

Adding Sensorial Capabilities to the Augmented Chemical Reactions Application

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Abstract— This work intends to describe and demonstrate a haptic prototype specifically developed to work with the software application *Augmented Chemical Reactions*. The main goal of the application and the additional sensorial device is to improve the user immersion in chemistry learning by offering 3D molecules visualization, on a monitor, by using augmented reality technology. The application allows students to manipulate the molecules using patterns for the interface instead of the common mouse and keyboard interface.

Index Terms— Augmented reality, Prototypes, Wireless communication.

I. INTRODUCTION

Teaching molecular structures in chemistry is usually done with two dimensional representations of molecules using blackboards or slides designed by teachers for their lectures. However, this could create additional difficulties to the students once the molecules are three-dimensional structures. The imagination of the spatial structure of the molecules in the 3D space could be a problem for them.

Therefore it is clear that understanding chemistry also depends on the comprehension of the spatial structure of the chemical parts. If the 3D understanding of the chemical structures is not given, the students have difficulties understanding certain behaviors of molecules.

There are many applications for the visualization of molecules in 3D on a two dimensional screen, which allow the rotation and the movement of 3D objects, but they are not that intuitive. With Augmented Reality, users can manipulate the virtual 3D objects in a simple and more intuitive way. We have shown [1] that the direct manipulation of a virtual object by using Augmented Reality improves the understanding of the spatial structure of a molecule more than using a 3D user interface with mouse and keyboard.

However, the human being should not be restricted only to vision, because he also can hear, feel vibrations and temperature. For this reason we decided to go a step further by integrating sound and vibration in this application and developed a haptic prototype. With the addition of these innovations it is expected that the learning experience will be enhanced.

II. AUGMENTED REALITY IN CHEMISTRY

Augmented Reality is a technology that adds virtual information or objects interactively and in real time to the real world. This generates the impression that the added information is part of the physical world.

Augmented Chemistry [2] and *Augmented Chemical Reactions* [3], [4] are systems which use Augmented

Reality to deliver a direct manipulation 3D user interface to control the position and orientation of the virtual objects.

The application *Augmented Chemical Reactions* employs a physical cube with a handle that is surfaced on all sides with black and white patterns. It also has the ability to vibrate when two molecules bind, varying vibration intensity depending on the distance between them.

In a usual setup, a learner holds the cube by the handle and manipulates it while sitting at a desk in front of a monitor, Fig. 1. A webcam captures the scene with the cube. *Augmented Chemical Reactions* uses a marker tracking algorithm similar to the AR-toolkit [5], [6] to detect and recognize the currently visible patterns on the cube.

According to the size and the deformation of the patterns, the algorithm calculates their positions and orientations relative to the webcam. With this data, the virtual molecule is drawn on top of the webcam image and the vibration feedback is given to the user. The virtual molecule moves in unison with the physical cube.

The application allows the easy addition of new molecules with their patterns and supports various displaying methods as stereo on two screens, stereo head-mounted displays and ambient occlusion for a better depth perception. It is also possible to visualize a molecular dynamics simulation of the two molecules while simultaneously interacting with them.

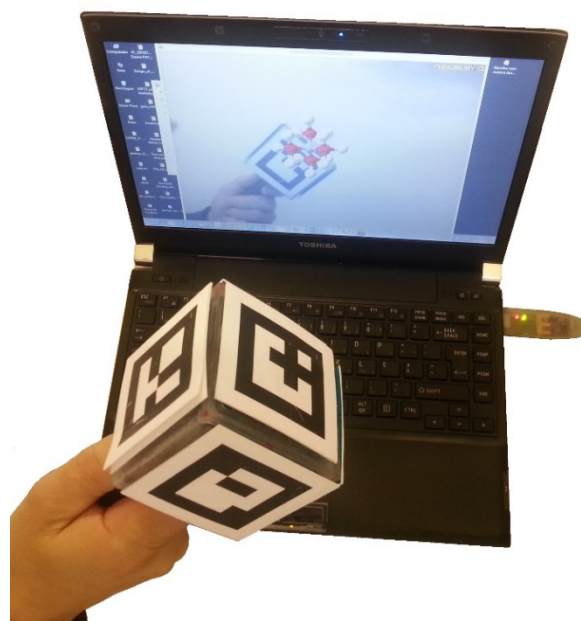


Figure 1. Augment Reality application and haptic prototype system.

III. CHEMICAL REACTIONS FEEDBACK PROTOTYPE

Looking to reach higher level of user immersion the integration of sensitive effects has been included into the pattern cube. A prototype to convey “feeling of chemical reactions” has been developed and will be described next.

The main requirements for the construction of the haptic prototype was the pattern cube size and the existence of wireless communication to ensure free movements between the pattern cube and the computer where the *Augmented Chemical Reactions* runs. The pattern cube with its handler and the USB antenna is presented in Fig. 2. The USB antenna is shown on the left hand side of Fig. 2 and on its right hand side is the pattern cube with the handler.

The electronic system includes: two microcontrollers and two antenna modules, both from Microchip Technology Inc., a vibration DC motor similar to those used in mobile phones, tension regulators, a battery charger IC and a motor controller.

The MRF24J40MA antenna modules were selected and employed for the USB antenna and for the prototype. This module supports the MiWi P2P Wireless Protocol, a simplification of the ZigBee protocol. The MiWi P2P protocol is designed to act in direct and simple connection process communication topologies, like STAR and P2P. One of the protocol simplifications is the handshaking which is made only in two steps: the demanding device sends out a P2P connection request command and any device within radio range responds with the adequate protocol command which ends the process [7].

The microcontrollers chosen for the USB antenna and for the pattern cube were different because of the needs for each situation. The USB antenna has the requirement for this communication and therefore a microcontroller with an integrated USB peripheral has been chosen. On the side of the pattern cube is important the ability to control a DC motor using the Pulse-Width Modulation (PWM) peripheral to drive the motor.

Inside the pattern cube the electronic board and a vibration motor was mounted. Fig. 3 depicts the developed electronic board.



Figure 2. Wireless solution of a haptic prototype for the *Augmented Chemical Reactions* application.

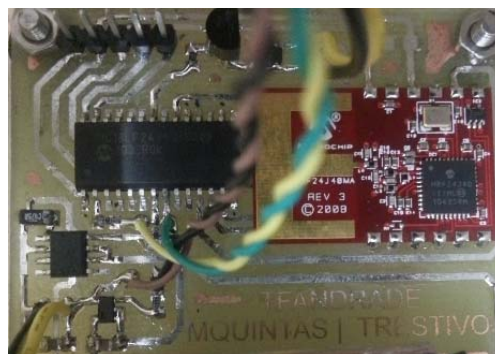


Figure 3. Electronic board located inside of the pattern cube.

IV. CONCLUSIONS

This work intends to describe and demonstrate a haptic prototype specifically developed to work with the software application *Augmented Chemical Reactions*. The main goal of the application and additional sensorial device is to improve the user immersion in chemistry learning by offering 3D molecules visualization, in a monitor, by using augmented reality technology. The application allows students to manipulate the molecules using patterns for the interface instead of the common mouse and keyboards keys.

The system was enthusiastically received by teachers from chemical area and from public in general. During the Exhibition Session at REV'14 a careful survey will be conducted in order to collect more solid results as well as during the present academic year with students in the Chemical field.

ACKNOWLEDGMENT

This work is funded by National Funds through FCT - Foundation for Science and Technology under the project (PEst-OE/EME/LA0022/2013).

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