

Interactive Learning of Computer Graphics Algorithms

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Abstract:

Nowadays, computer graphics course is usually taught with traditional teaching methodologies and tools, which has its own limitations. In this paper, we present an online interactive computer graphics tutorial. The practical part of the tutorial consists of example programs on the computer in which the users can test the theoretical concepts and generate their own experiences. The integration of the different theoretical and practical parts of the course is realized through a common Web-based interface to the system. The main objective is to allow the users to learn and practice with the algorithms of computer graphics. Two versions of the system in Chinese and English language are implemented.

Keywords: Computer graphics education, Java-3D, Web-based learning

1 Introduction

Over the past decades, computer graphics education has become increasingly rely on more powerful software tools to assist in solving more complex problems. But topics within computer graphics (CG) still cannot be adequately presented and explored with traditional teaching methodologies and tools. Therefore an integrative approach to combine lectures, examples, programming exercises, documentation etc. is greatly needed¹.

Teaching students to effectively understand these new algorithms or software tools in CG field may have problems. However, software tools or algorithms are best learned by "playing with" it. Usually the manuals for graphics software tools are often written for advanced users and can be difficult for newcomers to follow. The content of computer graphics course are discussed everywhere.^{2,3,4,5} The professors for teaching CG course often bring a notebook into the classroom, show the Powerpoint presentation, and demonstrate the program. And it is difficult for the students to take notes on the algorithms that are used. Therefore, in our project we develop an interactive CG course based on World Wide Web (WWW) and Java for teaching students to learn CG remotely and efficiently^{6,7}.

The rapid development of the WWW has provided unprecedented opportunities for educators to reach audiences of students and colleagues around the world. The WWW is a convenient and easy way to support hypermedia mechanism which is very useful in education. This approach increases student learning efficiency by using an interactive learning environment. Web-based education is a unique learning format

that allows you to attend class from the comfort of your own home. Web-based courses provide education through virtual classrooms on the Internet. Web-based education provides learners the opportunity to pursue academic programs around their personal schedules^{8,9,10}. While weekly studies and participation are essential, students can attend class anytime of the day from anywhere. Many students find this mode of learning to be the best option when juggling time constraints with work and personal responsibilities.

Java is an object-oriented programming language that plays to the strengths of the Internet. Object-oriented programming (OOP) is an unusual but powerful way to develop software. In OOP, a computer program is considered to be a group of objects that interact with each other. The best known feature about Java is that it can be used to create programs that execute from World Wide Web pages. These programs are called applets. A Java applet running on a Web page provide richer information and user interaction. Information can change in response to user input or updated dynamically as a Web page is viewed. In CG, lots of the algorithms will use the same techniques such as drawing line, shading and lighting, etc. The functions are reusable by using different user-defined class rather than repeat the same coding on different algorithms. Although Sun Microsystems has developed Java 3D, the performance is unsatisfactory. Compare with 3D in Java, the performance is much better than it especially involve lots of calculation.

The implementation of this interactive CG tutorial on the WWW provides several advantages. Using a personal computer

or workstation with access to the tutorial on the WWW, any users can follow the examples while browsing the tutorial. Students can get key concepts and design techniques by seeing and doing manner. Using the mouse, the tutorial examples' source codes can be downloaded without time-consuming typing and editing. Users can also explore the computer graphics algorithms written in Java and see the actual result and compare it to the tutorial. By using the hypertext markup language on the WWW, the tutorials are highly interconnected. Depending on user's ability, interest and available time, a user could take one of several different paths through the tutorials. The information contained in the tutorial is available to users when and where they are needed.

