One Approach for Development of Software Modules Adding New Geometric Primitives in 3D Graphics Applications

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Abstract – **Currently, the main expectations of the abilities of three-dimensional graphics applications increasingly are turning to the use of specific sets of models which perfect the realistic representation of the various objects and processes. There are many developments that provide new or improved models. This study provides an approach to the development of additional software modules that extend the capabilities of three-dimensional graphics applications in the field of modeling and implement new models already in place.**

Keywords – **Computer, Systems, Modeling, 3D, Graphics, Application, Geometric, Primitive.**

I. INTRODUCTION

The creation of photorealistic 3D images requires graphics applications to be developed constantly by adding new and more effective tools [9]. Main part of this process is the means of design that these systems provide. This includes: the coordinate space and viewports, graphics primitives and the models operating behind them, drawing instruments, transactions between graphic objects, modifiers and tools allowing interactive modeling [1].

Efficiency, reliability and functionality of the created or improved models and algorithms can be demonstrated and evaluated in practice if they are implemented in a 3D graphics application (3DGA). This could be done through the development of specialized software modules (SSM) for a specific system [3]. Then an analysis of their work and of the geometric primitives, tools or models that they create, could be performed. The main goal of this research is an approach for development of software modules that add new graphics tools in 3DGA to be offered.

A 3D graphics application can be designed to allow expansion of functional capabilities which further increase its level of usefulness and uniqueness [2, 10, 11]. Such applications have Software Development Kit (SDK) and/or script language. The main part of the toolbox consists of Application Programming Interface (API) which is usually a set of routines written in high level language.

For greater clarity and demonstration of the effectiveness of the basic concept that is given in this approach, a realization of a particular group of models in a specific 3DGA will be considered. The new group of models could be seen in [12, 13]. It represents three quadratic curves: ellipse, parabola and hyperbola, and nine quadratic surfaces: ellipsoid, paraboloid, hyperboloid, double hyperboloid, cone, elliptic cylinder, parabolic cylinder, hyperbolic cylinder and hyperbolic paraboloid. These twelve models of curves and surfaces are represented using NURBS (Non-Uniform Rational B-Spline) functions [13]. Using these new NURBS models of the quadratic curves and surfaces twelve SSM for Autodesk 3ds Max graphics application for design have been developed. They have been approved and received from "*HighEnd3D*" – Internet site for top-of-the-art technologies and 3D applications. They are also available for download as follows: NURBS Conical Arcs 1.4 - http://www.highend3d.com/f/4368.html, NURBS Quadratic Surfaces 1.2 - http://www.highend3d.com/f/4369.html.

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II. THE SOLUTION

The approach includes four stages. The first one consists a selection of a proper 3DGA and a performing of an analysis of this system in order to determine SDK and geometric models and primitives that it possesses; second stage includes determination of the main features of the new SSM; third one – development of the SSM; and fourth one – comparative analysis. A diagram, showing the main stages in the approach for the development of SSM, is exposed in Figure 1.

A. First stage: Selection and performing of an analysis of a 3DGA which has a toolkit for expansion

Comparative analysis of existing 3DGA and their applications in terms of their main features can be found in [6, 8]. Among them are: 3ds Max, (Autodesk), Maya (Autodesk), Cinema 4D (MAXON), Realsoft 3D (Realsoft Graphics), Blender (Blender Foundation), EIAS (EI Technology Group), form-Z (Autodessys Inc.) , Houdini (Side Effects Software), Softimage | XSI (Avid), SolidThinking (SolidThinking Ltd), TrueSpace (Caligari Corporation).

The first requirement that must be set towards the 3DGA is holding features for expansion. This must be at least one of the three: API, Script language, SDK. The models that are implemented in the 3DGA usually are based on mathematical apparatus. The second requirement that must be respected is this apparatus (or possibility of its creation) to be presented in the 3DGA.

Looking at the presented here example of the twelve new models one could see that the NURBS apparatus stands under.

This means that the representation of NURBS in the API of the chosen 3DGA is the best. For the implementation of the proposed new models of quadratic NURBS curves and surfaces Autodesk 3ds Max graphics system has been selected. The choice has been made taking into account its features. Autodesk 3ds Max is a powerful, comprehensive and well designed 3D graphics application for modeling, animation and rendering [1, 3, 5, 9].

