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Smart Shopping Cart for Physically Challenged

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***Abstract*—With the increase in Industrialization the number of supermarkets and malls are increasing. Irrespective of their numerous functionalities there has always been some issues for the special section of the society like senior citizens and Divyangjans which is the the time delay at the billing counter and the weight of the commodities that they carry which makes them more vulnerable to serious heath issues . In this work a new time and effort efficient technology has been proposed to help tackle these situations. For the ease of senior citizens and Divyangjans , a mechanism has been included to make the cart wirelessly follow them. Further, the mechanism to avoid collision has been included. This work also includes a mobile application that will provide information like product location , layout of the supermarket that will help the customers to navigate unhesitantly. Moreover , troubles for the merchant side that includes shoplifting , have also been taken care of in this work which makes this cart desirable for all.**

In this work Raspberry-pi 3,RFID module, load cell, ultrasonic sensors,camera module are used for implementing the above mentioned services in practice. With the application of raspberry pi it is possible to establish a wireless control mechanism for the cart.

***Index Terms*— Motors , motor drivers , Raspberry-pi , RFID reader , RFID tags ,Ultrasonic sensors**.

I. INTRODUCTION

Shopping mall is a place where people get their daily necessities ranging from food products, clothing, electrical appliances etc.In recent times all sections and age groups of the society are visiting malls and meeting their requirements.Often senior citizens and divyangjan face a lot of problems carrying the shopping cart and then eventually leading to the billing counter .It also takes a toll on their much vulnerable heath condition.Adding to that customers have problems regarding the incomplete information about the product on sale and waste of unnecessary time at the billing counters.Steady improvement is required in the traditional infrastructure of the malls to become future ready and improve the quality of shopping experience for the customers.To enhance the technology in the malls the team is designing a cart which will follow the customer[1] .In this work, ultrasonic sensors will be attached to the cart which is equipped with an RFID reader and Load cell. As a security measure to prevent shoplifting a load cell is also attached below the cart which will help the mall administration for smooth regulation. When the customer purchases a product, she/he first scans the RF tag of the product using the RFID reader and then places it into the cart[4]. While the customer is scanning the RF tag of the product, tag ID is taken and stored in the system's memory. This tag value is then compared with the lookup table and information associated with the tag, such as product names, cost, etc. are displayed if a match is found. Ultrasonic sensor used in the cart keeps a track of all the obstacles coming in its way while following the customer. At the end of shopping, when a customer reaches a nearby billing counter, the bill will be sent to the computer at the counter with the application of IoT through the raspberry-pi[5](Chandrasekar et al., 2014).

II. LITERATURE SURVEY

A. *Roussos, "Enabling RFID in Retail" IEEE, vol. 39, no. 3, 2006.*

This paper emphasizes on use of RFID technology, by enlisting its features and system information. RFID systems have two parts: the tag and the reader. An RFID tag consists of a microcontroller, an antenna either wire or printed using conductive carbon ink, and polymer encapsulating material that wraps around the antenna and processor. The reader initiates the identification process by generating an RF field at a specific frequency defined for the particular system, thereby causing a voltage difference at the tag antenna end points via inductive or capacitive coupling. The tag detects this change and, after optionally authenticating the reader via a challenge-response mechanism, responds by transmitting the identifier that it holds.

B. J.Borenstein and Y.Korean "Obstacle avoidance with ultrasonic sensors".

This paper gives an overview of existing devices for the guidance of visually impaired pedestrians and discusses the properties of the white cane and of conventional electronic travel aids. This paper also described the disadvantages of using a standard mobile robot for this purpose.So this novel idea is integrated in our work implementation increasing the scope of the work to vulnerable sections of the society such as senior citizens and differently abled .It guided us on focusing on the latest innovations which led us to dive down in the world of IoT which provides feasible solution to all the problems which were faced by us.Hereafter the team got to know that an obstacle avoidance system has to detect obstacles through its sensors and has to plan a path around them. Travel aids equipped with mobile robotics technologies have the potential of overcoming the fundamental shortcomings of existing travel aids, and can thus provide several advantages to the Divangjans.

