Outdoor Augmented Reality

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1 Introduction

1.1 Brief of Project

This project aims to delve into the effects of the exploitation of Augmented Reality (AR) Techniques on tourism and heritage.
A system is to be developed using Google's ARCore, enabling complex computer vision-based functions to be easily embedded within an android app.

1.2 Aims & Objectives

There are three main objectives to this project, which are to be explored and implemented to analyse the effects of their combination. Firstly, Augmented Reality is to be used and implemented in the setting of an outdoor environment, using several technologies provided by ARCore, we may explore different ways that this can be exploited for the best experience. This may even be combined with other sensory data such as the location for a better touch with reality. Secondly, an android application is to be developed, which will allow ease of use by most people, avoiding hurdles of installations and such. This application is to provide some method of direction to landmarks, and also incorporate the AR experience when appropriate. Thirdly, The application is to get information from a server, which will allow for a centralised and controlled method of managing landmarks, descriptions and their locations.

1.3 Functionality Developed

A system was developed comprised of two main components. An android application which in normal circumstances presents the user with a list of explorable landmarks, including details such as the name, a short description, distance and bearing. This information is obtained from the secondary component, being a centralised server, which contains information such as the landmark data and the connected devices location. The server provides several endpoints, allowing the device to update the information in real-time. If the server detects that a device is within close proximity of a landmark (geofence), the application may enter Augmented Reality (AR) mode. In this mode, information, a description and a carousel if image concerning the landmark is displayed on a floating Augmented Reality panel, which has its position fixed in 3D world space through plane detection.

2 Background Research

2.1 ARCore and Unity

Google ARCore is a framework for the creation of AR experiences on android and IOS devices, and comes with great capabilities out of the box, and simplifies the workflow by removing the need of reinventing everything from scratch. A simplified framework enables lower-cost projects [1], lower-qualified developers and faster integration of AR projects, providing a gateway to the mainstream acceptance of AR.
Unity 3D technologies combined with Google ARCore enhance the usability of ARCore, as developers are enabled to keep using existing, familiar tools to develop an Augmented Reality Experience. As unity has been a longstanding game development engine, it also has a wide range of support, add-ons

and a helpful community. Also enabling the development of different platforms such as desktop, web and mobile applications [2].

2.2 Augmented Reality and Tourism

Augmented Reality in the tourism domain is no new application works such as [3] show promising results of the applications in the tourism domain. Furthermore, [4] also presents an insight into the future of this domain application, and results show that the area is still blooming.

2.3 Augmented Reality Enhancment

Augmented Reality encapsulates a wide are of technologies that ultimately aims at enhancing, changing and manipulating some aspect of reality as we know it. AR can also be combined with other novel technologies, [5] delves into how the implementation and variation of these technologies can change the resultant experience, including technologies such as location, routing, interactive views and more. When these diverse technologies are combined with AR, we can change and improve the experience, tailoring it to specific applications, requirements and expectations. The whole experience can shift based on the device's real conditions, positioning and sensory data, allowing a deeper level of immersion to be reached.

3 Implementation Details

3.1 The Server

An API server was written in python, as due to the small scale of the application, this was ideal to meet the requirements whilst keeping the implementation simple enough. The server provides several endpoints which may be pinged, but only two particular endpoints are used.

3.1.1 Location Updates

The server keeps track of a list of active devices, (though a unique identifier provided on requests), and their last known location. The device regularly updates the sever with location information, and then requests nearby landmark data. The server loops through all landmarks, and calculates the distance between the device longitude and latitude positioning, and the landmark. If the distance is below some threshold, it is added to a list of potentially explorable landmarks, which is returned as a JSON response to the device. Each landmark entry also contains a geofence region, which when is larger than the distance, the landmarks are considered near the user, and the device can know that the AR mode can be enabled.

