AUGMENTED REALITY ASSISTED NAVIGATION APP USING MACHINE LEARNING AND COMPUTER VISION

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Abstract - Indoor positioning has built up popularity recently due to its potential to be used in the increasing complexity of indoor environment. Unfortunately, GPS signals are restricted to outdoor purposes. Indoor positioning systems helps in the localization of objects and spaces inside a building, where Global Positioning System (GPS) and cellular networks don't work skillfully. The main objective of this work is to design a new method to develop indoor positioning navigation system without using wireless technology. Apart from that, the work also aims to develop an interactive indoor navigation system. Augmented Reality is being used to cover the directional signage of the real view of the indoor environment in 3D form. To summarize, there is a strong unexploited potential in Augmented Reality techniques in the context of indoor navigation and we have attempted to demonstrate this through our application.

***Keywords* – Augmented Reality (AR), Global Positioning System (GPS), Indoor Navigation, Localization, Markers**

I. INTRODUCTION

A. AUGMENTED REALITY: AN OVERVIEW

Augmented Reality has been spotted as one of the next major platforms that will transform the way how we interact with software applications. AR offers users a view into the physical world augmented by computer generated data.

Augmented Reality implementations has been defined by many researchers. One definition of AR is a technology which allows computer to generate virtual imagery to exactly overlay physical objects in real time. [1] Another definition states that AR consists of a combination of three traits: (1) combines real and virtual worlds, (2) is interactive in real time, and (3) registers in 3D. AR has also been defined as the emergence of the real world with super imposed virtual images, combining the advantage of both real and virtual environments.

B. OUTDOOR AR

Existing work [2] in AR has focused primarily on outdoor applications. ARQuake, for example, uniquely represents user-generated virtual tags for upcoming retrieval using feature extraction tuples, namely two-dimensional vectors of the following form: <features, user content>, where features denote the key visual identifiers of the object being tagged.

C. INDOOR AR

Little progress has been made on extending AR to indoor environments, primarily because the scattering of objects differs greatly indoors versus outdoors. For example, [3] relevant objects might be located far closer together indoors versus outdoors (e.g. two adjacent chairs are closer together than two adjacent buildings). Thus, simple image feature extraction is no longer enough. Additionally, GPS no longer serves as a reliable means of obtaining object locations.

(1) Geometric Approach

Some indoor AR systems suggests localizing users within an indoor environment using a known reference point, such as a QR code. As seen in figure 1, user A may scan (via a mobile device) a QR code containing metadata about its own location. The user may then calculate his position according to how large or small the code appears on his screen. But studies have shown that geometric approach alone is not sufficient for a robust indoor AR.

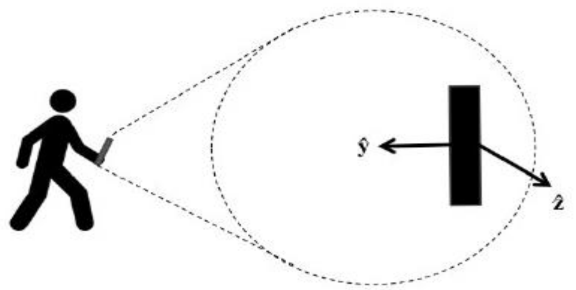

Figure 1. User localizing himself by scanning marker

(2) Computer Vision Approach

The second approach for indoor AR navigation makes use of modern Machine Learning. The model is trained over time to recognize images based on unique image features. Once a model starts recognizing images, we can assign specific actions to be taken once an image is placed in view.

Using this, an augmented element can be set to be rendered once an image placed in device's view is recognized. This method can also work with more complicated CV models which do not necessarily require an image but rather recognize the environment as an image and render the AR model right into the environment. This method is more reliable than geometric approach as it renders AR model by just using the image as a target reference and other factors such as distance calculation do not matter.

