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Self-Driven Smart Shopping Cart

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ABSTRACT

Supermarkets need a system that can trim down the shopping time as well as the billing time to meet customer necessities. Navigating the shopper to preferred products through shortest path and also maintaining a record of individual shopper's shopping list is the main aim of the product. We have come up with competent design of a cart which uses indoor positioning system, microcontroller and sensors to accomplish this task. Initial measurement unit (IMU) and rotary encoders are being employed for a novel indoor positioning system. In the proposed system, Wi-Fi module facilitates communication between cart and the main server to hold it on track. Various tasks like obstacle detection and harmonizing all tasks in real time is done by microcontroller.

Keywords: dead reckoning; indoor positioning system; inertial measurement unit; quadrature rotary encoder

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I. INTRODUCTION

Motivation of the field of retail has always been consumer demands. Previously, all products were generally fetched by an aide from shelves behind the merchant's counter while customers waited in front of the counter and indicated the items they wanted. In 1916, entrepreneur Clarence Saunders and his Piggly Wiggly stores introduced the scheme of a self-service grocery store to eradicate this laborious process. Shopping behavior represents the decision processes and acts of people involved in buying and using products [1]. Therefore, an innovative and handy system is necessary to change the conventional supermarket practices for patron's convenience.

Fig. 1

Above given diagram represents the supermarket business model. At all levels where bulk material has to be transported, automation has been put into practice using small electric cars that move goods from source to target. Level of local customers is the only potential level of improvement in terms of automation.

A. OBJECTIVE AND SCOPE

- A self-driven cart with embedded sensors capable of navigating automatically to desired location.
- To provide a user friendly shopping experience.
- Central server calculates path and directs the cart accordingly.
- To keep track of current location of cart for convenience.
- Wi-Fi connectivity helps maintain successful connection all over the shopping area within the mall.
- To keep track of users' shopping patterns in order to help provide better shopping suggestions.

II. EASE OF USE

The concept of a self driving shopping cart is a sole solution to make the shopping more consumer friendly. It will help the consumer save time in searching for products and standing in long billing queues.

This has been implemented using indoor positioning system. It is a versatile, multi-purpose, flexible and scalable method for tracking an indoor environment. By mapping an indoor environment, we can unlock infinite possibilities for tracking mobile devices. Global positioning system is incapable of being implemented inside an indoor environment due to signal attenuation caused by construction materials. Employing Wi-Fi signals has been widely adopted as estimating indoor location without expensive infrastructure cost [9]. However, Wi-Fi positioning system (WPS) requires signal training or indoor map. The training process should be performed by experts, which is time consuming and requires periodic management [10].

This is the reason why IPS is needed and is implemented using several methods like Wi-Fi access points, magnetic positioning and dead reckoning.

A traditional supermarket places its products based on various principles of layout:

- The first principle is consumer convenience. The layout of a supermarket is designed to create a high degree of convenience to the consumer to make the shopping experience pleasant.
- The second principle of layout is circulation. Circulation is created by arranging product so the supermarket can control the traffic flow of the consumer.
- The third principle of layout is coordination. Managers sometimes place different items in fast-selling places to increase turnover or to promote a new line.

Using an indoor navigation system to navigate the path taken by customer has many advantages. For example, during highly crowded hours of the day, the navigation can be done in such a way that the customers are given the least crowded path. The system can be useful to not only the customers, but also the retailers. For promotion, they can assign the customer a path that promotes their new product line.

Combining the proposed system with business analytics can give the retailers a unique insight of consumer demands as we can keep a track of hundreds of users' shopping patterns. This can also add an extra dimension in traditional techniques like Apriori algorithm used by retailers.

The Apriori algorithm, which is proposed by Rakesh Agrawal in 1993, is the most classical algorithm for mining association rules among data mining technologies [2].

III. LITERATURE REVIEW

Attempts have been made to change the supermarkets to suit the demands of increasing technological awareness of the users. QueVision. Kroger has embraced the use of technology to reduce shopper wait time at checkout, rolling out a new system called QueVision across its 2,400 grocery stores beginning in 2010 [3]. It uses infrared camera and predictive analytics to feed managers' real-time data of how crowded the supermarket was at particular time of the day, seven days of the week. This data was then used for demand forecasting. Effective demand forecasting was used to reduce the billing queues.

Disadvantages:

- The system took into account only the owner needs and not the customer needs
- Use of infrared camera at various locations needed image processing which was taxation on the central servers
- Differentiating users from one camera to another was a tough task

Italian supermarket chain Coop implemented an intelligent display system in collaboration with Microsoft to display the details of products visual displays of information such as ingredients, potential allergens, the origin or processing of the food, its carbon footprint, and even wine pairing recommendations [4]. This system failed to achieve the main aim of reducing shopping time of the customer.

