# Augmented Instructions - A Fusion of Augmented Reality and Printed Learning Materials –

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## Abstract

*Augmented Reality (AR), which overlays virtual objects onto real scenes, has large potential to provide learners with a new type of learning material. Although many AR systems have been developed for demonstration, there is a gap between their ideal and practical use. We discuss a concept for Augmented Instructions that mix AR and traditional printed materials. Improvement of human-computer interface is considered to serve as a bridge for the gap. To investigate on characteristics of Augmented Instructions and its appropriate interface, we conducted subjective evaluation, comparing 3D presentation systems; a handheld PC and a head-mounted display. The result suggested that a handheld PC was more suitable for a presentation tool of Augmented Instructions.*

## 1. Introduction

Multimedia learning environments have offered new ways for learners to interact with various educational resources. However, printed learning materials have been favored and used particularly for systematic study. They have been dealt with as totally different media that yield distinct learning environments, and learners can only get its alternative merits at each environment.

Our approach is Augmented Instructions that mix Augmented Reality (AR) and traditional printed materials. We discuss Augmented Instructions that bring multimedia into conventional learning environments, and show user study of a proof-of-concept prototype as a preliminary evaluation, investigating interface devices for Augmented Instructions.

AR enhances real scenes viewed by the user, overlaying virtual objects over the real world, and works to improve the user's performance in and perception of the world. AR has the following advantages: 1) one can get three-dimensional (3D) information based on a real scene, 2) one can see objects from their own viewpoint, and 3) one can interact with both virtual and real objects. Using the above features, many AR systems have been developed for demonstrations [1], and some of them have targeted their applications on education.

Earth-Sun Relationships [2] presents seasonal variation of light and temperature, and the virtual sun and earth are manipulated on a small handheld platform that changes its orientation in coordination with the viewing perspective of the student. Construct3D [3] has designed as a 3D geometry construction tool for mathematics and geometry education, and provided interactive learning environments through various scenarios. Augmented Chemistry [4] was a kind of virtual chemistry laboratory where students could view simple atoms and acquire their own complex molecules while being bound by the subatomic rules. Multimedia Augmented Reality Interface for E-learning (MARIE) [5] has been developed as an application for engineering education in order to enhance traditional teaching and learning methods.

## 2. Concept

The basic concept of Augmented Instructions is closely related to the MagicBook [6], proposed as a traditional AR interface that uses a real book to seamlessly transfer users from reality to virtuality. However, the MagicBook basically used a head-mounted display (HMD) as a device of information presentation, though it was adapted for a handheld type. As we mention later, HMD is not so suitable for long time use in learning as well as not common for usual learners. Besides, an inertial tracker for tracking the head orientation was not available for usual learners. We target Augmented Instructions at general learners

Proceedings of the Fifth IEEE International Conference on Advanced Learning Technologies (ICALT'05)
0-7695-2338-2/05 $20.00 © 2005 IEEE

and mainly consider supporting their study based on printed learning materials.

Figure 1 depicts architecture of Augmented Instructions. Supposing flexibility of learning methods increases with factors of interaction and individuality, AR is considered to improve the both factors of printed learning materials by interactively presenting information at user's viewpoint.

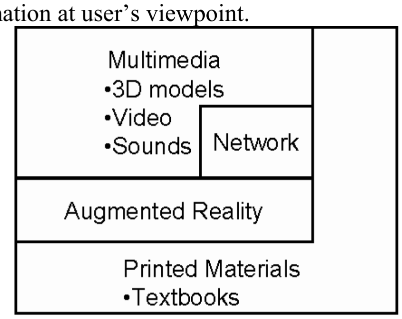


Figure 1: Architecture of Augmented Instructions.

We expect that the main reason why the printed learning materials are favorable is to be able to make systematic study. For example, textbooks are generally well organized according to the level of readers. Textbooks may involve many elements such as concepts, rules, analogies, and imagery so that information may be stored in long-term memory.

Augmented Instructions enable us to use a learning style based on printed materials and to access additional information using AR. Augmented Instructions can utilize multimedia for learning, while simultaneously exploiting the advantages of printed learning materials.

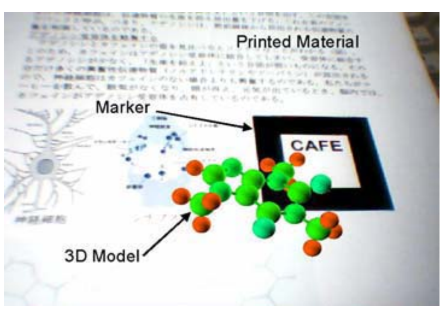


Figure 2: A 3D graphics image overlaid onto the scene.

