ENHANCEMENT OF NAVIGATION TECHNOLOGY USING AUGMENTED REALITY

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Abstract - Navigation technology has observed a tremendous advancement in the last 10 years with people shifting from using traditional maps to satellite based navigation smartphone apps such as Google maps and Apple maps. These applications mainly focus on outdoor navigation and represent the route in a 2-D layout, which sometimes lacks clarity when it comes to distinguishing between overlapping paths. One more area where this project is focused is indoor navigation. Indoor navigation can be helpful for navigating inside big buildings like hospitals, malls and airports. For example, when a user enters a mall and he or she needs to find a particular showroom, he just needs to put the name of that showroom and he would get 3-D augmented objects on his device which will point to that showroom as he follows the designated path. Augmented reality is used combined with satellite based GPS technology to navigate outdoors as well as indoors. The application uses 3-D markers to point the direction to the user in a real time environment on their devices which will be easy to understand and navigate. At the same time it will augment location based point of interest along the path, which will provide more clarity to the user about his or her environment. From this project we hope to develop a navigation application for users which is easy to use and understand.

Keywords: augmented reality; Unity 3D; placenote SDK; AR toolkit; Satellite based GPS technology; android, ios.

1. Introduction

It is an arduous task to guide people to particular pots inside buildings. Especially in big buildings such as malls, hospitals or other public buildings, operating authorities are combatting with the issue of escorting the visitors through their buildings. To reach their destination, visitors often have to go through different paths. Therefore, a guiding system must be tailored to the needs of a visitor or a specific task. This can be a customer, but also a person who has maintenance tasks to perform. Individual increased information can be presented to a user while walking through the environment. Display devices like smart phones or tablets can be used to present AR guiding information. AR comprises of adding virtual data to the physical world, enabling the client to improve their condition observation. The fundamental purpose of an AR framework is to enhance the user's impression of an association with this present reality through enhancing this present reality with 3D virtual items that seem to coincide in indistinguishable space from this present reality. In the recent years, location based navigation systems have become an essential topic for researchers as the application of these systems has become so vast. These systems are required not just for navigating to places but also to track orders for e-commerce websites, food - delivery apps, courier services and many more. Constant improvements in these systems have led to greater efficiency in service provided by the entities using it. AR is observing increasing use in navigation systems that may be used for navigating places, in industries for offering better assistance to quality inspectors to spot the errors easily and in healthcare for surgeons to carry out complex surgeries. With this study we hope to present an indoor navigation system using computer vision and AR to guide people inside big buildings and to decrease their dependency on others for asking the directions and the maps put up on the walls inside the building.
2. Existing System and its problems

Existing Navigation system comprises of Google maps and Apple maps which show a 2-D version of the route with 2-D arrows for pointing the directions on the road [14]. A major flaw with the existing system is that there is no system designed for indoor navigation as both of these applications focus on outdoor navigation. Secondly, while navigating using these apps, many times we encounter overlapping paths where a slight turn is to be made and since it is a 2-D display we are not able to make out which path to take, so we end up on the wrong path.

3. Related Works

Researchers have been trying to utilize augmented reality for various purposes such as teaching, navigation and presenting 3D structures of buildings.

Perception thresholds for augmented reality shows the use of 3D visual aids for determining the direction of the path and how changing the size and dimensions of these navigation aids can help in increasing the overall understandability of the path. It is a solution for low resolution AR based devices as they are not able to show the directions vividly. In our paper we are using modern phones which have high resolution screens as well as cameras which don’t face these kind of problems also the way points used in our app tilt according to the placement of the phone, so they are dynamic in nature [1]. Virtual heritage of a territory using augmented reality proposes marker based augmented reality to display the heritages of a territory as a real life 3D model which can enhance learning as well as teaching level for both students and teachers. It also proposes mobile pedestrian navigation system using GPS based navigation apps like google maps to determine the location and then use AR toolkit to integrate the 3D models of the heritage buildings with the maps [2]. Augmented reality can be used to display axis location coordinates in 3D for tele operators for operating robotic arms easily and minimizing navigation errors. All the hypothesis were confirmed in their study except path deviation, so, overall their system was more efficient to use with the help of augmented coordinates for hand controlled machines and end effectors [3]. Our project also requires vision based indoor navigation using marker based augmented reality in which user localization is done using image processing of the local environment around the user and recording the path from the initial to the final destination in a database. This was done using a wearable mobile PC with a camera, which in our case has been done with just an apple smartphone. The directions are displayed using AR toolkit which comes with its automated tools to point directions [4]. Our project focuses on making people independent of one other for locating places inside big buildings using our application similar to the efficiency of augmented reality based hand held guides for inspection purposes vs use of printed pictures. In a study researchers found that using AR in hand held devices for inspection, led to lower inspection times than the normal picture as the devices assisted the inspector in checking the products thoroughly by reminding them of checklists and the image processor used in the AR software helps in aligning the inspection device quite fast which in turn leads to a better inspection [5]. Augmented reality for outdoor navigation can be done by providing data visualizations which could help in assessing the outside environment in a better way. A study showed that it took lesser time to locate objects in external environment by using augmented reality to navigate them with rather than normal map. Only drawback was that there was occlusion due to incomplete 3D models while navigating outdoors which isn’t going to occur in our system [6]. Indoor navigation using augmented reality can also be done using deep learning which provided a solution for industries by developing a markerless augmented reality app for various machines in a factory which uses image processing for identifying that particular machine and tell information regarding its current specifications and use. It doesn’t provide navigation assistance to reach towards the desired machine as is done in our app using 3D arrows [7]. Researchers have also used the accelerometers inside the smartphone to calculate the number of steps of the user and by taking the height and step length of the user it determines the path to be followed to reach the final point inside a building. The application asks for the name of the initial point as well as final point before starting and then puts in augmented reality effects in the display. They used Dijkstra algorithm to find the best possible path to reach the final point which helped them achieve more than 90% accuracy in measuring number of steps of the user to reach the
destination through the path showed by their app. This also avoided the use of creating a map of the indoor surroundings beforehand to locate the desired route. They also used a database to store the location coordinates of the places inside a building [8][13]. Indoor naviation can also be done with the help of wifi and barometer sensor integrated system which can be useful in providing a higher navigation performance as it can also determine the height in a multi floor building, that could help when using stairs to travel. One drawback of this method is that it requires barometers integrated with wifi to be installed at various places in the building which makes it a bit expensive [17].

