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Authoring Augmented Reality as Situated Multimedia

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Abstract: Augmented reality (AR) is an enabling technology for presenting information in relation to real objects or real environments. AR is *situated multimedia* or information that is positioned in authentic physical contexts. In this paper, we discuss how we address issues in creating AR content for educational settings. From the learning theory perspective, we explain that AR is a logical extension of multimedia learning theory. From the development perspective, we demonstrate how AR content can be created through our in situ authoring tool and our platform for handheld AR.

Keywords: augmented reality, authoring tool, multimedia learning, situated learning

1. Introduction

Augmented reality (AR) is an emerging technology for educational settings. Our review (Santos et al. 2014) provides a useful summary of AR prototypes applied to learning. Currently, researchers have varying definitions for AR, depending on which of its features are emphasized. We define augmented reality learning experiences based on Azuma's (1997) definition of AR – "3-D virtual objects are integrated into a 3-D real environment in real time". This is a conceptual definition that is independent from enabling technologies. The "objects" mentioned are more understood as inserting computer graphics and aligning it to a video feed of the real environment. However, Azuma et al. (2001) explained that AR can potentially apply to all senses.

Although there are many AR prototypes for learning, researchers do not usually use the most important feature of AR – showing an explicit relationship between the virtual learning content and real objects found in the natural environment. There are many definitions for AR. As a technology for education, we propose to define AR to be *situated multimedia*. In other words, AR is multimedia (text, sound, images, animations, etc.) that is displayed in relation to the real environment. Thereby, the real environment becomes the "authentic context" of learning that is characteristic of situated learning (Herrington & Oliver, 1995). From this formalization, we then discuss our implementation of authoring tools that teachers can use for creating such situated multimedia.

2. Extending Multimedia Learning Theory to Augmented Reality

Previous research works have described AR to offer contextual learning (Specht et al., 2011) and ubiquitous learning (Dede, 2011). Indeed, AR has several benefits because it applies situated cognition (Wu et al., 2013). In this paper, we take a step back and explain that AR is essentially multimedia. As such, multimedia learning theory applies. In this theory, multimedia refers to pictures and words. It assumes dual-channels, limited capacity, and active processing (Mayer, 2009). First, humans have two separate channels for perceiving visual and auditory information. Second, humans have a limited capacity of information that they can attend to. Lastly, learning only takes place if learners actively make sense of incoming information using their prior knowledge. AR visualization can reduce cognitive load, thereby, allowing students to allot more effort to actively processing information. In a previous study (Fujimoto et al., 2012), we have shown that using AR visualization enables better memorization of abstract symbols. This result is consistent with the prediction of spatial and time contiguity principles of multimedia learning.

Multimedia learning is learning with *pictures* and *words* (both written and spoken). This theory applies to AR if we make the following logical substitutions: The real objects or the real environment is the *picture*. The virtual texts, symbols and pre-recorded sounds are the *words*. A *new picture* is created when real objects, real environment and the *original picture* are combined.

3. Authoring Augmented Reality Content

One of the difficulties for adapting situated multimedia is the lack of authoring tools to make educational content. Currently, several authoring tools exist. However, they do not address the needs of teachers for a simple but flexible tool for everyday use. Software libraries like the ARToolkit (Kato & Billinghurst, 1999), Vuforia[1] and PointCloud SDK[2] are authoring tools for programmers.

MacIntyre et al. (2004) and Hengel et al. (2009) developed desktop-based systems for non-programmers so that they can author AR content. On the other hand, Langlotz et al. (2012) created a system for handheld-based authoring. Although handhelds have less processing power than desktops, it has the key advantage of mobile authoring at any place in any time. Currently, Langlotz et al. (2012) draws basic 3D shapes and other features such as copying, deleting, etc.

3.1 Simple In Situ Authoring for Teacher's Use

For the purposes of teachers, it is enough for them to download pictures from the internet, and then place it on a real environment. As such, we implemented an authoring tool that enables teachers to download a picture, and perform affine transformations. Our prototype uses the ARToolkit running on iPad 2 (dual-core A5, 512MB DDR2 RAM, 32GB, 601 grams, 9.7 in display, 1024-by-768 at 132 ppi).

Figure 1 shows the interface for our simple authoring tool for teachers and a sample use case. In this example, teachers can download any image from the internet. This image is converted into a texture on the screen. Using gestures like swipe, pinch, and so on, the teachers can modify the appearance of the image. In this example, it is desirable to scale and position the lungs correctly on the body.

Figure 1. Simple Authoring Tool (left); Sample Use of the Authoring Tool (right)

3.2 Handheld AR Platform for Situated Multimedia

Currently, authoring tools focus on rendering fast and beautiful graphics on a real world scene. There are few authoring tools that emphasize on the use of sounds and text. For educational settings, teachers use a combination of image, sound and text to facilitate learning. As such, we developed a handheld AR platform for presenting images, sound and text onto real objects.

