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Enchanted Explorations: Augmented Reality Indoor Navigation and Immersive Point of Interest Discovery

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***Abstract*— There is a rapid growth in AR technology in recent years to solve different challenges. This project helps in exploring the indoor navigation on their point of interest and it changes the way we interact with indoor environment by making use of this technology. The objective behind this particular project is to create an AR-established indoor application that deals with an interactive and immersive experience. With the help of this application, users will be able to navigate different location and also, they will be able to obtain information about specific points of interest in the indoor environment. We have created an application that makes use of device's camera to detect and identify current indoor location of the user. The system then uses the power of computer vision and pathfinding algorithm to understand the physical environment of user location and providing guidance towards the chosen destination. The impact of this project can be seen in the field of social and economic areas. In conclusion, the impact of the proposed system is to help the user in immersive way to explore indoor spaces. It envisions a future where the chances of getting lost indoors becomes a thing of the past, enhancing the way people immerse in indoor exploration and transform into interactive and engaging environments for various kinds of users of this particular application.**

***Index Terms*— Augmented Reality, Pathfinding, Indoor Navigation, Computer Vision**

I. INTRODUCTION

The realm of AR is a latest technology that merges the digital and physical worlds. Using this technology, we can change the way we experience the real world. In today's technology, AR has reached superior levels, Entering different fields from entertainment and education to healthcare and industry. In this project, we are going to look at how augmented reality can play its role in helping various users with indoor navigation.

Augmented Reality works on a set of fundamental principles that combines both real world and virtual world. It uses camera for vision that allows devices to interact and understand the world. It uses complex algorithms that tracks objects, recognize patterns, and understand depth and perspective. Simultaneously, AR needs a good display mechanism, typically by making use of a handheld devices, tablet, or dedicated Augmented Reality headset to include digital elements in the real world that is viewable by the user.

There are many applications of Augmented Reality in the modern world starting from the field of education by

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making concepts simple and to better understand the things we can make use of different 3d models. In the medical field, we can utilize AR for visualizing complex anatomical structures and surgical guidance. In the architecture and design field, AR enables architects to visualize the building plans, offering a 3D model of their creations.
The main purpose of this project is to combine the advantage of this new technology of augmented reality with the navigation field by providing the facility for users to guide to both indoor and outdoor navigation. By using this application users can get a specific point of interest with less difficulty and can also get to know more in-depth information from an outdoor perspective as well. This enables the use of AR technology in tourism and helps the users with a better tool for navigation in an unknown environment.

A. Related Work

Ref. [1] displays the use of indoor position and way-finding methods for smartphone related applications making use of the new technology called Augmented reality. Using this user will get a real-world experience. In most cases, the maps only depict the 2D structure of the location. But it's difficult for us to imagine how the internal structure is built. We have built an application where we can see all the internal structure of the location. So, this has been done using the cutting technology Augmented reality. Outdoor areas use the navigation system, but indoor navigation is still in the very initial phases of the development. Positioning system and indoor wayfinding helps in the versatile guidance particularly in building complexes, and humans in puzzling and unexplored buildings. In locations where Global Positioning System is not used much more and absent, indoor based systems on wayfinding are becoming much more prominent. In current situations, the major wayfinding systems are based on signals that are received from Global Navigation Satellite System (GNSS), that are being used more for outside navigation but it's difficult to use for indoor navigation because of its poor reception level.
Ref. [2] shows the use of Open-air wayfinding systems are largely used across different kinds of smartphones. They make use of GPS (Global Positioning System). Due to the complexity of surrounding environments in which we live which is made up of many storeys, chambers, stairs and escalators, indoor wayfinding systems are work under progress. This paper includes design and implementation of Indoor Wayfinding making use of Unity in our hand-held devices. It depicts arrows in the direction of movement of the camera that uses smartphone's capabilities in combination with augmentation technological capabilities. In order to locate the user's current position, it makes use of Concurrent Isolation of position and plotting out approach which uses a angular momentum sensor and a capture device in user's mobile device for to finding the user's movement within the walls after obtaining the present coordinates of the user by scanning the two-dimensional barcode.
Ref. [3] uses an Internal wayfinding network replicas are an important way to find the terminus in a 3D model. To discover the optimal route for destination research focuses on minimizing the extent of the path. They might not be adequate enough to assist one in navigating because they only take into account the physical layout of the building. In this study ours real contribution is to adopt them to indoor paths. In this paper we first conduct an experiment by the help of the user to find and collect the all-possible patterns of navigation. And these patterns are compared with the indoor paths with the help of statistical comparison based on space syntax measures. With the help of the we find the shortest path for the specific destination. The centerline based MPRSSE is found to be most fitting navigation infrastructure to help the users to find the destination, Based on the on the traditional and space syntax measures.
Ref. [4] makes use of the navigation system is used to assist individuals in finding their desired location, measuring the distance they have travelled, and also in visualizing the route. While navigating the indoor buildings it lacks real-time digital directions, which confuses the users. In this paper, we have built an application using the cutting technology called augmented reality that provides a easy-access remedy and eliminates all the perplexity among the users. Our aim is the establishment of an indoor system of wayfinding that harnesses Augmented reality tools to elevate better human-computer interaction. We have built the two-dimensional barcodes for each of the locations. By scanning it user will get a better accuracy rate for the location. This will give better reliability and effectiveness for the navigation system.
Ref. [5] shows the current, Global Navigation Satellite System technologies are in wide usage for navigational purpose in bulk of the navigation that is used for commercial applications. Although this particular technology has not been as effective in case of indoor environment as that of outdoor environment. The objective behind this particular project is to depict an indoor navigation system that is both simple and which is cost effective. The proposed system makes use of established on-device sensors that are inlaid in most of the smartphones in order to identify the user’s whereabouts, which is then integrated with technology that uses augmentation capabilities to give users an absorbing interaction. This particular project uses an indoor wayfinding mobile app that was created and validated. The construction of this application makes use of Inbuidling technology for navigation which helps

