Navi Cart Using RFID

Remya K R[1], Aksayaa M[2], Bhavya Sree T[3], Isha S[4], Nivethitha K[5]

[1]*Associate Professor, Department of Electronics and Communication Engineering, Sri Shakthi Institute of Engineering and Technology, India.*

[2,3,4,5,] *Student, Department of Electronics and Communication Engineering, Sri Shakthi Institute of Engineering and Technology, India.*

***Abstract*—Navi Cart is an intelligent IoT-based shopping cart system meant to make the shopping experience easier and automated in a retail environment. It consists of two NodeMCU ESP8266 microcontrollers, which deal with separate responsibilities. One supports IR and ultrasonic sensors that facilitate line-follower navigation as well as avoid obstacles, whereas the other allows connection to an RFID reader to track items in real time. A hardware button enables users to delete items entered incorrectly. These NodeMCUs communicate through Wi-Fi, providing seamless data sync between the cart and cloud. The system features a web-based interface, providing real-time item and billing updates for logged-in users based on their name and phone number. Admins can view in-depth cart data, billing, QR code generation for payment, receipt printing, and cart resetting. The RFID-based system is quicker and more precise than the conventional barcode scan, minimizing manual errors. Information from every session is safely stored in the cloud, enabling traceability and analytics. The website is easy to use and is mobile-optimized, offering a smooth shopping experience. Navi Cart integrates embedded systems, IoT, and web technologies to offer an affordable, scalable solution for retail in the modern era. It minimizes staff engagement, accelerates checkout, and extends digital convenience to in-store shopping. The system maximizes efficiency, satisfaction, and store management, making it suitable for the smart shopping malls of the future.**

***Index Terms*—Smart Shopping Trolley, Line Following, Obstacle Detection, Digital Billing, Real-Time Tracking, Cloud Database, Wi-Fi Communication**

I. INTRODUCTION

In the fast-changing retail world, innovation is the driver for enhanced customer experience and operational efficiency. Long queues, manual billing, and barcode scanning, which are common in traditional shopping approaches, can be time-consuming. As the expectations of consumers rise, there is a need for smart systems that can mechanize these processes and provide a smooth shopping experience.

Navi Cart is one such solution—IoT-based intelligent smart trolley solution that can change the way we shop in brick-and-mortar stores.Navi Cart is founded on the robust integration of embedded systems, wireless communication, and web technology. It provides independent navigation via sensor integration and real-time tracking of products through RFID. It removes the necessity for conventional barcode scanning by simply enabling users to put products into the cart for automatic registration and billing. This accelerates the shopping process and dramatically eliminates the possibility of human error.

The system is driven by two NodeMCU ESP8266 microcontrollers, which perform specific tasks to make it efficient and reliable. One drives the motion and direction of the cart through IR and ultrasonic sensors, while the other handles scanning and the management of the contents of the cart. Their Wi-Fi communication and connection to a cloud database make all data updated in real time and viewable through a web interface. The web site has both user and administrator support with facilities such as live billing, management of items, payment integration, and session monitoring.

Navi Cart not only improves the customer's shopping experience but also provides store managers with useful features to track, manage, and optimize operations. It minimizes the need for manual supervision and staff, resulting in cost reduction and improved accuracy. With its scale-out architecture and user-friendly interface, Navi Cart will be an essential component of the new smart retail infrastructure, closing the convenience-independence gap between online shopping and in-store experience.

II. SYSTEM ARCHITECTURE

The Navi Cart system architecture is designed to provide smooth operation, modular control, and free communication between the hardware components and user interface. The architecture starts from a power management unit that is driven by a 12V battery and regulated by a buck converter to provide appropriate voltage levels to different parts of the system. This guarantees reliable and efficient delivery of energy to all the sensors, controllers, and modules in the system; hence the reliability of the system is improved.

