

# **Design and Development of Smart Tech-Trolley**

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**Abstract:** *The Design and Development of Smart Tech-Trolley is an innovative automated transportation system developed to reduce manual effort and improve efficiency in carrying goods across various environments. The system uses an ESP32 microcontroller integrated with ultrasonic sensors, IR sensors, RFID authentication, load cell with HX711 module, motor driver, DC motors, buzzer, and display unit for intelligent operation. It is capable of autonomous movement, obstacle detection, weight monitoring, secure user access, and real-time status indication. The trolley is useful in supermarkets, hospitals, airports, warehouses, and hotels where safe and efficient material handling is required. This project offers a cost-effective and user-friendly smart mobility solution and can be further enhanced with IoT connectivity, GPS tracking, and AI-based navigation systems..*

**Keywords:** Smart Tech-Trolley, ESP32, RFID, Load Cell, Automation, Obstacle Detection, Autonomous Navigation, IoT.

## **I. INTRODUCTION**

In the modern era of automation and smart technology, the demand for intelligent systems that reduce manual effort [1] and improve operational efficiency has increased significantly. Traditional trolleys used in shopping centers, airports, warehouses, and hospitals require continuous physical force for movement, which can lead to fatigue and inconvenience [2]. To overcome these limitations, the Smart Tech-Trolley has been developed as an advanced solution that combines embedded systems, sensors, and automated control for smooth and efficient transportation of goods.

The Smart Tech-Trolley is designed using an ESP32 microcontroller as the main control unit, which manages all sensing and operational tasks [3]. It integrates various components such as ultrasonic sensors for obstacle detection, infrared sensors for path guidance [4], RFID modules for secure access, and load cells for weight measurement [5]. These technologies allow the trolley to sense its environment, make decisions in real time, and provide reliable assistance to users in different working conditions.

The system also includes motor drivers and DC gear motors that enable controlled movement and steering [6]. A display unit shows important parameters such as load weight, battery level, and system status, while a buzzer provides warning alerts for overload conditions or nearby obstacles [7]. This smart combination of hardware and software improves safety, minimizes accidents, and enhances the user experience [8]. Such intelligent trolley systems are especially beneficial for elderly people, workers handling heavy loads, and users in crowded public areas.

The development of the Smart Tech-Trolley represents an important step toward future autonomous material handling systems [9]. It is a cost-effective alternative to expensive robotic transport systems and can be further upgraded with IoT connectivity, GPS tracking, mobile app control, and AI-based navigation. Therefore, the project demonstrates how modern automation can transform conventional transport equipment into a smart, efficient, and user-friendly solution for various commercial and industrial applications [10].

## **II. PROBLEM STATEMENT**

Conventional trolleys used in shopping malls, warehouses, hospitals, airports, and industrial sectors depend completely on manual effort for movement and handling of goods. This creates physical strain for users, especially when



transporting heavy loads over long distances. In crowded or busy environments, manual trolleys are difficult to control and may cause collisions, delays, or accidents. [1]

Existing trolley systems generally lack intelligent features such as obstacle detection, load monitoring, and secure access control. Overloading can damage goods or the trolley structure, while unauthorized use may create safety and security concerns in commercial and industrial applications [2]. Traditional systems also fail to provide real-time information regarding trolley status, battery level, or load capacity.

There is therefore a need to develop a Smart Tech-Trolley that can reduce human effort, improve transportation efficiency, ensure user safety, and provide intelligent automation features. The proposed system should be capable of autonomous movement, obstacle avoidance, load sensing, RFID-based authentication, and real-time monitoring using modern embedded technologies [3]. Such a system can improve productivity, convenience, and operational performance in various environments.

### III. OBJECTIVES

- To design and develop a Smart Tech-Trolley using an ESP32 microcontroller for intelligent control and automation.
- To implement obstacle detection and safe navigation using ultrasonic and IR sensors.
- To measure and monitor load weight using a load cell with HX711 module to prevent overloading.
- To provide secure access through RFID-based user authentication.
- To control trolley movement efficiently using motor drivers and DC motors with real-time status display and alerts.

