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The Application of 3D Data Visualization in Education and Research

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Abstract

Visualizing scientific data can be an invaluable aid to the researcher. Each user interacts differently with the presented data. When visualizing certain results, it is very important to take into account the human factor.

The evolution of data representation can be traced back centuries, starting with Da Vinci's drawings, his students' drawings, and so on. With the development of visualization, different branches of geometry develop. Over the last 40 years, differential and descriptive geometry have made great progress in this area. Discoveries were made that radically changed the mathematical description of curves and surfaces.

In the 1980s, the visualization of three-dimensional objects was done with the help of mathematical models. With the development of computers came the need for realism. For this reason, several different disciplines such as mathematics, physics, chemistry and computer science had to be combined and a new discipline appeared - computer graphics.

It is inherently interdisciplinary. The share of computer science is very large, but without physics we will never be able to achieve realism and images close to the real ones. The initial process of creating complex three-dimensional primitives is called modeling. It can be done in two ways: by mathematical description or artificially - photogrammetry or laser scanning. The next step is to apply a texture or material. We "put" a shell on our three-dimensional object. It has certain physical properties such as transparency, light absorption coefficient, diffusion coefficient, etc. Each of these elements determines the color of the primitive, whether or not it will cast a shadow in the world coordinate system.

The purpose of this report is to present our experience in teaching computer graphics at both universities - University of Library Studies and Information Technologies and South-West University "Neofit Rilski".

The general concept we use in this article is the application of 3D models in research and the ways of presenting them in an accessible and realistic way. We will briefly present two surveys and their results on the place of computer graphics in education. The survey was conducted among students studying computer science and social sciences. The main conclusion is that students are open to the application of three-dimensional technologies in education.

In the present study, we will show different ways and models for creating and visualizing 3D objects and complex primitives. A short description will be presented to create a complex primitive and ways to visualize it. We will give a brief overview of the main disciplines related to computer graphics, which are taught at both universities. We will make a brief analysis of the advantages and disadvantages.

Keywords: *3D Data Visualization, 3D model, education*

1. Introduction

The process of creating realistic images can be represented as the implementation of three consecutive and interrelated stages, called: modeling, rendering (model transformation) and rendering (visualization).

An interactive graphics software system has three components[1], [4]:

- the model that is created, processed and visualized [1], [2], [3];
- the application program, which takes care of its creation, the performance of operations on it, as well as its organization in a form convenient for visualization[2], [4];
- graphics system - provides a set of visualization tools that the application program uses to graphically display data from this application model. The graphics system is the part of the software that is most closely related to the technical devices and that actually performs the visualization after the application program has specified exactly what should be displayed[5].

It is natural for applications to be developed much more often than basic graphics systems [3], [5]. Each application program reflects the specifics of the respective application area, and even the

individual programs in the same area can be very different. Despite the huge differences, each application graphics program performs three main activities that have a certain significance [5]:

- modeling;
- description of the model for the graphics system;
- interactive work [8].

The model is an object of different nature, able to replace another object, thanks to a certain correspondence between the properties of objects.

Modeling is the process of building a model and studying the correspondence between the model and the source object in order to obtain new information about it [4], [6], [7].

2. Methodology

In the present study, we consider the creation, processing, and visualization of vector objects (realistic images), also known as primitives. The initial process of creating complex three-dimensional primitives is called modeling. It can be done in two ways: by mathematical description or artificially - by photogrammetry or laser scanning. Modeling is the process of creating or using this mathematical description, also known as a geometric model. The geometric model, in turn, is a geometric description of the object in the form of dimensions, contours, surfaces, etc. similar, given with real numbers - a mathematical description of the 3D model [10].

The next step, which is part of modeling, is to apply a texture or material. We "put" a shell on our three-dimensional object [11]. It has certain physical properties such as transparency, light absorption coefficient, diffusion coefficient, etc. Each of these elements determines the color of the primitive - whether or not to cast a shadow in the World Coordinate System (WCS). The WCS describes all objects relative to a single center and uses the right-hand rule. All created objects unite together and form WCS [5]. She is always right-wing. This is accepted as a standard. In order to be able to "see" in this darkness, it is necessary to add lighting fixtures. They can be diffused or focal light. The different ways of placing or brightness of the light are evaluated [12].

The next stage is the model transformation itself, called rendering. This is the process by which a digital image is generated from a model in computer graphics. In other words, rendering has the task of recreating a three-dimensional mathematical model on a flat two-dimensional surface using various mathematical algorithms [13], [14] (Fig. 1).

