IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue1, November 2023

Smart Shopping Cart using ESP

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Abstract: *The "Smart Shopping Cart" project represents a cutting-edge solution aimed at revolutionizing the traditional shopping experience through the integration of advanced technologies. Focused on the ESP32 microcontroller, this innovative shopping cart incorporates a sophisticated array of sensors, including IR and ultrasonic sensors for human detection and tracking, RFID technology for product identification and automatic pricing, and load cells for precise weight monitoring. A DC motor, coupled with a motor driver IC, ensures seamless cart movement, while a user-friendly display module provides real-time feedback on the cart's status. This project not only showcases autonomous cart navigation but also introduces features like automated pricing and overload alerts, promising to redefine and elevate the efficiency and enjoyment of modern retail shopping.*

Keywords: Shopping Cart, ESP32, Sensor Integration, RFID Technology, Automated Pricing

I. INTRODUCTION

1.1 Overview

The concept of a "Smart Shopping Cart" has gained significant attention in recent years, as it offers a potential solution to enhance the traditional shopping experience through automation and advanced technologies. This literature review explores relevant studies and developments in the field of smart shopping carts, with a focus on key components such as ESP 32 microcontrollers, sensors for human detection and tracking, RFID technology for product identification, and load cells for weight monitoring.

In a time marked by swift technological progress and a growing focus on convenience, the "Smart Shopping Cart" concept emerges as a novel solution to enhance the conventional shopping experience. This project signifies the amalgamation of advanced technologies and automation to create a shopping cart that actively trails customers, presenting a seamless and engaging shopping adventure. With ESP32 serving as the microcontroller and a suite of sensors, actuators, and display modules in its toolkit, this Smart Shopping Cart is poised to transform the shopping landscape.

The fundamental components of this endeavor comprise a DC motor for cart movement, IR and ultrasonic sensors to detect and follow humans, a motor driver IC for precise DC motor control, an RFID receiver for product recognition and automatic pricing, and a load cell for tracking cart weight. To ensure user-friendliness, the system integrates a display module that offers real-time feedback and information about the cart's status.

This introduction provides an overview of the Smart Shopping Cart project, shedding light on its pivotal features and functions. It outlines how each element contributes to an enhanced, efficient, and enjoyable shopping experience. From autonomous cart navigation to automated pricing and overload alerts, this project encompasses a wide range of capabilities, poised to redefine modern retail shopping.

The project is a groundbreaking initiative aimed at transforming the conventional shopping experience by harnessing the power of advanced technologies. Centered around the ESP32 microcontroller, this innovative shopping cart incorporates a sophisticated combination of sensors, including IR and ultrasonic sensors for human detection and tracking, RFID technology for seamless product identification and automatic pricing, and load cells for precise weight monitoring. The integration of a DC motor with a motor driver IC ensures smooth cart movement, while a user-friendly display module provides real-time feedback on the cart's status. This project not only showcases autonomous cart navigation but also introduces features like automated pricing and overload alerts, promising to redefine and elevate the efficiency and enjoyment of modern retail shopping. The motivation behind this endeavor lies in the aspiration to

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revolutionize the traditional shopping landscape, offering a seamless and engaging experience through the convergence of cutting-edge technologies.

1.2 Motivation

The motivation behind the "Smart Shopping Cart" project stems from a desire to revolutionize the traditional shopping experience by leveraging advanced technologies. With a focus on the ESP32 microcontroller, the project aims to integrate a suite of sensors, including IR and ultrasonic sensors, RFID technology, and load cells, to enhance human detection, product identification, automatic pricing, and weight monitoring. The goal is to introduce features such as autonomous cart navigation, automated pricing, and overload alerts, ultimately redefining and elevating the efficiency and enjoyment of modern retail shopping.

1.3 Problem Definition and Objectives

Traditional shopping experiences lack technological integration, resulting in inefficiencies and a static retail environment. Manual processes for cart navigation, pricing, and weight monitoring hinder efficiency and user engagement.

- Develop a "Smart Shopping Cart" using ESP32 microcontroller.
- Integrate IR and ultrasonic sensors for human detection and tracking.
- Implement RFID technology for automatic product identification and pricing.
- Utilize load cells for precise weight monitoring of the shopping cart.
- Enable autonomous cart navigation with a DC motor and motor driver IC.
- Provide real-time feedback through a user-friendly display module.
- Introduce features like automated pricing and overload alerts.
- Revolutionize the retail shopping experience by enhancing efficiency and user enjoyment.