4. Overview of AR - based indoor navigation application

The key technology of the proposed indoor navigation APP relies on A* algorithm which helps in identifying the shortest distance to the destination among the paths saved in the maps for different routes. We first save the routes to different destinations inside a building by walking and dropping way points on the route as shown in fig 1. Placenote SDK provides the cloud storage for our maps, waypoints and their locations. A* algorithm is applied in a recursive loop so as to look for the best possible route by comparing the distances between the different nodes starting from the initial point to the final location. User surroundings are mapped first using computer vision as shown in fig 1.2 and then saved onto the cloud storage [15]. Like this all the starting as well as end points are mapped first. The user gets to know his/her location inside a particular building through the GPS coordinates of that particular place stored on the cloud during mapping and then use the map to navigate to the desired location with the help of way points [12].

Fig.1: Showing how way points to be placed manually on the path to be followed using 3D markers

5. A* algorithm

A* algorithm is a kind of heuristic search algorithm which calculates the minimum cost of the path in order to find the shortest path from starting point to the final point. Evaluation function is used to decide which part to take. This function can be denoted as

\[ a(n) = b(n) + c(n) \]

\( a(n) \) represents the evaluation function, \( b(n) \) shows with node \( n \) from starting point to destination. \( b(n) \) represents distance between two alternate nodes, which is fixed. \( c(n) \) represents the stretch between the initial and the final node , whose length we need to calculate in the most efficient way possible [9]. For this we make use of Euclidean distance formula which is the square root of sum of squares of difference coordinates of the location points [10]. For example points \((a1,b1,c1)\) and \((a2,b2,c2)\) in 3D space, the Euclidean distance between them is calculated as

\[ \sqrt{ (a2-a1)^2 + (b2-b1)^2 + (c2-c1)^2 } \]
6. User localization

According to user’s location we need to find the area of the building in which he/she is located and we do smartphone’s camera. We make use of computer vision to process and match the image stored in our cloud storage. The smartphone’s screen shows green dots on the screen when it captures an object from the surrounding. Initially we map the surroundings of all the objects present in it and store it the cloud database. Then when the user requests for a path to place inside the building from his location, he first need to scan the area around him so that the system gets to know his location and then show the best path to his destination. In this paper we propose an indoor navigation application with AR technology [18]. This application helps users to navigate through complex building such as hospitals easily with the help of directional 3-D markers integrated with their phone’s GPS location. We use A* algorithm to find the most cost effective path(precise) to reach our destination by mapping it before using computer vision and saving it so, that we can localize it later [9]. We make use of Placenote SDK which is an AR based SDK. Placenote SDK provides cloud storage solution for saving the location of each way point in a map for x number of maps and makes accessing the information easy. It saves the coordinates of each of the way points separately and a script can be used to access those when needed.

![Fig.2: Describes mapping of the surrounding using computer vision and user localization](image-url)
Fig.3: Describes Indoor traversal using 3D arrows and direction locator using a small directional arrow.

7. Indoor mapping

Before loading the maps we need to map all the possible paths to the final destination from a starting point that the user may choose and also all the other routes from one point to another inside the building. We do this by taking the smartphone and then marking the path by waypoints, which are essentially 3D markers that help in marking a particular path. Also while doing this, we make the use of the smartphone’s gyroscope which can later help in pointing the 3D directional arrows on the screen to point the end user to his destination. 3D waypoints are stored as separate nodes with their location coordinates on the cloud storage through placenote SDK that automates the whole process and allocates unique location for each of the nodes. A* algorithm is applied, which enables the program to efficiently calculate the shortest of the paths to the required destination by comparing the location coordinates of all the way points stored in the cloud [9].

Fig.4: Workflow diagram of the indoor navigation app
8. Result
With this study we found out that the application developed by us was successful in reducing the time taken to navigate inside a building when compared to doing the same using a paper map. Also with this application in place we found that people became more independent in reaching to their desired location rather than asking other people to show them the way with the help of guiding 3D arrows which guide to tilt the phone so that the directional arrows are clearly visible.

9. Conclusion
In this study, we have created Augmented Reality application that can be used to encourage both indoor and outside route effectively. This application can be really useful to navigate in the big buildings especially hospitals since it gives precise directions to the place a user wants to go in the building. In addition, we intend to think about various other technologies which can be used to map locations easily as it isn’t possible to map all the outdoor locations manually, but at the same time this solution can help solve the problem of path overlapping in 2D navigation apps as it displays the directions precisely and 3D markers are easily visible on the screen since they are just super imposed on the surroundings.

10. FUTURE PROSPECTS
With the advancement in technology and new software releasing regularly, we hope mapping locations can become easier in future and can be just left onto the machine to figure out rather than doing it manually as we did in our study. Also individual 3D maps of indoor locations could be made separately and stored on cloud storage [16]. This could potentially eliminate the need to map the path manually but currently building 3D map of an indoor building on Unity3D is a cumbersome and a long process, which is why it is being implemented on a very small scale that too for research purposes.

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