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AR-based Inorganic Chemistry Learning Support System using Mobile HMD

Masaru OKAMOTO[a*], Tsukasa ISHIMURA[a] & Yukihiro MATSUBARA[a]
[a]*Graduate School of Information Sciences, Hiroshima City University, Japan*
*okamoto@hiroshima-cu.ac.jp

Abstract: In this paper, we proposed inorganic chemistry learning support system using smartphone. For the proposed environment, smartphone, VR viewer and some markers are used as interface. To construct smartphone based HMD, user attach smartphone to VR viewer. By wearing HMD on user's head, user don't need to hold smartphone with his/her hand. To perform the virtual experiment in the proposed system, a user operates marker in recorded area of smartphone's camera. Based on recorded image, proposed system constructs virtual environment. Constructed virtual environment is displayed on smartphone's display. By watching smartphone's display and moving and arranging markers on the desk, user can confirm process of virtual experiments. By using proposed system, user can perform virtual experiment in various locations without PC and camera. In this paper, effectiveness of proposed approach was shown.

Keywords: inorganic chemistry, augmented reality, head mounted reality, experience based learning

1. Introduction

In chemistry of high school education, it is important that students perform experiment. However, students don't have many opportunities to perform chemistry experiment. Okamoto *et al*. developed AR (augmented reality)-based learning support system for inorganic chemistry. (Okamoto *et al.*, 2014) By using this system, a user can repeatedly perform virtual inorganic chemistry experiment. The system is constructed by USB camera, PC and markers as input interface. In the system, to perform virtual experiments, a user operates some markers that are regarded as actual instruments and solutes. A USB camera records image of the user's operation. Based on recorded real image, the system determines the kind of marker and the position of marker. The constructed virtual environment is displayed on a display. However, it's difficult to perform virtual experiment anywhere, because the system needs a PC and a USB camera.

Recently, many researchers developed learning support system that can be used anytime and anywhere. (Chen *et al.*, 2012, Tabata *et al.*, 2015, Yan *et al.*, 2012) For constructing these systems, smartphone or a tablet device are usually used. It is easy for a learner to carry smartphone or tablet. Therefore, by using these devices, user can learn anytime and anywhere. By constructing inorganic chemistry learning support system based on smartphone, it is possible to increase learning opportunity.

In this paper, we proposed inorganic chemistry learning support system using smartphone. We construct a system using smartphone that can perform same virtual inorganic chemistry experiment as the existing system. To use same interface as the existing system, the proposed system uses some marker. In proposed system, a smartphone record marker and display virtual environment. To construct smartphone based HMD, user attach smartphone to VR viewer. By wearing HMD on user's head and operating markers, user can perform virtual experiment using same operation as the existing system. From the above, the proposed system is constructed portable devices (markers, smartphone, VR viewer). Therefore, by using these devices, user can learn anytime and anywhere, and it is possible to increase learning opportunity.

2. Proposed Approach

2.1 System

We construct a system using smartphone that can perform same virtual inorganic chemistry experiment as the existing system. To construct the system that use same interface as existing system, the proposed system use markers, smartphone and VR viewer. Figure 1 shows a user using the proposed system. As shown in Figure 1, by wearing HMD on user's head, user doesn't need to hold smartphone with his/her hand. A user can operate marker using both hand same as existing system. Some markers correspond with instrument and reagent, and so on. By operating these markers in recorded area of smartphone's camera, a user can perform virtual experiment with the proposed system.