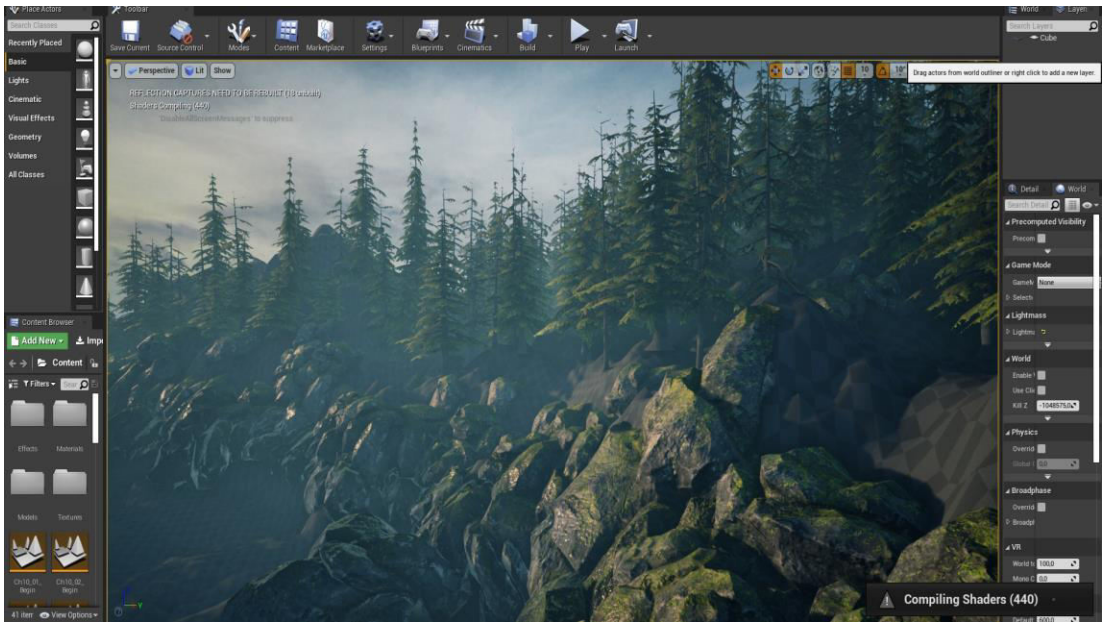

Figure 1. A woodland model created in Unreal Engine

3. Result and Discussion

With the development of 3D technologies, virtual walks have become an important factor in learning about cultural and historical heritage. They provide a realistic way to more fully present architectural sites, museums and galleries in the digital space. The 3D representation of the models must include the necessary information so that the users get the same knowledge as when actually visiting the site.
Training in the field of CHH is a complex and multifaceted process, requiring interdisciplinary approaches to achieve in-depth knowledge of existing knowledge and at the same time build capacity for discovery, research, storage and promotion of new discoveries. To examine how open young people are to new technologies and whether they want new teaching methods to be included in their lectures, we conducted two surveys [12], [14]:

- Among students studying computer science and
- Among students studying the humanities.

The purpose of the empirical research is to establish, analyze and summarize the extent to which students are familiar with the application of 3D technologies in lecture courses at the university, as well as their attitude to the problems of preserving the cultural and historical heritage of Bulgaria.

Sub-objectives of the study are to examine[12], [15]:

1. The level of knowledge and awareness of the problem of what is mixed reality.
2. The attitude to the problem of the application of mixed reality in the training and promotion of CIN.

In the framework of empirical research, the goal is achieved by solving the following research tasks:

1. To establish the degree of cold knowledge of issues related to the nature of 3D technologies and their application in education;
2. To establish and analyze the level of competence of students regarding the application of mixed reality promotion of CHH.
3. To establish the effectiveness of education and the application of 3D technologies in direction 3.5 "Social Communications and Information Sciences" and the need to introduce this type of education in universities that do not offer it.
5. To establish the attitude and desire of the surveyed students to be included in projects using mixed reality in the training and promotion of CHH.

The two studies were conducted within the project "Application of mixed reality in the education and promotion of cultural and historical heritage in the university information environment" led by Prof. Irena Peteva [12].
Today, 3D modeling is used even more widely from medicine to engineering applications. It and the visualization made it possible to improve the technology, especially together with the animations, the use of these models is more common than before. Early computer graphics were vector graphics made up of thin lines, while graphics today are based on pixels.
We can summarize that the search for opportunities to expand access to cultural content through digitalization and the creation of 3D models, helps to overcome the problems associated with social exclusion, digital divide, as well as to facilitate access to cultural heritage throughout the territory of the Republic of Bulgaria [12], [16].
The trend was investigated through a survey. We tracked through pre-set indicators the change in the number of users interested in new 3D technologies and the extent to which students are interested in them. Innovative technologies and equipment open new opportunities for students and provide them with incomparable competitive advantages, additional knowledge and skills for their professional qualification.
The results of the survey were more than interesting [17]:

- Of interest are the answers to the question "Do you think that studying disciplines related to 3D technologies would enrich your education?" About two thirds (66% say that this would enrich their education. to make an assessment (20%) Only 14% of the respondents answered negatively to the question;
- To the question "Do you think that computer graphics training is at the required level?" 91 answered in the affirmative, 94 in the negative and 65 could not. The results show that the majority of respondents believe that computer graphics training is not at the required level and this shows that it would be good to strengthen computer graphics training;
- Of interest are the answers to the question "Should new computer graphics courses be added?" More than half (53%) indicate that new courses need to be added.

However, the percentage of students who cannot make an assessment is worrying (18%);

- Also of interest are the answers to the question "Would you start a career in computer graphics?" 119 indicate that you would start a career in computer graphics. Unfortunately, there is a high percentage of students who cannot make judgments (44), which may be due to poor knowledge of computer graphics and insufficient knowledge of its capabilities.

The survey shows that computer graphics training is not at the required level. Three new disciplines have been introduced at the University of Library Science and Information Technology: Graphic design systems; 3D modeling and Development of computer games. The disciplines are elective[17]. The number of enrolled students is very large. The university management started working with some of the leading companies in the field of computer graphics Autodesk and Epic games. The companies have agreed to provide us with their products for free and currently our training is done through their software such as maya, 3Ds Max and Unreal Engine [4] [18].

Our findings show that the future lies in blended learning. The combination of traditional learning and modern digital technologies works wonders. Our negotiations with the company EON reality for the introduction of mixed reality in education are at an advanced stage. The opportunities provided by the new 3D technologies support the development of students' creativity and provide an opportunity to create complex objects and primitives [18].

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