Smart Container System

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Abstract:

This paper focuses on developing an affordable and user-friendly smart container system to address a common household challenge. Many households experience the need for constant monitoring of kitchen supplies, especially groceries. Often, the responsibility falls on the family's female to track the diminishing stock, eventually resulting in an ever- growing shopping list on the fridge. This leads to frequent visits to supermarkets which is slightly difficult for working females. Leveraging the capabilities of the Internet of Things (IoT) this project introduces the concept of a "Smart Container" to automate and streamline this process.

Keywords: Load cell, Weight sensor module HX711, Arduino Uno, LCD, GSM modem, GSM module SIM900.

I. Introduction

In contemporary society, individuals have increasingly hectic lifestyles, leading to deep immersion in their work schedules. As a result, many find it challenging to allocate time and attention to their household responsibilities. The modern pace of life has made it slightly difficult for people to focus on and manage their kitchen-related tasks. The kitchen, once a central hub of activity, has now become a room that is seldom visited by individuals caught up in their demanding daily routines. Consequently, tracking and managing kitchen items have become significant challenges for many in their day-to-day lives.

Smart Container is an IoT-based container that uses a weight sensor (HX711 sensor) to track the exact amount of content present in the container

This real-time weight monitoring system ensures that the users are always aware of their grain inventory, helping them avoid the inconvenience of running out of essential kitchen staples unexpectedly.

Smart Container will be linked to a smartphone via GSM module (SIM900) to allow users to access container data remotely by receiving low-stock alerts, and can purchase grains online from nearby stores. This automated ordering process saves time and ensures that users never run out of essential kitchen supplies.

II. Literature Review

Internet of Things (IoT) involves integrating sensors and connectivity to monitor contents. The Internet of Things (IoT) revolutionizes connectivity by embedding sensors and communication in everyday objects. It enables data exchange, automation, and remote control, impacting various sectors like healthcare, agriculture, and smart cities, transforming how devices interact and enhancing overall efficiency and convenience.[4] Developing a Smart Container System using the IoT technology enables remote tracking, alerts, and efficient management of container resources for a seamless and automated home experience.[3] This can be done by using a high- precision, low-capacity strain gauge-based load cell for electronic scales that involves integrating precise strain gauges designed into a carefully engineered structure[1] followed by creating an Arduino-based weighing scale using a load cell that involves connecting the load cell to an Arduino, utilizing specialized libraries for data interpretation. Arduino- based weighing machine involves integrating a load cell with an HX711 module for precise weight measurements.[2] The load cell senses force and the HX711 converts analog signals to digital, allowing the Arduino to process and display accurate weight readings for applications.[5] GSM module (SIM900) is used for device-to-device communication. The data from the sensor will be displayed on the smartphone via SMS.[6]

III. Hardware & Software

Load cell:

A load cell is a transducer that is used to measure weight. It converts mechanical force(load) into an electrical signal. It incorporates strain gauges as its sensing elements. Strain gauges are devices that change their electrical resistance when subjected to mechanical deformation or strain. It is made of a metal structure that deforms when a force or load is applied to it which alters its resistance.

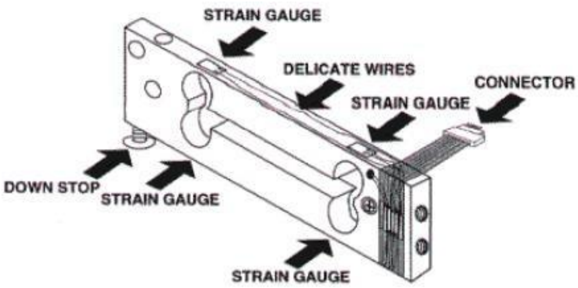

Fig.: 1 - Strain gauge load cell

Strain gauges are attached to the surface of the load cell where deformation is expected to occur. Gauges are made of a thin conductive material and are sensitive to mechanical strain. The change in resistance produces a small electrical signal. This electrical signal can then be measured, amplified, and calibrated to provide accurate and precise weight or force readings.

