Real-Time Dynamic Lighting Control of an AR Model Based on a Data-Glove with Accelerometers and NI-DAQ

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Abstract. The lighting of models displayed in Augmented Reality (AR) is now one of the most studied techniques and is in constant development. Dynamic control of lighting by the user can improve the transmission of information displayed to enhance the understanding of the project or model presented. The project shows the development of a dynamic control of lighting based on a data-glove with accelerometers and A/D NI-DAQ converter. This device transmits (wired/wirelessly) the signal into the AR software simulating the keystrokes equivalent to lighting control commands of the model. The system shows how fast and easy it is to control the lighting of a model in real-time following user movements, generating great expectations of the transmission of information and dynamism in AR.

Keywords: Real-time lighting, NI-DAQ, Accelerometers, Xbee, Data-glove, augmented reality.

1 Introduction

Augmented Reality (AR) is mainly a developed tool for the visualization of 3D models and other relevant information overlaid in a real world scenario. Using this technology, we find previous studies about the relationship between student motivation, degree of satisfaction, and the user experience or student perception in the interaction with and teaching of applied collaborative works is extensive, with recent contributions that have helped to design new e-learning experiences or dislocated teaching using IT, and advanced visualization tools like AR [1], [2].

This technology is more extensively studied from a technological perspective (the Institute of Electrical and Electronics Engineers (IEEE) International Symposium on Mixed and Augmented Reality (ISMAR) is the global reference in these advances) or from the perspective of sociological and communication impacts (as addressed by the annual conference of the International Communication Association) instead of its educational capacity or ability to transform teaching and education.

From the first experiences using this technology [3], we find different works that proposes a prototype that helps users to interact with the world, and more recent

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proposals for users in their everyday interactions with the world [4], which shows a device that provides real-time information to the user.

The 3D models are being used in the field of architecture for the visualization of projects for years [5]. The incorporation of AR to these types of projects [6] has increased expectations of the use of this tool reaching to situate the 3D model in the place where it will be build [7].

This capacity of AR technology, which shows a "completed" reality superimposed on reality, allows for the creation of an impossible image of what does not exist as a result of the analysis of existing building systems (e.g., structural, facilities, and envelope) and geo-location and photo composition. AR could facilitate rehabilitation and maintenance tasks, systems verification, and interactive updates in the same place and in real time, promoting more efficient management and control processes of building construction elements [8].

All of these improvements in space visualization and interpretation have clear relevance to the professional world and lead to a teaching process that allows for the rapid assimilation of concepts by the student [9].

The main objective of the project is generate a simply dynamic lighting control based on a data-glove with accelerometers to interfere in advanced 3D visualization software used in the architecture framework to evaluate the behavior of shadows in 3D project models used in architecture education.

2 Using AR and Advanced Lighting in Educational Environment

One of the challenges of visualization in these types of projects is lighting. Previous experiences have been developed with students in the visualization of objects that include lighting as a resource to achieve a better light immersion. The problem of virtual models illumination and how it can be integrated into the scene has been also widely discussed. In the first approaches to RA, the virtual object was simply overlapped in the real environment.

Major advances in technology focused on the correct calibration and registration of objects, studying the possible effects of occlusion and spatial coherence of objects, regardless of any other adaptation of the object in the scene. In other words, once the object was included in the scene, it was an artificial object, unable to adapt to the changes in environmental light. That kind of configurations lacked realism, and consistency of the scene was based only on geometrical aspects [10].

The sensation of realism in the scene is obtained primarily through visual interactivity. While it is true that as more senses involved, a greater sense of realism is achieved, a realistic immersion system should be able to create a complete visual simulation or as close as possible to it “Fig. 1”.

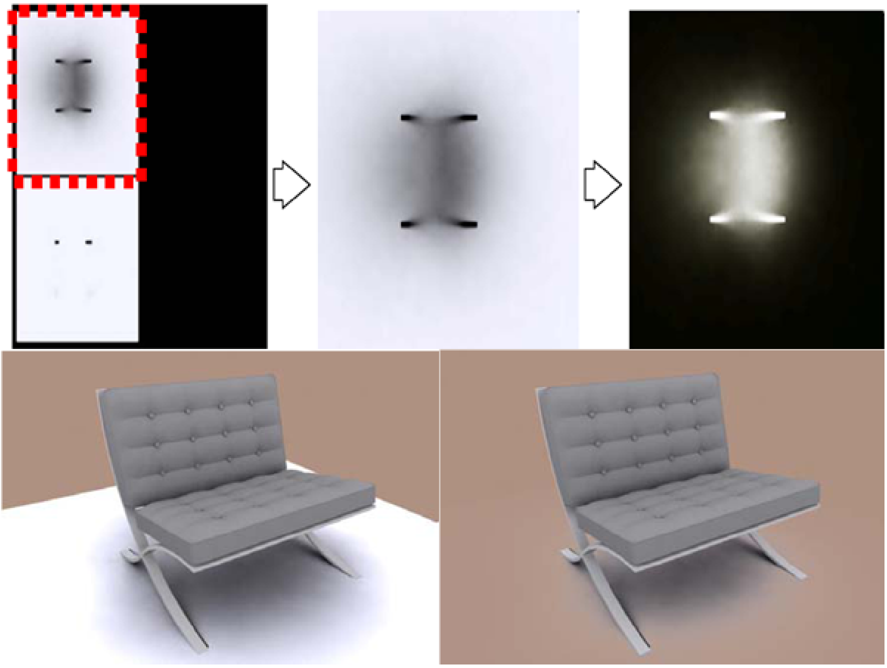

Fig. 1. Texture maps to cast shadows in real space. On model basis, a lightmap is assigned as the main texture, and its inverse image is assigned as an opacity map to acquire transparency. So black pixels remained transparent, leaving visible only the cast shadow area.