1.4. Project Scope and Limitations

The project aims to develop a "Smart Shopping Cart" using the ESP32 microcontroller, incorporating advanced technologies such as IR and ultrasonic sensors, RFID technology, and load cells. The scope includes implementing autonomous cart navigation, automated pricing, and overload alerts to redefine and enhance the efficiency of the retail shopping experience.

Limitations As follows:

- The project may face budget constraints affecting the extent of sensor integration.
- RFID technology may have limitations in identifying certain products accurately.
- The load cell's precision might be impacted by external factors.
- Human detection using sensors may have occasional inaccuracies.
- The project's scalability to larger retail environments may be a consideration.

II. LITERATURE REVIEW

Title: Follow Me Smart Shopping Trolley

Authors: L.S.Y. Dehigaspege, A.S.M.A.P.B. Disanayake, D.M.A.S.C. Dissanayake,I.M.N.S. Iresha (2022)

Description: This paper presents a smart shopping cart that can follow the customer automatically using ultrasonic and IR sensors. The cart is equipped with two ultrasonic sensors at the front and two IR sensors at the back. The ultrasonic sensors are used to detect the distance between the cart and the customer, while the IR sensors are used to detect the direction of the customer. The cart is controlled by an Arduino Uno microcontroller, which uses the sensor data to calculate the speed and direction of the cart.

Title: Smart Shopping Cart with Customer-oriented Service

Authors: M.D.R. Abdeen, M.S. Islam, M.M.R. Khan, M.D.R. Islam, M.D.H. Bhuyan (2023)

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Description: This paper describes a smart shopping cart that uses RFID tags and ZigBee communication to provide customer-oriented services. The cart is equipped with an RFID reader and a ZigBee module. When a customer places an item with an RFID tag in the cart, the RFID reader reads the tag and identifies the item. The cart then uses the ZigBee module to send the item information to the store's central billing system. This allows the customer to view their bill and pay for their items without having to go to a checkout counter.

Title: Development of Smart Shopping Carts with Arduino
Authors: H.R. Patel, B.R. Patel, M.S. Patel (2022)
Description: This paper presents the development of smart shopping carts using Arduino. The cart is equipped with two DC motors, two IR sensors, and an ultrasonic sensor. The IR sensors are used to detect the direction of the customer, while the ultrasonic sensor is used to detect the distance between the cart and the customer. The cart is controlled by an Arduino Uno microcontroller, which uses the sensor data to calculate the speed and direction of the cart.

Title: Smart Shopping Cart with Automatic Billing System
Authors: A.M. Patel, M.M. Patel, J.J. Patel (2022)
Description: This paper describes a smart shopping cart with an automatic billing system. The cart is equipped with an RFID reader and a barcode scanner. When a customer places an item with an RFID tag or barcode in the cart, the RFID reader or barcode scanner reads the tag or barcode and identifies the item. The cart then calculates the price of the item and adds it to the customer's bill. When the customer is ready tocheckout, they can simply tap their credit card on the cart's payment terminal to pay for their items.

Title: Design and Implementation of a Smart Shopping Cart with Arduino
Authors: S.S. Jadhav, S.S. Patil, S.A. Patil (2023)
Description: This paper presents the design and implementation of a smart shopping cart using Arduino. The cart is equipped with two DC motors, two IR sensors, and an ultrasonic sensor. The IR sensors are used to detect the direction of the customer, while the ultrasonic sensor is used to detect the distance between the cart and the customer. The cart is also equipped with an RFID reader and a load cell. The RFID reader is used to identify the items placed in the cart, while the load cell is used to calculate the weight of the items in the cart. The cart is controlled by an Arduino Uno microcontroller, which uses the sensor data to calculate the speed and direction of the cart, as well as to keep track of the items in the cart and their prices.

III. REQUIREMENT AND ANALYSIS

Functional Requirements:

Autonomous Navigation:

- The system should enable the shopping cart to navigate autonomously within the store premises.

Human Detection and Tracking:

- Incorporate IR and ultrasonic sensors to detect and track the presence of customers around the shopping cart.

Product Identification:

- Utilize RFID technology for accurate product identification when items are placed in the cart.

Automatic Pricing:

- Implement an automated pricing system based on RFID-tagged products added to the cart.

Weight Monitoring:

- Integrate load cells to monitor the weight of the cart, providing real-time feedback on the added items.

DC Motor Control:

- Ensure precise control of the DC motor for seamless cart movement using a motor driver IC.

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User-Friendly Display:

- Include a user-friendly display module to provide real-time feedback on the cart's status, pricing details, and alerts.

Automated Alerts:

- Introduce automated alerts, such as overload alerts, to notify users of potential issues.