II. LITERATURE REVIEW

We have found a number of indoor navigation system in available from various resources whose documents we have selected and effectively evaluated. The author of [4] proposed a mobile navigation system proposed with Augmented Reality, RFID indoor positioning and group communication function. This system was able to use a mobile device to provide real-time analysis on exhibits, demonstrate various multimedia and 3D navigation information, and utilize and active RFID indoor positioning navigation mechanism to enable the user to determine their real-time position, which is convenient for finding interesting exhibits.

[5] presents a novel design of an Augmented Reality interface to support indoor navigation. The author combined activity-based instructions with sparse 3D localization at selected info points in the building. Based on localization accuracy and the user's activities, such as walking or standing still, the interface adapts the visualization by changing the density and quality of information shown.

III. RELATED WORK

Localizing a user within the environment is important not only for navigation systems, but also in general for any location-aware application. Unfortunately, GPS cannot be used indoors because the satellite signal is usually unavailable when inside a building. An extensive coverage of technologies for indoor localization is beyond the scope of this paper.

[6] Hightower and Borriello used different types of sensing infrastructure as a basis for indoor localization. For example, RFID tags, computer vision to find fiduciary markers on the wall and many more. All these solutions require instrumentation of environment and knowledge about the location of receivers or of artificial markers in the environment.

IV. SYSTEM DESIGN

Our system assists the user by directing them from their current location to the next node point to eventually direct them to their required destination. In order to achieve this, our system design can be classified into 3 different sections:

A. SELECTING START AND END POINTS

The user is required to select the start and end points of their navigation request. A predefined list of nodes will be available to the user to choose from. The predefined list allows us to reduce computational effort and also gives the user a good idea of all important points in the building.

Upon selection of source and destination by user, a path from source to destination is generated on the system with all intermediate path nodes indicated on it.

B. SCANNING TARGET MARKERS

The user is required to then scan their nearest target marker, a discrete image that will be placed in strategic locations to serve as nodes, in order to give the system a better idea of the user's location with respect to other locations and with the source and destination.

Upon scanning a target marker, a 3D AR model of a pointing arrow is rendered on top of the image which will then point to the next node in the path. The user will follow the arrow's direction to find the next node and scan the marker and so on.

C. REACHING DESTINATION

After following the markers, the user should reach their required destination. Here, upon scanning the final node marker target, a different 3D AR model, checked flag, will be rendered to signify to the user that they have reached their destination.

