Smart Cabinet: Efficient Inventory Management

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***Abstract*— Inventory management plays a crucial part for small and large-scale businesses as well as household groceries. Managing this inventory helps to optimize the stocks which plays a big role in supply chain management for various businesses. Most of the time, unexpectedly people may fall short of the things they need the most. This issue can be solved by the smart cabinets. They are one of the efficient and standardized solutions for managing the stocks of the products. This system incorporates a number of technologies to improve user engagement and inventory management. This paper gives an overview of the design and implementation of a smart cabinet using ESP32, a barcode scanner, an ultrasonic sensor, Alexa and Google Scripts. This conception and execution serve as an excellent example of how many technologies may be seamlessly combined to produce a clever and user-friendly solution for effective inventory management. The presented methodology addresses issues such as keeping real-time availability and track of the supplies, utilizing shelve space effectively and reduces manual error.**

***Index Terms*— Smart cabinet, Alexa, ultrasonic sensor, Inventory management**

I. INTRODUCTION

Technology has evolved tremendously. With the help of IoT, embedded systems, sensors, cloud services and artificial intelligence (AI) technology we can make a huge impact in society making people's life easy [1]. Smart cabinet is one of the modern systems that combines cutting-edge technology to transform conventional storage management.

A smart cabinet has many advantages in terms of effectiveness, accuracy, and convenience due to the integration of sensors, networking features, and intelligent functionalities [2]. Managing and organizing stored items has typically been a time-consuming and error-prone procedure. Stockouts, manual inventory inspections, and ineffective space utilization have all been frequent problems for enterprises and organizations. However, the development of smart cabinets has fundamentally changed how we think about managing our storage space. In order to keep track of the things being added to or withdrawn from the cabinet, smart cabinets use sensor technologies like RFID or barcode scanning. This real-time inventory tracking reduces the possibility of errors and does away with the necessity for manual counting [3].

Through a central management system or mobile application, users can remotely access inventory data, which enables them to keep track of item locations, monitor stock levels, and get alerts when there are shortages or expiration dates. Storage space optimization is one of a smart cabinet's main benefits. Based on variables like size, frequency of usage, or other pertinent criteria, intelligent algorithms and analytics are used to advise the most effective arrangement of things within the cabinet. Businesses may lower storage costs, improve accessibility, and increase overall efficiency by making the best use of their available space.

II. LITERATURE REVIEW

R.Pavithra et al [1] in an IoT-based Smart Pantry level monitoring system have reported a system that collects data on the stock level of items in the container. The data is constantly collected, saved, and updated in the cloud. Force Sensitive Resistor (FSR) - is used in the system. The FSR is a sensor whose value changes depending on the force applied to it. The Arduino uses this sensor to calculate the weight of the stock in the container. This method allows a user to see the level of things in a container from any location. The system notifies the user if the container's level falls below the minimum weight and also sends a message to the shopkeeper to make an order for a specific item.

The main goal of the study presented in [2] by María del Carmen León-Araujo et al., was to evaluate how the implementation of a straightforward and user-friendly automated system (RFID Smart Cabinet) for the traceability and monitoring of medical supplies and products improved the information about inventory management for cardiothoracic surgeries. Examining the product traceability and consumption per patient of surgical supplies, keeping track of lots, stocks, and expiration dates, and converting from paper-based records to electronic sheets were some of the specific goals. Finally, time savings for the supervisory personnel at the Hospital Cruces resulting from the adoption of RFID were assessed in contrast to the previous non-automated logistics system.

V.Lalitha et al, [3] Describes how a smart shelf is equipped with an ultrasonic sensor to measure the distance between the shelf and the product using sound waves, which subsequently represents the amount of stock in the store application. A microprocessor is put on the shelf for data processing Android applications, using this android application notifications are sent or received from the microcontroller. Automatic replenishment of smart shelves is possible by sending an alarm to the back-end system when the shelf runs out of products. Depending on the store's system application, the alarm is either transmitted to the backroom or to a mobile computer. Thus, the system facilitates stock inventory monitoring through the use of load sensors, an Arduino Uno, an HC-SR04, Bluetooth, and a mobile device application.

