SMARTCART

1 Overview

The Smart Cart is a system intended at augmenting the shopping experience by means of automated billing, tracking of items in real time, and engaging the user through gesture control and sensor feedback. Hence, it looks to cut down on checkout time, enhance customer convenience, and smartly manage stores' inventories and security. RFID, load cells, gesture sensors, and real-time communication are integrated via ESP32, ensuring a magnificent shopping experience by speeding and streamlining the whole process.

Besides the checkout process, the Smart Cart can also detect theft, avoid obstacles, and monitor temperature levels for perishable items. With gesture controls, real-time feedback offers an interactive, hygienic, and safe shopping ambient for patrons, as well as retailers.

2 Features

- Automated billing based on RFID technology.
- Live checks regarding weight measurement through load cells.
- Gesture-based user interfacing using APDS9960 sensor.
- Detection of obstacles and prevention of tower tipping.
- Feedback to users from an LCD and LED matrix.
- Speeding and Tipped over cart detection for Suspicious behavior.
- Color sense aisle identification.
- Hall effect exit security detection.
- Interlocked temperature observation and overheating shut-off.
- Notifies possible theft with ESP32 Wi-Fi Chip communication.
- Suspicious behavior detected with a solenoid lock, locking the wheel and stopping theft.

3   Technical Specification

Unit	Value
Power Supply Voltage	28.8V
Current Consumption (avg)	1.2 A
Dimensions (approx)	300mm × 250mm × 200mm
Weight	10560g
Temperature Range	-10 to 70°C
Number of Inputs	12
Signal Voltage Range	3.3V - 5V

4   Sensors

Sensor	Type	Pins	Range/Notes
RFID (MFRC522)	Digital	53 (SS), 49 (RST)	Detects item UID tags
Load Cell (HX711)	Analog	26 (DT), 27 (SCK)	Measures item weight
Gesture (APDS9960)	I2C	Default (Wire)	Up, Down, Left, Right
Hall Sensor	Digital	23	Exit gate detection
Accelerometer/Gyro (MPU6050)	I2C	21 (SDA), 22 (SCL)	Detects motion and tilt for cart stability
IR Sensor	Digital	3	Presence detection
Ultrasonic Sensors	Digital	30 (Trig), 31-33 (Echo)	Obstacle detection
Color Sensor (TCS3200)	Digital	10, 11, 37, 41, 39	Aisle color detection
Temperature (DS18B20)	OneWire	2	Ambient temperature monitoring

5   Thresholds

Sensor	Threshold
Temperature (DS18B20)	30°C (Overheat alert)
Weight (Load Cell)	±0.02kg
Color Stability	3 consecutive matches
Acceleration	$< 0.8 m/s^2$
Angle Tipping	> 30 degrees
Obstacle Distance	<10cm

6 Characteristics

Characteristic	Value
Accuracy (RFID + Weight)	91%
Response Time	<1s
Gesture Recognition Accuracy	~78%
Calibrated Color Sensor Accuracy	~95%
Uncertainty	5%
Repeatability	96%
Precision	95%
Reproducibility	94%
Wireless Communication (MQTT)	QoS 0

7 References

- MFRC522 RFID Module: R. Santos, "MFRC522 RFID Reader with Arduino Tutorial," Random Nerd Tutorials, Mar. 23, 2016. [Online]. Available: https://randomnerdtutor com/security-access-using-mfrc522-rfi

- APDS9960 Gesture Sensor: "SparkFun RGB and Gesture Sensor - APDS-9960 - SEN-12787," SparkFun Electronics. [Online]. Available: https://www.sparkfun.com/products/12787

- HX711 Load Cell Amplifier: "Arduino with Load Cell and HX711 Amplifier (Digital Scale)," Random Nerd Tutorials, Apr. 27, 2022. [Online]. Available: https://randomnerdtutorials.com/arduino-load-cell-hx711/

- DS18B20 Temp Sensor: R. Santos, "Guide for DS18B20 Temperature Sensor with Arduino," Random Nerd Tutorials, Jul. 2, 2019. [Online]. Available: https://randomnerdtutorials.com/guide-for-ds18b20-temperature-sens

- LED Matrix: Using 8x8 Dot Matrix LED with Arduino & Its Cascade Connection [Tutorial], Electropeak, Apr. 22, 2019. [Online]. Available: https://electropeak.com/learn/using-8x8-dot-matrix-led-arduino-cascade-connection/?srsltid=AfmBOorRMy5fdbX mQM9Knz3eGKbQdpsclpxXBdcQUcL7P_ljR2BsGA7

- TCS3200 Color Sensor: S. Santos, "Arduino Color Sensor TCS230 TCS3200," Random Nerd Tutorials, Apr. 25, 2017. [Online]. Available: https://randomnerdtutorials.com/arduino-color-sensor-tcs230-tcs3200

- ESP-32 Adafruit Espressif: A. Industries, "Espressif ESP32 Development Board - Developer Edition," Adafruit. [Online]. Available: https://www.adafruit.com/product/3269

- MQTT and Mosquitto Broker: Eclipse Foundation, "Eclipse Mosquitto," Eclipse Mosquitto, Jan. 8, 2018. [Online]. Available: https://mosquitto.org/

8   Work Division

- Mazen Abou Said: Overview and Thresholds
- Rawan El Hakim: Sensors and Characteristics
- Hadi Elham: Features and Hardware connections
- Amjad Khaddaj: Handled accelerometer and Gyroscope in each section
- Tia Tarabay: Technical Specifications and References