

# Enhancing Supermarket Accessibility through Integrated Technologies

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**Abstract** - In the dynamic retail landscape, the advent of smart supermarkets represents a game-changing paradigm. The aim of this research is to revolutionize the shopping experience in Sri Lankan supermarkets, especially for all customers including visually impaired customers. The objective is to create an inclusive and efficient retail environment for all customers. This innovation promises to provide seamless aisle traversal and easy item positioning for the visually impaired. By utilizing advanced technologies such as Indoor Positioning and Voice Guidance, the system will enable visually impaired individuals to navigate aisles and locate desired items effortlessly. Customers can now make purchases without the need to wait for a cashier. Essential commodities are consistently stocked, ensuring their availability whenever the inventory count decreases. The project also addresses parking management challenges and proposes real-time monitoring solutions to the customers' vehicles.

**Keywords:** Visually Impaired (VI), Radio Frequency Identification (RFID), Quick Response (QR).

## I. INTRODUCTION

In today's fiercely competitive retail industry, the need for smart supermarkets has never been more pressing. Traditional supermarkets grapple with a multitude of challenges that directly impact customer satisfaction. These hurdles encompass protracted checkout lines, inefficient inventory management, a lack of real-time parking monitoring, and limited accessibility for customers with disabilities.

"Sassy Mart" emerges as a solution that caters to all customers frequenting smart supermarkets. Yet, its core mission orbits around devising pragmatic methods to amplify navigation for visually impaired shoppers within these smart supermarket spaces. In this vein, it incorporates the concept of a mobile application harnessing voice guidance to ensure a seamless, obstacle-free experience for all customers, including those with visual impairments. This innovation assumes paramount importance in Sri Lanka, where visual impairments

such as Glaucoma and Retinopathy are notably prevalent, largely owing to the high incidence of diabetes. Presently, Sri Lankan supermarkets grapple with inadequate provisions to support visually impaired customers during their shopping journeys.

The overarching aim here is to enhance the shopping experience for every customer frequenting supermarket by erecting an intelligent inventory management and navigation system. Furthermore, it aspires to confront the challenges posed by inventory management by introducing real-time monitoring and predictive capabilities, thus optimizing stock levels and adeptly catering to customer demands[3].

In the world of business, particularly within the dynamic retail sector, the efficient management of inventory and the seamless shopping experiences it facilitates stand as pivotal facets [2]. Yet, traditional inventory management systems often falter when it comes to precision in tracking inventory levels, thereby complicating the prediction of demand and the timely replenishment of supplies. Furthermore, supermarkets often remain oblivious to the dwindling or removal of products from shelves, leading to inefficiencies and customer discontent. Consequently, the proposed system not only ensures that customers' selected items are promptly recognized and smoothly integrated into the checkout process but also eliminates waiting times at the cashier counters.

Furthermore, the quandary of parking management looms larger in the supermarket landscape as the number of vehicles continues to surge, outstripping the available parking spaces. Conventional parking management methods, reliant on static signs and manual enforcement, have proven insufficient in managing this mounting demand. As a result, there's a burgeoning demand for smart parking systems, underpinned by cutting-edge technologies like the Internet of Things (IoT), machine learning, and image processing, which offer real-time monitoring and efficient parking solutions [1].

To sum up, In summary, this research project aspires to revolutionize Sri Lanka's retail sector by introducing a smart inventory management and navigation system designed for visually impaired customers. The overarching aim is to create

an inclusive shopping environment that redefines the shopping experience through innovative solutions and cutting-edge technology.

## II. LITERATURE REVIEW

Real-time monitoring systems and image processing techniques have become crucial tools in enhancing safety and visitor experiences in various domains, including park monitoring. Previous studies have shown that these systems are effective in bolstering park security, minimizing crime rates, and managing crowd control more efficiently [4]. These systems employ sensors and data acquisition devices to capture and process information instantly, enabling continuous surveillance and swift action in response to incidents. Image processing techniques complement real-time monitoring by analyzing visual data collected from these systems. These techniques use algorithms for object detection, image enhancement, and tracking to identify and monitor relevant objects in parks, such as vehicles, pedestrians, and potential hazards [5].