2 Design Methodologies

2.1 Functional Requirement

It is expected that the system should be able to provide three main functions:

- * Computer Graphics Tutorials
- * Computer Graphics examples using Java
- * Download area for source codes downloading

To make the web page more attractive and practical, some design principles are obeyed during the design stage:

- * **WYSISYG Display**
With the support of WYSISYG, users can learn the CG algorithm directly through the web page.
- * **Multimedia Support**
Multimedia such as animation, video and audio play an important role on WWW. With the aid of multimedia support, the web page can be more attractive. Therefore, users will play more attention on it.
- * **Animating Examples**
The algorithms of CG are often difficult to understand through text descriptions. An animating example can help the user easier to understand.
- * **Online Examples**
Besides the animating examples, online examples should also be added. Users can specify the parameters such as line attributes, color of the object, etc. and perform the function interactively. Users can understand more deeply by the interactive online examples.
- * **Downloadable Source Code**
After the user understand the concept of the algorithms and try those examples, they may want to learn the lower level part that is the source code of the examples. Provide the downloadable source code allow the users not only learn the conceptual part but also the implementation part.
- * **Portability**
Portability should be another consideration in addition to internationalization. The tutorial is platform independent

since it is written in HTML and Java code.

?? WWW Connection

The new or updated version of examples will be changed by time. So, it should allow the user download through WWW. Thus a connection with WWW is necessary.

2.2 System Design

Electronic textbook on CG is a multimedia-based system. The whole design concept is under an easy-to-use philosophy. Since one of the purposes of the system is to provide an easy learning environment on CG, the web environment is chosen for the whole system. Users can learn the CG when they want by just click on the web page.

(1) System design considerations

Graphical user interface: Most online tutorials are text-oriented form. They provide much of boring plain text for the users. The tutorial should provide the necessary text with attractive graphics, animation include sound.

User Characteristics: The system is mainly designed for students. They may have little or even no background knowledge on CG and little computer knowledge. Those factors are considered to affect how they interact with the system. In order to provide a suitable, user-friendliness system and achieve the need of the user, an analysis of user characteristics is needed before designing the system.

Attracting Users: In order to make the success of this tutorial, the materials and the method of presentation must attract the users. It is especially an important factor in clearly presenting one theory to another. To accomplish this, the tutorial should employ the multimedia technology. It includes playing sound, video and animation. These not only attract the users, but also give great impression to them. It can help the users to keep visit on this page.

User Friendly: From the user point of view, the system should be simple and easy to use. Users just click on what the topics and examples they want.

Interactive: Most CG tutorial web sites are only presented in several plain text. They are usually organized into a long flow of passage with little graphics in the web sites. The multimedia information is only presented in CD-ROM only.

The system should provide an interactive environment to the users. This can accomplish by providing interactive information and hypermedia. In interactive information, users can receive an immediate feedback on their selection. While in the contents presentation, people can click the links to demonstrate the examples or click the start button to run the Flash movie.

(2) System Architecture

In our electronic CG textbook, the users can directly click on any examples, viewing the results or the related program source code. The system architecture is transparent to the users

which means users will not know how the program actually works out. The system architecture is shown as Fig. 1.

