Development of a VR-Based Sculpture Curves and Surfaces System–WebDeGrator

Wen-Chai Song*, Shih-Ching Ou*, Song-Rong Shiau**

songchen@ms10.hinet.net songchen@acm.org song1208@ms5.hinet.net

***Department of Electrical Engineering,** National Central University, Taiwan

****Department of Electrical Engineering,** National Taipei University of Technology, Taiwan

Contact Address: **4F,NO.184-1,Kee-Kin 1st Road,An Lo District, 204 Keelung ,Taiwan**

Contact email: songchen@ms10.hinet.net Contact fax: +886-2-24324075

Abstract

The purpose of this research is to apply the principle of constructivism to the design of Web-based training systems for teachers and learners. Several issues will be addressed in this paper including the development of an Integrated Learning Graphics System (ILGS) to create a better learning environment.

In this paper, we have developed a web-based learning system to simulate and adjust computer graphics through Bézier, B-spline and NURBS algorithms. It is completed in this research that the features of Computer-Aided Design (CAD) and Virtual Reality (VR) are being integrated in the network system. Another advantage of this proposed graphics system is that it is portable across different operating systems such as Windows 2000, and Linux because the network browser is a common platform in Internet and Intranet. In fact, this graphics system is capable of sharing the resources with each other.

Keywords: Web-based, Surface, Curve, NURBS, Graphics, Learning, Virtual Reality

1.Introduction:

As the Internet has improved in the last ten years, a web-based system of graphics learning has emerged and become very important in Internet .In recent times [3], the distance learning by using Internet has been established and developed in the Computer-Assisted Instruction (CAI) system [7]. In the paper, a web-based system is developed for users to design and learn sculpture curves and surfaces on personal computer in an interactive way. This graphics system has a friendly interface in operating procession.

The implementation of this graphics system is mainly based on the functions of OpenGL, which is capable of showing complex 2D and 3D graphics. The platform of this learning system is network browser and VR-based browser. Users can draw curves or surfaces via assigning these points in graphics area. When the user has accomplished setting the control points successfully, he can drag the control point on the curves or surfaces to modify the graphics in real-time. And then the user can select the save files or change other variables' values on the curves or surfaces such as weight, color..etc. Finally, the user can convert the browser graphics to a VRML file of which it can be realized on the VR browser.

The purpose of this study is to develop an integrative graphics learning system in real time. Drawing the complex curves and surfaces in network browser instantaneously is a new technology nowadays. In this work, we have combined Web with CAD to create a brand-new idea of great originality.

2.Development Environment

As the earth has become an Internet world, all Internet services have entered into our daily life. World Wide Web (WWW) is one of the most important services relating to Internet because it has already contained all kinds of multimedia in itself such as text, images, graphics and sound [15].

While WWW has become more and more popular, the development of multi-dimensional computer graphics, web-based technology, and virtual reality (VR) have increasingly grown and become significant subjects to be studied [7].

On the other hand, since the performance of computers has turned out to be faster and faster each day, several 3D graphics and VR applications can be realized on a cheaper computer such as personal computers (Intel inside PCs) or some low cost workstations. Basically, 3D graphics and VR have changed the computer world from flat to become three dimensions and from one way static output to emerge as two way interactive displays.

Recently, several famous computer companies have proposed to combine the 3D graphics and VR capabilities with Internet. The designer of Virtual Reality Modeling Language (VRML) said: " because the world is not flat "[12]. Most media currently supported by WWW are using 2D media; for example, text, images and two dimensions (2D) animation. There are only few 3D graphics and VR media available for user to perform 3D on Internet.

3.Technology of the Internet--*Internets and Intranets:*

The networking technology of the Internet is *scalable*. That is, the network' s components, wiring, and protocols can connect together and provide services along with resource sharing between two computers on a local network or among millions of computers across an Internet network. In addition, Internet technology is *platform independent*. It works well with PC, Macintosh, and Unix computers in any combinations.

Because of its scalability and interoperability, Internet technology has grown to replace special-purpose, and proprietary networks in many organizations. Often times, these in-house *intranets* are not connected to the Internet, and they are used solely to carry on the private work of the organization. In many cases, in-house document sharing, file sharing, and message sharing systems based on the TCP/IP protocols are taking over much of the work formerly entrusted by the proprietary systems.

One of the main purposes of in-house intranets and WWW Internet is to deliver the information to persons with the need to know. Intuitively, these are information processing and delivery systems, which are no different in purpose from the "data processing" systems back in old days. Only the technology and its associated capabilities are changed.

