Smart Trolley for Auto Billing System

G vinodkumar[1], Harish MK[2], Hemanth R[3], Kariyanna[4] and Prathibha P[5*]
[1,2,3]*Department of Electronics and Communication Engineering, Sapthagiri College of Engineering, Bengaluru, India*
[5]*Assistant Professor, Department of Electronics and Communication Engineering, Sapthagiri College of Engineering, Bengaluru, India*

*Corresponding Author

Abstract: The proposed project presents an intelligent human-following smart trolley designed to optimize the shopping process in automated retail environments. The system employs autonomous user-tracking mechanisms to maintain a safe and consistent distance while following the customer, thereby eliminating the need for manual handling. It incorporates an automated item identification approach that enables real-time detection of products placed into or removed from the trolley without manual scanning, ensuring accurate inventory tracking.
The system continuously processes item data to dynamically update the total purchase cost and maintain a real-time billing summary. Upon completion of the shopping activity, the finalized bill amount is securely transmitted to the owner's mobile device, significantly reducing checkout delays and minimizing congestion at billing counters. The proposed project enhances operational efficiency, reduces human intervention, and improves billing accuracy. This solution is well-suited for large-scale retail stores and crowded shopping environments and contributes to the advancement of smart retail automation systems.

1. Introduction

Innovation has always been driven by human needs, with modernization aiming to make life faster and stress-free. Today's busy lifestyle leaves people with limited time for shopping, leading them to prefer malls where all products are available in one place. However, traditional shopping involves long queues at billing counters, which is time-consuming and requires more manpower.
To overcome this issue, a Smart Trolley system is proposed. It reduces billing time, minimizes human effort, improves shopping efficiency, and helps prevent theft. Automated solutions like smart trolleys represent the future of the retail industry by enhancing the overall shopping experience.

1.1 Problem Statement

When we go for shopping, there must be problem that we have some budget but we take things more than our budget. But after going to counter we realize that our shopping extends the budget. Design a system which will reduce billing time in the supermarket and will be cost efficient. An innovative product with societal acceptance is the one that aids the comfort, convenience and efficiency in everyday life. Purchasing and shopping at big malls is becoming daily activity in metro cities. There will be rush at these malls on holidays and weekends. People purchase different items and put them in trolley. After completion of purchases, one needs to go to billing counter for payments. At billing counter, the cashier prepare the bill using bar code reader which is very time-consuming process and results in long queue at billing counter. In this Project, we are implementing a system being developed to assist a person in everyday shopping in terms of reduced time spent while purchasing. The main objective of proposed system is to provide a technology oriented, low-cost, easily scalable, and rugged system for assisting shopping in person.

1.2 Literature Survey

R. Sharma et al. [1] developed an autonomous human-following trolley using ultrasonic sensors and a PID-based control algorithm. The system continuously measured user distance and adjusted motor speed accordingly.
Anita Kumari et al. [2] proposed an intelligent trolley that follows customers using infrared sensors combined with a Bluetooth-based identification tag. The trolley locked onto the customer's signal and maintained a fixed trailing distance.
S. Rakesh and P. Gopinath [3] implemented a vision-based human-following cart using a Raspberry Pi camera and OpenCV color-tracking algorithms. The system detected the user's clothing color and navigated by adjusting wheel rotation.
M. Lokesh et al. [4] designed a hybrid human-following trolley combining IR, ultrasonic, and accelerometer sensors for improved reliability. Their fusion algorithm filtered sensor noise and enhanced real-time response, reducing jerky movements.
M. Prakash et al. [5] presented a Raspberry-Pi–based barcode identification module intended for low-cost retail automation. The authors integrated an HD camera with OpenCV to decode 1D and 2D Iot.
Anusha R. et al. [6] implemented a barcode scanning model using Raspberry Pi 3 and a Python-based decoding library. The study demonstrated improved flexibility over conventional scanners, enabling additional modules such as Wi-Fi billing and mobile notifications.
Vikram Singh et al. [7] introduced a Pi-based embedded vision barcode reader that utilized a 5-MP Pi camera module. The system employed distortion correction, autofocus algorithms, and multi-angle scanning, ensuring high reliability even when users hold products at varied angles.
R. Mahendran et al. [8] built a portable barcode acquisition unit on Raspberry Pi that communicates with a backend store server. The authors highlighted that their design consumed lower power and allowed multi-threaded processing to speed up recognition.
A. Gopal et al. [9] proposed an automatic scanning trolley using UHF RFID readers that detect multiple items simultaneously. They demonstrated that RFID improves operational speed by eliminating line-of-sight scanning.
N. Shashidhar et al. [10] developed an IoT-based auto-scanning basket using HF RFID tags. The system uploaded every detected item to a cloud server and verified the product ID in real time. The proposed prototype minimized scanning errors and reduced bottlenecks at checkout counters, proving effective in small and medium retail environments.
G. Sreelatha et al. [11] introduced a hybrid scanning technique combining barcode and RFID to improve accuracy. The hybrid model ensured that even untagged or low-frequency items could still be scanned through barcode fallback.
R. Swetha et al. [12] developed an automated item-capturing system using IR and weight sensors to confirm item presence inside the trolley. The sensory fusion technique helped avoid false detections when multiple RFID tags interfered.
S. Kaushik et al. [13] developed an RFID-based automatic item detection system where each product was tagged with a passive RFID label. The trolley contained an onboard reader that identified items the moment they were placed inside.
Meghana P. and Vishal K. [14] proposed a hybrid solution using load cells to detect weight changes in the trolley, combined with a local product database. The system compared weight increments with predefined item weights to infer the product added..
A. Thomas et al. [15] implemented a computer-vision–based detection method using a Pi Camera and YOLO-based object recognition. The system captured item images and automatically matched them with stored product models. The results indicated that vision-based detection is effective for non-tagged items but requires controlled lighting.
R. Banerjee et al. [16] designed a multi-sensor item detection module using RFID, weight sensors, and ultrasonic presence detection. Their fusion algorithm filtered false positives and validated item entry using cross-verification.