Non-Functional Requirements:

Performance:

- The system should operate with minimal latency, providing real-time responses for efficient user interaction.

Reliability:

- Ensure reliable operation of sensors, actuators, and the microcontroller for a consistent and trustworthy shopping experience.

Scalability:

- Design the system to be scalable, allowing for potential expansion to accommodate larger retail environments.

Security:

- Implement security measures to protect user data, particularly with RFID technology and any connected databases.

Usability:

- Ensure a high level of user-friendliness, making the system accessible and intuitive for customers and store staff.

Maintainability:

- Design the system with ease of maintenance in mind, allowing for straightforward updates and repairs.

Cost:

- Consider cost-effectiveness in the selection of components and technologies, ensuring the project remains within budget constraints.

Compliance:

- Ensure compliance with relevant standards and regulations, especially regarding user privacy and data security.

IV. SYSTEM DESIGN

4.1 System Architecture

The below figure specified the system architecture of our project.

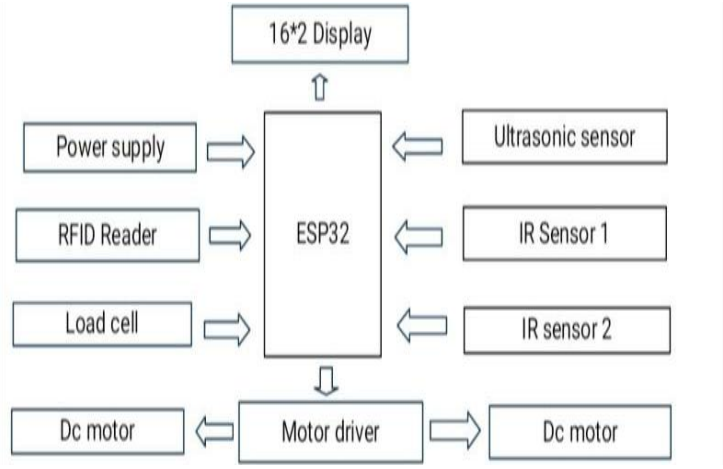

Figure 4.1:System Architecture Diagram

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4.2 Working of the Proposed System

The proposed system seamlessly integrates several key components to create an efficient and intelligent solution. At the heart of the system is the ESP32 microcontroller, serving as the central processing unit. The system's interaction with users is facilitated by an LCD display, providing real-time feedback and information about the smart shopping cart's status. Ultrasonic sensors and IR sensors contribute to human detection and tracking, ensuring the cart follows customers autonomously throughout their shopping journey.

The system incorporates a power supply to ensure consistent and reliable operation, supporting the various electronic components. A load cell is employed for precise weight monitoring, allowing the smart cart to provide alerts in case of potential overload situations. RFID technology is leveraged through an RFID reader, enabling automatic product identification and pricing. The DC motor, controlled by a motor driver, drives the autonomous movement of the shopping cart.

In summary, the ESP32 microcontroller orchestrates the seamless collaboration of these components, creating a smart shopping cart that not only autonomously navigates but also offers features like automated pricing and overload alerts. This innovative system is poised to redefine the shopping experience by combining cutting-edge technologies for enhanced efficiency and user convenience.

4.3 Hardware Modules

1. ESP32:

- **Description:** The ESP32 is a powerful microcontroller unit (MCU) based on the ESP32 dual-core processor. It integrates Wi-Fi and Bluetooth capabilities, making it suitable for IoT applications.
- **Functionality in the System:** As the central processing unit, the ESP32 controls and coordinates the various components of the smart shopping cart. It manages sensor data, communicates with the RFID reader, drives the DC motor, and interfaces with other peripherals.

2. LCD Display:

- **Description:** LCD (Liquid Crystal Display) is a visual output device that provides a user-friendly interface for real-time information display.
- **Functionality in the System:** The LCD display presents essential information to users, such as the cart's status, item details, and any alerts. It enhances user interaction and provides a clear interface for a seamless shopping experience.

3. Ultrasonic Sensor:

- **Description:** Ultrasonic sensors use sound waves to measure distance by emitting ultrasonic pulses and calculating the time for the echo to return.
- **Functionality in the System:** Ultrasonic sensors enable the smart shopping cart to detect obstacles and, in this context, help in human detection and tracking. They ensure the cart follows customers autonomously, maintaining a safe distance.

4. Power Supply:

- **Description:** The power supply module provides the necessary electrical power for the entire system to function.
- **Functionality in the System:** The power supply ensures a stable and continuous electrical power source for all components, allowing the system to operate reliably during the shopping experience.

