NEW TRAINING PROGRAMS IN POWER ENGINEERING USING VRML VISUALIZATION METHODS

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ABSTRACT

The increasing complexity of technical systems, shorter innovation cycles and new global markets has placed increasingly higher demands on the qualifications required of service personnel. Traditional training programs have the disadvantage of long downtimes and high costs. For specialized power system engineers a continuous and high-quality training is required. Computer Based Training (CBT) provides a good enhancement to the classic learning methods. This paper presents the implementation of a new prototype of a virtual maintenance course in the area of future education and training of power system personnel. New training programs integrating innovative techniques, such as virtual reality using Virtual Reality Modelling Language (VRML), make it possible to display detailed customer-specific plant situations virtually and to recreate different learning scenarios. Three-dimensional virtual representations of a fuel cell, wind turbine and power switch by means of VRML have already been developed at the Otto-von-Guericke University's Institute of Electric Power Systems in Magdeburg, Germany. The representations provide the learner with information about the most important functions and operational problems of each system. These three special learning scenarios (modules) can be performed as a demonstration or as an interactive three dimensional training. Different methods and experiences with regard to the design, development, and support of the implementation of new training programs in power engineering using new visualization techniques will be presented in this paper.

INTRODUCTION

The use of new didactic techniques for education in the scope of power systems is on the rise [1]. An e-learning module can makes it easier to learn complex correlations. This procedure can be indefinitely repeated because the access of the modules is time and place independent.
The variety of techniques available allows for the generation of visual information, which provides two-dimensional as well as three-dimensional virtual system representations [2]. Further, e-learning combines synchronous and asynchronous communication between the user and the learning material.
The implementation of three-dimensional virtual representations makes it possible to view electrical plants that are otherwise difficult to explore because of time constraints, cost, natural hazards, or access restrictions. Complex systems, electric plants and machines share many of these restrictions; thus a virtual representation of power plants/machines should prove to be an effective tool for exploring these spaces. A virtual world simulation can facilitate spatial experiences otherwise unavailable to students and professional personnel alike.
The increasing complexity of technical systems, shorter innovation cycles and new global markets has placed increasingly higher demands on the qualifications required of service personnel. For manufactures and operators of complex systems, plants and machines, this method can permit effective training and fast familiarization with operation, control and process sequences.
Virtual Reality Modelling Language (VRML) technology has an important advantage for such tasks, namely its flexible operation platform, which can be easily accessed with an internet browser [3]-[4]. VRML technology is already used in many scientific areas like medicine, chemistry, earth science and electrical engineering. This paper presents the uses of this technology for electric power systems courses, continuing education, and industrial training.

DESIGN AND DEVELOPMENT

The major challenge for a learning environment is to meet as many needs and expectations as possible. This starts with the graphical presentation of the learning environment and includes the navigation, clearness of the structure of content and the learning method. By means of new graphic software and techniques it is now possible to digitalize a flat picture and display it as a three dimensional structure.
The level of topological and graphical detail is often overlooked during the design process, and the effects are obvious, namely the overload of text and pictures. The virtual learning environment should motivate and activate the user and also make him/her more interested in new knowledge [2]-[6].
A student should be curious about what is to be seen in the next level. It is possible to avoid the overload of content through the proper structure of a module. The structure of the learning module means the organisation and formation of the content, for example into specific themes or assigned to the specific level of difficulty (Figure 1). One should plan at the beginning of the design process the order in which the various parts are to be displayed. The user-friendly structure of a module makes the navigation much easier. It is also possible, depending on the student's need, to either jump between the modules or to choose the sequential way through the sections.
For manufactures and operators of complex systems, plants and machines, this method can provide effective training and fast familiarization with operation, control and process sequences.