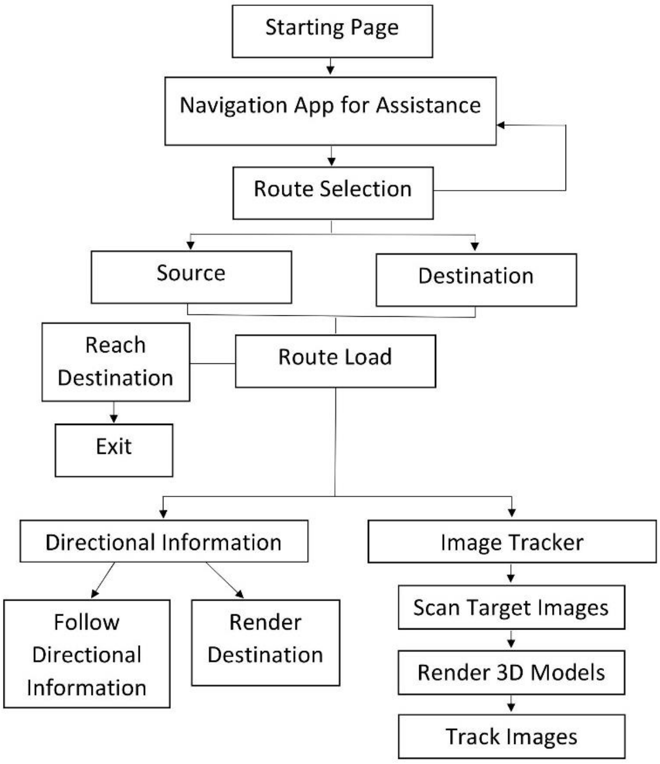

Figure 2. System Flow

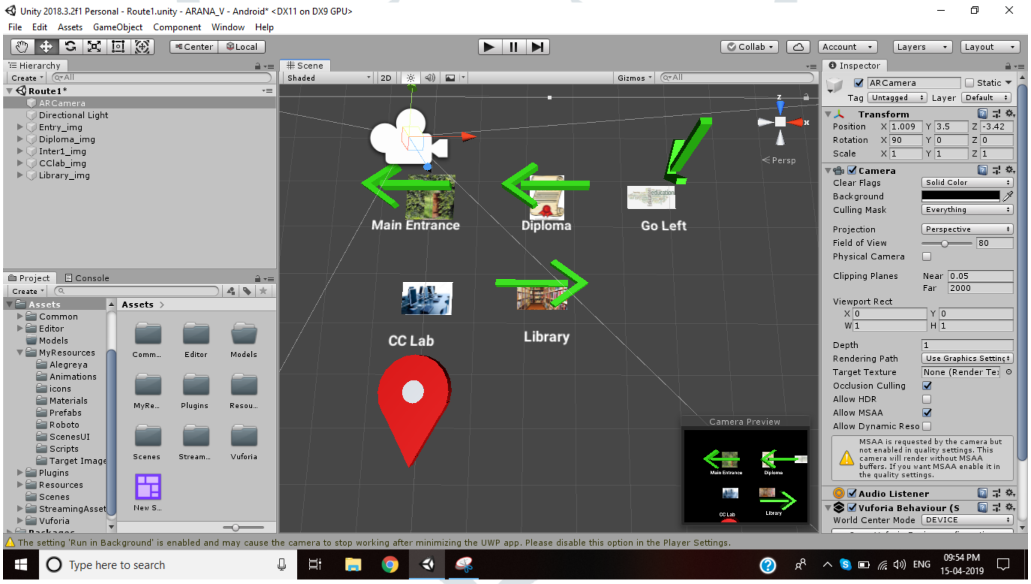

Figure 3. Unity Development Environment of our app

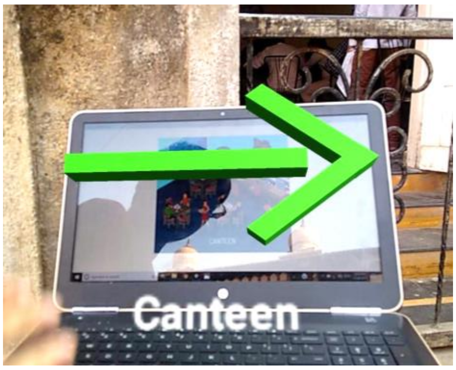

Figure 4. Example of On-Site Testing

V. Results And Discussions

This section focuses on our analysis of the impact of the interfaces of navigational performance and shows the results of some of the basic questions when asked to a group of users.

Figure 5. Navigation Directions

Figure 6. Reaching Destination

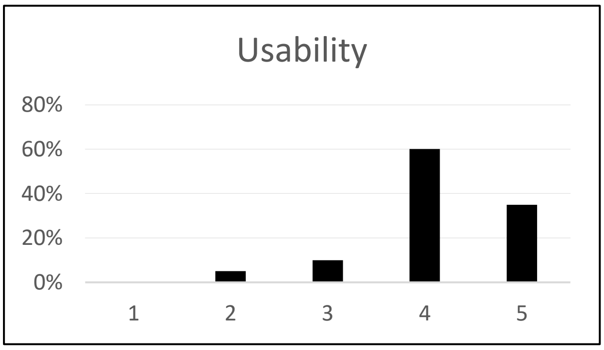

Figure 7. How easy is to use the application?

