Primary School Interactive Learning Tool Based On Video Capture Virtual Reality

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Abstract—**In this study, an implementation of an education programme was designed by using Virtual Reality technology. This education system includes primary school course contents and uses Video Capture Virtual Reality technique. This technique used in many areas enables the creation of low-cost virtual environments. By preferring the low cost system, it was intended that virtual environment would pave the way for all primary schools to achieve the ability of use. Virtual system basically includes course menus in which three-dimensional objects and animations exist. Also, virtual system both increases three-dimensional perception of primary school students and eliminates the need for additional materials.**

Keywords—virtual reality; video capture; three-dimensional objects; interactive learning.

I. INTRODUCTION

Virtual Reality (VR) is a rediscovered technology at present which allows the implementation in different areas. At first, this concept found place in fictional books in 1950's [1]. Since VR systems can be costly installed, it caused this technology to be used only by specific companies and universities for a while. Nowadays, installation of these systems at affordable prices opened the door to utilization of VR nearly in every area.

Most people almost every day inadvertently faces VR implementations in such cases while watching weather forecast or playing multiplayer games on local area network (LAN) in internet cafes or surfing the web page of newly enrolled university via virtual tours and so on. As the given examples, virtual-real implementation can be developed in every area. Here, how much reality perception this VR system can provide is of great importance. In such a system, one of the most important criteria which provide "reality" perception is the ability of user to interact with the system similar to those in the real world. Basically, VR can be defined as specific ratios of virtual and real materials for representing real-time interaction. By shifting this ratio, various levels of VR can be generated. VR is defined as the combination of display technologies in which model world and direct manipulation immerse the users and real time interactive three-dimensional (3D) graphics [2].

II. VIRTUAL REALITY

Most people in this area take Ivan Sutherland's definition as the basis of the emergence of VR idea in 1965 [2]. The definition can be expressed as a world in the window which looks, sounds and feels real and can respond realistically to the user's actions [2]. The reality feeling mentioned in this definition still cannot make the users perceive it a hundred percent in new generation computers. Instead, virtually generated objects or virtual worlds can be considered as the acceptable reproductions of the real ones [3].

To emphasize VR, it can be thought as the illusion penetrating into a synthetic environment rather than just monitoring the environment. VR is based on 3D, stereoscopic head-tracker displays, sound and also hand-body tracking. VR can be explained as being an immersive and multi-sensory experience. [2]

In terms of sensory, VR is stated as immersive, interactive, multi-sensory, viewer-centred, 3D computer based environments and union of essential technologies to create these environments [2].

In the light of these definitions, the following parameters are prerequisite for modelling VR system.

Four basic factors to experience VR are virtual world, immersion, sensory feedback and interactivity [4].

"Virtual world" is a collection of objects in a computer generated space and the rules and relationships dominating those objects [4].

"Immersion" is the feeling of being in a created virtual environment (VE). Immersion can be examined under two different titles as physical and mental immersions. Physical immersion surrounds user physically by the devices composing VE. Various senses of user are stimulated in a real manner. Mental immersion is used for making user "feel" in the VE and for directing his/her behaviours accordingly. [4]

"Sensory feedback" should be provided according to the user's physical position in VR system. For this reason, the user's movements can be continuously tracked. Although most VR systems address visual sense, systems addressing haptic sense also exist. [4]

For "interaction", system should collect data from user by various methods and should give a respond to him/her simultaneously after data evaluation. This respond can be given to user as sensory or environment can be modified by the user movement. [4]

VE-software, hardware, input/output devices and the user are the basic factors that create a general VR system [15]. To classify these systems, user's real (outer) world perception (hear, touch, see) degree is taken into consideration when using the VE [3]. The VR system can be classified into three groups as fully-immersive, semi-immersive and non-immersive systems [3].

Systems that completely cover the user's field of view are named as "fully-immersive systems". User can see VE via Head-Mounted Displays (HMDs) [3].

"Semi-immersive systems" utilize large screen projections where VE is reflected [16]. "The CAVE Automatic Virtual Environment (CAVE)" virtual rooms are the basic examples where the user can see both VE and the real world at the same time [3].