### IV. LITERATURE SURVEY

1. **K. Patil et al. (2025), “Review on Smart Shopping Trolley with Auto Follow, Real-Time Scanning and Billing”** presented an advanced smart trolley system that combines RFID technology, barcode scanning, touchscreen display, and ultrasonic sensors for automatic following and billing. The trolley can track products placed inside it, generate instant bills, and move automatically with the customer. The study highlighted reduced waiting time at billing counters and improved customer convenience. This paper is highly relevant as it combines navigation and billing features similar to the proposed Smart Tech-Trolley.
2. **R. Sharma et al. (2025), “AI-Powered Smart Shopping Trolley”** proposed an IoT-based trolley integrated with autonomous customer-following capability, RFID scanning, obstacle detection, and mobile app connectivity. The system uses AI algorithms for efficient navigation and provides real-time billing updates. The authors concluded that intelligent trolleys can improve shopping efficiency while reducing physical effort. This work supports the use of automation and AI in the proposed system.
3. **M. Hasan et al. (2025), “Smart Supermarket Shopping Cart using RFID and Zigbee”** developed a smart cart using RFID reader, Arduino controller, LCD display, and wireless Zigbee communication. The system automatically detects purchased items and updates the total bill on the display screen. The research showed that automated billing systems can significantly reduce checkout queues and manpower requirements. This paper provides useful insights for RFID billing integration in the Smart Tech-Trolley.
4. **S. Verma et al. (2024), “Hands-Free Smart Shopping Trolley with Human Following Mechanism”** introduced a trolley capable of following the customer without manual pushing. The system uses sensors, computer vision, and embedded control units for user tracking and safe movement. The study emphasized convenience for elderly users and people carrying heavy loads. This literature is important for implementing autonomous movement in the proposed trolley.
5. **Rahman et al. (2024), “IoT-Based Human Friendly Smart Trolley”** designed a trolley using Raspberry Pi, RFID reader, camera module, ultrasonic sensors, and gear motors. The trolley follows the customer using image processing and performs automated billing using RFID tags. Experimental results showed reduced customer effort



and faster billing operations. This paper demonstrates the practical implementation of multi-sensor smart trolley systems and directly supports the proposed project development.

## V. WORKING OF SYSTEM

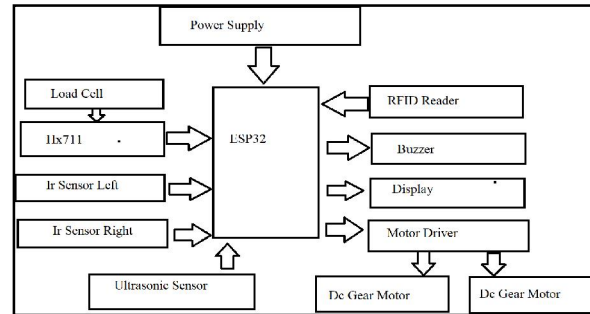


Fig 2: Design of the system

### A. Power Supply and Central Control Unit

The power supply provides regulated electrical energy to all components of the Smart Tech-Trolley. The ESP32 acts as the main controller of the system and coordinates the complete operation. It receives signals from all input sensors, processes the data, and sends control commands to output devices such as the motor driver, display, and buzzer.

### B. Load Monitoring Section

The load cell is used to measure the weight placed on the trolley platform. Since the load cell produces very small analog signals, the HX711 amplifier converts these signals into digital values that can be read by the ESP32. If the weight exceeds the preset limit, the controller activates the buzzer and displays an overload warning on the screen.

### C. Obstacle Detection and Navigation Section

The ultrasonic sensor continuously detects obstacles in front of the trolley by measuring distance. If any object is detected within a short range, the ESP32 stops or changes the movement of the trolley to prevent collision. The left and right IR sensors help in path guidance, side obstacle sensing, and maintaining proper directional alignment during movement.

### D. Security and User Interface Section

The RFID reader is used for authentication of authorized users. When a valid RFID card or tag is scanned, the system becomes active and allows trolley operation. If an invalid card is detected, the buzzer gives an alert. The display unit shows system information such as user access status, load weight, battery condition, and movement status.

### E. Motor Driving and Movement Section

The motor driver receives control signals from the ESP32 and drives two DC gear motors connected to the trolley wheels. These motors provide forward, reverse, left, and right movement based on commands from the controller. Smooth speed regulation and directional control ensure stable trolley navigation with reduced manual effort.