5. Load Cell:

- **Description:** A load cell is a transducer that converts force or load into an electrical signal.
- **Functionality in the System:** The load cell is utilized for precise weight monitoring of the shopping cart. It helps in detecting and alerting users in the case of potential overload situations.

6. RFID Reader:

- **Description:** An RFID (Radio-Frequency Identification) reader reads data from RFID tags attached to objects for identification and tracking.

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- **Functionality in the System:** The RFID reader identifies products with RFID tags, allowing for automatic pricing and a streamlined checkout process.

7. IR Sensor:

- **Description:** Infrared sensors detect infrared radiation and are commonly used for proximity sensing.
- **Functionality in the System:** IR sensors contribute to human detection and tracking, aiding in the autonomous navigation of the smart shopping cart.

8. DC Motor and Motor Driver:

- **Description:** The DC motor is an electrical motor that converts electrical energy into mechanical motion. A motor driver controls the speed and direction of the DC motor.
- **Functionality in the System:** The DC motor, coupled with a motor driver, enables the autonomous movement of the shopping cart. The motor driver regulates the motor's speed and direction based on input from the ESP32, allowing the cart to navigate through the store autonomously.

V. CONCLUSION

5.1 Conclusion

In conclusion, the development of the "Smart Shopping Cart" represents a significant stride towards revolutionizing the conventional shopping experience by seamlessly integrating advanced technologies. The amalgamation of key hardware modules, such as the ESP32 microcontroller, ultrasonic and IR sensors, RFID reader, load cell, DC motor, and LCD display, forms a sophisticated system that enhances user interaction, automates processes, and elevates overall shopping efficiency. The ESP32 serves as the central processing unit, orchestrating the functions of each component to ensure seamless navigation, autonomous movement, and real-time information display. The collaborative efforts of these modules provide users with a novel and engaging shopping adventure. The system's ability to detect and follow customers, automatically identify products, monitor weight, and offer alerts contributes to a more efficient and enjoyable retail experience. The "Smart Shopping Cart" not only showcases the capabilities of modern technology but also underscores the potential for innovation in optimizing everyday activities. As we advance further into the era of smart solutions, this project stands as a testament to the transformative power of integrating cutting-edge hardware components for the betterment of daily experiences.

5.2 Future Work

The "Smart Shopping Cart" project lays the groundwork for an innovative shopping experience, and its future scope holds promising avenues for further enhancement. One potential direction for expansion involves integrating machine learning algorithms to analyze customer preferences based on their shopping history. This could enable the cart to provide personalized recommendations or even assist in optimizing store layouts for better customer engagement. Additionally, incorporating environmental sensors could allow the cart to adapt to its surroundings, ensuring seamless navigation and improved obstacle avoidance. The project could further explore partnerships with retail analytics platforms, enabling retailers to gather valuable insights into customer behavior and preferences. As technology evolves, exploring the integration of augmented reality (AR) features could provide users with interactive and immersive shopping experiences. Furthermore, collaboration with smart payment systems could lead to a fully integrated, cashless checkout process. The future scope of the "Smart Shopping Cart" project extends beyond automation to create a dynamic, personalized, and technologically advanced shopping ecosystem.

5.3 Applications

Autonomous Shopping Assistance: The "Smart Shopping Cart" application provides real-time autonomous assistance to shoppers by actively following them throughout the store. The cart utilizes sensors such as IR and ultrasonic sensors for human detection and tracking, ensuring a seamless and convenient shopping experience.

Automated Pricing and Product Recognition: In real-time, the RFID reader integrated into the cart instantly recognizes products as they are added or removed. This enables automated pricing, allowing shoppers to view the

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total cost of their items on the cart's LCD display in real-time, facilitating budget management and decision-making.

Weight Monitoring and Overload Alerts: The load cell incorporated into the cart provides real-time monitoring of the weight of items placed inside. Should the weight approach or exceed a predefined limit, the system triggers overload alerts, prompting shoppers to manage their load or seek assistance, ensuring a safe and efficient shopping experience.

Dynamic Navigation and Obstacle Avoidance: The ESP32 microcontroller, coupled with sensors, facilitates real-time dynamic navigation. The cart can adapt to its surroundings, navigate through aisles, and intelligently avoid obstacles. This ensures efficient movement and prevents disruptions in the shopping flow.

User-Friendly Interface: The application includes a user-friendly display module on the cart, offering real-time feedback on the cart's status, pricing details, and potential alerts. This interface enhances the overall shopping experience, providing shoppers with instant information and control over their purchases.

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