C. N. Anju Latha,B.Rama Murthy, K. Bharat Kumar,"Distance Sensing with Ultrasonic Sensor and Arduino".

This paper tells us about Ultrasonic ranging.The Ultrasonic ranging is the technique used by bats. Ultrasonic sensors provide an easy way in distance measurement. The sensor is perfect for distance measurements between moving or stationary objects. Ultrasonic Sensors measure the distance of the objects in air through non-contact technique. They measure distance without damage and are easy to use and reliable.Ultra Sonic sensors are widely used for distance

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measurement purposes. They offer low cost and a precision of less than 1 cm in distance measurements of up to 6m.. However, the most popular method used in these measurements is based on the time of flight (ToF) measurement. This ToF is the time elapsed between the emission and subsequent arrival after reflection of an Ultrasonic pulse train traveling at the speed of sound. This causes large response times for a single measurement. Thus it is concluded that Ultrasonic sensors are the best for distant sensing.

D. Y. Leng Ng, C. Siong Lim,K A. Danapalasignam, M. Loong Peng tan and C. Wei Tan, "Automatic Human Guided Shopping cart with Smart Shopping System".

This paper gave us the idea of the shopping cart following a person with the help of remote sensing. There are also shopping cart safety issues such as sliding down from an escalator. It is known to be an inconvenience and time wasting for customers who are in a rush to search for desired products in a supermarket. Therefore, an automatic human and line following shopping cart with a smart shopping system is developed to solve these problems.The result of the testing on the used sensors like ultrasonic are presented in this paper for due reference.Users can then enjoy shopping without pushing the shopping carts themselves. Meanwhile, the smart shopping system allows users to access the location of items that they plan to purchase in the supermarket by using their Android application and calling the shopping cart to move automatically. Thus, the shopping cart can lead the users to their desired location of items that they plan to buy.

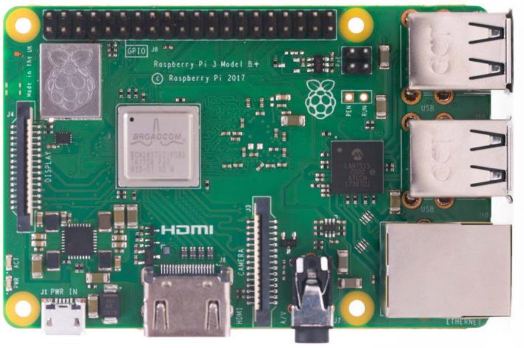
E. Swati Zope, Maruti Limkar, "RFID based Bill Generation and Payment through Mobile", Volume 1, Issue 3, June 2012.

With the increasing prevalence and affordability of radio frequency identification (RFID) tags in everyday authentication systems, RFID holds great promise in the retail world for both customers and stores in inventory control, convenience, and cost savings. It can be utilized these RFID tags to automate the checkout process by building a system that could read the RFID signals of all the objects that were placed in proximity to an antenna platform. This eliminated the need for barcode scanning of each individual item, making checkout a significantly faster experience. Furthermore, as each item has a unique tag, even copies of the same product contrasted to the current UPC model, much better inventory control, recall ability, and monitoring of consumer behavior trends are possible, with privacy concerns considered of course.

III. DETAILS OF THE COMPONENTS USED

A. Raspberry-pi

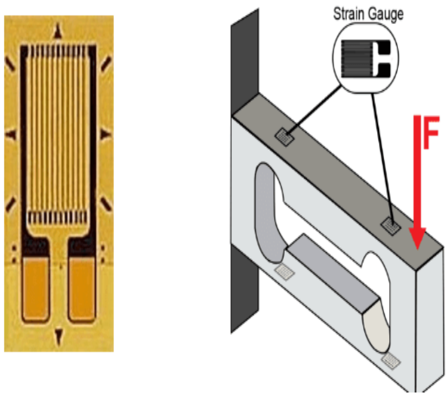
The Raspberry Pi 3 Model B+ is the latest product in the Raspberry Pi 3 range, having a 64-bit quad-core processor operating at 1.4GHz, dual-band 2.4GHz and 5GHz wireless LAN, faster Ethernet,Bluetooth 4.2/BLE, and PoE capability via a separate PoE HAT The dual-band wireless LAN comes with modular compliance certification, allowing the board to be designed into end products with significantly reduced wireless LAN compliance testing, improving the desirability of the product. The Raspberry Pi 3 Model B+ maintains the same basic framework as both the Raspberry Pi 2 Model B and the Raspberry Pi 3 Model B.