"Non-immersive systems" only present VE via a monitor [16]. These systems have the lowest cost among these three groups [3]. User is a little nearly no immersed by VE.

This study aims the utilization of VR environment as a visual learning tool in primary school education. Building interactive learning environment is the main purpose of this system. Additionally, virtual 3D geometric objects are employed to facilitate 3D concept teaching.

A. Virtual Reality in Education

VR devices have very high prices. Therefore, VR was only used as training simulations in the beginning. Flight training simulations are the most used VR examples among the training simulations. By reduction of VR device prices with time and presence of low-immersion providing VR systems, VR started to be used in education area.

VR technology with an "acceptable copy" labels has a chance to be utilized in most areas after the elimination of the promise of a hundred percent reality. In this study, VR applications in education area were examined.

As a distance-learning based application, Hatem's e-learning system which was created using a VE simulates chemistry and foreign language laboratories via internet for distance learners. These laboratories give users chance to perform chemical experiments or to match foreign words through interactive web page. [5]

Instead of web page by which users get an access through input devices such as mouse or keyboard, this paper introduces a VE of interaction without touching.

Another application investigates "Augmented Reality (AR)" for creating VEs. Briefly, AR means overlapping virtual materials and animations with focus point of the images collected from the real world. This method aims to display the real world images more detailed and more effectively.

Chen and Tsai's work utilizes "Augmented Reality Library Instruction System (ARLIS)" which provides computer assisted learning for elementary school students in Taiwan where they cannot afford library instructions as a result of limited budget and human sources. By this means, library abilities and concepts are tried to be taught through 3D technology. To show enhancement of the learning performance of library instructions, this implementation compares ARLIS model with librarian face-to-face instruction model. [6]

Adamo-Villani et al. aimed to build a new immersive VE in which deaf children could learn mathematical skills and American Sign Language (ASL) mathematics terminology by interacting with 3D visual signers and objects. Interaction with the VE was supported by gesture control systems including pinch gloves and wrist tracker. [8]

Minogue et al. used VR programme supported by haptic feedback for middle school science instructions. The aim was to explore the structure and function of animal cell in a conceptual and haptic way. For haptic feedback, Phantom® desktop device [11] was employed. At the end of this study, it was stated that the programme increased the students' understanding of cell concept. [9]

Kerawalla et al. simulated the day and night formation according to the position of sunlight as AR implementation by AR tile. This tile is a kind of card which includes black 2D geometric shapes on a white background. Finally, the system showed that it was helpful for 10 year old children to get the point of sunrise and sunset. [10]

VR opens new horizons in education area as well as the other areas. It can be used for various purposes such as distance learning and individual learning.

III. METHOD

VR application that will be used in education should have low-cost as possible and should be established by the devices that can be found in every computer class for extensive usage. In this study, the only needed device is a projector which can be used optionally except the used system installed on a personal computer (PC) with a web-camera (webcam). VE which is reflected onto a larger screen by a projector can create a deeper immersion by covering the user's view more than PC screen.

VR system created by using webcam and projector is called a "Video Capture VR" technique. This technique was firstly used in Krueger and his friends' "Videoplace" study [7]. As a basic principle, Video Capture VR takes the user's images continuously with webcam and merges these images with the computer generated virtual objects using various computer programmes. Images including the virtual and real materials are shown to users through computer screen or projector device. By this way, users can see both the virtual materials and their silhouette in the reflected image and then they can move their silhouette by moving themselves in the real world in order to interact with the virtual objects. This method can be called "interaction without touching", because user does not physically touch any of the virtual objects. By just moving themselves, users make their silhouette touch the virtual objects reflected by the projector.

In order for the VR system to be built as software three basic stages were employed. The first stage is graphical stage which draws basic two-dimensional (2D) objects and 2D buttons that will be used for controlling the programme. "Open Graphics Library (OpenGL)" [12] was used in this unit. The latter is computer vision stage which uses "Open Source

Computer Vision Library (OpenCV)" [13] for processing images coming from webcam. 3D animation unit in which more detailed 3D images are drawn is the last stage of this three layered structure. "Blender" [14] designing programme was utilized for modelling internal organs and geometric objects like pyramid in this unit.

