Smart Rationing System: Rationing done easy

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***Abstract*— The smart ratioing system is an automation project developed to enhance a more fluid and transparent way for ration distribution in public stores. Another application includes grocery stores like D-mart and reliance where a more efficient way of working can be implemented. This project includes Arduino mega as the controller and many more modules to help assist the process. the components like ultrasonic sensors and load cell help tell us about the stock conditions, whereas the RFID will give each customer their own id in order to ensure smooth functioning.**

Index Terms*— Smart, Rationing System, Arduino Mega 2560, Public Distribution System (PDS), Food items dispensing system.

I. INTRODUCTION

The World Wars always brought some significant change in people's lifestyles. One of them was the start of Indian Rationing system. It began during World War II (1940s) during the British Rule to counter the food shortages, but the system was still continued to provide national food security and ensure that the economically weaker sections can also afford their daily meals after India got its independence.

The grains distribution in the rationing system varies as per the tiers set by the government. But, due to human interventions, the customers are not able to get their rightful share of food items. Therefore, to prevent the malpractices in the system, this Smart Rationing system is visualized.

This system holds the database, which includes the customers as well as their food allowance and every time they shop, the respective amount of food items will be reduced from their monthly allowance.

Using an RFID card, they can access and purchase the food items. They first need to scan the RFID card, and when the user is detected, the system displays the allowance for that user. The user is then given with a choice to select their desired food item and the quantity needed. This user interaction is carried out by using LCD and Keypad modules. The system then checks the availability of that food item using the ultrasonic sensor. If the food item is in stock, it gives a message to the user to put the container or bag to dispense the food item in it and then tares the weight of the container. With the help of Load cell weighing machine and servo motor, the correct amount asked, is given to the customer.

This system not only reduces the malpractices in the rationing system, but also automates the process of buying food items, which is much needed nowadays.

II. LITERATURE SURVEY

Sharma, K. et. al. "Multi-Modality Biometric Assisted Smart Card Based Ration Distribution System" authors mention the use of fingerprint scanning and facial recognition instead of RFID cards or tags to enhance the security. A database is required which will store the records of the user's purchase history as well as the user's unique characteristics for identification. They have used a cloud system to maintain transparency as well as allow the users to access data records in other retail stores.[25]

Dr. M. P. Rajesekaran, et.al proposed an "Automated Smart Ration Distribution System for Prevention of Civil Supplies Hoarding in India". In this system, smart electronic measuring devices are employed to ensure the system is efficient and accurate. Data related to transactions will be digitally stored using an Arduino microcontroller that precisely calculates the product dispensed or bought and then continues to update the inventory and database.[26]

M. Agarwal, M. Sharma, et.al has put forward the "Smart Ration Card Using RFID and GSM's". In this paper, they have mentioned the use of RFID cards which will be authenticated by the on-board microcontroller. Each RFID card is linked with the family members of the card holder and if the user is found out to be genuine, the user will be provided with the food items based on the members of the

family as well as their allotted allowance in the rationing system.[27]

Ashish Kumar, Harsh and Dr. Prem Prakash Yadav have put forward the "RFID Based Smart Card Ration Distribution System" in which the have mention how they have used an Arduino Mega 2560 microcontroller which automates the process of ration delivery and also enhances user verification, accuracy, and communication. This rationing system is equipped with various types of modules and components like LCD, GSM, etc. to handle identification, user interaction, dispensing control, and real-time communication.[28]

