The Scientific Approach in Designing a Virtual Reality Educational Program

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Abstract

Educational Virtual Reality (VR) is an improved multimedia tool that creates a computer simulation learning environment which is very close to reality. It is realized a sufficient improvement level in several applications, such as education, research, and training. The implementation of virtual reality offers numerous educational benefits which leads to use it for more than the traditional instructions. But, the main limitation of using this technology is the cost. In this paper, the main concepts, bases, approaches, requirements, and components that are essential to create an educational virtual reality program and its main strength and weakness points are explored. In addition, the design making process of the virtual reality program and the use of fuzzy logic in the building of educational virtual reality program are described.

Keywords: Virtual Reality (VR); VRML; HMD; Educational units,

المستخلص

الواقع الافتراضي التعليمي (VR) هو أداة تحسين الوسائط المتعددة التي تخلق بيئة تعلم قريبة جدا من الواقع تحاكي الكمبيوتر. تم تحقيق مجموعة من مستويات التطور في هذا النظام ليشمل تطبيقات متعددة مثل التعليم والبحث والتدريب. تنفيذ الواقع الافتراضي يوفر العديد من الفوائد التعليمية التي تؤدي إلى استخدامه أكثر من الإرشادات التقليدية. لكن المشكلة الرئيسية لاستخدام هذه التكنولوجيا هي التكلفة. في هذا البحث، تم توضيح أهم المفاهيم والقواعد والمناهج والمتطلبات والمكونات المهمة لإنشاء برنامج الواقع الافتراضي التعليمي واهم نقاط قوة وضعف هذا البرنامج. بالإضافة إلى ذلك، تم شرح عملية صنع القرار لبرنامج الواقع الافتراضي التعليمي واستخدام المنطق الضبابي في بناء البرنامج.

I. Introduction

Recently, computers are widely used as an educational tool due to their flexibility, rapidity, and capability to make a decision and show several images. Improvements of computer systems as well as multimedia technologies facilitate the improvement of new education and training technologies. These new technologies are currently recognized and established to offer enhanced educational environments. Several issues must be taken into account in order to understand the complexity of these systems, such as recognized techniques of documentation, qualifications, design and implementation. [1, 2, 3]

Several educational and learning technologies are widely employed in order to improve the learning efficiency and enhance the proficiency in the nowadays complex technological environment. No one of these technologies is established to verify the technological environment meaning that is made by people with gradually more complicated equipment, complex operations and enlarged safety worries. The solution of these problems is the use of educational virtual reality technologies. [4, 5]

Recently, the main tools that are utilized in the storing and processing of data in the established educational systems are: Textbooks, individuals' minds and pencils. The most significant and valuable performer in the nowadays educational environment is the online learning or as called also virtual learning. [5, 6]

Virtual reality technology is the main educational technology that is used to enhance the interactivity. It is widely utilized in medical training, services training, entertainment and aerospace design in order to offer an appropriate environment for the analysis and evaluation of designs, decrease both the improvement time and cost and enhance the superiority as well as usability of several products. [7, 8, 9]

Several training and teaching material are used in the environment of educational virtual reality technologies due to the development of visualization techniques as well as computer hardware. Educational virtual reality technologies are utilized as training and educational tools since these technologies are secure, protected, inexpensive and completely controllable. In addition, these technologies improve learning since they offer learners with interactivity and practicality. [10]

This paper is divided into several sections as follows: Section I explores an introduction about the

virtual reality technologies, section II reviews some of the related works of the virtual reality program, section III explores the main concepts and bases of the educational virtual reality program, section IV explores the main approaches of building a virtual reality program, section V explores the main features of this program, section VI illustrates the main strength as well as weakness of the virtual reality program, section VII explains the requirements and components that are essential to create a virtual reality program, section VIII describes the basic concepts of designing a virtual reality program, section IX explores the design making process of this program, section X explores the use of fuzzy logic in the building of educational programs, section XI explores the main fuzzy set expressions, section XII gives a conclusion of this paper and section XIII illustrates some of the future improvements of the virtual reality program.