Anastasis c. Polycarpou et al. [4] has developed an intelligent Library Management System (LMS) based on Radio Frequency Identification (RFID). To enable the required library capabilities and user requirements, a Graphical User Interface (GUI) was carefully created. In order to provide limited coverage in the area around the shelf and prevent the unintentional identification of books kept on neighboring shelves, prototype smart cabinets were constructed and tested utilizing various types of near-field

shelf antennas. Human phantom models were used as a backdrop for the SAR (Specific Absorption Rate) simulations, and they were placed near to the cabinet.

Megha R. Mane et al [5] proposed an Electronic Shopping which includes a Barcode Scanner for product identification and a stable Wi-Fi connection to the shop's server. It also contains an LCD display that shows clients goods pricing, discounts, deals, and the final cost. The product is identified by the barcode reader, and the bill is updated. Following shopping, the consumer can hit the End shopping button, which sends the data to the shop's server, after which the customer can pay the money and depart.

Due to physical limitations or hectic schedules, people find it challenging to go grocery shopping. The solution provided by Muhammad Asad Khan et al.[6] enables users to view the contents of the refrigerator and cabinet online. Food waste is significantly minimized when one is aware of how much food is still in the refrigerator and cabinet. Furthermore, this technology automatically places an online purchase with the user's permission to replenish the used food items when they run out inside the refrigerator and cabinet. As a result, the proposed approach simplifies life for those who are unable to go grocery shopping. This smart refrigerator employs cameras instead of sensors like weight and IR sensors, in contrast to earlier models of comparable refrigerators. Consequently, the technology offers more accurate findings.

V. N. Prithvish, Shraddha Agrawal and John Sahaya Rani Alex [7] have reported about an intelligent IoT-based smart cart prototype consisting of a modern barcode scanner, feedback system that delivers the product weight as well as product image, a cloud-based database, and integrated hardware to link the above. The technique allows the customer to add and remove things while shopping, as well as instantly updating the bill and reflecting changes in inventory. The framework includes a cloud-based inventory to make management easier for the owner. Further emphasis has been placed on the right positioning of all components on a cart for the optimal operation of the business.

III. METHODOLOGY

The heart of the system is the ESP32 microcontroller. The barcode scanner, ultrasonic sensor and load cell act as an input to the microcontroller. On the other hand, the google sheets and Alexa are the outputs of the system which helps in keeping track of the space in the shelves of the cabinet and the products available, this information is available to the user on the tip of fingers. Fig 1 shown below gives an overview of the architecture of the smart cabinet.

The flowchart shown in Fig 2 effectively describes the working of the system in a chronological manner. The user can start by commanding Alexa to add a particular product which automatically starts the barcode scanner. The user then can scan the product and add it to the google sheets after fetching the product information through the barcode and sharing it with the google scripts API. The additional information regarding the product can also be added in the google sheets. The flowchart also describes the procedure followed to remove a product from the database and to enquire about the amount of space available in the cabinet.

