Research Direction for Android Based Indoor Navigation Solution for Shopping Malls through Augmented Reality-EasyMap

HMCK Herath[#], A Wanniarachchi and R Fernando

Department of Computer science, Faculty of Computing, General Sir John Kotelawala Defence University, Ratmalana, Sri Lanka

#35-se-0010@kdu.ac.lk

Abstract - Shopping malls have become extremely popular among society because they are very convenient. A shopping mall is a collection of shops and stalls in one large space. When clients are unfamiliar with the shopping area, it can sometimes be difficult to determine where the store is located, hence time wasting. Requirement gathering and data analysis techniques such as surveys, interviews and literature survey clearly provide the best idea of existing systems, used methods, techniques and their pros and cons. Through the above-mentioned requirement gathering techniques, the best solution for a problem domain is the proposed application for visually indoor navigation. The mobile application is the best way to release it to the masses with indoor navigation to find the destination by using step-by-step directions. Augmented Reality is one of technologies that is rapidly evolving and can deliver new experiences to the world. It can guide visualized directions to users for navigating to the destination through the Augmented Reality environment. Other than the navigation feature, this application provides more different functionalities, such as the user can search the destination using a shop's name or product's name they need to purchase, and categorize the shops and stalls in a shopping mall. The development of this app involves a different variety of interesting tools and software such as IndoorAtlas, ARCore and Android studio SDK. Throughout this paper, a smart solution for the above-mentioned problem and design, used technologies and how they have evolved to the implementation of Android-based Indoor Navigation Solution using Augmented Reality for shopping malls are discussed.

Keywords: mobile application, indoor navigation, shopping mall, augmented reality

I. INTRODUCTION

As a result of the world's development and globalization, everything is developing increasingly day by day. Economics and business are one of the major parts in these development areas. Therefore, the growth of international business and competition among countries in the world. As a result of this situation, one of the mainly focused areas is shopping malls in countries. It widely targeted foreigners and local civilians. Now these shopping malls have become a tourism attraction and a major trend among people. Most people like to visit shopping malls because the shopping mall can be explained as everything in one place. They can enjoy it, buy anything and dine in etc.

Shopping and shopping areas are getting bigger these days. When shoppers are unfamiliar with the area, it can sometimes be difficult to determine where the store is. In some shopping malls, the floor plan is enormous, and the maps are complex. Sometimes clients cannot find the staircase in some shopping malls. Some people who are not so good at direction may not understand the map and may not find the store easily. That is one of major problems faced by new customers during their visit to a shopping mall, it is difficult to find the shops they need properly. Some malls and stores have their own applications. However, those applications do not support finding the destination, only provide information on the shops. Sometimes, when a store or store is repaired or closed, customers are not notified, and they become frustrated about

wasting time looking at it. The other major problem is users cannot use Google maps to get direction in the indoor areas.

Nowadays, most shopping malls do not have an appropriate method to navigate users in the indoor area. They already display the floor plan of the shopping mall and provide banners and labels as a navigating method. Therefore, here proposed EasyMap android-based mobile application as the best solution to address the above-mentioned difficulties faced by customers at shopping malls. This mobile app is very helpful to visitors because that application navigates the user at the shopping mall by providing visualizing navigation path. By using this EasyMap application, the user can quickly check out food courts, garment outlets, electric outlets and bathroom etc. when they are categorized. The user can quickly enter the name of the shop or the name of the items they need on the search bar, and the app displays a suitable shop, floor number, details about the shop, daily offers related to the shop or shopping items, navigation map and navigates the user through the camera using AR technology. Therefore, this shopping mall navigation app is more interesting and useful for visitors to do the shopping with happiness and easily find the shops they want.

This research paper walked you through it as follows. First section will give an overview introduction and section two descriptive information about the existing or similar applications to the research and what their pros and cons are compared to the proposed system. Section three will give you the understanding about the system design of this system and section four will give you a clear idea of how the system works with methodology and section five will include different variety of technologies that are being used. Finally, section six will give a possible future works and the conclusion of this research.

II. RELATED WORKS

As above mentioned, there are so many difficulties faced by customers during their shopping at the shopping mall. Each and every shopping mall uses a mapping method for making it easy to find a destination through maps. They currently map and present the inside location. The survey revealed that some shopping malls in Sri Lanka are currently using their own software applications for their publicity and to enter details of stalls. However, they do not include maps and navigation methods to make it easier to find the destination in the indoor area.

Indoor navigation technologies and related applications have become a major trend among other technologies. Nowadays, most researchers are focusing on indoor navigation techniques and reducing the gap among other applications. Various studies have been conducted to classify different types of technologies related to indoor navigation. All these studies briefly explain how to address the problems to solve indoor navigation.

