The development of a virtual laboratory based on Unreal Engine 4

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Abstract. In our days we have the problem in the system of training highly skilled engineering staff– the impossibility of teaching students high-tech equipment because of its fragility and high cost. The solution of this problem is the creation of a virtual laboratory works, which represent a computer simulation of the real hardware – the simulator. The main advantages of virtual laboratories is the lack of significant costs for the buy, repair and maintenance of expensive equipment, increased visibility of the processes of the explored process, unlimited up building the virtual laboratory's functional and etc. At the moment the laboratory work is developed and its purpose is to research the hysteresis of linear deformations of piezoelectric elements and it is tested in real educational process. Further development of this work is to increase the number of training models, and of course as support for mobile devices.

Keywords: Educational system, Virtual laboratory, Virtual reality, Unreal Engine 4, Blueprint.

1. Introduction

The main task of education was and always is the development of the student's personality in conjunction with the mastery of knowledge, skills and abilities that can be applied in practice. In the system of higher professional education, especially for the training of engineering staff, it is extremely important to obtain practical skills in working with equipment. And the main opportunity is to receive them in the process of training is the performance of laboratory work.

We have the first problem of the existing system of education. For training highly qualified staff for advanced areas of the economy, it is necessary to develop skills in high-tech equipment, for example, equipment is used in the production of integrated circuits. In view of the extremely high cost of such equipment and consumables to it, as well as the complexity of operation (requirement of special skills for its use, the possibility of failure due to incorrect use), doing laboratory work on a regular basis is extremely difficult.

Also, in our days, the activity of higher educational institutions is in priority of the organization of the scientific research, while the provision of the educational process by the laboratory fund is financed in a limited way. Timely updating of the laboratory base is a costly and extremely inertial measure, the effectiveness of which is not obvious. However, employers as one of the criteria put forward exactly the skills of working on modern equipment.

The solution of this problem may be the simulation of laboratory equipment. Simulation which is built on well-known mathematical models of various physical and chemical phenomena can be approximated to the actual experiment. And such approach will make it possible, without significant expenditures and significantly expand the range of practical issues to improve the knowledge of material on the topic of the discipline.

Another important aspect is the fact that virtual laboratory's works can help to solve another problem. We are talking about a rapid increase in the abstractness of the processes under investigation, which further increases the gap between theory and practice.

The use of virtual laboratories can help to relieve tension in this contradiction "theory-practice", it allows forming primary (basic) skills of working with research high-tech equipment without wear and tear of the latter, establishes and / or maintains the connection of theoretical knowledge with practical activity develops and consolidates interest to the chosen professional sphere.

The student's interest in professional activities, in turn, allows:

- to reveal the potential of students, because its promotes the development of the ability to set, formalize and solve problems, generate new ideas and create new knowledge;
- to improve the efficiency of the research work of the unit, because an enthusiastic student wants to expand the range of tasks from standard training to unique research.
- to show students a culture of production, because it opens the prospects for a systematic approach to solving the tasks.

2. Advantages of virtual laboratories

What is the advantage of virtual laboratory work in compare with the real ones? I just want to say that their use does not exclude the work with real equipment, but is in addition to it.

For the training of highly qualified staff for the advanced fields of the economy (micro and nanotechnology), it is necessary to develop skills in high-tech equipment (such as plasma-chemical etching facilities, electronic lithography, precise analytical equipment, etc.). In view of the extremely high cost of such equipment and consumables to it, and the complexity of operation (requiring special skills for its use, the possibility of failure due to incorrect use), laboratory work on a regular basis is extremely difficult. Virtual laboratory work can solve the problem. Virtual equipment does not break down, does not wear out and does not require materials for the work.[1]

Another important advantage is an increase in the visibility of processes and phenomena. Progress now dictates the high speed of development of technologies in the direction of their complication and increase of abstractness of the studied processes. High abstractness can reduce the effectiveness of understanding the material in the preparation of highly skilled engineering staff. The use of virtual reality solves this problem, allowing visualizing the physical and chemical processes and visualizing them. The motivation of students to the learning process is increased, making it interesting, and also adding game moments.

Also, the advantages of virtual laboratory work is unlimited increase in functionality, the addition of new laboratory works and other methodological developments that require visualization without changing the hardware complex or with irrelevant additions.

3. Why Unreal Engine 4?

For realizing the software component of the project is used the game engine "Unreal Engine 4" from Epic Games.[2] It is used for arranging objects at the level, writing logical and mathematical operations, adjusting lighting and materials (textures), and final assembly of the application. Advantages of its using are:

- providing an accurate lighting model makes it possible to achieve a realistic picture;
- visual programming system "Blueprint" accelerating the development process and eliminating necessity for knowledge of programming languages. We can see it in figure 1;
- extensive set of the development tools.