II. Related Works

Several researchers developed many computer education and learning technologies which offers opportunities for users to get real education and learning sense and to enhance their skills. Virtual reality technologies are interactive interfaces among persons and computers. Rheingold explored that the use of virtual reality technologies and defined them as practices where students are surrounded by computer formed demonstration. [11, 12]

Ashton explored that the virtual reality technologies are assistant educators that let students capable to visit several places and learn several cultures. Biocca contrasted among the beginning of virtual reality technology and television in the beginning of 1940s. [13, 14]

Nilan described the main cognitive space features in which virtual reality technology is utilized as illustrious to distinguish between these features and those of the physical space. Schwier supposed that the three-dimensional environment of virtual reality technology let both system and students equally adaptive which is considered as an essential issue in the learning improvement. [15, 16]

Smedley and Higgins supposed that virtual reality means anything. In other words, its definition can be ranged uncomplicated simulation program to complete fascination tools. This range of definition discovers the several virtual reality levels. The use of virtual reality in learning offers an important educational enhancement more than

the traditional techniques, since the virtual reality technology is an interactive tool and offers real educational environment. [17]

Miltenoff and Rogers compared among the PowerPoint software and virtual reality programs. PowerPoint program provides users with several reactive tools and allows the importing of images and creating conversions and animations among slides. In addition, PowerPoint program permits the use of sounds and music which in turn improve the presentations superiority. So, Miltenoff and Rogers explored that these two programs are extremely different in which the PowerPoint program shows pictures and the virtual reality program makes three-dimensional illusion. [18]

III. Concepts and Bases of an Educational Virtual Reality Program

Educational virtual reality program an improved model of the interface among students and computers. It facilitates the traveling of students to influence several objects and practice many consequences. It offers a generated sensory indication which is adequate to produce disposed suspension incredulity in students. Virtual reality program is a set of student computer interfaces, networking, sensor

techniques and graphics. The use of virtual reality program let students believe that it is a real environment. Thus, this program is the most excellent way that is utilized to offer several experiences for students in a real environment. [19, 20]

Virtual reality program is a completely immersive and reactive experience of a reality by utilizing a computer where student reacts with several simulated objects. In addition, many students can see each other as well as react in a communal environment. Virtual reality program can be divided into two mean categories; immersive virtual reality and non-immersive virtual reality. The immersive virtual reality depends on immersive demonstration techniques, while the non-immersive virtual reality illustrates images in a typical screen and permits students to react with these images. [21]

In the virtual reality program, students influence in a real environment where they are completely engaged, wear gloves as well as a Head Mounted Display (HMD). These two components that used by students are utilized to sense and record the movements of students. Fiber optic cables are used also to transfer data to the computer which in turn reads data and transmits it into visual descriptions.

In this technique, students react with computers without using keyboards or mouse. In addition, students can wear a helmet which fully guarantees their ears and eyes. The used helmet consists of a video screen for each eye in which the virtual reality environment is seen in a three-dimensional way by these two screens. When a student looks at another direction, then computer will redraw what emerges in the helmet and make the delusion that the student is gazing around in a similar way to the real world. [17, 22]

IV. Approaches of Modeling a Virtual Reality Program

The model of the virtual reality program is shown in figure 1 below, this model consists of three main approaches; instruction design, educational content and development units.
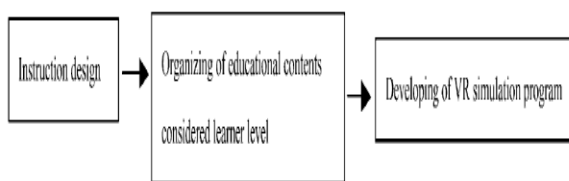

Figure 1 model of virtual reality program [23]

The instruction design approach consists of three stages, which are: Exploring of a given virtual environment by students in order to write their own comments and conclusions, discussing these comments and conclusions with teachers in which any wrong explanation is removed, using new ideas in the examination of another situation where the proposed educational cycle is repeated again. [23]

In the educational content approach, the educational contents are placed in the student's educational concept level structure. This structure is formulated with several analysis techniques of the examination level. The analysis of both concept level and examination level is followed by building the educational contents levels for several accepted, difficult and corrective courses. Investigational attributes and enactive demonstration between the educational types are used in the choosing of the learning contents by utilizing the virtual reality technology. [23]