A. Block diagram

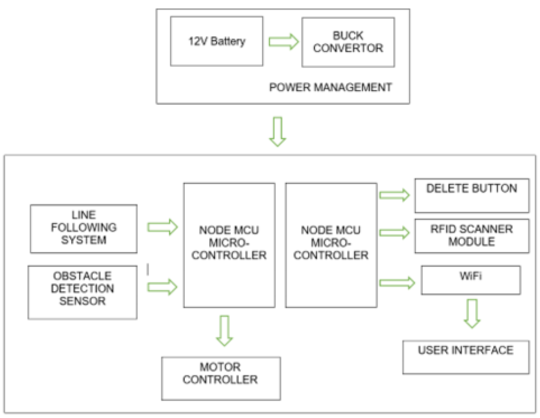

Figure 1. Block diagram of navi cart using RFID

Two NodeMCU ESP8266 microcontrollers form the heart of the architecture, each serving particular purposes. The first NodeMCU is wired to the line-following system as well as obstacle detection sensors, enabling the trolley to move automatically along a set path while detouring obstacles in real-time. It also communicates with a motor controller, facilitating motion control as per sensor inputs. This division of functions allows navigation to be managed independently for improved performance and quicker response. The IR sensors pick up the black path on a white background to facilitate accurate movement on the shopping aisles, and the ultrasonic sensors assist in collision avoidance with people or objects. The motor controller is given instructions based on sensor feedback to dynamically adjust the speed and direction of the trolley. This configuration maximizes overall system reliability and lowers the likelihood of failure during navigation.

The second NodeMCU serves for item communication and management. It is combined with an RFID scanner module for detecting items being added to the cart and a delete button to remove items. The microcontroller also manages Wi-Fi communication by connecting to a web interface and cloud-based database. The user interface makes it possible for customers to login, see items in cart and monitor billing real-time, but administrators can access cart information, create bills and reset cart. Every item that is scanned automatically gets pushed on the cloud for accurate tracking, and users will get instant updation of their bills. Delete button provides one-click functionality of deleting unwanted stuff, making usage easier and lower the chances of billing errors. The platform is optimized both for mobile and desktop usage with a uniform user experience across the devices.

Due to its module-based design, the system can be easily expanded and maintained by separating tasks uniformly between navigation and inventory management.

III. CIRCUIT DESIGN

A. Circuit Design

The following circuit diagram illustrates the entire electronic structure of the Navi Cart IoT-based Smart Trolley system. It is built with a double NodeMCU ESP8266 configuration, each performing different tasks for proper system operation. The first NodeMCU is interfaced to the IR sensors, ultrasonic sensor (HC-SR04), and the L298N motor driver. The IR sensors are utilized for line following, interfaced to digital input pins of the NodeMCU, whereas the ultrasonic sensor helps in detecting obstacles through its trigger and echo pins. The motor driver gets control signals from the NodeMCU and is tasked with controlling the movement of the trolley. All these components are driven using a buck converter, which regulates voltage from a 12V battery to 5V or 3.3V, as needed by the NodeMCU and the sensors, making safe and efficient power delivery possible.

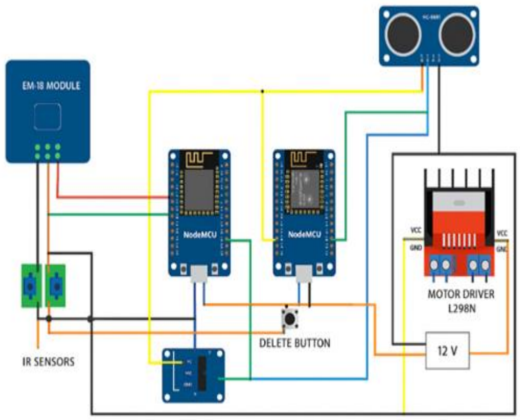

Figure 1. Circuit Design

The second MCU is for user interaction and item tracking. It is linked with an EM-18 RFID reader, which scans RFID-tagged items as items are added to the cart. A push button is also linked to this NodeMCU, enabling users to remove an item from their virtual cart in the event of an incorrect addition. The NodeMCU communicates with a cloud database and web interface in real-time using its onboard Wi-Fi module, updating the bill and syncing scanned items instantly.

Both NodeMCUs are connected with the same power supply through the buck converter, and all modules' grounds are connected to provide stable signal communication. This distinct segregation of the tasks of navigation and inventory among the two microcontrollers guarantees modularity, debugging simplicity, and optimal system performance.

