Final Project: Integrating HCI Techniques in the Design and Development of AR/VR Technologies

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Abstract— **This paper reports on the development of a Mixed Reality (MR) game prototype via HoloLens and Unity Engine. We aim to investigate how we can incorporate immersive multimedia technologies such as HoloLens as a potential form of STEM learning for students in the HCI context. The project idea is to investigate applying the Human-Computer Interaction (HCI) context to Augmented Reality (AR) for education . We want to identify the user interactivity with the AR digital content and how Mixed Reality technologies such as HoloLens as a potential form of STEM learning for students. This paper also proposes methods for testing the game's effectiveness as a learning tool. The aim of this project is to provide insights into how HCI principles can be effectively applied in AR for educational purposes. We expect to develop AR prototypes that can enhance the learning experience, as well as provide recommendations for further research and development in this area. The project will include different AR scenes using Unity engine: Including Menu bar, buttons, 3D model objects. And will determine the user interactivity with the different objects.**

Keywords: **Mixed Reality, AR/VR, Gestures, Applications, Interaction, HMD, Spatial, Implementation, HCI**

I. INTRODUCTION

The Augmented Reality (AR) displays have an exceptional characteristic from the Human–Computer Interaction (HCI) perspective. Thus, this study describes personalised gesture interaction in VR/AR applications for immersive/intelligent environments [1]. Augmented Reality (AR) and Virtual Reality (VR) are burgeoning areas of study within the field of Human-Computer Interaction (HCI). They offer the potential for highly immersive and interactive experiences, which can transform fields such as education, healthcare, entertainment, and many others

With the integration of AR/VR technologies into training purposes, new forms of learning are possible in STEM classrooms, encouraging engineers to innovate and develop new technologies while training for tasks that can benefit them in their future careers. In many STEM classrooms, the notion With new technologies, educators can reach more users through a more interactive experience. They can increase the level of understanding for each student by, for example, engaging them with a game- like device that hooks them onto the material and teaches many concepts and theories [2]. A technology that is at the forefront of various emerging technologies is Mixed Reality (MR), which has shown the potential to benefit the academic field in many ways [3]. MR is a combination of Virtual and Augmented Reality that enables users to interact with digital objects (Virtual) in a physical environment (Augmented).

II. SECTION: REVIEW OF LITERATURE

A. Related Research in Visual Learning

Visual learning constitutes an essential aspect of how students engage with the learning process, and we aim to show that an interactive educational tool like MR can fulfil that role. This multimedia technology would not only help students understand how the user interacts with 3D model objects. One study in Malaysia points out the importance of MR when integrated into the learning process by experimenting with primary school students [6]. Their study was showed that motivation levels were high because children never gave up the game. Even when feedback showed the children were playing incorrectly, nobody quit the game until reaching the solution. The children's overall reaction to the system was very positive in the experiment, and most importantly, they concluded that the system didn't make the learning process go wrong. This study suggests that MR can help students with their imagination and originality, which is an essential aspect of our research..

B. Related Research in AR/VR in Industrial

Implementing AR/VR eliminates the need to be physically present at a factory. It allows high-risk tasks to be replicated with ease and possibly no injuries, therefore proving the effectiveness of MR applications in the industry. Sims [5] introduced Boeing VR/AR technology for aircraft design and manufacturing, where engineers in helmet-mounted displays can explore the aircraft long before any production begins. Previous studies have explored innovative methods of teaching

plant design in chemical engineering courses, such as [9], who found that a virtual field trip was a helpful supplement to real field trips to chemical plants, and [10], who designed a problem-based learning method for teaching plant design.

C. *Related Research in HCI in AR/VR*

Moreover, in the HCI context this made me realize the importance of feedback and hints when users are playing the game this brings the concept of HCI in context. The AR app will include interactions and animations added to the 3D Industrial model, and we crossbuilt the Unity application to the HoloLens device, allowing the user to interact with the model in a real-world environment. The game

III. SECTION: METHODOLOGY

This section we are going to talk about the different components of AR/VR technologies are related to the HCI.

