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ViewPoint: An Augmented Reality Tool For Viewing and Understanding Deep Technology

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Abstract. This paper will explore the use of augmented reality, and its ability to reveal deep technologies (hidden technologies)", as a means to create more effective tools for developers or students studying embedded computing, which are typified by topics such as the *internet of things, pervasive computing and robotics*. This approach aims to enrich the experience for developers learners by constructing a meaningful view of the invisible things around us. Thus, we will propose and explain a general model, called ViewPoint, which consists of several components such as learning design specification, collaborative environments, augmented reality, physical objects and centralised data. Furthermore, to support the proposed model, we present a 4-dimensional learning activity task (4DLAT) framework which has helped us to structure our research into several phases where we can scale up from single-learner-discrete-task to group-learner sequenced-task, based on the proposed scenario. As a first step towards these lofty ambitions, this study will focus on developing Internet-of-Things systems based on a small self-contained eco-system of networked embedded computers known as Buzz-Boards.

Keywords. Mixed Reality, Augmented Reality, Internet-of-Things, Cloud-of-Things, Learning Activity, Mobile Augmented Reality, Buzz-Boards.

Introduction

Since the beginning of creation, learning has been one of the most natural things in human life. People like to be involved in a process whereby they can gain knowledge and skills and improve themselves. Furthermore, with the advancement of technologies and the development of techniques, the possibility of using these technologies in the field of education has increased and they are considered an important means to improve and develop the learning of students. Pena-Rios [1] describes some of the technologies used in the education sector, such as mixed reality, augmented reality and virtual environment, which have transformed learning and teaching from traditional methods to new high-tech methods. In addition, collaboration and interaction in these

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technologies can be exploited in educational practices. Also, the exercises in collaborative learning have advantages in terms of enabling learners to clarify their ideas and develop better concepts through the discussion process[2].

Linking real and virtual worlds allows augmented reality to create a reality that is both enhanced and augmented[3]. Augmented reality provides new possibilities for learning and teaching, which have been recognized by educational researchers[4]. Learners can benefit from the coexistence of virtual objects and real environment in several aspects. First, it allows learners to visualise complex spatial relationships and abstract concepts[5]. Second, learners can interact with 2D and 3D synthetic objects in the Mixed-Reality (MR)[6]. Third, it allows phenomena that are not existent or impossible in the real environment to be experienced by the learners. Finally, it allows learners to develop important practices that cannot be developed in other learning technology environments[7]. These advantages have made augmented reality one of the key emerging technologies for learning and teaching over the next five years[8]. In addition, connecting various innovative technologies such as mobile devices, wearable computers and immersive gadgets, could create augmented reality[4]. However, the educational benefits of augmented reality not only concern the use of the technologies but also how augmented reality is designed, implemented and integrated into learning settings, both formal and informal[4]. AR might be based on technology, but it should be conceptualized beyond technology [4].

To this end, the aim of this work-in progress is to explore how augmented reality could be used to make the invisible things visible in order to construct a meaningful view for developers and learners to understand better the abstract concepts of the internet-of-things surrounding us. As a first step towards these lofty ambitions, we have proposed an AR model we call ViewPoint which we propose to apply to the development of an Internet-Of-Things based desktop robot that is constructed from a small self-contained eco-system of networked embedded system known as BuzzzBoards [30].

1. Related Work/Literature Review

1.1. Mobile Augmented Reality

Augmented Reality (AR) is an approach centered on the overlay of virtual objects in a real-world context, and has the ability to induce in users feelings of sub-immersion through facilitated interactions between virtual and actual world[9]. Augmented Reality (AR) integrates or mixes generated virtual objects in real world images. From the user's perspective, the objects rendered complement reality and coincide in the same environment [10]. Accordingly, there is the need for alignment between the virtual world and the real one; this will facilitate the creation of such an illusion. A number of theoretical AR applications have been examined, including entertainment, maintenance and repair, manufacturing, medical visualisation, and robot environment planning[11]. AR necessitates accurate scene registration, which subsequently causes the issue of camera pose prediction in the context of the 3D environment [12].

