Augmented Reality Based Smart Supermarket System with Indoor Navigation using Beacon Technology (Easy Shopping Android Mobile App)

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***Abstract*— Augmented reality (AR) applications have recently become popular on modern smartphones. We explore the effectiveness of this mobile AR technology in the context of grocery shopping, in particular as a means to assist shoppers in navigating to the desired products and making healthier and beneficial decisions as they decide which grocery products to buy and even do shopping while staying at home. A supermarket is a customer base premises; means the customer is the one who decides what he is going to purchase and the customer satisfaction may be crucial. In-house shopping in supermarkets has earned popularity among majority of the customers and at the same time most of the customers looking for remote shopping which they can do get the shopping experience just sitting at home. Shopping malls has combined with the IT industry and create more innovative and creative apps, which are beneficial for both the customer and seller parties. So, the main objective of this work is to design a fully functional mobile application that has an innovative positioning and navigation system using AR core technology and Augmented Reality. The other major parts of this application are customer base shopping list handling, personalized recommendations by object detection using AR and remote shopping. Overall the scope of study involves research on AR core technology, Augmented Reality and other additional technologies. The idea of this work can be broadly applied to mobile devices such as mobile phones as an added physical shopping mall functionality using above mention technologies. The proposed Easy Shopping android based mobile app has been tested at the KEELS supermarket in Sri Lanka.**

Keywords— AR-Augmented Reality, AR core, Easy Shopping, Android

I. INTRODUCTION

This research targets on enhancing the customer satisfaction with the use of innovative technologies towards the grocery supermarket chain in Sri Lanka. The retail industry drives a larger proportion of the Sri Lankan economy and therefore plays an important role in building up the gross domestic income of the country. The supermarket chains in Sri Lanka have come up as a major segment within the retailing industry and the industry is showing signs of continued robust growth. A supermarket can be simply described as "a large self-service retail market that sells food and household goods". In the modern world people has a very tight schedule in their day to day life, hence they seek very quick and easy ways in order to fulfill their shopping requirements. Since supermarket industry is a customer centric industry customer satisfaction is one of the most important as well as the most crucial factor which determines the profitability and competitiveness over supermarkets. This study is concerned with identifying prevailing problems faced by customers when they deal with supermarket industry as relates to Sri Lankan Supermarkets with a view of exploring how supermarket dealers can minimize these problems to achieve competitive advantage through customer satisfaction using the innovative technologies. The use of innovative technologies towards digitization to accelerate customer satisfaction and in return supermarket dealers can obtain competitive advantage. It is well known that supermarket dealers invest heavily on IT driven services. Supermarkets aims to attract more and more customers by introducing innovative functionalities to the supermarket chains of Sri Lanka. Among those services this research has studied about most essential and common problems faced by customers who have not been addressed by any of those modern applications. The traditional supermarket occupies a large amount of floor space, usually on a single level. It is usually situated near a residential area in order to be convenient to consumers. The basic appeal is the availability of a broad selection of goods under a single roof, at relatively low prices. As the ultimate outcome of this research we propose to develop a mobile application which gives a solution to all

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aforementioned issues found by customers and improve the service quality of online shopping. This article describes the design and concept of Easy Mart, an Android-based, fully-cellular software that supports, indoor navigation through AR, personalized advertising and marketing and context-sensitive shopping assistance and remote shopping functionality which takes the form of augmented imaging using Augmented Reality (AR) technologies and the content of the help is built on the idea of dynamic contextualization.
So, the final product enriches all the features that are there to achieve the goal of smart supermarket providing many more features and benefits to the app users when comparing to the existing similar products. The workflow of this whole system can show as showed in the Figure 1.

