DESIGN AND DEVELOPMENT OF I-TROLLEY: A LOW-COST INTELLIGENT AND AUTONOMOUS TROLLEY WITH ANTI-THEFT MECHANISM

Project Reference No.: *45S_BE_2519*

College ***:*** *Dayananda Sagar College of Engineering, Bengaluru*
Branch ***:*** *Department of Electronics and Communication Engineering*
Guide(s) ***:*** *Prof. Manasa R*
Student(S) ***:*** *Mr. Prabhjot Singh*
Mr. Kartavya Raushan
Mr. Sai Nikhil Kandagiri

Keywords:
Autonomous Movement, Smart Billing, Pose-detection Model, Theft-Detection, RFID.

Introduction:

Shopping and buying are an integral part of our daily lives and Trolleys are used as tools to make shopping simpler. It is usually a tiresome process for many consumers to shop for everything while handling the trolley and then stand in long queues, just for billing of the goods purchased leading to wastage in time. However, considering the COVID situation - customers might hesitate to touch the trolley.

Our Project "*Design and Development: A Low-Cost Intelligent Autonomous Trolley with Anti-Theft Mechanism*" - presents a design for an autonomously powered trolley, which will follow the user throughout the shopping, thereby reducing the effort required by the customer to move the trolley & incorporates smart billing along with theft detection, eliminating the need to stand in a billing counter. This aims to reduce the total waiting time of customers, lower the total staff requirements and expenses for supermarkets as well as provide contactless billing process to the customer.

To summarize the working, the customer scans a QR code on the trolley from the Smartphone App, which uniquely identifies the trolley and a communication is established over Bluetooth between the trolley and the App. After capturing an image of the customer, the trolley can identify the human silhouette and can start following the customer. Using a RFID scanner on the trolley, the items are scanned & billed concurrently in the Smartphone App. If a customer/meddler removes/adds a certain item from/to the trolley without scanning, a Vibration along with an alert is displayed on the app, to indicate tamper/theft. The customer can finally Checkout using any Digital payment method to pay for the billed amount.

Objectives:

- To design and develop Intelligent Autonomous Human following mechanism using Computer Vision and Ultrasonic Sensors.
- To minimize the billing time in supermarkets using "Smart Trolley" with implementation of RFID scanners enabling auto-checkout, suitable for Old Aged, Pregnant Women and the Disabled.

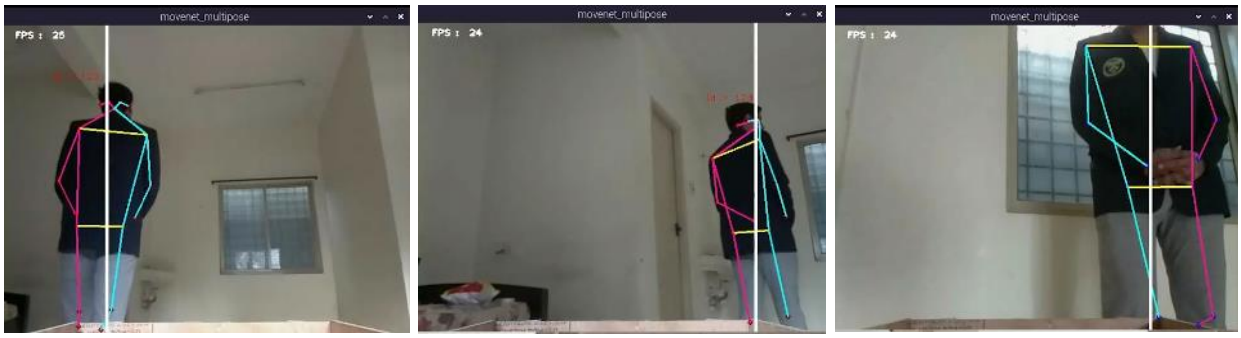
- To install anti-theft mechanism to eliminate tamper/theft from the Smart Trolley (integrated in the smartphone App).
- Designed a Smartphone application that responsible for the Smart Billing & Theft-detection.

Methodology:

Materials Used Design & Development

The Trolley prototype was made using plywood-sheets and equipped with the following components – Ultrasonic Sensors, 12V DC Motor (60RPM), Servo (Steering), Power Distribution Board (Buck Converter, Motor Driver, and extensions), ESP-32 DevkitV1 Microcontroller, MFRC522 RFID Scanner cum writer (13.56 MHz), Load Cell (10Kg), Raspberry Pi 4 Model B (4 GB) & Raspberry Pi Cam (5 MP). A Flutter Smartphone app was developed from scratch, exclusively for Smart Billing and Theft Detection and is used to connect to the Trolley's ESP32 MCU.

For Autonomous following of the trolley, a TensorFlow Lite Model - 'Pose Estimation Model' has been used to detect the user's Silhouette. This model has been chosen as it best outlines the crucial landmark features of the human body accurately (all sides) and is a decent performer for use on Raspberry Pi.



The Model detecting the person in Back view, Side view and Front View.

This data is used to steer the trolley to keep the person centered. When no person of interest is detected on the frame of the camera, the trolley detects everything as an obstacle and by using one the left and right ultrasonic sensors, avoids any obstacle while moving.

The Smart Billing is accomplished by using RFID Technology, maintained by the ESP32 MCU. Since the ESP32 powers and communicates with RFID Module & Load Cell directly, the communication between smartphone App and ESP32 is handled using BLE (Bluetooth Low Energy) on the SoC. Whenever 'RFID Tags are read', the *ProductID* is sent along with the simultaneous values of load sensor readings over a single Bluetooth Service with two separate Bluetooth Characteristics, for Tag Data and Load Cell Reading.

