International Scientific Journal of Engineering and Management (ISJEM) ISSN: 2583-6129
Volume: 04 Issue: 08 | Aug – 2025 DOI: 10.55041/ISJEM04975
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

A Survey on Automated Line-Following Trolley with Smart Billing System

Pooja K H[1], Rakshitha G[2], Sahana S K[3], Sahana E[4], Dr. Raghukumar B S[5]

Department of Electronics and Communication Engineering Adhichunchanagiri Institute of Technology

Emails: poojakhp98@gmail.com, rakshithagrak24@gmail.com, sahanamurthi0@gmail.com, sahanaesahana@gmail.com, raghuacu@gmail.com.

Abstract: The Automated Line-Following Trolley with Smart Billing System is designed to make shopping faster, easier, and more efficient. It can move both forward and backward, following a predefined path on the store floor using line-following sensors. The trolley detects obstacles and stops immediately when its path is blocked. For safety and to prevent misuse, it resumes movement only when the same user re-scans their RFID tag. In terms of billing, the trolley includes a barcode scanner that verifies each item against a preloaded database to ensure product details are accurate. After shopping is complete, the system calculates the total bill-including item names, quantities, discounts, and the final amount and sends it directly to the user's phone. This eliminates the need to wait in checkout lines and reduces the chance of billing errors. Overall, this project integrates navigation, security, and billing into single smart solution that enhances the shopping experience.

Keywords: Smart Trolley, Line Following, RFID, Barcode Scanning, Obstacle Detection, Auto Billing.

I. INTRODUCTION

In today's fast-paced retail environment, long queues at billing counters and manual inventory management remain key challenges in delivering an efficient and satisfying customer experience. With the growing demand for automation in public spaces, smart systems that reduce human intervention and ensure accuracy are becoming essential. The retail sector is increasingly shifting towards intelligent solutions that minimize time and errors while enhancing overall shopping convenience. Among these, automated trolleys integrated with navigation and billing capabilities represent a practical advancement. Manual billing and checkout procedures often result in crowding, human errors, and customer dissatisfaction. To overcome these drawbacks, a smart trolley system is proposed that combines navigation, object detection, product scanning, and secure user verification. The trolley is designed to follow a predefined path using line sensors, while also supporting forward and backward movement to improve mobility in various store layouts. In the presence of an obstacle, the trolley halts immediately and only resumes operation once the same user's RFID is scanned, ensuring both safety and authorized access. At the heart of this system lies a barcode-based billing module. The scanner reads item barcodes and cross-checks them with a preloaded database to ensure product validation and pricing accuracy. Upon completion of shopping, a detailed bill containing item names, quantities, discounts, and total cost is generated and sent directly to the user's mobile device. This paper examines how the proposed system improves checkout efficiency, reduces errors and minimizes human dependency. Various technologies such as RFID, barcode scanning, and automated navigation have been integrated and optimized to ensure smooth operation. Challenges like obstacle handling, unauthorized access, and billing mismatches are addressed through a combination of hardware and logic-based controls. The aim of this work is to provide a reliable, cost-effective, and user-friendly automated trolley that can be deployed in malls, supermarkets, or smart retail stores. This paper also examines the practical implementation and performance of the system under various test conditions, ensuring accuracy, speed, and ease of use.

II. SYSTEM DESCRIPTION

This system introduces an Automated Line-Following Trolley with Smart Billing, which integrates navigation, item identification, billing, and communication into a single embedded platform. As shown in Figure 1, the core of the system is an ESP32 microcontroller, which manages all sensor inputs and output functions. The IR sensor detects and follows a predefined line path, ensuring guided movement through store aisles. To prevent collisions, an ultrasonic sensor is used to detect obstacles and stop the trolley when necessary. The ESP32-CAM module captures images or scans barcodes for product recognition and billing. The L293D motor driver enables bidirectional control of both left and right motors, allowing the trolley to move forward and backward based on system logic. A 16x2 LCD displays the billing information in real-time. A buzzer alerts the user in case of errors. Additionally, if the customer moves away from the trolley and does not return within a set time, the buzzer will be activated. A Telegram Bot is used to send billing details directly to the user's phone for remote and digital checkout. A reset/start button allows the customer to initialize or restart the process as needed. This system enables smooth navigation, safe operation, and smart billing. It not only reduces the time spent at billing counters but also provides a hands-free and contactless retail experience.