Some researchers like in [5] used radio frequency identification (RFID) to observe the preference of customers on products. The main aim was to associate products with passive RFID tags to detect their movement caused by customers. Thus, the retailer could find out popular products or what products customers pay attention to. However, these systems lack interaction with customers. The idea was for each customer to use a smart phone with an RFID reader to look for the location of desired product. However, it only guided the customer to the destination product shelf without addressing the dynamic environment (i.e., obstructions and crowds) in a supermarket.

IV. METHODOLOGY

For the actuators, the wheels of the cart are to be coupled with geared Johnson DC motors of torque around 7kg per cm. Wi-Fi module on the cart that will communicate with the central server. Using Inertial Measurement Unit (IMU) along with rotary encoders for indoor positioning system by inertial navigation system. The Arduino controller controls the actions of the motor driver with inputs from the rotary encoder. The rotation encoder is fitted to the motor shaft to record the number of rotations completed by the motor. The motor drivers control the direction of rotation of the motors [12].

We use IMU because IMUs with different dynamic ranges make it possible to measure inertia over an extended dynamic range without introducing a significant amount of noise [7]. When high accuracy and resolution are a must, commercial sensors are usually in the form of rotary encoders based on pulses [6].

- Using Kalman filter for extracting yaw, pitch, roll and linear acceleration using measurements of IMU.
- Using Dijktra's algorithm to find the shortest path.
- Using laser sensors, ultrasonic sensors for obstacle detection.

Advantages:

- Will help solve main problem customers of long time in billing queues.
- The indoor positioning will work in absence of GPS.
- ESP8266 Wi-Fi module is used to transmit the detected sensor and IMU data to the base station using the Wi-Fi 802.11b and then transmit that data to the end user by Arduino using the ESP8266 module. It can also send command from server to the cart to control the configuration of the module [11].
- Real time obstacle avoidance and detection makes an active robotic device that a user can rely upon.
- A system is developed that is scalable, flexible and easily alterable according to the changing dynamics of a supermarket.
- The proposed system can be easily implemented without making much change in the current infrastructure.

The proposed system is more economical as compared to other systems and the cost can be further reduced in mass production.

V. SYSTEM ARCHITECTURE

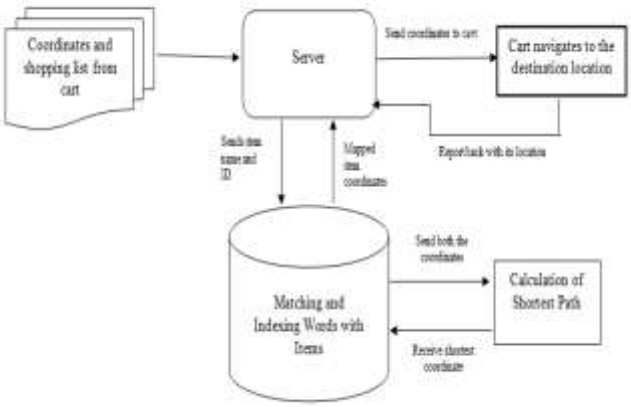

Fig. 2. System architecture

A. OVERVIEW

- Cart sends connecting request to the server and the server acknowledges it.
- Current co-ordinates of the cart and the shopping list is transmitted *via* Wi-Fi module to the centralized server.
- Server matches indexing words with the items and calculates the shortest path.
- It then sends the next nearest intermediate co-ordinates to the cart.
- Micro-controller on the cart commands the actuators to move accordingly.
- The motors work using the DC power from the battery suing the L298N motor driver.
- L298N is a dual H-Bridge motor driver, so it can drive the motors which can be controlled in both clockwise and counter clockwise direction [8].
- Cart approaches the intended location and transmits back its co-ordinates to the server.
- Above steps are repeated until the cart reaches its destination.

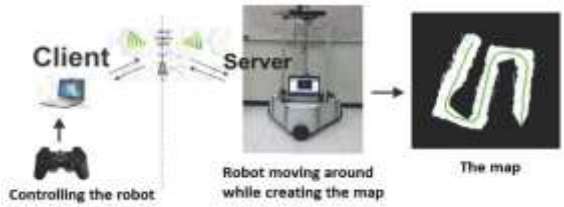

Fig. 3(a)

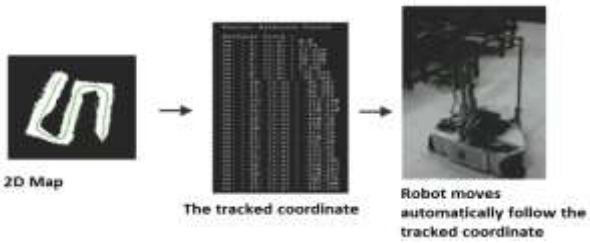

Fig. 3(b)

B. INDOOR POSITIONING SYSTEM

- Initially, the cart is moved around the mall.
- A map is thus created containing co-ordinates of major locations of the mall which is then stored in the database.
- According to the data received from the server, the cart follows the tracked co-ordinates

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