Transactions of the Korean Nuclear Society Autumn Meeting
PyeongChang, Korea, October 30-31, 2008

How does the Augmented Reality Manual enhance cognitive activity while doing complex maintenance tasks?: Augmented Tutorial Overlaid Manual (ATOM)

Ho Bin YIM and Poong Hyun SEONG*
Department of Nuclear and Quantum Engineering, Korea Advanced Institute of Technology and Science.
*hobinyim@kaist.ac.kr, *Corresponding author:phseong@kaist.ac.kr*

1. Introduction

It has been more than a decade since the concept of Augmented Reality (AR) was introduced. Many related technologies, such as tracking and display, to animate this concept have improved to certain levels. AR is well suited for interaction with the cognitive vision system. In contrast to the virtual reality, AR applications enrich the perceived reality with additional visual information which ranges from text annotation and object highlighting to complex 3D objects [1].

AR has been tested its potentiality in various forms of applications. For example, visitors wear Head Mount Display (HMD) to see virtual guides explaining artifacts in a museum or soldiers are informed geographical features about unfamiliar operation sites. Recently, researchers tried to use AR as a means of teaching or training apparatus [2]; however, there are still some technical obstacles to put this fascinating technology into practice.

In this study, we will use Cognitive Load Theory (CLT) to design a manual of pump maintenance and convert it to AR technology to propose a proto type of an on-line AR maintenance manual to prove its possibility as an interactive learning tool.

2. Related Work

There have been many attempts to use AR technology for maintenance purposes especially in aviation industries as well as manufacturing purposes in other industries. Miwa *et al*. tried to clarify how controllable and perfect-transparent digital manual realized by AR technology effects on worker's cognitive processes, and to examine its practicability[3] while Nickolas D. *et al* investigated a application of AR as learning paradigm and compared it to other learning paradigms to measure its ability to affect immediate and long-term recall [4].

However, no studies have been conducted to prove that AR can transfer information from working memory to long-term memory while working, in other words, workers can learn with specially designed AR manual without awareness.

3. Method and Approach

3.1 Augmented Reality

The definition of AR is simply to supplement the real world with virtual (computer-generated) objects that appear in the same space as the real world. In this sense, it was defined that an AR system requires having following three properties:

- combines real and virtual objects in a real environment;
- runs interactively, and in real time; and
- registers (aligns) real and virtual objects with each other.

Until recently, most AR proto types concentrated on displaying information that was registered with the world and did not significantly concern themselves with few potential users would interact with these systems [3].

This study will involve such interacting features as buttons and pointers so that the maintenance personnel can not only manipulate the contents of the manual, but also communicate with supervisors while doing their tasks.

3.2 Cognitive Load Theory

It has been widely known that Miller [5] proved, unlike infinite capacity of long-term memory, limited volume of working memory hinders people from learning. One of the theories to scrutinize this phenomenon hence to increase learning effects is Cognitive Load Theory.

According to Sweller *et al*., There are three categories of cognitive load and each one has different properties and function on our learning processes. The first one is *intrinsic cognitive load* because demands on working memory capacity imposed by element interactivity are intrinsic to the material being learned. Second, CLT is concerned with the instructional implications of this interaction between information structures and cognitive architectures. The manner in which information is presented to learners and the learning activities required of learners can also impose a cognitive load. When the load is unnecessary and so interferes with schema acquisition and automation, it is referred to as *extraneous cognitive load*. The last form of cognitive load is *germane cognitive load*. Like extraneous cognitive load, germane cognitive load is influenced by the instructional design. Whereas extraneous cognitive load interferes with learning, germane cognitive load enhances learning because it deals with forming schemas [6][7][8].

By forming schemas simultaneously during the maintenance task with the AR manual we design, learning effect can more likely appear than with traditional manual.

We also consider human factors in maintenance tasks and usability of devices. Comparison data between two types of AR systems- a mobile system and a fixed system-will be gathered to measure usability [9][10].