IV. WORKING PRINCIPLE

A. *Implementation of NodeMCU 1 for Autonomous Navigation and Motor Control*

The deployment of NodeMCU 1 in the Navi Cart system is aimed at facilitating autonomous navigation through the implementation of two IR sensors for line following and an ultrasonic sensor for obstacle sensing. IR sensors are placed in front of the trolley and are wired to NodeMCU 1's digital input pins.

These IR sensors sense the black line over a white background, enabling the trolley to move along a set path in a precise manner by constantly modifying motor direction. At the same time, the ultrasonic sensor is installed at the front and interfaced through trigger and echo pins to sense any obstruction in the way of the trolley. Depending on the inputs from the IR sensors as well as the ultrasonic sensor, NodeMCU 1 provides suitable signals to the L298N motor driver module, which drives the DC motors in a suitable direction and speed accordingly. When the IR sensors pick up deviation from the line, the NodeMCU corrects the path by adjusting the motor outputs, and if an obstacle is sensed at a certain distance, the motors are stopped to avoid collision. Such synchronized logic allows for intelligent and smooth navigation within the shopping environment.

B. *Implementation of NodeMCU 2 for Item Scanning and Cart Management*

NodeMCU 2 of the Navi Cart system is mainly tasked with the identification of items and cart operation via the interconnection of the EM-18 RFID reader module and push button for item removal. The EM-18 RFID reader is interfaced to the digital input pin of NodeMCU 2 and utilized to read RFID-tagged items when deposited into the trolley. When scanned, the distinctive tag ID is transmitted over Wi-Fi to a cloud database, and the item information and price are retrieved and shown on the user's interface in real-time. For improved user command, a push button is also interfaced with the NodeMCU; upon activation, it initiates a function to remove the last scanned item or a given item from the virtual cart, adjusting the bill appropriately. This configuration enables smooth, touchless product tracking and easy cart modification, providing a smooth and error-free shopping experience.

C. *Web Application for User and Admin Interaction*

A special site has been built to make the user experience richer and give admin control over the Navi Cart system. It is a web platform through which users as well as admins can log in using a very easy and intuitive interface from various devices. They must input their name and phone number to enter their virtual cart, which is where they are able to see scanned products, observe the running bill, and see changes made in real-time. Admins, however, use a safe username and password to access backend capabilities like observing trolley data, seeing all cart items, producing final bills, and clearing carts for the next user.

The site directly interacts with the NodeMCU through Wi-Fi, enabling it to get real-time information regarding items scanned using the EM-18 RFID module or pulled out using the push button. This integration is seamless, meaning all operations done on the trolley are immediately updated on the site, giving users and administrators accurate, synchronized data

Figure 1. Login page

D. User Cart Interface and Monitoring

After the user logs in to the site using his name and phone number, he gets access to a customized dashboard from where he is able to view his shopping trolley in real time. The product information gets fetched and shown on the user interface immediately when products are added to the trolley through the scanning of RFID tags through the EM-18 module. The system indicates a clear list of all scanned products and the quantity of each product, the precise time added, individual costs, and the current total bill. This allows users to track their purchases and expenditure as they shop. Further, in case a product is added by mistake, users are able to remove it from their cart through the push button combined with the trolley. The site responds to this update in real time, redisplaying the item list and the bill total instantaneously. This instantaneous synchronization between the trolley hardware and web interface makes shopping a seamless, open, and interactive process.

Figure 2. User Interaction Page

E. Admin Control and Cart Management

Admins, on the administrator side, securely login with name and password to access the Navi Cart system backend. Once they have logged in, the admin can input the trolley's unique ID to see products currently available in the particular cart.