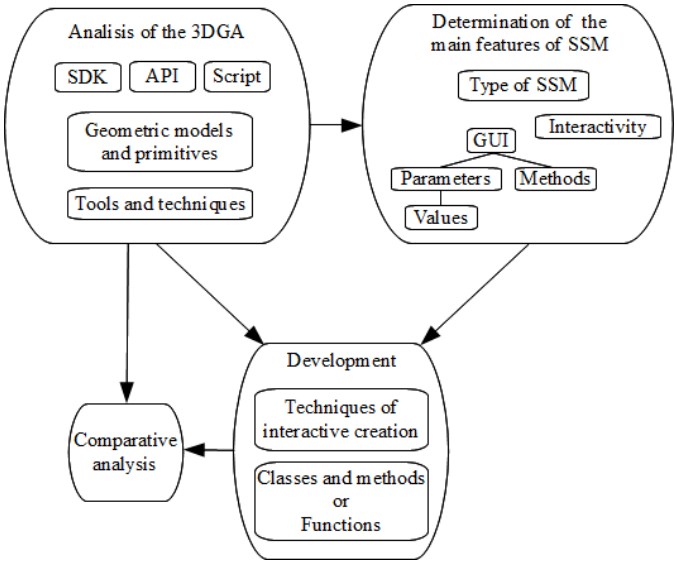

Fig. 1. The main stages in the approach for development of SSM.

An analysis of the types of the geometric (mathematic) models and primitives that are presented in the 3DGA should be performed. Parametric forms and objects should be modeled efficiently as well. There are some types of geometric primitives for design: poly, mesh, patch, subdivided, Spline and NURBS.

For example, all these types of primitives are presented in 3ds Max. Moreover, a fast scan-line algorithm and rendering for high quality production are realized in 3ds Max. It has a full range of effects, several light sources (including photometric lighting), atmospheric effects, calculation of shadows, materials, libraries of textures and creating systems of particles, which provide all the necessary components for creating realistic images and animation.

Autodesk 3ds Max has SDK which is called MaxSDK [2]. MaxSDK is an object-oriented library for creating SSM for the system. MaxSDK provides a fully comprehensive set of classes that developers can combine and expand to create a variety of SSM. In the context of the 3DGA SSM is called plug-in.

Autodesk 3ds Max also features a scripting language called MaxScript. It is specially designed to allow expansion of the system [3]. It may be useful in many ways: automating repetitive tasks, establishing standard procedures, importing and exporting data, creating plug-ins. It may also be responsible for many important features of the program and also be part of the user interface. MaxScript is object-oriented C++-like programming language. MaxScript contains object-oriented API that provides all the functionality and power of scripting applications.

Therefore, 3ds Max has two opportunities for development of SSMs: MaxSDK and MaxScript. Both instruments have the necessary resources for development of the modules according to the requirements that are set out above. If the modules are developed using MaxSDK however, then the SSMs need to be edited and recompiled for each new version of the program in order to run into the system. Furthermore, they should be redistributed and installed by the users. If they are designed using MAXScript for a lower version of 3ds Max (version 4.0 for example), then they will be able to perform correctly and work of each higher version of the application. Based on the fact that versions of the program are released fairly often (every year), MaxScript is more effective way for developing new SSMs.

B. Second stage: Determination of the main features of the new SSM

There are three very important questions that should be taken in mind:

- What tool or primitive does the each SSM represent?
- Which parameters of the model will determine the work of each tool or primitive? This concerns mainly the GUI of each one.
- Will they afford an opportunity for interactive construction in each viewport?

Thus the main features of the new SSMs could be determined.

In the present case NURBS models of quadratic curves and surfaces should be implemented as new graphical modeling primitives in Autodesk 3ds Max. For this purpose, software modules have been developed, which are tools for creating new primitives in the system. The following requirements have been set:

- ✓ They can build curves and surfaces in each of the coordinate plane and orientation depending on the selected viewport.
- ✓ Each of them must represent one drawing primitive (a curve or surface).
- ✓ They must have GUI. This concerns setting the parameters of the curves and the surfaces in their parametric representation of the model.
- ✓ They must provide an opportunity for interactive construction and modeling of curves and surfaces in real time.

Usually, there are different types of modules in 3DGA. Some of them are: *utilities*, *macros*, *plug-ins* and *plugin-scripts*. They can have graphics user interface or not. The main task is the determination of the type of the new SSM. This determines their future structure and behavior.

Some types of SSM are presented in 3ds Max. Concerning the requirement that one SSM should represents one drawing primitive, the type *plugin-script* has been chosen. Plugin-scripts are integrated into the user interface and thus become part of an integrated set of groups of graphical primitives. They are divided into three types: extensions - to expand the existing plug-ins; systems - to create nodes; and

plugin-scripts to create new plug-ins that create new graphic primitives.

Implementation of the proposed models of quadratic NURBS curves and surfaces requires the development of new tools that provide new graphics primitives. Therefore, the third type of plugin-scripts has been chosen, namely plug-ins for creation of new graphics primitives.

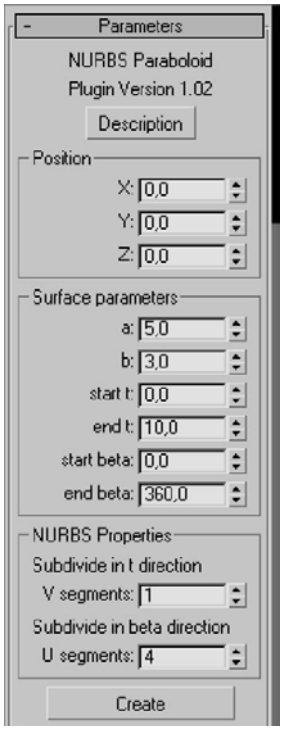

Fig. 2. GUI of a SSM.