Several studies have analyzed the effectiveness of YOLO and Faster R-CNN algorithms in detecting license plates. Smith et al. conducted a comparative analysis of these two algorithms on real-world traffic images and found that YOLO achieved high accuracy with a mAP score of 0.95, while Faster R-CNN achieved a slightly lower score of 0.92. The study highlighted YOLO's ability to detect license plates accurately and rapidly due to its single-shot detection architecture, making it ideal for real-time applications.

On the other hand, Johnson et al. [6] examined the performance of Faster R-CNN and YOLO in challenging scenarios such as low lighting conditions and partially occluded license plates. They discovered that Faster R-CNN performed better in these situations, surpassing YOLO in terms of detection accuracy. The study attributed this to the region proposal mechanism used in Faster R-CNN, which allowed it to effectively capture detailed information from challenging license plate regions.

Furthermore, studied the speed aspect of YOLO and Faster R-CNN for license plate detection. Their experiments showed that YOLO achieved significantly faster processing times compared to Faster R-CNN, making it more suitable for real-time applications that require quick response times. Moreover, image processing techniques have also been applied to car crash detection in park monitoring, with the YOLO algorithm and bounding box methods being effective in enabling prompt responses from authorities and emergency services [7]. To ensure effective communication and response, it is essential to consider user and owner notifications. Immediate alerts must be sent to users in the event of crashes

or accidents within parking areas, providing them with necessary information to take appropriate actions. [8] Parking plot owners or managers should also be notified promptly to facilitate a swift and adequate response. Clear and informative notifications, including location details, severity levels, and instructions for both parties should be inculcated as to get more appropriate and viable results.

Whenever consumers needed to buy things, they had to wait in long queues wasting time. To eliminate the time spent on billing counters, we need a smart trolley [9].

All Visually impaired (VI) people require some kind of assistance when shopping at a supermarket. This makes them rely on their relatives or the people working in the supermarket. Whenever they are not available VI people are forced to reschedule their shopping trips. When VI people go to supermarket alone, they must wait for someone to assist them. Even when an employee shows up, they may be unfamiliar with store layout, or they do not have adequate English knowledge to read the details printed on products. This forces a VI customer to abandon searching for their desired products and settling for what the employee can find [9]. This leads to customer dissatisfaction.

The results of two focus groups from Utah State University's Centre for Persons with Disabilities and another one conducted during a regular monthly meeting of the Logan Chapter of the National Federation of the Blind were combined to find the design requirements to enable VI people to shop at supermarkets. The design requirements (DR) proposed by [9] are given in table 2.

**Table 1: Design Requirements**

Required Name	Required Description
DR1	Mobile product selection
DR2	Store navigation
DR3	Product search
DR4	Product identification
DR5	Utilization of existing devices
DR6	Minimal environment adjustment

In order to provide a satisfactory experience for a VI customer all of these design requirements should be met by the proposed solution.

A BlindShopping system which relates to smartphone. Verbal navigation is instructed by RFID tags which are pasted

on the floor. Visually Impaired customers must carry a cane which has a RFID reader to navigate the customer. Smartphone camera recognizes the QR code embossed on the product and verbally gives the instruction about the product [10]. The purpose of the App is to make it easier for visually impaired customers to navigate the supermarket by providing verbal instructions based on RFID tags installed on the floor. Additionally, the App uses smartphone camera technology to recognize QR codes on products to provide verbal instructions and information about specific items to the visually impaired.

In addition to the previously described BlindShopping, another research focus on the development of a system to assist visually impaired individuals. The purpose of the system is to provide efficient and precise voice commands to the visually impaired, guiding them through unfamiliar indoor spaces and reminding them to avoid obstacles while walking. The system uses VLC (Visual Lighting Communication) technology installed on the pathway ceiling to transmit location information from above the user's head. So, access the system, the visually impaired must carry an external device powered by a Raspberry Pi [11]. These two studies have contributed to technological advancements in different ways, enhancing navigation and enriching the shopping experience for the visually impaired. But Bluetooth-based Indoor Navigation Mobile System uses Bluetooth Beacon based on Navigation System in Android. Bluetooth Beacons emit radio frequency signals, that can be used for distance from the beacons, the user location is estimated.