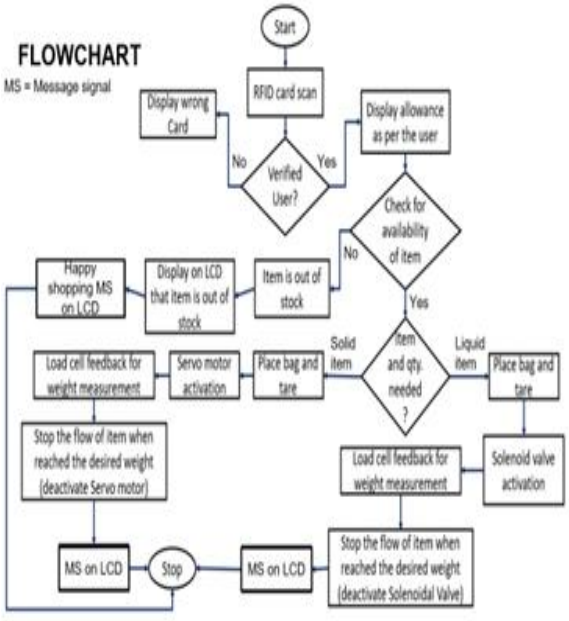
III. WORKING AND FLOWCHART

A. Smart Rationing system working

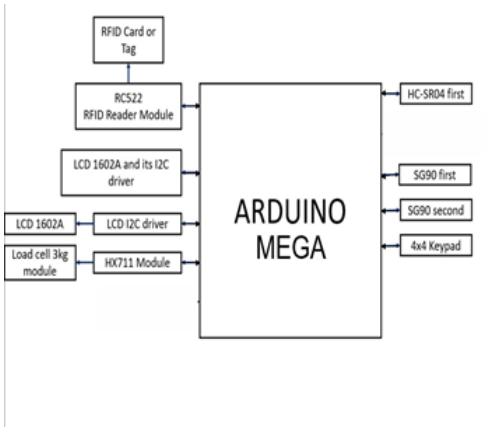
- This Smart Rationing system uses a some commonly used sensors and actuators like SG90, a servo motor, HC-SR04 an ultrasonic sensor a lot more. The use of these components is done in such way that –
    - When a person will come to buy his/her ration, the person will have an RFID tag or card which the person can attach to their keys as key chain or can put it in his/her wallet. Whenever the person scans his/her RFID card, the UID (unique ID which is different for each tag or card (discussed in further sections)) will be scanned by the RFID detector. This UID will be searched in the database of customers and their ration allowance and price per item would be displayed on the LCD display.
    - After this, the customer can choose which item they want by pressing the desired keys on the keypad.
    - Likewise, the customer gets to pick the quantity of the item by again pressing the desired keys on the keypad.
    - The system then checks if the item is in stock using the ultrasonic sensor and if the distance calculated using ultrasonic sensor is more than the reference distance (which depicts that enough amount of item is inside the container such that we can say the item is still in stock), then the system will consider that the item is out stock and will display a message regarding the same on the LCD.
    - If this distance calculated by the ultrasonic sensor is less than the reference distance, then the system prepares to dispense the item selected.
    - Before dispensing it gives 5 seconds so that the customer can put a container such that the item can be dispensed in it.
    - After the 5 seconds are over, the weight of the container is tared and a message for dispensing the item is displayed on the LCD.
    - For solid items, servo motor is used to control the dispensing. To dispense, the servo motor (SG90) with attached flap (control element) rotates such that the items dispense from the opening. After the required amount of solid item like wheat, measured by a load cell (which is the system's weighing machine), is dispensed the servo motor rotates to come back to its original position to stop the dispensing. Let's say if a customer wants to buy 500g of wheat, ideally, the servo should rotate to come back to its position at 500g but, in real life, the rotation of motor take time and fast flowing items like Semolina, etc. can be dispensed more, exceeding the limit. For this the servo motor shut can be scheduled when the load cell detects 490g, thus until the servo comes back to its place, the rest 10g can be dispensed giving exact quantity of the item. But this variation will vary from item to item.
    - For liquid items, a solenoid valve is used as the control element and it is given a logic 1 signal by Arduino mega to dispense the liquid until it reaches the target weight. After reaching the target weight, the Arduino mega sends a logic 0 signal to close the valve indicating the item has been dispensed. Here, as 1L of liquid item and weight in kg varies, conversion of litres to kg is done using mathematical formula, that is, let's say 1L of a liquid is 0.88kg, then target weight for 1L of that item is 0.88kg then for xL it would be (x)(0.88). This will vary according to the liquid item.
        - After dispensing a message will be displayed on the LCD and again after a delay LCD will display 'Scan your RFID card' message to show the order

has ended and the systems has moved onto the next order.

