MID-YEAR TECHNICAL REPORT

Tsz Hei (Harry) Li

ID: 601904517

Email: tli623@aucklanduni.ac.nz

Department of Civil and Environmental Engineering

Project 140:

Improve the effectiveness of design meetings in projects with smartphone AR

Research Partner: Sahil Kapadia

Supervisors: Vicente Gonzalez & Nasser Giacaman

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1.0 Research

1.1 Unity 3D

Unity 3D is a multi-platform 3D engine that provides users with a user-friendly environment that can facilitate 2D and 3D development for games and applications in virtually all existing platforms. Even though it provides a workspace that's easy enough for beginners to use, it is also powerful enough for the likes of professional developers.

There's a number of advantages in developing the prototype on Unity 3D. Firstly, the prototype can be easily deployed into IOS and Android devices. This means the prototype development process is not constrained to a particular platform, thus allowing it to be more time-efficient. Secondly, the abundance amount of resources, such as pre-made models and script that are readily available in the asset store allows for a streamlined development process. Above all, the majority of the core functionalities within Unity 3D can be found within the free version, which was sufficient enough for this particular project. Therefore, Unity 3D is the most compelling software for this particular project.

1.2 ARFoundation

ARFoundation is one of the most popular types of platform used for Augmented-Reality development on mobile devices. It allows developers to create apps that are compatible with both IOS and Android operating systems at once by providing common multi-platform APIs in Unity3D. Furthermore, developers are allowed to work with functionalities from different platforms such as ARCore and ARKit, as shown below in Figure 1.

	ARCore	ARKit	Magic Leap	HoloLens
Device tracking	✓	✓	✓	✓
Plane tracking	✓	✓	✓	
Point clouds	✓	✓		
Anchors	✓	✓	✓	✓
Light estimation	✓	✓		
Environment probes	✓	✓		
Face tracking	✓	✓		
2D Image tracking	✓	✓	✓	
3D Object tracking		✓		
Meshing		✓	✓	✓
2D & 3D body tracking		✓		
Collaborative participants		✓		
Human segmentation and occlusion		✓		
Raycast	✓	✓	✓	
Pass-through video	✓	✓		
Session management	✓	✓	✓	✓

Figure 1: Table of features support per platform

As a result, ARFoundation can provide an immersive and robust AR experience with these functionalities. Firstly, light estimation automatically adjusts the colour temperature and brightness of virtual objects based on the real-world surroundings. Therefore, allowing virtual objects to appear realistic at all angles. On top of that, human segmentation and occlusion allow virtual content to integrate into the physical world realistically. Furthermore, ARFoundation's plane tracking and raycast functionalities are

used to detect and develop its own understanding of the real world. In order to provide a high-quality AR experience for users. All mobile devices must pass the certification process where the quality of the camera, motion sensors, CPU and the design architecture must be sufficient enough for providing good performance. Although the number of compatible devices has greatly increased in recent years, the vast majority of them are either flagship or mid-range mobile devices. As a result, it raises the barrier of entry which makes it less feasible financially for companies.

1.3 Vuforia

Vuforia Engine is one of the oldest AR development platforms, with support for mobile devices and eyewears. It consists of computer vision technology that's able to effectively detect planar images and the physical surrounding in real time, to enable intuitive interactions with virtual objects through deep learning and shape recognition of the real world. It then determines the position and orientation of the image target to allow the user to view the virtual objects with respect to the perspective of the image target. Thus, making the virtual objects to be integrated into the physical surroundings.

Vuforia Engine comprise a number of features which ultimately leads the ability for the app to effectively track images and place virtual contents on different types of surfaces. Image targets are used to show virtual content on certain flat images by comparing it's natural features with the known Vuforia database. Cylinder targets can detect and track images that are in cylindrical shapes.

As a result of the difference in the functionalities of both platforms, Vuforia Engine is optimised for a larger number of mobile device, especially for vision-based features such as image targets where it is less demand in terms of performance and quality. Therefore, making Vuforia Engine a more viable in terms of finance and convenience.

2.0 Development Process

2.1 House model development

The objective of the project was to determine the feasibility of the use of AR in facilitating visualisation for 3D models in design meetings. Therefore, similar to the previous project, Revit's 2019 Architecture Basic Sample Project was used as it fulfils the key criteria for the building model which were: ability to create perspective drawings, related to the AEC industries, high degree of customisability and low polygon count.