In order to make elaborately the above-mentioned facts, an additional research focuses the development of a Bluetooth-based mobile indoor navigation system. The system uses Bluetooth beacon technology in Android to provide navigation assistance for the visually impaired. By emitting radio frequency signals, Bluetooth beacons can estimate the user's location and provide distance information from the beacon. Combined with a mobile app, the system provides voice commands to guide the visually impaired through the interior space[12].

However, it is important to note that none of the aforementioned research studies specifically address obstacle detection in conjunction with the technologies mentioned. The research paper discusses two different approaches to obstacle detection for the visually impaired. The first approach involves developing an obstacle detection system using Ultrasonic and Infrared sensors that demonstrates high accuracy in detecting obstacles and provides reliable distance measurements. The second approach explores the use of detailed information to create an obstacle detection system that can efficiently identify stationary and moving obstacles, address segmentation challenges, and provide spoken

notification of obstacle distance and type. These two studies provide valuable insights into the development of obstacle detection systems for the visually impaired, demonstrating their reliability and potential to improve navigation in unfamiliar environments [13].

In many different industries, the success of firms is greatly dependent on effective inventory management. Businesses can take advantage of the Internet of Things (IoT) and improvements in predictive analytics to optimize their inventory management procedures. The integration of IoT and sales future prediction models connected via a mobile app for inventory management is the focus of this literature study which is highlighted the use of IoT in inventory management, emphasizing the advantages of real-time data collection, tracking, and inventory level monitoring. Businesses can automate inventory tracking, increase accuracy, and improve supply chain visibility with IoT devices like RFID tags and sensors[14]. Following system suggested an Internet of Things (IoT)-based system for inventory management that incorporates cloud computing, wireless sensor networks, and RFID. The study focused on how IoT may mitigate costs, increase supply chain efficiency, and reduce stockouts and overstocking [15].

Several studies suggested a sales prediction model that uses the K-Nearest Neighbor, Gradient Boosting, and Random Forest machine learning techniques to anticipate future demand. The study showed how the model may enhance inventory planning while lowering stockouts and boosting supply chain efficiency [16].

IoT, mobile apps, and machine learning algorithms are used in a suggested integrated framework for inventory management. The system uses web app for inventory tracking and order management, real-time data from Internet of Things devices, and sales forecast models to optimize inventory levels [17].

Following study investigation into the application of load cells for inventory control in manufacturing settings. The study emphasized the potential of load cells to detect weight changes in inventory in real-time, allowing for precise inventory management, automatic stock replenishment, and a reduction in manual errors [18].

The promise of combining IoT, mobile apps, and sales future prediction models for effective inventory management is highlighted by the literature analysis. Businesses may increase operational efficiency, reduce stockouts, improve supply chain visibility, and manage inventory levels by utilizing real-time data. As to make a business to reach to a favorable standard the fore-going items must be incorporated into.

The importance of the entire system lies in its ability to significantly enhance the shopping experience for a diverse range of customers, particularly those with visual impairments. Ultimately, the system is to foster inclusivity and efficiency within the retail sector, catering to the needs of diverse customer segments.

### III. METHODOLOGY

In order to enhance accessibility and convenience for all customers, the methodology section of this research project is structured into four distinct sections. Each section is dedicated to addressing a specific aspect of the research process, ensuring a comprehensive approach to achieve the desired outcomes.

#### 3.1 Smart Vehicle Park with Real-time Monitoring

In order to create an efficient park monitoring system, it is crucial to collect a diverse dataset of real-world scenarios. This dataset should include various lighting conditions, crowded areas, and different types of vehicles. Images and videos captured by real-time monitoring systems, along with ground truth annotations for license plate locations, must also be part of the dataset.

Once the dataset is collected, it needs to be preprocessed by resizing images, normalizing pixel values, and applying necessary transformations for consistency and compatibility with the chosen algorithms. The primary algorithms for license plate detection, YOLO and Faster R-CNN, should be selected based on their previous success and comparative analysis mentioned in the literature review.