In the development approach, the virtual reality simulation is improved by using several software programs, such as the three-dimensional webmaster which is a multifunctional tool. These programs help in the making of animated shapes, textures, clustered objects and uncluttered objects. In addition, these programs

make several viewpoints in order to observe and analyze the virtual reality world. [23]

The 3D webmaster is a Virtual Reality Modeling Language (VRML) that is similar to the HTML. It can ascertain common standards that make the virtual reality program simply language in the internet. This software creates a completely interactive environment in the web in two-dimensional pages. In addition, it offers rapid, practical and very interactive worlds. Various script languages can be used in order to create practical and helpful worlds to allocate performances to objects in the created world, carry out compound actions and adjust the virtual environments depending on the actions of the users. The interface of the software regulates the whole interaction, movement and object exploitation in the virtual environment via utilizing keyboard, mouse or joystick. [23]

The model of developing the virtual reality simulation program process is shown in figure 2 below. [23]
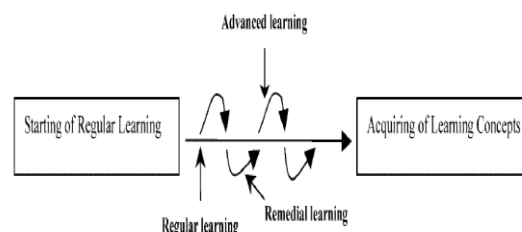

Figure 2. model of developing the virtual reality simulation program process [23]

V. Features of an Educational Virtual Reality Programs

The main features of virtual reality programs that make it an important educational tool are: [24, 25, 26]

A. Virtual reality program assists in the understanding of complicated, theoretical and non perceptive systems and perceptions. Virtual reality program utilizes several graphics as well as simulation techniques in the modeling and visualization illustrations of information, perceptions and events. In addition, this program facilitates the interaction of learners with three-dimensional models and helps them in the working with applicable parameters and employing of several viewpoints in real time.

B. Virtual reality program improves education by making the education like a game without changing fundamental contents. Due to the use of videogames, students

are extremely provoked to play these interactive games. Thus, students can master and preserve knowledge better than the traditional techniques since they are occupied with making the knowledge via studying though doing.

C. Virtual reality program permits the making of enhanced educational environments for students who cannot understand well by using the traditional techniques. This program can reengage students with learning outside the school.

VI. Strength and Weakness of Using the Virtual Reality Program as an Educational Tool

Virtual reality programs are new techniques that are suited with some applications and they are not with other ones. The main strength and weakness of these programs are: [22]

Strength:

Virtual reality programs provides several benefits for learners, such as experimental learning, capability to provide students with new styles of teaching, utilization of several systems that offer educational data and engagement of students in educational environments. Virtual reality programs can show spatial relations as well as discover environments which are unreachable.

Weaknesses:

The main critical significance of virtual reality programs is the effecting speed which requires cooperation in the precision of simulation and details in order to preserve sensible performance of the system. In addition, the limitation in accessing with the outside environment and the small declaration of learners are the main reasons of decreasing the efficiency of visual perception. Virtual reality programs are not suitable for showing equations, methods and texts at this time. Direction controls are not recognizable by all students as well as they are not obtainable for all computers.

VII. Requirements and Components of an Educational Virtual Reality Program

Virtual reality program is a simulation form that depends on the graphics of computers in order to make a virtual environment. This program allows students to compact with the created virtual environment by using simulation as well as several devices. The created virtual environment is a real time reactive system that acts in response with the inputs of students as well as change the created virtual environment along with the inputs of students. The

virtual reality program can modify and enhance the educational ways. [1, 27]

Hardware and Software Requirements:

The main hardware and software requirements which are essential in the building of a virtual reality program are: [28]

- Hardware requirements include: Displays, computers with multimedia services, actuators and sensors.
- Software requirements include: modeling software programs, such as AutoCAD, simulation systems, such as animation system and toolkits that sustain several applications.

Components of a Virtual Reality Program:

Virtual reality program consists of four main components that are shown in figure 3 below, these components are: [28]

- Virtual environment: In which a student can see and react with several units via a display screen and stereo spectacles.
- Virtual devices: The main devices are information acquisition and allocation unit which is the interface of computer with other devices, sensors that are utilized in the tracking of the student's

hands and head direction and position in the three-dimensional space, gloves that are used to facilitate the communication of student with the virtual world by a finger control and stereo spectacles that permit the view of images in three-dimensional depth via students.