in aligning the user in internal environment through technology which detects the user's placement, obtains the passage to the selected terminus and makes use of Core package for augmentation technologies in order to exhibit augmented directions for the assessed track. Inquiries were done to find the success rate of the approach and to accumulate various feedbacks from the participants.

Ref. [6] depicts the development of applications that are augmentation capabilities is helpful for different surroundings such as library for improving the navigation and to enable smart guidance in this urbanized world. In this paper, the objective is to develop such applications that have augmented capability so that people who use the application get the required knowledge and guidance easily using such applications that use the capabilities of augmentation when walking in environments such as library. By making use of the augmentation capabilities, we can impact the journey by guiding them towards the right terminus and presenting them the right knowledge quickly. This software uses Vuforia which sets the picture marker and processes the result using Unity3d and makes use of Android Studio to build the interaction that they are going to have with the handheld device. The speech will be recognized using technology of IBM with the name Watson. Tests are conducted which provides details whether it has helped and has increased the efficiency of the way people use the capabilities of this new solution.

Ref. [7] leverages software that help us in tracking and pinpointing in interior environments are very important. The open-air wayfinding is easier but the interior wayfinding is much difficult. This paper introduces wayfinding for spaces situated in interior locations that uses capabilities of augmentation to track the way challenging residencies are going to be traversed and using services based on cloud where the access of tracking these residencies is controlled by administrators and they can also change the route of the wayfinding systems. They have used the APIs of software called as Unity three dimension to develop the applications of handheld devices with augmentation potential. This software executes on handheld devices. The interaction and the way people feel while using the software has been impacted very highly due to the capabilities of augmentation than the age-old two-dimensional approach or maps made of paper which are present on signboards to help people in tracking the terminus they want to reach. The effectiveness was tested by executing the software at a medical building.

Ref. [8] shows that the educational community and business have seen an upsurge in attention of the new solutions presented by handheld augmentation. There are two different types of augmentation-based devices that is software based and hardware based. The website-based augmentation solutions provide very good interactions and immerse them through the software. In this paper, the handheld capabilities of augmentation have been explored through website giving a competition to the technologies that make use of software-based augmentation solutions. They have given detailed explanation and different answers which adopts the parallel services of website to increase the power of augmentation capabilities. This paper utilizes the solutions that are presented by website and combines it with augmentation capabilities along with the growing technology of 5G to give competition to 3G and 4G based solutions.