A. *Display Technologies*

This includes VR headsets, AR glasses, smartphone screens, or monitors. These devices are critical to HCI because they're the primary interface that allows users to visually interact with the digital environment. The user can interact and manipulate the virtual objects and move them from place to place to achieve mission goals that allow them to transfer to the upcoming level. For Head-Mounted Display (HMD) devices are a significant part of the evolving landscape of Human-Computer Interaction (HCI). HCI is about designing and understanding the interaction between humans and computers, and HMDs present a new and innovative way for this interaction to occur. HMDs, especially those used in VR and AR applications, often use different interaction methods. This can include gaze tracking, gesture recognition, and even brain-computer interfaces. These new interaction methods present new challenges and opportunities for HCI researchers and practitioners. HMDs can provide a highly immersive experience, which can dramatically change how users interact with computers. For example, in a virtual reality application, users can feel like they're inside the computer-generated world, and in augmented reality applications, digital information can be overlaid onto the real-world.

Figure 1: Example of HMD Devices in the current market

B. *Input Methods – Mode of Interaction*

The main methods to interact in a Mixed Reality environment via HoloLens are using gaze, gesture, and voice. Gaze involves targeting the hologram, gesture allows the user to select or interact with the hologram, and voice adds another dimension to interactivity where users can say commands to virtual objects. Voice can also be used to seek assistance when a user is stuck on stage in the game. Figure 1 shows the possible hand gestures. Users can perform the bloom gesture in opening the application while the remaining gestures help the user interact with the objects.

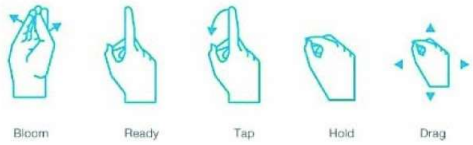

Fig. 1. Progress of phone biometric system for screen lock

We can harness this technology to bring a user's technical and abstract concepts to life by having a visual depiction of the ideas they learn. The main methods to interact in a Mixed Reality environment via HoloLens are using gaze, gesture, and voice. Gaze involves targeting the hologram, gesture allows the user to select or interact with the hologram, and voice adds another dimension to interactivity where users can say commands to virtual objects.

C. *UI/UX Interaction*

This encompasses the design of the information presentation and the overall experience of interacting with the system. AR/VR systems often require novel UI/UX approaches to make the interaction intuitive and immersive. From an HCI perspective, this is a significant area of focus and research.

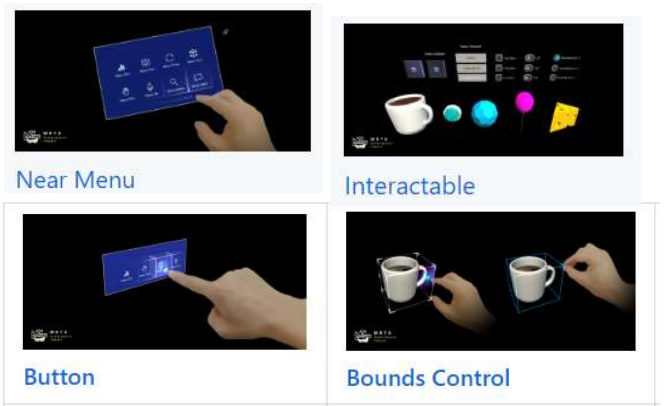

Figure 3: Different UX building blocks in HoloLens

The above figure shows the difference UX blocks used in HoloLens. For example, interactable have script for making objects interactable with visual states and theme support.

IV. SECTION: IMPLEMENTATION

We are going to implement a game application using Unity engine. The application will include a Mixed Reality Desalination plant model made in Unity Software engine. The application will show the different HCI aspects of the Mixed Reality application.

A. *Setting up the Scene*

1) Install the required software

Have the necessary software installed on your machine. This includes the Unity Engine itself, which is available from Unity's website. Additionally, you need the Mixed Reality Toolkit (MRTK) for Unity, which is available in GitHub, provides a set of components and features used to accelerate cross-platform MR app development in Unity.

Figure 5: Software and tools to set up MR environments

2) Create Project

Once the software is installed on your machine. Open Unity and create a new project. Choose the 3D template for a mixed reality project as shown in below Figure 6. Prefer to chose Unity LTS version 2018 and higher.

