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Self-Driving Smart Cart

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***Abstract*: Smart shopping is a feature oriented project which solves some of the major difficulties which we face during shopping in supermarkets and hypermarkets. It eliminates the effort of the customer to push, steer and shop simultaneously. This project has successfully implemented a Self-driving smart shopping cart for customers. The automatic billing unit of the cart not only provides the customer with information about the product such as product expiry and price which helps keep a check on their total expenditure, but also allows the customer to bill the product instantly and avoid long queues to make payment. The self-driving feature of the cart acts as a guide for the customer to easily reach their product in shortest possible path. The cart is controlled using a Raspberry Pi single board computer (for self-driving) along with an Arduino micro controller (for automatic billing unit) and NodeMCU (for wireless communication) that can guide the user automatically to the desired product. Four 12V DC gear motors are used for the motion of the cart. This cart is integrated with RFID reader module to bill the product in real time. Breadth-First Search algorithm is used for finding shortest path. Image processing is used to realize the shortest path algorithm.**

***Keywords*: Breath First Search, Open CV, RFID.**

1. Introduction

Ever since the debut of wireless technology, electronic commerce has been developed to such an extent to provide convenience, comfort, and efficiency in day-to-day life. Research is being carried out in order to simplify the lifestyle of human beings. Shopping centers or malls form a great source of convenience to consumers, since all the products from different categories are found under the same roof. Retailers are updating to newer technologies so that they could make the shopping experience more simplified. This would not only help consumers but also improvise the economic inflow of such shops as well.

The customer needs to go around the supermarkets or hypermarkets to find the location of products they require, even the sales employees at certain times would not be able to direct the customers to the exact location making this a time consuming problem. Even after reaching the location of the desired product, there will be a wide range of brands under the same product hence making it difficult for the customer to choose. Also the customers need to know details about the product like product rate and product expiry before selecting any product. Along with this the customer has to push and steer the cart all around the shopping center or mall. Also they are required to wait in long queues to get the payment done. The main purpose of this project is to provide centralized and automated billing system using RFID communication integrated with controller to provide self-driving capabilities. Every product available in supermarkets and hypermarkets will be tagged with an RFID tag, to identify the product. Every cart contains a PID controller. Specifically, a PID controller contains a micro controller, LCD, and a RFID reader. There will also be a centralized database from which we can provide product information and recommendation to the customer.

Programmers build up software applications every day in order to augment efficiency and productivity in a mixture of situations. A system is a way of working, organizing or doing one or more than one task according to a fixed plan, program, or set of rules. A system is also an arrangement in which all its units assemble and work together according to the plan or program. An embedded system is one that has computer-hardware with software embedded in it as one of its most important component. It is a dedicated computer-based system for an application(s) or product. It may be either an independent system or a part of a larger system. As its software usually embeds in ROM it does not need secondary memories as in a computer. These systems are designed with a single 8- or 16-BIT micro controller; they have little hardware and software complexities and involve board level design. They may even be battery operated. When developing embedded software for these, an editor, assembler and cross assembler, specific to the micro controller or processor used, are the main programming tools. Usually, C is used for developing these systems [1].

Radio frequency identification (RFID) is a rapidly growing technology that has the potential to make great economic impacts on many industries. While RFID is a relatively old technology, more recent advancements in chip manufacturing technology are making RFID practical for new applications and settings, particularly consumer item level tagging. These advancements have the potential to revolutionize supply chain management, inventory control, and logistics. At its most basic, RFID systems consist of small transponders, or tags, attached to physical objects. RFID tags may soon become the most pervasive microchip in history. When wirelessly interrogated by RFID transceivers, or readers, tags respond with some identifying information that may be associated with arbitrary data records. Thus, RFID systems are one type of automatic identification system, similar to optical bar codes. [2] Cart is

moved with the help of two dual bridge motor drivers connected to four dc gear motors which is controlled using a NodeMCU which then creates a local server 192.168.4.1 using ESP8266 Wi-Fi SoC. This allows the user to select self-driving as well as manual riding mode.

2. Self-Driving Smart Cart

Self-driving smart cart functions basically with help of Breadth-First Search Algorithm (for shortest path finding) and Dual H bridge for the control of motors. It also uses NodeMCU, which creates a Wi-Fi access point to which the mobile can be connected. Fig. 1, shows the functional flow chart of the self-driving smart cart.

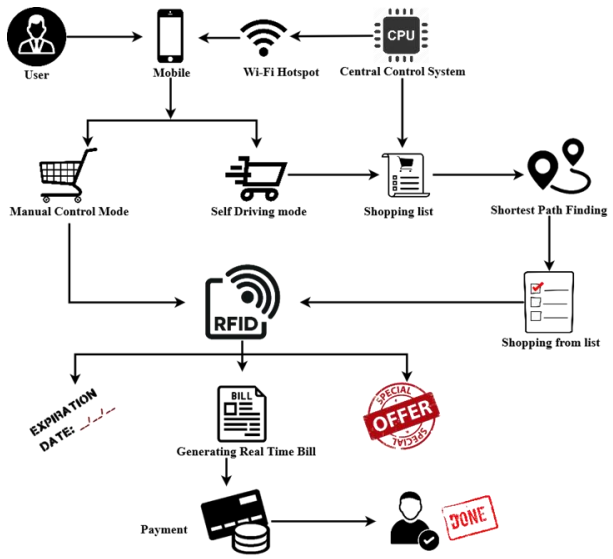

Fig. 1. Functional flow chart of self-driving smart cart

An intelligent shopping aid that assists the customer to locate and select products and inform them on the product/s details dynamically as they move in the shopping arena. When customer enter into the shopping mall, firstly they have to connect their smart phones to the Wi-Fi. Then they will be provided with a window with options Manual Driving mode and Self-driving mode. Customer has to select between the options according to their requirement, if customer opt for manual driving mode they will be provided with control keys and they can control the cart using mobile phone. If the customer is opting for self-driving mode they will have to input the required products one by one, then the cart will analyze the shortest path from its initial position and will guide the customer to the desired product section. Customer can select desired product and drop in the cart. RFID reader attached in the cart read the product identification code which is stored in the RFID tag of the product. This gives entire product details including product expiry date, existing offers etc. Thus the selected product will be automatically added to the bill, moreover if the customer does not require any of the product in the cart, they will just have to keep the product back and the product will be automatically deducted from the bill.