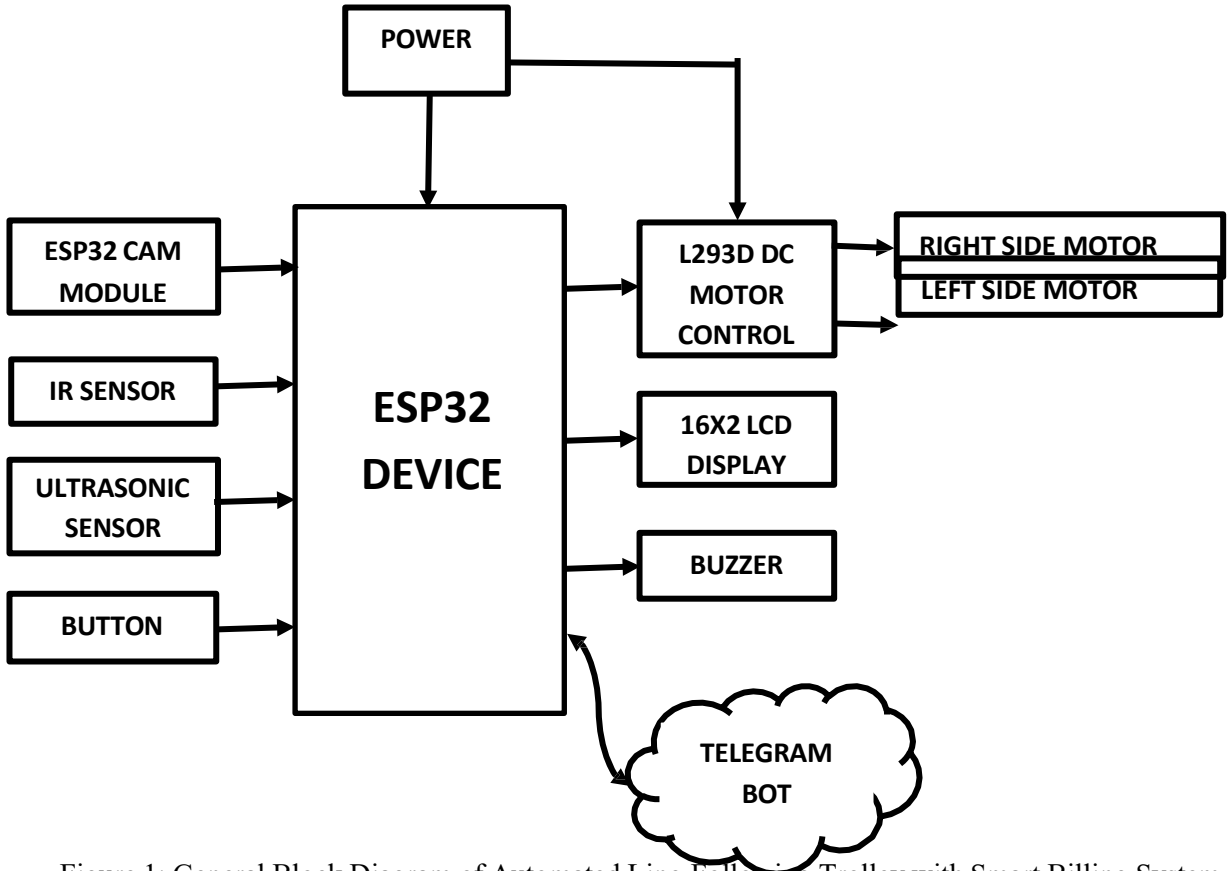

Figure 1: General Block Diagram of Automated Line-Following Trolley with Smart Billing System

III. SURVEY

M. Saravanan, M. Swetha, S. Vedhasruthi, T. Saranya, Palanichamy Naveen, K. Ramakumar (2023) designed a smart shopping trolley that connects to a mobile app to ease supermarket billing. The trolley is equipped with RFID tags a NodeMCU, the trolley automatically tracks items as they are added or removed. Customers can view their updated bill in real time on the Blynk app. Payments can be made directly through UPI, Paytm, or PhonePe. A

reset option in the app allows users to remove unwanted items. This system helps save time, avoids checkout lines, and makes shopping smoother and more efficient retail experience.