A study directly addressing the problem domain of this research (Bakheet, Abd and Ahmed, 2014) has been conducted by Abdalwhab Bakheet and others regarding the Android mapping application. This study was most related to the proposed solution, indoor navigation included a mobile app. This application was originally implemented for the University of Khartoum. They provide two modes of maps such as online mode displaying and an offline mode displaying a pre-downloaded map that does not need an Internet connection.

As a result of the popularity of the indoor positioning technology, indoor navigation applications have been famous around the world. Bo-Chen Huang and others discussed(Huang et al., 2020) the topic based on Augmented Reality Based Indoor Navigation System. In this research, explained the limitations of a 2D navigation map, which can be stressful and confusing for users as they make a connection between the real environment and the 2D navigation map before proceeding. For this reason, they developed ARBIN and enhanced reality-based navigation system that publishes on-screen navigation instructions in real-world environments for ease of use. They used Bluetooth low energy beacons to detect the current position in this system.

Timothy Reu Radaha and others proposed a paper that talked(Radaha, 2013) about "Mobile Indoor Navigation Application for Airport Transits". The main goal of the passenger is to incorporate it into their flight and arrive safely at

their destination. One solution to help travelers through unfamiliar airports is to incorporate technology, especially in the form of mobile applications. The purpose of this research is to develop the logic and concept for a mobile home navigation application and study the benefits to passengers. This article cites some developers who are trying to improve users' place in the home environment, and digital mapping providers such as Google and Meridian have provided a mapping tool for home navigation capabilities. For Google, they developed Google Maps in- house in addition to existing Google Maps, including adding a detailed floor plan of an airport building and an arrow showing a person's orientation and location.

Claudia Barberis and others discussed(Barberis, Bottino and Malnati, 2014) experiencing indoor navigation on mobile devices. They also mentioned the above-mentioned problem, GPS data is unavailable and highly unreliable inside areas such as buildings. Airports, malls and hospitals are the most common places that indoor navigation problems have been overcome. The indoor navigation app aimed to be more than a static map of the environment for showing the path. From a mathematical-algorithmic viewpoint, the possible routes in a building are internally represented as nodes, turning points and edges are the path segments. The shortest path algorithm is used to compute the shortest path between two points.

Sung Hyun Jang was a great researcher found on Google Schooler, conducted(Jang, 2012) many more researches on indoor navigation and proposed a paper that discussed "A QR Code-based Indoor Navigation System Using Augmented Reality". In this paper, it makes clear that many researchers have explored home positioning systems, while other researchers have explored how AR information interfaces integrate with location information. Technologies such as Assisted GPS, Radio Frequency Identification (RFID), Infrared and Ultrasonic are commonly used for indoor positioning. They developed some systems indoor and outdoor positioning using AGPS technology. QR codes are used here to identify the user's current location. They have constructed two instances of using QR codes to

provide in-house positioning data for navigation systems with an AR interface in this article.

Pei-Huang Diao and others had discovered(Diao and Shih, 2018) "Mobile Smartphone AR System for Path finding in a Dark Environment". The developed application name is MARINS. In this study, the Mobile AR Home Navigation System (MARINS) is illuminated only by the LEDs on the phone camera to guide users to exit the 0-luxury backdrop using a smartphone. This system is developed using Apple ARKit SDK and mapping function on the Unity platform. This study developed an iPhone-based AR system, using Apple ARKit SDK on the Unity platform. The system consists of a real-time environment viewing module, AR guide graphic module, LED lighting module, a route witching module and a spatial information database. This research could be developed for the home navigation system specifically for power outages.

Swaleha Khan and others suggested a solution for the stadium using a web application. That talked about(Khan et al., 2020) "Indoor Navigation in Stadium using Virtual Reality". This system is a web application which is divided into 3 major parts: The Front-End, the Middleware and the Back-End. 360-degree photos of each node are captured for each node. The camera used for this is a Samsung Gear 360. Uses Action Director to get a complete photo sphere. The data on each node is stored in the Mongo DB, which is the NoSQL database.

Lilian PUN-CHENG and others conducted a paper that discussed(Pun-cheng, Li and Sar, 2014) "Optimal Path Finding Independent of Center line Topology". This paper addresses and presents a new method for calculating the optimal path with a connection graph. All inputs to the proposed format are just a digital map without any network preparation in advance. The model is based on the specific cell decomposition method to generate a connection graph by connecting a path between two adjacent horizontal cells. Pedestrians can generate possible routes to provide useful information in determining their route. The main advantage of this new system is that a digital map identifies the user's familiar land features to get the desired results of finding the route. Without the generation and maintenance of the arc-node network data, the

format and customized program automatically handle routes and information.