Mobile AR is recognised as being an organic platform geared towards various 'killer apps', as they are named. It has been highlighted by Wagner et-al[13] for instance, that an interactive AR museum can be described as "a virtual media that annotates and complements real-world exhibits". In this same vein, a training application is introduced by[14]which enables the staff of oil refineries to observe instructional diagrams positioned on top of the tools being utilised and learned. A number of other applications are known, such as [15], equipment maintenance [16], and document annotation [17], amongst others. Regardless of the application, however, there are a number of characteristics in common. For example, all of these applications depend on there being vast distributed and dynamic data, and there is a need for all links between relevant data and recognisable visual targets to be maintained. Such links will ultimately alter through application development or with the growth of the underlying data. Essentially, there is the need for the presence of a presentation layer, which describes how data can be rendered as virtual media. In some instances, although this rests on the data's nature, it may be sensible to render various mixes of icons, images, texts or 3D objects. The exact conversion from information to virtual content ultimately rests on the type of application. Various users adopting different mobile devices could be able to collaborate and share data. This therefore suggests the requirement of a central data store with the ability to monitor the actions of users, as well as the system state overall[18]. In addition, collaboration in augmented reality can be more valuable, especially when multiple users discuss, state their viewpoints and interact with 3D models at simultaneously[19]. However, for educational purposes, much research has already been done in the area of collaborative AR which used 3D objects [20,21,22], for example: the struct3D, tool which was used to teach mathematics and geometry[23] ; Web3D, which was used to help engineering students[24] ; and magicbook, which were used for multi-scale collaboration. Most of these applications are based on screen-based AR, using see-through displays, and see-through head-worn displays. Moreover, augmented reality has the potential to provide multiple points of view of the same object, which can aid learners to go further than the information available to them[25].

1.2. Internet-Of-Things

It was stated by Ferscha et-al [26] "smart things are commonly understood as wireless ad-hoc networks, mobile, autonomous and special purpose computing appliances, usually interacting with their environment implicitly via a variety of sensors on the input side and actuators on the output side". In addition, the hidden functionalities of any system that humans cannot see are considered deep technologies. These hidden technologies are embedded in the environment and are invisible to human sight, although they are still there. They can increase users' perception of the environment surrounding them, if presented to them in a natural way. Thus, linking the physical world with the virtual one is an important aspect, and this can be achieved by using means such as mixed reality or augmented reality. For example, Ferscha et-al [26] developed a 6DOF DigiScope, a visual see-through tablet that supports "invisible world" inspection. Another example is the University of Essex's iClassroom, which includes projectors, whiteboards, wall-mounted touch-screen, and handheld devices which are all networked together in order to aid learning and teaching [1].

1.3. Learning Activities and Pedagogical Approach

The IMS (Instructional Management System) produced by the Global Learning Consortium has defined specifications that can be used to create, plan and share a collection of learning activities that students can achieve during an online session [1,31] (Figure 1). Units of Learning (UoL) is the structured sequenced of activities; this can be led by zero or more conditions before completing or starting the tasks; the teacher, on the other hand, creates the UoL by using the services in the environments. The goal of this structure is to allow students/learners to achieve the learning goal. These specifications have several benefits, such as completeness, personalisation, formalisation, compatibility and reusability.

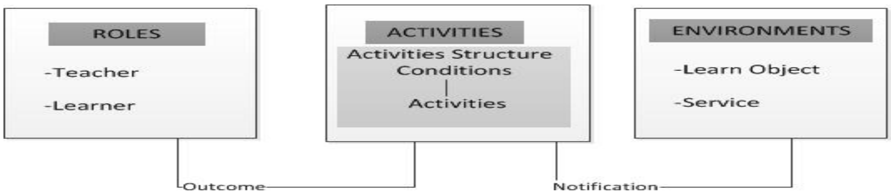

Figure 1 IMS Learning Design Specification (adapted from [1])

A good description of a learning theory is an effort directed towards explaining the way in which people learn, thus facilitating understanding of and insight into the intrinsically complicated learning process. Human learning is undoubtedly complicated, and a number of different scholars have suggested various theories on the different types of learning[27]. The basic learning theories centred on people can be broken down into three many categories, namely behaviourism, cognitivism, and constructivism [28]. The objective of this paper is to utilise the constructivism theory in order to devise augmented reality learning using smartphones/tablets. Importantly, it is held by constructivists that learning is an on-going and continuous process, where learners are seen to create their own knowledge in line with individual preferences according to their experiences within a matrix; this is commonly established by the instructor or otherwise as a result of a search carried out by the learner[29]. In addition, knowledge may also be garnered through the sharing of viewpoints [28].

2. System Model

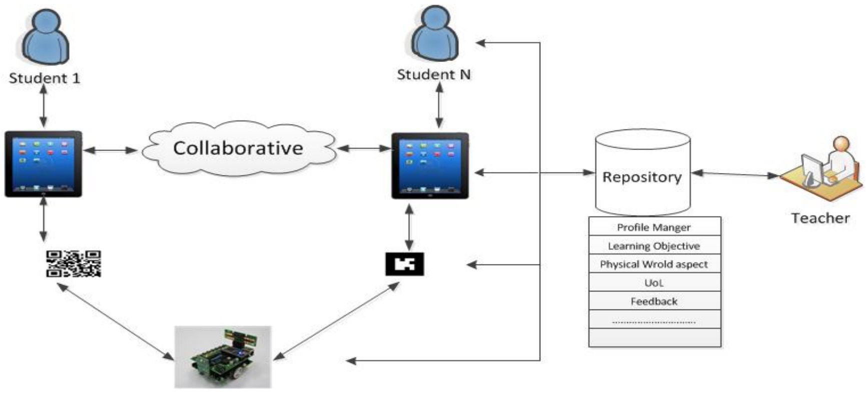

Figure 2 High-Level View of the ViewPoint Model

A high-level view of the proposed model, ViewPoint, is shown in Figure 2. This is based on several aspects that integrated together such as the learning design specification (Figure 1), the collaborative environment, the augmented reality characteristics, the physical objects and the central data that manage the whole system.