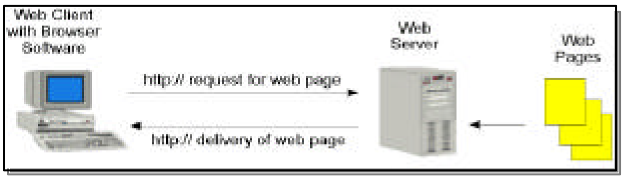

Figure 1. Request and access to and from web pages.

Web sites can be located through the browser by using special addresses called ***Uniform Resource Locator (URL)*** being recognized by the http protocol. These addresses specify the web site and the location of web pages at that site. An example of a URL address is: http://www.ncu.edu.tw/~myfolder where "http://" specifies the http protocol, "www" indicates a World Wide Web site, "ncu" is the server identification, "edu" is the type of organization, "tw" is abbreviated for Taiwan, and "~myfolder" is the name of the directory containing the hypertext documents.

4.Web-based Instruction

The World Wide Web (WWW) is an exciting new medium for the development of classroom activities. The advent of the WWW was so fast that much of the design for web-based instruction (WBI) has been profit-making in terms of educational settings, focusing on the technology rather than theory [14]. The design of web-based instruction should focus not only on the technology but also on the goals of the class, the needs of the learner, and the nature of the task involved [16]. Therefore, there is a demand for more sound research regarding the effect of WWW on learning.

Reeves [5] conducted a survey in 1995 with regard to 650 two- and four-year colleges and universities on their use of the Internet and WWW. The results revealed that there are over seven million students and faculty members who use the Internet and WWW routinely, yet there exists only 6% of all courses that are currently tapped into the web resources. Clearly, there is a lack of integration of WWW into the actual teaching and learning. At the present time, most WWW applications are: upgrading access to course materials, documenting course discussions, searching course glossaries, posting projects for critiques, providing course reference material, displaying students' writing and art, providing tutorials and drills, facilitating group work, providing learning support, engaging in collaborative web projects, and enabling reflection [9].

The WWW cannot guarantee the success of learning. The rich media and linkages available on the web are not unique to WBI. What so unique about WBI is the pedagogical dimensions that can be designed to deliver. Sound pedagogical dimensions must be considered when designing WBI; these dimensions of learning can determine the WWW's ultimate effectiveness and worthiness [3]. Factors such as the object of the goal, interactivity & learner's supervision, multiple media, motivation, and structure must be taken into account in the hypermedia environment such that the design of WBI would enhance the educational opportunities of the learners.

5. Features of Web-Based Learning

5.1 Application sharing. A feature that allows two or more people located at different areas to work together using the same software application concurrently. During application sharing, one user initiates the application program and it appears on all participants' computers simultaneously. Both (or all) users can input information and control the application using keyboard and mouse. Although it may seem that the application is running on both PCs, it is actually running on one only. In other words, the person who starts the application has the option to lock out the other person from making changes, so the person being locked out has no access to control the program.

5.2 Asynchronous function. A type of communication that occurs with a time delay, allowing participants to respond at their own convenience. Asynchronous is literally defined as not synchronous, i.e., not at the same time. Asynchronous capabilities give learners access to course materials including readings, embedded & streamed multimedia, and external Web sites. They also help learners participate in facilitated discussions and complete their assignments individually and collaboratively.

5.3 Browser Interface - Denotes that the host software allows the usage of most product features through Java-enabled browser such as Internet Explorer or Netscape Navigator/Communicator. It is widely believed that some additional software (generally referred to as a "java applet" or a "plugin") has been added to the browser to increase the selective functionalities.

5.4 Computer-based training (CBT). This is an approach with which the computer is capable of providing a series of interactive & instructional stimuli to the student ranging from questions to be answered to choices or decisions to be made, thus replacing the function of an instructor. The CBT then provides the feedback based on the response of students.

5.5 Distributed learning. It offers a variety of technologies such as learning methodologies, on-line collaboration, and instructor facilitation to obtain desirable results of learning due to its truly flexible, anytime/anywhere fashion, which is not possible for traditional education system to achieve.

5.6 Real-time. The processing of information appears to be real-time with results returned instantaneously. Telephone calls and videoconferencing are examples of real-time applications. These kinds of real-time information not only need to be processed almost instantaneously, but also need to arrive in the exact order of which it was sent. Either the delay between parts of a word or the transmission of video frames out of sequence would make the communication unintelligible. See also section 5.7 Synchronous.