Despite of all these improvements, the uses may lose the attention of the presentation during short necessary breaks needed for the presenter to interact with the computer for activating necessary commands (such keystrokes or mouse movements) for generating the desired changes to the model.

From an educational point of view, it is proved [11] that removing or minimizing the impact of these breaks can avoid the loss of attention from audience/students. Previous experiences [12], aims to improve comprehension of the project presented.

For this reason our department (Architecture La Salle, Ramon Llull University in collaboration with Graphical Expression Department of the Polytechnic University of Catalonia – UPC) has an active open line of research about the impact of technology on improving the understanding of the information presented.

As a part of that line of research we are working on a project that allows the possibility of interaction with the hardware used for showing the information in a real-time intuitive way.

One of the hypotheses of the project is to quantify the change in the dimension of the project presentations.

To allow this interaction, we have embedded electronic components such as accelerometers and sensors to devices like "data gloves", commands, models or objects related to the project. This offers a wide range of possibilities in constant development up to date, making the presentation more spectacular.

These devices allow independence and self-reliance during presentation, so that the transmission of the information can be better focused on the audience as revealed by other studies [13].

In this case an application has been implemented for acting in the software AR-Media Plugin® of Inglobe Technologies® for Autodesk® 3DS MAX.

The main thing of the software developed consists in simulating the keystrokes and mouse movements which controls the AR-Media Plugin depending on the information received from the device controlled by the presenter.

Thus, with this movements acquired by the "data-glove" or model we can modify the parameters of the light source, its path or even show additional content of the project with no need to approach at the computer.

We are currently working on the first of the four phases in which the project is formed:

- **1st Phase: Project Definition:** Defining the problem; Proposed solution; Implementation; Study hypothesis.
- **2nd Phase: Study.** First tests; Data acquisition.
- **3rd Phase: Analysis**. Analysis of results; Hypothesis review; Proposed improvements.
- **4th Phase: Improvements**. Implementation; Test.

3 Materials and Methods

The lighting control is performed by an application in Visual Studio.net (VS.net) that is able to acquire data from external devices such as sensors, transducers and accelerometers, as in other references [14]. The developed system provides an effective solution for the data collection system in real practice [15].

This particular project has been implemented in two versions, the wired version (A) and the wireless version (B) with same functionality but different features. In both cases we use the triple-axis ADXL335 accelerometer.

3.1 Wired Version (A)

The accelerometer is embedded inside a polystyrene sphere "fig. 2", simulating the Sun as light source. With NI-DAQ6009 from National Instruments® supplies 2.5V and capture input analogic signals in AI0, AI1, AI2.

This system proposed allows scanning full scale and captures the sensibility of the movement by the user changing the position of the light source. Once we have the signal digitalized and quantized a basal value is fixed corresponding to a neutral position of the accelerometer.

From this point, the movement of the data-glove modifies the output signal corresponding to x, y, z axis.

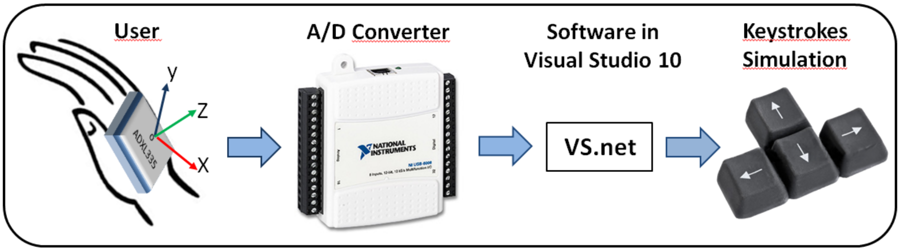

Fig. 2. Application architecture of version A

The developed software associates each value of the NI-DAQ6009 inputs with light controls of the plugin for modifying the position of the light source.

For moving the light source to the right, the software simulates the keyboard key "→", move left "←", move forward "↑" and move backwards "↓". To move upwards in z axis the user needs to push the following key combination: "Ctrl+↑" and "Ctrl+↓". The "Fig. 3" shows the diagram of the dataflow generation and acquisition.