B. Work Flowchart



C. Block Diagram



IV. COMPONENT DESCRIPTION

A. Arduino Mega 2560

It is a powerful microcontroller board based on Atmega2560 chip offering 54 digital I/O pins, 14 analog pin and 4 UART pins.[1] It is generally used in projects that require more I/O pins, memory and processing power that standard Arduino board like Uno.[1]

Due to the use of more components, especially 4x4 Keypad and RC522, the pins provided by Arduino Uno were not enough to control the entire system.[2] So, there were two ways, either use Arduino mega 2560 or connect 2 Arduino Uno such that they work as one control unit.[3] The first option was more feasible as the attempts to face multiple Arduino Uno proved impractical and inefficient, making Arduino Mega 2560 the optimal single-board solution.

Fig[1] – Arduino Mega 2560[1]

B. RC522 & RFID cards and tags

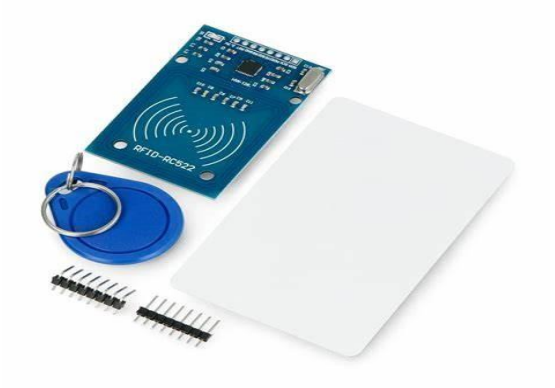
It is a 13.6MHz RFID reader/writer module which is based on NXP MFRC522 IC.[4] It is used to communicate with the ISO 14443A standard RFID tags and cards including MIFARE 1k, 4k, etc. [4]

It is used in this system for access control. It supports UART, SPI (default and commonly used) and I^2C communication modes.[4]

The RFID tags and cards are passive devices that operate at 13.6MHz and store an UID (Unique Identifier) along with some user data in memory.[5] They interchange information with RFID reader like RC522 via Radio frequency, using the ISO/IEC 14443A standard. They don't require battery as the get powered by the electromagnetic field generated by the reader.[5]

Working –

- RC522 generates a 13.6MHz electromagnetic field using its onboard antenna.[4]
- The passive tags, when brought near to the RFID reader, receive the power from this field and respond with their UID (Unique Identifier).[4]
- This UID is read by Arduino and thus the Arduino is able to differentiate between tags/cards based on their UID, thus authenticating RFID tags or cards based on their UID.[4]
- The RC522 module can also read/write data to RFID tags/cards with built-in EEPROM.
- The data interchange follows the ISO 14443A protocol.[4]



Fig[2] – RC522 and RFID tag and card[13]

C. 4x4 Keypad

It has 16 keys arranged in 4 rows by 4 columns matrix to provide user input such are numbers, characters or commands to microcontroller-based systems like Arduino, PIC, ARM, etc. [6]

1	2	3	A
4	5	6	B
7	8	9	C
*	0	#	D

These keys are connected at the intersection of rows and column wires and when a key is selected, one row and one column are shorted like a switch.

The microcontroller sets rows as output and the column as input (or vice versa). When a key is pressed the specific row is set at HIGH wile the others are set at LOW.[7] Then the microcontroller checks for the inputs, that is columns, for the current flow from the row and that column input goes LOW thus indicating which key has been pressed.[7]

Fig[3] – 4x4 Keypad [14]