- Virtual real time modeling: It consists of algorithms which are used in the creation of a virtual environment and in the generation of three-dimensional graphs and mathematical models that are used to model the virtual reality environment.
- Virtual control software: The main functions of the used software are real time signal processing of virtual environment data, control of the modified virtual environment and communication among several virtual reality program components.
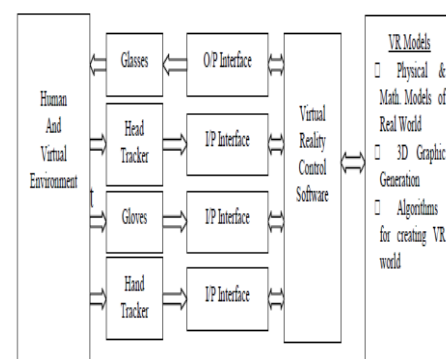

Figure 3 main components of virtual reality program [28]

Roles of Teachers:

The main roles of teachers in the virtual reality programs are: Describing the main educational outcomes and making a learning world with the purpose of addressing them, underlining contents instead of technology, offering notice and attention in order to sustain students' reactions and develop the learning community, changing the educational environment until achieving the required educational outcomes and considering the main process in order to expose the main principles of design which informs several investigators, instructors and expected projects. [5, 29]

VIII. Virtual Reality Program Design

The environment of a virtual reality program determines the popularity of this program. The most exciting characteristics that affect on the program popularity are: lights, music, colors and noises. Virtual reality program illustrates an educational environment which is simulated by using a computer. The majority of virtual reality programs are visual practices that are shown on a computer screen. [30]

Several programming languages can be used in the creation of virtual reality environments, such as the Virtual Reality Modeling Language (VRML). The use of this language facilitates the exploring of the three-dimensional world of the program, zooming and interacting with this environment. VRML contains several multimedia components, like images, sounds and videos. An example of virtual program architecture is shown in figure 4 below. [30, 31]
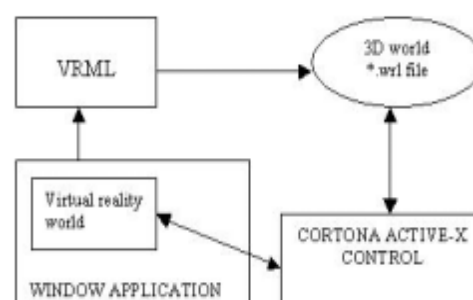

Figure 4 architecture of a virtual program [31]

The main programs that are used in order to offer a fundamental gratitude of the virtual reality educational applications are shown in the following table. The main purposes of using these programs in the virtual reality technologies varies from allowing students to visit the virtual environment to providing teachers who will utilize it in order to convene their learning objectives in the class with the virtual reality program. [32]

The main four stages of designing a virtual reality program are: [33]

- Stage one: Learn how to make a presentation.
- Stage two: Train with software and its psychoanalysis.
- Stage three: Build a virtual simulation that consists of several educational units.
- Stage four: Explore analysis of the designed virtual program that relates among practice and theory.

The virtual simulation aims to achieve four main findings, which are: [33]

- Visualization of educational processes.
- Enhancement of three-dimensional revelation as well as the spatial cleverness.
- Recognition of three-dimensional shapes.
- Solving several problems as well as enhancing the performance.

Table 1: Programs used in the creation of virtual reality program [32]

	Program Name	Participants
Outreach	Virtual Reality Roving Vehicle (VRRV)/Washington	Teachers and students grades 4-12
	VRRV/Nebraska, Phase I and II	Teachers and students
	Mobile Aeronautics Education Laboratory (MAEL)	Students grades 9-12
Web	—	Teachers
Teacher Education	VRRV/Nebraska, Phase III	Teachers
	Educators' VR Series	Teachers
	Virtual Reality in the Schools	Teachers
	Virtual Education - Science and Math of Texas (VESAMOTEX)	Teachers
	VR Concentration, M.A. in Education	Teachers
Collaborative	VR in Education	Teachers
	Virtual Reality in the Schools	Teachers

IX. Design Making Process of the Educational Virtual Reality Program

The educational virtual reality program offers a simple way to transform from one educational level to another one depending on the background of the student. The educational program can be divided into three main paths, which are:

- Educational path A which contains the learning unit review that is relatively adequate for expert students.
- Educational path B which contains the typical data which are offered by teachers to normal students.