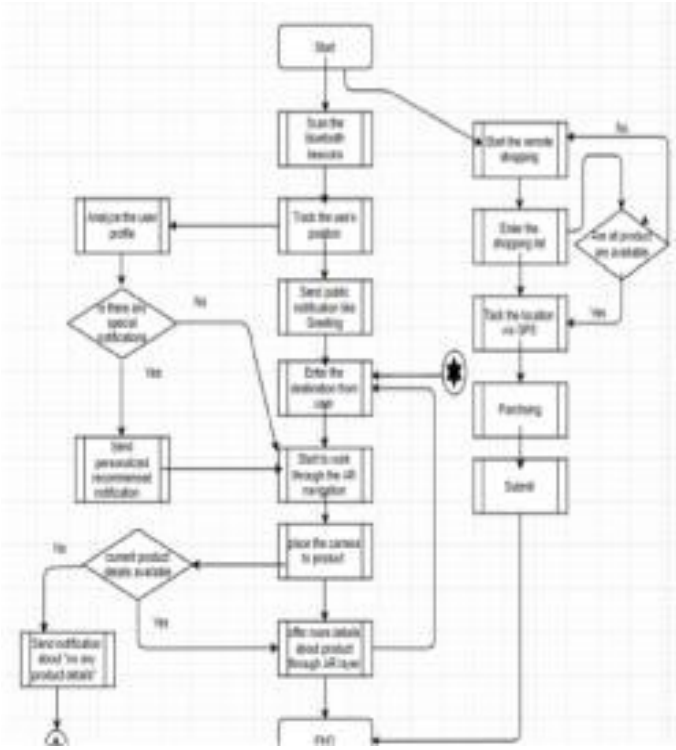

Figure 1: The work flow of this system

The main research problems that we concerned about are mentioned below.

GPS do not support in indoor navigation.

 Using Global navigation satellite systems (GPS or GNSS) are generally not suitable to establish indoor locations, since microwaves would attenuated and scattered by roofs, walls and other objects. To solve this problem, IPS (indoor positioning system) technologies such as WI-FI hotspots, Bluetooth Beacons signals, cellphone signals and Infrared can be used.

Less accuracy of localization method

 Localization methods such as Wi-Fi, RFID are less accurate than using Bluetooth beacons technology.

The approaches used to show navigation details are complicated and hard to understand

Navigation component is the most important component in the indoor navigation system. It should be user friendly and easy to get familiar with. Target of Indoor navigation system is to show the destination that user need to reach using the shortest path. But if it is complicated and hard to identify the best path, then definitely user will be unsatisfied with the system. Interface design also must be user-friendly and should not be very complicated. We use augmented reality technology in order to provide an interactive way of navigation.

Misleading feature of doing shopping without visiting to the physical shopping mall.

 There is no such solution to deliver the good items from the supermarket without visiting the real physical store. So, we have proposed a novel feature of remote shopping to archive the above mention scenario using augmented reality technology.

Misleading function of customize service and product's further information

 There is no any system which provides a personalized services such as providing personalized recommendations on health concerns and further details about a particular product. In this case, two methods are used in order to convey information to the customer using augmented information layer and by sending notifications.

II. LITERATURE REVIEW

A. Map box

Using Map box anyone can make custom online maps for websites & applications, since 2010 Map box has enhanced the niche of custom maps as a reaction to the limited choice supported by the map providers like Google Maps. Map box is the maker of or provide important contribution to some open source mapping libraries and applications. You can display maps inside your Android application using the open source developer platform. It is the location data platform for mobile & web applications providing the features of maps search & navigation to any experience you create. It helps to change the way people walk around cities and roam the world. Within the app the map the Map box provide work with map box robust data. The Maps SDK for unity is a set of tools for building unity applications from real time map data. It provides unity developers to deal with the Map box web services APIs such as Maps, Geocoding & Direction APIs and game objects via a c# base API and graphical user interface.

B. Unity

Unity is known as a cross platform game engine developed by Unity technology SF Company. This engine can be used to create both three-dimensional and two-dimensional game as well as simulations for computers, consoles and mobile devices. This gives us opportunity to develop mobile apps in both 2D and 3D, and the engine offers a primary scripting API in C#.

C. *Vuforia*

Unity supports to develop twenty-seven platforms as iOS, Android, Tized, Day dream, Android TV, Vuforia and etc. Vuforia is an AR software Development kit [SDK] for mobile devices that enables the creation of Augmented Reality applications. It uses computer vision technology to recognize and track planar images [image targets] and simple 3D object, such as boxes in real time. This enables to position and orient virtual object is a part of the real-world scene. This support to 2D and 3D target types including 'mark less' image targets. As well as an additional feature SDK include localized occlusion detection using 'Virtual Buttons' run time image target selection and the ability to create and reconfigure sets programmatically at runtime.