A. Breadth-First Search algorithm

BFS produces a spanning tree that is a graph without loop. It uses queue data structure with minimum size of total number of vertices in the graph to implement BFS of graphs. BFS algorithm begins with the root node and explore all the neighboring nodes. Then for each those nearest nodes, the algorithm explores their unexplored neighbor nodes and so on until the queue become empty. So that there will not be revisiting of a node. The final spanning tree is created by removing all the unused nodes from the graph.

B. Image Processing using OpenCV

Visual information is the most important type of information perceived, processed and interpreted by the human brain. Image processing is a method to perform some operations on an image, in order to extract some useful information from it. An image is nothing more than a two dimensional matrix (3-D in case of coloured images) which is defined by the mathematical function f(x,y) where x and y are the two co-ordinates horizontally and vertically. The value of f(x,y) at any point is gives the pixel value at that point of an image, the pixel value describes how bright that pixel is, and/or what color it should be.

For grayscale images the pixel value is a single number that represents the bright- ness of that pixel, the most common pixel format is the byte image, which is stored as an 8-bit integer giving a range of possible values from 0 to 255. As a convention is taken to be black, and 255 is taken to be white the values in between make up the different shades of gray.

To represent color images, separate red, green and blue components must be specified for each pixel (assuming a RGB color model), and so the pixel ‘value’ becomes a vector of three numbers. Often the three different components are stored as three separate ‘grayscale’ images known as color planes (one for each of red, green and blue), which have to be recombined when displaying or processing. Sub-tasks in image processing could be categorized as follows:

1. Image acquisition, storage, transmission: digitization/quantization, compression, encoding/decoding.
2. Image Enhancement and Restoration: for improvement of pictorial information.
3. Information Extraction: for further computer analysis.

C. Working of self-driving mode

Step by step working of self-driving mode is explained

1. The customer has to access a local server 192.168.4.1 via his/her mobile phone. The customer can either choose self-driving option or manual driving.
2. If the customer chooses self-driving, the customer is directed to a page to select between various

products available.

3. When the customer presses anyone of the product listed, the coordinates of that product is passed on as the destination coordinate and the current position of the customer is the starting coordinate.
4. The shortest path between the starting coordinate and destination coordinate is found using the Breadth-First Search Algorithm.
5. The cart moves from one coordinate to another as specified by the Breadth-First Search Algorithm.
6. Each coordinates are identified by using colour detection and the control signals to reach the next coordinate in the path is predefined.
7. As and when the cart reaches the destination coordinate the cart comes to rest.
8. The customer can provide the next location from the step 3, Then the final coordinate is updated and the current coordinate is set as the starting coordinate The steps 3-7 repeats.
9. This process comes to an end when the customer finishes the shopping.

3. Hardware Implementation

The given fig. 2, shows hardware modules for the device which is attached to shopping cart of supermarket. It consists of three microcontrollers viz. Raspberry Pi 3 B+, Arduino, ESP8266 NodeMCU along with RFID reader, L298N Motor Driver, Power Distribution Board, 12V DC Gear Motor and 12V DC power supply. The battery power source increases the mobility of the device.

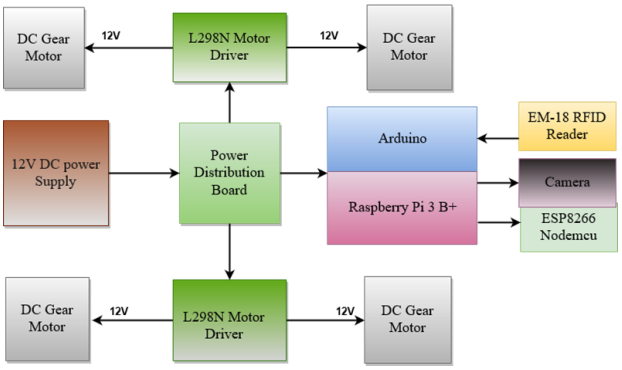

Fig. 2. Block diagram

4. Results

The entire project was done at three stages: they are Automatic billing unit, Base part construction and self-driving mode. Automatic billing unit include the construction of billing unit and its programming part. Base part was constructed as second stage and then it was controlled using a NodeMCU through a remote made with HTML. Last stage was the construction of self-driving mode. In which raspberry pi was used as the central controller and all motor connections were shifted from NodeMCU to Pi.

Fig. 3. Complete assembled figure of self-driving cart

5. Conclusion

This project has implemented a self-driving smart cart with centralized and automated billing system using RFID communication integrated with controller to provide the self-driving capabilities. It has the advantages of (i) making the billing process automated, (ii) Providing product information to customers (iii) Optimizing the shopping time. In addition, the cart can guide the customers to reach their desired set of products through the shortest possible path autonomously. A prototype is designed and hardware is implemented using raspberry pi single board computer. Automatic billing unit of the cart is controlled using Arduino micro controller and EM 18 RFID reader module. The self-driving part of the cart is controlled by a Raspberry pi single board computer which is connected to a Node MCU and L298N motor driver interfaced with DC gear motors. In future capabilities of artificial intelligence and machine learning can be used for the motion of the cart as well the billing.

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