Theses aspects can be further described as follow in more details:

a) *LD Specification:* the teacher creates the unit of learning, the learning objective, the expected learning outcomes and specifies the task that should be completed by the students. Furthermore, the students perform a sequence of actions to achieve the goal of the activities that set by the teacher. In addition, they would be able to see their performance and score for the task which would be retrieved from their personal content profile and could also can be seen by the teacher.

b) *Collaborative Environment:* This is where multiple users with separate smartphone/tablets can communicate, collaborate and share data during the learning activities. Furthermore, the environment can notify other users for the updating data/information.

c) *AR Characteristic:*

- *AR Display:* Is the user interface/ the client application/ the output device where users can see things on top of devices' camera, and these things/artefacts can be rendering, recognized and tracked in order to overlay virtual content in the user display such as text annotation, icons , video, image and 3D model.

- *Visual Targets:* Is the techniques/targets to be used in order to access and interact between the real objects and the virtual objects. The interaction could be undertaken by diverse technologies such as Quick Response code (QR), Bar Code, Near Field Communication (NFC), Video Markers, Computer Vision (object recognition), Global Position System (GPS), interactive sensor/effector systems and computer networks (e.g. micro sub-nets).

d) *Physical Objects:* Is the object which the users want to track, visualize and manipulate. The physical objects could range from the things that we use in our daily life such as cars, washing machine, TV, aeroplane, robotics, Buzz Board (Figure 3) to the mobile technologies.

e) *Central Data: Is* the repository where the whole system managed. This contains all the Units of learning, assessments, Role for users (teachers and students), the share data, the virtual content, and the physical objects functions/representation.

Figure 3 Some BuzzBoard Internet-of-Things Components (an Internet Radio)

2.1. Augmented Reality Scenario

John is a smart teacher who always makes great ideas/tasks for his students, which motivate and engage them in the activities. John teaches embedded system at The University of Essex, which maintains the state-of-the-art embedded system laboratories, and which comprises all the facilities needed for learners, from hardware through to complete software, such as Robotics. Many computer science and engineering students find the embedded system abstract subject difficult to learn and understand. For this reason, John devised an idea that uses advanced technology, such as Augmented Reality, which may reveal the hidden aspects/functionalities/process in the embedded system, thus facilitating students' understanding in a better manner.

John created a maze escape for robots as a test bed (Figure 4), and assigned a task for students to write software to build a desktop robot that can escape in the maze (based on BuzzBoard technology [30]). The assignment is structured in such a way that each student assumes responsibility for building one function of the robot control system (e.g. obstacle avoidance, Path follow, turning left/right, reading signpost). When combined into the final robot solution, none of these internal functions are visible. In order to test and debug their robot, the students use standard debugging tools, although this can commonly result in a disconnection between the problem abstraction and the behaviours, as exhibited by the real robot. In this scenario, the students each use an iPad/tablet to point at the robot and to determine the invisible aspects of the robots from various perspectives while discussing the problem. They can then combine as a team to develop the robot together as well as seeing how the robots functions in the real practice.

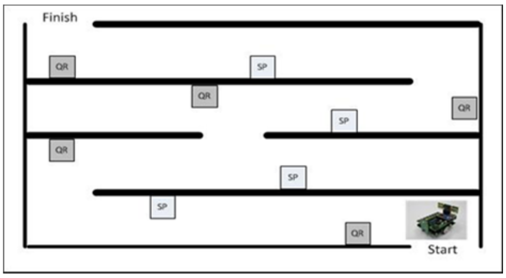

Figure 4 Maze Escape Scenario

In order to make the maze-escape more fun, John distributed several cards/visual targets for the students, such as QR code, NFC, Barcode, etc., which the students could place in the maze-escape in order to reach the final target faster. These cards are represented as signposts for the robot, which tell the robot which direction should be followed, or which may otherwise simply tell the robot for more information, such as location and clues, etc. The student can track the robot and see how it interacts with these cards by using their iPad/tablet. Figure 5 shows the modularised robot which is assembled by students who plug together various hardware and software modules (there is also potential for students to create their own software and hardware).