Five different versions of the building model was created: one consists of the entire building, one consists of top roof being elevated, one with the top flour elevated and one only including the living room from the first floor and final version of solely the kitchen. These model versions are shown below. On top of that, there are 3 different versions of the drawings generated for living room, kitchen and the whole building. These drawings has different elevation views, as well as plan views which will be used as paper models.

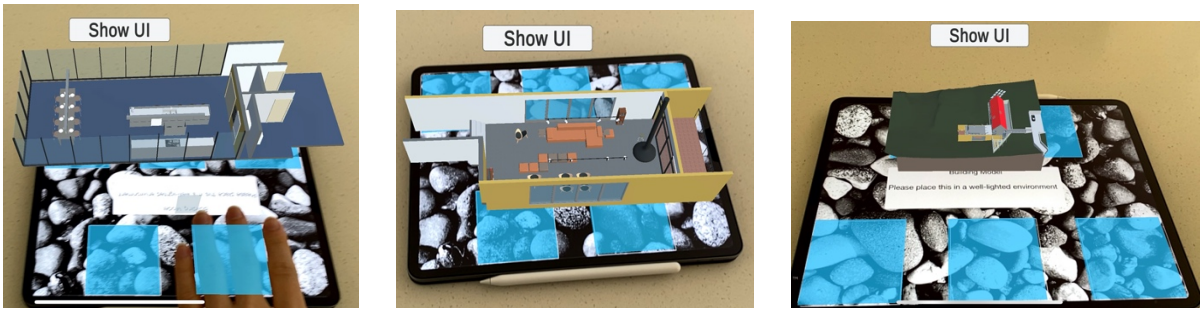

Figure 2: Virtual Models: Left: Kitchen, Centre: Living Room, Right: Building Model

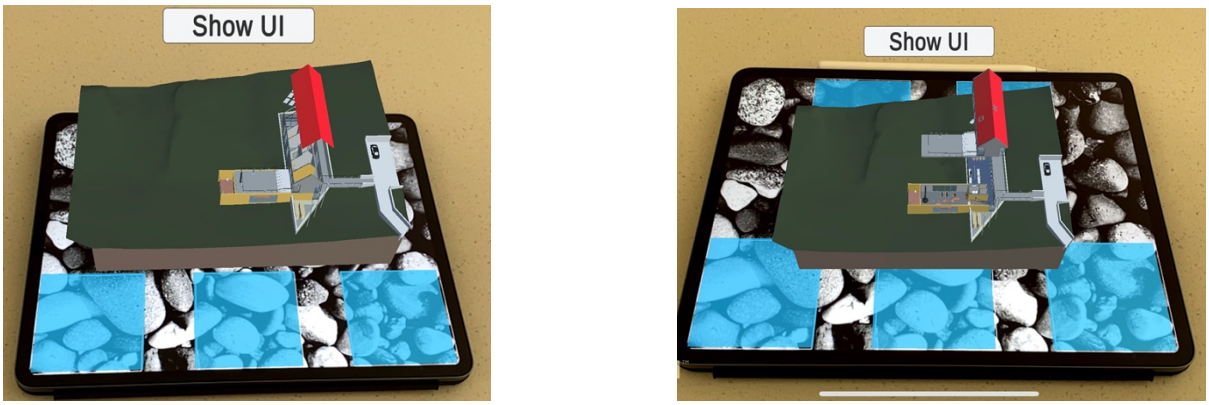

Figure 3: Building Models: Left: Model with elevated roof, Right: Model with elevated top flour

2.1 Dragging, Rotating and Rescaling Model

Since visualisation plays a crucial role in the design phase of the project. It is important for designers to be able to freely interact with the building model to facilitate their understanding. These interactions include being able to intuitively drag, rotate and rescale the building model using finger gestures, similar to how objects move in real life. These were implemented using the scripts within the 'Lean Touch' asset package.

The dragging feature allows the building model to be moved at different locations relative to the image target. The user places a finger on the model, drag it to their desired location and release once they are happy with it as shown in the images below.