Prof. Shwetha M, Dhanush G B, Akshatha B R, Manjushri K N (2024) proposed an intelligent shopping cart solution to reduce billing time and support social distancing after COVID-19. It uses a Raspberry Pi, barcode scanner, LCD, and touch display to scan items and update bills instantly. It communicates with a backend server via Wi-Fi and integrates a load sensor to discourage and detect potential theft. Customers can log in, communicate between carts, and pay through UPI. The system also analyzes shopping behavior for better service. Overall, it reduces labor, improves billing accuracy, and offers a smooth, modern shopping experience.

Atshaya C, Parvathavarthini S, Danushree V S, Krupa N S, and Sowndharya R proposed (2025) "RFID based Human Following Smart Trolley with Real-Time Pricing". This work aims to resolve shopping inefficiencies such as crowd congestion, manual trolley handling, and delayed pricing updates. The system uses IoT-based automation for real-time price updates and human-following capabilities. Components like ultrasonic and IR sensors ensure safe navigation, while an Arduino UNO handles motion control and pricing. An integrated GSM module sends the final bill via SMS. The approach blends automation, obstacle detection, and real-time billing to provide a contactless, user-friendly retail experience.

Dr. K. Sathesh, Sreesailam Phani Tej, Kowsalya P, Shaik Mahammed, E. Aravindraj, and Nandyala Manikanteswar Reddy (2024) put forward "Integrated Smart Trolley System: Arduino Nano-Based RFID Billing and Weight Sensor Augmentation". This paper focuses on an Arduino Nano-based system integrating EM-18 RFID modules and HX711 weight sensors. The trolley automatically identifies items via RFID, confirms their presence using weight data, and displays details on an LCD. Bluetooth connectivity allows real-time billing interaction via a mobile app. The system ensures accurate inventory and theft prevention through weight validation and camera integration. It also introduces a digital wallet interface for direct payment, highlighting a seamless and secure shopping process.

IV. KEY DISCOVERIES OF THE REVIEW

The table below presents a comparative analysis of various smart trolley systems developed to enhance shopping efficiency through automation and IoT integration. It summarizes key research contributions by outlining the authors and titles, describing the methodologies used, reporting significant outcomes, and identifying challenges encountered in each system along with proposed strategies for enhancing future designs. These systems commonly incorporate technologies such as RFID, microcontrollers, sensors, and mobile applications or wireless communication. The primary objective is to reduce human involvement in the billing process, minimize customer wait times, and improve the overall shopping experience.

SI NO	Author, Title	Methodology	Results	Limitations and Recommendation
1	Atshaya C, Parvathavarthini S, Danushree V S, Krupa N S, Sowndharya R (2025) "RFID based Human Following Smart Trolley with Real- Time Pricing"	IoT-based smart trolley system using Arduino UNO, RFID, IR & ultrasonic sensors, GSM module	Enables autonomous human-following trolley with real-time price update and SMS billing	- Dependent on sensor accuracy for human tracking - May face limitations in crowded environments - Needs enhancement with image-processing for item recognition

2	Dr. K. Sathesh, Sreesailam Phani Tej, Kowsalya P, Shaik Mahammed, E. Aravindraj, N. Manikanteswar Reddy (2024) "Integrated Smart Trolley System: Arduino Nano-Based RFID Billing and Weight Sensor Augmentation"	Arduino Nano-based system using RFID (EM-18), HX711 weight sensor, LCD, Bluetooth app	Real-time billing, product identification, anti-theft (via weight validation), and digital wallet integration	- Lacks support for image-based product detection - Security depends on accurate sensor calibration - Not optimized for large-scale retail deployments yet
3	Mohit Kumar, Jaspreet Singh, Anju, Varun Sanduja (2015) "Smart Trolley with Instant Billing to Ease Queues at Shopping Malls using ARM7 LPC2148: A Review"	ARM7 LPC2148 microcontroller with RFID, LCD (16x2), and Zigbee modules	Automates billing by scanning RFID- tagged items and transmitting details to billing counter via Zigbee	- Requires manual payment at the counter - Limited to basic item detail display - Less user interactivity than mobile-based solutions
4	M. Saravanan, M. Swetha, S. Vedhasruthi, T. Saranya, Palanichamy Naveen, K. Ramkumar "Design and Implementation of an Intelligent Shopping Trolley Integrated with a Mobile Application and Shopping Model."	IoT-based smart billing system using NodeMCU, RFID Reader, Blink App, and mobile connectivity. RFID tags enable product tracking; the bill is updated live-in the mobile app. Power regulation through 7805 IC; item removal via rescan and reset. Payment through UPI/Paytm/PhonePe.	Real-time bill updates, product addition/removal via RFID; smooth app-trolley integration; reduced queue time; enhanced customer experience; future-ready smart shopping model.	Blink app requires stable hotspot connection; RFID must be precise; full deployment requires retailer cooperation; backend data sync & regulatory concerns exist; requires regular maintenance and RFID stock tagging.
5	Santhosh V, Gokulakrishnan D, Purushothaman S, Suganthi S U "An Automated Billing System for Smart Shopping Using IoT", IRJAEH, 2024	RFID-based smart trolley with Arduino, cameras, LCD, and weight sensors. Uses real-time detection of products and sends data to a centralized billing system.	The system significantly reduces queue times and improves customer experience. Supports automatic billing and inventory management.	- Requires RFID infrastructure for each product. May not function effectively if RFID or camera detection fails. Does not address multi-user interference. Limited in scalability for large stores.