B. Load Cell

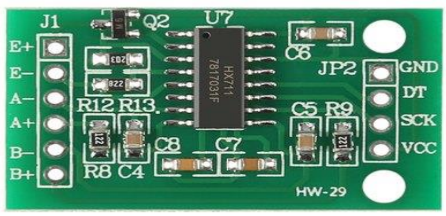
A load cell (or loadcell) is a transducer that converts force into measurable electrical output which helps determining the weight of the product or entity. Although there are various force sensors, strain gauge load cells are the most likely one.

A load cell works by converting mechanical force into digital values that the user can read and observe. The inner working of a load cell differs based on the load cell that you choose. There are three types of load cells which are hydraulic load cells, pneumatic load cells, and strain gauge load cells. Strain gauge load sensors are the most used one among the three. Strain gauge load cells contain strain gauges within them that send up voltage irregularities when under load. The variation in voltage change is covered in digital reading as weight.



C. HX 711

HX711 is ADC for weight scales.The change in resistance results in a change in output voltage. This small change in output voltage (usually about 20 mVolt of total change in response to full load) can be measured and digitized after careful amplification of the small milli-volt level signals to a higher amplitude 0-5V or 0-10V signal.



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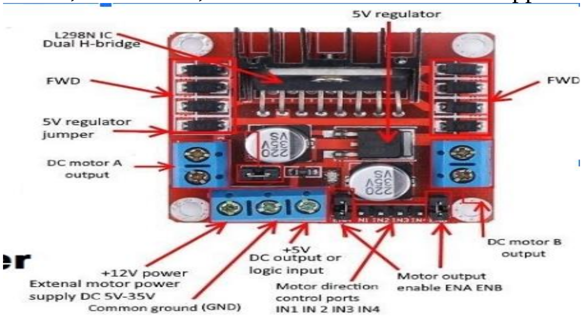
D. L295 Motor Driver

This L298 Based Motor Driver Module is a high-power motor driver perfect for driving DC Motors and Stepper Motors. It uses the popular L298 motor driver IC and has the onboard 5V regulator which it can supply to an external circuit. It can generally control up to 4 DC motors, or 2 DC motors with 2 features that are directional and speed control.This motor driver is perfect for robotics and mechatronics projects which are the need of the hour and perfect for controlling motors from microcontrollers. Perfect for driving DC and Stepper motors for the line following robots, robot arms, and all other sorts of robot applications.



E. RC 522 RFID Module

This RC522 RFID Card Reader Module 13.56MHz is a low-cost MFRC522 based RFID Reader Module is easy to use and can be used in a wide range of applications.The MFRC522 is a highly integrated reader/writer IC for contactless communication at 13.56 MHz.RC522 is the highly integrated RFID card reader which works on non-contact 13.56MHz communication, is designed by NXP as low power consumption, low cost and compact size read and write chip, is the best choice in the development of smart meters and portable hand-held devices.

F. Miscellaneous

Apart from these components a DC motor and wheels are used to support the movement of the cart.

IV. BLOCK DIAGRAM

This work has two major parts:

Movement of cart .

Billing through cart.