We implemented the whole platform on iOS7 running on iPad 2. Figure 2 shows the package diagram and a sample application for vocabulary learning. The main part of the platform is the Controller, which has access to learning contents. It receives the marker ID and camera view matrix

[1] https://developer.vuforia.com/
[2] http://developer.pointcloud.io/sdk

from the Tracker and uses these information to specify the behavior of the on-screen display. The Tracker was built using ARToolkit, and the Renderer was built on OpenGL ES 2.04. In the sample use case, students can learn the word "pindutin" (Filipino for "to push") by animating a hand which pushes a real button. This is an example of situated multimedia because it shows explicitly the relationship of the animation with real objects such as a coffee maker found in the learner's natural environment.

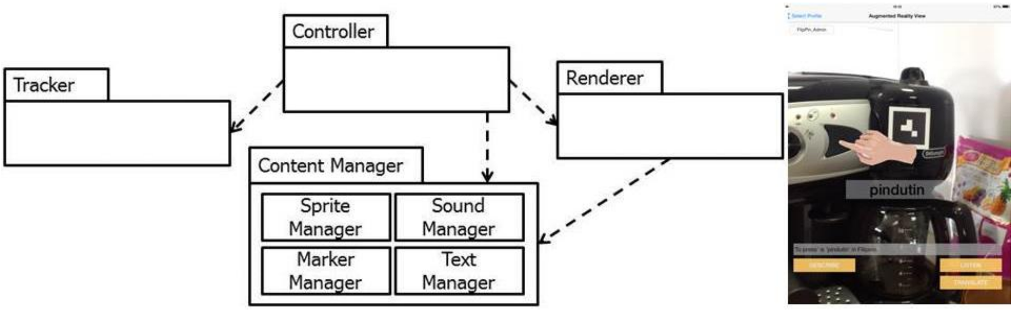

Figure 2. Package diagram of handheld AR platform (left); Sample Interface using the platform (right)

4. Conclusion

We defined augmented reality as situated multimedia. For the first time, we point out that AR could be better understood and designed by applying multimedia learning theory. Aside from graphics, sound and text is also required for creating AR learning materials. As such, we implemented two prototypes for authoring situated multimedia content namely, in situ authoring and our handheld AR platform. Currently, we are conducting evaluations of the interface with teachers. Educators can benefit from this research because it will enable them to design educational content in authentic contexts.

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Behavioral Analysis of Learners Using Smart Devices in an Indirect Learning System

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Abstract: The main method of learning carried out generally is still direct learning, that is, a method of learning that directly and actively focuses on the object of learning. We call indirect learning the learning of a subject matter indirectly as a result of having actively studied another subject matter. We have aimed to establish the information technology required to put indirect learning into practice. This research deals with the behavior of system users when they use smart devices and realize indirect learning in implementing a task. We report results based on analysis of notebooks and videos recorded at the time of learning.

Keywords: Indirect learning, smart devices, face-to-face communication, user analysis

1. Introduction

In his book, The Last Lecture (Pausch and Zaslow, 2008), Pausch said that when we learn something we should not learn it directly: instead he emphasized indirect learning in which learning proceeds indirectly by focusing on another object. However, even today, the type of learning normally carried out is direct learning. Until now proposals have also been made on indirect learning (Adler, 1993). Still, it has been difficult to make a quantitative evaluation of indirect learning itself, and there are almost no examples of the achievement of practical indirect learning. In this study, we introduced a face-to-face meeting support system (Ishitoya et al., 2012) for a small number of people. This system uses tablet devices and large displays as a practical indirect learning system that makes use of information technology. We report on indirect learning in task implementation in English language education.

2. Indirect Learning Systems using Smart Devices

2.1 System Overview

In indirect learning systems, as shown in the processes of indirect learning in Figure 1, it is necessary to carry out support for both individual indirect learning (through investigations, thought, and organization) and indirect learning within a group (through discussions and organization.) We developed and operated a face-to-face meeting support system. This system is composed of two parts. The first part, called the Time Machine Board (hereafter TMB), is a framework for recording the content of meetings. The second part, called iSticky, is client software for collecting content related to individual activities and inputting information into the TMB. TMB uses a large display as a computerized whiteboard, and iSticky is operated by a tablet device (iPad).

2.2 Use in Individual Learning

iSticky has two functions. One of them is to act as a log that records and controls individual daily learning activities. The other is link to an informationally expanded TMB and act as a user interface that presents part of the learning log on a large display. We assumed that the iSticky would be carried around by learners in their daily activities. The learning log recorded on an iSticky can be saved on an indirect learning cloud connected with a network.