## VI. SYSTEM DESIGN

The Smart Tech-Trolley is designed as an intelligent automated transport system that combines sensing, processing, control, and mechanical movement. The system consists of a central microcontroller, multiple sensors, motor driving circuits, user interface modules, and a rechargeable power supply. All components are integrated to provide autonomous navigation, load monitoring, obstacle avoidance, and secure operation.



### ESP32 Microcontroller

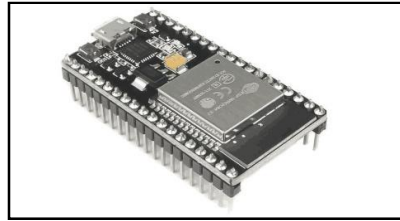


Fig 2: ESP32 Microcontroller

The ESP32 is the main processing unit of the system. It receives data from all sensors, processes the inputs, and controls output devices such as motors, display, and buzzer. It offers fast performance, low power consumption, and built-in wireless capabilities for future IoT upgrades.

### Load Cell and HX711 Module

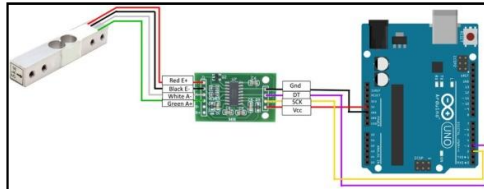


Fig 3: Load Cell and HX711 Module

The load cell is used to measure the weight placed on the trolley platform. The HX711 amplifier converts the small analog signal from the load cell into digital form so that the ESP32 can read accurate weight values. This section helps prevent overloading and ensures safe operation.

### Ultrasonic Sensor

The ultrasonic sensor is installed at the front side of the trolley for obstacle detection. It continuously measures the distance between the trolley and nearby objects. When an obstacle is detected, the controller can stop or redirect the trolley to avoid collision.

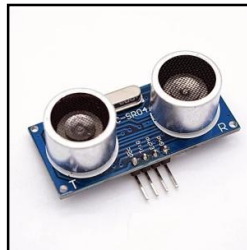


Fig 4: Ultrasonic Sensor

### IR Sensors

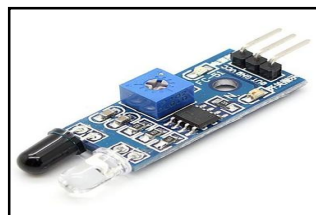


Fig 5: IR sensors



Left and right IR sensors are used for short-range object detection, line following, or side alignment. These sensors improve navigation accuracy and help the trolley move properly in narrow paths or predefined routes.

### **RFID Reader**



Fig 6: RFID reader

The RFID reader is used for user authentication and security. It reads RFID cards or tags and allows only authorized users to operate the trolley. This feature is useful in public places, industries, and restricted areas.

### **Motor Driver**

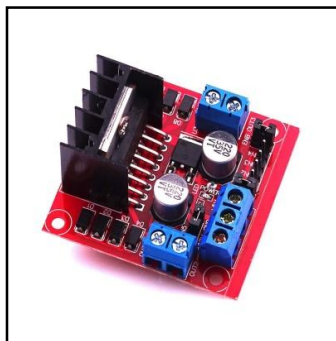


Fig 6: Motor driver

The motor driver acts as an interface between the ESP32 and DC motors. It receives low-power control signals from the controller and supplies sufficient current to drive the motors in forward, reverse, left, or right directions.

### **DC Gear Motors**



Fig 7: DC gear motors



Two DC gear motors are connected to the wheels of the trolley for movement. These motors provide high torque at low speed, making them suitable for carrying loads smoothly and efficiently.

### Display Unit



Fig 8: LCD or OLED display

An LCD or OLED display is used to show system parameters such as load weight, battery level, RFID access status, and warning messages. It improves user interaction and system monitoring.

### Buzzer



Fig 9: Buzzer

The buzzer provides audio alerts during overload conditions, obstacle detection, or unauthorized access attempts. It increases safety and informs the user instantly.

### Power Supply

The system is powered by a rechargeable battery pack with voltage regulation circuits. It supplies stable power to electronic components and motors, ensuring reliable and portable operation of the Smart Tech-Trolley.

## VII. RESULTS

The developed Smart Tech-Trolley prototype was successfully fabricated and tested for basic automated movement, obstacle detection, and load carrying operations. The trolley structure was built using a lightweight plastic container mounted on a wheeled chassis with DC gear motors for smooth movement. The front-mounted ultrasonic sensor effectively detected obstacles placed in its path and helped the system stop or change direction to avoid collisions. The ESP32 controller successfully coordinated sensor inputs and motor outputs, demonstrating reliable real-time response during operation.