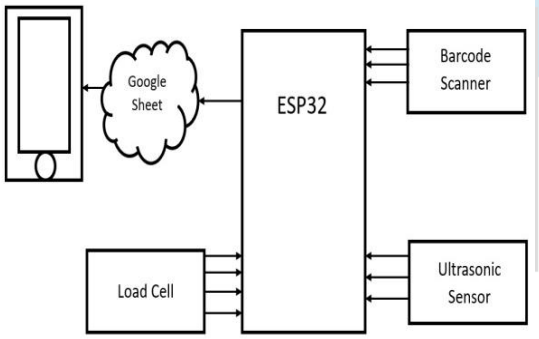


Fig.1. *Block diagram of the system*

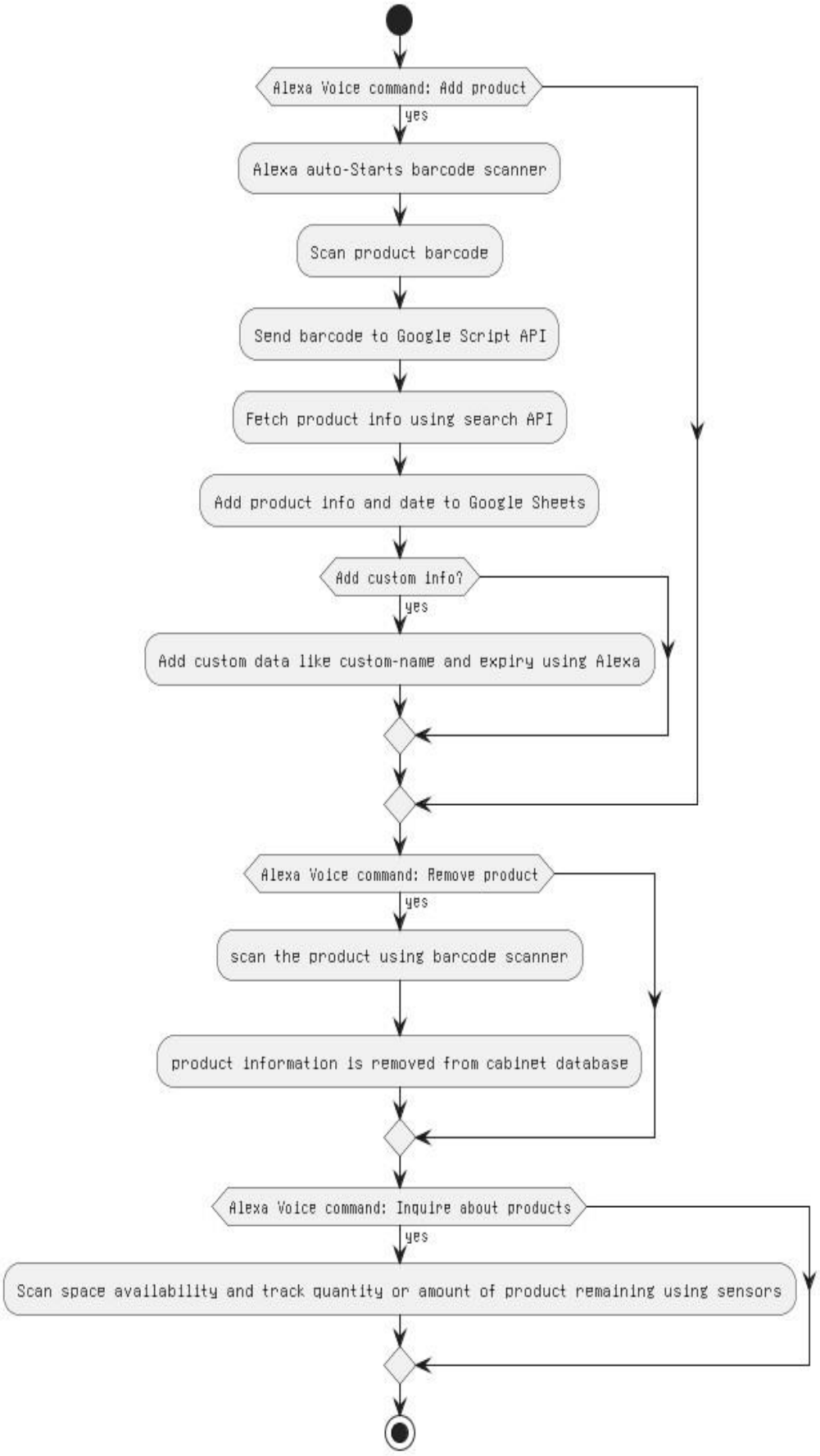


Fig.2. Operational Flowchart

Hardware Requirements:
ESP32: ESP32 allows for wireless networking and communication with other devices with integrated Bluetooth and Wi-Fi capabilities. The ESP32 has a strong ecosystem for development and is widely accessible. The ESP32 is included into the smart cabinet for better dialogue and effectiveness. Due to its adaptability, it is perfect for integrating cutting-edge features and intelligence into conventional cabinets. Its low-power characteristics help the smart cabinet system to be energy efficient.