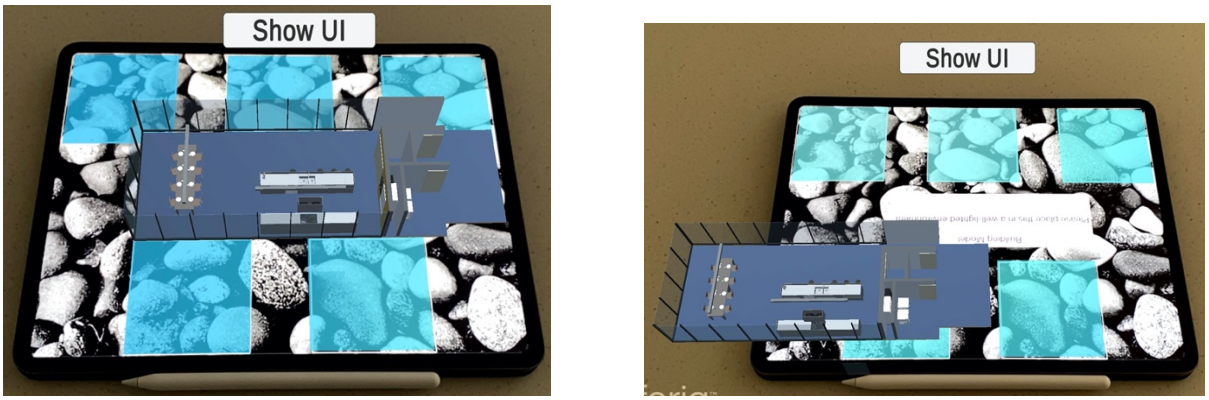

Figure 4: Model moved to a different location by dragging

Rotating feature allows the user to freely adjust the orientation of the model. This can be achieved by placing two fingers on the building mode and moving both fingers in either clockwise or anti-clockwise as shown below.

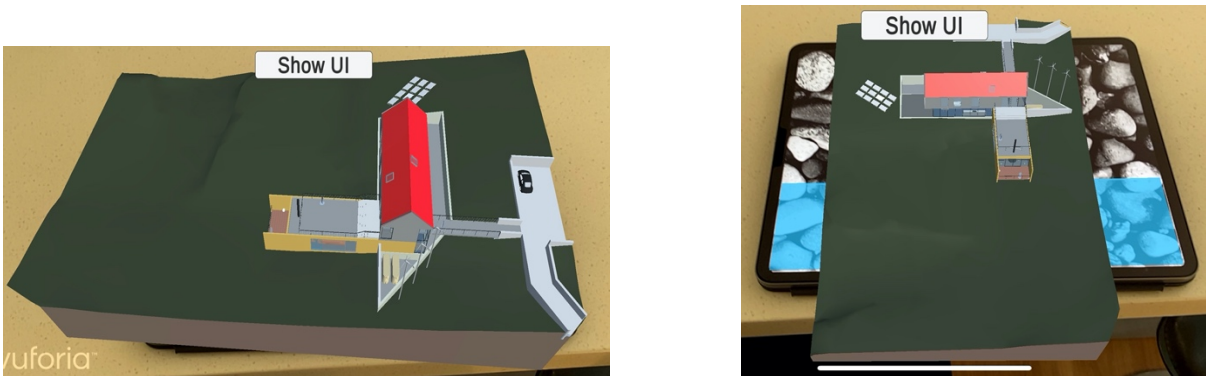

Figure 5: Model rotated to a different orientation

The size of the model can be adjusted easily to see the interior along with other small details throughout the building model. This can be done by placing two finger on the model and either bring both fingers closer together for scaling up or further apart for scaling down as shown.

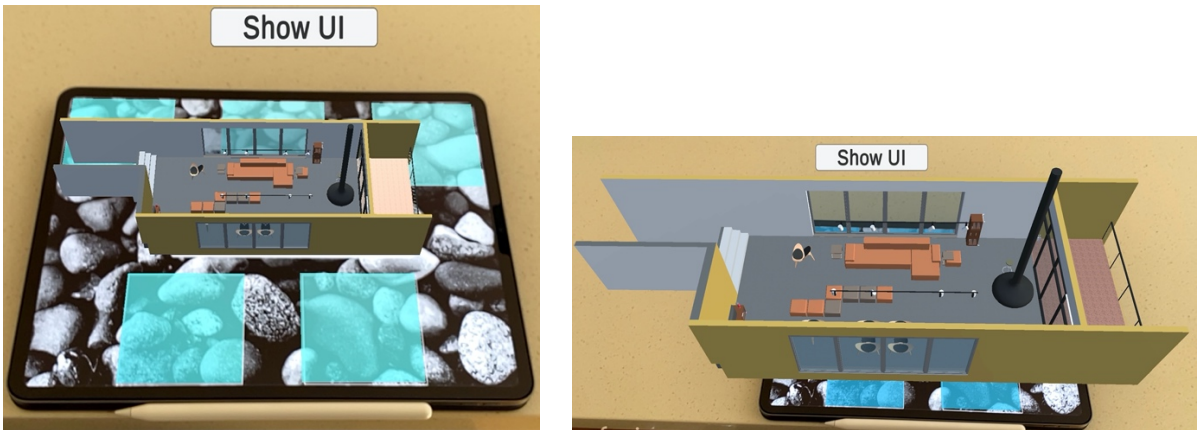

Figure 6: Model enlarged using the rescale feature

2.2 Image Targets and Virtual Buttons

For the app to be primarily based of vision features, image targets must be used to allow virtual content to be augmented appropriately. Therefore, image targets must have enough natural features for it to be sensed and tracked as shown below in figure 7. Target star rating indicates whether the image target is distinctive enough to be augmented.