III. METHODOLOGY

The overall workflow of the system is shown in Figure 1. This project was mainly divided into four major parts. (1) Localization and handling personalized notifications (2) Indoor navigation using Augmented Reality;
(3) Augmented Reality based Information provider; and (4) Remote shopping.

(1) Localization and handling personalized notifications is an important function of this project and it also can divided in to two main parts: (a) Indoor localization using BLE-Bluetooth Low Energy; and (b) Handling personalized notification handling.

(a) Indoor localization using BLE

This project was an android based mobile APP which would increase the customer satisfaction towards do shopping inside a supermarket. Users can navigate to their goods through this APP easily. Longitudes and latitudes are used to indicate the core location of the person (mobile node). The core location needed to load the indoor map according to the mobile node located. MAP BOX software framework automatically loads the map according to the longitudes and latitudes which get by GPS technology. GPS can't use in indoor premises for tracking the location, as in indoor premises the GPS signals are very poor. According to that problem we used Bluetooth signals for indoor tacking. BLE – Bluetooth Low Energy technology tracks the position by using strength of the radio signals. In this method we used a small hardware device called Bluetooth Beacons (Figure 2).

Figure 2: iBKS Bluetooth beacon set

The system calculates the distance between beacon and mobile node, and send these beacon IDs and distance estimation to server. Server camper their data and send the accurate location for navigation system. Distance Estimation, and Position Estimation were two steps which was used for localization. For Distance estimation used RSSI method (Radio Signal Strength Indicator method). RSSI method is based on the received signal strength indicator to estimate the distance between neighboring Bluetooth node. This is the algorithm which was used for estimate the distance between mobile node and beacons. [1][2]

$$RSSI\ (d) = -10n\log 10\ (d) - C$$

n = path loss exponent, C=environment constant

Trilateration was the positioning method which used to indicate the position. This system counting the distances from a point to, at least, three references, and forms circles where the intersection of these three will give the location of the point. This method describes correctly by Figure 3.

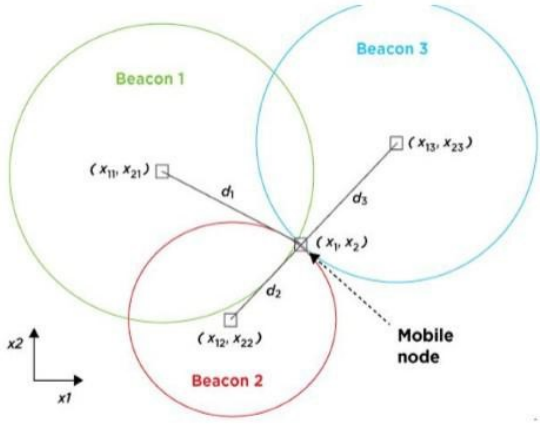

Figure 3: Trilateration positioning method

Using these distance estimations (according to above Figure3 d1, d2, d3) the system tracked the accurate location [3]. The whole process is shown in Figure4.

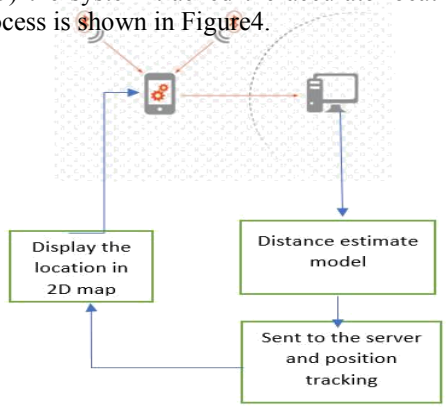

Figure 4: Localization overall process

(b) Handling personalize recommended notification

In this system the personalized recommend notifications are sent to the customer. Once the customer is registered to our app, the information about his or her must entered to the system such as the age gap, gender. Also the notifications about discounts, newly arrival products which matches to their age gap, gender etc are sent through the app. For an example if a new female perfume newly arrived to the supermarket, a notification to the female customers will be sent when she walks near at that perfume rack.