Ref. [9] shows how complicated public buildings like airports utilize diverse structures help humans to a sure terminus. These processes commonly display a ground plan, having directional indicators and symptoms or shade encrypted strains on the floor. The monitoring and the guiding a part of a reliable indoor navigation requests a three-D version of the environment. for that reason, a three-D model technology algorithm turned into implemented, which spontaneously creates a vectorized transformation into 3d mesh 2nd ground plan. This FOVPath is designed to react no longer only to the placement of the user and the target, but is also depending on the view route and the sphere of view (FOV) capabilities of the used device. This ensures that the consumer constantly receives affordable statistics in the contemporary FOV. to assess the concept technical reviews and person research had been and can be finished.

Ref. [10] shows the way technology has increased giving us new solutions has led people to increase the way they interact with smartphones. There have been many new discoveries and inventions made across diverse fields, but most of them are in systems that does positioning. This study focuses on making a system that uses lens, inclinometer and parts of directional indicator that are present in the handheld devices for pinpointing our location. To make sure that we don’t rely on maps, the solutions of augmentation has been introduced which enables the built-in lens of the handheld devices to guide the users without the requirement of maps.

Ref. [11] makes use of the study which comprehensively states the blueprint, development and evolution of an untagged surroundings technology for a technology’s compatible with augmentation power, based on applications supporting indoor wayfinding, adjust efficiently to operate on a HMD. The Google’s innovation called Glass, which is being used as a display device had a certain pitfalls like slow processing speed, lower quality visual display and short battery life. But this technology was able to overcome these limitations by providing the precise, very efficient, and good navigation experience. It shows the destination track with shortest distance in the form of

3D model. The proficiency that is measured and administered based on the efficacy and practicality of the device for daily wayfinding process. After conducted assessment of portable and wearable devices also validated the portable suited devices for indoor wayfinding.

Ref. [12] displays the mistakes in drift are very common and the power of Heuristics in its advanced form helps eliminate these mistakes. In systems that enables pedestrians to traverse the interior spaces, the mistake of positioning is caused by azimuth error. John Borenstein has proposed a way to reduce this error through an algorithm that is HDE. The concrete structures that divide our rooms are either perpendicular or parallel to one another including the corridors in interior spaces. The directions of these structures are named as dominant directions. This paper discusses the approach used. It has two steps, first we are going to find if users walk in straight-line or not. If they are not following a straight-line the inclinometer are estimated and updated. If they are walking in straight-line then the algorithm calculates the direction that is dominant is being traversed or not. Using this data, the algorithm then finds out the correct inclination for eliminating the error of azimuth so that the direction closes to dominant is found.

Ref. [13] shows how navigation systems adapted for outdoor use are unsuitable for indoor environments, requiring the development of specialized maps and mapping techniques. This paper addresses the significant challenges associated with indoor navigation in locations such as shopping malls, hotels, and airports, where conventional map matching algorithms prove inadequate. The primary goal is to introduce a sophisticated mapping algorithm that increases the accuracy of positioning motors and ensures a natural representation of pedestrian trajectories. Building on previous research, this study proposes new internal map comparison algorithms that offer insight into their strengths and weaknesses. The significance of this research lies in adapting map matching strategies to meet the specific requirements of indoor navigation, thus laying the foundation for increased location accuracy and a more intuitive representation of pedestrian movement in indoor spaces.

Ref. [14] paves way for new solutions that are emerging which are very rapid and one such solution is the power of Augmentation which can be used to impose those pictures that are processed electronically into our environment making it look realistic. This makes it more immersive and interactive for the users. This paper discusses the power of Augmentation in utilizing it for solutions that can be combined with wayfinding technologies. The interior spaces are different and requires a different approach as compared to open-air surroundings. The position of user in interior environment cannot be judged using the signals coming from satellite. Here, they discuss a different technique to determine the position of an individual in an interior space and display that knowledge in a more helpful way to the users.

Ref. [15] shows that in today's era, most of them put faith in systems based on Global Positioning Signals to locate a terminus. Nevertheless, finding a terminus within an interior space is challenging since Global Navigation Satellite Systems do not work in interior spaces, and most of them still use age old method of referring to the signage or physical plan of storeys. This paper indicates that they have used a handheld based application that makes use of representational cues and dead reckoning of foot passengers to create a collaborative system based on wayfinding in interior spaces using the power of augmentation capabilities. The sensors that are used includes G-meter, directional indicator and camera, the ones that are already embedded in today's smartphones. By making use of these technologies, a blueprint for an application based on handheld devices called Sun Map is created to demonstrate the power of augmentation in the university campus environment for localization and wayfinding.