5.7 Synchronous function. It is one of the two-way communications, which occurs with virtually no time delay to allow participants to respond in real time. Also, a system containing regularly occurring events in time intervals is kept in sequence using some form of electronic clocking mechanism. Synchronous capabilities add a live and vivacious dimension to online learning. Generally speaking, it includes tools supported by standards-based data, audio, and videoconferencing — like whiteboard, application sharing, and question-and-answer.

5.8 Web-based training (WBT). It is a form of computer-based training in terms of which the training material resides on pages accessible through the World Wide Web. Typical elements of media used are text and graphics. Other media such as animation, audio, and video can also be used with the requirement that each of them needs more bandwidth and in some cases additional software. The terms "online courses" and "web-based instruction" are sometimes used interchangeably with WBT.

6.WebDeGrator (Web Design Graphics)

Curve and surface design is an interdisciplinary issue involving a theoretical background based on mathematics, computational algorithms, and engineering applications [4]. Although it has great potential values for research and software development, this unique design technique causes problems for undergraduate education due to the fact that students can't manipulate this design technique good enough unless they have learned all three curriculum fields and become proficient in them. For example, teaching curve and surface design in a computer graphics course is a challenging task owing to its complicated mathematics, accounting for why most instructors often omit this aspect during the progress of the course. Moreover, many computer science educators believe that curve and surface design is not curriculum-related even though software engineers and programmers are required to have the expertise in computer graphics and computer-aided design [15]. Furthermore, despite the fact that mathematical foundation is inherited to support the theory of geometric design and geometric modeling, mathematicians rarely consider these research areas, accounting for the exclusion of these materials from mathematics curricula. Meanwhile, in recent years, most major computer-aided design systems have supported curves and surfaces, especially B-spline and NURBS. However, engineering curriculum has focused only on how to use available systems rather than providing the behind-the-scene foundation [7]. Such negligence could pose a serious dilemma because the lack of understanding of the subject would result in introducing incorrect or flawed elements into software design by the designer.

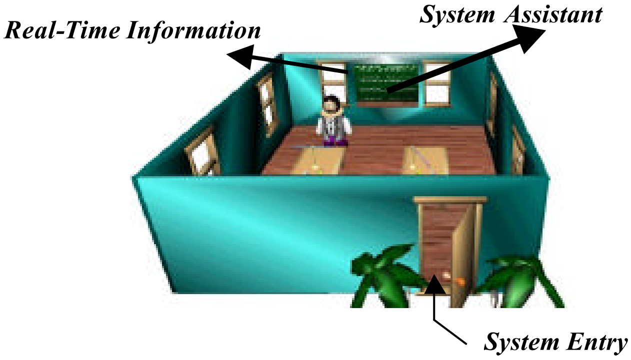

Figure 2 An Interactive Real-Time Computer Graphics System-**WebDeGrator**

To effectively resolve the above-mentioned problems, we have designed an interdisciplinary course (named as Interactive Real-Time Computer Graphics System) for engineering, computer science, and science majored students in the second year. This course encompasses important topics that are frequently used in the areas of computer graphics, geometric design, computer-aided design and visualization. A tool of pedagogical interface, **WebDeGrator (Web Design Graphics)**, has also been designed for teaching curve and surface design. This course employs an intuitive and non-mathematical approach so that students can rapidly and efficiently learn the majority of the fundamentals instead of spending too much time on mathematical derivations and algebraic manipulations.

Moreover, **WebDeGrator** provides students with an interactive environment so that they can grasp important concepts and algorithms. While a commercialized software product can be used for this purpose, we believe that a simple system to isolate the complexity and complicated operations from the students would facilitate the pedagogical process. Technically, WebDeGrator is a system designed to help both teachers and students to conduct the academic training interactively without the restrictions caused by different operating systems.

This work addresses all three types of parametric curves and surfaces i.e. Bézier, B-spline and NURBS. Our discussion starts with the hierarchy of these curves and surfaces:

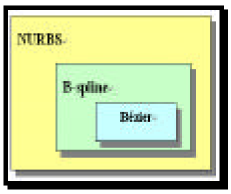

Figure 3 The hierarchy of these curves and surfaces

6.1System Features

In reality, designers or users usually do not worry about the mathematics and equations that establish the framework behind the software. They are more or less focusing on getting their job done. Therefore, a system that supports users to design curves and surfaces must possess the following characteristics.