Proximity Based method was used for this function. In this proximity-based method, the near beacon is detected the position that the mobile device locates. When the user is close to the beacon, the system detects that location and push up the notification to customer through analyzing personal information about customer. According to the unique signals from beacons retailer's app which the beacon is enabled on the phone sends the signal to an online platform. The platform tells the app to perform an action. After that, the app formats the information for the customer. The customer receives the targeted personalized message. [2]

(2) Indoor navigation using Augmented Reality

In indoor navigation functionality, the user will be able to enter and select the products that he/she needs to by, using graphical buttons. The app will display an augmented arrow showing the direction. As an added functionality the user is able to add the product as a list that he/she prefer to buy if there is more items or search the previous good list, make relevant changes and get updated good list and search for the navigation. So the app will show the nearest or the shortest route that you can reach to buy the whole goods list. We need to create a dataset containing vector features such as walls, racks and all. So we uploaded a GEO TIFF image of the supermarket blueprint to Map box. For the rendering purpose from our tileset we used a "MapWorldScale" with a "RangeAroundTransformTileProvider". We need the map to render in the real world scale to support the Augmented Reality experience .So for that we use "MapAtWorldScale". "RangeAroundTransformTileProvider" get the AR camera's root transform to load tiles around it. Further used height & material modifiers to excrete the walls with a masked shared to provide occlusion in Augmented Reality. We used the beacons technology to get the user's accurate location. Dijkstra's algorithm is for finding the shortest paths between nodes in a graph, which may represent, for example, road networks, inside a building. We used dijkstra's algorithm to get the shortest route of a good list. [4]

(3) Identifying the products and pop up the details in an information layer(AR based information provider)

This major function was proposed to prepare with the intention of adding a more impressive and a more value adding feature to the Easy Shopping app. Through this feature the customer would be able to get to know the important details of that particular good/product such as the price and substitutes for that product comparing the prices, special offers, reviews, and discounts etc., once the user reached to the desired product. As well as we enhanced this feature in order to customize that information in the customer perspective as there is no any personalized service provided for a single customer in the current Sri Lankan supermarket chain, the user doesn't have a way of seeing personal recommendations such as allergies for them etc. and personalized special offers. And even on the supermarket point of view, the new products are wanted to be introduced to the customers and through that obtain profitability. The supermarket retailers, need to expose their information about deals and discounts to their loyal customers and attract more customers to the supermarket with the intention of maximizing their sales. [5]

As in order to achieve the ultimate objective of this part we came up with a solution to identify a particular product and show the relevant details of that particular product on the top of the screen. Hence object detection, tracking and displaying the details as an information layer and how it should be done was the fundamental area which we focused under this section. We used the augmented reality technology which enables a person to capture more information regarding the environment thus, enhancing their perception. Through AR, the information regarding the products in display can be shown to the user on top of the view of the real world. Then the user is able to capture more information regarding the product and also will make it an interactive experience. Simply what happens is once the user pointed the camera it will search for contrast feature points and if enough of them are found, object is detected, then it should be transferred to the API (Web service severer) and then should be matches with the information in the device database. Then the object is recognized quickly and perfectly and transmitted via the API to the smartphone and displays the relevant details on the screen as described in the Figure 5.