The programme's hardware and software parts can be summarized as basic lines as shown in Fig.1. This figure also presents the Video Capture VR technique. 2D and 3D computer generated virtual objects and animations are combined with the continuously received user images in computer environments and then shown to user preferably by using projector for enlarging the image. Users can interact with the virtual objects by moving their reflected silhouette.
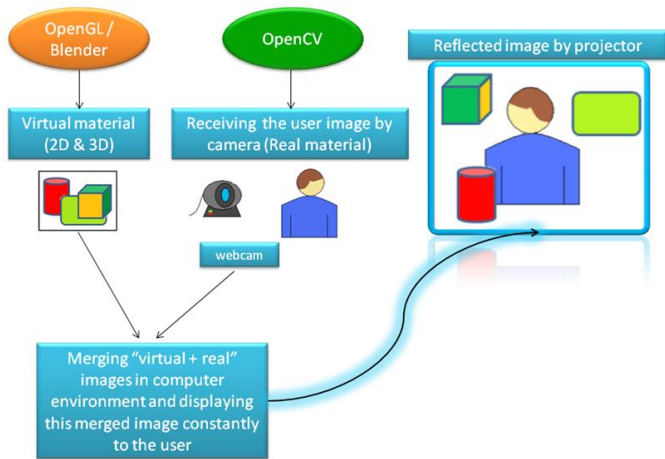

Fig.1 Virtual system hardware and software creation stages

IV. IMPLEMENTATION

Interactive visual learning implementation environment with VR usage is addressed to primary school education. Implementation has three course menus for four classes which were designed according to the Turkish Ministry of National Education. These basic courses consist of "Mathematics", "Science of Life" and "English" as foreign language. Only for the fourth class, "Science and Technology" course menu was used instead of "Science of Life" menu.

"Mathematics" menus are shown in Fig.2. Numbers from 1 to 10 and their spellings are included in the first class. In the second class, two-digit number addition, subtraction and multiplication examples and in the third class, two and three digit number addition, multiplication and division examples are included. For the fourth class, 3D geometric objects such as cube, cylinder and pyramid are presented with their explanations.
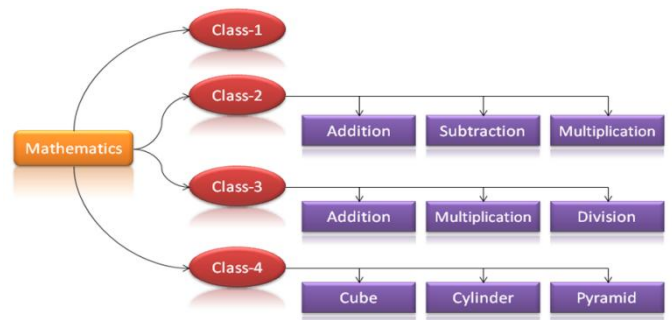

Fig.2 Mathematics menus and submenus regarding four classes.

Fig.3. shows "Science of Life" menus. For the first class hour based daily planning and corresponding activity images are given. Five senses of human body and locations of sensory organs are shown in the second class. Internal organs and their positions are depicted in the third class. For the fourth class, the Sun, the Earth and the Moon concepts are explained by using the moving models under the "Science and Technology" title.
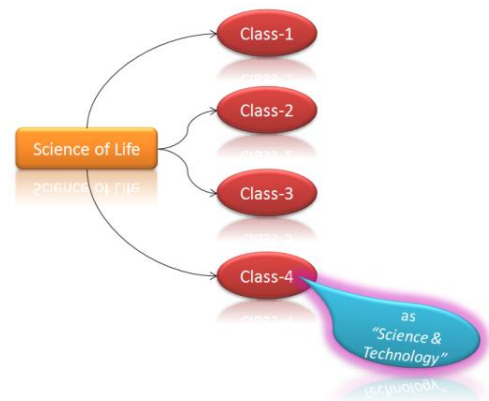

Fig.3 Science of Life menus regarding four classes.