3.2 Landmark Menu

3.2.1 General User Interface

Unity provides a wide range of features that can be used to implemented UI in the application. Modern solutions make use of a canvas gameObject which promises several features such as user interaction, screen scaling/responsiveness, and list managing features such as scrollable lists. A scrollable list was used to show a list of the landmarks returned by the server. The title, a short description, the raw distance from the location and the bearing to the location is shown for each entry, so the user may

have some basic information on how to reach a target. Whenever some landmark is very close, the entry becomes interactable, and the user can press it to enter AR mode near the landmark.

3.2.2 Location Service

On the device, the location is updated every second, with an intended accuracy of 0.1 metres (usually not met, but we try to be as accurate as possible).
The integrated unity function is used, and a listener is used to check for updates, which update the server, and the landmarks list accordingly.

3.2.3 Geometric Bearing, Distance & Geofencing

In the aims of ensuring timely server responses, a library called 'haversine' was used to calculate distances between two coordinates. This is not very straightforward, as in calculations one needs to consider the curvature of the earth, and take distance measurements as lengths in circumference. Each landmarks entry has a "rad" attribute, and when the distance between the device and landmarks is smaller, the device can be considered as being inside the geofence!
The Geometric bearing was calculated on the device, as the server did not have many other uses for the bearing of the device. Here we once again use the coordinates of the device, the current magnetic heading of the device and the coordinates of the landmark to find a relative bearing (clockwise angle from the north).

3.3 AR Mode Technologies

In this mode, the camera is shown to the user, and a 3D translucent floating window is spawned in 3D space. The user may move around the panel, and observe the panel stays locked in 3D space. The panel shows some deeper description of the near landmark. A carousel allows the user to see some images of the place (as provided through the API).

3.3.1 Fixed Positioning & Interactability

When combined with unity, ARCore gives the developer access to the AR camera and the pose driver, which are responsible for synchronizing movements carried out in real life, with the movement inside the game engine. A 'World Canvas' gameObject was used so that we can use UI features in 3D space, allowing for a simpler implementation when handling image placement, text sizing, and any other form of user interaction with the panel. By appending the information panel to this type of canvas, we also inform ARCore that we want to synchronise the gameObject positioning between the real world and the virtual unity world space.
Through the aforementioned pose driver and AR camera, a system is used where 1 unit in the unity engine corresponds to 1 meter when viewed in AR mode. Thus If we need to create a 30cm box, we can just set the size in the engine to 0.3, without needing to do any manual conversion, etc.

3.3.2 Information Panel Instantiation

Using the aforementioned techniques, we first create a generic prefab for the Information Panel. This includes the colouring, text placement, title placement, and other things such as button placement and functionality etc. We also provide some relative sizing, which will be scaled accordingly when the prefab is used.

The Instantiation of the information panel happens upon clicking on the desired entry from the landmarks menu, where the information of the landmark is transferred to the AR Mode scene. This information includes data such as the landmark title, a long description and an array of image URLs. We then simply populate the prefab with the information provided and instantiate the panel as a child of the world canvas, relative to the AR camera position. The Pose driver then ensures that the panel stays fixed in the in-game position, whilst varying the AR camera position to match real-world movements of the device.

3.4 Testing Performed

Due to the domain of this project and the technologies adopted, it was not as straightforward to test the raw performance of the system. As there is no performance metric or such that can be analysed and compares to other instances [6].

3.4.1 On-Site Testing

Several tests were performed on-site, where the locations were actually based, all with the aims of exploring how the system handles different cases. This included normal usability and even edge cases such as using the panel where we know plane detection will struggle.
Firstly, the panel was tested on floors that had discernable planes features, and on others where there was a repeated pattern (a known struggle-point of plane detection).