Guillermo Amat and others are researchers, they are mainly focused on the indoor mapping tools. This paper concluded(Amat, Fernandez and Ramos, 2014) the research based on the topic, Using Open Street Maps data and tools for indoor mapping in a Smart City scenario. Google, the world's most important map provider, has launched its Google Home Maps However, their use is limited to public buildings and their map upload service is not automated. ESRI is also considered a leading provider of geographic information. Their indoor technology is a complete bundle offering indoor mapping, 2d and 3D visualization and routing. The proposed system's architecture's data layer persistence was relayed to MongoDB. The mapping function has three parts. First, first, all spaces and access structures were established following the instructions set out in the OSM's indoor mapping draft. After that, Create a navigable indoor environment with Open Trip Planner. This system uses Wi- Fi fingerprinting for positioning.

Haiyan Hu and others conducted researches based on social functions. This proposed a paper(Hu and Jasper, 2007) that talked about a "Qualitative study of mall shopping behaviors of mature consumers". The study used 30 in- depth interviews to gain insights into the complex business experiences of mature consumers. After this research, they found five elements that are important for mature customers to get a sense of the shopping malls they often visit: choice, convenience, crowd, atmosphere, parking, and hedonic shopping orientation. This paper was widely discussed on the layout of shopping malls.

From questionnaires, surveys, interviews and this literature review, can be identified and get a clear idea about existing systems, used technologies for indoor navigation and pros and cons of currently implemented systems related to indoor navigation. The target group for the questionnaire- based survey is lecturers at the university, software engineers, employees, undergraduates and school students. Another data collecting method is the interview. It is conducted with the Manager of Kandy City Center. For making this system more user- friendly, can be used graphically visualized method to navigate the users through the mobile app. After analyzing the related works, it is finally confirmed that the best method to implement the navigation function is using Augmented Reality technology because it provides visualizing environment to navigate the users.

III. SYSTEM DESIGN

This section will briefly describe how the application is designed, what its features and functions are according to the results of the conducted requirement analysis stage. In the requirement analysis phase, data gathering techniques such as questionnaires, interviews and surveys were used to gather qualitative and quantitative data required for creating the requirement specification for the mobile app. A combination of qualitative and quantitative methods was used to analyze data and take into account the project scope to provide adequate action topics to provide the functionality required for software success. The main advantage of mixing those data analyzing methods is the ability to develop a comprehensive software solution that covers all conditions of the system.

Here, conducted two questionnaire-based surveys for collecting the data. One survey is based on identifying the difficulties when shops at shopping malls are located, and another one is to get a clear idea about existing apps used in shopping malls from the population. From the results of the survey, the most common difficulty faced by visitors is difficult to find some shops and time wasting. After analyzing the data, found one best mobile app developed for the One Galle Face shopping mall. However, it does not include any indoor maps and navigation function. It only provides details of shops.

After analyzing data found from different requirement analyzing techniques, the best solution for shopping malls navigation problem is to guide the users through a mobile application. Then, design what functions, features and modules should include for solving the issue. Identified the main functional requirement of EasyMap mobile app as following.

- The system should be able to navigate the user using AR technology.

- The system should be able to provide a 2D map.
- The system should be able to detect the current location of user.
- User can search shops by shop' name or items they need to buy.
- The system should be able to shops will categorize.
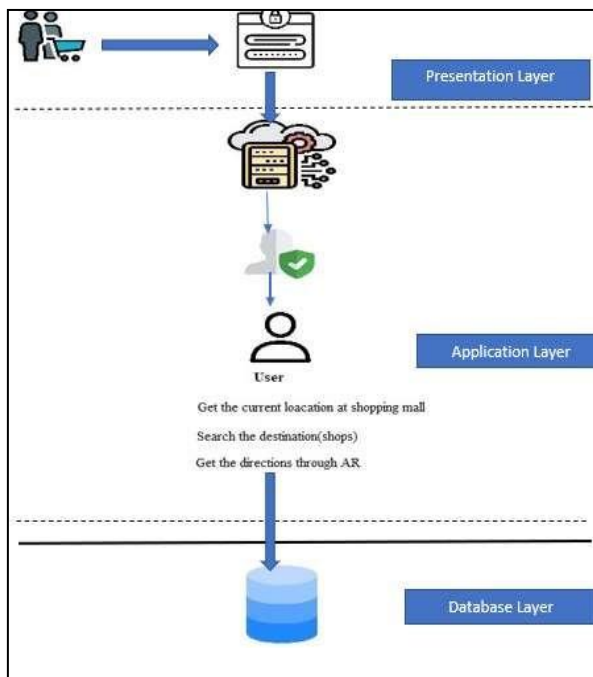- The system should be able to provide user authentication system.