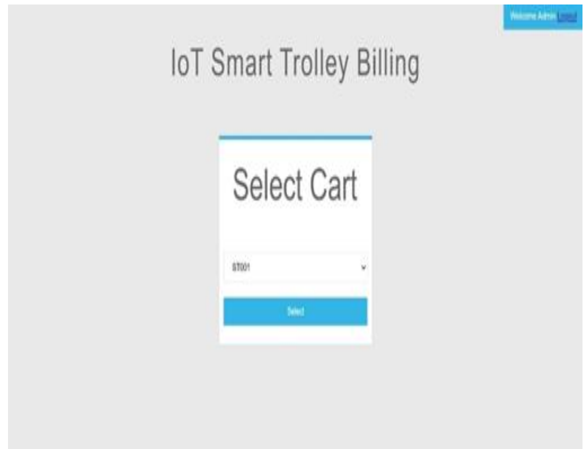

Figure 3. Selection of Cary ID

The interface shows all the relevant information, such as product names, quantity, price per item, and total bill value. When billing is finished, a "Clear" option enables the admin to clear the cart, wiping all data and setting the system up for the next user. This efficient admin panel guarantees quick cart management, proper billing, and seamless user switching.

Figure 4. Admin Control Page

Admins have the ability to print the customer's final bill and create a QR code for quick digital payment.

Figure 5. QR Code Generation

V. METHODOLOGY

The design and development of the Navi Cart system adopts a modular and logical approach, unifying embedded hardware and web platforms to form an intelligent, end-user retail product. The task is structured under two broad modules: hardware design and web-application software development. Hardware deployment constitutes two NodeMCU ESP8266 microcontrollers with separate functionality. The initial NodeMCU is used to control navigation, communicating with two IR sensors for line tracking and an ultrasonic sensor for collision detection.

Depending on sensor feedback, it provides control signals to the L298N motor driver to control the movement of the trolley. The second NodeMCU is used for tracking items and communication. It is interfaced to the EM-18 RFID reader module to read RFID-tagged items and a push button for the removal of mistakenly added products.

Both the microcontrollers are powered using a shared 12V battery provided with a stable voltage supply using a buck converter. The NodeMCUs connect via Wi-Fi, allowing for real-time data exchange between hardware and cloud storage database. A web application is implemented to establish independent interfaces for users and administrators. Users log in through their name and phone number to track cart contents, view product details, view the bill, and clear items if necessary. Admins log in with their credentials to see carts by ID, print the bill, generate a QR code for payment, and reset the cart for the next customer.

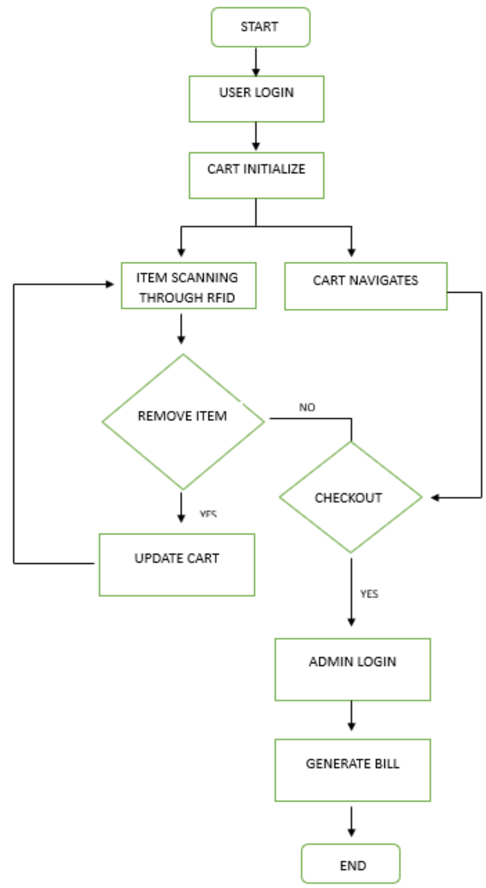

Figure 1. Flowchart of Navi cart using RFID

This whole system provides a frictionless shopping experience by integrating real-time product tracking, self-navigating movement, and wireless communication to successfully close the gap between conventional and smart retailing.

VI. RESULT AND DISCUSSION

The deployment of the Navi Cart system produced extremely functional outcomes, effectively incorporating IoT-based automation into a shopping experience in a retail setting. The trolley moved along pre-programmed routes with high precision using IR sensors, and the ultrasonic sensor ensured effective detection of obstacles to avoid collisions. The line-following and obstacle avoidance logic ran smoothly through the motor control system via the L298N driver, providing smooth movement. This proves that the navigation module, which is driven by the first NodeMCU, operates effectively in real-time settings such as supermarkets with pre-defined routes.