For our project, RFID Cards are used which are written manually with a unique *ProductID* as the data, for each product. When the RFID Tag-affixed products, are scanned on the RFID Reader, the data is sent to the app. The app processes this *ProductID* data to add / remove the product in cart and calculates the total bill thereafter. For Theft Detection, Load Cell readings are constantly being sent over the channel are processed and detect any changes in weight. This enables us to quickly detect any changes in weight (increase/decrease) and alert immediately on the Smartphone app with a continuous

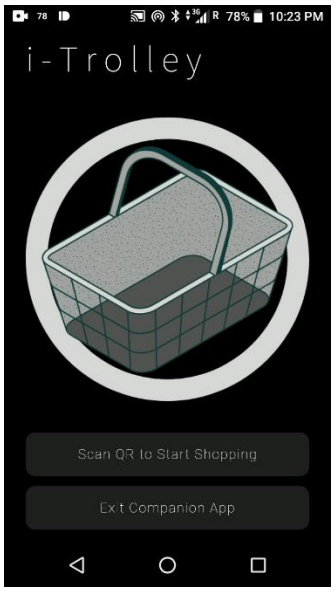
Vibration and a short message and prevents any attempts at tampering / theft by any meddler.

Results and conclusion:

The cart has been successfully designed, developed and fabricated and the following objectives are successfully met:

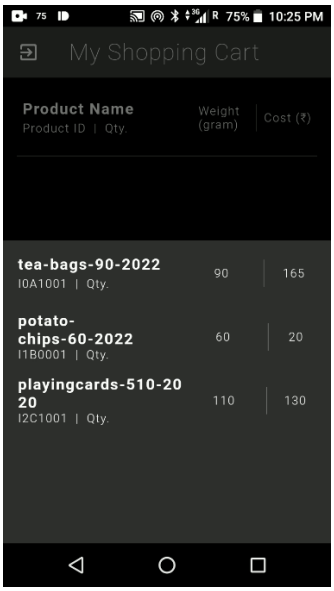
- Autonomously following the user and maintaining a safe margin of distance.
- Proper working of anti-theft detection and warning the users of any tampering attempts.
- Cohesive, simple and smart billing of products.

iTrolley app and its salient feature:

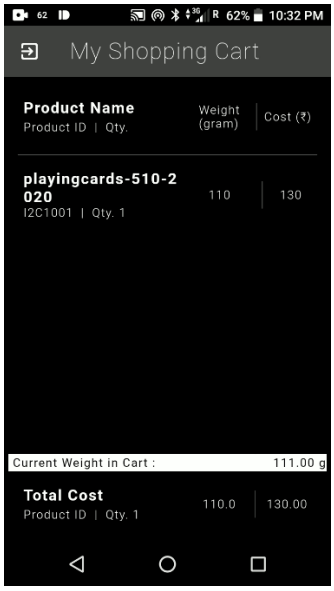


Home Screen

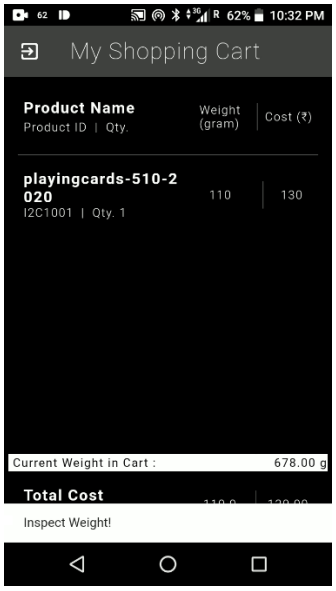
QR Scanning Page



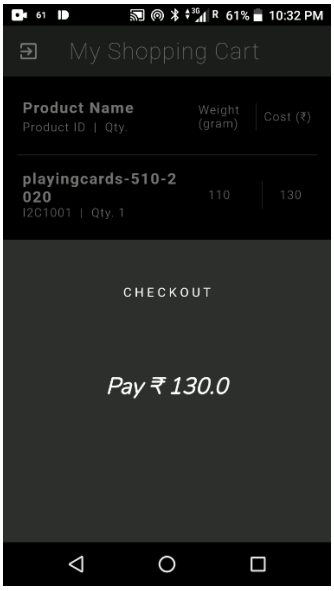
Backroom Products



Current List (Normal)



Weight Abnormality Detected



Checkout Screen

Our Autonomous trolley can aid Old People, Pregnant Women, people with limited ability and more, to shop in an effortless manner with the trolley autonomously following the User. The customer could save time in the billing process and be provided safe and secure

billing using the Smart Billing System. The Anti-Theft mechanism, ensures nothing is stolen from the trolley or added without information. According to the literature survey, although many Smart Trolley Designs have been made, Implementation hasn't been done in a large scale available to public and none provide a more cohesive environment for User interaction as our project. We believe that with further improvements and research, our design is cheap enough and efficient for mass production and implementation in industries.

Future Scope:

Future Scope of the Project is expected but not limited to the following features:

The App could be integrated with actual Digital Payment Gateways and APIs with multiple options to pay. A quick payment method using the supermarket's loyalty points could also be implemented. Further, the autonomous following part could be improvised by being able to detect non-User persons as obstacles, this could be achieved by using on-the-spot Training of model on the User's Image such that the autonomous following becomes more accurate and gives less false-positives. The algorithm and model could also be optimized to run faster on ARM-based processors. With further improvements to the infrastructure of the Supermarket, the trolley could be configured to follow the user to their vehicles after shopping, if required and restack at a Station. Finally, the design used in the project could be compacted, scaled and modularised to retro-fit on existing trollies.