Fig.: 2 - Load cell

Weight Sensor Module HX711:

Weight Sensor Module HX711 is a 24-bit analog-to-digital convertor used for measuring weight and operating a bridge sensor. It provides high integration, fast response, and immunity at low cost by using a chip which eventually increases performance and reliability.

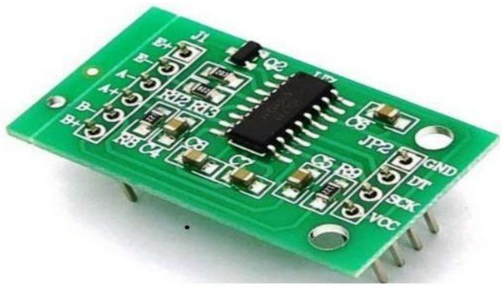

Fig.: 3 - Weight Sensor Module HX711

Weight Sensor Module uses HX711 chip which is 24 high-precision A/D converter. HX711 Weight Sensor Module is an intermediary between load cells and microcontrollers that measures weight by converting analog signals into digital data.

Arduino Uno:

Arduino Uno is an open-source microcontroller that is the core of the proposed project i.e., Smart Container System. It helps in easy prototyping and development of projects. Arduino Uno is based on ATmega328 having 14 digital I/O pins and 6 analog inputs. Out of 14 digital I/O pins 6 pins can be used as PWM outputs.To initiate the Arduino Uno, a straightforward approach involves connecting it to a computer using a Universal Serial Bus (USB) cable. The Arduino Uno is programmed with Arduino Integrated Development Environment (IDE). It has libraries which are collections of sketches (C-based program code for Arduino) used to perform specific functionalities.

Fig.: 4 – Arduino Uno

Arduino can either work autonomously without being connected to a computer or can be programmed by sending commands from the computer via various software interfaces. HX711 sensor output is connectedto Analog pin 2 of Arduino. The resulting value will be displayed on LCD.

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LCD:

LCD acts as an output interface for displaying real-time data and user information. The LCD module provides a clear and readable display for presenting inventory status and notifications directly on the smart container unit. This visual feedback enhances user interaction and facilitates quick decision-making regarding grocery management.

Fig.: 5 – LCD

GSM Module:

A GSM (Global System for Mobile Communications) module is a hardware device that helps in communication between a wide range of electronic devices over the GSM network. It allows devices to send and receive data that includes text messages (SMS) and voice calls. GSM modules are based on the GSM standard, which is a digital cellular communication standard used to transmit mobile voice and data services.

Fig.: 5 – GSM Module

GSM module communicates with the GSM network through a Subscriber Identity Module (SIM) card that has information such as mobile number and authentication credentials. It has interfaces such as serial communication ports like UART (Universal Asynchronous Receiver-Transmitter) and sometimes additional interfaces like SPI (Serial Peripheral Interface) or I2C (Inter-Integrated Circuit) that connect to external devices. These modules are controlled using AT commands (Hayes commands) which are simple text commands sent to the module to perform various functions such as sending SMS, making calls, and configuring network settings. This module has an antenna to transmit and receive signals.

Circuit Diagram:

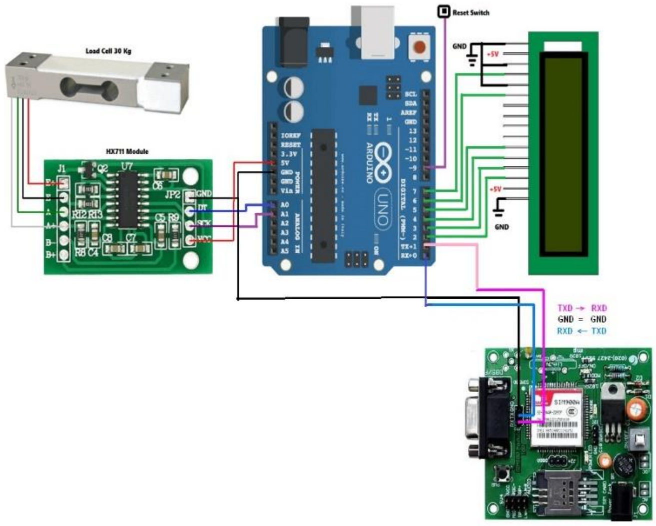

Fig.: 6 – Circuit diagram for the proposed system usingthe above components

IV. Design Methodology

The design methodology for a Smart Container system comprises interconnected components that combine to create an intelligent system for monitoring contents in a container. The system architecture emphasizes real-time monitoring, automated alerts, and user-friendly interaction without relying on cloud-based services.