In Augmented Instructions, markers or tags are added to the text to identify information related to the descriptions in the text, and are detected with an image-processing tool, ARToolkit [7]. 3D geometric information is especially effective when used in Augmented Instructions, because texts are limited to two-dimensional presentations. Figure 2 shows a 3D graphics image overlaid onto the scene captured by a camera.

## 3. User Study

We conducted a preliminary experiment in order to investigate on characteristics of Augmented Instructions and its appropriate way of human-computer interaction. We dealt with chemical properties of caffeine as a topic for Augmented Instructions, and prepared a two-page document for the experiment. A handheld PC was compared to a HMD as a presentation system for Augmented Instructions.

### 3.1. Method

22 university students (15 women and 7 men) participated in the experiment. All the participants had normal vision and no previous experience of Augmented Instructions.

The simple task was prepared for subjective evaluation of Augmented Instructions and the presentation systems. Participants were required to read the two-page document and see a 3D model with the presentation systems.

Two kinds of presentation system were prepared for presenting 3D information, as shown in Figure 4; a: Handheld PC [Type-U (Sony) and WebCam Notebook (Creative)] and b: HMD [iVisor (Daryang E&C) and Qcam Pro 4000 (Logitech)]. For each system, the same format was used to present a 3D model of caffeine. When a participant controlled direction of a camera so that a marker in the document would be presented on the display, the 3D model the marker identified was detected and presented on the display.

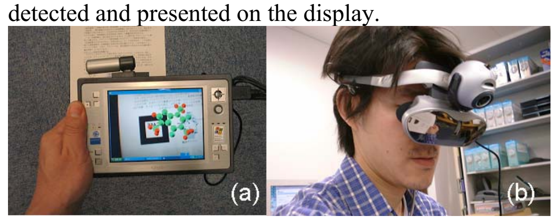


Figure 3: Presentation Systems.
(a) Handheld PC (b) HMD

We measured participants' impressions for each system using a questionnaire. Questions were answered on a scale from 5 to 1, ranging from "strongly agree" to "strongly disagree". The items of the questionnaire are listed in Table 1. We also obtained open-ended comments from the participants on aspects of Augmented Instructions immediately after they finished the trials.

Table 1: Items of questionnaire.

| | Item |
|---|---|
| 1 | The system presents the 3D model appropriately. |
| 2 | The system works stably. |
| 3 | The system response is enough to be fast. |
| 4 | You have to be accustomed to using the system. |
| 5 | You get fatigued after using the system. |
| 6 | The system is good at long-time use. |
| 7 | The system can be used together with printed materials |
| 8 | You want to use the system in practice. |

Participants first read the instructions for the experiment. They then practiced using the presentation systems, and any questions they had were answered at that time. Participants were asked to perform the task with each presentation system and to answer the questionnaire including open-ended comments.

### 3.2. Result and Discussion

Figure 4 shows the average rate for the items from 1 to 8 in the questionnaire. The white and black rectangles correspond to average values of the handheld PC and HMD, respectively. The bar indicates the standard deviation. There was statistically significant difference ($t(42)=3.03$, $p<0.05$) in item 6, and no significant difference in the other items ($p>0.05$).

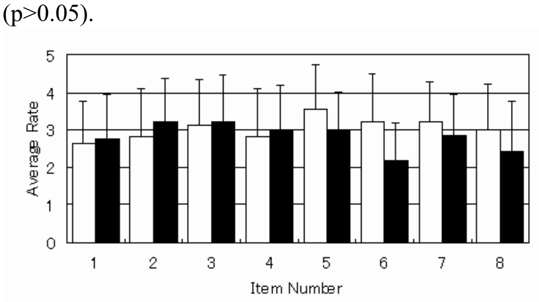


Figure 4: Results of the questionnaire.

The handheld PC was rated to be significantly better than the HMD in terms of long-time use. Although the items 5,7, and 8 related to fatigue, compatibility, and inclination were not rated to be significantly different, there were tendencies that the handheld PC had higher rates than the HMD. These imply that a handheld PC is more favorable than a HMD as a presentation system of Augmented Instructions.

The open-ended comments supported this interpretation. There were several participants who stated that the HMD was better because it did not require using their hands. While, it was difficult to read the document because of the low resolution. In addition, they felt the HMD was a bit heavy to be used for many hours. Several participants remarked that they felt the display size of the handheld PC was small but it was not so bad because of the high resolution. They also stated that they felt the handheld PC had good compatibility with action of reading the document.

## 4. Conclusion

We discussed the features of Augmented Instructions, in which AR is combined with traditional printed learning materials. They have the potential to provide us with a new way to use printed learning materials, making a seamless connection to multimedia. The result of the experiment suggested that a handheld PC was more suitable than a HMD as a presentation s system for Augmented Instructions in terms of long-time use.

**Acknowledgments**

This research was partially supported by a Grant-in-Aid for Scientific Research (15500653) in Japan.

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