Create 3d Models by Explicitly Describing and Moving the Virtual Camera Using EEG Signals

Ivan Trenchev[1], Dinko Stoykov[2], Metodi Traykov[3], Alexey Stefanov[4], Miglena Trencheva[5], Iliyan Ivanov[6]

South-West University "Neofit Rilski", Bulgaria [1, 2, 3, 4, 5, 6]
University of Library Studies and Information Technologies, Bulgaria [1]
New Bulgarian University, Bulgaria [3]
American University in Bulgaria, Bulgaria [3]

Abstract

The use of computer graphics is now well accepted in computer science education. In the past few years, the subjects of computer graphics have played an important role in the research of information and computer technologies. The inclusion of elements of computer graphics in the curriculum is motivated not only by modern technologies, but also by the opportunities it provides. At the University of Library Science and Information Technology and Southwestern University "Neofit Rilski", subjects such as Computer Graphics, Graphic Design are taught for a number of years. In addition to visualization and graphical data processing, subjects are focused on practicing and expanding the knowledge and practical skills of students specializing in the exact sciences and humanities. In this report we present the goals, structure and educational techniques in the disciplines. We will also present some practical results. We will briefly present several softwares that we use in our training. One of the main goals of our training is to stimulate the creativity of our students by using different approaches in creating 3D primitives. In this report, we will introduce different methods of creating complex 3D objects - by explicit description and by photogrammetry. We will present a new technology for moving a virtual camera through brain waves. An EEG (Electroencephalogram) signal is a neurons signal that is generated due to various electrical activities in the brain. Different types of electrical activity corresponds to different states of the brain. Any physical activity of a person is due to an activity in the brain, which in turn generates an electrical signal. In this article, we will briefly describe the algorithms used to classify EEG signals and how these algorithms can be used to control the movement of the virtual camera.

Keywords: *EEG Signals, moving the virtual camera*

1. Introduction

Graphics systems can only offer modeling tools (just a few), and it is the application that creates the model. The application program performs the following main activities, at the center of which is the geometric model [1-3]:

- maintenance - creation, deletion and modification of elements and links in the model;
- crawl for preview: presenting the geometric model information for the graphics system. This activity can be elementary for models whose objects are the very graphic primitives of the graphics system: segments, arcs and broken. It can also be relatively complex if objects are not stored as graphical primitives, and each object is itself an algorithm for obtaining these primitives[4, 5-6];
- search and analysis crawl: this activity is related to the execution of processing algorithms, as well as some specific analysis on it. More complex interactive application programs are called geometric modeling systems due to the importance of the model and the presence of powerful tools to support it [8].
  Real-world objects are rarely indivisible.

Even if they are solid, we model them as composed of parts, each of which has a specific functionality. The human body is indivisible, described as a structure of arms, legs, head, etc. that The hierarchical separation of parts into objects that one creates is particularly clear. In designing, this hierarchy is best distinguished, where even each level of the hierarchy has a separate name: detail, node, assembly. The use of hierarchically structured components in a single model offers several advantages [2, 5, 7, 8]:

- the ability to create each of the components individually and independently of one another;

- complex objects are created by simply assembling constituent components;
- each component can be described only once and included as an integral part of many other objects;
- the ability to manage the change of objects by changing their components.

2. Methodology

Descriptive geometry was used before applying mathematical and computer models in the manufacturing process, design and production. Many of his methods have been ported to computer graphics. Surfaces are often depicted as a network of curves arranged in orthogonal secant planes with three-dimensional contours of parts [8]. Pierre Bezie proposed a method for creating curves and surfaces of any shape. It brings the mathematical basis of their method of geometric images. The result is equivalent to a Bernstein basis or a polynomial approximation function [8-10].

