A VIRTUAL REALITY BASED EDUCATIONAL MODULE FOR KNOWLEDGE LEARNING & SKILLS TRAINING

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ABSTRACT

Advances in computers and multimedia technology have changed traditional methods for learning and skills training. Today, multimedia education has been popular, it can provide an environment where virtual reality can be used to create interactive interfaces and real-time software can monitor every response made by the user. This paper presents an attempt to introduce the concepts of fuzzy set theory and multimedia technology in the design of a virtual reality based educational module. Such a module can deal with uncertainties in the knowledge acquisition, representation and decision making. It provides a powerful educational tool that can assist users in learning and training without actually handling real tools.

Keywords: Computer aided learning & training, Fuzzy set theory, Decision making, Multimedia technology, Software Engineering, Virtual reality systems.

1. Introduction:

The computer has recently become the most powerful tool in education. This is due to it's speed, flexibility, and ability to take a decision and display images. It can be used to process text, organize documents, and create a real physical representation [1]. The development of computer systems and multimedia technology has opened up new possibilities for education and training. Computer-based education and training techniques are now well established, and provide an environment to create interactive interfaces, and real-time software can monitor every response made by the learner or the system. The complexity of such systems can not be understood by one person, therefore, formal techniques of specifications, design, implementation and documentation are essential [2,3].

Several efforts have been made to develop computer animation-based learning and training system [4,5]. However, computer animation alone will not provide users with opportunities to obtain real-sense learning/training and develop their skills. For that reason, there is a need to explore more advanced technologies to improve learning and training [6]. Virtual reality has found a number of applications in learning and skills training. For engineering education, virtual reality has been used for chemical reaction engineering at Michigan University [7], for aerospace engineering at Syracuse University [8], for teaching structural analysis at National Chiao University, Taiwan [9], for designing a set of experiments in physics at Houston University [10], and for visualizing molecules and designing new drugs at North Carolina University [11].

As the number of students entering the higher education increases along with the requirement for greater cost efficiency, the potential benefits of computer based

learning and training are great. The diversification into distance learning, community education and industrial training which higher education is currently exploring can also be enabled through the adoption computer based learning and training, especially if they can be delivered over networks which reach into homes, factories as well as educational institutions. Clyde Virtual University is a test bed for exploring, developing and evaluating techniques for delivering learning materials, supporting collaborative learning and training over the internet [12]. This university has successfully converted courseware in a number of subject areas for delivering to any user with access to ClydeNet. This material has been installed on the university server and will remain available for years to come. Between May 1996 and April 1997, over 1400 students had registered to use this virtual university. Well over half a million requests had been made to the server for individual items.

On the other hand, real educational processes deal with uncertainty in human knowledge. However, most of available educational systems use classical methods to handle vague information in the knowledge representation and decision making [5]. Furthermore, fuzzy set theory incorporates precise techniques for solving such problems. In fact, fuzzy logic concepts have been used in several expert systems for knowledge representation and reasoning [4,5]. An expert workstation has been designed and implemented as an instructional tool for engineering education [3]. In this system the capability of fuzzy logic is combined with artificial intelligence concepts to produce an intelligent educational package.

This paper outlines how a virtual reality based educational system can be used for knowledge learning and skills training without using real tools. The current level of the user is used to obtain the appropriate learning path in this system. Using such a system will enable users to see what happens rather than to imagine what should happen.

2. Computer-Based Learning and Training:

Training means the transfer of skills, it is very important part of modern education. Some training aspects can be acquired from a book, or in a classroom, but there is no substitute for training with the real thing. Students may not have opportunities to acquire practical knowledge, which are very important in many courses. Today, it is very difficult to offer such costly courses, for a number of reasons, such as;

- limited funds for running such programs,
- limitations on laboratory facilities,
- insufficient support of technicians,
- number of students, and
- safety considerations.

Training through simulation provides significant benefits over other methods. Simulating the actual behavior of a certain process requires accurate modeling of each part in the process and integration of real-time 3-D graphics. In this case, each instrument is electronically driven by real-time computers that generate output signals based on a software model describing the instrument behavior. A computer-based flight simulator, for example, is a training system where pilots can acquire flying skills without involving a real airplane or airport [6].

The development of computers and multimedia technology has opened up new possibilities for training based on virtual reality. Virtual reality is the most powerful extension of simulation based systems. In virtual reality there is a move to three-

dimensional, multi-sensory interfaces. Virtual reality is something, which is not real, but can be considered to be real while using it. Virtual reality provides an environment where multimedia tools can be used to create interactive interfaces and real-time software can monitor every response made by the user. Virtual reality can be used to evaluate how a user can achieve new experience in training without the support of physical environment. Such training systems use a virtual environment as a substitute for a real environment.