Figure 01: Flow of Activity Diagram
Source: author

The above-mentioned activity diagrams explain the activities of the EasyMap app and how they interrelated the overall system architecture and the use cases of the developed system.

Each function is assigned to execute one or more activities of the entire system to achieve the desired end goals. The requirements for developing the app using Android Studio SDK, Cloud Firebase (Fire Storage, Authentication), IndoorAtlas, Google SDK Geolocation, Google API and maps SDK, Open Street Map, ARCore for design AR model and language requirements are Java, CSS, JavaScript. First, start the implementation process, application design with the main GUI including all the confirmed features.

IV. HOW SYSTEM WORKS

This chapter describes how the EasyMap Android mobile app is developed after the completion of the system designed. The software architecture is mainly considered 3 layers. There is a presentation layer, application layer and data layer. The presentation layer consists of the user-side, that means customers come to the shopping mall. The application layer interacts with the presentation layer where the information is stored and the interfaces in which the interface is run. To predict the current location and find the destination of the user and provide virtual environment applies in the application layer. The data layer is for the storing and managing all the data storage operations and relationship between the entities of the database of the overall system for database requirements of the system. In this EasyMap mobile application, the cloud-based database is used to achieve database functions. The android app uses geo location and google map libraries to track the client's current location and then provide directions to destination by using a cloud server and API's.
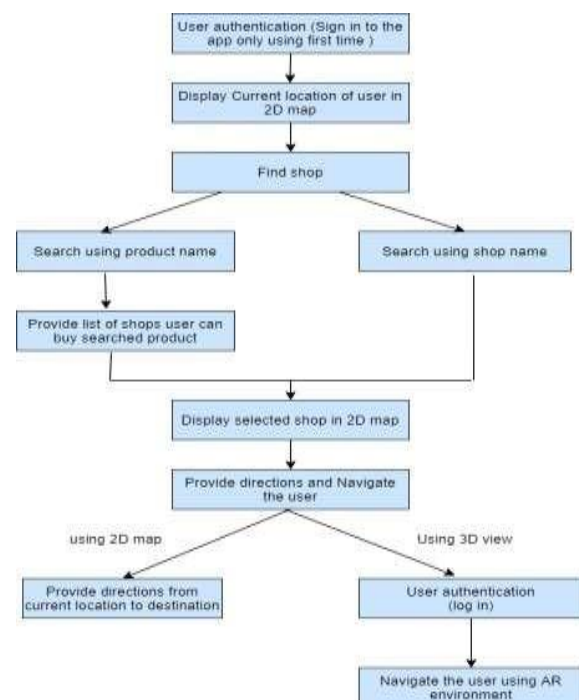

Figure 02: Overall Software Architecture
Source: author

Methodology of developing the system, Iterative model was used until the complete system is implemented. Because this project is a mobile application. Therefore, many of the key

requirements are clearly defined, however further development requires the addition of certain requirements and the ease of access to the scope of the project throughout the software development life cycle. Major requirements were identified from the beginning of the project and developed throughout the project. Developing the prototype model was given to the users and their rapid feedbacks were used to get reviews and updates and test all the functions and achieve the project final goal with high customer satisfaction.

