Augmented Reality as Teaching Aid:Making Chemistry Interactive

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***Abstract*—Augmented Reality (AR) is a combination of real world and digital data. It facilitates and enhances user experience of interaction with physical world by imposing virtual images on real ones. The idea presented in this paper is to show how AR can be used to enhance the learning experience of students in chemistry lab. The Augmented Reality Chemistry application presented here is a teaching aid supplementing the work of teacher in the chemistry lab. It proposes to make chemistry easy and interactive, while warning the students of any harmful effects / reactions by wrong use of chemicals in the laboratory.**

Keywords- Marker-based Augmented Reality; Virtual Reality; Speech Recognition.

I. INTRODUCTION

AR is a field of computer science that is midway between reality and virtuality. Augmented Reality applications can enhance the learning experience by indulging video, text, graphics and audio into the real world of a student. Efficient interaction of students with computer-generated graphics can be used to improve their learning and understanding. Students and instructors can learn by carrying out interaction through virtual objects and learning materials.

Students always have problems in understanding chemistry reactions in laboratory. The other potential problem is the use of wrong chemicals while performing lab experiments. We propose an application of AR in chemistry with following objectives

1) to help students to actively interact in labs performing experiments to increase their understanding
2) to make them learn by doing rather than by reading.
3) to make users aware of the harmful reactions before accidently performing them.
4) to help students to test their knowledge by performing alternate experiments.

The usual way in a chemistry lab is that the curriculum prescribes a set of experiments to be performed by each student. For each experiment there is a step by step procedure, which is given in lab manual. In a traditional set up, the experiments are self contained, with no scope of augmentation. The student, if he wishes to learn beyond the scope of the experiment, usually would have to rely on teacher / instructor present in the lab. Also, the teacher / instructor might be busy with other students and aiding them to perform other experiments. Eg. Suppose the experiment requires the student to perform an experiment on chemically reacting potassium iodide with lead nitrate. They would do the prescribed experiment, but will never try to find out that what will happen if potassium iodide is mixed with something else say hydrogen peroxide and liquid soap. The results would be different and this reaction is a bit dangerous too. Some of the students are quite eager to know about different combinations of chemicals/compounds other than taught in the lab. They can come up with new molecules formed by combination of some others but are unable to do so sometimes just because the teacher might not be able to attend them and tell about such combinations as he/she might be busy with other students in the lab and or the material might not be available at that time. But with the AR chemistry app, not only the students would be able to perform physical experiment, check their result themselves with the help of the app, but also answer their inquisitive questions by extrapolating visualizations given in the app. So the students can try such experiments on the AR device and know the results before performing. Throughout the paper we are going to discuss about the establishment of marker based AR Chemistry system. It would also prevent the wrong chemical reactions to take place by giving certain warnings.

II. AUGMENTED REALITY AND VIRTUAL REALITY

Augmented reality is different from virtual reality. In virtual reality, what you see is virtual. You only see the virtual thing. But augmented reality you're still seeing the real world. It just augments some virtual information on top of the real world. It preserves the user's sense of being in a real world. Augmented reality and virtual reality are just like two ends of the RV continuum [1] (Fig. 1).

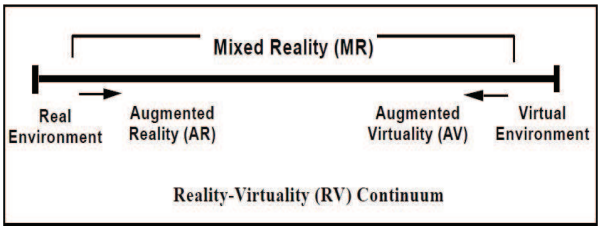


Fig. 1. Reality-Virtuality continuum

III. Related Studies of Virtual And Augmented Reality Laboratories

Physics Education Research group at Ohio State University, Columbus has developed a Virtual Reality (VR) platform for performing several VR-based experiments. These help students to view and perform experiments in a more detailed and controlled way than is possible with existing equipment. Students can adjust parameters in their own way as they are provided with more freedom to choose what conditions to test. Friction can be turned off and on to allow students to carefully observe how motion is affected. Processes can be run in a slow motion so that students can get detail of them which otherwise they may miss. For eg:
The Linear Motion VR lab allows students to prove Newton's 2nd law using the Linear Motion VR software. A box is placed on the track at rest and the student can apply force on it using touch sensitive joystick. All parameters are adjustable: the initial conditions, the mass of the block and the coefficient of friction [8].