Smart Container is equipped with a weight sensor which collects data regarding the container's contents. The weight sensor is responsible for measuring the weight of contents in a container accurately. The data of the sensor is fed into the Arduino. The Arduino microcontroller processes data from the weight sensor. It manages data communication as well as controls the overall functionality of the Smart Container.

The system is powered by an external power supply, which is a standard AC-to-DC adapter providing the necessary voltage for the components to operate. This power source ensures a stable and reliable voltage supply to the system components. This ensures continuous functionality without reliance on battery power.

The GSM module enables communication with mobile networks and allows the system to send alerts and notifications via SMS. In case of predefined thresholds being exceeded the Arduino Uno triggers the GSM module to send SMS alerts to predefined phone numbers. When certain thresholds are met, the system can generate SMS alerts prompting users to reorder specific items.

The system is configured to support automated ordering of groceries. This feature enhances user awareness and facilitates timely responses to potential issues. By leveraging these IoT components, the system provides users with a cost-effective, efficient, and user-friendly solution for managing kitchen inventory and ensuring optimal storage conditions.

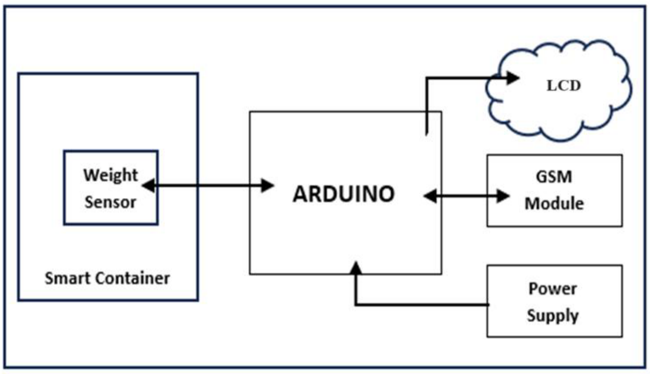

Fig.: 7 – Block diagram of the proposed system

V. Working

The working of the Smart Container system involves a coordinated flow of processes. Smart Container is equipped with a weight sensor that collects data regarding the weight of the contents inside the container. Then the data from this sensor is sent to the Arduino microcontroller for processing.

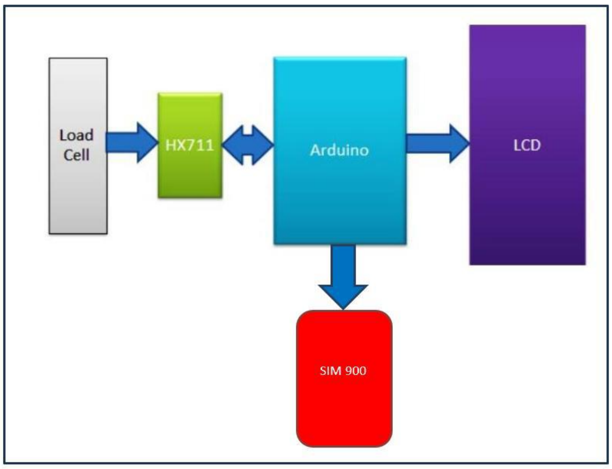

Fig.: 8 – Data flow diagram of the proposed system

The Arduino is programmed in such a way that it reads the values received and manages data communication. It reads the values from the weight sensor and compares them against predefined thresholds to determine what action needs to be taken. If the weight of the container's contents falls below a predefined threshold, indicating low stock, the system triggers an alert. When threshold is crossed, the Arduino Uno activates a GSM module connected to it.

The GSM module is responsible for sending alerts via SMS to predefined phone numbers. The GSM module sends an SMS alert containing relevant information of low stock and instructions for the user for refilling, to the designated recipients' mobile phones. Upon receiving the SMS alert, the user can make a note to replenish the depleted items during the next shopping trip. This system provides real-time data from the sensor.

