S. L. Wong et al. (Eds.) (2010). Proceedings of the 18th International Conference on Computers in Education. Putrajaya, Malaysia: Asia-Pacific Society for Computers in Education.

Prototyping Paper-Top Interface as Note-taking Support

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Abstract: We developed a PTI prototype system for supporting note-taking. The prototype system is realized as a fusion of notebooks and digital learning materials by visual-marker-based AR (Augmented Reality). A student can take a note with pencils, viewing digital learning materials projected onto his/her notebook. It is expected that the prototype system decreases burdens in and increases learning effect by note-taking.

Keywords: Note-taking, digital learning materials, AR, classroom education

Introduction

ICT (Information and Communication Technology) has been introduced in classroom education and necessary for classes in the digital age. This is because ICT changes the traditional classes and provides new effective styles of instruction and learning.
Meanwhile in the traditional classroom, students generally write learning outcomes (e.g., their constructed knowledge, thinking process, questions, and ideas) on their notebooks―they take notes. Even if ICT is introduced more rapidly, a prevailing learning activity of students must be note-taking without ICT. It has been actively investigated and discussed how note-taking influences learning effect [1]. And now, note-taking is recognized as a universal learning activity for increasing learning effect in a classroom. For example, an investigative study focusing on university students reported that high correlations were found between the quantity of notes and examination performance [2].
In this study, we propose Paper-Top Interface (PTI for short) as note-taking support. PTI uses AR (Augmented Reality) as ICT for classroom education to fuse digital learning materials (the virtual world) into notebooks (the real world). The purpose of PTI is to decrease burdens in and increase learning effect by note-taking. We developed a PTI prototype system, which uses a visual-marker-based AR and projects digital learning materials onto the corresponding papers (pages on a notebook) on a classroom desk. In other words, PTI is a digital projector-based AR and does not require a computer display or HMD.

1. Note-Taking Support

PTI supports note-taking in a class (classroom) where digital learning materials are projected onto the front screen and students do the following learning activities.

(1) View digital learning material on the front screen.
(2) Listen to the teacher's dictation.
(3) Transcribe the content of the material on their notebooks―this is one style of note-taking.
(4) Think through (1) and (2) and write their learning outcomes on their notebook―this is another style of note-taking.

We suppose that students tend to spend a lot of time for (3) in classes where the students are not given paper handouts of the material. In addition, the teacher does not necessarily give the students enough time for (3). In other words, the teacher may switch (turn over) slides (pages) of the material before the students finish (3). Thus, note-taking is not completed if the students do not transcribe the content quickly. Therefore, the note-taking of (3) may be hard to help understand the class content smoothly and is a big burden to the students.
Meanwhile, we suppose that students tend to spend a lot of time for (4) in classes where the students are given paper handouts of the material and can annotate and/or underscore the handouts flexibly with pencils or pens. This means that the students do not have to transcribe the content of the material and are given more time for (4). Therefore, the note-taking of (4) may be easy to help understand the class content smoothly and is a small burden to the students. Our basic policy of note-taking support is to reduce a note-taking burden by shifting the note-taking style from (3) to (4).

2. Prototype System

2.1.1 System Composition

Taking account of availability in a classroom, we developed a PTI prototype system from well marketed equipments. The prototype system is composed of a projector, a video camera, and a personal computer (Figure 1). The projector is mounted on a metal frame above a student's head, being in a downward direction. The video camera is mounted beside the projector and shoots the table. The PC processes the video and generates digital learning material images to be projected onto a notebook (on the table).