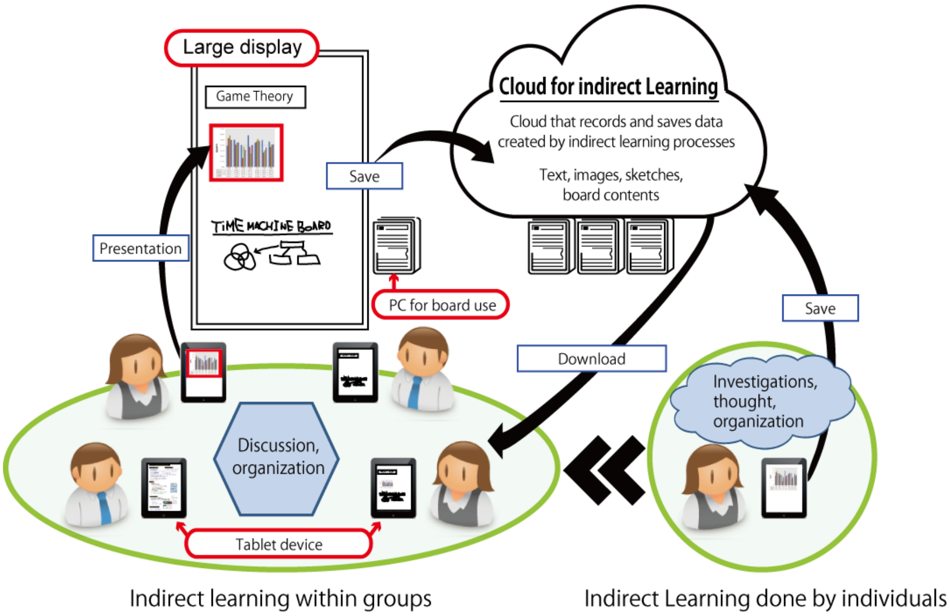

Figure 1. Indirect learning processes.

2.3 Use in Group Learning

There are some studies concerning the mixed use of mobile devices, shared displays, and cloud services (Liu et al., 2009; Jansen et al., 2013). In indirect learning carried out by small groups, students can hold discussions among themselves while they organize and present to other learners some of their ideas, thoughts, and results, which they investigated in their daily activities by using TMB and iSticky. The TMB is composed of a large display and a single PC. With iSticky, individual learning logs such as sketches, images, and text that are stored on a cloud for indirect learning can be transferred to a PC and presented on a large display. With the iSticky board tab, learners can confirm the content displayed on the TMB. They can copy part of the learning log onto the board tab, and by moving, enlarging, or reducing the elements on the board, they are able to manipulate the information presented on the TMB.

3. Collection of Indirect Learning Data

We used this system for indirect learning in which students carried out a task using graded readers, and we collected indirect learning data. The participants were ten second-year university students (9 males, 1 female). TOEFL ITP scores ranged from a high of 620 to a low of 450, with a mean of 510. We first divided the students into small groups of five members. Then we gave the students this indirect learning assignment: "Decide on a theme from any branch of knowledge that you like. Then create a poster that will communicate in an easily understandable way the history, the current situation, and the future of this branch of knowledge." As material for the students to refer to when doing their assignment, we designated books from the Oxford University "A Very Short Introduction" series as graded readers. We divided implementation of the task into five phases: (i) selection of a theme and assignment of roles (ii) report on investigations (iii) design of posters (iv) presentations and (v) feedback meetings. We made use of an indirect learning support system in the discussions and operations of each phase.

4. Analysis of Indirect Learning Processes

We analyzed the recorded data of operations and of discussions of learners among themselves during indirect learning. We analyzed this data in terms of whether indirect learning systems based on TMB and iSticky were used or not. When these systems were not used, whiteboards and posters were used instead of a large display, and paper notebooks were used instead of tablet devices.

4.1 Analysis of Notebooks and Posters

As a result of comparing the number of characters written in notebooks for each page in the extensive reading text, there was almost no difference between the iSticky and the notebooks, but the number of English words was 2.2 times greater in the iSticky than the notebooks. Furthermore, when the number of characters presented on the whiteboards was compared in terms of time, the rate was 2.9 times more for the TMB than for the whiteboard. Regarding the number of characters on the posters, the TMB had about 11% more, and the time required for making the poster was about 52% less. From the above, we found that when this system was used during a limited time period, it was able to present information efficiently. As a result, more time could be used for communication such as discussions.

4.2 Use of Video Data to Analyze Verbal and Non-verbal Information

We used ELAN to provide annotations to the video data for indirect learning processes. Specifically, we wrote out the content of conversations as verbal information, and we analyzed and recorded eye direction and nodding as non-verbal information. Consequently, the number of characters included in statements per unit of time was about two times greater when smart devices were used. When smart devices were used instead of posters, listeners tended to nod more and have better eye contact with the speaker. The result was that in the discussions immediately after the presentations, we found that groups using the smart devices were asked more questions.

4.3 Questionnaire Survey

Through the whole task of making a poster, we had the learners evaluate, then we found that groups using smart devices had higher evaluations on the understandability of the poster and on the degree of satisfaction with the discussion. We asked the students about any skills other than presentation skills they felt they obtained. Regardless of whether the students used or did not use the indirect learning system, they gave answers such as communication skills overall, ability to impart what I want to say, cooperation, and ability to summarize. Furthermore, students using the system said they improved their ability to create a consensus, their powers of comprehension, and their ability to discuss and debate.

5. Conclusion

We analyzed the behavior of system users when they realized indirect learning through implementation of a task with smart devices. As a result, we found that tablet devices were highly efficient in the presentation of information and more time could be used for communication activities such as discussions; furthermore, we learned that the degree of satisfaction in carrying out the task was higher for those using the system. On the other hand, we learned that there was a trade-off between the redundancy of tool operation and the re-usability of information.

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