6	Aravindhan A, Palepu Shiva, Priyadharsan S, Vasanthakumar R "RFID Based Smart Trolley for Automatic Billing System", IJFMR, 2023	EM-18 RFID reader, Arduino UNO, LCD, HC-12 & SI4463 wireless modules. Detects items via RFID and displays real-time bill on trolley screen.	Reduces billing time by scanning multiple items simultaneously. Customer gets real-time bill and weight info.	Relies heavily on RFID tag readability. Barcode removal or failure to detect tags can affect billing. Limited fault-tolerance in system architecture.
7	Prof. Shwetha M, Dhanush G B, Akshatha B R, Manjushri K N "Smart Trolley for Smart Shopping with an Advance Billing System", IJARCCE, 2024	Smart trolley using Raspberry Pi, barcode scanner, LCD, weight sensor, and Wi-Fi for IoT integration. Enables self-billing with product information display and cart-to- cart communication.	Significant reduction in billing time and queue waiting. Provides real-time billing on cart and integrates with store database. Improves customer experience and reduces manpower.	Requires proper barcode visibility and scanner accuracy. Depends on uninterrupted Wi-Fi connectivity. Initial hardware installation may involve moderate cost.
8	Vikram Ghadage, Shubham Chavan, Saurabh Chavan, Kaustubh Dhole, Bhagesh Dongare "Line Following Trolley", JETIR, 2021	Line following trolley using IR sensors, photodiodes, DC gear motors, Arduino UNO, and LCD for distance display. Uses a basic line detection and obstacle avoidance logic.	Trolley follows a black line path using sensor logic. Displays distance travelled on LCD. Can be used for automation in industrial and domestic applications.	Basic prototype with limited complexity. No wireless communication or billing functionality. Lacks IoT integration. Not suitable for commercial retail environments without significant upgrades.

V. CONCLUSION

This survey paper presents a comprehensive analysis of different approaches and advancements in automated shopping trolley systems with integrated billing features. The primary aim across all models is to enhance the customer shopping experience by reducing queue times, minimizing human interaction, and improving billing accuracy through technologies such as RFID, barcode scanning, weight sensors, and IoT connectivity. Each approach contributes uniquely some emphasize real-time billing and mobile app integration. Although these technologies have shown considerable potential, obstacles persist regarding scalability, sensor precision, and consistent performance in ever-changing retail settings. Most solutions are still in prototype or limited deployment stages, requiring further optimization for widespread adoption. The integration of line-following capabilities, secure user verification, and wireless billing updates, as proposed in recent research, shows potential in overcoming many of these limitations. In conclusion, automated smart trolley systems represent a transformative advancement in retail automation.

REFERENCES

[1] Atshaya C, Parvathavarthini S, Danushree V S, Krupa N S, and Sowndharya R, "RFID based Human Following Smart Trolley with Real-Time Pricing," Proc.5th Int. Conf. Pervasive Comput. Social Netw. (ICPCSN- 2025), IEEE, pp. 1902–1907, 2025.