1. ***Intuitive:***
   It is expected that every step and every algorithm should have an intuitive and

geometric interpretation.

2. ***Flexible:***
The system should provide the users with more flexibility in terms of designing and editing the shape of a curve and surface. The way to create and edit a curve and surface should be done easily and geometrically without the manipulation of equations.
3. ***Unified Approach:***
The method to represent, create and edit different types of curves and surfaces (i.e., lines, conic sections and cubic curves) must be the same. That is, it does not require different techniques for manipulating different curves and surfaces (i.e., conics and cubics).
4. ***Invariant:***
The representation of geometry of curve and surface will not be changed as a result of geometric transformations such as translation, rotation, parallel shift, and perspective projections.
5. ***Efficiency and Numerically Stability:***
A user utilizing a curve and surface design system may not concern about the delicacy of the underlying geometry; but he definitely expects the system to deliver the curve and surface he wants fast and accurately. Moreover, this proposed system allows large amount of computations without causing any distortion of the shape and the curve (i.e., numerical stability).
6. ***Portable and across different platform:***
Network browser is a common platform. In Internet and Intranet, the graphics system can be portable across different operating systems such as Windows 95, and Linux.

7. Web-Based Learning Theories– Constructivism

Many researchers and educational practitioners believe that VR technology has provided new insight to support education. For instance, VR's capability to facilitate activities of constructivism learning is one of its key advantages. In contrast, others have focused on alternative forms of learning -- such as visually oriented learners-- as potential to provide support for different types of learners. Still, others see the accessibility for learners, and educators to collaborate in a virtual class that transcends geographical boundaries as a major breakthrough.

In traditional academic environments, students are expected to learn by assimilation, i.e., by listening to an instructor's lecture about a subject. Currently, the educational approach is that students are better off to be able to master, retain, and generalize new knowledge while they are actively involved in constructing that knowledge in a learning-by-doing environment. This is a philosophy of pedagogy called constructivism and its supporters vary ranging from those who see it as a useful supplement to teaching-by-telling method to those who argue that the entire curriculum should be reinvented by gently guiding students with discovery learning. [10]

As noted by Jonassen [17], the major difference between traditional instructional design and constructivism is that the former focuses on designing instruction that has predictable outcomes and on intervening during instruction to map a predetermined conception of reality onto the student's knowledge, while the latter focuses on instruction that fosters the learning process instead of controlling it. Jonassen also points out that constructivist's focus on learning environments rather than instructional sequences, recommending features such as those identified in **table 1-1.** Originally, this proposed graphics system was established based on the concept of constructivism. In other words, constructivism is the predecessor that leads to the creation of this proposed web-based graphics system.

The supportive VR technology to provide environment for constructivist learning is discussed in details by Winn [21]. Winn suggests that the engagement of VR technology allows users to obtain three kinds of knowledge-building experiences that are not available in real world-- size, transudations, and reification, which are important for learning. To be specific, VR technology allows the radical changes with respect to the relative sizes of a student and his VR objects. Using Winn's examples, on the one hand, a student could enter an atom to examine and adjust electrons in their orbital, thus altering the atom's valence and its affinity to form molecules; or on the other hand, a student could acquire the knowledge of the relative sizes and distances in the solar system by flying between planets. Transudations refer to the use of interface devices to present information that is not readily available to human senses.

Within the philosophy of constructivist, various pedagogical approaches can be taken by using different methods. The most popular pedagogical approach is the guided-inquiry where, by performing tasks such as experiments, students are guided to uncover critical concepts for themselves. An experiential approach is the second most common approach. As all virtual worlds allow a user to experience a virtual situation, the term "experiential" is used in this paper to indicate a learning process that takes more than simple walkthroughs of a virtual world. Additionally, educational applications of VR to be described as experiential require some further interaction and efforts initiated by the student.

Table 1-1 Constructivist Learning Environments (Based on Jonassen [17])

1. Provide multiple representations of reality, thereby avoiding oversimplification of instruction and representing the natural complexity of the real world.
2. Focus on knowledge construction, not information reproduction.
3. Present authentic tasks (contextual quality that excites enthusiasm rather than abstracting instruction).
4. Foster reflective practice.

5. Enable context - and content-dependent knowledge construction.

6. Support collaborative construction of knowledge through social negotiation, not competition among learners for recognitions.