4. Experiment and Hardware Set-up

4.1 Experiment

The purpose of this study is to prove how the AR manual designed with cognitive aspects can enhance human learning activities. All participants who perform the maintenance task will be novices assumed to have no previous knowledge of the task. They will be grouped in three: the first group will be given a pump repair task with an electronic manual and the second group will perform the same task with an AR manual with sequential order while the CLT based AR manual, we deliberately made, will be assigned to the third group. The task will be conducted just after a brief introduction of the task and take an hour break. After the break the subjects will perform the task again. Finally the subject will conduct the same job on following day and fill out the questionnaire. We are going to collect the date of time to complete the task and between the steps, accuracy, numbers of help by a supervisor and level of completion so that we can evaluate the learning effect varied with mode of manuals. We are expecting that the third group will show the best results.

4.2 Hardware Set-up

There are two main problems to bring AR systems in practice. One of the main problems in AR systems is tracking. To get over this issue, an accuracy matter to be exact, researchers tried many ways of tracking and came out ones with shortcomings, for example, one method is accurate but inconvenient to use or other one is robust and easy to handle but very slow to respond. That is why it is still remained challenging. We will use an IR tracking system instead of an ordinary marker system. The IR system is as accurate and quick to respond as the maker system. The reason why we use the IR system for tracking is that the maker tracking system has a critical drawback; when obstacles, such as hand and tools, cover any part of a square maker's frame, which gives information of imposed objects, then, objects disappear. Moreover, objects also vanish unless the maker is positioned within sight of camera. In maintenance task, these properties will possibly interrupt maintenance personnel's rages of repair movement and thus, make them spend more time on a certain amount of tasks.

The other problem is display. In recent studies, researchers tend to use binocular type video see through HMD. The advantage of this device is that the scene of real world comes through a camera first and processed in a computer with objects. So there is no need to adjust our focus to see the finally combined view; nevertheless, when the virtual contents are displayed on a screen, all real objects are placed under those contents. It is obvious that maintenance personnel will not find the exact point because of the imposed contents. We use monocular type video see through HMD. With this device, maintenance personnel have to move focal length of their eye to watch the HMD view after seeing the real world.

5. Conclusions and Further Work

Even though it is still remained with few critical drawbacks to solve, AR is a promising medium with the potential of diverse applications. There have been many AR applications dealing with manufacturing and maintenance procedures; however, those AR applications alone have not shown learning effects. If it is possible to reduce cognitive load with our CLT based manual hence to positive effects on our learning activities and cognitive process, it can be used in many fields, such as time consuming maintenance and education.

REFERENCES

[1] H. Siegl, M. Hanheide, S. Wrede, A. Pinz, An Augmented Reality Human-Computer Interface for Object Localization in a Cognitive Vision System, Image and vision Computing 25, 1895-1903, 2007.
[2] Ronald Azuma, Yuhan Baillot *et al.*, Recent Advances in Augmented Reality, IEEE Computer Graphics and Applications, Nov/Dec 2001.
[3] Miwa Naknishi, Toshiro Miura, Yusaku Okada, How does the Digital Manual with Controllability and Perfect-Transparency Effect on Workers' Cognitive Process?: Application of Augmented Reality Technology to Manufacturing Work.
[4] Nickolas D. Macchiarella and Dennis A, Vincenzi, Augmented Reality in a Learning paradigm for Flight and Aerospace Maintenance Training, Embry-Riddle Aeronautical University.
[5] Miller G. A, The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information, Psychological Review, 63, 81-97, 1956.
[6] John Sweller, Cognitive Load Theory, Learning Difficulty, and Instructional Design, Learning and Instruction, Vol. 4, pp. 295-312, 1994
[7] Fred Pass, Alexander Penkl and John Sweller, Cognitive Load Theory and Instructional Design: Recent Developments, Educational Psychologist, 38(1), pp.1-4, 2003.
[8] Slava Kalyuga, Paul Chandler and John Sweller, Managing Split-attention and Redundancy in Multimedia Instruction, Applied Cognitive Psychology, Vol. 13, pp. 351-371, 1999 .
[9] A. K. Gramopadhye, C. G. Drury, Human Factors in Aviation maintenance: How We Got to Where WE Are, International Journal of Industrial Ergonomics, 26, 125-131, 2000.
[10] D. Walter, Competency-based on-the-job Training for Aviation maintenance and Inspection – a Human Factors Approach, International Journal of Industrial Ergonomics, 26, 249-259, 2000