Ultrasonic sensor: Ultrasonic sensors are used to measure the available space or find things. It is interfaced with the ESP32, to interpret the distance readings and give users the feedback. This sensor is fitted at the side wall of the cabinet as shown in Fig.6, one for each rack and readings are scaled in percentage as shown in following table 1 to monitor the space available.

Table 1 Cabinet status based on ultrasonic sensor readings

Ultrasonic sensor reading (approx)	Status of the cabinet
100%	Cabinet is full
50%	Cabinet is half full
0%	Cabinet is empty

Barcode scanner: Using a pattern of parallel lines or squares, pictorial representations of data are encoded in barcodes, which are read by a barcode scanner. A barcode scanner is used in the system to identify and monitor objects by scanning their barcodes. The barcode picture is captured by the scanner using optical technology, and the encoded data is then extracted by software once the image has been decoded. Integrated processing of the scanned data and connection with microcontrollers that is the ESP32 is made possible. The management of objects in the prototype is significantly more accurate and efficient due to barcode scanners.

Weight sensor(optional): A weight sensor, measures the force or weight applied to it. It is incorporated into the system to track and measure the amount of liquid within a container. The ESP32 microcontroller processes the electrical signal that the sensor creates from the applied force. The prototype maintains inventory levels, identifies changes in item amounts, and offers real-time updates on stock availability by weighing the goods. This data is used to monitor inventories, place new orders, or send out warnings when predetermined or liquid amount criteria are achieved. In the proposed system, weight sensors help with precise item quantity monitoring and management.

Software Requirements:
Arduino IDE: The Arduino IDE (Integrated Development Environment) software is used to create and upload code to the ESP32 microcontroller.
Google sheet: In order to manage information and to continuously monitor the inventory, Google Sheets are used as a database. It is a cloud-based spreadsheet platform that enables group input, storage, and analysis of data. It is used in the system to keep track of inventory data, track the number of items, and keep an eye on consumption. Through Product Search API which is an open-source API that allows us to scrape information from the internet. If we pass a barcode or name of the product along with the country to the API then it fetches the exact product from different ecommerce websites, this information will provide name and size weight of the product which are getting added to the google sheet. Other information like expiry date, custom name for the product, count or quantity of the product can be added manually and also using Alexa. There are different sensors and microcontrollers in the prototype that are interfaced with Google Sheets to enable automatic data entry and real-time changes. This makes it possible to manage inventories effectively, share data with ease, and view inventory data from any location with an internet connection.
Alexa: Alexa is incorporated into the proposed system to offer voice control and interaction. Users communicate with the smart cabinet via voice commands with the help of Alexa. It is used to check inventory, add products to shopping lists, get notifications and manage cabinet functionalities when Alexa is linked to the cabinet's microcontroller. The user experience is improved by the hands-free, simple interface, and makes it easy to use natural language commands to conveniently manage the smart cabinet. “Alexa skills” is used to make Alexa work with our custom commands. Blynk IoT cloud APIs and variables are used to make logic for integrating Alexa with microcontroller. The variables on the Blynk cloud are continuously getting monitored by the microcontroller using Blynk API. When a user says a command to Alexa which is associated with communicating with hardware, a variable on the Blynk cloud is set from 0 to 1 for this changes API request is sent from backend server of Alexa which is coded in python, as soon as this change is detected by hardware, it starts the hardware, takes the reading from sensors based on users command and send it to google sheets using google script API or send it to the Blynk cloud and from there again send it to the Alexa using Blynk cloud APIs and then Alexa shows this data coming from hardware to the user. Similarly, Alexa fetches information from google sheets using google script APIs.