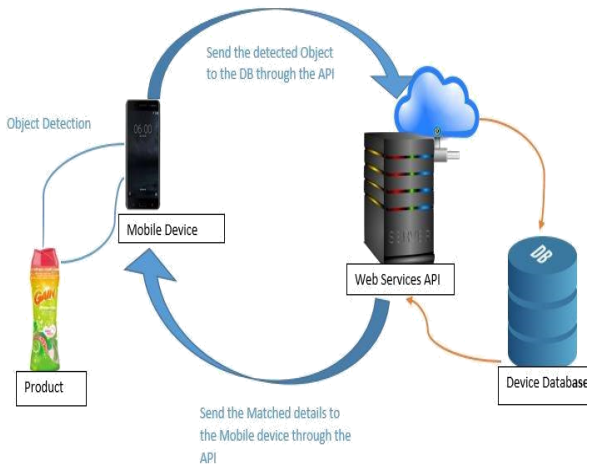

Figure 5: Object detecting and information provider

We selected the platform of android; OS should be 6.0 or above and Unity 2017.4.0f1 as our developing platform tool since it was a fully integrated build out engine that dispense substantial interactive 3D content. Unity can be used in order to collect the assets in the real-world environment which adds lighting, audio, special effects, physics and animation to it. And we used Vuforia SDK as a standalone library for Unity which facilitates the recognition of images and objects in the real environment.

The Vuforia db was used to store images and object targets and the SQLite was used as the SQL database engine embedded for unity. The application was developed using the C# language and since this app was android based we used the Android studio along with Unity as other developing tools. WIFI or mobile data should be used to as the communication interface to connect the Database to the application. The AR camera was expected to use no more than 500MB of Ram to identify the objects and also to display related information in AR scale. Database was expected to use no more than 150MB to save imperative data and the application was expected to use no more than 2MB of memory for the cache. These constraints were managed accordingly. [6]

(4) Augmented reality based remote shopping

M-commerce enables the transactions through wireless devices interacting with computer networks that have the ability to conduct online merchandise purchases. In this function any person can order grocery items online though the mobile application from any place and know the availability of grocery items when, entered the product list. So the user can order substitute items in case the products are not available.

When the user ordered something, system checks the availability of each and every grocery item with the database and inform customer about the availability. And the system should recommend substitute items to the unavailable items. Once the shopping list is finalized by the user, payment happens through a payment gateway if the customer pays online. Then system automatically checks the available delivery riders in the supermarket from created ARSS API, and shopping list will be assigned to a delivery rider with a notification. The delivery rider get the customer location through the Google Place API and seek for the easiest path from Google Map API to reach the customer. Customer also can track the delivery rider through google Map API. All these functions can be monitored and databases can be managed with an admin who has credentials.

Customer or the user can manage the shopping list with the mobile application. Customer can manually search for items, can add them to the list or else can enter goods to the shopping list through the object recognition. Searching goods through this application is very easy to customers as it provides search suggestions based on recent user queries, that matches actual results in the application data.

Managing shopping list through object detection is an innovative part of this shopping application. Easy shopping can recognize the good through the Vuforia library which has a combination of augmented reality and object recognition we use in android developing

Finding the customer location is the next most important feature in this function. As this is an Android version, geolocation was implemented using Google's Places APIs. It can intelligently managed underlying location technology while meeting various development needs when implementing location-based features. So, this will support both customer and the delivery rider. The Google Places API for Android allows customer to build location-aware apps that responded contextually to the local businesses and other places near the device.

Deliver rider can find the easiest path to reach the consumer through the Google Maps Android API. It routes and directions are made possible. You can keep in track of your products right from the time it gets out the supermarket till it reaches your doorstep. Google Map Android API is something that contains Maps, Navigation and Places. This helps to navigate the deliver rider to the customer door steps with less time in the easiest path.

Payments can be happened both on cash on delivery and credit card payment methods in this mobile application. Payment gateway enables easy payment to the customer and facilitates the transfer of information between a payment portal and the front-end processors or acquiring bank**.**

III. RESULTS

For performance evaluation, the project had been tested at the KEELS supermarket (Pittugala) Sir Lanka.

The map loading and detected position of the correct location is shown in Figure 6. After entering the destination, the path which the customer wants to reach will be displayed as an augmented reality arrow as shown in Figure 7. When the customer wants to check the personalized information about goods, they can target the specific good through the back camera. The AR based information layer displays all information that related to that particular item and provide personal recommendations based on health concerns as shown as in Figure 8 and 9.

