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Development of AR Application for Product Museum

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Abstract

Augmented reality is a newer technology than VR, with an interdisciplinary application framework in which education appears to be the most researched fields. Indeed, augmented reality (AR) can help with learning by improving material comprehension and memory retention, as well as learning motivation. However, while VR benefits from better defined and distinct sectors of application and study, AR is still growing in scientific contexts.

AR is an efficient approach to represent a model that requires visualization. It also enables seamless interaction between the real and virtual worlds, as well as the utilization of a tactile interface metaphor for object handling.

Keywords*—AR, VR, Indoor Navigation, virtual environment, Android app*

I. INTRODUCTION

In comparison to traditional learning, a learning interactive module is created to give a platform for users to participate more in the learning environment. This study offers a conceptual approach for assessing the possibilities of a new type of Virtual Reality (VR) application known as Augmented Reality (AR) Technology in the field of education. AR differs from VR in that it allows for integrating 3D virtual items into a real-time environment, allowing users to relate to them with their actual surroundings, as well as making learning more engaging.

AR learning allows users to engage with the technology by touching the screen, flipping the device, rotating the device, and so on.

AR Navigation is also discussed in this paper which users in navigating from one product to another from their tablets. Apart from tradition 2D indoor navigation this makes users to identify the targets position easily.

II. RELATED WORK

Ronald T. Azuma [1], explains the field of Augmented Reality, in which 3-D virtual items are merged into a real-time 3-D environment. In his article, he discusses the applications that have been investigated in the fields of medicine, manufacturing, visualization, path planning, entertainment, and the military. Description of Augmented Reality systems and trade-offs between optical and video blending techniques are included in a thorough discussion in this article This article covers current attempts to address registration and sensing mistakes, which are two of the major obstacles to developing efficient Augmented Reality systems.

Nor Farhah Saidin, et al. [2], has identified the solution for the problem that AR technology will create in the field of education. As a result of this, a passive learning process is created when the technology is not utilized it does not stimulate critical thinking, and metacognition. When AR was first introduced, it showed great promise for making learning more dynamic, productive, and engaging. As a result of its sophisticated technology, consumers may engage with virtual and real-time apps, allowing them to have a more natural experience. According to this review, AR may be used in a variety of disciplines of study including medicine and chemistry. This research compares AR to traditional technology (such as e-learning and courseware) as well as traditional teaching approaches (chalk & talk and traditional books).

Tasneem Khan, et al. [3], here students at the University of Cape Town's School of Health Sciences were given an augmented reality smartphone application to see how it affected their learning motivation. Student learning motivation was assessed before and after the augmented reality smartphone application was used. Seventy-eight individuals completed the pre- and post- usage questionnaires for the augmented reality mobile application, resulting in a total of 78 participants. Students' enthusiasm to learn raised because of utilizing augmented reality smartphone applications.

Maria Shehade and Theopisti Stylianou-Lambert [4], shows museum professionals' experiences and perspectives of VR technology in museums. It also discusses the pros and disadvantages they see with VR technology in museums. Based on interviews conducted in a few countries, this article presents an in-depth examination of the experiences of museum professionals who have worked on VR projects at home.

Afnan, Khan Muhammad, et al. [5], explains what's happening in today's classrooms when it comes to new technologies such as augmented reality (AR) and virtual reality (VR). A set of four applications for learning the English alphabet, decimal numbers, animals, and birds, as well as an AR Globe to learn about different nations across the world has been designed by the authors to make learning more successful. If a tablet or mobile device is available and the needed target pictures are available, these applications may be played anywhere and anytime without Internet access. In these apps, students' work is assessed using performance evaluation quizzes (PEQs).

III. PROBLEM BACKGROUND

The conventional way of explaining things does not satisfy the visitors of product museum and it leads to a decreased interest towards the product. This happens because the interaction between visitors and the product is static such as user manual, text & photos. It becomes hard to visualize.

IV. OBJECTIVE

The main objective was to develop a self – explanatory module for product museum which can navigate users to the product and explain those in detail using a hand-held device, which contains exploded view and cross – sectional view of the product for better explaining.