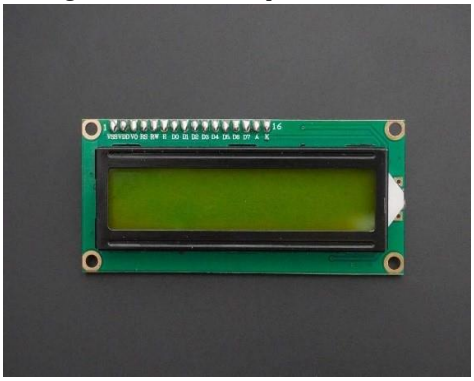
D. LCD – Liquid Crystal Display 1602A and LCD I2C driver

It is an alphanumeric display used to display numbers, characters and symbols for status update and user interaction.[8]

In this system it used with an I2C driver (PCF8574) to improve and optimize the pin allotment on the microcontroller making it easy to work with. It reduces the loose connection errors significantly. It reduces the use of 6 pins on Arduino to 2 Pins (SDA and SCA) on Arduino for communication.[9]

1602A is a commonly used LCD with Arduino. It consists of 16 columns (characters per line) and 2 rows.[8]

The PCF8574 chip receives command or data from Arduino over I2C. It then converts the data into parallel signals which are required for the LCD.[9]



Fig[4] – 1602A LCD with PCF8574 at the back soldered[15]

E. SG90 – Servo Motor

It the commonly used, beginner-friendly and a micro rotary actuator used with Arduino and other embedded electronic projects.[10]

It is small, light weight and is perfect for precise angular rotation control.[10]

It is a closed loop system; it knows the angle of the output shaft by using the internal feedback mechanism consisting of a potentiometer, enabling position control.[10]

It is used in this system it is employed to control the dispensing of solid food items like grains.

Fig[5] – SG90 Servo Motor[16]

F. Solenoidal Valve 12V 2A

It is an electromechanical device that uses an electromagnet (coil) to actuate the magnetic plunger or valve and is used to control the flow of liquid or gas.[11]

There are two types of Solenoidal Valve –

- Normally Closed (NC) – Valve stays shut when the power is turned off. Mostly used in water and safety systems.[11]
- Normally Open (NO) – Valve stays open when the power to solenoidal valve is not provided.[11]

In this smart rationing system NC Solenoidal Valve of 12V and 2A is employed which ensures safety, preventing any leakage or flow when the power is off.

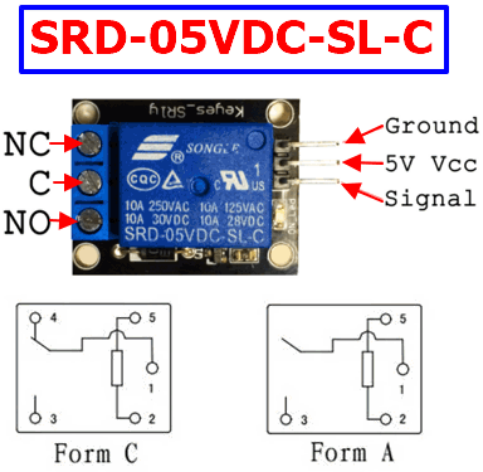
Fig[6] – Solenoidal Valve[17]

G. Relay module SRD-05VDC-SL-C

It is an electronically operated switch which allows low voltage devices like Arduino (5V) to safely control high-current or high-voltage devices like the Solenoidal Valve (12V, 2A).[12]

To control the power flow for devices, it physically opens or closes itself.[12]

The module features output terminals for COM (Common), NC (Normally Closed) and NO (Normally Open) switching configurations, allowing versatile control logic.[12] The COM terminal is the main contact, it either connects to NO or NC.[12] The NC terminal is disconnected by default, hence normally closed, but is connected to COM when energized. The NO terminal is connected to COM by default, hence normally open, but gets disconnected when relay is energized.[12]



Fig[7] – Relay Module[12]

H. HC-SR04 Ultrasonic Sensor

It is the most popular ultrasonic distance sensor used with microcontrollers Arduino. It is used to measure the distance to an object using ultrasonic sound waves.[19]

It works like a bat – it sends a sound pulse and waits until it receives the echo.[19]