Google scripts: Google Scripts is used in the system to automate processes and improve functionality. To link the data from the cabinet with Google Sheets and other Google services the Google Scripts is used to build these specialized tasks. This enables the automatic notifications, data analysis, and real-time synchronization of inventory data. In a smart cabinet setting, Google Scripts offer a potent toolkit for streamlining procedures and using the possibilities of Google services.

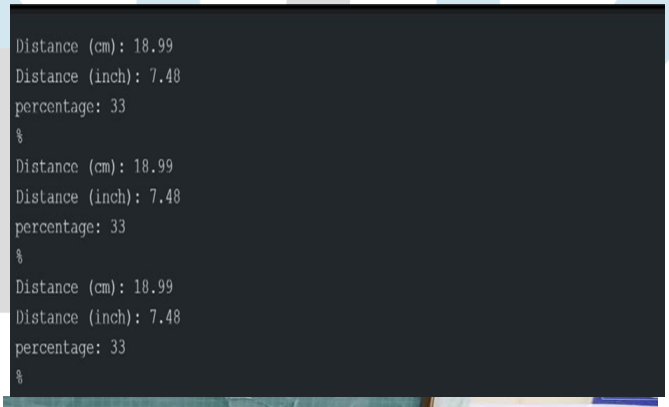
IV. RESULTS

With the help of the described setup one can keep a real time track of the space remaining in the shelf which will not only help in space optimization but also reduces the cost. Fig 3 shows a cabinet filled with products and the result generated by the ultrasonic sensor regarding the amount of space available is displayed in Fig 4. The Fig.7 displays the conversation carried out by the user with Alexa and the integration of the google sheets to add/remove products.

The results obtained for the smart cabinet system presented here are for specifically designed cabinet with dimensions of 50 x 30 cm. The assembly of the barcode scanner for the same is shown in the Fig.5, the Fig.6 displays the placement of the ultrasonic sensor. The system can be made more scalable, robust and adaptable with the help of future research and development for which this prototype can serve as a good reference and example for decision making. The emerging technologies can be integrated with this system for optimal performance.