V. PROPOSED SOLUTION

The software's and SDK's used for augmented reality construction is carefully taken into consideration and all possible combination have been made and tested. Initially Unity 3D with Vuforia engine was tired, due to the limitation in designing of user interface and usage of complex program for animations, this concept was not considered. Next, google AR core was used, this gave an attractive user interface and easy animations but the reusability of this package for all the products was not possible, so this combination was not considered. Finally, Vuforia studio with Creo illustrate was tried, this gave a user-friendly UI and reusability of a particular template for other products. So, this combination was selected and further moved for the next process.

VI. HARDWARE ARCHITECTURE

To accomplish the above-mentioned requirements an android tablet (Samsung Galaxy Tab A7) is used. It has AR Core support which is the main requirement for Vuforia View app to display the AR experience. This tablet consists of a 10" large display for the users to interact with the product. This also has a RAM of 3GB which is more than enough to process the augmentation and has a ROM of 64GB to support the applications to store the required files. To support the indoor navigation, phase this tablet is built with Accelerometer and Gyro sensor. The Fig. 1 shows the hardware architecture of the project

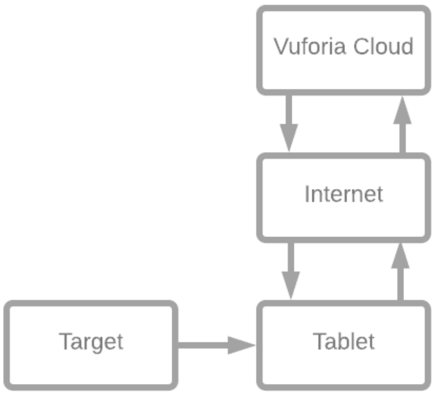

Fig. 1. Hardware architecture

Now the target is recognized by the tablet, and it is compared with the database in Vuforia cloud. If the targets are matched, then the corresponding AR experience will be pulled from the Vuforia cloud to the tablet via internet. Now the user will be able to experience the augmentations in the android tablet.

VII. SOFTWARE ARCHITECTURE

This research work is divided into three phases: Augmentation phase, app development phase, indoor navigation phase

A. Augmentation Phase

This is the initial phase where the CAD model of the original product will be augmented using Vuforia studio with the help of different cross-sectional views, assembly and dismantle views. The entire workflow of the augmentation phase is shown in Fig.2.

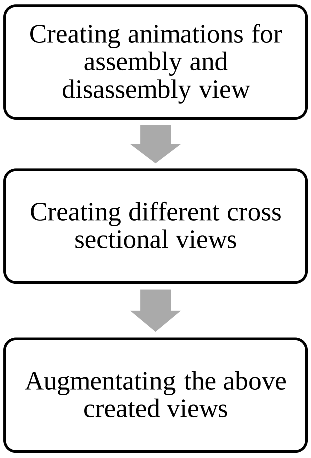

Fig. 2 Augmentation Phase

Initially the part files will be built using the Creo illustrate by bottom-up approach into an assembled final product. Then the animations for assembly and dismantle process is generated with the help of exploded views. Once the animations are done various cross-sectional views like x-axis, y-axis, z-axis, and quarte cut sectional views are generated to get a detailed explanation of the product.

B. App Development Phase

In this phase the main app which integrates the indoor navigation module and augmentation module is developed. This app facilitates the Login feature for different type of users and all the details about the museum can be found here. The workflow of app development phase in shown in Fig. 3.

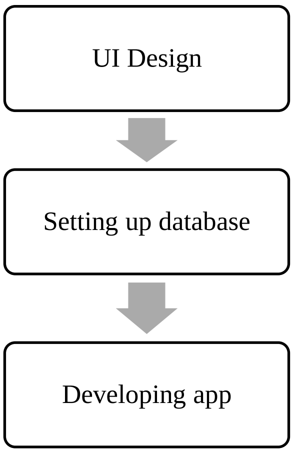

Fig. 3. App Development Phase

The UI for the individual pages such as introduction, login, signup, password reset, home, about US, Products will be designed. A database will be created in the google cloud. If any user signs up for the first time the login information will be sent to the google firebase. If any of the users logs in, the user credentials will be matched with the one stored in the database if it matches, the user will be allowed to login. The corresponding tags for the individual pages and elements of each page will be assigned and the final file from the figma is exported to bravo studio, where the final app will be built.