3. Components of a Typical Virtual Reality System:

Virtual reality is a type of simulation in which a computer graphics are used to create a virtual world [1]. It enables users to deal with a virtual (realistic-looking) world through the use of computer simulation and special devices. The virtual world is a real-time and interactive system that responds to the user's physical inputs and modifies the virtual world according to the user's inputs. Virtual reality has the potential to change and improve the ways in which students are educated [13]. In fact, future trends in learning and training will use virtual reality based education laboratories to support every type of education program.

A special hardware and software requirements are necessary to construct a virtual reality system, these includes;

(a*). Hardware requirements;*

- Sensors and actuators,
- Head-coupled displays, and
- A personal computer with full multimedia facilities.

(b). Software requirements:

- Modeling virtual worlds using AutoCAD, 3Dstudio,…..
- Physical simulation: computer animation systems,
- Virtual reality toolkits: software environment to support a wide range of applications.

A typical virtual reality system consists of four basic components, as illustrated in Fig.1, these components are:

(1). Virtual Environment: A user can view and interact with entities through a stereo display monitor and stereo glasses.

(2). Virtual Reality Devices: These include;

- Stereo Glasses; which allows the user to view computer-generated images in true 3-D stereo depth.
- Gloves; which allow the user to communicate with virtual environment through finger control.
- Position Sensors; which are used for tracking the position and orientation of the user's head and hands in 3-D space.
- Data Acquisition and Distribution unit (card) for computer interfacing with virtual devices.

(3). Virtual Reality Modeling: real-time modeling, which includes;

- Mathematical models of real (actual) world environments.
- Algorithms for on-line 3-D graphic generation.
- Algorithms for creating virtual environments.

(4). Virtual Reality Control Software; which represents the main part of the virtual reality system. The functions of this software include;

- Signal processing on the real-time information from the virtual world.
- Real-time control of the changing virtual reality.

- Real-time communication between different virtual reality components.

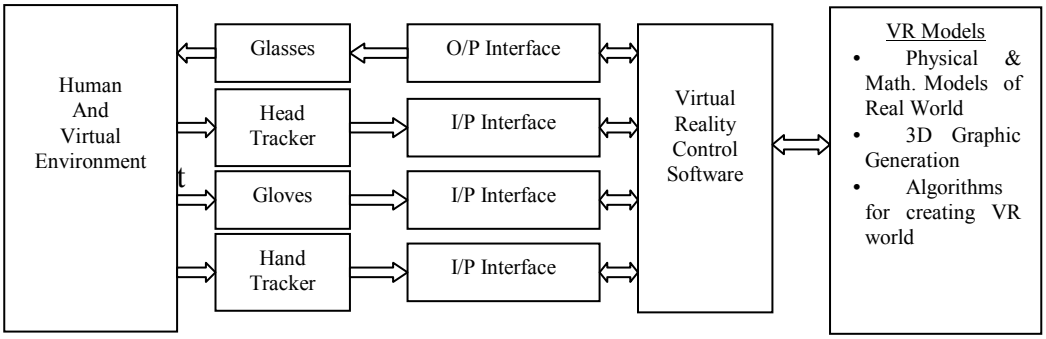

Fig.1: A typical virtual reality system.

4. Fuzzy Set Theory and Virtual Reality Systems:

One of the most important requirements that precede the design of the educational system is to adopt suitable methods for knowledge acquisition and real-time modeling of the actual world. In fact, human thinking and reasoning involve vague information, therefore, educational systems should be able to cope with such vagueness. The aforementioned vagueness is related to the following source [5]:

- Information provided by the learner.
- The current knowledge level of the learner.
- The evaluation of the leaner level.
- The experience of the instructor.
- The objective behind the course materials.

The knowledge representation used for decisions learning management has a great importance in designing virtual reality based educational systems. The sequence of the educational events that is based on the instructor's experience is the core of such educational systems. Therefore, it is important to model the experience of the instructor in such away that the educational system should be flexible, easy, and at the same time enables the learner to deal with the course materials which are suitable to his knowledge level.

Several papers [3, 5,14-16] have mentioned that the modeling process of the instructor experience and course related physical world is not an easy task. Due to the knowledge acquisition vagueness, it is essential to use an efficient tool that is capable enough to model this knowledge in order to build a flexible decision rules. The fuzzy logic is the most suitable tool to deal with vague knowledge and the process of decision making in the educational system.