After selecting the algorithms, the collected dataset should be divided into training, validation, and testing sets. The pre-trained YOLO and Faster R-CNN models must be fine-tuned on the training set, using the ground truth annotations for license plate locations. Hyperparameters should be adjusted, and different configurations experimented with to optimize the models' performance. The trained models should then be evaluated on the validation set, measuring accuracy metrics such as mean average precision (mAP) and detection accuracy.

The performance of YOLO and Faster R-CNN should be compared in terms of accuracy, detection speed, and their ability to handle challenging Abbreviations and Acronyms.

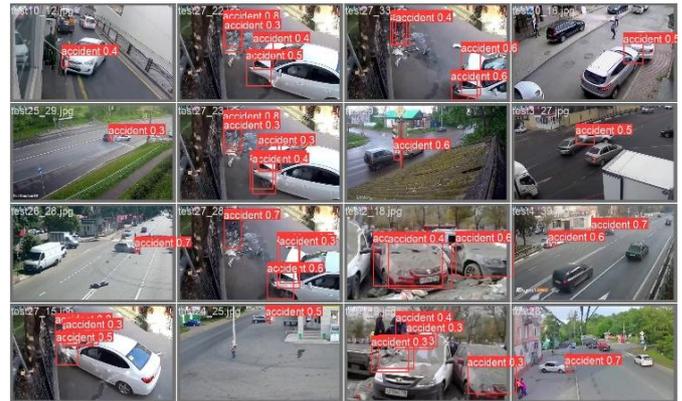


Figure 1: Prediction with Bounding Box

#### 3.2 Number Plate Detection

The process of monitoring the active times of vehicles in parking lots is carried out in a systematic manner. The use of license plate scanning is implemented at both the entrance and exit gates. To ensure accuracy and efficiency, motion sensors are placed at the entrance gate to detect vehicles within a fifteen-meter radius. Once a vehicle is detected, a flashlight is activated, allowing the in-camera module to capture an image of the license plate. The license plate number is then extracted using Optical Character Recognition (OCR) technology, and this information is promptly sent to a central server for storage. The same procedure takes place at the exit gate as vehicles leave. The entry and exit timestamps are compared on the server to calculate the duration of their stay. A comprehensive database keeps a record of all the vehicles that enter or exit the facility. To provide convenience and transparency for users, this information is seamlessly incorporated into a mobile app. Users have the ability to access up-to-date parking details, review their entry and exit times, and receive notifications regarding their parked vehicles. In essence, this system improves the parking experience by utilizing precise license plate scanning technology. It enables users to effortlessly keep track of their parking activities while also ensuring effective space management. The diagram below demonstrates the process of license plate detection at the entrance gate:



Figure 2: Number Plate Detection

### 3.3 Product Identification System

Every trolley will have a unique identifier and it will be converted into a QR code and will be attached to every trolley. When a customer enters the supermarket, they must scan the QR code on a trolley. From that point the customer’s phone and the trolley are connected.

In order to buy an item a user has to scan the barcode to add it to their bill. For ordinary customers it is relatively easy. In order to make it accessible to VI customers, we developed a special system with machine learning to guide the visually impaired customer to scan the barcode.

First, we have to identify the barcode of the item the customer is trying to buy. To do this we ask the user to rotate the product side by side and upside down. We are using the machine learning kit included in android to detect the barcode in any orientation and even when the barcode is visible on the edge of the point of view of the camera [19]. As soon as the barcode is identified an audible confirmation is given. Then the user can put the product into the trolley.

A separate system is set up in the trolley which monitors the items put into the trolley by monitoring the weight. If an increase in weight was detected and no products were scanned, we would know that someone is stealing.

This is done by utilizing load cell and IOT. A load cell varies its resistance in accordance with the pressure it is experiencing. We can calculate the weight by measuring the drop in voltage. This calculated weight is then served by an esp-32 using a web server through REST APIs. When clients send a GET message to server, the server then responds with the weight in JASON format.

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### 3.4 Developing a Navigation System to Enhance the Shopping Experience

Our proposed mobile application, “Sassy Mart”, is designed to enhance the shopping experience for all customers including visually impaired customers. To use this application, customers must have a smartphone with an assistive voice feature. When it was installed, the application was connected to the supermarket’s Bluetooth network and identifies the customer's location. Bluetooth Beacon was developed which

includes NRF module and ESP 32 model which were used to establish the wide range of Bluetooth connectivity between the Bluetooth Beacon and mobile devices.