Figure 6: Loaded indoor map with displaying position

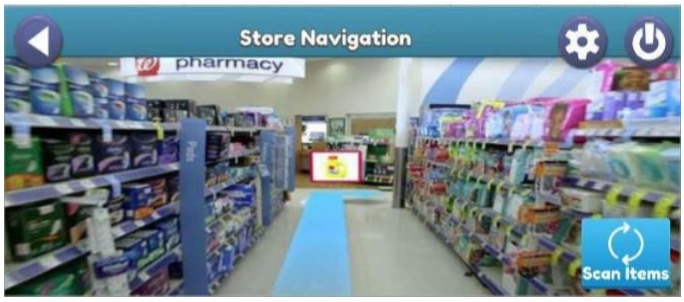

Figure 7: Augmented Reality base navigation

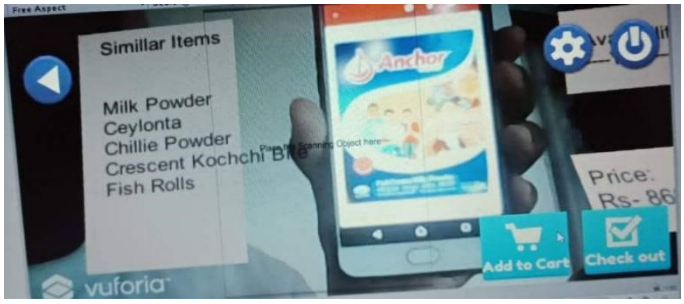

Figure 8: Augmented Reality information layer

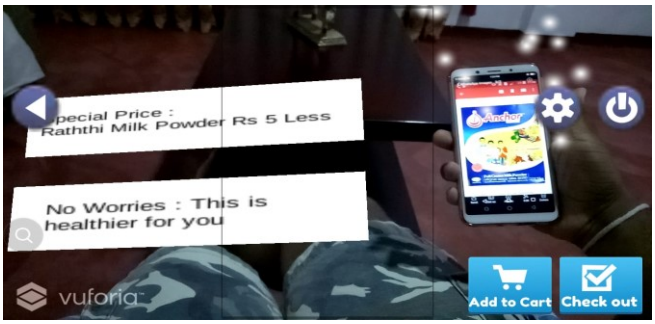

Figure 9: Augmented Reality based information layer

IV. CONCLUSION AND FUTURE WORK

This study was concerned with identifying prevailing problems faced by customers when they deal with supermarket industry as relates to Sri Lankan Supermarkets with a view of exploring how supermarket dealers can minimize these to achieve competitive advantage through customer satisfaction. So this research work demonstrated the implementation of a mobile application to get a smart and an easy shopping experience at the supermarket and outdoor shopping. Most of the customers have a poor understanding about the quality and details of the products, personal recommendations regarding products and due to the lack satisfaction about the supermarkets' infrastructure they usually face difficulties in locating the products inside the supermarkets and when they couldn't find a particular item they typically go for another store and look for it. Due to the enormous space of a large supermarket and the large number of products and goods, the consumers have a difficulty when searching for their necessary items inside the supermarket even though the goods and products are stored in the labeled racks etc. We noticed that, though most of the customers have the tendency to buy products from the very advantageous supermarkets, yet they are puzzled over the offers and discounts offered to them due to lack of information provided at the supermarket. They also prefer to have an analysis on consumer behavior patterns to make decision on that. Due to the hectic lifestyle, most of the people very rarely use a shopping list and as a result, the consumer may forget the items that should be bought, and also they find it difficult to go to a supermarket to do shopping (in house shopping). As the ultimate outcome of this research, we propose to develop a mobile application which gives a solution to all aforementioned issues found by customers and improve the service quality of online shopping. This article describes the design and concept of Easy Shopping, an Android-based, fully-cellular software that supports, indoor navigation through AR, personalized advertising and marketing and context sensitive shopping assistance and remote shopping functionality which takes the form of augmented imaging using Augmented Reality (AR) technologies and the content of the help is built on the idea of dynamic contextualization. In the future work we have planned to increase the effectiveness of feature extraction process to enhance the system to be able to assess people from any country in the world with several appearances, and support for more languages. In the future we planned to develop a voice recognition part for blind people to get same smart supermarket experience like other customers as well, and we planned to develop an automatic bill calculating part for the shopping as well.

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