Constructivism has emerged in the last decade as an alternate pedagogy closely related to the advancement in educational technology. Interest in constructivism has blossomed considerably as conventional instruction and assessment techniques have been criticized for their inflexibility. There is a trend that educational scheme is turning into more flexible, open-ended, adaptive, and multi-dimensional instructional techniques as well as more qualitative, observation-based methods of evaluation. As a result, many educational technologists embrace constructivism and this is proved with the excess of multimedia and computer-based software spreading from the constructivist premises. In the course of adopting this constructivism this proposed graphics system makes an ideal foundation to comply with this new theory in terms of establishing open, informal, and virtual learning environments.

8. The structure of the graphics system:

(1) System' s operating process and interface:

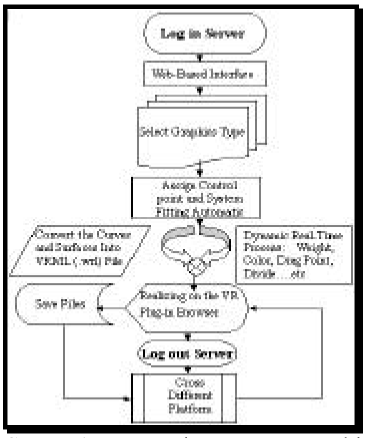

Figure 4. System' s operating process and interface.

(2) Graphics algorithms:

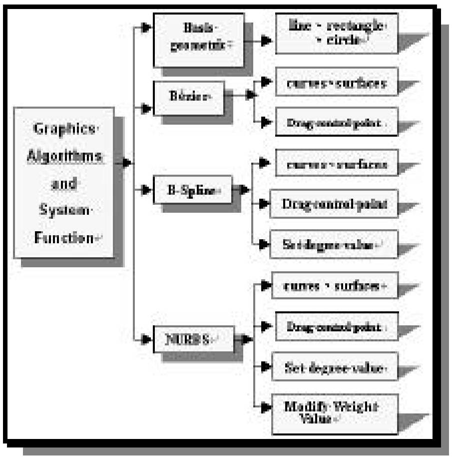

Figure 5. Dendrogram depicts system' s functionality and its graphics algorithms.

9.Curve Modeling and Surfaces Modeling

This emerging field in constructivism has rapidly motivated researchers to utilize an effective tool for improving their working environment. Therefore, we have constructed a program package for modeling and analyzing parametric curve to be named as CM ("Curves Modeling") method. It is written in OpenGL to consider not only 2D but also 3D curves as well. Three various methods are incorporated in CM at the first level in the menu. Counting all levels in the menu, there are ten methods or their corresponding modifications. In the interpolation methods, a curve passes through all control points. In the approximation methods, however, a curve passes only near the control points.

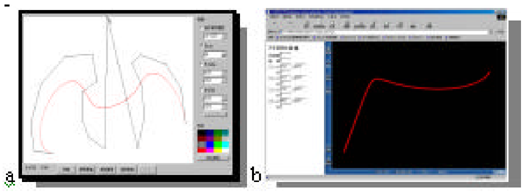

Figure 6-(a). The Curve modeling interface

Figure 6-(b). The Curve modeling of real-time simulations and adjustments

This study has constructed a program package for modeling and analyzing of parametric surface methods called SM ("Surfaces Modeling"). A surface is determined by an equation in parametrical form (parameters u and v). Of particular concern are u and v directions (parametrical view) or pertaining to direction X and direction Y, respectively (2D screen view). In the knot vectors for u and v (Uknot, Vknot), there are parametrical values u and v for patch boundaries.

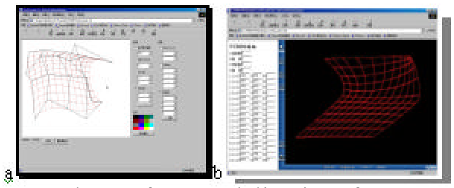

Figure 7-(a). The Surface Modeling interface.

Figure7-(b). The Surface Modeling real-time simulations and adjustments.

10.Implementation and Illustrative Example:

The following diagrams provide illustrative examples when implementing the **WebDeGrator (Web Design Graphics)** system. This study emphasizes that this proposed new technology can be used to develop the following system **(Interactive Real-Time Computer Graphics System)**. Some of the subsequent illustrations do not have a complete content.