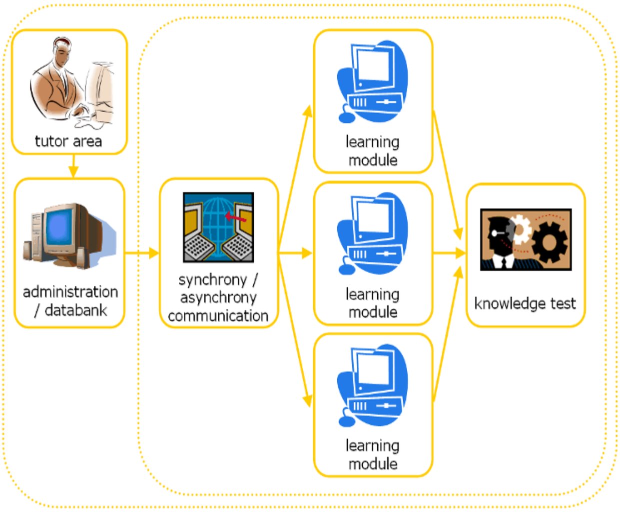

Figure 1. Basics segments of the learning management system

By using computer based learning (CBT) it is possible to make the presentation of knowledge more attractive. It can be very helpful to use such tools as sounds, pictures and graphs. But, there is limited display ability and sometime it is not enough. Here is where the major advantage of three-dimensional representation of objects and complex systems can be seen, namely it delivers new possibilities in a graphical presentation of information. Virtual Reality Modelling Language (VRML) allows us to build a virtual model of either real equipment or an entire system, depicting it from all sides. VRML also makes it possible to manipulate heavy equipment otherwise impossible to move or visit up close [8]. Using VRML many aspects and physical rules from reality can be easily adapted into the virtual platform. For example, the objects have their own visual attributes, namely their definite geometry, they are made from different materials and they are also light sensitive. It is possible to touch, per mouse click, the objects and move or rotate them. The user is able to cause an action which can trigger off another event in the virtual environment. The huge advantage of VRML technology is its flexibility. It is a standard scene description language, which can be used to describe complex 3D objects and worlds to be deployed over the web.

LEARNING MODULE

In the Chair for Electric Power Networks and Renewable Energy Sources (LENA) at the Otto-von-Guericke-University Magdeburg, the projects RegEn – M (Renewable Energy - Multimedia) and RegEn – VL (Renewable Energy – Virtual Laboratory) have been successfully realized and integrated into the program of studies [6]-[7]. The design and development concept follows two strategies: teaching scenarios and didactic design. Both projects consist of the following teaching modules:

- Basic principles of energy production
- Photovoltaic energy source
- Wind as an energy source
- Fuel cell systems and Small water power plants.

Figure 2. Start page of the RegEn – M – Wind module

RegEn is an online web application and consists of a group of modules which are available from the main menu (start page) of the project (Figure 2).
In order to promote the learner´s skills, the e-learning system is sub-divided into three areas:

- learning section – lectures to explain theoretical correlations,
- practical section – 3D virtual trainings to gain practical skills working on electrical problems, and
- testing section – testing the acquired knowledge.

To complete the learning module the learner must successfully complete all three sections.
Our ambition was to construct the learning module so that it can be used accurately not only at the beginning of student training but also for refreshing the knowledge after some time. The main information carrier on this learning level is the text (Figure 3).

