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Integrating Building Information Modeling with Augmented Reality for Interdisciplinary Learning

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ABSTRACT

Augmented Reality provides a way to enhance the classroom experience. In particular, student learning about building systems in the fields of Architecture, Civil, and Mechanical Engineering may improve, if visualization outside the classroom is provided. We propose that AR-SKOPE, an application that integrates Building Information Modelling and Augmented Reality may improve learning. This application allows students to visit specific buildings and investigate their various systems with supplementary information using a phone or tablet. We are currently testing our early prototype to conduct a semester-long study.

Keywords: Augmented Reality, Teaching Tools, Building Information Modelling, Architecture and Engineering Education.

Index Terms: H.5.1 [Information Interfaces And Presentation]: Artificial, augmented, and virtual realities; K.3.1 [Computer Uses in Education]: Computer-assisted instruction (CAI).

1 INTRODUCTION

Recent research shows that Technology Mediated Learning Environments, particularly Augmented Reality (AR) can be critical in developing the next generation of computer-based learning environments [1]. These environments can be designed to create realistic, immersive learning experiences for a variety of educational contexts [2].

The project described here is developing "AR-SKOPE Learning System"–a learning environment designed to improve students' understanding of complex building design and construction systems. In addition, it aims to facilitate interdisciplinary collaboration among students in the Architecture, Engineering and Construction Management Fields. The focus of our work is to describe AR-SKOPE, its functionality and its path forward as we prepare to enter a semester-long study.

AR-SKOPE integrates AR with Building Information Modelling (BIM), visual simulations, and interactive lessons. Using this tool, students can walk around a building and experience it with augmented information and lessons. As if having an x-ray vision, holding a handheld device (e.g., tablet), students can move around the building and interact with its various components. The AR-enabled walk-through of buildings is expected to facilitate students' learning process by providing an interactive, annotated 3D model of the building for visual understanding of details. By providing location-sensitive information and supplemental lessons, student learning is supported through engaged interaction and experiential learning [3].

2 BACKGROUND

Various applications that bring together AR and BIM have been developed. Such applications are built with a focus on information about important buildings in select places. For instance, Lee and Billinghurst developed CityViewAR—an application capable of providing information about historical places that have been damaged in the city of ChristChurch, NZ [4]. Another example is Smart Vidente—an application used for visualizing underground infrastructures design and maintenance [5]. Other applications, although not focused on the exterior aspects of buildings have made practical use of BIM and AR with a focus on Interior Design [6]. One aspect common to all these applications is the means through which the information obtained from both real and virtual environments is intertwined and delivered to the users. Mobile technologies serve as the bridge between both worlds. With regards to the means through which positional data is obtained, most of these applications make use of the GPS information that is made available by the mobile platforms as in [7].

3 AR-SKOPE

AR-SKOPE will be available for students taking a multi-disciplinary class at Florida International University. In the near future, we expect the application to be publicly available. We have developed a typical nearest neighbour algorithm (see Figure 1) using PostgreSQL (with standard PostGIS functions) using geo-data from our own map services (www.terrafly.com) and other geo-location services. The application is currently built based on Unity 5 with Java and Android bindings for direct access to motion sensors (Unity filters the accelerometer). The main contribution of this application is to use sensor fusion (GPS + motion sensors) to determine the students' position (once the building has been locked). Through the primary use of this application, students can gain additional information after class about the structures they learned. Architecture students create the models and internal structures. The application is developed to be used by students in architecture, civil engineering, mechanical engineering and construction management classes.

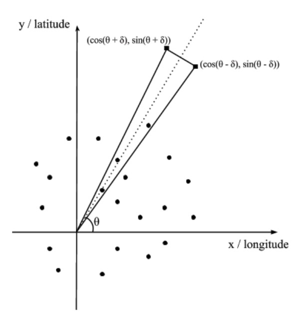

Figure 1: Geo-Location Algorithm.

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Figure 2: AR-SKOPE showing the building's mechanical system information overlaid on the building.

AR-SKOPE provides a navigation menu that has four tabs of 1) Envelope System, 2) Structure, 3) Mechanical System, and 4) Construction, as shown in Figure 2. Selection of each tab activates the correlating component of the BIM model, revealing visual and textual information. These tabs can be used to display a building component individually or in combination with others. When combined, they can provide a better understanding of the relationships between the components and their integration.

Each tab, once clicked, presents its own submenu which contains new tabs for diagrams, animations, and other content specific to the building components being displayed. These learning modules work in coordination with the current components as a secondary and more detailed overlay of information. The content can then be toggled on an off at the user's request, as they are overlaid and updated in real-time.

For example, when the envelope systems tab is selected, it enables the user to visualize the components of the façade that are not explicitly visible from the exterior. This consists of multiple layers of information including wall composition, façade elements, as well as the assembly system. It allows the user to better understand the complexity of the building's envelope system. For example, the student can understand what she is looking at is composed of reinforced concrete with a layer of gypsum board, insulation, window casing, form tie, aluminum window frame, and double glazed window system.

With these details now visible, textual information appears to describe the envelope components and their functionality. The student is also able to see the list of these materials with their thermal resistance (R-value) and other important metrics. While exploring various features of the application, the student also has access to the Core Concepts modules directly by using any of the tabs in the displayed submenu. The Core Concepts Modules include lessons with animations and highly detailed graphics.

The digital content of AR-SKOPE is constantly updated to match the user's direction, location, and video background by accessing the device internal sensors. This allows the virtual information to overlay accurately with the building in the real world. The application's content is updated based on both the user's location and viewing direction.

In order to track the user's movement, the application uses the device's motion sensors (accelerometer, gyroscope, and compass) in conjunction with periodic checks from the GPS. The angle and direction of view of the user are determined using the device's gyroscope along with the compass. The data is constantly collected during runtime and passed through algorithms to filter and smooth out as much noise as possible from the device. The filtered data is then used to translate and rotate the virtual camera to match the device camera in the real world. This technique of using multiple sensors in conjunction calls for a more accurate overlay of digital content over the building. This information can then be displayed according to the user's input via the user interface.

4 Conclusion

This project builds on recent educational theories that show novel developments in AR, coupled with improved user interface technology that presents numerous opportunities in support of teaching and learning environments [2]. The described project here is an early prototype. It is expected to run a study with a class for Fall 2016 to see if the use of this application will improve learning strategies. Moreover, the collected data from the project testing will contribute to our understanding of how people learn with the integration of BIM and AR technologies.

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