University of Colorado, Colorado Springs have virtual laboratories for chemistry courses. The VR chemistry lab is to provide students with an opportunity to carry out laboratory experiments that might not otherwise be possible because of hazards, expense, or time. Thus these experiments enhance the student's laboratory experience, rather than as a replacement for their conventional hands-on activities. They have five experiments involving radioactivity, and three involving gas laws. The experiments utilize photographic images of real laboratory equipment, and students are allowed to freely manipulate the objects in the laboratory. Each experiment has a lab manual that contains the instructions for carrying out the experiment, and procedures and questions for analysis of the results. The apparatus or either objects can be dragged and dropped and selected by clicking [9].

Augmented Reality has developed in various fields today like Games, Medical, Industry, Advertisements and Education. Augmented reality in Teaching is a good approach for making students learn and understand concepts in a better and interactive way.
Morten Fjeld, Benedikt M.Voegtli(2002) ("Augmented Chemistry: An Interactive Educational Workbench") describes about the application Augmented Chemistry(AC). AC is a workbench offering its users to see and interact with 3D molecular models in an intuitive and direct way [2].

Salaheddin Odeh, Shatha Abu Shanab, Mahasen Anabtawi, Rami Hodrob in "A Remote Engineering Lab Based on Augmented Reality for Teaching Electronics"[3] discussed about the appropriateness of Augmented Reality in Electronics Labs. The remote AR lab enabled the students to interact and perform experiments with the experimental setup that is located at some other place. This is made possible through internet and the students can easily access and perform experiments and know the output sitting anywhere.

IV. SYSTEM SETUP

In this setup, there is a handheld device like a tablet that would act as user interface AR device. We would have all the elements /chemicals in the laboratory labeled with a marker.
Markers play a very important role in Marker based Augmented Reality. Markers are the patterns or a type of 2D barcode that are scanned by the camera to view the overlaying image, any 3D object , a video etc behind them (as if it is placed on the top of the marker itself) on the AR device (Fig. 2)[5] . They work by software that recognizes the pattern of the marker. They are usually a square frame of black and white colour [4].

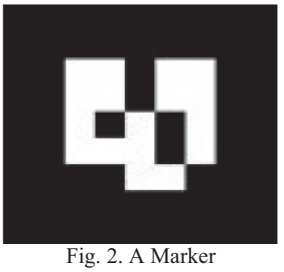
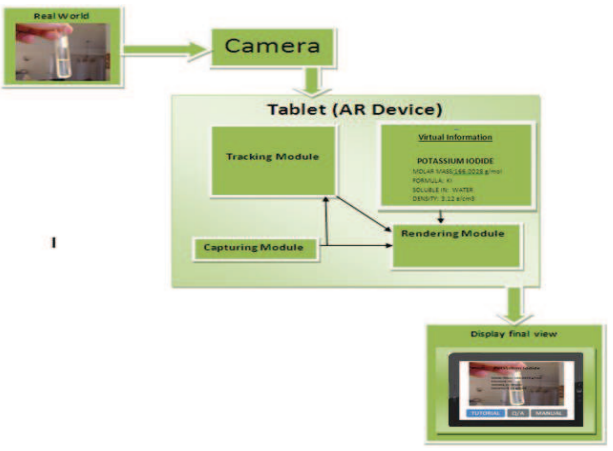


Fig. 2. A Marker

Markers aid the design of the Marker based AR systems .They are easy to implement and the toolkit of markers in also available easily and it provides a good base for AR systems development. Also the first step towards Augmented Reality is Image Processing, so the 3D coordinates of markers image are scanned and processed in order to view the augmented reality. So markers are the basic requirements for the marker based augmented reality and they support the AR systems.
The handheld device has a camera that would capture that marker on the containers of the chemicals. Markers are also pasted on the apparatus that are used to carry experiments.