Basic B- spline functions are defined by Cox-de Boer recurrence formula.

$$N_{i,0}(u) = \begin{pmatrix} 1 & u \in [u_i, u_{i+1}) \\ 0 & u \notin [u_i, u_{i+1}) \end{pmatrix}$$

and higher-level functions (p≥1) are calculated by (Fig. 2)

$$N_{i,p}(u) = \frac{u - u_i}{u_{i+p} - u_i} N_{i,p-1}(u) + \frac{u_{i+p+1} - u}{u_{i+p+1} - u_{i+1}} N_{i+1,p-1}(u)$$
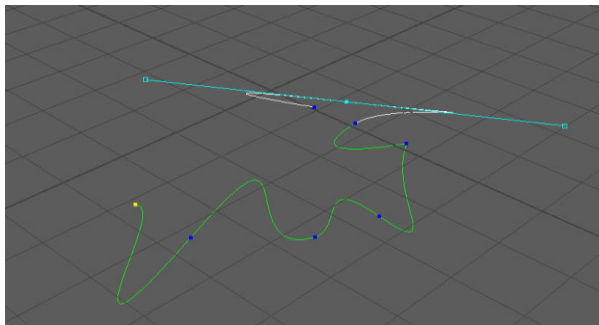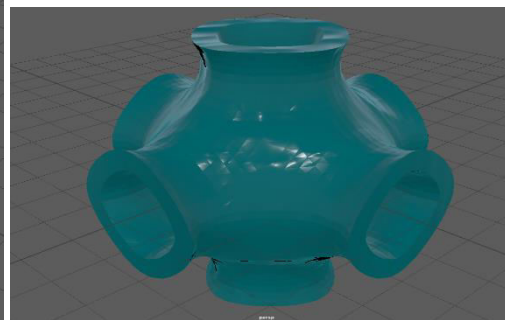

Figure. 1. Bezie's curve in Maya Surfaces   Figure. 2. Surface from Maya

Surfaces and their description play an important role in design and production. Obvious examples are the development and production of car bodies, ship hulls, fuselages and aircraft wings; fan blades, turbines, compressors and blades; appliances, furniture and shoes. In this case, the essence of the structure, or for functional or aesthetic reasons, is the shape or geometry of the surface. Surface description also plays an important role in the presentation of data obtained in medicine, geology, physics, and other natural sciences [2].

It is advantageous to develop a "real" three-dimensional mathematical surface model in computer graphics and computer design. Such a model makes it possible to analyze the surface characteristics. For example, curvature or physical quantitative characteristics depending on the surface; for example volume, surface area, inertia moment, etc., at an early stage and relatively easily. Surface visualization is simplified, used to develop or monitor development progress. In addition, in comparition to the traditional method using a grid of lines, the generation of information required for surface production, such as control programs for a numerically controlled machine, is also significantly simplified [1-3, 8].

There are two main ideas that are the basis of methods for describing the surface. In the first, they are trying to create a mathematical surface according to previously known data connected mainly with the name of Koons {quotation}. In the second, they try to create a mathematical surface ab initio (from the beginning) mainly related to the name Bezie. Initially, industries related to numerical parameters, such as design, preferred the first approach, while industries that accounted for visual, tactile, or aesthetic factors, such as designers and artists, chose the second one (Fig. 1). Rogers' work on interactive ship hull and Cohen surface development systems have shown that the two approaches are compatible [8].

3. Result

Photogrammetry is a technique for determining the three-dimensional geometry (location, size and shape) of physical objects by measuring and analyzing their two-dimensional photographs. Generally, photogrammetry is divided into two categories: aerial and terrestrial photogrammetry. In aerial photogrammetry, images are obtained through aerial photographs of aircraft, providing topographic maps and details of land use.

In terrestrial photogrammetry (also called non-topographic photogrammetry), images are acquired at locations near or on the earth's surface and provide detailed information about the size of an object. When the size of the subject and the distance between the camera and the object are less than 100m (330 feet), terrestrial photogrammetry is further referred to as close-up photogrammetry, an approach whereby images are obtained around an object with strongly approaching camera orientations , usually pointing to the center of the object [1].