C. Indoor Navigation

In this phase an indoor navigation module is developed which navigates the user from any part of the museum to the desired location where the products are displayed. In this module all the target locations will be listed where the user can select the required target location and can navigate to that location. The methodology used is indoor navigation is shown in Fig. 4.

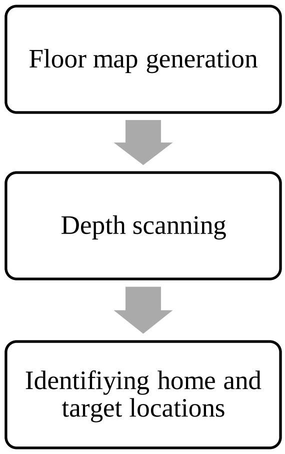

Fig. 4. Indoor Navigation

Here the floor map of the required locations is accurately designed in Revit and converted into a 3D model. This model consists of all the objects placed on the location and all the openings like windows and doors are clearly mentioned. The above created 3D model is now given into the ARWAY studio, then a depth scan is made using the mobile phone to collect all the cloud points from the location. Now the collected cloud points and the 3D models combined. Now the model created in the above stage is taken, first the home position is calibrated with the real time world then all the target locations are listed. Routes are generated to all the target locations from the home location. Finally, the application will calibrate according to the cloud points and will display the route for the specified target location from the home location

VIII. AUGMENTED EXPERIENCE

For creating the augmented reality environment, a 1:1 CAD model of each product should be developed using CAD modeling software. These CAD models should be assembled in prior to being imported into Vuforia studio but should be able to dismantle to obtain the individual part of the product.

Using Creo illustrate the assembled CAD model is imported for creating assembly animations and dismantle animations. Also, these files are used for creating various sectional views like quarter cut view based on x, y and z axis. After creating all the required animations, the illustration files are converted into .PVZ file and imported into Vuforia studio. Now the initial position and orientations of the product as assigned so that it looks complete.

A virtual identification pattern called Thingmark as shown in Fig. 5 is attached to the previously mentioned animated files. Here the thingmarks serve as a reference for the position of the objects and each thingmark will act as a key for all the product because the augmentation will happen only if these marks get scanned by the camera.

Fig. 5. Thingmark

The AR front panel or the user interface panel should be configured to provide functionalities that are required to play the augmentations. For instance, the play all, reset, stop buttons are added to start the created animation or to stop or reset the ongoing animation sequence. While the select widget is used to select the desired view from the dropdown. Then the X and Y Coordinate sliders are used to move the model in x or y direction. Finally, the X and Y rotate sliders are used to rotate the model in x and y axis.

Here a label is also configured to display the current sequence name to the user for a better understanding on what is playing.

IX. APP DEVELOPMENT

In this research to minimize the use of code and to make an attractive User interface, the modern method of app development is used. First step is to design the UI using UX/UI designing software like figma or adobe XD. The pages like welcome, login, signup and password reset pages should be created and the corresponding bravo studio tags are assigned to the UI components to make is a functioning part in the app.

Next the home page is created which allows the users to navigate between the augmentation module and indoor navigation module. The corresponding tags are assigned to the UI elements which allows to navigate between the apps.

After assigning the required tags to the corresponding components on the design file, they are imported to the bravo studio for further process. On the next step the required third part services like login authentication, push notifications are assigned to the app using their unique authentication key. These services will be used in login pages and can be used to push notification inside the app. Finally, the firebase is integrated to the bravo studio to store the login credentials. After firebase integration a debug apk is generated from the bravo studio, after testing the generated apk the final version of the app is generated from the bravo studio and published to the play store directly using the unique keystore code.

X. INDOOR NAVIGATION

Indoor positioning technologies are divided into two categories: wireless transmission techniques and computer vision systems. To locate a device, wireless transmission techniques employ technologies such as ultra-wide band, wireless local area networks, and radio frequency identification.

These technologies frequently need the deployment and installation of physical infrastructures in the interior environment, such as Wi-Fi routers and Bluetooth beacons.

Most of these methods are not quite accurate and involve significant localization problems. During the detecting phase, certain technological options, such as Bluetooth and infrared technologies, have a large latency. Although these technologies are popular for localization, they have difficulty in predicting the user's orientation and are hence unsuitable for AR applications. Computer vision techniques, on the other hand, are more suited for AR-based applications, and prior research has indicated that computer vision technologies are more accurate than Wi-Fi-based fingerprinting.