Block Diagram of Chemistry Augmented Reality System

The user can interact by scanning any container in front of the camera. The capturing module captures the image from the camera. The tracking module calculates the correct location and orientation for virtual overlay. The rendering module combines the original image and the virtual components using the calculated pose and then renders the augmented image on the display. Scanning the container would display information about the chemicals or substance contained in that container. The students can take the chemicals he needs for his experiments in the corresponding apparatus with the same marker. Whenever the student brings the two apparatus containing the chemicals/substances together he can see the combination results on the AR device before actually performing the experiment. He will come to know what compounds will be formed. After seeing the combination results the students can actually perform the same experiment on his own and that results can be checked by the teacher. The AR device will have 3 options visible to the user:

A. TUTORIALS

With the tutorial option , the user can learn to perform experiments. He can just scan the apparatus containing the desired element through camera and the properties of that element would be displayed on his screen. Similarly if he needs to learn how one element reacts with another element he can just scan two apparatus containing the different elements and the reaction result of the elements would be displayed on the AR device. If the user is trying to react two elements that are risky to react then the message of "RISKY REACTION" would be displayed on the screen.

Suppose he brings test-tube containing potassium iodide marker in front of the tablet he will see properties of potassium iodide. (Fig. 4a)

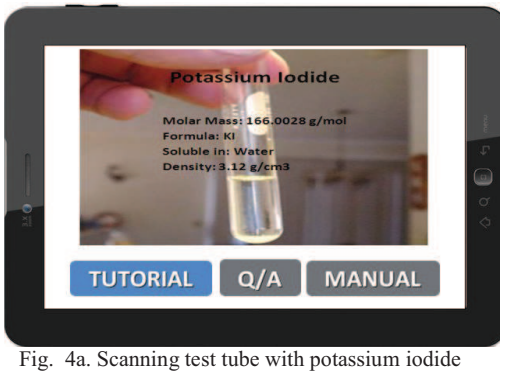


Fig. 4a. Scanning test tube with potassium iodide

If he scans test-tube containing lead nitrate he would see properties of lead nitrate. (Fig. 4b)

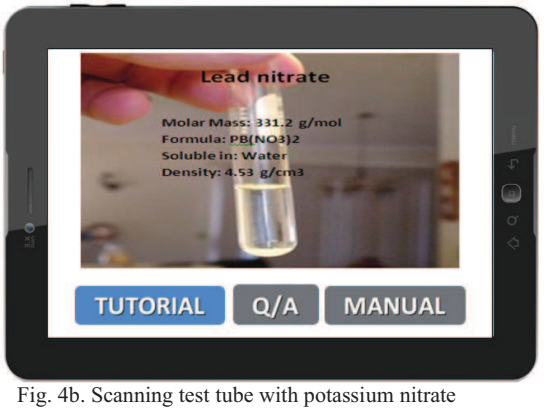


Fig. 4b. Scanning test tube with potassium nitrate

If he scans both test-tubes containing potassium iodide and lead nitrate together he will see the resulting reaction. (Fig.4c)

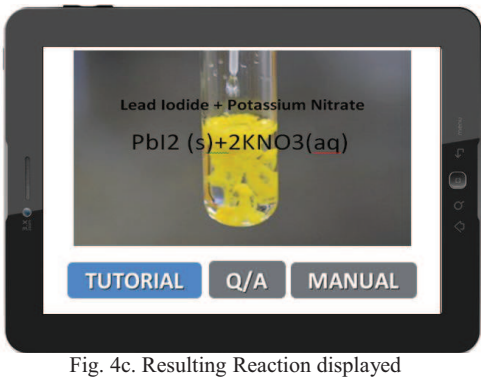


Fig. 4c. Resulting Reaction displayed

After seeing the results on his tablet he can perform the same experiment and get it checked by his teacher.

B. Q/A

It is the option for attempting a kind of test in which the user is asked question like "How is lead iodide and potassium nitrate formed?"(Fig. 5) .The user can tell the answer of the question by scanning the elements i.e; test-tubes containing potassium iodide and lead nitrate. If he is scanning the correct elements then the message would be "Correct" else it would be "Incorrect" and the correct answer would be displayed.