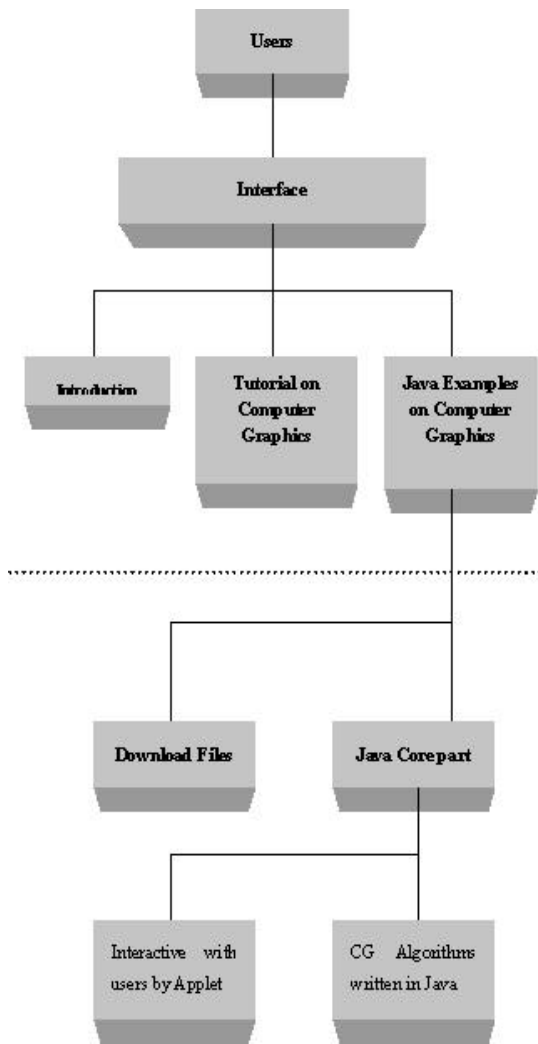


Fig. 1 The system architecture

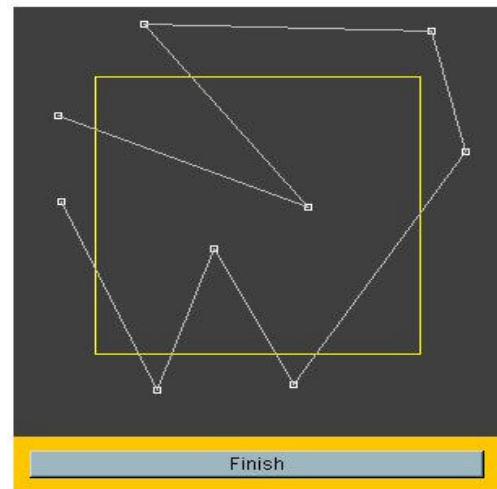
3 Samples of Java Examples

In this section, we will give some examples, which are generated from the two experimental systems (English version¹¹, and Chinese version¹²)

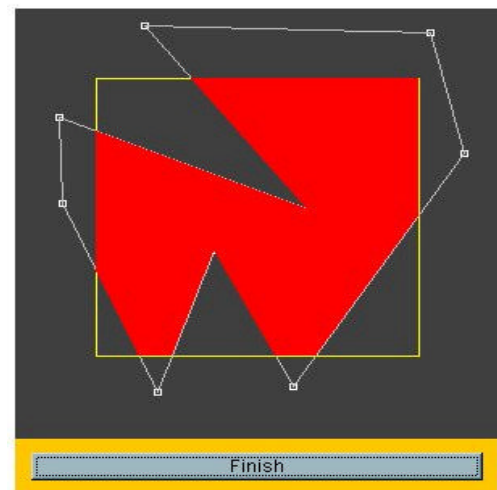
3.1 Example 1 : Polygon Clipping

In this example, the applet will show the user how the polygon is being clipped (See Fig. 2). Initially, there is only a rectangle on the center of the applet. On the bottom of the applet, there is a button call “ Finish” . First, the user should click on the applet. The applet program will record the position it clicks and show a small rectangle on it. The user should click at least three points to form a polygon. Then the user should click the “ Finish” button to finish the process. After clicking the button, the applet

will draw the polygon with lines and fill the clipped polygon in red color.



(a) Clipping Polygon definition



(b) Clipping results

Fig.2. Example of Polygon Clipping

3.2 Example 2: Bezier Surface

In this example, the applet will show the difference between the surface before and after applying using Bezier surface (See Fig. 3). The applet will first generate the original surface. Then it will generate a Bezier surface with the point relevance to the original one. The Bezier surface will generate and display and the right hand side. The “ Random” button at the bottom of the applet allows the user to generate a new surface by randomly select the point value. The applet will then display the new Bezier surface on the lower window as described before. The electronic textbook also supports other kinds of surface, and the users can explore the characteristics of the surfaces.