The RFID scan module, which was run by the second NodeMCU, properly scanned RFID-tagged products inserted in the trolley using the EM-18 module. Scanned products were updated instantaneously on the web interface with relevant details such as product name, price, scan time, and number of items. Push-button removal for items was also reliable to remove any improperly scanned item with instantaneous updating on the billing interface. This interactive movement of the user and trolley system confirmed the efficacy of the inherent control logic and real-time database synchronization through Wi-Fi.

The web application responded well on both user and admin portals. Users could login, view their cart in real time, and see the updated bill with ease. Admins could track a specific trolley through unique IDs, create and print end bills, and give QR codes for payment. Upon checkout, the reset feature functioned with perfection such that the cart was now ready for another user. This consumer-oriented web system increased transparency and simplified the retail process, minimizing the need for manual intervention.

Overall, the project was a cost-efficient and scalable solution for contemporary retail settings. By integrating embedded systems with IoT and web technologies, Navi Cart bridged the divide between traditional and intelligent shopping. The outcomes show that such a system can dramatically improve the efficiency, accuracy, and convenience of shopping experiences and minimize human error and manpower dependence. This renders it a viable prototype for future commercial use in smart retail outlets.

VII. CONCLUSION

In summary, the Navi Cart project offers a holistic and creative solution to automating the shopping experience in retail using IoT, embedded systems, and web technologies. The system efficiently employs two NodeMCU ESP8266 microcontrollers to split tasks between autonomous navigation and item management, providing seamless performance and modularity. The initial NodeMCU effectively powers the line-tracking mechanism and object detection with IR and ultrasonic sensors, along with controlling trolley movement through the L298N motor driver. The second NodeMCU controls product recognition through the EM-18 RFID module and item removal through a push button with real-time communication over Wi-Fi to a common cloud database. The web interface created for administrators and users provides simple login, live cart tracking, billing, QR code generation, and receipt printing. This arrangement not only enhances customer convenience but also minimizes the use of human personnel, thus reducing operational mistakes and enhancing efficiency in retail settings. The project shows an economically priced, scalable smart shopping solution that connects the physical-digital gap and thus makes a perfect fit for the age of smart retail. On the whole, Navi Cart presents an emerging shopping paradigm that boosts user experience along with backend efficiency and leads to an enhanced, intelligent, and integrated retail environment.

REFERENCE

[1] Chandrashekhar P, Ms.T. Sangeetha ―Smart shopping cart with automatic central billing system through RFID and zigbee‖, IEEE,2014

[2] D. D. Pradhan, S. Mali, A. Ubale, M. M. Sardeshmukh, S. Pattnaik and P. B. Sindhe, "Smart DYPCOE, DEPARTMENT OF 24 E&TC (2022-23) Shopping Trolley Using Raspberry Pi," 2021 International Conference in Advances in Power, Signal, and Information Technology (APSIT), 2021, pp. 1-4, doi: 10.1109/APSIT52773.2021.9641206.

[3] Mr Kumar and Mr Gupta. A “Smart Trolley using Arduino”, International Journal of Advanced Research in Computer Engineering & Technology (IJARCET),12 December 2013.

[4] Patil, Shishir & Mathad, Shridhar & Gandhad, S & Ellemmi, M. (2022). Smart Trolley with Automatic Billing System using Arudino. IAES International Journal of Artificial Intelligence (IJ-AI). vol.2, no.2, (pp.2268-2273)

[5] Meghana T K, Rahul S Bedare, Ramakrishna M, Vignesh P, Maria Pavithra, (2020), Smart Shopping Cart with Automated Billing System, International Journal of Engineering Research & Technology, vol.8, issue 11, (pp.1-8).

[6] Sanghi, K., Singh, R., Raman, N.: The Smart Cart –An Enhanced Shopping Experience. TA:Justine Fortier Team 41 (2012)

[7] Gareth R.T. White, Georgina Gardiner, Guru Prabhakar, and Azley Abd Razak."A Comparison

of Barcoding and RFID Technologies in Practice". Volume 2, 2007