A. Movement of cart:

First ultrasonic sensors start sensing if the customer is in particular range with cart the ultrasonic sensors send the distance to raspberry pi and it will give appropriate instruction to motor driver and motor driver move motor according to the instruction cart will follow the customer and if the user try to minimize the distance between cart and him cart will move backward.if the customer is out of range with cart, cart will go in same direction and stop moving after some time.when the customer take a turn the ultrasonic sensors receive data from other directions and take a turn in that direction where sensor is not getting data(range of distance decided by the authors).To differentiate between the cart user and another person camera module is used

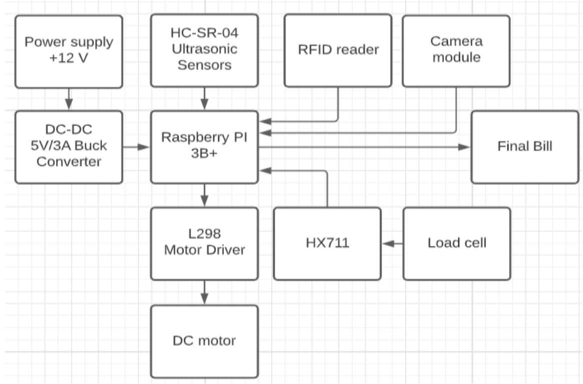


Fig. A. Block Diagram

B. Billing through cart:

When user put their product in cart containing RFID the RFID reader read the product and a green led will glow and the data of product get stored in raspberry pi and due to weight of product the HX711(ADC) send the data of load cell to raspberry-pi if there is a product inserted in cart without RFID reader reading the product HX711 send the data to raspberry-pi but there is no data from RFID reader so a red LED or buzzer will glow or alarm.After shopping, customers will get their final bill at the cash counter.

V. METHODOLOGY

This work has been implemented in a very systematic manner, it started with designing and proper component selection with appropriate requirements. As Raspberry Pi is being used the team installed the Raspbian software which is a linux based operating system by flashing it to our SD card[7]. Thereafter the team accessed the Raspberry pi through SSH and installed the required libraries and software on it. After that team started with testing our components for proper functioning and control, once satisfied with the results, thereafter the authors began their journey for actual implementation. Firstly the team built the base of the trolly with chassis wheels and motors then connected the motor to the L298N driver with 2 motors to one channel.

Then the team tasked itself to work upon the upper part of the cart and placed the ultrasonic sensors on the sides of the cart. The ultrasonic sensor (or transducer) works on the same principles as a radar system. An ultrasonic sensor can convert electrical energy into acoustic waves and vice versa[2]. The acoustic wave signal is an ultrasonic wave traveling at a frequency above 18kHz. The famous HC SR04 ultrasonic sensor that generates ultrasonic waves at 40kHz frequency is used in this work for obstacle avoidance[3] and following purpose Typically, raspberry pi is used here for communication with ultrasonic sensors. To begin measuring the distance, the raspberry pi sends a trigger signal to the ultrasonic sensor. The duty cycle of this trigger signal is 10µS for the HC-SR04 ultrasonic sensor. When triggered, the ultrasonic sensor generates eight acoustic (ultrasonic) wave bursts and initiates a time counter. As soon as the reflected (echo) signal is received, the timer stops. The

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output of the ultrasonic sensor is a high pulse with the same duration as the time difference between transmitted ultrasonic bursts and the received echo signal. With the help of ultrasonic sensors the cart avoids collision with the obstacle on it's way[3].
The next part was to make the cart follow a particular person so the team added a 5MP raspberry pi camera module which will provide the real time imaging of the person. The image then will be processed with openCV python library for the feature extraction and image classification. The features such as clothes coloring and movements will be used for navigation[9].
Then the team attached the load cell inside the cart which is connected to HX711 ADC with Raspberry pi and then fitted a wooden sheet on top of the load cell where the products can be placed. It is a resistive load cell. Resistive load cells work on the principle of piezo-resistivity. When a load/force/stress is applied to the sensor, it changes its resistance. This change in resistance leads to a change in output voltage when a input voltage is applied
After that the team implemented the job of fitting the RFID reader on the cart. It is an electronic tagging technology[4] that allows an object, place, or person to be automatically identified at a distance without a direct line-of-sight, using an electromagnetic challenge/response exchange. An RFID system is composed of readers and tags. Readers generate signals that are dual purpose: they provide power for a tag, and they create an interrogation signal. A tag captures the energy it receives from a reader to supply its own power and then executes commands sent by the reader.In this the team implemented the automatic billing system.
Then the team developed an android application using android studio[10] for interacting with the trolly i.e. knowing products in trolly, also to know different product sections, billing and checkout.
Now comes the final testing part, here the team is using python codes for the control and operation. The coding of ultrasonic sensors based on distance ranges and for turning left or right sensors with appropriate codes are used.