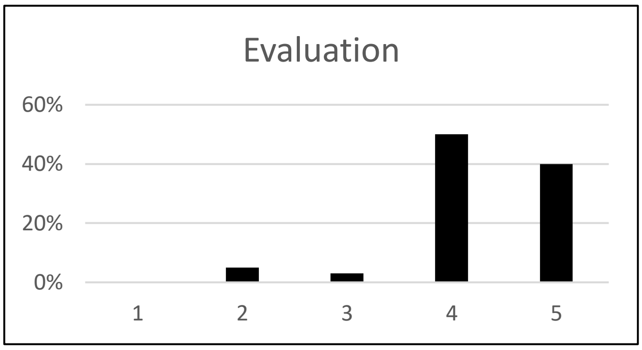

Figure 8. How good will you rate the application?

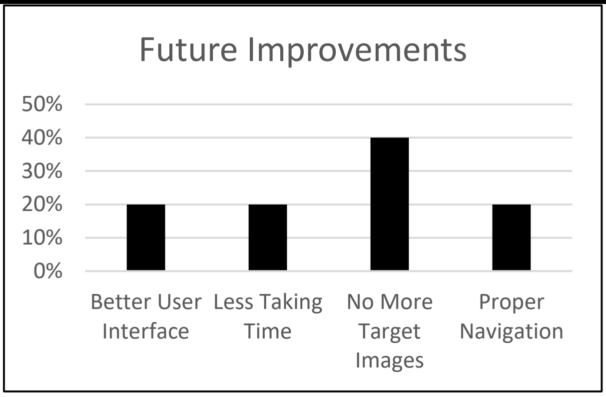

Figure 9. Which factors of application needs to be changed?

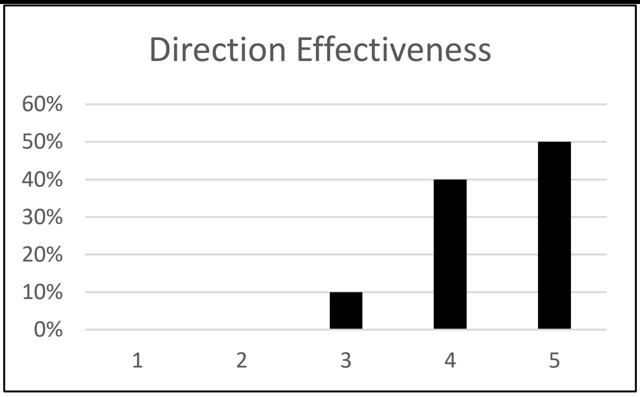

Figure 10. Effective of 3D models generated

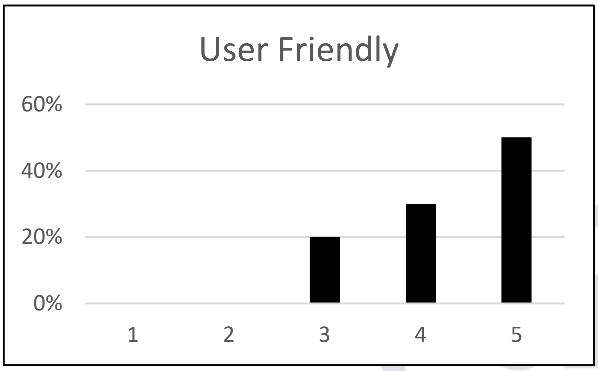

Figure 11. How helpful and easy is the UI?

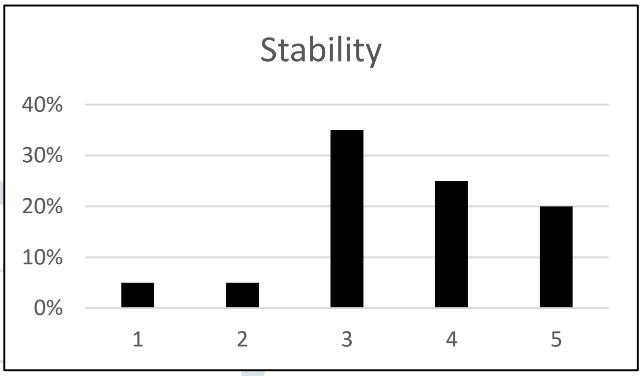

Figure 12. How stable are 3D models that are rendered?