Many successful and varied applications of short-range photogrammetry can be found in the fields of industry, biomechanics, chemistry, biology, archeology, architecture, automotive and aerospace engineering, as well as accident reconstruction, to name a few [2-4] (Fig 3. Fig.4).
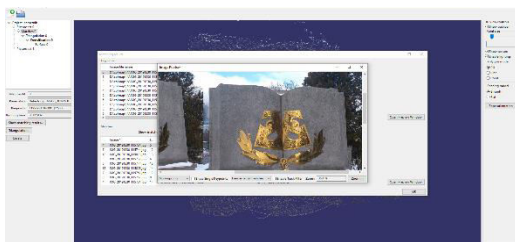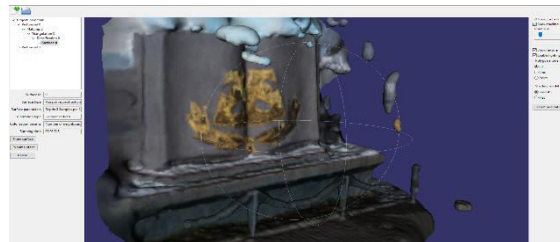

Figure 3. Photo of the real object

Figure 4. Creating a real object through photogrammetry

Various methods are used for acquiring EEG signals. They differ in the way the electrodes are placed. The methods [10-13]
can be categorized as follows:
   a) Invasive - Subdural EEG electrodes and Depth EEG electrodes,
   b) Non-invasive.
   In our study, ECG signals were obtained using a helmet developed by eMOTIV. They were obtained at the University of Library Science and Information Technology by Prof. Dimitrov (Table1)**.**

PICTURE_	TIME_IN	AF3	F7	F3	F5	T7	P7	O1	O2	P8	T8	FC6	F4	F8	AF4
LEFT.png	1500	4109,49	4193,72	4094,74	4077,56	4108,21	4108,08	4108,33	4095,77	4093,72	4115,51	4116,54	4072,31	4089,49	4090,51
LEFT.png	1500	4107,31	4183,08	4072,05	4069,49	4110,64	4088,97	4109,62	4070,51	4065,51	4115,13	4114,87	4041,67	4057,82	4066,67
LEFT.png	1500	4104,87	4188,33	4078,72	4080,13	4111,54	4100,64	4107,69	4081,79	4074,49	4115,00	4114,10	4050,90	4070,26	4075,51
LEFT.png	1500	4114,10	4227,05	4122,05	4107,18	4112,05	4129,49	4108,33	4125,90	4121,15	4115,38	4117,69	4101,15	4127,82	4121,41
LEFT.png	1500	4110,13	4242,82	4136,41	4111,92	4107,69	4132,18	4107,05	4133,59	4132,18	4115,38	4118,85	4117,44	4148,97	4139,36
LEFT.png	1500	4106,92	4223,08	4125,64	4104,87	4109,36	4121,28	4107,44	4121,41	4115,13	4115,00	4115,26	4104,36	4136,79	4126,28
LEFT.png	1500	4112,05	4216,54	4135,00	4110,26	4115,64	4125,77	4110,77	4135,51	4123,46	4115,13	4114,87	4109,62	4137,69	4127,95
LEFT.png	1500	4106,41	4210,13	4133,21	4106,79	4113,46	4128,33	4108,72	4136,03	4126,03	4115,51	4118,08	4110,90	4127,95	4126,54
LEFT.png	1500	4108,21	4184,62	4108,33	4096,67	4110,13	4117,05	4109,49	4110,77	4104,23	4115,26	4116,92	4087,82	4102,56	4107,05
LEFT.png	1500	4110,77	4169,10	4102,31	4096,54	4110,13	4109,23	4109,62	4105,90	4097,44	4114,62	4113,85	4078,46	4102,56	4102,44

Table 1. EEG (Electroencephalogram) signal generated in a computer lab by Prof. Dimitrov (2016) [11-12]

The motion of the camera is generally described by ordinary differential equations. The resulting description is often called a dynamical system.
Let $x = (x_1, x_2, . . . , x_n)$ denote an n-dimensional state vector and x_i corresponds to a position or orientation parameter for a rigid body[11 -14].
The integration of each state variable determines the value at time t.

$$x_i(t) = x_i(0) + \int_0^t \dot{x}(s)ds ,$$

We tried to classify the input signals as the observed subject thinking about the four directions.
We used three approaches for this purpose:
   - K-Nearest Neighbor (KNN)
   - Linear Discriminant Analysis (LDA)
   - Naive Bayes.

These algorithms are described in detail by Umale 2016.