– Educational path C which contains a full data that assists in the educational process for beginners.

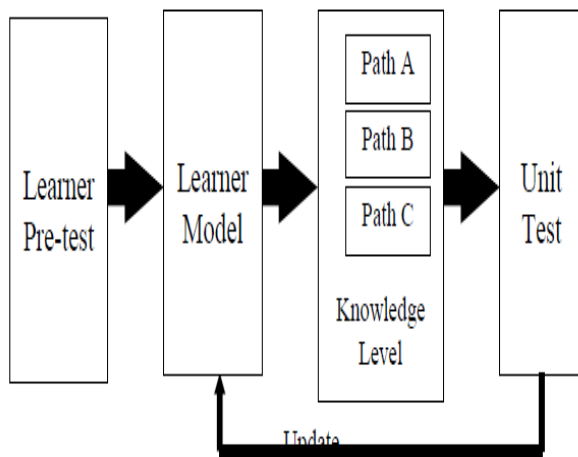Figure 5 below summarizes the proposed educational program.

Figure 5 the proposed educational program [28]

The use of the proposed learning system permits expert students to go throughout the learning units with less time. In the other hand, beginners take long time with more effort to go throughout these units. By using this system, the course must be divided into different learning units depending on the course syllabus which is approved by the course instructor. This educational system operates as following: [28]

– A learner should take a pre-test in the beginning in order to indicate his learning level that let him go through the first learning unit.

– A Feed-forward education must be done depending on the recent student learning level.

– The student capability should be tested at each learning unit in order to inform the student's model as well as to find the next educational unit path.

– The obtained test determines the transformation of student form one level into another as shown in figure 6 below in which:

➢ The student with grade very good or good is transformed to level A or is transformed from C to B in the next unit.

➢ The student with grade fail is transformed from level A or B to C and continues in the same unit.

➢ If the result of the test is unsatisfied, then the student will be transformed from level A or B to C and continues in the same unit regardless of his educational path.

➢ If the result of the test is fail with level C, and then the student will be informed to leave the learning system.
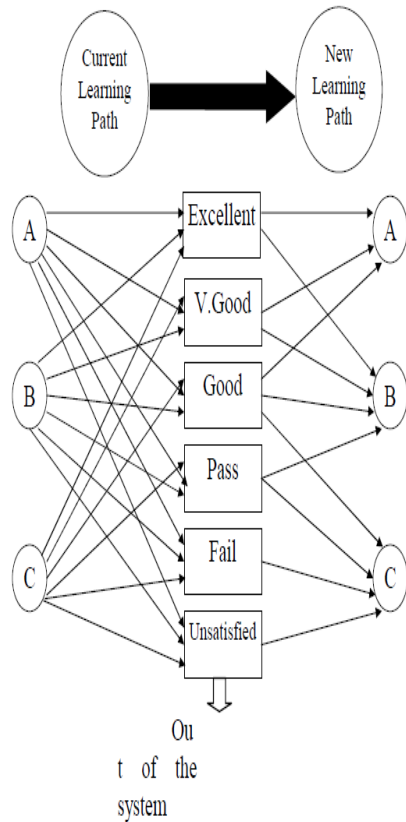
Figure 6 the educational decision making process [28]

X. Fuzzy theory in educational virtual reality systems

The main issue that must be taken into account in the building of an educational program is the use of appropriate methods for both the achievement of knowledge and making of virtual environment in real time. Actually, individual thoughts and analysis occupy indistinct data. Thus, educational programs must have the ability to manage this indistinctness which is cause by several sources, such as: [34]

- Offered data by students.
- The recent educational levels of students.

- Estimation of the student educational level.
- Teacher knowledge.
- Course objectives.