At last, Fig.4 presents "English" menus. The first class includes basic concepts as numbers, colours and words, the second one shows basic school life concepts and the third one depicts types of jobs. These three classes used 2D images to enhance the visualization. The fourth class contains basic question/answer templates.
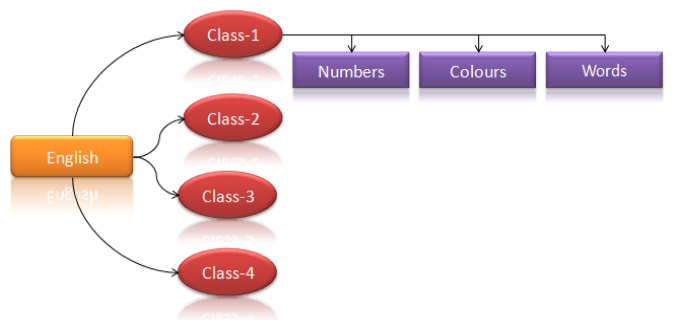

Fig.4 English menus and submenus regarding four classes.

In Fig.5, the VE containing the user's real image and computer generated virtual objects is shown. This screenshot indicates the fourth class' Mathematics Cube submenu. When

the user interacts with the programme through the button, the colour of this button turns from blue to green at that time.
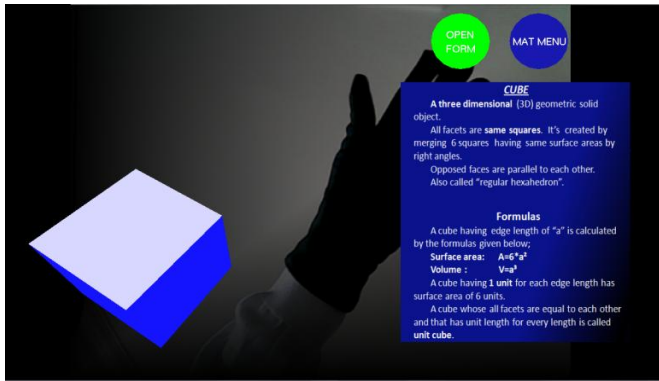

Fig.5 Mathematics Cube submenu screenshot.

V. Conclusion & Future Works

This study basically aims interactive learning. Also, the facilitation of the perception of 3D objects and their visualization were targeted. Need for additional course materials like real 3D cartoon models or plastic solar system models were eliminated by utilization of the virtual 3D objects and the illuminated virtual solar systems representing the day and night formation. In the system, data input is only based on the user's hand movements which give a chance to students who cannot use computers to interact with the VE. Therefore, it provides convenience for those ones. The feature provided by Video Capture VR technique for people who cannot use computers is frequently employed in variety of areas like medicine and rehabilitation.

The feeling of controlling the programme and interaction with the virtual objects create an enjoyable environment for students and increases their concentration on the courses.

This VE was tested on the 1st, 2nd, 3rd and 4th class students of a private primary school in Turkey. After the programme had been used by the students, a 7-question survey was conducted. According to the survey results, this programme's performance was tried to be measured regarding some criteria of the survey questions. The results show that most of the students could easily understand the course contents (Mathematics, Science of Life, Science & Technology, and English) and they could learn new English words. But some students stated that they had difficulties in using the buttons while interacting with the programme. The reason for this difficulty is assumed that the students employed the VE for the first time. A majority of the students stated that the programme was funny and they wanted to use it at home when studying. Also, most of them wanted their teacher to use such a programme while teaching.

For the purpose of using this programme commonly at schools, virtual system is designed with open source libraries and free animation software programme. Also, hardware part of the system is created to have low-cost and designed with easily reachable devices like webcam.

In the future, the programme can be used widely by developing the existing courses and adding new class menus. After regulations, this programme can also be used in elementary and high school courses as an interactive learning tool. Geometrical applications in Cartesian coordinate system for elementary school's Geometric course or mitotic division for high school's Biology course can be simulated.

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