt, 3.-5. 6. 2002**. ISBN 90-77039-07-4**: pp. 431-435.

[2] Kofránek, J., Andrlík, M., Stodulka, P., Kripner, T.: From Art to Industry: Development of Biomedical Simulators. *The IPSI BgD Transactions on Advanced Research* 2005; **1 #2** (Special Issue on the Research with Elements of Multidisciplinary, Interdisciplinary, and Transdisciplinary: The Best Paper Selection for 2005): pp. 63-68.