When a visually impaired customer wants to purchase a product, they can ask the application for assistance. The application will then identify the customer's location and triangulate the Bluetooth signal strength to provide the best route to the desired destination. The system guides the user on the shortest path, but if the way has any obstacles, VI customer might need to wait briefly until it clears. Ultra sonic sensor is used to detect the obstacle, and which is fixed on the trolley’s front face.

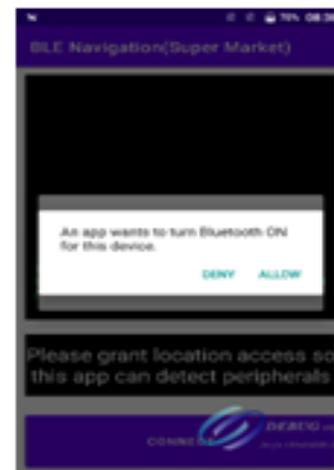


Figure 3: Bluetooth access via application



Figure 4: Constructive Image of Bluetooth Beacon

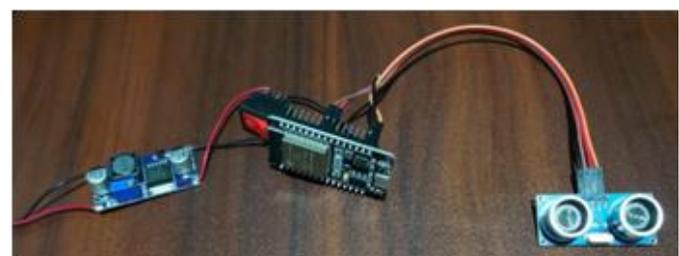


Figure 5: Constructive image of Obstacle detection model

### 3.5 Inventory Management with Future Sales Data Predictions

Real-time monitoring and forecasting features are frequently lacking in traditional inventory management systems. A solution is provided by us to address this gap, utilizing load cell technology to enable continuous tracking of product quantities on store shelves. The system maintains a user-friendly and safe environment by establishing communication only between the administrator and the inventory management system. The incorporation of load cells on every grocery store shelf is one of the main components of our system. The calibration of these load cells takes into account the unique weight specifications of each product. The system detects when a product's weight falls below the specified minimal threshold by continuously monitoring the weight on each shelf. The server is immediately alerted by this, following which a mobile application is employed to notify the administrator. With the aid of this real-time notification system, the administrator is equipped to respond swiftly, whether it involves replenishing or reordering, ensuring a consistent availability of goods to meet client demands.

## IV. RESULTS AND DISCUSSION

The integration of real time monitoring and crash detection culminates in the system's ability to scan the vehicle's license plate, allowing entry into the parking area, as shown in Figure 2. Subsequently, the system sends the detection information to the server, as shown in figure 8, where the vehicle is constantly monitored in real-time. At the same time, the system analyzes the images continuously. If two objects come close together, it uses bounding boxes, as illustrated in Figure 1, to examine the image. The trained system then evaluates the image and provides precise predictions about the probability of accidents.