In fuzzy sets, a linguistic variable takes on words or sentences as values. For example, let the variable $\boldsymbol{x}$ be the linguist variable "learner average result", then the following term {Excellent, Very Good, Good, Pass, Fail, Unsatisfied} can be constructed as shown in fig.(2) . Each term in the set is a fuzzy variable. Now, if $\boldsymbol{x}$ in an element of a fuzzy set, then the associated grade of x with it's fuzzy set is described by a membership function $\mu(x)$, which takes values between zero and one.

In virtual reality based educational system, the fuzzy set theory concepts can be used for solving problems related to the:

- Modeling of the learner.
- Modeling of the instructor experience.

- Identification of the learner knowledge level during each educational unit.
- Modeling of real world environments.
- Algorithms for on-line 3-D graphic generation.
- Algorithms for creating virtual environments.
- Real-time control of the changing virtual reality.
- Decision making for learning path selection.
- Overall evaluation of the learner.

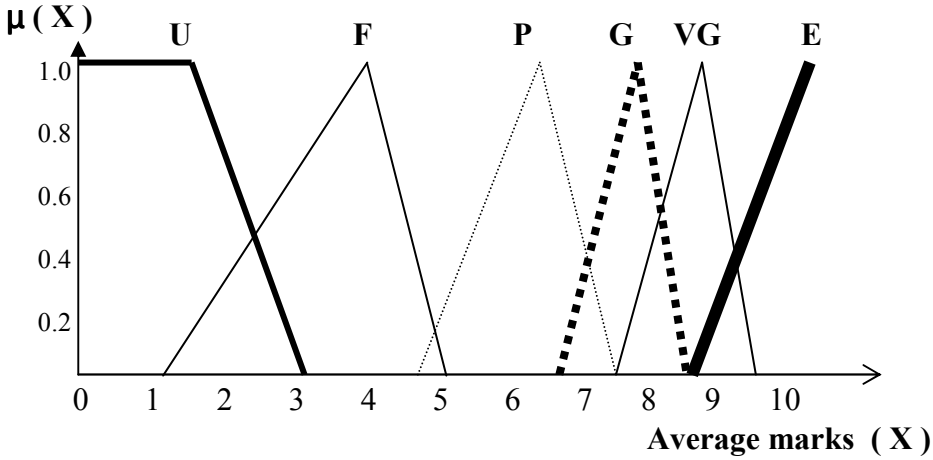

Fig.2: The fuzzy notation of the variable 'test result'.

5. Decision Making Process:

The flexible educational system provides an easy way to make possible the transformation from one learning level to another according to the learner background. In this case, three educational paths can be used;

- Learning path (A); includes a summary of the educational unit, which is quite enough for high quality learners.
- Learning path (B); includes the usual information as that given by the instructor for normal learners.
- Learning path (C); includes a detailed information that facilitates the learning process for beginners.

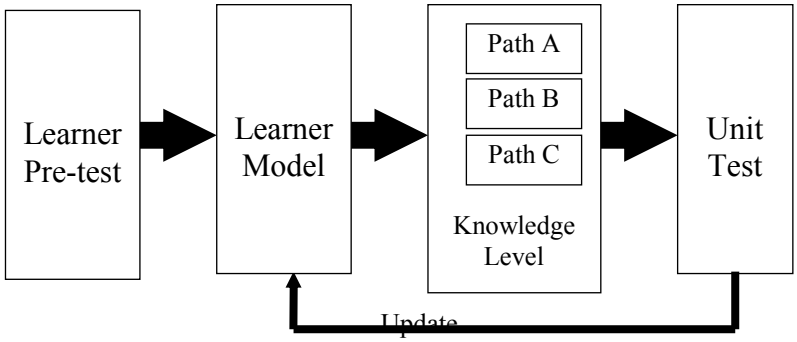

Fig.3: Block diagram of the proposed educational system.

The above educational paths allow the high quality learner to go through the educational units so easily with minimum time while slow-witted learners take more time with high effort to pass each educational unit.

Figure (3) shows a block diagram of the proposed educational system. The course material should be distributed for several educational units according to the syllabus adopted by the institute and the instructor's experience. The operation of this system can be summarized as the follows;

- A pre-test must be taken by the system to specify the knowledge level of the learner which enables him to enter the first educational unit.
- Feedforward learning according to the current educational level of the learner.
- The system will test the ability of the learner at each educational unit to update his/her model and to specify the new learning path for the next educational unit.
- According to his/her test in the current educational unit, the learner with grade (Good) or (Very Good) can transform from knowledge level (B) to (A) or from (C) to (B) in the next educational unit, as shown in fig.(4).
- The learner with grade (Fail) will transform from the current learning path (A or B) to learning path (C) and remain at the same educational unit.
- If the test result at a certain educational unit is (Unsatisfied) then the learner at knowledge level (A) or (B) will remain at the same educational unit and at learning path (C) regardless of his/her learning path.
- If the test result of the learner at knowledge level (C) is (Fail) then the system will advise the learner to leave this educational package.