[2] Dr. K. Sathesh, Sreesailam Phani Tej, Kowsalya P, Shaik Mahammed, E. Aravindraj, and Nandyala Manikanteswar Reddy, "Integrated Smart Trolley System: Arduino Nano-Based RFID Billing and Weight Sensor Augmentation," Proc. 10th Int. Conf. on Communication and Signal Processing (ICCSP-2024), IEEE, pp. 958– 963, 2024.

[3] Mohit Kumar, Jaspreet Singh, Anju, and Varun Sanduja, "Smart Trolley with Instant Billing to Ease Queues at Shopping Malls using ARM7 LPC2148: A Review," Int. J. Adv. Res. Comput. Commun. Eng. Vol. 4, No. 8, pp. 39–42, August 2015.

[4] M. Saravanan, T. Saranya, M. Swetha, S. Vedhasruthi, K. Ramkumar, and P. Naveen, "Design and Implementation of an Intelligent Shopping Trolley Integrated with a Mobile Application," Proc. Int. Conf. Sustainable Commun. Netw. Appl. (ICSCNA 2023),IEEE, pp. 1144–1149, 2023. DOI: 10.1109/ICSCNA58489.2023.10370352

[5] Santhosh V, Gokulakrishnan D, Purushothaman S, and Suganthi S U, "An Automated Billing System for Smart Shopping Using Internet of Things," Int. Res. J. Adv. Eng. Hub (IRJAEH), Vol. 2, No. 4, pp. 981–987, April 2024. DOI: 10.47392/IRJAEH.2024.0137

[6] Aravindhan A, Palepu Shiva, Priyadharsan S, and Vasanthakumar R, "RFID Based Smart Trolley for Automatic Billing System," Int. J. Multidiscip. Res. (IJFMR), Vol. 5, No. 2, pp. 1–7, March–April 2023.

[7] Prof. Shwetha M, Dhanush G B, Akshatha B R, and Manjushri K N, "Smart Trolley for Smart Shopping with an Advance Billing System," Int. J. Adv. Res. Comput. Commun. Eng., Vol. 13, No. 6, pp. 36–41, June 2024. DOI: 10.17148/IJARCCE.2024.13606

[8] Vikram Ghadage, Shubham Chavan, Saurabh Chavan, Kaustubh Dhole, and Bhagesh Dongare, "Line Following Trolley," J. Emerg. Technol.Innovative Research (JETIR), Vol. 8, No. 6, pp. 651–656, June 2021. ISSN: 2349-5162.

[9] S. Sinchana Kakade et al., "Enhancing Care and Communication for Paralyzed Patients: A Microcontroller- Based Gesture Sensor Approach with GSM Integration," 2024 International Conference on Recent Advances in Science and Engineering Technology (ICRASET), B G Nagara,Mandya, India, 2024, pp. 1-5, doi: 10.1109/ICRASET63057.2024.10895385.

[10] B. S. Balaji, S. V. Sandeep, S. Nischitha and B. S. Raghu Kumar, "ZigBee Empowered Wireless Paging for Seamless WPAN Communication," 2024 International Conference on Knowledge Engineering and Communication Systems (ICKECS), Chikkaballapur, India, 2024, pp. 1-4, doi: 10.1109/ICKECS61492.2024.10617402.

[11] Sandeep, S.V., Nischitha, S., Balaji, B.S., Naveen, K.B., Raghu Kumar, B.S. (2025). MAC Design and Performance Improvement Using 64-Bit VMultiplier Based on UTS. In: Patnaik, L.M., G. K., R., Prasad, N.H. (eds) Advances in Communication and Applications. ERCICA 2024. Lecture Notes in Electrical Engineering, vol 1398. Springer, Singapore. https://doi.org/10.1007/978-981-96-4679-1_20

[12] B. Naveen, B. Nayaka, V. Goutham, J. K. Anusha and B. S. Raghukumar, "Simplified Agrirobot For Modern Agricultural Techniques Using IoT," *2021 IEEE International Conference on Mobile Networks and Wireless Communications (ICMNWC)*, Tumkur, Karnataka, India, 2021, pp. 1-4, doi: 10.1109/ICMNWC52512.2021.9688543.

[13] Raghukumar B S and Mr. Ravi H Talwar. "Grading of Rice Grains by Image Processing." International Journal for Scientific Research and Development 2.6 (2014): 393-395.