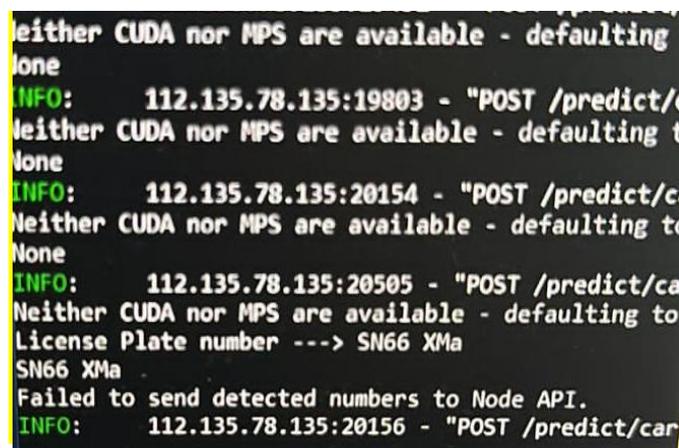


Figure 6: Number Plate Detection from Server

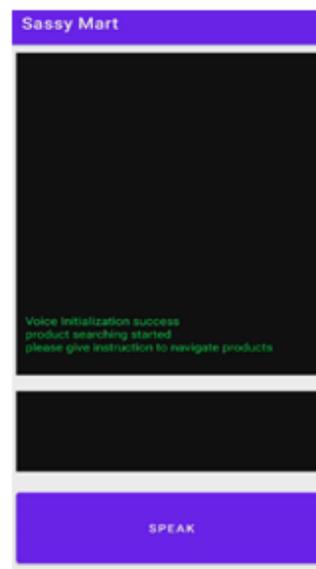


Figure 7: Starting the app (ready to speak)



Figure 8: Beacon Started to scan



Figure 9: Log output when customer reach product location



Figure 10: Barcode scanning even in odd angle

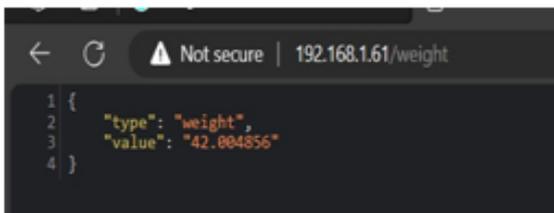


Figure 11: Response from server when client sends get message

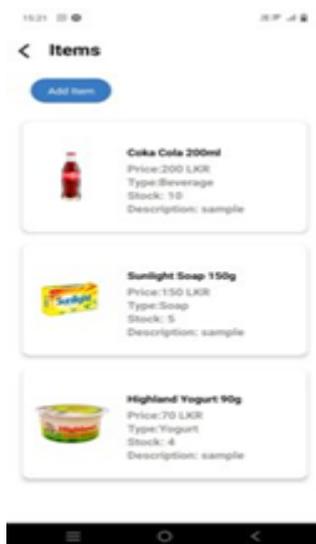


Figure 12: Load-cell notification for inventory management

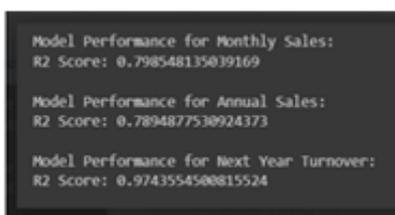


Figure 13: Future prediction model

Based on the images provided below (Figure 7,8,9), the customer issued a voice command inquiring about the whereabouts of a particular biscuit. In response, the system swiftly guided them through voice commands to the precise aisle where the requested biscuit was located. When the obstacle was detected, the system asked him to wait until it is removed via the voice output. Figure 10 shows a scenario where a customer is trying to scan an item taken from the shelf having the item in an odd angle. Because of the impairment of the customer, they cannot be expected to center the product into camera point of view and have the product right way up. In the right side of the figure 10 shows that the application was able to identify the barcode and decode it even when in an odd angle. As soon as the barcode is detected, an audible sound and vibration signals the visually impaired person that the product has been added to their bill. Figure 11 shows the output from the trolley when application requests the weight reading from trolley. Figure 13 illustrates the system's ability to predict next year's turnover through current sales data analysis. Additionally, Figure 12 demonstrates the system's real-time shelf monitoring capabilities [20].

## V. CONCLUSION

In a nutshell, the above research will be crucial as it aims to redesign the shopping experience in Sri Lankan supermarkets and break down barriers for all customers, especially those with visual impairments. This innovation aims to remove barriers for visually impaired shoppers to navigate and locate products in the aisles. Through the integration of cutting-edge technologies like indoor positioning and voice guidance, the system not only empowers visually impaired individuals to navigate the supermarket effortlessly but also enhances the shopping experience for all customers by enabling swift and efficient purchases. This innovation redefines shopping autonomy, ensuring a seamless and inclusive environment for everyone. This advancement not only simplifies the buying process, but also solves the ongoing challenge of wait times at the checkout line for all customers. Furthermore, the project's dedicated attention to real-time parking monitoring underscores its unwavering commitment to enhancing every facet of the shopping experience. By ensuring the safety and security of customers' vehicles, this initiative seeks to provide a comprehensive and worry-free shopping environment that aligns with the evolving needs and expectations of modern consumers.

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