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Poster

An Adaptive AR Tutor For Cabling a Network Topology

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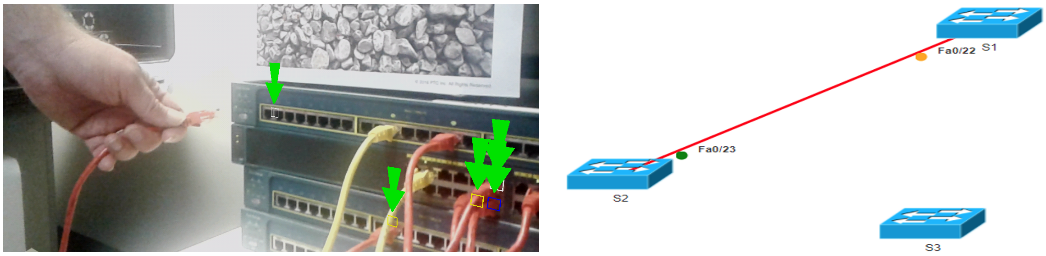

Figure 1: Desktop and AR Interfaces Screenshots

Abstract

We present an Augmented Reality (AR) network cabling tutor that provides visual annotations for improving learning in psychomotor tasks. Unlike many existing AR learning systems, our system combines AR with an intelligent tutoring system (ITS) that should enhance learning over existing desktop solutions. We intend to use this prototype as a test-bed for evaluating learning differences between a desktop web-based user interface, a hand-held AR display and a Head Mounted Display (HMD) AR display.

CCS Concepts
***•Human-centered computing** → Mixed / augmented reality; **•Applied computing** → Computer-assisted instruction; **•Networks** → Physical topologies;*

1. Introduction

This paper presents a novel Augmented Reality (AR) Network Cabling Tutoring System (NCTS) that guides learners through cabling a network topology by overlaying virtual arrows and icons on the hardware as shown in Fig. 1. Our prototype extends existing AR learning systems by combining an Intelligent Tutoring System (ITS) with AR using The Generalized Intelligent Framework for Tutoring (GIFT) to provide real-time learning support [SH13]. For example, unlike many previous systems, NCTS does not require the learner to perform the cabling sequence in a predefined order and detects incorrect cabling solutions.

Physical cabling of a network rack is an essential part of installing and maintaining a network infrastructure. In one study, eighty-six percent of participants rated it as a usable or transferable skill in employment [Raj11], but incorrectly wiring cables is a common occurrence. Ports on a switch look identical, making it difficult to know which ports need to be connected. AR may help learners identify the correct ports by overlaying virtual arrows and icons on the port [WMB15]. The task is also more complex than a simple assembly task because there is greater potential for mistakes, making it more suitable for use with ITSs. We intend to run a user study, comparing the learning differences between a desktop web interface, an Head-Mounted Display (HMD) AR display and a hand-held AR display by answering the following research questions:

1. Does using AR improve learning over desktop-based ITSs?
2. Which AR platform provides the most effective learning experience?
3. Which dimensions of learning (i.e. motivation, knowledge, self-awareness) do AR tutors improve?

2. Related Work

ITSs provide problem solving support and feedback during a learning activity [WMB15]. However, many ITSs are desktop-based and

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may not be ideal for psychomotor tasks [SL15]. On the other hand, AR has been shown to be effective for improving learning in psychomotor tasks [WMB15]. When ITSs are used in conjunction with AR, learners may feel more involved and report higher knowledge gains compared to learners that use AR alone [WMB15].

There are some notable AR systems that use ITSs: ARWild [LWB*15] and the Motherboard Tutor [WMB15]. However, Westerfield et. al. [WMB15] only evaluated knowledge recall and did not measure other dimensions of learning such as motivation or engagement. ARWild also focused on psychomotor tasks, but no user evaluation was carried out and neither did it evaluate learning [LWB*15].

3. Prototype Description

Our system uses a client/server architecture. The NCTS server communicates with three different kinds of interfaces: (1) a desktop web-based interface; (2) AR Handheld interface and (3) a HoloLens (HMD) interface and with GIFT, an external ITS framework [SH13]. GIFT has been modified to add a special web-based authoring interface that supports cabling tasks. Domain experts use this separate web-based authoring system to setup the learning task. Learners either use a Samsung Galaxy tablet, a HoloLens HMD display or a desktop web-based interface to experience cabling a physical rack. The AR interfaces were developed in Unity3D using Vuforia as the tracking solution.