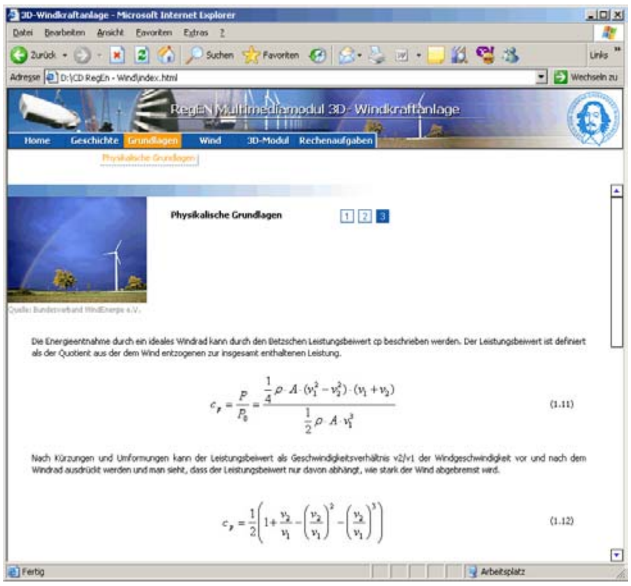

Figure 3. Learning level from module RegEn – VL – Wind

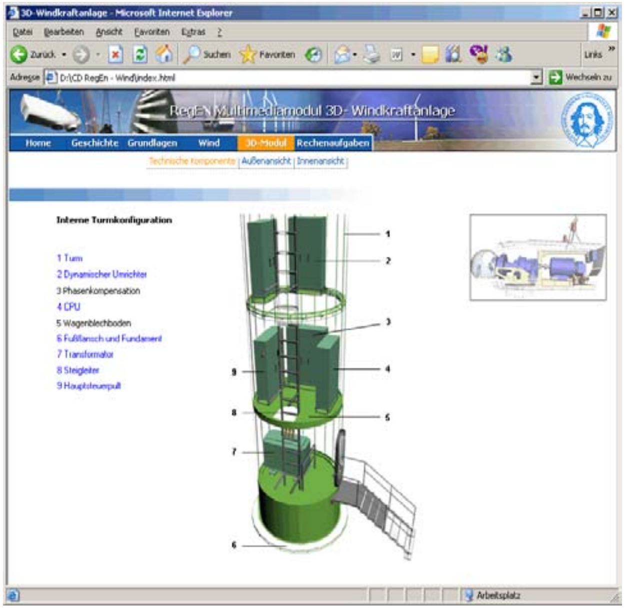

Figure 4. Internal tower configuration

After starting the learning module the user can chose from four different chapters (Figure 4):

- History of the wind power – the main part of this selection is the historical evolution of wind power and an interesting historical overview about the first practical use of wind turbines.
- Technical fundamentals – each element of the wind power plant is illustrated and described here in-depth. The learning success is deepened during the virtual observation of the constituent parts of the wind power plant. Interesting here is the possibility to see the exact placement of the individual parts and how these elements work together with the rest of the wind power plant.
- 3D – wind power plant – this is the main chapter of the learning module and, for better clearness, is additionally separated in three parts: technical components, exterior view and interior view of the wind power plant. Such subdivision is important for the clearness and panoramic view of the learning module and helps the user to adjust faster to the new environment and his/her task.
- Arithmetic tasks – the focus here is on a few different mathematical tasks, which the students have to calculate one their own.

During the training the learners are able to choose the structure of the wind power plant, and the whole system with its components (Figure 5). Here the user has a "hands-on" opportunity to examine the structure of the wind power plant by him/her self in the virtual field. At the same time information and data schemes for each element can be offered or requested. The student has the opportunity to learn and to see all of the specific functions of the different parts. In the training module different views of the wind power plant are available. The learner only needs to click to the navigation support with the right mouse button on the background and choose the desired camera view from the context menu.

Figure 5. Tower view in the virtual wind power plant

Furthermore, demonstrations are integrated into each chapter which can be called-up and played. They provide additional visual information about the chapter content. Additional written information gives details and instruction about the system operation and control.

The fundamental problem of dimensionality mismatch in a 3D format using two dimensional input devices for navigation tools is solved by integrating three navigation modes:

- Walk – is a mode that together with fly mode reflects the navigation in the real world.
- Fly – navigates as in a real world simulation.
- Study – the unique feature here is that this mode is not possible in the real world; because it enables users to examine the three dimensional object from many different viewpoints.

Each of these styles has four methods of movements (plan, pan, turn and roll), for example in the pan function the user can displace the whole 3D object up, down, right or left; it also provides an exact zoom-in of the different elements. All those different movement methods can be used independently of the viewed 3D object, and user position in the 3D virtual representation.

For the successful implementation and acceptance by the learner an authentic virtual representation of the real wind power plant and its elements is needed. When creating the virtual elements it was important to represent the models as realistically as possible. Very complex elements were formed into groups of object in order to accelerate the application operation and to minimize the data loading time. Our test with some students showed that participants with high visual spatial ability spent more time on task relevant content than students with low visual spatial ability. That is why, depending on the navigation or the subject choice, a new virtual object can be loaded or some part of the system can be made transparent to focus the student's attention on some important piece of information or object.

CONCLUSION

The development and implementation of a new prototype of a virtual maintenance course by means of the language VRML in the area of power system education and training was presented in this paper. Nowadays, visualisation technologies offer more and more possibilities for information presentation. The aim of this work is to discuss the possibility of integrating innovative teaching and 3D-geometry concepts in selected tasks in power systems.
The main goals for the realization and development of such alternative programs for virtual training in power engineering education are a simple and clear representation of complex systems, visualisation of a critical system situation and meeting the requirements of a state of the art education for the knowledge based service society.
Such virtual modules may be used extensively in electrical and power engineering courses as well as for continuing education classes and industrial training. RegEn – M makes it possible to experience learning in a three-dimensional virtual reality, and in this way to increase the occupational qualification and provide the student with an advantage in the local and world competition. For manufactures and operators of complex systems, plants and machines, such an innovative visualisation method permits effective training and the fast familiarization with operation, control and process sequences. It is possible to display customer-specific plant situations virtually, and in detail, and to recreate different scenarios.
The project RegEn - M has been implemented into the teaching process in a laboratory for simulation and design at the Otto-von-Guericke University Magdeburg.

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