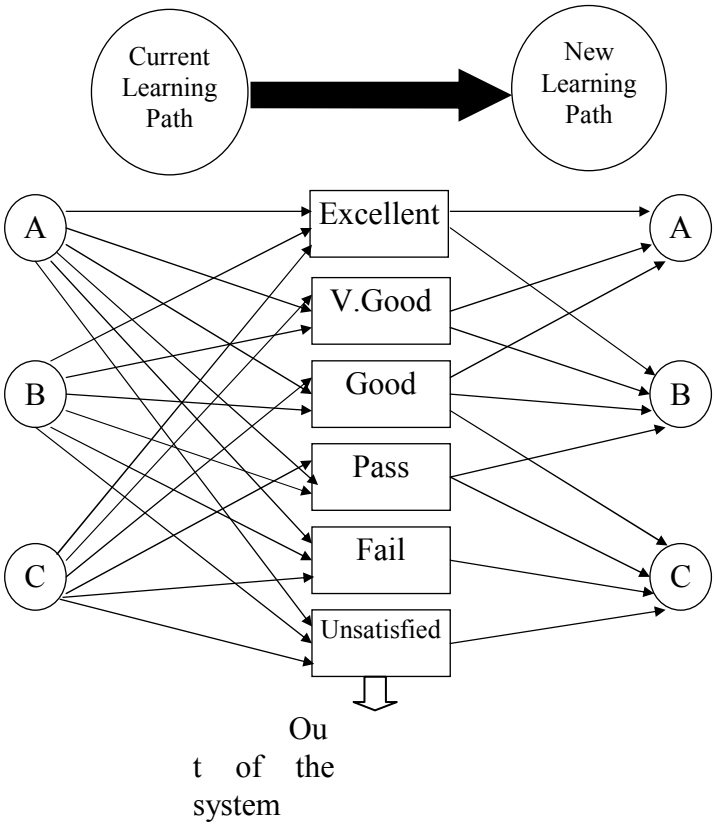

Fig.4: Layout of the decision making process.

A set of fuzzy rules that combine the current learning path and test result can be defined as given in table (I). In general, a rule is an implication statement expressing the learning level, test result and learning path in the next educational unit. For example, the rule;

IF CLB AND TVG THEN NLA

This means that if the current learning path (CL) is path (B) and the test (T) is very good (VG) then the next learning path (NL) is path (A). In this system 18 rules have been used to specify the decision making process.

	CLA	**C LB**	**CLC**
TE	NLA	NLA	NLB
TVG	NLA	NLA	NLB
TG	NLA	NLB	NLC
TP	NLB	NLC	NLC
TF	NLB*	NLC*	NLC*
TU	NLC*	NLC*	OUT

NOTE : (*) Stay in the same unit
(C) Current , (T) Test , (N) Next , (L) Learning Path

Table(I): Rules for fuzzy decision making.

6. The Need for Software Engineers:

As we approach the next century, our society is changing into knowledge and information society. There will be new opportunities and new challenges in all dimensions of our life. One of the challenges will be that we have to continue dealing with large-scale software systems. Virtual reality based systems are real-time, large scale, and complex systems. Such systems are designed and built by a team of engineers. Ian Sommerville[17] defines software engineering as "an engineering discipline concerned with the practical problems of developing large software systems".

There is a need for new programs in software engineering education tacking into account the following points;

- Software engineering education is a difficult task, because it integrates many aspects of software development life cycle, combines theory and practice, requires teamwork,…
- A software engineer should have a good background in computer hardware and software. Good knowledge about software engineering foundations and practice is a must.
- Teamwork is important.
- Communication skills are very important.
- Due to rapidly changing technology, university should prepare students for life-long learning.
- The software engineering curriculum would reflect the specific needs of software industry in the Arab world.
- University/industry co-operation is an important factor.

7. Conclusions:

This paper addressed the importance of using virtual reality technology and fuzzy set theory principles in learning and skills training. Course material (theories and related experiment knowledge) can be integrated with on-line display through virtual environments. Moreover, modeling and decision-making based on fuzzy logic

effectively contribute in dealing with vague information. The decision making process in this system is taken place according to the actual knowledge level of the learner.

Future trends in education will use virtual reality technology to support every type of educational program. The virtual reality system provides a powerful education tool that can assist users in learning and training through a computer system and some special devices. Such a system is flexible, cost effective and safe. These systems are designed and implemented by a team of engineers.

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