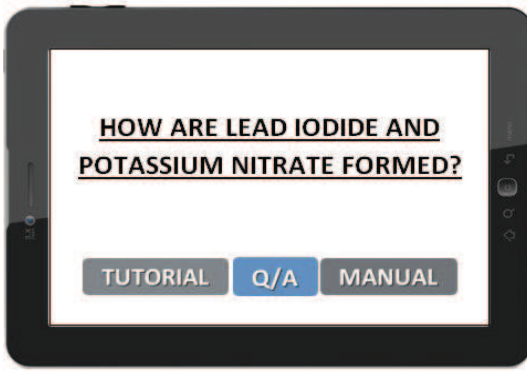


Fig. 5

C. LAB MANUAL BASED ON SPEECH RECOGNITION

Speech Recognition is a method of taking voice commands from the user as input and processing according to the said commands. Basically the voice taken as input is converted into electrical signals which are then transformed into coding patterns. This process allows the user's hands to remain free, so he can perform his experiments easily. This improves input speed to the computer because a person can speak much faster than they can use their hands typing or controlling the mouse [6] [7]. All the experiments of lab manual would be shown how to perform step by step. The user can perform the experiments with the step by step instructions. Once he performs one step he can give the voice command "Next Step". Using speech recognition the AR device shows the next step. Similarly it does for the previous step.

V. CONCLUSION AND FUTURE SCOPE

Augmented Reality is surely blurring the line between real environment and the augmented environment. AR applications are finding their rightful place in education very rapidly. The idea of using AR in chemistry labs is thought of because it has been observed that in chemistry lab chances of accident are high due to wrong reactions of chemicals. The App described in this paper can be used to reduce the danger of wrong chemical reactions. We can give tutorials for any number of reactions according to the prescribed syllabus of the students. Moreover the app also augments the learning experience of the student by making chemistry lab more interactive and interesting. Also this application would act as a teaching aid helping the teacher in the lab. Even if the teacher /instructor are not available in the lab the students can do their work. This app describes use of marker-based recognition of the chemicals in the lab. Each student can use his own tablet/ android device for using this App but we can also use a common camera or tracking device if the students are not in position of having their own device. In future, the app may use feature based recognition using state and colour of the chemicals / compounds.

VI. REFERENCES

[1] Mark Billinguist: "Augmented Reality in Education",Dec 2002,journal of New Horizons for Learning, Vol. 12

[2] Morten Fjeld, Benedikt M.Voegtli(2002) "Augmented Chemistry: An Interactive Educational Workbench", journal of Mixed and Augmented Reality,2002.Ismar 2002. Proceedings. International Symposium on Oct 2002 , p. 259 – 321

[3] Salaheddin Odeh, Shatha Abu Shanab, Mahasen Anabtawi, Rami Hodrob in "A Remote Engineering Lab Based on Augmented Reality for Teaching Electronics", June 2013,International Journal of Online Engineering;Jun2013 Special Issue 5, Vol. 9, p. 61

[4] Young-geun Kim and Won-jung Kim, Department of Computer Science Sunchon National University Sunchon, 540-742, Korea "Implementation of Augmented Reality for Smartphone Advertisements" ,International Journal of Multimedia & Ubiquitous Engineering,2014, Vol. 9 Issue 2, March 2014,p. 385,

[5] Siltanen, Sanni: Theory and applications of marker-based augmented reality. Espoo, VTT. 199 p. + app. 43 p. VTT Science 3, 2012, p. 38

[6] http://www.hitl.washington.edu/research/knowledge_base/virtual-worlds/EVE/I.D.2.d.VoiceRecognition.html , 25/09/2014 ,12:50pm

[7] http://www.123helpme.com/view.asp?id=44053: "Speech Recognition Software", 25/09/2014 , 8:18 pm

[8] Dedra Demaree, Stephen Stonebraker, Wenhui Zhao, and Lei Bao in "Virtual reality in introductory physics laboratories" in Physics Education Research Conference 2004, Part of the PER Conference series Sacramento, California : August 4-5, 2004 , Vol. 790,pp 93-96

[9] David R. Anderson, Ph.D. and Anthony C. Syme, Department of Chemistry, University of Colorado at Colorado Springs, http://www.uccs.edu/vgcl/about-the-vgcl.html, 2/10/14, 7:39 pm