Demonstration of a low cost implementation of an existing hands-on laboratory experiment in electronic engineering

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Abstract— The PhD work on Computer Aided Engineering Education (CAEE) scheme is concerned with the use of computer aids for the enhanced, interactive delivery of educational materials in the field of engineering while maintaining existing pedagogical contents and standards. The work considers two separate components, one for classroom and another for practical hands-on laboratory work in engineering. The CAEE component for hands-on laboratory practical work focuses on the use of mixed reality (video-based augmented reality) tools on mobile devices/platforms. This practical demonstration highlights some of features of the CAEE version of an experiment such as the ability to closely implement an existing laboratory based hands-on experiment with lower associated costs and the ability to conduct the experiment off-line.

Index Terms— Augmented reality, computer aid, laboratory experiment, tutorial exercise.

I. INTRODUCTION

In electronic engineering hands-on practical laboratories, bread-boards are used as the basis for most basic modular circuit based experiments. Bread-boards allow the interconnection/arrangement/wiring of low level (basic) components such as resistors, capacitors and diodes into functional circuits. For higher level circuitry especially micro-electronics, the bread-board is used to interconnect/wire both low-level components and high level modular devices such as integrated circuits and/or micro-processors together. In certain experiments, when the intended learning outcome is not necessarily about the circuitry, such as teaching about the programming and use of embedded devices, pre-fabricated boards play the same role as the bread-boards and allow the interconnection of highly modularized (integrated) components such as sensors and other processing devices together. The use of pre-fabricated boards allows the learner to focus on the high level objectives rather than the low-level circuitry as some of the components are already wired together in a functional manner that permits easy extension. In the classical electronic engineering laboratory, the equipment (bread-boards, pre-fabricated boards and other components) is physically located at a fixed location (inside a laboratory), and the learners have to present in the laboratory concurrently with the equipment in order to use them. Apart from the costs for large learner population, practical classes in electronic engineering are becoming difficult as more and more learners have to use bread-boards and pre-fabricated boards either concurrently (shared) or in a time-limited manner.

A. Background

The education of engineers involves an integral component of hands-on (interactive) work along with delivery of theoretical (sometimes abstract) concepts [1].

This is also true for many science and technology based subjects such as Physics which include a compulsory experimental component [2]. During actual laboratory experiments, learners enjoy physical contact with the laboratory apparatus (equipment) as well as working together in groups.

The PhD work on Computer Aided Engineering Education (CAEE) scheme is concerned with the use of computer aids for the enhanced, interactive delivery of educational materials in the field of engineering while maintaining existing pedagogical contents and standards.

The CAEE component for hands-on laboratory practical work focuses on the use of video-based augmented reality on mobile devices/platforms with a goal of replicating as much as possible the experience obtainable from an actual physical laboratory through the innovative use of augmented reality technology running on mobile devices.

Augmented reality is still a growing field of research despite the appearance of the technology in the 1960s [3]. In virtual reality technology, the goal is to immerse a user (viewer) within a virtual environment and so real objects are excluded (or removed) from the environment around a user as all objects is computer generated models.

Virtual reality systems are usually classified according to the degree of immersion in to three different level of immersion, namely none, semi and fully immersive [4]. Non-immersive virtual reality systems generally do not provide a stereo view of the environment. For example, viewing a virtual reality environment on a typical computer screen is a non-immersive experience as the virtual environment exists only inside the computer screen and interactions with the environment could be through the keyboard, mouse or sometimes joystick devices. Semi-immersive virtual reality systems provide a bigger view of the computer generated environment. This is typically archived through the use of a large screen device or through the use of special eyewear or goggles. In semi-immersive virtual reality systems, special input devices such as wands, special gloves or controllers are also
commonly used. The user has a view of both the computer generated environment and the surrounding real world environment. A good example of a semi-immersive virtual reality environment is a gaming station typically used for car racing, in which the output is a combination of one or more large-screen monitors and the input consists of a mock-up driving station complete with steering wheel and foot pedals. Fully-immersive virtual reality systems eliminate completely any reference to the real world environment. This may be archived by wearing special helmet devices with mounted displays or by housing the user in specially designed rooms called CAVES (Cave Automated Virtual Environments) where all the walls (including floor and ceiling) are essentially replaced by large screens monitors. In both cases, the computer generated environment is projected on the displays or monitors all around the user. Fully-immersive environments also track the user movement particularly orientation and may track the user’s gestures and movement for input or optionally use wands, special controllers or special gloves in case tracking of individual finger movements is required for the simulated environment.

Unlike virtual reality, in augmented reality, the goal is not to exclude the real world but to “blend” additional information or computer generated information with real-time information from the real world around a viewer, augmented reality systems are also called mixed reality systems as they attempt to mix both real and virtual objects.

Virtual and augmented reality are often referred to as expensive technologies, especially when special devices and equipment are used [5], however, mobile devices especially smart-phones and tablets devices are a cost effective, technologically accepted solution that may be used as acceptable augmented reality viewers due the improvement in hardware and the wide range of included sensors such as video camera, touch-screen.

II. DESCRIPTION

A. Hands-on Laboratory

The popular seeduino pre-fabricated boards is used extensively to teach about embedded sensors in micro-electronics. A seeduino board already includes a low-power programmable micro-processor and associated circuitry that allows the connection or addition of one or more modular/functional devices such as low-power sensors/wireless radio transmitters alongside basic components such as resistors.

An introductory experiment with the seeduino board demonstrates the use of the board in driving a Light Emitting Diode. In the actual physical hands-on version of this experiment, 2 additional components (an external resistor and light emitting diode) are connected to the seeduino board and the board is then driven via a laptop or suitable personal computer running the integrated development environment (IDE) programmed to pulse the LED at different frequencies.

The goal of the experiment is to familiarize the user with the seeduino board, connect simple components and obtain the desired results of a pulsating LED, when completed.

B. CAEE version

The CAEE version of this experiment uses a low-cost 2D photographic mock up of a seeduino board and an augmented reality application running on an android tablet to archive/demonstrate the same effect. The android tablet requires a camera which is used to capture and provide the real environment in the mixed reality world. The augmented reality world is composed of computer generated information (text and graphical components) merged with a real-time video feed containing a 2D photographic (mock-up) of the seeduino board.

Most augmented reality tools work by tracking the outline of an object (the seeduino board) and so are incapable of identifying individual components on the board or alternatively tracking several two dimensional images such as QR codes placed as markers on individual components within the board for tracking [6].

The CAEE tool successfully tracks either the real seeduino board (or its photographic mock-up) along with the individual components on the board even from different angles of view, distances and resolution.

The android application also acts as a smart interactive manual to the seeduino board as touching a component brings up a pop-up with textual description of the component. This feature may also be used for linking to on-line datasheets and/or other experiments that use the component.

Simple finger movements are used for manipulating and attaching components (resistor and diode) within the augmented environment.

The participant in the demonstration is expected to verify the same functionality is obtained by step-by-step procedure (pedagogical content and instructional material) is used for both versions of the experiment.

III. CONCLUSION

This experiment highlights some of innovative features of the CAEE version of an experiment such as the ability to closely implement the step-by-step procedure of existing laboratory based hands-on experiments; lower costs (especially if learners use their own mobile device) and the ability use off-line (on-line aspects would be mainly used for submissions of analytics such as number of attempts & completion time-stamp). Importantly, it is noted that the seeduino board functionality is not simulated but rather the expected outcome of interconnecting both the LED and resistor to the seeduino board is simulated.

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