(1) Brief Overview of the WebDeGrator

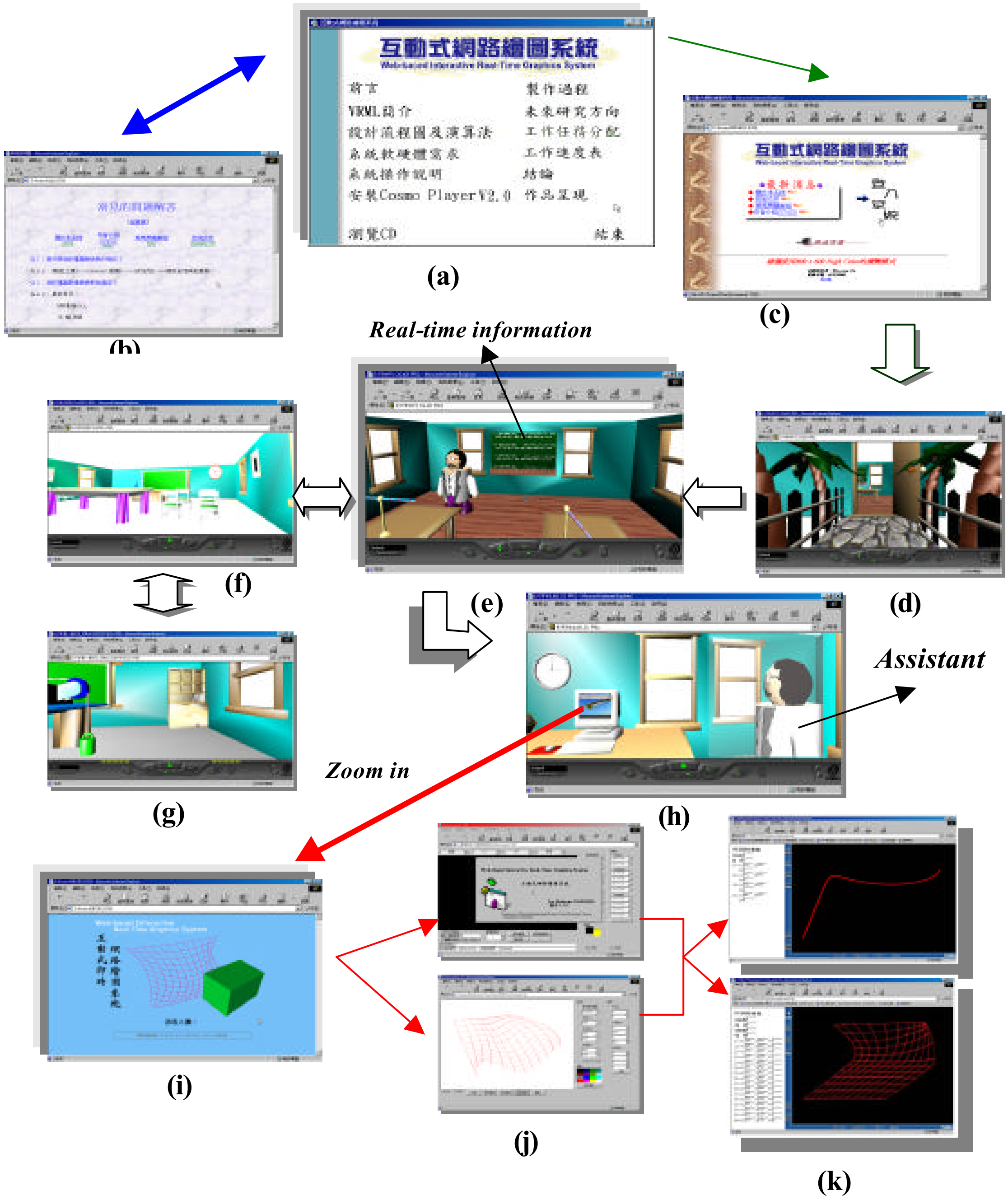

Figure 8 (a) System auto run and main menu.
(b) Online documents and Q&A. (c) Login Server.
(d) Enter 3D virtual world. (e) Assistant.
(f),(g) The outlook of virtual classroom. (h) The entry of learning and designing.
(i) Interactive Real-Time Computer Graphics System.
(j) WebDeGrator System.
(k) The Curve and surfaces modeling of real-time simulations and adjustments..