We used the script of AIDEMIR (2016) we got the signal classification. The classification was 27%, 25% and 31%. All simulations were performed in the Matlab system.
This result is not very good, but it does give us an opportunity for future research. Our goal is to develop a virtual museum in a mixed reality system. For our development we use Unreal engine and the language C ++ [14-16].
At South - West University "Neofit Rilski" and the University of Library Science and Information Technology, a project is underway to create a real 3D model of the ancient city of Skaptopara [17], located near Blagoevgrad. The first phase of this project ends in June 2020 and the results are quite promising.

Acknowledgments

References
[1]   Akatsuka Y., and Bekey G., "Compensation for end to end delays in a VR system. In Proceedings IEEE Virtual Reality Annual International Symposium, 1998, 156–159,
[2]   Bowman D., and Hodges L., "An evaluation of techniques for grabbing and manipulating remote objects in immersive virtual environments" In Proceedings ACM Symposium on Interactive 3D Graphics, 1997, 35–38
[3]   Lanman D., and Luebke D., "Near-eye light field displays". ACM Transactions on Graphics, 32(6), 2013, 45-48
[4]   Marschner S., and Shirley P., "Fundamentals of Computer Graphics", 4th Ed. CRC Press, Boca Raton, FL, 2015
[5]   Yost W., "Fundamentals of Hearing: An Introduction", 5th Ed. Emerald Group, Somerville, MA, 2006.
[6]   Guentner B., Finch M., Drucker S., Tan D., andSnyder J., "Foveated 3D graphics. Technical report, Microsoft Research", 2012. Available at http://research.microsoft.com/
[7]   Steven M. LaValle, VIRTUAL REALITY http://vr.cs.uiuc.edu/, Cambridge, MA,. 2019
[8]   Ruhland K., et al., "A review of eye gaze in virtual agents, social robotics and hci: Behaviour generation, user interaction and perception". Computer Graphics Forum, 34(6), 2015, 299–326
[9]   Umale Ch., et al. "Feature Extraction Techniques and Classification Algorithms for EEG Signals to detect Human Stress – A Review", International Journal of Computer Applications Technology and Research, 5– Issue 1, 2016, 08 – 14, ISSN:- 2319–8656
[10]   Dimitrov G., Panayotova G., "Performance analysis of the method for social search of information in university information systems "Published in: Artificial Intelligence and Pattern Recognition (AIPR), International Conference on, Date of Conference: 19-21 Sept. 2016, Date Added to IEEE Xplore: 13 October 2016,
[11]   Panayotova G., Dimitrov G.P., " Modeling and data processing of information systems" Published in: Artificial Intelligence and Pattern Recognition (AIPR), International Conference on, Date of Conference: 19-21 Sept. 2016, Date Added to IEEE Xplore: 13 October 2016, ISBN Information: Electronic ISBN: 978-1-4673-9187-0
[12]   AYDEMIR O., "Common spatial pattern-based feature extraction from the best time segment of BCI data", Turk J Elec Eng & Comp Sci 24: pp.3976 - 3986 doi:10.3906/elk, 2016, 1502-162
[13]   [Zhao Q., Zhang L., Cichocki A., "EEG-based asynchronous BCI control of a car in 3D virtual reality environments". Chinese Sci Bull., 54, 2009, 78-87.
[14]   Trejo L., Rosipal R., Matthews B. "Brain-computer interfaces for 1-D and 2-D cursor control: designs using volitional control of the EEG spectrum or steady-state visual evoked potentials". IEEE T Neur Sys Reh., 14, 2006, 225-229.
[15]   Mc Farland D., Sarnacki W., Wolpaw J.. "Electroencephalographic (EEG) control of three-dimensional movement". J Neural Eng 7, 2010, 1-21.
[16]   Asensio-Cubero J., Palaniappan R., Gan J., "A study on temporal segmentation strategies for extracting common spatial patterns for brain computer interfacing". In: IEEE 2011 UK Workshop on Computational Intelligence; 7{9 September 2011; Manchester, UK. New York, NY, USA: IEEE., 2011, 99-102.

[17] Trencheva, T., Todorova, T., Tsvetkova, E. "Intellectual Property Training of Library and Information Management Bachelor's Students". Communications in Computer and Information Science 810, 2018, 294-302