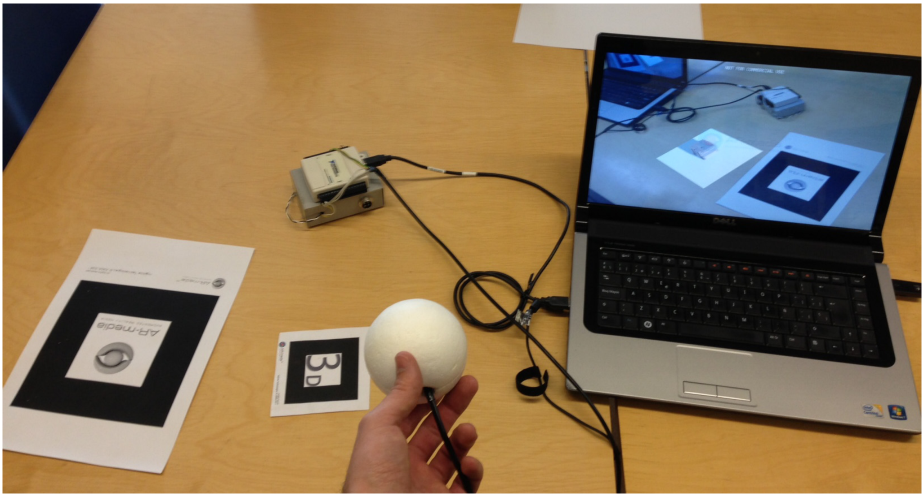

Fig. 3. Image of the implementation with the wired polystyrene sphere and the NI-DAQ6009

3.2 Wireless Version (B)

In this case, two XBee® RF Modules are used [16]. These Modules, the 3-axis accelerometer and the breakout board FT232 RL USB to Serial are weld and configured properly "Fig. 4".

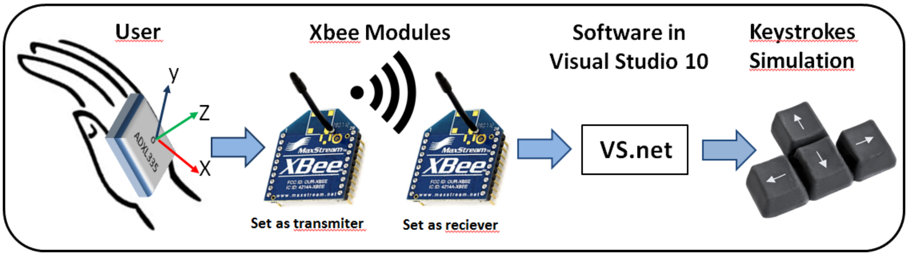

Fig. 4. Application architecture of version B

When connecting any analogical output of the accelerometer to any digital input of the XBee® set as a transmitter, it is important to know the behavior of the data transfer system. If the value of the signal from the accelerometer exceeds 2,5V, the behavior on the digital input it is like writing a “1” and when the value is lower than 2,5V, means writing a “0”.

This data package is received by the other XBee® module set as a receiver and transmitted to the PC via the breakout board FT232 RL USB to Serial port. The software reads this data package as data-glove movements and according to these values the keyboard keys are simulated “Fig. 5” in the plug-in AR-Media® in 3DS MAX® environment.

```
If X_Axis > 2.6 Then
    SendKeys.Send("{DOWN}")
End If
If X_Axis < 2.1 Then
    SendKeys.Send("{UP}")
End If
If Y_Axis > 2.6 Then
    SendKeys.Send("{RIGHT}")
End If
If Y_Axis < 2.2 Then
    SendKeys.Send("{LEFT}")
End If
```

Fig. 5. Commands in VS.net for simulating keyboard keys for *x* and *y* axis of the accelerometer. The same for *z* axis

4 Conclusions

The results of the design of the project make us to fix the target in the following concept: how is it possible to increase the ease of use in dynamic lighting control based on a data-glove with accelerometers or other human interface and the ability to interfere in advanced 3D visualization software with simple lines of code.

The partial control of the 3D software with two versions with the same functionality notes that the design of the project developed improves handling and speeds up user interaction. Furthermore, the real-time gestures read by the device give more realism and makes the user immerse itself into the project.

This project has been developed in the department of Architecture La Salle, Campus Barcelona, Universitat Ramon Llull. The aim of the research is to find new ways to explore interaction of users with projects of architecture. This study case goes deep into the lighting processes of the architecture illumination. The interaction in real time could improve the strategies to project the shapes of architectural designs of the buildings in order to get profit of the solar radiation and being more energy efficient. This approach to solar studies will generate results which will be one way to reach a sustainable architecture thanks to Augmented Reality.

The next phase (modeled by the CAD/BIM/AR group of the same faculty), will be perform during the 2012-2013 academic year with students in their fourth year of an Architecture and Building Engineering degree. The experimental framework is in progress in the course “Sustainability and Energy Efficiency,” a nine-ECTS-credit course that is taught in the second semester.

In summary, this project presents a smart way to interact on very powerful software packages allowing emulate its commands from an external device equipped with sensors, accelerometers or other components integrated in data-gloves or data-suits. Simulating control commands with few lines of code enhance the presentation to a higher level. The solution tested in this project with 3DS MAX® and the AR-Media Plugin®, can be extrapolated to almost all 3D modeling and AR programs.

Next step in Phase 2 of the project is the evaluation with users to obtain results in order to study the first design and possible changes to improve the system.

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