Educational virtual reality system design based in the first place on the demonstration of knowledge that is utilized in the controlling of decisions education. The educational system core is the knowledge of teachers, thus it should be modeled to make the educational programs more flexible and simple and to allow students to contract with the material of course which is appropriate to the student educational level. [26]

The modeling of teacher knowledge and course world is a difficult task due to the proposed vagueness. Thus, the use of a competent tool which is able to model the teacher knowledge and course world is an important issue in order to create flexible and simple rules of decision. The most competent tool is the fuzzy logic in which a linguistic variable employs words as values. [28]

The use of fuzzy theory in the building of educational virtual reality system can solve several problems that resulted from: [28]

- Modeling of student, teacher knowledge and virtual reality environments.

- Detection of the student's educational level in each learning unit.
- Algorithms for three-dimensional graphics and virtual environment production.

- Controlling variations in virtual reality programs.

Evaluation and estimation of students and their levels.

XI. Fuzzy Set Expressions

The main two fuzzy sets are the Interval Valued (IVFS(X)) and the Intuitionistic (IFS(X) fuzzy sets. For the intuitionistic fuzzy set that is a function of X in which X does not equal to zero and Card is also a function of X equals to K, the following formula describes its expression [35]:

$$A = \{< x, \mu_A(x), v_A(x) > | x \in X\}$$

Where: $\mu_A: X \to [0,1]$ and $v_A: X \to [0,1]$, $0 \leq \mu_A(x) + v_A(x) \leq 1$ for all $x \in X$, $\mu_A(x)$ represents the membership degree of element x to the set A and $v_A(x)$ represents the non-membership degree of element x to the set A. [35]

The main expressions for all A, B in the set X are: [35]

1.When$\mu_A(x) \leq \mu_B(x)$and$v_A(x) \geq v_B(x)$for $x \in X$, then A is less or equal to B

2.When$\mu_A(x) \leq \mu_B(x)$ and $v_A(x) \leq v_B(x)$ for $x \in X$, then $A \leqslant B$

3. $A \vee B = \{< x, \mu_A(x) \vee \mu_B(x), v_A(x) \wedge v_B(x) > | x \in X\}$and $A \wedge B = \{< x, \mu_A(x) \wedge \mu_B(x), v_A(x) \vee v_B(x) > | x \in X\}$These two expressions are simply generalizable to the case of various intuitionistic suzzy sets

4. $A \leq B$ and $B \leq A$, then $B = A$

5. $A_c = \{< x, \} v_A(x), \mu_A(x) > | x \in X$

For all $| x \in X$, $\mu_A(x) + v_A(x) = 1$, thus A is considered as a fuzzy set. The following expression of the fuzzy set is considred as a the intuitionistic fuzzy set case:

$$A = \{< x, \mu_A(x) > | x \in X\} = \{< x, \mu_A(x), 1 - \mu_A(x) > | x \in X\}$$

Fuzzy sets are used widely in the provlems of decision making. The intuitionistic fuzzy set problem can be solved by considering an alternatives set and criteria sets as IFSs. In addition, the distance among the membership function and the non-membership function of a specific element is considred as a score function in relationship to both the criteria set and the alternatives set. This distance is called the Hamming fuzzy distance. The use of the Hamming fuzzy distance in the intuitionistic fuzzy set offers the following formula [35]:

$$2. d_{H_{IFSs(x)}}(A,B) = \sum_{k=1}^{K} |\mu_A(x_k) - \mu_B(x_k)| + |v_A(x_k) - v_B(x_k)|$$

By considering that A and B belong to IFSs(X) (x) and xi is an element in the set X, then the following expression represents $d(x_i)$: [35]

$$2. d(x_i) = |\mu_A(x_i) - \mu_B(x_i)| + |v_A(x_i) - v_B(x_i)|$$

This proofs that: [35]

$$d_{H_{IFSs}(X)}(A,B) = \sum_{i=1}^{K} d(x_i)$$

XII. Conclusion

Virtual reality program is an improved educational technology of the interface between students and computers that is used to enhance the learning process. It is used in the education and training in order to provide a suitable environment for the analysis and estimation of designs, reduce both the improvement time and cost and develop the superiority and usability of several products.

XIII. Future Improvements

Some of the future improvements of the educational virtual reality program are using it to sustain all categories of learning programs, looking more properly at the educational display and demonstration efficiency and comprising a speech identification technique that will help a student to get notes during his research.

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