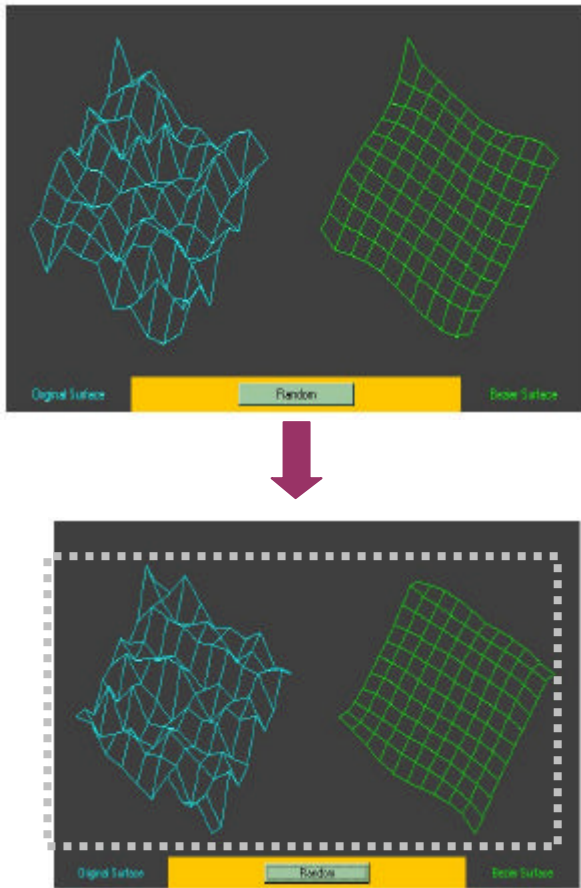
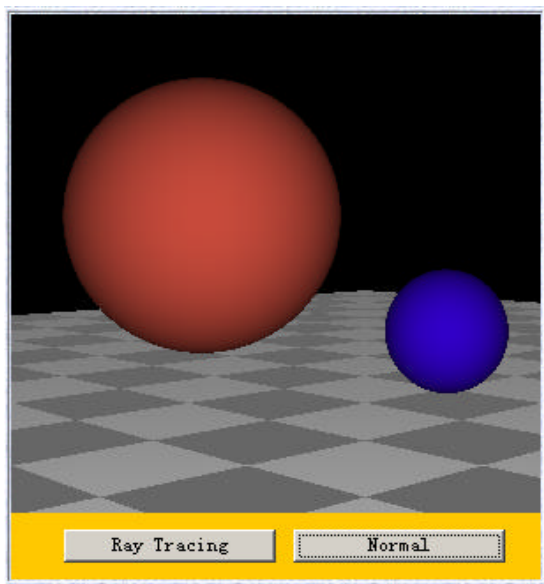
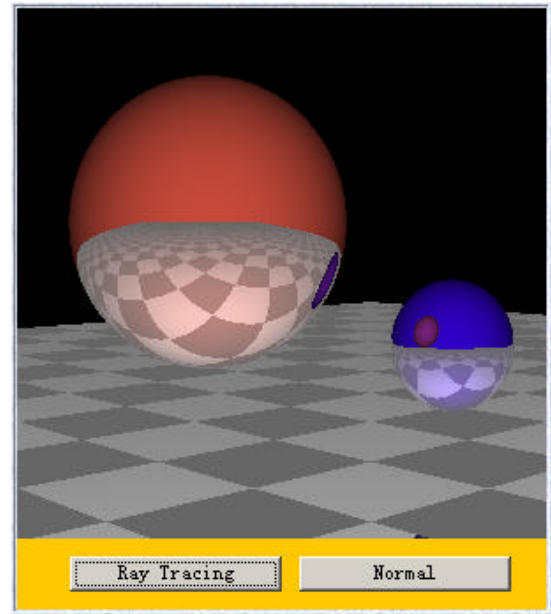