(2) Some exemplary examples:

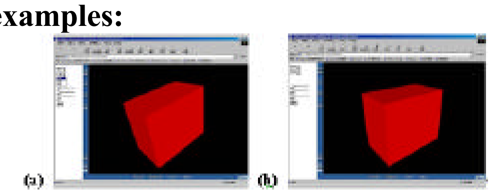

Figure 9(a) Setting or adjustment of the weight value
(b) Real-time regular viewpoint by fill in left blanks

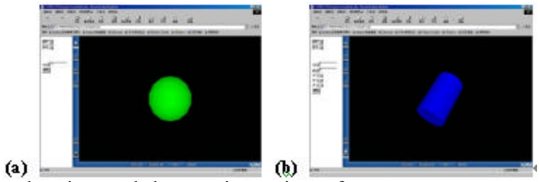

Figure 10 (a) Select a control point and degree in various forms.
(b) Illustration of a cylinder solid

Figure11 (a) Expression of triangle cone
(b) Rotation of the triangle cone in real-time by dragging the Control Points

Figure 12(a) Illustration of NURBS curve (Randomly Assign the Control Points and System Automatic Fitting)
(b) Real-time Local Modification (Real-time regular parameters by filling in left blanks)

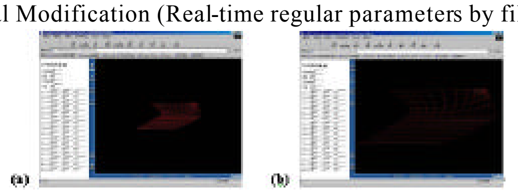

Figure 13(a) Illustration of NURBS surface (Randomly Assign the Control Points and System Automatic Fitting)
(b) Real-time Local Modification (Real-time regular parameters by filling in left blanks)

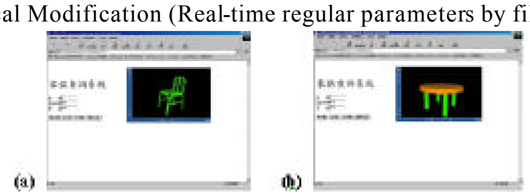

Figure 14(a) Combine 3D VRML graphics and Database with a real-time 3D query interface.
(b) A variety of queried merchandises.

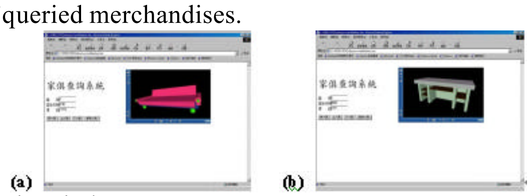

Figure 15(a) Queried by variety index
(b) Real-time dynamic view by dragging this 3D modeling.

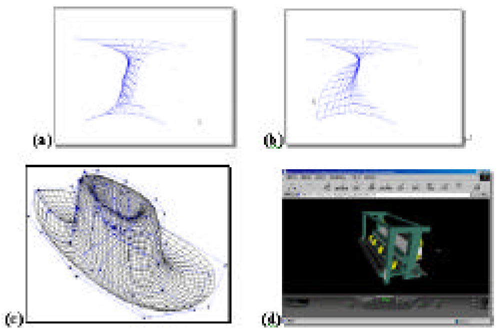

Figure 16(a) Illustration of a revolution NURBS surface **(b)** Make a real-time modification
(c) Illustrative Example of a hat by NURBS **(d)** Conversions of 3D Dynamic Graphics

11.Experiment results:

This investigation tested the effectiveness of Computer Graphics learning among CAD and CAGD Students at National Central

University of Taiwan who were enrolled in ACAD team. The team was divided into three groups: the virtual reality group used a virtual reality model of a computer graphics, the physical model group used an Web-based model computer graphics, and the printed materials group had a diagram of a computer graphics for examination. The three groups were given a pretest and a post-test with their scores compared to determine if the three groups significantly differed. While the groups were significantly different, the virtual reality group performed was the best; the Web-based model group was better than the printed materials group.

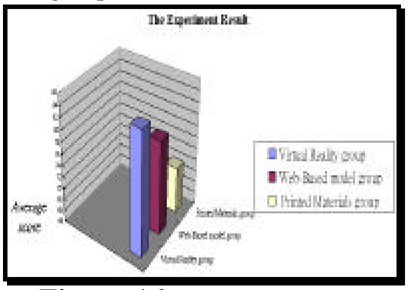

Figure 16 Experiment results

12.Conclusion and Future Work

This study has established a novel Web-Based real-time graphics system. In summary, the proposed system has the following merits:

1. **Capability to develop an Integrated Graphics Learning System in real time.**
2. **Capability to share the resources in networks.**
3. **Capability to establish a computer network assisted learning system.**
4. **Capability to explore and compare these algorithms of the sculpture curves and surfaces.**
5. **Capability to integrate VRML with web–based learning system and realizes 3D graphics in VR environment.**

The **WebDeGrator (Web Design Graphics)** system was designed to provide users and teachers with a convenient, easy and useful workspace in learning CAD. It provides a web-based learning environment including web-browser and VR-browser. The capabilities for user to walkthrough the 2D and 3D environment when simulating the designed curves and surfaces can increase the effect of learning.