The prototype also showed stable mechanical balance and efficient mobility on flat indoor surfaces while carrying small loads. The integrated electronic components such as power switch, wiring modules, and control board functioned properly during testing. The trolley moved forward, reverse, and turned as programmed, proving the effectiveness of the motor driver and wheel arrangement. Overall, the experimental model validated the feasibility of developing a low-cost smart trolley system that can be further improved with RFID access, load cell monitoring, mobile app control, and advanced autonomous navigation features.



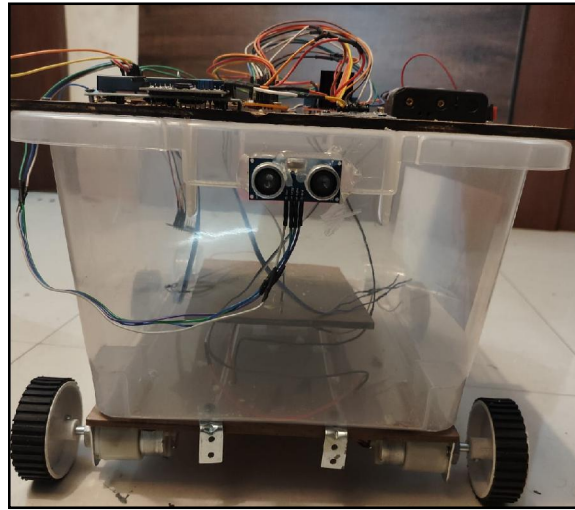


Fig 10: Model prototype

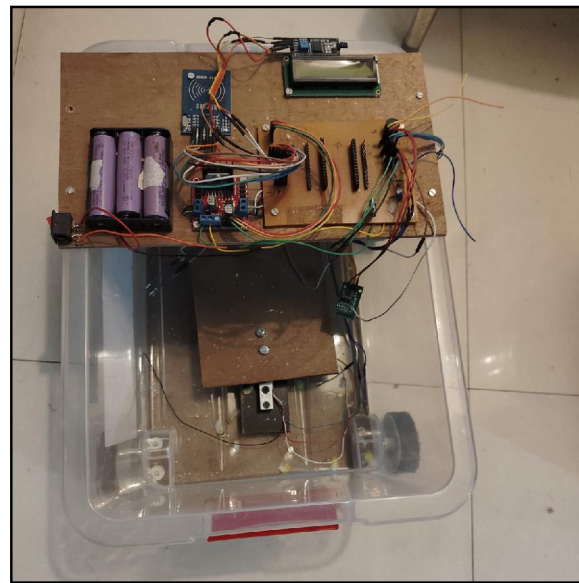


Fig 11: Model prototype top view

### VIII. CONCLUSION

The Smart Tech-Trolley was successfully designed and developed as an intelligent automated transport system that reduces manual effort and improves convenience in carrying goods. The prototype demonstrated effective movement control, obstacle detection, and stable operation using an ESP32 microcontroller, ultrasonic sensor, motor driver, and DC gear motors. The system proved capable of safe navigation and efficient load transportation in indoor environments.

The project confirms that low-cost embedded technologies can be used to create practical smart mobility solutions for shopping centers, hospitals, warehouses, airports, and domestic applications. With further enhancements such as RFID



security, load monitoring, IoT connectivity, and AI-based path planning, the Smart Tech-Trolley can become a highly advanced and user-friendly autonomous transport system for future needs.

### IX. FUTURE SCOPE

The Smart Tech-Trolley can be further enhanced by integrating advanced technologies to improve automation, efficiency, and user convenience. RFID and biometric authentication systems can be added for better security and controlled access. A load cell with digital monitoring can be installed to measure carried weight accurately and prevent overloading. Mobile application connectivity through Wi-Fi or Bluetooth using the ESP32 can enable remote control, live status monitoring, and battery updates.

Future versions may include GPS tracking, voice command operation, and AI-based autonomous navigation for smarter movement in complex environments. Solar charging systems and improved battery management can increase operating time and energy efficiency. Camera modules with computer vision can help in object recognition and path planning. With these developments, the Smart Tech-Trolley can become a fully intelligent transport assistant suitable for malls, hospitals, industries, airports, and smart city applications.

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