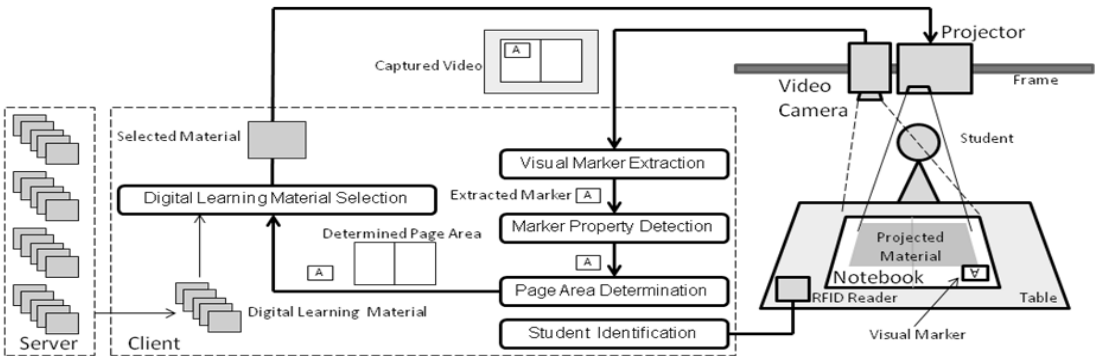


Figure 1: System Composition and Procedure

2.1.2 Procedure

The procedure of PTI is roughly divided into three phases: visual marker processing, learning material selection, and learning material projection.

2.1.3 Visual Marker Processing

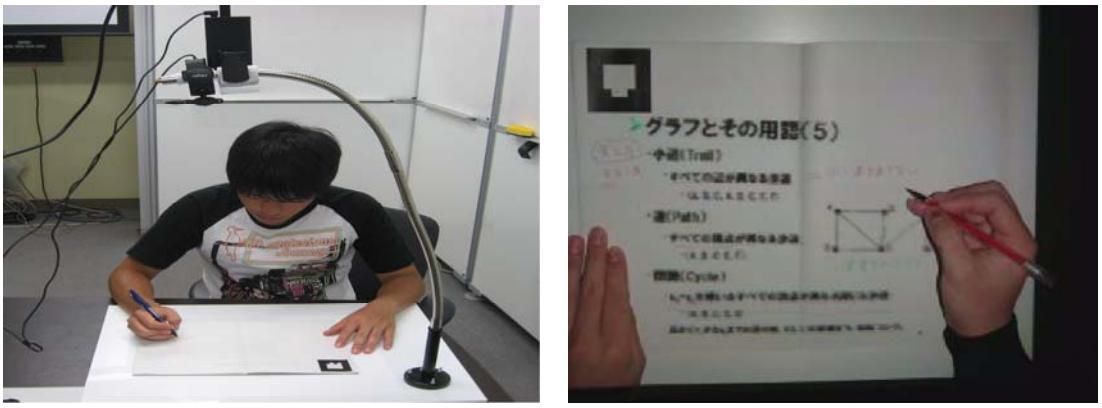
A different visual marker must be printed or pasted on every page of a notebook beforehand. Videlicet, one learning material corresponds to one page. The marker is up-down and left-right asymmetry because directions of the projected learning materials must be considered. The prototype system calculates the match degree of the detected marker and the marker registered beforehand, and then performs learning material selection if the calculated degree exceeds a threshold value.

2.1.4 Learning Material Selection

We assume that a digital learning material mainly used in classes is digital slide show (e.g., PowerPoint). Therefore, a main learning material of the prototype system is also digital slide show. If digital slide show is used as the learning material, each slide (page) is converted into one image file. The filename of a slide and the ID of a marker are linked with one to one relation.

2.1.5 Learning Material Projection

The selected learning material (slide) is projected at the lower right of the marker position within the size of a standard notebook so that the prototype system does not fail in marker recognition due to covering the marker with the projected material. As a matter of course, the prototype system can track the notebook on the table, moving and rotating the projected material from the detected markers' properties. A student turns over a page and immediately the material corresponding in the one-to-one relation is projected. Figure 2 shows snapshots of the prototype system in use and the projected material (a slide of discrete mathematics).



(a) Prototype system in use (b) Projected material

Figure 2: Snapshots of the prototype system

3. Summary

We developed a PTI prototype system, which can support note-taking by projecting digital learning materials onto a notebook on a table. Note-taking is diverse and may depend on cultural aspects including learning styles by country and region. In Japan, many students tend to transcribe the contents displayed on the classroom screen or written on the blackboard. Therefore, the PTI will work well for Japanese students.

Acknowledgement

This study was supported in part by Grant-in-Aid for Young Scientists (B) No. 21700815 from the Japan Society for the Promotion of Science.

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