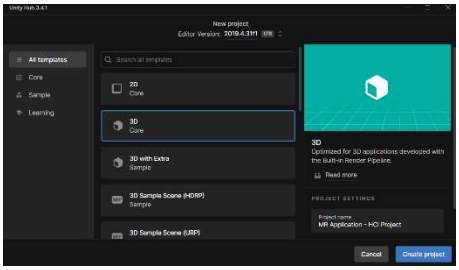

Figure 6: Three representation of Images uploaded to the network[1]

In the above Figure 6, The two images uploaded is of the same person (Picture No 1 and Picture No 2) and the third image (Picture No 3) is another person's face.

3) Import MRTK toolkit

Import the MRTK packages into your Unity project. You can do this by navigating to Assets > Import Package > Custom. Package, then selecting the MRTK package you downloaded. Once imported, MRTK provides a configuration profile that sets up your project for mixed reality.

4) Setting up Scene

The scene your project is set up for Mixed Reality. The below scene involves adding and arranging 3D objects, applying textures, and setting up lighting to make a Desalination plant. The individual 3D components were imported open source 3D modelling websites: CGTTrader, Unity's Asset Store.

Figure 7: Desalination 3D Model in unity scene

5) Adding Interactivity

The interactivity is added by creating C# scripts or using pre built custom scripts from MRTK library. These include hand grabbable script to drag and drop 3D objects from one position to another in scene space. We also use FSM tools such as Playmaker to add logic state interactions. Example of this is given below Figure 8.

Figure 8: playmaker State Logic interactions [1]

B. *HCI Concepts in Scene*

1) Safety Game Scene

The below pictures represent the simulation using the Unity software. Since the headset is not available therefore the emulation view is shown to the user using the play scene in the

Unity software. The scene should accurately simulate the industrial plant and potential safety scenarios, and respond appropriately to the worker's actions and purposeful.

Figure 8: Safety Scenario animation 3D Model in unity scene

The above Figure is a scene provides a training scenario what happens if there is a fire outbreak in the Desalination plant. The User should select the Inventory components which can reduce the effect of the fire and eliminate the hazard. needs to be robust and responsive. We can see the Fire extinguisher (blue) and the green arrow pointing to provide the user the location of the hazard.

By using the custom script. ManipulationHandler from the MRTK toolkit library. We can able to drag 3D objects from one location to another. Therefore in this instance, created a plane location which is correct. Since the Desalination plant works like a process. Therefore the user have to drag the right component in the correct location.

Initially the user can see two arrows. The arrow to the far right is pointing to the inventory section. Which shows the user to drag the component. And the arrow pointing to the left is the destination of the component for the object. The arrows guide/provide an instruction to the user through a certain process to place the 3D model to a specific location

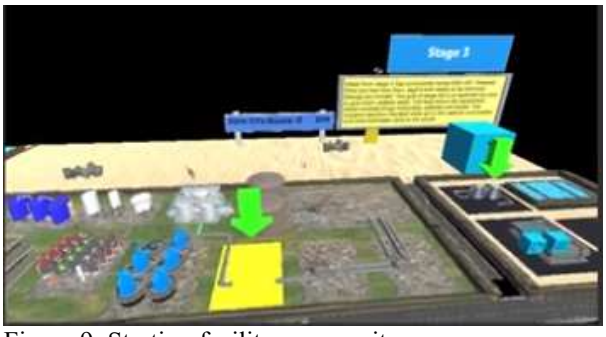

Figure 9: Starting facility game unity scene

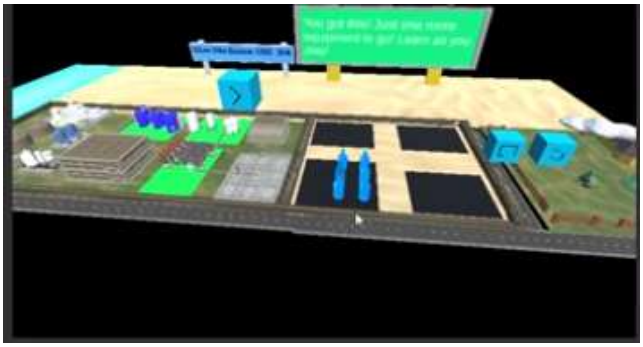

Figure 9: User placing correct object

The above Figure shows the component being dragged from the Inventory section to the Facility section in the correct location (which represents the green plane).