Both the HoloLens and the handheld tablet interfaces display arrows and icons overlaid on the ports (Fig. 1). These annotations are displayed only when the learner experiences difficulty, allowing learners remain motivated by practicing for themselves. Feedback messages are displayed on the tablet screen and may be dismissed with a single tap of the screen. In HoloLens implementations, a Heads-Up Display (HUD) is used to display feedback and is dismissed using an air tap gesture.

In the desktop User Interface (UI), learners see a 2-dimensional representation of the network topology, which shows the devices that are connected (Fig. 1). Similar to the AR implementations, Windows style message boxes are used to display ITS feedback.

4. System Evaluation

To answer the research questions presented in section 1, we will conduct a within-participants study using the prototype described in section 3. In the study, each participant will complete three cabling tasks with different interfaces; a HoloLens display, a handheld AR display and a desktop user interface. It is necessary to understand which interface provides the most effective learning experience since they all have different advantages. For instance, tablets do not require special hardware. A HMD frees the users' hands, so they can work more easily. Desktops have been used in many ITS studies and provide a benchmark for evaluation.

Each task will vary in difficulty to mitigate potential knowledge transfer by attempting to normalise knowledge gain. Potential learning affects will be mitigated by counterbalancing the interface presentation order and provide a unique solution for each of the three tasks.

Experiential learning theory suggests that learning involves multiple dimensions [KCN14]. We will use a questionnaire adapted from Konak et. al. [KCN14] to evaluate three dimensions of learning: Affection, metacognition and cognition [SH13]. Affection traits include: stress, motivation, engagement, interest. Metacognition traits include: perceived relevance, self-awareness and perceived competency. Cognition traits include: domain knowledge, critical thinking and knowledge application. Cognitive traits will be measured using a separate questionnaire developed for the study. It will be administered before and after each task to discover the differentiated knowledge gain [GLST05].

5. Conclusions

The prototype presented in this paper combines AR and ITS together to provide an enhanced learning experience. It provides three different interfaces for psychomotor learning: (1) AR Handheld; (2) AR HMD and (3) Desktop. There are three dimensions of the learning process: Affection, meta-cognition and cognition. Previous work has primarily focused on cognitive aspects of learning. Future work will involve using this prototype as a test bed for evaluating learning differences between the three different interfaces. This will evaluate broader dimensions of learning than has been done previously with AR / ITS systems and provide insight into design characteristics of these systems.

6. Acknowledgements

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References

[GLST05] GOLDSTEIN C., LEISTEN S., STARK K., TICKLE A.: Using a Network Simulation Tool to Engage Students in Active Learning Enhances Their Understanding of Complex Data Communications Concepts. In *Proceedings of the 7th Australasian Conference on Computing Education - Volume 42* (Darlinghurst, Australia, Australia, 2005), ACE '05, Australian Computer Society, Inc., pp. 223–228. 2

[KCN14] KONAK A., CLARK T. K., NASEREDDIN M.: Using Kolb's Experiential Learning Cycle to improve student learning in virtual computer laboratories. *Computers & Education 72*, Supplement C (Mar. 2014), 11–22. 2

[LWB*15] LAVIOLA J., WILLIAMSON B., BROOKS C., VEAZANCHIN S., SOTTILARE R., GARRITY P.: Using augmented reality to tutor military tasks in the wild. In *Interservice/Industry Training Simulation and Education Conference* (2015), vol. 15050. 2

[Raj11] RAJENDRAN D.: Does embedding an ICT certification help align tertiary programs with industry?: A study of CCNA workplace perceptions. *Journal of Applied Computing and Information Technology 15*, 1 (2011), 2011. 1

[SH13] SOTTILARE R. A., HOLDEN H. K.: Motivations for a generalized intelligent framework for tutoring (GIFT) for authoring, instruction and analysis. In *AIED 2013 Workshops Proceedings* (2013), vol. 7, p. 1. 1, 2

[SL15] SOTTILARE R. A., LAVIOLA J.: Extending intelligent tutoring beyond the desktop to the psychomotor domain. In *Interservice/Industry Training Simulation & Education Conference, Orlando, FL* (2015). 2

[WMB15] WESTERFIELD G., MITROVIC A., BILLINGHURST M.: Intelligent Augmented Reality Training for Motherboard Assembly. *International Journal of Artificial Intelligence in Education 25*, 1 (Mar. 2015), 157–172. 1, 2