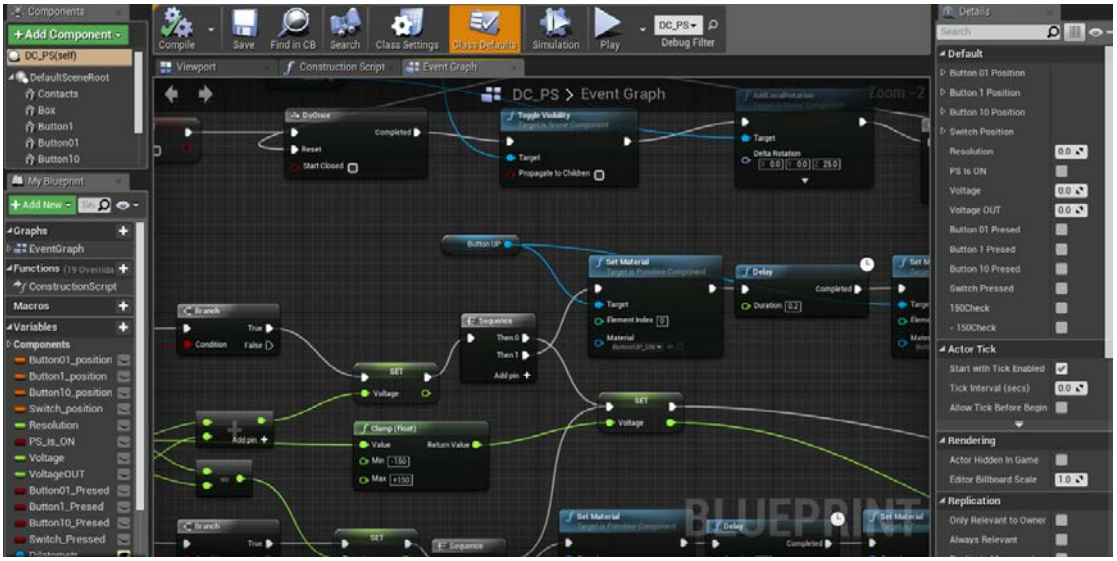

Figure 1. Visual programming system "Blueprint".

4. What is finished?

At the moment, the development of the laboratory work "Investigation of the hysteresis of linear deformations of piezoceramic elements" in the discipline "Physical and chemical bases of micro- and nanotechnology" is being actively carried out. [3] Laboratory work is based on the model of the hysteresis loop, John Chan, and relatively accurately describes the reality. Each sample of the piezoelectric ceramics is studied in the work has some unique options used by a mathematical model that allows you to create a huge variety of training options for laboratory work. When it is executed, the students can clearly study the process of polarization and the piezoelectric effect due to the demonstration booths, as well as to use a voltmeter, a power source and a capacitive dilatometer, which are as much close to real prototypes.

The basic principles of developing logical and mathematical algorithms, applications based on them and 3D visualization are mastered. By now, the performance of laboratory work is carried out using a keyboard and mouse and it is the management of an abstract character in the first person.

The room in which the laboratory work is divided into 3 sections:

1. The training rooms. At the beginning of the virtual laboratory work is necessary undergo training in the basics of control and interaction with objects;

2. Room of demonstrations. It contains extensive displays showing the monitoring process (and in particular the hysteresis of piezoceramics) in different levels, starting from a general view of the piezoelectric element, ending with the crystal lattice;

3. Room with laboratory equipment. It contains laboratory bench and rack with the samples is shown in figure 2.

Figure 2. Laboratory bench and rack with the samples.

In any time the student can access the electronic methodical instructions and to study the theory or to ask a drone - assistant is presented in figure 3.

Figure 3. Drone – assistant.

The application is at the testing stage in the conditions of a real educational process. Also work is being done on the sound accompaniment of laboratory work, which is an important factor that allows using an additional channel of human perception.

5. The next stage

The next stage of work on this project will be the use of virtual reality technologies. As a helmet of virtual reality, HTC Vive is supposed to be used. The laboratory equipped with it, created as a result of the completion of the next stage of the project will consist of two parts: hardware and software.

The hardware will consist of a high-performance computer, a virtual reality helmet, controllers and a motion capture system. The general view of the laboratory is equipped with a helmet of virtual reality is presented in Figure 4, where:

1) HTC Vive's virtual reality helmet, provides a highly detailed stereoscopic image for each eye;

2) The system of motion sensors Lighthouse - projects the real movements in the movement of a managed virtual character;

3) High-performance laptop - the computational core;

4) Limiter of an accessible area for movement, designed to ensure the safety of others and the person using the helmet.

5) Controllers that allow you to interact with objects in virtual reality (buttons, toggle switches, knobs, curtains, touch panels, etc.).

The program part will include several modules of virtual laboratory work, interactive presentations and training videos in a 360° format.

Figure 4. General view of the training laboratory.

6. Conclusion

Time goes on. Technologies are progressing every day towards complication and increasing the degree of integration. Nanotechnology already allows you to solve many problems. However, to further advance in this area, a great deal of intervention is needed in the field of training highly qualified specialists. To help students to learn, increase their interest in this professional field, as well as improve the understanding of the material, virtual laboratory complexes are needed that not only allow you to clearly explain and show work on complex equipment, but even at home, it is safely and more cheaper. Of course, working with real equipment should still be the main thing in this matter, but in view of the current situation in the field of technical education, the use of virtual laboratory works is actual and very promising.

7. References

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