First step in indoor navigation is to create a map for the location. A 360- degree photo of the interior environment is captured. It should be verified that captured photos intersects each pathway of the defined interior environment. After verifying these photos, a floor map is created by uploading these into a online map creator.

Fig. 6. 2D and 3D Floor map

Once the 2D map of the floor is generated it should be imported into Autodesk Revit for converting it into a 3D model as shown in Fig. 6. In Revit all the objects present in the environment should be placed on the corresponding places to obtain high accuracy during navigation.

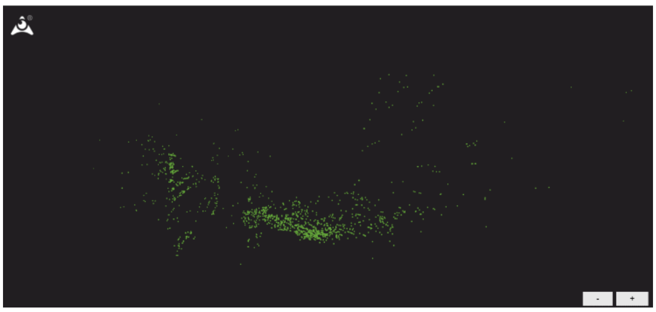

Fig. 7. Cloud Points

The next step is to capture the cloud points around the environment as shown in Fig. 7. A 3D scan is made using ARWAY mapping mobile app which captures the environment and collects the cloud point according to the environment.

Next is the navigation module which is a different system. It allows the user to view a full map of the region or go to a specific location. When a user inputs a location, the quickest route to that destination is shown to the user. These instructions are also visually placed on the screen. We utilize the Dead-reckoning method to estimate the user's current location given a known beginning position. Dead reckoning is the technique of determining the current position using previously computed positions and then updating that position using known or guessed data. This approach may be implemented with the assistance of sensors included in our smartphones.

The approach of Dead reckoning using these sensors is explained in Fig. 8.

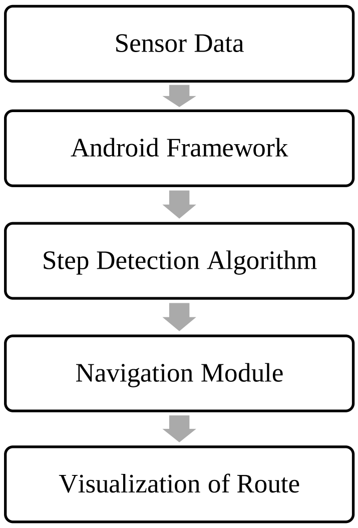

Fig. 8. Indoor navigation workflow

A. Defining the coordinate axes

The Android OS sensor framework uses a standard 3-axis coordinate system. The horizontal X axis is oriented to the right, the vertical Y axis is oriented upward, and the horizontal Z axis is oriented away from the screen face. In this system, the areas behind the screen have negative Z values. The axes are not swapped when the device's screen orientation changes.

B. Sensor data

The magnetometer may be used to determine the smartphone's orientation. However, due to the existence of structural components or electronic devices that have a substantial influence on the magnetic field, this sensor occasionally produces incorrect data. Other techniques of orientation detection are not available on most cellphones. As a result, the smartphone's orientation can only be determined via an incorrect magnetometer. Because the Dead-reckoning algorithm relies on the magnetometer to identify the user's orientation, such problems will result in incorrect results. To solve this problem, we take the moving average of the last 10 magnetometer data. This allows us to reduce estimate mistakes.

The accelerometer data is used in step-detection algorithm, which is then coupled with orientation data to determine the user's current position.

C. Step detection algorithm

When a user walks with his smartphone parallel to his body (in landscape mode), we see that the value of acceleration along the X axis fluctuates in a predictable way. As demonstrated in the graph below, there is a significant rise in $x_{(\mathrm{acc,t})}$. As a result, we can calculate the number of steps taken by the user by counting the number of such peaks in the, $x_{(\mathrm{acc,t})}$ value.

When walking regularly, the time between two successive steps does not vary significantly. As a result, to improve the accuracy of our step-detection method, we discard identified peaks whose length is less than half that of the preceding step.