Ref. [16] has lately shown that wayfinding in interior spaces has become a trending topic worldwide. With substantial building construction happening, the importance of interior wayfinding has grown more as compared to outdoor navigation. In this written work, we discuss about non wired based systems for locating especially in interior locations, especially using Wireless technology of Fidelity (Wi-Fi), Bluetooth, or other existing solutions which measures different signals. This paper discusses the inclusion of image-based tracking in interior solutions that makes use of smartphone’s capability of the upcoming augmentation and motion tracking. The calculative capabilities in combination with many sensors such as Global Navigation Aiding Signals, motion sensors, lens, wireless capturers, these power the smartphone and software sector to become breathtaking innovations in interactive technologies.

II. Proposed Solution

Fig 1. Illustrates the sequence of interactions and data flows within the proposed methodology, highlighting key components such as Mobile Application, Navigation Logic, Augmented Reality Module, Data Management, User Profile and Preferences and Server.

The Mobile Application consists of a User Interface. It is made up of AR view, Navigation Interface and Information Overlay. The AR view displays a real-world environment captured by user's camera. The Navigation Interface provides information about user's current location, destination and navigation cues. Information Overlay displays details about the points of interest in indoor environment.
The Navigation Logic contains Pathfinding Algorithm, Location Detection and Database Query. The Pathfinding Algorithm determines optimal route from user's current location to the chosen destination. Location Detection uses computer vision and device sensors to identify user's current indoor location. The Database Query is used to retrieve the information about the points of interest from the database.
The Augmented Reality Module contains AR Rendering, Markerless Tracking and User Feedback. AR Rendering is used to overlay navigation cues and digital content onto the real-world view. Markerless Tracking utilizes Visual Simultaneous Localization and Mapping (SLAM) for accurate virtual element placement. User Feedback allows users to provide feedback on the AR experience.
The Data Management module contains Database and Real Time Data Integration. Database stores information about indoor environments, points of interest and user preferences. Real Time Data Integration connects to external data sources for live updates on events, locations and changes within the indoor environment.
The User Profile and Preferences module contains Personalization and Feedback Collection. Personalization considers user preferences and past interactions to enhance the user experience. Feedback Collection gathers user feedback for continuous improvement.
The Server module contains Path Generation, Data Processing and Response Handling. Path Generation calculates and processes optimal routes based on user inputs and current conditions. Data Processing manages the consistency and reliability of data acquired from various sources. Response Handling communicates with the mobile application to provide timely information.
User first starts the application and interacts with the mobile application. Then the Navigation Logic processes the collected user inputs, then calculates the optimal routes and queries the appropriate database for the point of interest information. Then the AR module overlays the navigation cues that are obtained and the digital content on the user's real-world view. The real time data integration provides the users with live updates on events and changes that occur in the indoor environment. User Feedback is collected so that the mobile application can be continuously improved. Server is also used so that the path that needs to be generated based on the obtained user's inputs can be overlayed onto the user's real-world view, to obtain data consistency and to better handle the responses of the user's queries in an efficient manner.