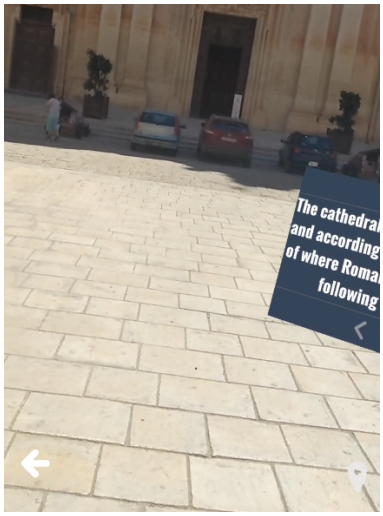

Figure 1: Panel Glitching due to repeated pattern

Figure 2: Stable Panel showing text

Figure 3: Stable Panel showing image

Figures 1, 2 and 3 show the panels in action on the different conditions tested. As can be seen, in good conditions, the panels stay in place and are also interactable, where one can see text and the carousel of images, behaving as expected. Next, in order to test the bearing accuracy, the north pole was temporarily added as a landmark, and a general comparison between the bearing shown and a compass was used. The application was also used with a subpar GPS connection to see the impact on the overall experience (as some parts of Mdina do not have good coverage).

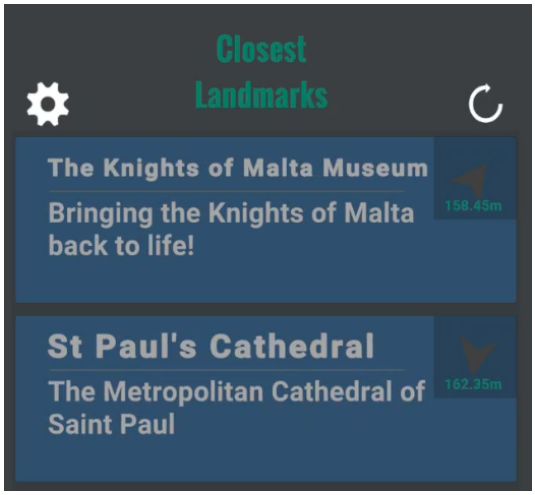

Figure 4: Explorable Landmark Entries

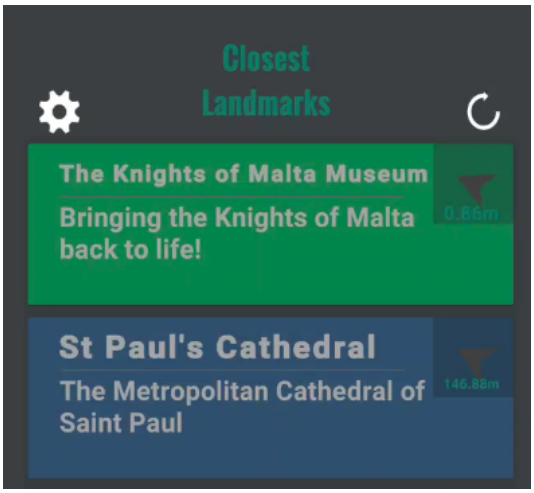

Figure 5: Landmark Entry Activated (In geofence)

Finally, Figures 4 and 5 show the landmarks menu, both when the user is not inside the geofence and also how the UI changes when the user is inside.
Further testing is shown in the video, as it's the best way to convey the experience.

4 Evaluation & Analysis

4.1 Test Analysis

4.1.1 Landmark Menu

The solution as an application was very stable in general, since unity was used, any changes can be done directly through the unity editor, and the benefits of being a unity-based application are retained. The aim to provide some sense of direction to the user was also satisfied, as when the GPS connection was established, distance and bearing data was accurate. When the GPS connection was unstable, the bearing direction and distance were a little off, yet immediately normalized when the connection was restored.

4.1.2 AR Mode

In general, when discernable plane features are present, the panel stays fixed in place as intended. Unfortunately, plane detection by design struggles when there are no close discernable attributes (the floor has a regular pattern for example) and there is not much which can be done to counteract this issue. The tests performed have also shown that in rare cases, this affects the stability of the position of the panel. However, this does not occur very often, and the general experience rarely suffers.

4.1.3 Server Communication

Through using the application, the server was also being tested. The solution developed was very responsive, and provided very quick and usable results. Distance calculation and geofencing also worked punctually, and the device's locations were updated in real-time.