D. Shankar et al. [17] introduced a smart cart system that used reverse weight tracking to detect item removal events. When a product was taken out, a weight drop was recorded and matched against stored weight profiles. This enabled accurate adjustment of the billing list and minimized checkout disputes.
Harini S. et al. [18] implemented an RFID-based removal detection mechanism in which the trolley automatically updated the
T. Venugopal and R. Reddy [19] developed an IoT-enabled trolley featuring a user interface that allowed customers to confirm or cancel items. The system synchronized item
M. Kavin Kumar et al. [20] proposed a smart basket system that combined computer vision with weight drop detection to identify when a product was taken out.
P. Sandeep et al. [21] designed a smart cart that generated an electronic invoice and transmitted it to the customer via SMS using a GSM module.
H. Kavitha et al. [22] implemented a cloud-based billing system wherein scanned items were stored online and the final bill was pushed to the customer's mobile application.
Shreya A. and Dilip M. [23] developed an IoT-enabled billing module using Firebase as a backend. The trolley automatically uploaded billing data and sent a mobile notification upon checkout.
R. Murugan and A. Vishwa [24] created a QR-based final billing system where the trolley generated a QR code containing the complete bill. Scanning the code on the user’s mobile opened the final invoice and payment page. The authors noted that QR billing removes hardware dependencies like GSM modules.

2. Objectives and System Architecture

2.1 Objectives

- To Develop a human following smart trolley.
- To Design and integrate a barcode scanning module.
- To detect items placed in the trolley without manual scanning.
- To allow easy removal of items from the trolley.
- To send the final bill amount to the owner’s mobile

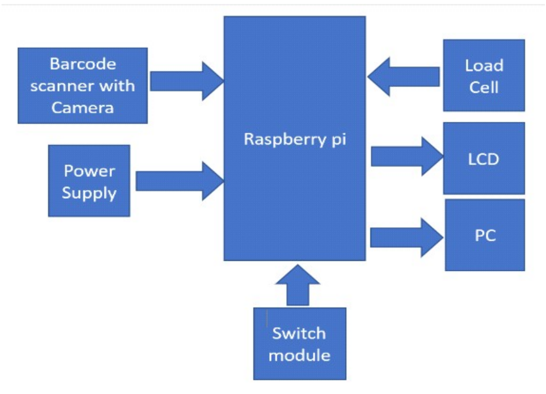

Fig 1. Block diagram of smart trolley system

Fig 1. shows the block diagram of the Smart Trolley system. The core component is a Raspberry Pi, which connects to the network using Ethernet or a USB Wi-Fi module. The system includes a load cell to measure product weight, converting mechanical strain into analog voltage signals. A camera-based barcode scanner is used to capture and decode barcode information. Three toggle switches are provided for adding items, removing items, and billing. A 16×2 LCD displays product details such as name, weight, and price. The process starts by initializing the Raspberry Pi and scanner, continuously scanning for barcodes. Once detected, the barcode is decoded, product details are retrieved from the database, and the information is sent to the billing system. The fig 2. shows the Flow chart Flow chart of Smart Trolley for Auto Billing system.