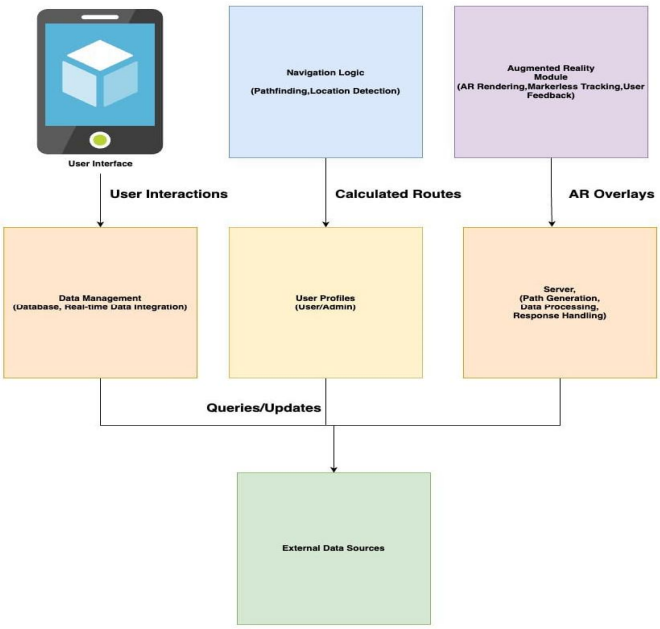

Figure 1. Architecture Diagram of Proposed System

A. Results

For the college facility, we were able to successfully develop an augmented reality mobile application to help the students better navigate the indoor environment. Fig. 2 shows the first step that admin does to identify the class room numbers. Fig. 3 shows that once the text is correctly identified we can proceed with the next step. Fig. 4 shows that we are going to create an entry node for each room numbers. Fig. 5 shows that once node entry is created for each room number, we create a path node to different classrooms. Fig. 6 shows the link created between path nodes. This data will be stored in the database. Fig. 7 displays how user will be successfully be directed by the arrows along the linked nodes when he opens the mobile application and selects his start position and the end destination. This prototype can be extended to work in other complex places such as malls, airports, etc. by allowing the admin to enter a custom text to detect it and repeating the above-mentioned steps for creation of entry nodes and linking them. Building this will increase the efficiency, ease of access within complex buildings and helps reduce the frustration among the individuals to ask people for directions to the destination that they were trying to find. The application has been tested at the college campus, which produced correct results and effectively generated a path leading to the destination with an accuracy of 80%. When the server's internal speed and response time are consistent, it takes around 4-5 minutes to generate and process results. However, this time may vary depending on network speeds and the server's request and response timings.

Figure 2. Text Detection

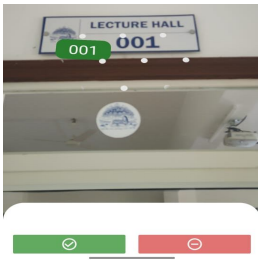

Figure 3. Text Identification

Figure 4. Entry Node Creation

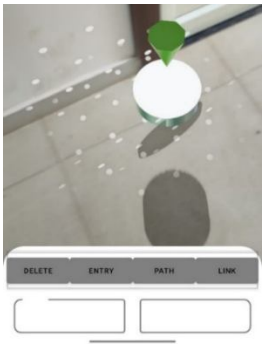

Figure 5. Path Node Setup

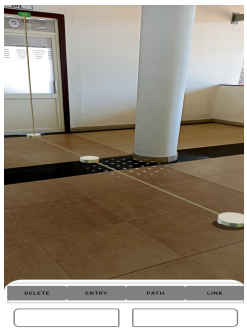

Figure 6. Linking Path Nodes

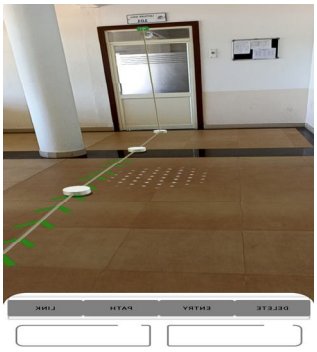

Figure 8. Path Generated to Destination

B. Discussion

We have used ML text identification algorithm. This helps in identifying the user's current location. The admin first scans the room number, creates an entry node for each classroom and then setups path nodes and links them. When the user scans and selects the destination, an AR marker will be overlayed on the screen in the real-world view guiding the user towards his destination. This is different from the commonly adopted method of using a QR code or by using a Bluetooth beacon. It requires installing the QR code at various places and Bluetooth beacons to be setup which can cost a lot. This approach enables lower cost and installation time. It can also be extended to various places than being limited to few places. The efficiency of this approach is 10% higher than the previously mentioned approach.

II. CONCLUSIONS

The development of the project gave us a wonderful learning experience, allowing us to delve into the exciting realm of Augmented Reality and explore its applications in enhancing point of interest information and indoor navigation. Our project highlights the immense potential of AR. One of the most valuable lessons we learnt is the importance of data acquisition and preprocessing. In order to deliver accurate and timely information to users, we had to ensure that our data sources were reliable and up to date. The implementation of AR technology itself was an important aspect of our project. We adopted marker less tracking, leveraging Visual Simultaneous Localization Mapping (SLAM) to anchor virtual elements in the real word accurately. In conclusion, our journey in the world of AR-based indoor and outdoor navigation has been both enlightening and rewarding at the same time it has enhanced our knowledge in the field. By means of this application, we hope to create an application which the users can use to enhance their navigation within indoor environments.

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