Regular maintenance ensures the proper functioning of sensors and connectivity modules. This approach provides a simple yet effective means of keeping users informed about the status of their kitchen supplies and ensuring optimal storage conditions.

Flow Diagram:

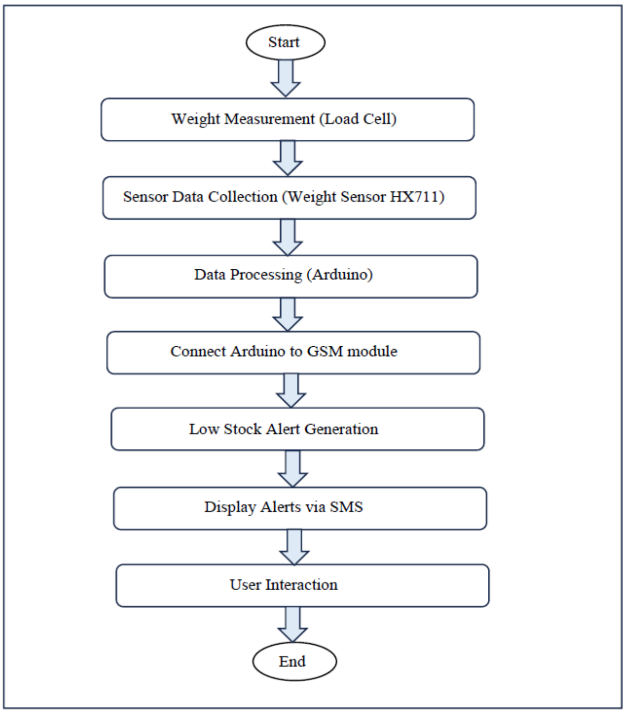

Fig.: 9 – Flow Diagram of the proposed system

VI. EXPERIMENTAL SETUP

The Experimental setup is as follows: A transparent container filled with grain was used for the process. An Weight Sensor was placed at bottom of the container with GSM transmitter and Mobile network receiver that used to sense the level of the commodity.

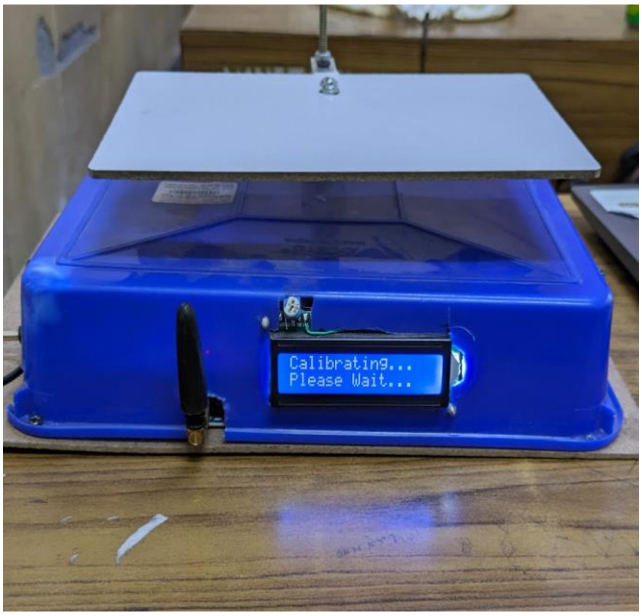

Fig.: 10 – Setup of the smart container

When the weight is put on this system power supply initiate the current flow and activate the load cell placed within the container.