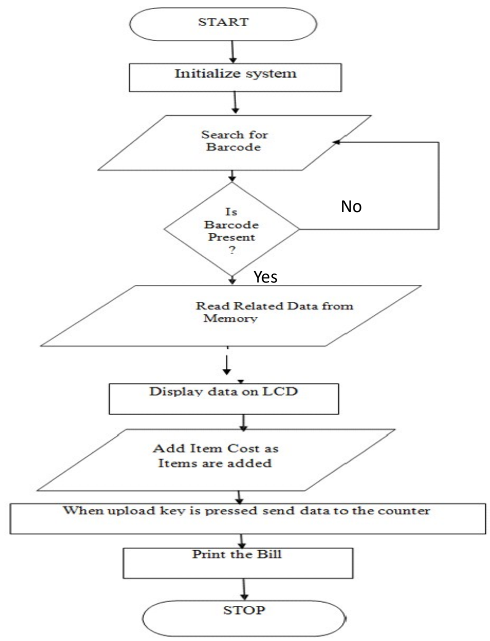

Fig 2. Flow chart Flow chart of Smart Trolley for Auto Billing system

3. Results and discussion

The Protype was rigorously evaluated against the objectives of latency, accuracy and usability.

3.1 Operation of the System:

A customer enters the Smart Shopping Centre. On entering, she/he first picks a Smart Shopping Trolley. Each trolley is given a unique ID and every customer is associated with the ID of the trolley chosen. The functioning of the system is listed below: When the customer picks up a product that s/he wishes to purchase, s/he first scans the barcode of the product using the barcode scanner and then places it on the slab of the cart, which is meant to play the role of putting the products into the cart when it is triggered to do so. At the server, this transmitted information is received. This information is then used to fetch relevant information about the product from the database corresponding to the barcode. The database consists of the following details at least: the barcode, name of the product, price and weight. Once the product is inside the trolley, the role of the load-cell comes into play. The weight of the product is estimated and then transmitted to the main server. At the Base Station, the weight which is received from this cart is compared with the weight that was retrieved earlier from the database corresponding to the same cart ID. This procedure is repeated for every product the customer purchases. Finally, when the customer finishes shopping, s/he goes to the counter in order to pay the bill amount. If the two weights are found to be equal then the total bill amount will be sent through an email-id to the main server where it displays the detailed bill of the customer's purchase. This implies that the customer can pay the bill amount and carry on. On the other hand, if the two weights are found to be different at the main server, then during the final bill there will be a buzzer, indicating that an attendant has to request the customer to wait for the check-out process again. If a customer changes his mind, the reverse process has to be carried out. After the customer takes the product out, it has to be scanned and the image of the scanned product is then captured. The main server has been programmed to handle this case which enables the customer to do so. This implementation also takes care of all discrepancies in the same manner. Fig 3 illustrates the image of final ha

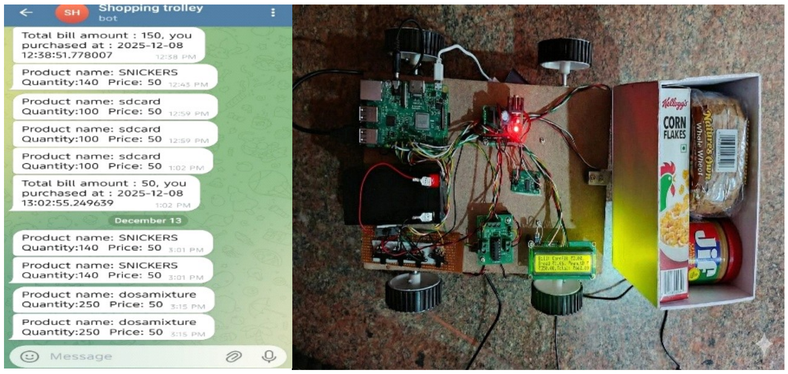

Fig 3. Final project module and bill prototype of Smart trolley.

4. Conclusion

The human-following smart trolley system successfully integrates sensing, control, and communication technologies to enhance the shopping experience. Using ultrasonic sensors and DC motors, the trolley automatically follows the user, reducing physical effort. A USB barcode scanner and load cell–based weight detection system ensures accurate product identification and reliable billing with real-time updates. The final bill is securely sent to the user's mobile phone via the Telegram application, enabling fast and contactless checkout. Overall, the system is cost-effective, scalable, and suitable for modern retail environments, with scope for future improvements such as advanced navigation and mobile payment integration.

References

[1] R. Sharma, A. Verma, and K. Singh, "Autonomous human-following trolley using ultrasonic sensors and PID control," International Conference on Intelligent Systems and Control (ISCO), Coimbatore, India, pp. 215–220, 2019.

[2] A. Kumari, S. Patel, and R. Meena, "Intelligent customer-following shopping trolley using IR sensors and Bluetooth," International Journal of Engineering Research & Technology (IJERT), vol. 8, no. 6, pp. 1021–1025, 2019.

[3] S. Rakesh and P. Gopinath, "Vision-based human-following cart using Raspberry Pi and OpenCV," International Conference on Communication and Signal Processing (ICCSP), Chennai, India, pp. 1345–1349, 2020.