Depending on the number and types of parameters, defining the primitive, GUI must be designed. Some 3DGA have separate instruments. In 3ds Max it is called Visual MaxScript. After loading the SSM (automatically or manually) in 3ds Max, two groups of plug-ins NURBS Conical Arcs (containing three primitives) and NURBS Quadratic Surfaces (containing nine primitives) are added to the box “Create”, category “Geometry”. Each SSM has a separated GUI (Figure 2).

The values of the parameters are set in the numeric fields that can receive integer or real numbers. These values should be limited. Usually, there are several events and exceptions that happen during the operation of the SSM. This may be because the user should be aware of something and to correct his/her actions. This is done by message boxes.

C. Third stage: Development of the SSM

Based on the selection of a 3DGA and determination of the main features the development of the new SSM could begin. First, the methods for development of the geometric primitives should be created.

The group NURBS Conical Arcs has a check box in case it is necessary not only NURBS curve to be created, but also a line-shape form. However, the creation of such a form requires more time, so at this point progress control is appeared.

Each plug-in has a button "Create" which the curve or surface is created by. This is an alternative method to the interactive creation in the space. The values of the parameters (length of curve, positions of the focuses, distance between the focuses, eccentricity, etc.), related to specific properties of this object, are displayed in MaxScript Listener window.

Routines that create the new SSMs should be developed. They can be a list of functions added in the main structure of the SSM or a new objected oriented structure that could be used in the plug-in.

A set of routines for the creation of the NURBS models in the new SSM has been developed. They are conditionally divided into two groups. The first group consists the functions that define the main control vertices, the key vectors and all control vertices of the curve or surface. The second one consists the functions which have already the details of the curve or surface and using them create a NURBS object in the scene.

Tools for interactive creation of objects should be developed. Creation of an object could be done by setting values in the GUI but also setting values by mouse movements. This could be done if routines, that are run when events are generated from the mouse, are presented. This depends on the 3DGA. Usually, the interactive creation sets values for a part of the parameters.

The code of the scripts is written by using a command *tool* and two major actions: *mouseClick* and *mouseMove*. These actions determine how the SSM behaves when the user clicks and drags the mouse.

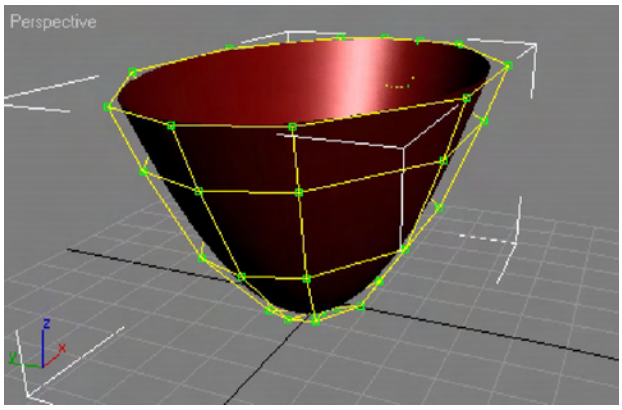

Fig. 3. NURBS Paraboloid created in a selected viewport.

The manipulator of the event *mouseClick* determines what the tool will make in situations when left mouse button is clicked for the first time and when it is released for the last time. The manipulator of the event *mouseMove* determines what the tool will make when the mouse is moved.

In 3DGA the creation of the NURBS objects should be done in all available viewports. Therefore, a routine that concerns the correct creation of the objects, depending on the selected viewport, should be developed (Figure 3).

Often the values of the parameters of the SSM should be localized. This is necessary when the mathematical models require.

The values of the parameters which define the curves and the surfaces are limited by values given by their parametric equations. The permitted values are taken into account in the implementation of the new SSM. These limits can only be subintervals of the intervals given by the quadratic parametric equations of the curves and surfaces.

D. Forth stage: Comparative analysis

Once the SSM have been developed a comparative analysis could be made. The work of the new SSM and the performance of existing tools and techniques in the system can be compared.

For example, a comparative analysis of existing tools and techniques in 3ds Max and the operation of the new SSM have been done. This is reflected both the analysis of their work and the analysis of the results obtained by their work. The main characteristics that are monitored are:

- Number of steps in construction;
- Time of construction;
- Opportunity for local modification;
- Number of control points;
- Level of visualization (for surfaces only).

III. CONCLUSION

In this paper an approach for development of software modules adding new geometric primitives in 3D graphics applications has been presented. This approach includes four stages sown in Figure 1. On the basis of this research and using new NURBS models of quadratic curves and surfaces twelve SSM for Autodesk 3ds Max graphics application for design have been developed. They have been approved and received from "*HighEnd3D*" – Internet site for top-of-the-art technologies and 3D applications.

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