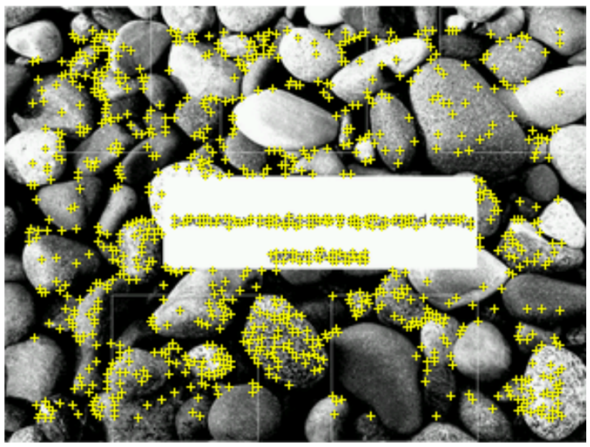
Figure 7: Natural features sensed by Vuforia highlighted in yellow

This image target was uploaded to the database for the developer portal of Vuforia engine and was then import into the unity project file. This is done to allow the Vuforia Engine to continuously comparing the natural features obtained by the camera against a known target within the database.

Virtual buttons provides another way of interacting with the augmented content besides UI buttons. This mechanism allows the image target to be interactive by displaying an area at which can be touched in the real world by user's hand. This is useful as it allows for a robust AR experience as additional features can be implemented without sacrificing screen real estate with extra UI buttons. There's a number of factors that influences the usability of virtual buttons which are: area of the virtual buttons relative to the image target, location on the image target and the details below the virtual buttons.

2.3 Highlight and Delete functions

The delete function was added to allow users to removing any part of the building, to allow users to have a better understanding of the model as this provides an opportunity to visualise the model without certain parts. For example, removing the balcony to see the living room as shown below. This function can be turned on by pressing the "delete" button; it is on when the text is in bald and vice versa.

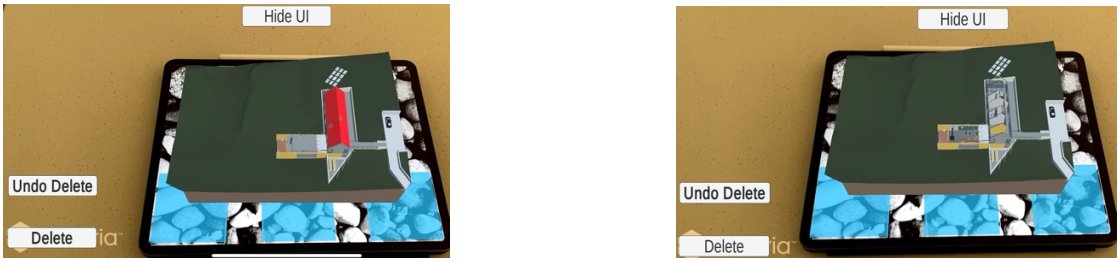

Figure 7: Left: Delete mode turned on, Right: Delete mode being implemented

The highlight function allows users to change the colour of any part of the building to either red, blue or green. Due to the complexity of the model's structure, it allows user to emphasise their opinion on certain parts. The highlight colours can be select in the dropdown menu at the bottom right corner of the screen. Similar to the delete function, the "highlight" button must be in bald for it to be on by pressing it.

Figure 8: Left: Dropdown menu for colour selection, Right: Highlight mode turned on and implemented

An undo feature was also implement for both features to allow users to revert any unnecessary changes incrementally. This situation can be encountered commonly during a meeting, where it would be time consuming to reset and implements changes on the model again.