As expandability was also in mind, it is really easy to add, remove and change landmarks, as a simple JSON file is provided, where every bit of detail can be changed.
Due to the centralised nature of the application, an internet connection needs to be maintained for most features to work, as all landmark information is obtained from the server.

4.1.4 Critical Analysis

The few tests performed show that the technologies used are very applicable to the aims and objectives. The strengths of the application match up with the strengths of AR as a concept, providing a deep sense of immersion whilst also being informative. On the other hand, the weaknesses of the application are also in sync with the limitations of the concepts by design. Particularly, the application suffers where a stable plane is not detected and a plane with lower certainty has to be used, which may cause the information panel to shift positions unexpectedly.

4.2 Potential Further Testing

Three key points mentioned in [6] have great potential in giving a more formal understanding of the performance of such systems.

4.2.1 Variation of Independant Variables

The feedback provided after variation of independent variables can be used as a performance metric and help analyse the experience of the user, these variables include things that are not varied by the user during the test. Examples of such variables include the device size and the field of view of a device's camera, which can help conclude the applicability of the technologies adopted with the devices used.

4.2.2 Variation of Dependent Variables

The variation of these variables gives a robust metric of how the users react to the application presented, such as the number of attempts taken to carry out an action. Yet this is very application-specific and does not allow much room for comparison between other systems, as tasks in an application usually are specific to it.

4.2.3 Questionnaires

Questionnaires were mentioned as another performance metric, in contrast to the other tests, this metric is purely subjective. In applications such as the tourism domain, this is of utmost importance, as it follows that from the user-centric nature, the ultimate goal is to maximise the users' resultant experience, and thus feedback directly from the users may be key.

4.3 Possible Improvements

4.3.1 Augmented Images

Ideally, the augmented imaging feature mentioned in appendix 1 is implemented as another landmark type, as it would allow for a wider range of applications and immersion. This application would also be applicable in places such as inside museums where for example it would enhance a painting, or have some animation overlayed on it. Another possible improvement is to give better direction towards

landmarks, the current application simply gives baring direction and straight line distance between points, without any consideration for the streets/obstacles.

4.4 Future Work

During development, it was made sure to keep the system as open as possible. Through the centralised API, unity engine and other technologies used, the system is meant to be dynamic and expandable. With minimal effort, it can be easily be adapted to different uses such as an AR game, using google APIs for international standardized locations or even showing 3D models in AR mode.

5 Conclusion

From the results obtained, through the combination of different technologies, AR provides deep potential when applied to tourism, whilst the libraries allow for easier and a more mainstream adaption of the technologies. The effects of location and compass sensory data have also been observed to enhance the AR experience even further. Finally, the centralised nature of the server proves for greater expandability and allows for data to be changed and reflected in the application in real-time.
Overall, I managed to meet the intended aims and objectives, and during the process also obtained hands-on experience of using the latest technologies to apply the theories learnt into practice. Augmented Reality and computer vision as a domain also turned out to be extremely rewarding, as the effort done is immediately reflected in tangible progress.

Appendix 1 - Image Recognition & Augmentation

Image Recognition was also a really interesting feature to use, yet unfortunately, it is not used in the application. This may have been able to be implemented, yet with the current implementations of the landmark menu and the ARMode switching, It did not make much sense to be used. (As in the near landmark menu, there is no access to the camera), and the user may only use AR Mode when near a landmark.
However, this feature is also fully working, and may easily be implemented if a better use in the context of outdoor AR is identified. In the case of this project, a quick database manager was created in which a list of images could be inserted. These images also need to have specific features, to be distinguishable from other places (for example some image of plain grey gravel is not very easily distinguishable, but an image of the earth is). And actions would be taken according to the image detected!

Testing

As augmented images were implemented some basic testing was also involved, where a simple image of the earth was detected, and overlayed with a 3D spinning globe. The image was recognized from different angles and light settings whilst tracking also was really responsive to even moving the image.

Figure 6: Earth Image Key

Figure 7: 3D sphere overlayed

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