In this initial stage, the mobile app was targeted to implement for Kandy City Center and chose one floor and a different variety of shops such as clothes, food, electrical etc. to develop this EasyMap. Then using IndoorAtlas to create a 2D map view using the indoor plan of KCC and given coordination to place the map. There are different methods to finding the current position of user at shopping mall. Users can give their current location as manual inputs using such as QR codes or current location etc. Another method is using GPS for finding the current location. For indoor areas, using GPS is less accurate than manual input method. However, users are giving inputs using such a QR code or current location is not user friendly and not feasible, because more than one-time users need to give their current position as manual inputs to the system to find the current location. One of this system's main goals is user friendliness and based on Human-computer Interaction. Therefore, to find the current position, EasyMap used GPS compared with a manual input process. Finally, when the user gives a destination, EasyMap can provide directions using a created AR modelAR model is basically a design using ARCore. It can track the positions through the phone in the real world, and it can be understanding of the surroundings by identifying physical things such as floors and walls in the environment.
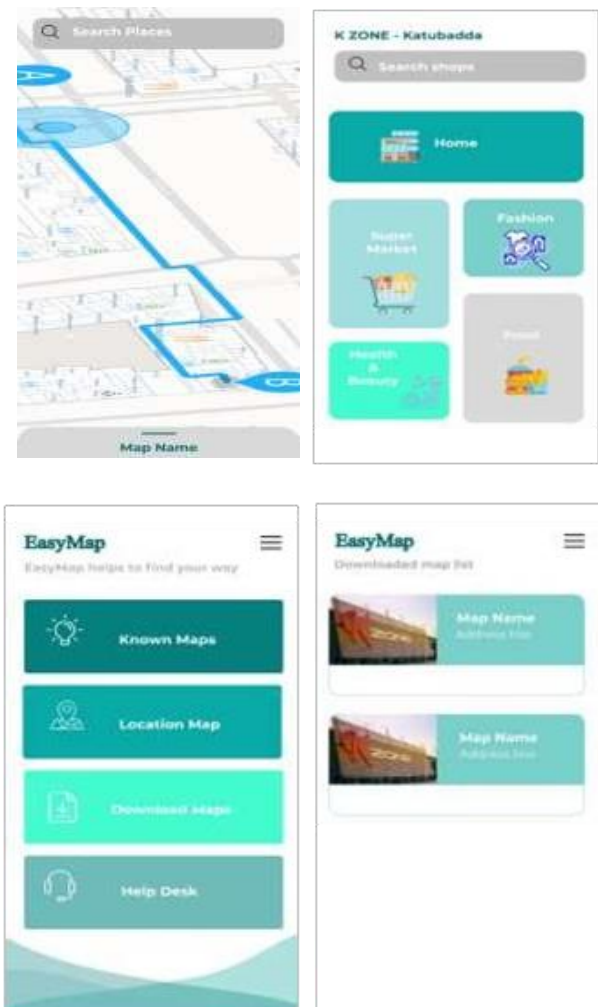

Figure 03: Sample UI designs
Source: author

Above-mentioned images are some designed User Interfaces for the EasyMap including main functionalities.

V. RESULTS AND EVOLUTION

Find the destination at vast indoor areas is very difficult. Indoor navigation is a very helpful method, and mobile application is a solution to present it. Therefore, before the implementation process data collection method is very important to identify what are the current requirements and find the best solution for the problem domain. Surveys, Literature review and Interviews are the used data collection protocols for the project pre iteration of project planning. Choose needed requirements and functionalities and design the graphical user interfaces which include identified functions are the main roles of the systemdesign part. Then software evolution is another iteration in SDLC using results of the pre iteration.

VI. CONCLUSION & FURTHER WORK

This research investigated the future scope of the existing systems and used to understand what features, adaptations and abilities which should be applied to the development. It may be helpful to give the best solution to the problem domain. As a solution, an android-based mobile application is a better way to solve the complexity and not reliability of existing systems, it uses Augmented Reality (AR) technology to solve the indoor navigation feature.

Using this mobile application after user authentication, users can find the indoor destinations at KCC shopping mall quickly and user-friendly. EasyMap finds the current location using GPS in a created indoor map. Then users can search the shops in different ways, such as using the shop's name or using the product's name. According to the user requirements system, find the shortest and optimal path and navigate to the destination through a 2D map or using an AR environment.

At this development stage, EasyMap is implemented only for the KCC. Other famous shopping malls will be added for expansion of the project scope such as One Galle Face, Marino mall, Kzon etc. as further development of the system. Therefore, users can use this EasyMap Shopping mall app when they visit any kind of shopping mall in Sri Lanka. Another main goal of this project is to develop the system based on human computer interaction and also user-friendly to use this mobile app anytime for satisfying the user requirements quickly and easily.

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AUTHOR BIOGRAPHIES

HMCK Herath is currently a BSc. Software Engineering undergraduate at the Department of Computer Science, Faculty of Computing, in the University of General Sir John Kotelawala Defence University.

Mr. WAAM Wanniarachchi the supervisor of this project is a Lecturer (Probationary) of the Faculty of Computing, General Sir John Kotelawala Defence University. He holds a Bachelor

of Science Degree in Information Technology in General Sir John Kotelawala Defence University. His main research interests include Machine Learning, Computer Networks and Database Management Systems.

Ms. JJRS Fernando, another supervisor of this project is an Instructor Gr. II of the Faculty of Computing, General Sir John Kotelawala Defence University. She holds a Bachelor of Science Degree in Computer Science in University of Kelaniya. Her mainresearch interests include Machine Learning, Data Science and Computer Vision.