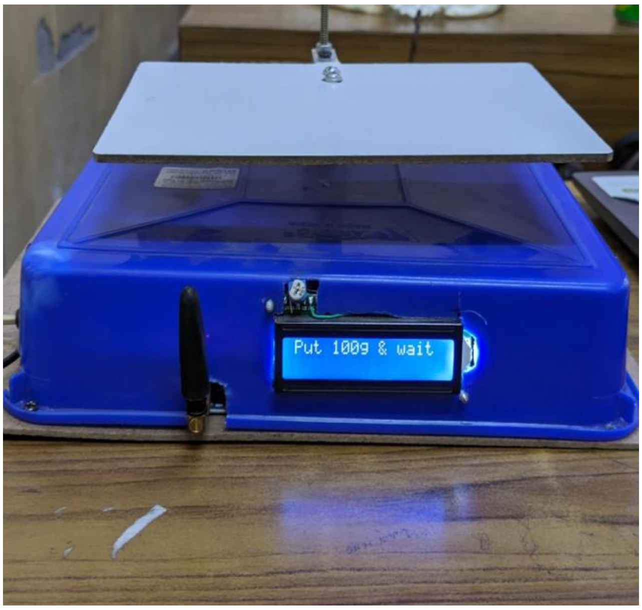

Fig.: 11 – Monitoring the weight

Load cell takes the weight of the objects in container and transmit it to weight sensor. This sensor measures the current weight of the container's contents. It typically consists of a load cell connected to an analog-to-digital converter (ADC) on the Arduino Uno.

The Arduino reads the analog signal from the weight sensor through the ADC. The raw data from the sensors might need filtering and calibration to ensure accuracy. This involves converting the sensor readings into meaningful units (e.g., grams for weight).

Fig.: 12 – Arduino data processing

The Arduino microcontroller reads the value and checks for the threshold value. The processed data is compared against predefined thresholds. For example, if the weight falls below a certain level the Arduino recognizes these conditions as triggers.

Fig.: 13 – Checking threshold value

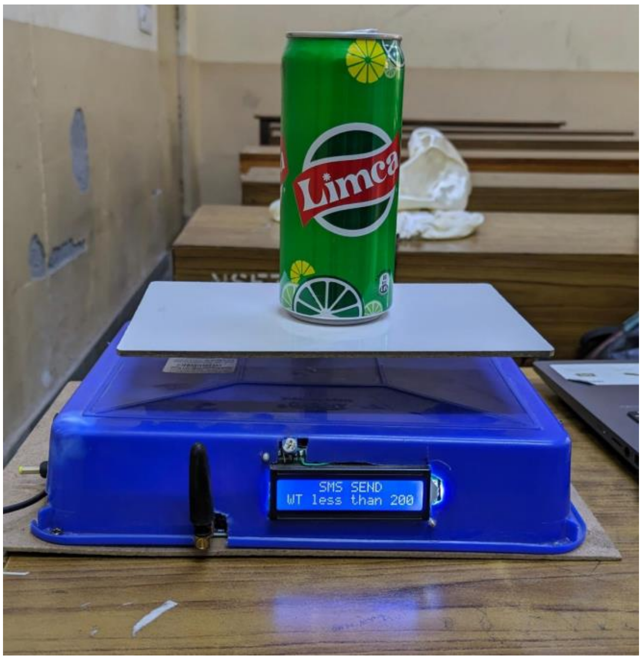

Fig.: 14 – Triggering Alert

The module is configured to send SMS messages. The Arduino sends commands to the GSM module through serial communication to compose and send an alert message. The GSM module sends an SMS alert to the user's mobile phone, notifying them of the low stock level. Users receive SMS alerts on their mobile phones, providing real-time updates on the container's status.

Measure of quantity by the sensor	**Indication Message**
390g	No message
550g	No message
201g	No message
90g	Message Sent
198g	Message Sent
110g	Message Sent