Figure 9: Left: Before reverting highlight changes, Right: After reverting highlight changes

Figure 10: Left Before reverting delete changes, Right: After reverting delete changes

2.4 Implementing Tutorial

A tutorial was implemented to ensure anyone, from experienced professionals of the AEC industry to university student, are able to maximum the potential of the AR system. This is done by the addition of a second image target, which allows the user to practise the features in co-ordination with the instructions. There are four virtual buttons where each displays different instructions on how to interact with the models. Firstly, it covers the ability for the prototype to intuitively manipulate the model using basic finger gestures as shown below. Next, the tutorial covers other miscellaneous features such as interacting with virtual buttons, UI buttons for highlighting and deleting and hiding UI buttons.

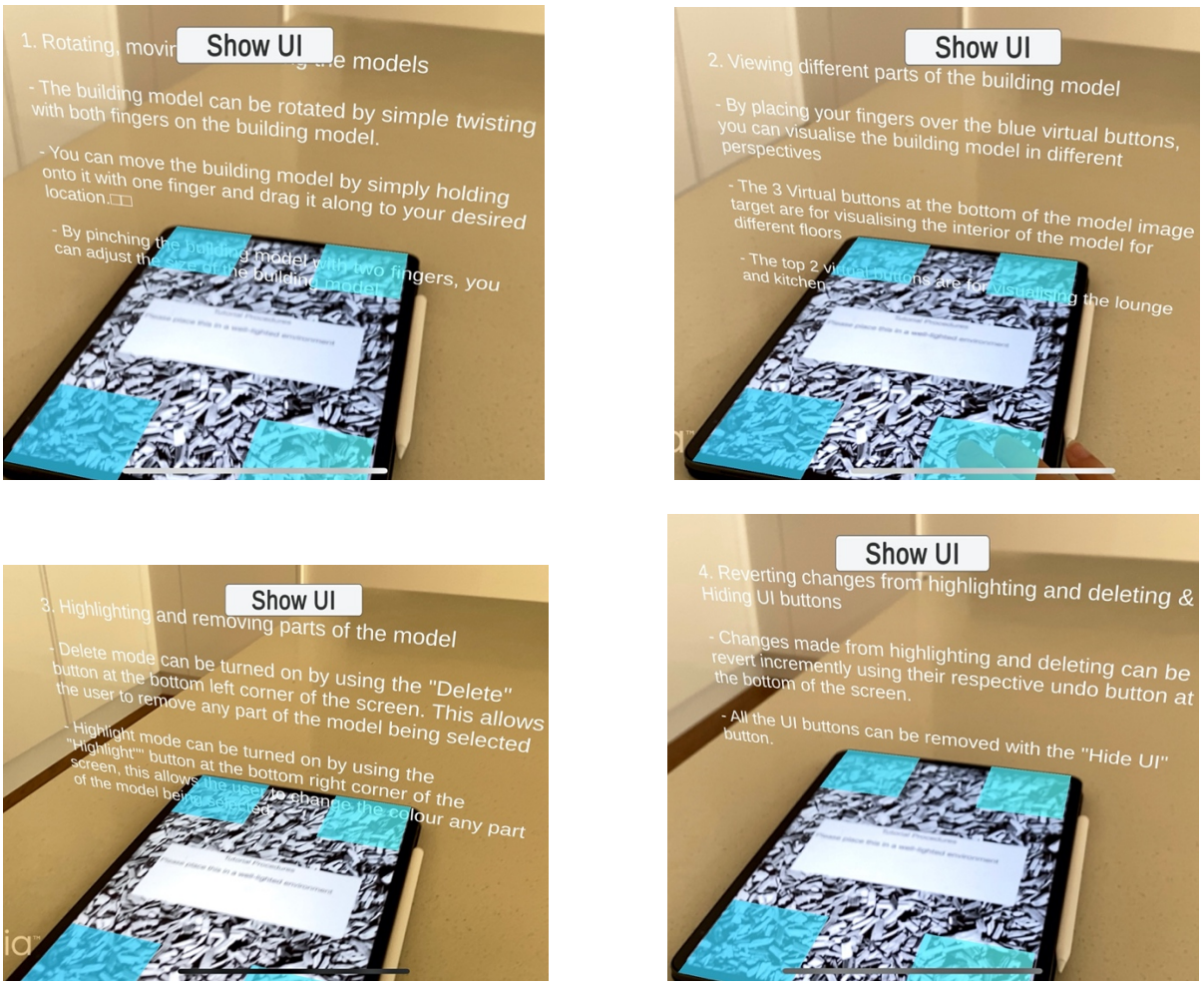

Figure 11: Top left: Instruction for manipulating the models, Top right: Instructions for utilising virtual buttons, Bottom left: Instructions for editing model elements, Bottom right: Instructions for reverting changes from editing and hiding UI buttons.