Working –

- The Arduino send a 10µs HIGH pulse to the Trig pin of Ultrasonic sensor.[19]
- Then the sensor emits 8 ultrasonic bursts of 40kHz.[19]
- These sound waves travel through air, and bounce right back when they hit an firm object.[19]
- When the sensor receives the signal back, it sends a HIGH pulse on Echo pin.[19]
- The duration of this echo reception is proportional to the distance at which the object is kept from the sensor.[19]

This sensor is used to measure the distance such that the distance is in range where we can say that the item is in stock. If the distance is more then, that means that the item is out of stock.[20]

Fig[8] – HC-SR04[18]

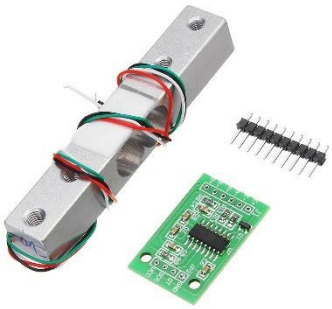
I. 3kg Load cell

It is a precision sensor used to measure weight or force; it is commonly used in weighing system like in this system.[21]

It is a strain-gauge based transducer to which if a force is applied, the internal metal structure bends slightly which causes a change in resistance of strain gauges attached to it.[21]

The change is very small thus a millivolt-level output is generated. Since the generated signals are weak, an amplifier module named HX711 is used to interface the load cell with microcontrollers like Arduino Mega 2560.[21]

This HX711 module not only amplifies the signals from the load cell, but it also provides power to load cell and send the amplified data to Arduino via DT (Data Line) and SCK (Clock) pins.[21]

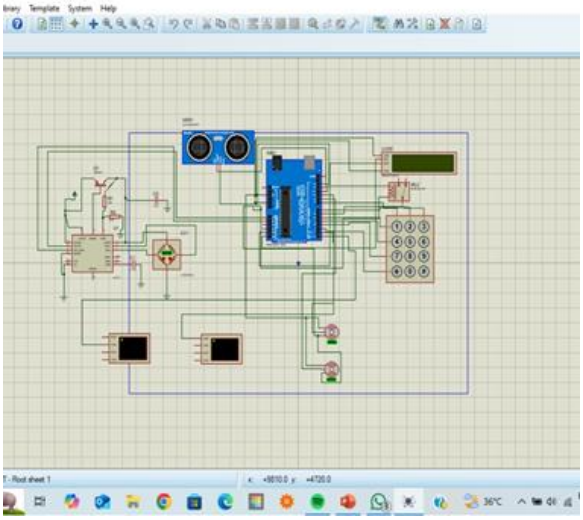


Fig[9] – 3kg Load Cell and HX711[22]

V. SIMULATION & EXPERIMENTAL RESULTS

Arduino IDE – It is a software platform used to develop and upload embedded C/C++ codes onto Arduino mega.[23] It is an open-source software and supports real time monitoring, making it suitable for code development, monitoring and testing. It is compatible with multiple OS like Windows, Apple, etc.[23]

Proteus Simulation Software – It is a professional circuit simulation software developed by Labcenter Electronics and id widely used in creating and designing microcontroller circuits, visualize the working of components, etc.[24]



Fig[10] – Proteus simulation of basic circuit for the system

To check the accuracy of weighing machine (Load cell), first a known weight of 250g is taken and the accuracy of Load cell is checked.

Expected Weight (in g)	Weight on Load cell (in g)	Accuracy (in %)
250	242.6	97.2
250	246.4	98.56
250	246.80	98.712
250	250.04	100.016
250	239.6	95.4
250	250	100
250	240.2	96.008
250	239.4	95.76