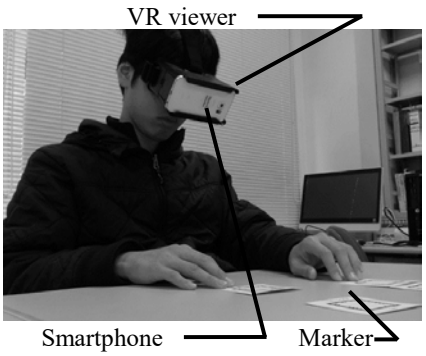

Figure 1. Overview of the proposed system

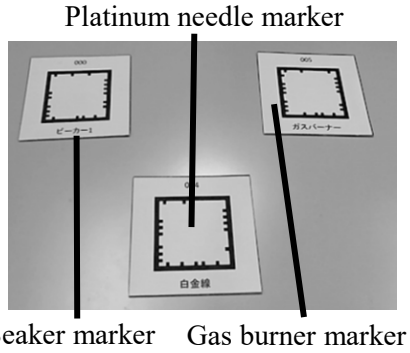

Figure 2. The image of markers

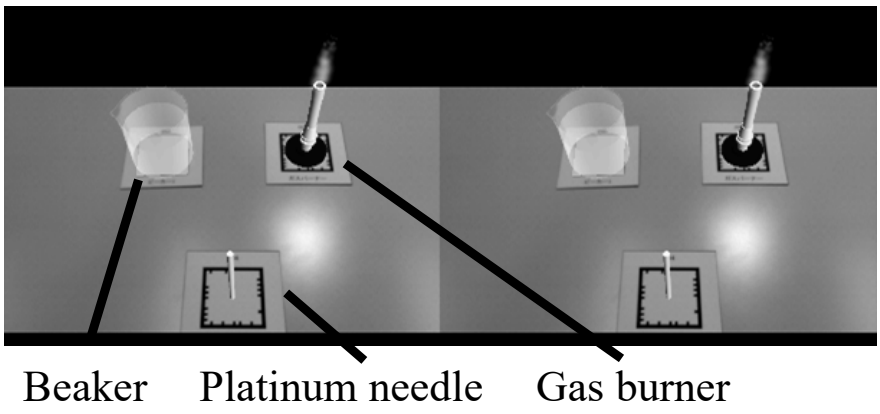

Figure 3. Virtual environment displayed on the smartphone

Figure 2 shows an image of markers that is recorded by smartphone's camera. In Figure 2, a beaker marker, a burner marker, and a platinum wire marker are recorded by smartphone's camera. By recording arranged markers, a user can input information of markers into the system. Based on recorded real image, the system determines the kind of marker and the position of marker. To construct the virtual environment, the system display CGs based on user's operation of markers. And Figure 3 shows a virtual experiment displayed on smartphone's display. The constructed virtual environment is displayed on both side of the screen of a smartphone. The image of virtual environment is constructed based on the real image of Figure 2, and the image is displayed on the screen of the smartphone. By operating markers in recorded area, user's operation is recognized by the system. And a user can perform various virtual experiments. In Figure 3, three instruments CGs are displayed on the real image (1: beaker, 2: gas burner, 3: platinum needle). A user can confirm the virtual environment displaying these CGs.

3. Experimental Evaluation

To evaluate the effectiveness of proposed probabilistic selection of given questions and learning process using virtual environment, learning experiments about chemical reaction were conducted. Four subjects (A, B, C and D) participated in the experiments. All subject learned about the knowledge of the

chemical reaction using the proposed system. As a candidate for comparison, results of the previous systems (Okamoto *et al.,* 2014) are used.

The results of the experiments of four subjects using proposed method are shown in Figure 4. For comparison, other four subjects using previous method are shown in Figure 5 too. All eight subjects took paper test after each experiment. By learning repeatedly, in the 17th experiment, all subjects using proposed system have acquired all the knowledge of chemical reactions corresponding to all questions given to subjects in the virtual environment. Next, to compare with a proposed system, experimental result of other subjects is shown in Figure 5. As shown in this figure, four subjects' learning experiment is ended by 19 times too. The learning results of Subjects using previous system are like Figure 4's result. From these results, by performing repeatedly learning using proposed system, there is possibility that a learner can get all knowledge of inorganic chemical reaction which the Japanese high school students should study.

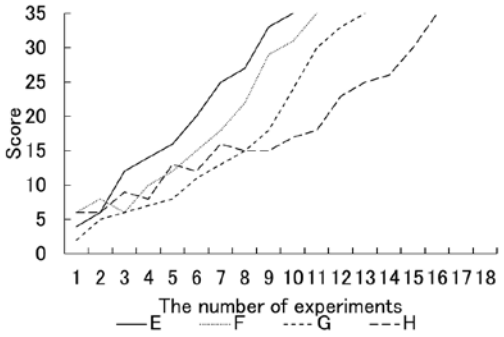

Figure 4. Results of Proposed Method

Figure 5. Results of Traditional Method

4. Conclusion

In this paper, we proposed inorganic chemistry learning support system using smartphone. By using proposed system, user can perform virtual experiment in various locations without PC and camera. From results of evaluation experiment, it is confirmed that subjects can perform virtual experiment as directed. In future works, we would like to confirm effect of learning.

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