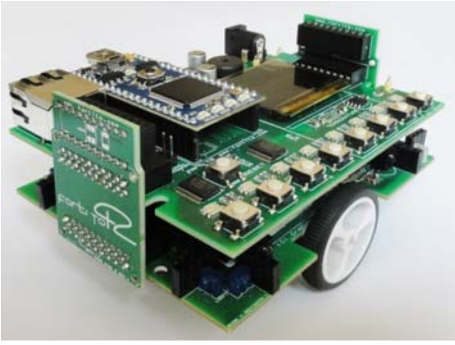

Figure 5 The BuzzBot (a modularised educational robot)

2.2. Implementation Approach

The proposed scenario can be broken into sub-tasks; this is scale from single-user discrete-task to multi-user sequenced-task (easy to difficult). These tasks are represented in a learning activity framework (Figure 6), as this work-in progress, our aim is to go through all the tasks based on the scenario.

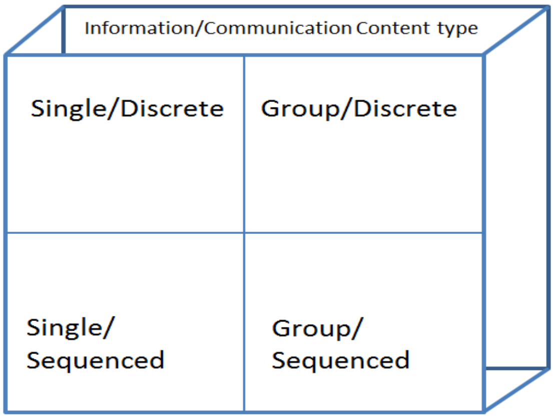

Figure 6 4-Dimensional Learning Activity Framework

The learning activities tasks utilise a Fortito's Buzz Boards which is an educational technology toolkit that contains several software and hardware modules [30]. It is used to produce students' assignments and projects, both interesting and simple such as mobile robots, mp3 players, heart monitors etc. Buzz-boards can be assembled using various methods. A variety of hardware applications can be made that then allow students to program in order to gain skills and motivations. Moreover, the functionality and physical form of buzz-boards are determined by the concept of pluggable modules. Buzzbaords provide a lot of information that is useful to the AR system via the network. Examples include providing ID when they join the micro-net ,or sending out events when modules are plugged together, or when actions occur (user or device), all of which can be integrated with other sources such as cameras [30].

The focus of this paper is to describe the left side of the framework both single learner discrete and single learner sequenced task. Both tasks are based on a UoL schema so as to achieve the learning objective of each task. The single-learner discrete-task gives the learners the basic knowledge for constructing a Buzz-Board module. The task works by allowing students to work individually in order to identify the different pluggable modules of the buzz boards by pointing their tablets/smartphones over visual targets that represent each module. This will overlay virtual information about each module such as text annotation, image or 3D module that gives additional information for the students such as its use, function and process. It might also pictorially show software or communication process, plus sensory fields, which are normally invisible to the student.

In the second dimension, single-user sequenced-task, the learning objective is to allow the learner to construct the whole buzz board modules together. The users/learners can follow step by step instruction which guide them to build the final modularized modules using their tablets. However, in case of plugging the buzz board wrongly, the augmented reality should inform the learners about it and give a suggestion for example; go back to the previous steps. In addition, the learners can view different layer of information representation, this will allow the learners to view the whole components of the buzz board module, or focusing on one component of the module.

Finally, the following stage of the implementation consists of the construction of the right side of the framework where both group-learners discrete and group-learners sequenced tasks are undertaken. The aim in the right side is take the research into more complex situation where a variety of collaborative tasks are carried out simultaneously by several users.

3. Conclusion and Future Work

In this paper we have explored the use of augmented reality, and its ability to reveal deep technology (hidden technologies), as a means to create more effective learning tools for students studying courses in embedded computing, which is typified by topics such as the *internet of things, pervasive computing and robotics*. This approach aims to enrich the learning experience for learners by constructing a meaningful view of the invisible things around us. Thus, we proposed and explained a general model, ViewPoint, which consists of several components such as learning design specification, collaborative environments, augmented reality, physical object and centralised data. Furthermore, to support the proposed model, we produced a 4-dimensional learning activity task (4DLAT) framework. This helped us to structure our research into several phases where we can scale up from single-learner-discrete task to group-learner sequenced-task, based on the proposed scenario. The paper explained the implementation of left side of the 4DLAT framework, whereas the right side will be one of our aims for future works for this research.

In our future plan, we aim to continue implementing the left side of the research, and using the buzz board system as a physical object and pedagogical test bed for our experiment work. In addition, there is still much research to be done, this relates to how to create effective learning design activity using augmented reality as well as the interaction procedure with the invisible technology. In addition, finding the appropriate techniques for visualizing embedded technology requires further investigation. Furthermore, the evaluation of our work is a crucial factor which we will take it into consideration on our future progress. Finally, we look forward to presenting more on this work-in progress at future conferences.

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