An interesting area for future research is to investigate how to extend VR's learning systems, and how to convert the network database and learning system into an intelligent learning system that can record every user's data with regard to their learning condition and status.

13.Acknowledgments:

The authors would like to thank the **National Central University** for financially supporting this research. The thoughtful suggestions and valuable comments of the anonymous reviewers are greatly appreciated.

14.References:

[1] Ainge D. J., "*Upper primary students constructing and exploring three dimensional shapes: a comparison of virtual reality with card nets*", J. Educational Computing Research, 14(4), pp 45-369.1996.

[2] Bricken, M. A, *"Description of the Human Interface Technology Laboratoryí s Virtual Worlds"*. Technical Report, Human Interface Technology Laborat ory, U. of Washington, Seattle: 1990

[3] Bricken, M. "*No Interface to Design. Cyberspace*: *The First Steps"*. MIT Press, Cambridge, MA: 1991

[4] Bricken, W. VEOS *"Preliminary Functional Design"*. Technical Report, Human Interface Technology Laboratory, U. of Washington, Seattle: 1991

[5] Bruner, J. Actual Minds, *"Possible Worlds. Cambridge, Ma"*: Harvard University Press: 1986

[6] Campbell Bruce, Marrin Chris: *"Teach yourself VRML 2 in 21 days"*, sams.net Indianapolis, pp. 20-117, 1996.

[7] Christine Youngblut.."*Educational Uses of Virtual Reality Technology"*. Institute for Defense Analyses. 1998

[8] Clark, R.E. *"Reconsidering Research on Learning from Media"*. Review of Educational Research, Winter, Vol. 53, No. 4, pp. 445-459, 1983

[9]Dede, C., MC. Salzman, and R.Bowen Loftin. 1996a.*"MaxwellWorld: Learning Complex Scientific Concepts via Immersion in Virtual Reality."*InProc.IEEE Virtual Reality Annual International Symposium, pp.246-253

[10]Dede,C.1997a.Personal communication.

[11] Elias, Jim (Executive Director, US West Communications). *"Tele-Virtuality and the Potential Role for Communications. Presentation"*, Industry Symposium on Virtual Worlds Technology, Seattle, WA; Feb. 1991

[12] E. Soloway, S.Jackson, J. Klein, etal. *"Learning Theory in Practice: Case Studies of Learner-Centered Design"*. In Proceedings of Computer-Human Interaction ' 96, 6, New York,. ACM Press. pp 189-19 ,1996

[13] Flanagan, D.: *"Java in Nutshell, A desktop quick reference - Java 1.1"*, Second edition, O'Reilly, 1997.

[14] Gerald Farin. *"Curves and Surfaces for CAGD a practical guide"*.ACADEMIC PRESS. 1996

[15] GERALD "*NURBS from Projective Geometry to Practical Use"*. FARIN,1999

[16]Harel,C.m.1996.*"Water on Tap: The Use of Virtual Reality as an Educational Tool."* Ph.D. Dissertation. University of Washington, Seattle, WA.

[17]Jonassen,D.H.1994.*" Thinking Technology."* Educational, April,pp.34-37.

[18] Middleton, T., & Boman, D. ""*Simon Says": Using speech to perform tasks in virtual environments"*. Presented at the second annual conference on Virtual Reality and Persons with Disabilities. San Francisco. 1994

[19] Pantelidis V. S., *"Virtual Reality in the Classroom"*, Educational Technology, pp 23 .April 1993.

[20] Richard S. Wright,Jr. *"Michael Sweet. OpenGL SuperBible"* ,Second Edition . Waite Group Press ,2000.

[21]Winn,W.1995.*"The Virtual Reality Roving Vehicle Project. "* T.H.E.Journal (Technological Horizons in Education), 23(5),pp.70-75.

[22] Vygotsky, L. *"Mind in Society: The Development of Higher Psychological "*.Processes. Cambridge: Harvard University Press, 1978