Fig 3. Example of Bezier Surface



(a) The result of normal rendering algorithm



(b) The result of ray-tracing algorithm

Fig. 4. The results of two kinds of rendering algorithms

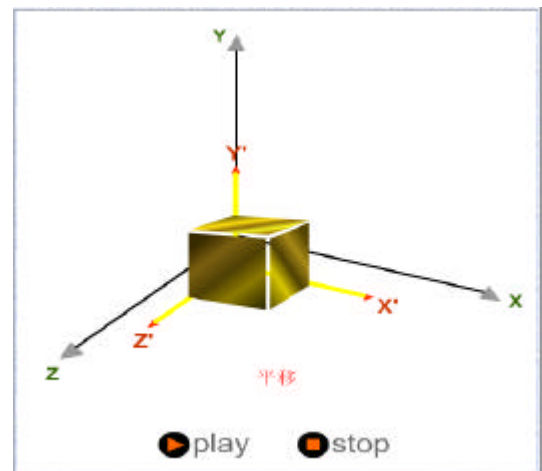


Fig. 5. Illustration with Flash animation

3.3 Example 3 : Rendering Algorithms

In this example, the applet will show the difference between the results of two kinds of rendering algorithms, in the upper window, the result of normal rendering algorithm is shown, while in the lower window, the result of ray-tracing algorithm is displayed. And the users can view the source of the two rendering algorithms if necessary.

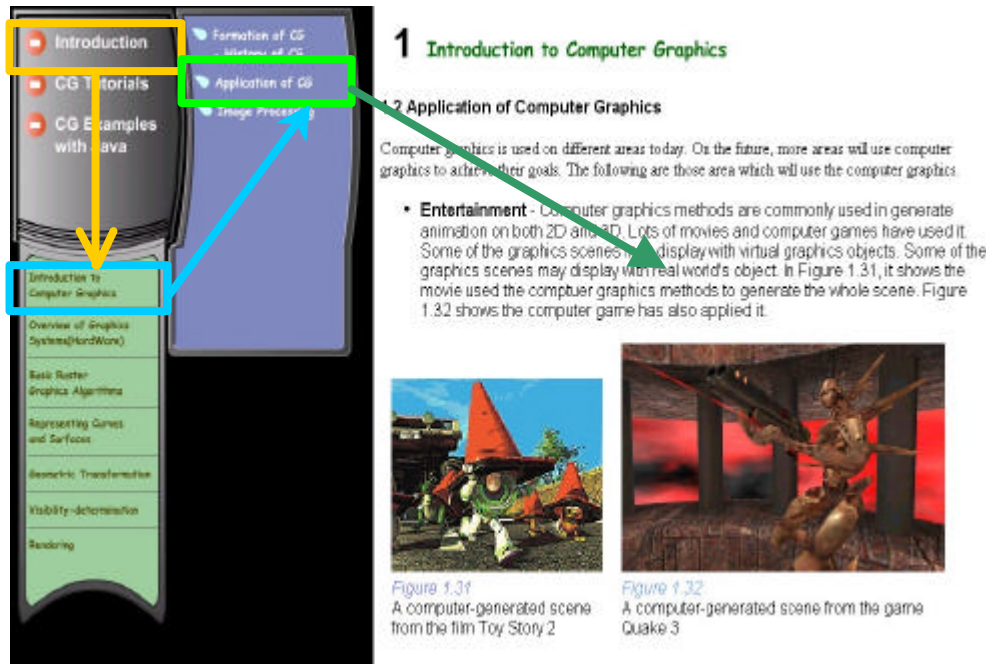
3.4 Example 4 : Flash used in our system

To illustrate some basic concept, and principle, we use some Flash animations, which are welcomed by the users. Fig. 5 is an example, it is used to explain the transformation in three dimensional space.

4. User Interface Design

This online tutorial is run with browser such as Netscape, Internet Explorer. The resolution is designed under 1024 X 768. So, it is better view under this resolution. After the selection of

the subtopic, the content page will be displayed on the right frame. Figure 6(a) is a snapshot of our English version of the interactive CG textbook. And Figure 6(b) is a snapshot of our Chinese version of the interactive CG textbook.



(a) User interface of English Version



(b) User interface of English Version

Fig 6. User Interface of the two experimental systems

Acknowledgements: This research project is co-supported by ACM SIGGRAPH Education Program in 2002, Excellent Youth Teacher Program of MOE in China, and Young Personnel Foundation of NSF in Zhejiang Province (grant no: RC40008).

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