[4] M. Lokesh, R. Karthik, and S. Naveen, "Multi-sensor-based human-following smart trolley for indoor applications," International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, vol. 9, no. 4, pp. 2891–2897, 2020.

[5] M. Prakash, S. Aravind, and V. Kumar, "Raspberry Pi based barcode identification system for retail automation," International Conference on Computing, Communication and Networking Technologies (ICCCNT), Kharagpur, India, pp. 1–5, 2018.

[6] Anusha R., P. Sumanth, and K. Reddy, "Barcode scanning and billing system using Raspberry Pi," International Journal of Computer Applications, vol. 182, no. 21, pp. 7–11, 2018.

[7] V. Singh, A. Mishra, and S. Tiwari, "Embedded vision-based barcode reader using Raspberry Pi,"

International Conference on Smart Systems and Inventive Technology (ICSSIT), Tirunelveli, India, pp. 642–646, 2019.

[8] R. Mahendran, S. Balaji, and P. Arun, "Portable barcode acquisition system using Raspberry Pi," International Journal of Engineering and Advanced Technology (IJEAT), vol. 9, no. 2, pp. 3324–3328, 2019.

[9] A. Gopal, R. Suresh, and V. Anand, "Automatic billing shopping trolley using UHF RFID," International Conference on Emerging Trends in Engineering and Technology (ICETET), pp. 98–103, 2017.

[10] N. Shashidhar, M. Tejaswini, and K. Ramesh, "IoT based smart shopping basket using RFID," International Journal of Innovative Technology and Exploring Engineering (IJITEE), vol. 8, no. 9, pp. 1785–1789, 2019.

[11] G. Sreelatha, P. Keerthi, and S. Divya, "Hybrid barcode and RFID based smart trolley system," International Conference on Electrical, Electronics and Computer Engineering (ICEECE), Hyderabad, India , pp. 411–415, 2020.

[12] R. Swetha, K. Harshini, and V. Pavani, "Automated item detection in smart trolley using IR and weight sensors," International Journal of Scientific Research in Computer Science, Engineering and Information Technology, vol. 6, no. 3, pp. 215–220, 2020.

[13] S. Kaushik, R. Malhotra, and P. Jain, "RFID based automatic item detection system for smart carts," International Conference on Internet of Things and Applications (IOTA), Pune, India, pp. 229–233, 2018.

[14] Meghana P. and Vishal K., "Load cell based automatic item identification in smart trolley," International Journal of Engineering Research & Technology (IJERT), vol. 9, no. 7, pp. 456–460, 2020.

[15] A. Thomas, J. Mathew, and S. Joseph, "Vision-based item detection using YOLO for smart shopping carts," International Conference on Smart Technologies and Systems (ICSTS), Kochi, India, pp. 88–93, 2021.

[16] R. Banerjee, A. Dutta, and S. Paul, "Multi-sensor fusion for automatic item detection in smart trolley," IEEE International Conference on Consumer Electronics (ICCE), Las Vegas, USA , pp. 1–4, 2020.

[17] D. Shankar, R. Prakash, and S. Kumar, "Reverse weight tracking based smart shopping cart," International Journal of Advanced Computer Science and Applications (IJACSA), vol. 10, no. 5, pp. 312–317, 2019.

[18] Harini S., R. Anitha, and K. Lavanya, "RFID based item removal detection in smart carts," International Conference on Smart Computing and Informatics (SCI), Hyderabad, India, pp. 521–526, 2018

[19] T. Venugopal and R. Reddy, "IoT enabled smart trolley with real-time item confirmation," International Journal of Internet of Things, vol. 8, no. 2, pp. 45–50, 2019.

[20] M. Kavin Kumar, S. Pradeep, and V. Arun, "Smart basket using vision and weight sensors for item removal detection," International Conference on Artificial Intelligence and Signal Processing (AISP), Amaravati, India, pp. 376–380, 2020.

[21] P. Sandeep, R. Naveen, and K. Chaitanya, "GSM based electronic billing system for smart carts," International Journal of Electronics and Communication Engineering, vol. 7, no. 4, pp. 189–194, 2018.

[22] H. Kavitha, S. Renuka, and P. Mahalakshmi, "Cloud based mobile billing system for smart shopping," International Conference on Cloud Computing and Data Science (ICCCDS), Noida, India, pp. 112–116, 2019.

[23] Shreya A. and Dilip M., "IoT enabled smart billing system using Firebase," International Journal of Engineering and Technology (IJET), vol. 9, no. 3, pp. 221–226, 2020.

[24] R. Murugan and A. Vishwa, "QR code based final billing system for smart trolley," International Conference on Smart Electronics and Communication (ICOSEC), Trichy, India, pp. 587–591, 2021.