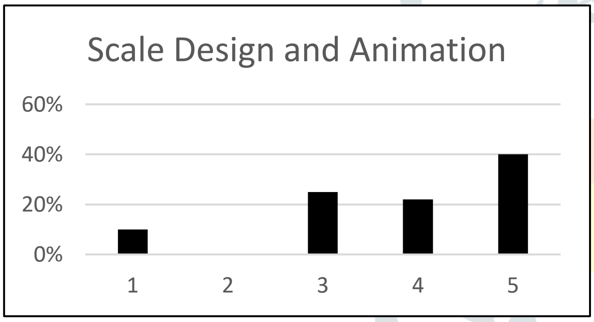

Figure 13. Rate the design and animation of 3D models

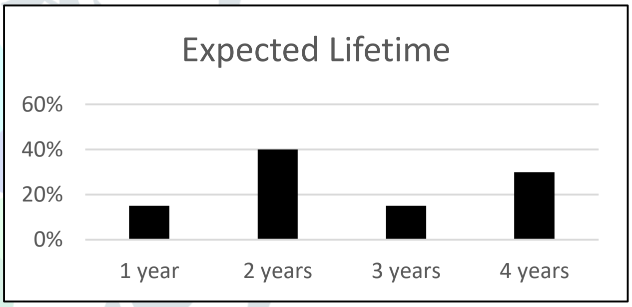

Figure 14. Expected lifetime of the application

- Usability - This question asks the users to compare the current application with the previously existing systems with respect to the Usability and the flow of every feature present on the scale of 1 to 5. The reviewing users have given a 'Good' response for the Usability of the application which accounts to an average of 4 units out of total 5.

- Evaluation - The above question requests users to state how often they can use the current Augmented Reality application and how comfortable it would be for them to use it during the course of the day. Given the test results, the application is very comfortable for a day long use and that no improvements have been requested by the users.

- Future Improvements - Every android application has a particular technology after which it gets outdates in order to keep the users from preferring another and an improved version of a similar technology.

- Direction Effectiveness – This question asks the user about the quality and accurateness about the 3D models generated at directing to the next point.

- User Friendly - Every android application has a particular user interface to make the application famous and user friendly. So, our user interface score is 4 units which quite good.

- Stability – This question asks the user to compare and tell how stable are the 3D models that are rendered and the result we got are 3/5 units.

- Scale Design and Animation – The user rated the design and animation of our application. The ratings we got are quite impressive.

- Expected Lifetime - Every application has its predicted lifetime till another more supervised technology comes into competition. The review takers were expected to predict the life of the app in years. Here, maximum users predicted that the app will last for at least on average of 4 years. This is because the proposed system has all the features in one application which the previous existing systems lack.

VI. Conclusion and Future Scope

Constructing a robust indoor Augmented Reality platform continues to be a difficult but fruitful research challenge. Overall, our interface was validated as an effective means to support indoor navigation with AR.

Our project has proposed a solution to the modern problem of indoor navigation while utilizing the latest technologies available. The Augmented Reality element of the solution allows us to dynamically display directional information which is not possible when using traditional methods. It also successfully eliminates the need of traditional navigation technologies such as GPS by using predefined nodes to locate the user. When the user selects the node and destination, the appropriate route and the nodes get loaded into the application. The user then can follow the directions and reach their desired destination faster.

Our solution can be improved further and applied to more use cases. Some of the improvements include:

- Completely marker less implementation.
- Persistent directional information provided by interacting 3D model.
- Implementation on other platforms such as iOS, UWP, etc.
- Integration with popular traditional navigation applications.

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