VI. RESULT AND DISCUSSION

The smart shopping cart can perform various functions that are automatic billing using RFID , follow the customer in the mall, especially the aged and differently abled ,in order to help them move freely in the premises of the supermarket. The android application will guide the users inside the supermarket and will help them to locate their desired products easily.
The load cell of the shopping cart was calibrated before its use.The equation was derived after finding the different values to form the table A given below.
The given table.A is used ahead for getting the exact weight of the articles.

Load Cell Actual Weight(X) In Grams	Reading in the Loadcell(Y)
5	2050
10	4350
20	9000
50	21000
100	42000
200	89000
250	109500
300	226000

Table.A

The Equation obtained from the table A is equation below which is derived from the linear part of the table

$$x = \frac{(y + 31.25)}{438}$$

Eq. (A).

Thereafter we plotted the graph for the same using the equation.

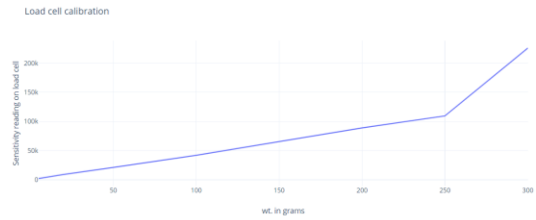

Fig. B. Load cell calibration graph

The cart is supposed to move 5kg in the initial stage.So the tactile torque of 1.5 Nm.
The calculation for the same is as follows
Tactile Torque = Tactile Force* Mean Radius of the wheel
=5 * 9.8 * 3 * 10 ^-3
=1.47Nm
To this work there are certainly major challenges which need to be addressed prominently.The first is movement of the cart in a crowd. In crowded malls it becomes challenging to make the cart follow a particular person. Secondly, the limitation of the cart to carry a certain amount of load.This is another challenge ie. to move the cart with a heavy load that is greater than the permissible weight.The load will also play a crucial role in the speed of the cart.This is a challenge which can be focused upon if this work is continued ahead. Heavy load can reduce the life of motors used. Thirdly, the whole work runs on electrical energy so the issue of discharging batteries is prominent.This needs to be taken care of and the batteries should be checked from time to time otherwise the cart may not work as a smart cart because the raspberry pi will not get power if the batteries discharge.

VII. CONCLUSION

This paper discusses the ease of using a smart cart and eradicating the traditional way of shopping. If this smart system is implemented in supermarkets, it will reduce the long waiting queue in front of the counter, thus saving the time of customers for a very enjoyable shopping experience[1]. It reduces time by using RFID Technology and improves utilization of resources like manpower. The different locations in the shopping mall and various products can be tracked easily by using an Android application. Both communicate via IoT technology. A weight sensor is placed at the bottom of the cart to provide security and transparency

VIII. FUTURE SCOPE

There is some room for further improvement of the work. Firstly, the mechanism of the cart should be enhanced and designed in a simpler way, to ease the installation under a shopping cart. Secondly,an interactive display screen showing all the amenities in the mall will be very helpful and along with that if the display can provide additional information related to the product it will be addition of great value.For users along with all the above mentioned , acceptance of debit/credit cards/UPI will be touchwood .Thirdly, a more advanced algorithm should be developed so that the shopping cart is able to move in a crowded environment and follows the user automatically in any direction.When we move ahead in the advance stage of the work we need to take care of the network of carts that will be coordinating with each other .

Finally , an improved Android application that can remind the users of the items they need to purchase when they are unintentionally passing by the goods location. In addition, it can also remind the users who have health problems about the nutrition of products.The integration of artificial intelligence can help achieve this objective.Also an option for users to create a shopping list in the app will be a great feature to add upon .Besides that, the locations of shopping carts are tracked by GPS and can be displayed to allow supermarket staff and users to know the shopping cart current locations.

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