Fig.3. Filled smart cabinet

Fig.4. Result of ultrasonic sensor



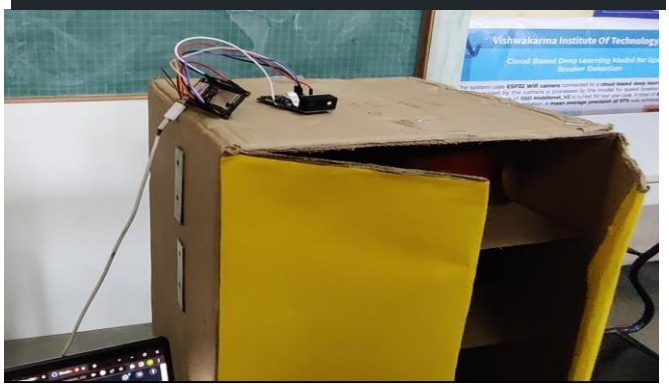


Fig.5. Assembly of ESP32 and Barcode Scanner

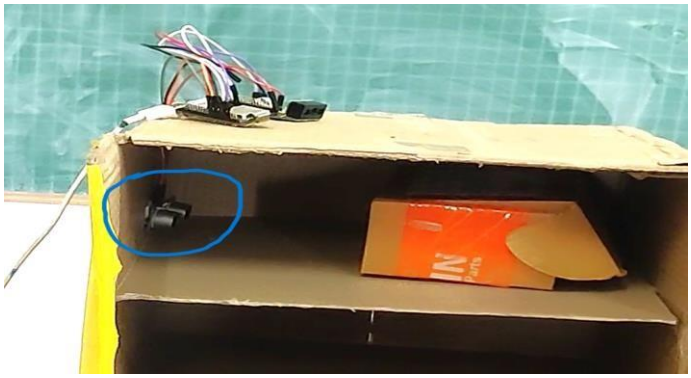


Fig.6. Assembly of ultrasonic sensor

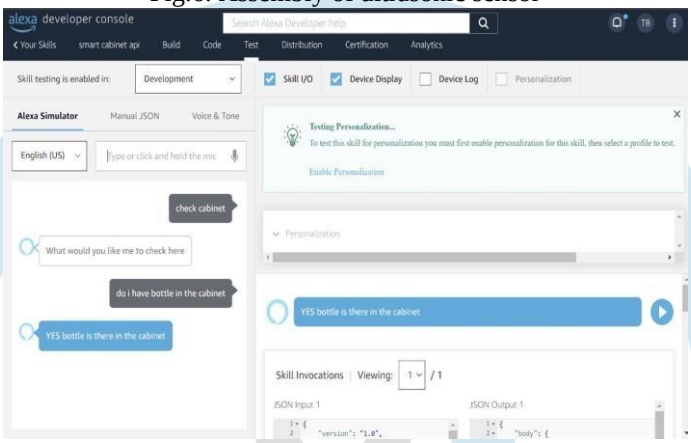


Fig.7. Integration of Alexa

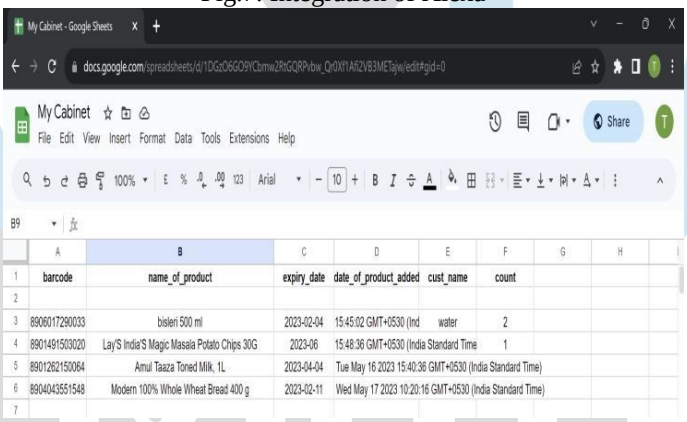


Fig.8. Integration of Google Sheets

V. FUTURE SCOPE

The capabilities of a smart cabinet could include maintaining inventory levels, keeping tabs on the freshness and expiration dates of food, and suggesting recipes based on the present contents. However, it lacks complete visibility into other products in the fridge and pantry, and its perspective is restricted to what is kept inside the cabinet itself. Once goods are removed, it is also unable to monitor actual consumption and usage. Accurately identifying a variety of foods is further hampered by technological limitations with regard to sensors and computer vision. Additionally, because they use cameras to track meals, smart cabinets present privacy concerns. Another major issue is cost, which makes them unaffordable due to the inclusion of components like cameras, sensors, and voice assistants. While Smart Cabinets can aid in organization, they have limited technical accuracy, high expenses, partial data, and privacy issues. Smart Cabinets have several important features overall, but they also lack comprehensive food oversight and insight.

VI. CONCLUSION

In conclusion, by merging cutting-edge technologies and intelligent functionalities, smart cabinets have revolutionized storage management. In addition to automated inventory tracking, real-time monitoring, data analytics, and improved space utilization, these cabinets provide a number of advantages.

By removing the need for manual inventory checks, smart cabinets lower the possibility of mistakes or stockouts. Businesses can have an accurate and up-to-date view of their stored objects with real-time tracking and remote access to inventory data, resulting in increased productivity and cost savings.

The Smart cabinets use cognitive algorithms and analytics to optimize storage space by recommending the best locations for goods. It increases space utilization, lowers storage expenses, and improves accessibility.

As technology continues to advance, we can expect that the proposed system can become even more sophisticated and integral to storage solutions in various industries and will play a huge role in inventory management.

VII. ACKNOWLEGMENT

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