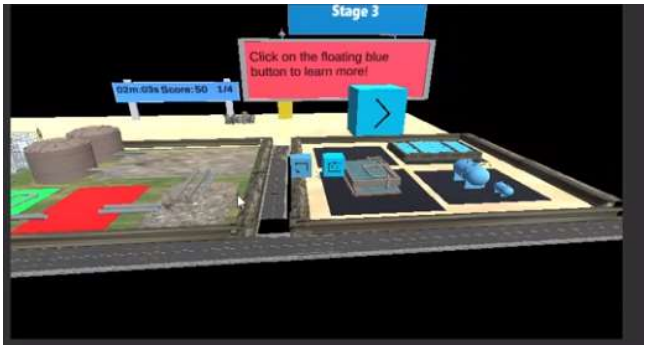

Figure 10: User placing incorrect object

The above Figure shows another component being dragged from the Inventory section to the Facility section in the wrong location (which represents the red plane). The above two images show different plane colour represents the correct and incorrect action from the user. This provide feedback to the user.

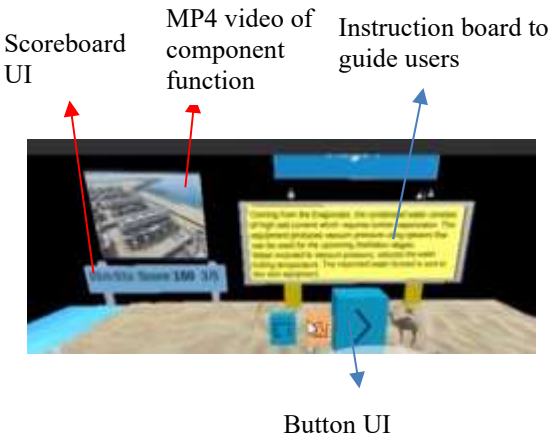

Figure 11: Different UI components ın the scene

The above figure shows the different UI components which are placed behind of the scene. This includes text boards, mp4

video, buttons. The mp4 video appears when user clicks mp4 button (orange) in Figure 11.

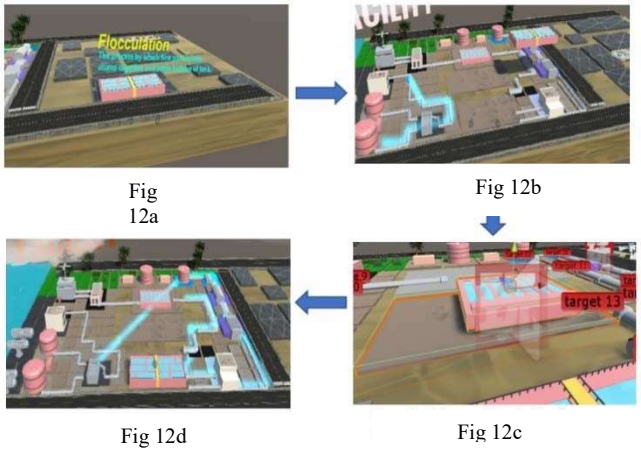

Fig 12a

Fig 12b

Fig 12d

Fig 12c

In figure 12a (top left), the user first gazes at the element, which provides the component name in yellow font and its description in blue font. This interactive text that is centralized on top of the model allows the user to see the text and the 3D model at the same time.

Compared when the user is reading a textbook, the text and the figures can be in different locations of the page, and pictures are 2D that cannot be rotated or moved, thus reducing the visual form of learning. We can also see the water flow movement represented as particles.

V. SECTION: CONCLUSION

We can see the digital content in this case the Industrial Desalination plant is integrated into the user's physical environment, which allows the user to have a more immersive and intuitive user experience. The project aims to complement the learning process of technical concepts through the implementation of HCI techniques in multimedia technology like HoloLens. By considering different visual elements and interactivity to the users, this will allow users to be more engaged in the subject matters they learn, and our project provided a visual element to their learning process. However, in some cases need to consider potential issues of overload (too much 3D animation for the HMD to process which can cause lagging), and the virtual objects don't quite match the realism of the real world. In conclusion, the HoloLens is reshaping the landscape of HCI, pushing the boundaries of interaction design, user experience, and spatial computing. As with any emerging technology, there are challenges to be addressed, but the potential for creating intuitive and immersive interfaces is significant. This project also gives a new experience and perspective towards analysing and integrating HCI techniques in the design and development of AR/VR applications. Additionally, our project can be a stepping point for individuals to expand their research abilities to implement Mixed Reality technology to create more informational tools for self-educating purposes.

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