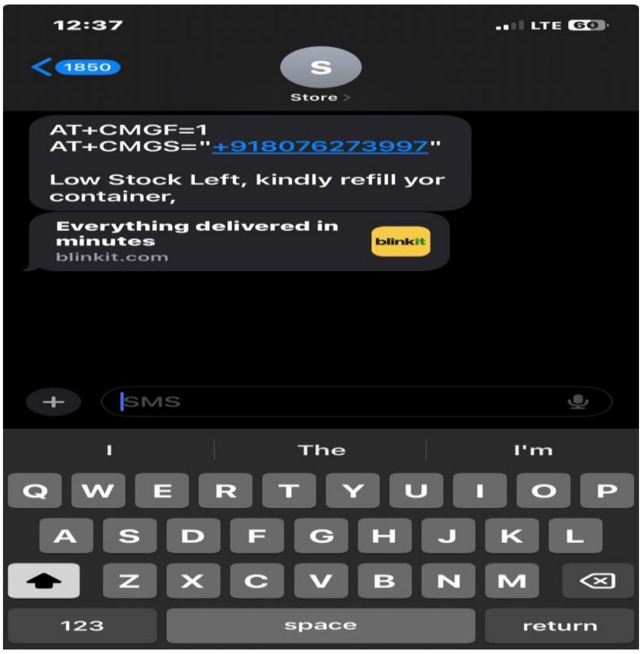

Fig.: 15 – SMS alert

Table 1 Results of recognition of levels of commodity measured in the smart container system

In addition to SMS alerts, the Smart Container system features an LCD for local display of critical information. The LCD provides users with immediate visual feedback on the container's contents, further enhancing the user experience. Users can quickly check the current weight and temperature readings, as well as any alert messages displayed on the screen.

Regular maintenance and calibration are essential to ensure the accuracy and reliability of the Smart Container system. Periodic calibration of the sensors and system checks verify the proper functioning of the Arduino, GSM module, and LCD. These maintenance tasks ensure that the system continues to provide accurate data and timely alerts, enabling users to effectively manage their kitchen inventory.

The Smart Container project integrates multiple components to create a seamless workflow for real-time monitoring and user interaction. The Arduino Uno processes data from weight and temperature sensors, communicates alerts via a GSM module, and displays information on an LCD. Users interact with the system through SMS, receiving updates and sending commands as needed. Regular maintenance and calibration ensure ongoing accuracy and reliability. This comprehensive workflow ensures that users can effectively manage their kitchen inventory, preventing shortages and maintaining optimal storage conditions.

VII. Future Scope

The future scope of a Smart Container system presents several promising possibilities for expansion and improvement. Predictive analytics can be achieved by implementing machine learning algorithms within the system. The system can be trained from usage patterns and suggest when the items need replenishing. The mobile application interface can be improved continuously to offer more features and a better user experience. This may include personalized dashboards, historical data analysis, and customizable alerts.

Smart Containers can be connected to broader smart home ecosystems that will enable seamless interaction with other devices. Advanced security protocols can be implemented to protect user data and ensure the privacy of data collected from the container.

Localization and integration with different online marketplaces can make the system more accessible globally. Smart Containers can be further used commercially such as in restaurants, hotels, or large- scale food storage facilities.

By considering these avenues, the Smart Container system can evolve into a more sophisticated, user- friendly, and widely applicable solution with a broader impact on household management and beyond.

VIII. Conclusion

In conclusion, the Smart Container system addresses the challenges faced by individuals in managingkitchen supplies amid increasingly hectic lifestyles. This project uses the power of Internet of Things (IoT) to give an innovative solution. The weight sensor in the Smart Container gives real-time data of the contents present in the container to avoid running out of essential kitchen staples unexpectedly. This will bring convenience to the users. The introduction of a GSM module adds a new dimension to the project, enabling the transmission of alerts via SMS. This feature ensures that users receive timely notifications directly to their mobile phones, regardless of internet connectivity or the availability of cloud-based services. In situations where immediate action is required, such as low-stock alerts, the GSM module ensures that users are promptly informed, enhancing the overall responsiveness and utility of the system.

The absence of cloud-based services or mobile applications does not detract from the effectiveness of the Smart Container system. Instead, it underscores the project's focus on simplicity, accessibility, and autonomy. By relying on local processing and communication mechanisms, the system maintains a high level of independence, allowing users to manage their kitchen inventory with minimal reliance on external infrastructure.

The project's emphasis on affordability and accessibility ensures that the benefits of IoT technology are accessible to a wide range of users. By utilizing off-the-shelf components and open-source software, the Smart Container system remains cost-effective without compromising on performance or reliability. This democratization of technology empowers individuals from diverse backgrounds to embrace innovation and improve their quality of life.

In essence, the Smart Container system addresses the immediate challenge of household inventory management and sets the stage for a more connected, efficient, and sustainable approach to daily living. As technology continues to evolve, this project serves as a stepping stone toward a smarter and moreresponsive future for household management.

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