Practical results –

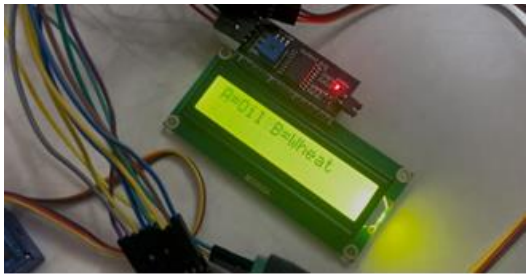
Fig[11] Project with full setup

Fig[12] Initial system ready message displayed

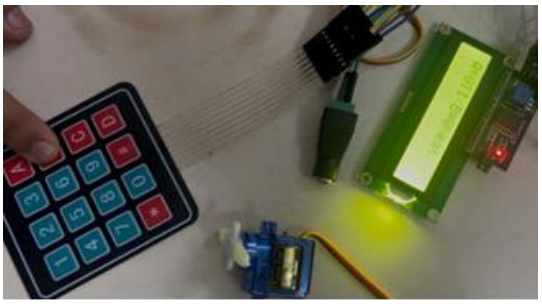
Fig[13] Request to user for scanning the RFID card

Fig[14] UID displayed after positive customer identification

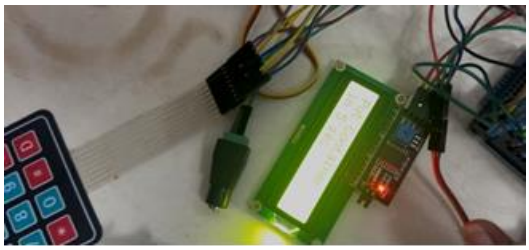
Fig[15] Allowance and prices of food items displayed for a customer



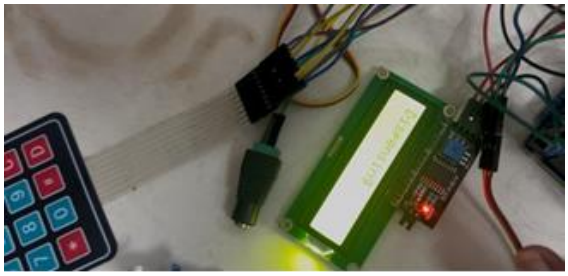
Fig[16] Choice displayed



Fig[17] Quantity of Wheat choice entering



Fig[18] Message displayed which requests the customer to put container before dispensing



Fig[19] Message displayed when the system starts dispensing

Fig[20] Message displayed after the system is done dispensing

IV. CONCLUSION

The proposed Smart Rationing System using Arduino Mega 2560 provides a practical and efficient solution to the longstanding challenges in India's Public Distribution System (PDS), including manual errors, unfair distribution, and beneficiary fraud due to human intervention. By integrating RFID technology, servo-controlled dispensing, Solenoidal Valve and relay, Ultrasonic Sensor, Load Cell, and a user-friendly interface via I2C LCD and Keypad, the system ensures secure identification, precise ration dispensing, and real-time updates on the LCD.

The use of Arduino Mega 2560 provides improved I/O capability, enabling smooth integration of multiple peripherals including the RC522 RFID reader, HX711 load cell amplifier, ultrasonic sensors, relay modules, solenoidal valves and many more. This makes the system automated, scalable and adaptable for distributing both solid and liquid rations. Furthermore, the Proteus simulation and experimental verification through Arduino IDE confirmed the precision and feasibility of the design. The Smart Rationing system offers a cost-effective, transparent, and technologically sound alternative to conventional ration distribution methods, especially for rural and semi-urban areas. It not only reduces the dependency on manual processes but also ensures that the right quantity reaches the right

person with proper authentication and automated logging.

Future enhancements could include efficient systems design for proper operation of system as well as to give the system some appealing look. Also we look forward to integrate centralized Aadhaar-based biometric authentication and solar-powered operation to make the system more robust, tamper-proof, and environmentally sustainable.

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[13] Fig[2] - Arduino Uno R 3 Rfid Starter Kit for sale | eBay

[14] Fig[3] - Sensors Modules 4x4 Keypad Module | Sensors Modules

[15] Fig[4] - LCD 16x2 Interfacing With Arduino Uno | Arduino

[16] Fig[5] - How To Remote Control A Servo Motor Sg90 Using Raspberry Pi

[17] Fig[6] - Solenoid Valve Adalah Apa Itu Solenoid Valve Dan Bagian - Vr

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