While integrating the 3D model made from Revit is imported into the Unity3D engine and combined with the collected cloud points now the above-mentioned algorithm is coded, and the final application is generated as shown in Fig. 9.

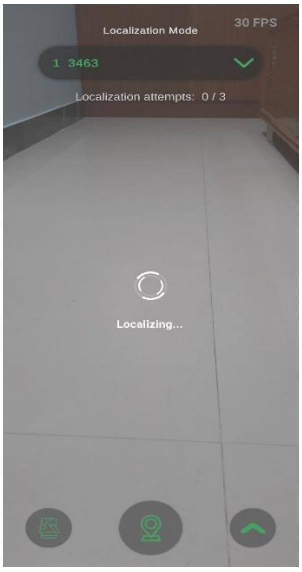

Fig. 9. Localizing

Whenever the application starts a list of target *locations* are shown where user is allowed to select one target location. After selecting the target location, the dead-reckoning algorithm starts to work. Whenever the user makes a move, the algorithm starts to collect the data from the sensor and start to calculate the steps.

XI. IMPLEMENTATION

First the developed application should be installed in the android device from playstore to avoid the discrimination while accessing the location and camera. After the successful installation user signs into the application with the given user credentials then selects the required product. On the next screen, product description will be shown where the option for Augmentation will be shown. On selecting the augmentation, the scanner will be opened.

Here thingmark will be assigned to each individual product, on scanning the thingmark the corresponding augmented experience will be imported into the android tablet as shown in Fig 10. Then the desired animations can be performed in the android device. On the product description page if the indoor navigation option is chosen, the IPS module starts to collect the current location of the android tablet and all the data’s related to the coordinates for the tablet will be taken from gyroscope sensor of the tablet.

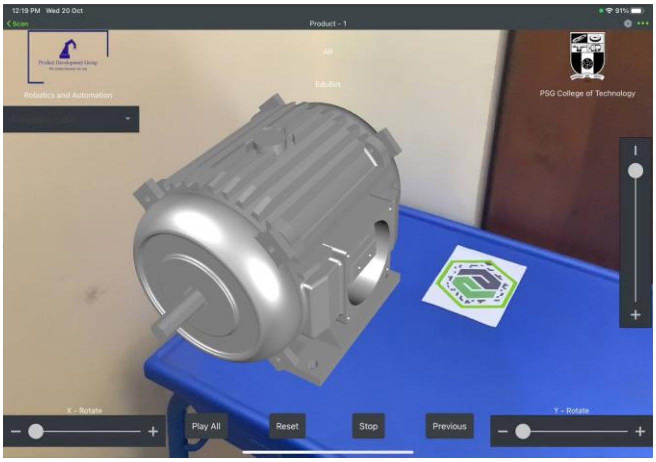

Fig. 10. AR Implementation

These raw data is sent to the android framework then to the algorithm which calculates the step count and displays the route to the desired target location as shown in Fig. 11.

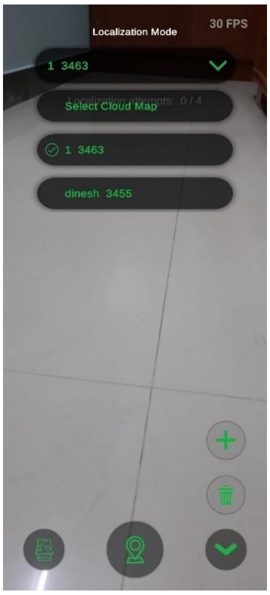

Fig. 11. List of Target Positions

XII. CONCLUSION

In this research the module developed for product museum using commercial augmented reality platform have been reported. This approach has the advantage that it is more robust, than creating a new software from the scratch. This application also does not require additional tracking and projection equipment's since it works seamlessly with smartphones with ARCore and ARKit. Which resulted in reduced developing cost.

This thesis also described the existing architecture for developing these AR apps by utilizing various tracking technologies and interaction approaches. The created indoor navigation application was able to run with optimum efficiency at typical walking speeds, and the program was able to process and show the AR-based directional information to the user efficiently.

XIII. FUTURE WORK

Future work will be focusing on increasing the accuracy of positioning. ThingMark is currently used as a reference position for matching the actual and AR environment. However, the latest version of Vuforia studio can also use area targets for augmentation phase and navigation phase. With this area targets the use of AR technology can become more flexible.

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