AUTOMATED MESUREMENT AND DISPERSION SYSTEM

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Abstract

The retail industry rapidly moves from manual systems to automated solutions to achieve operational excellence and improved customer service quality by giving the customers good user experience. This project develops a modern Automated Measuring and Dispensing System which gives supermarket customers full control over commodities such as wheat, grains and flour making them independent from staff help.

The system uses mechanical elements together with electronic components to create an affordable solution that users can easily operate. A storage barrel contains the product, yet a combination of an Archimedes screw driven by a gear motor controls the dispensing process. A 4*3 keypad provides user interaction and real-time feedback appears on a 16*2 LCD screen which uses I2C for clear display. The Arduino Uno controls the entire system that combines weight reading from four 50kg load cells using an HX711 amplifier with motor control performed through an L298N driver.

The automated measuring system cuts down waiting periods and reduces human mistakes as well as delivering uniform portioning precision. All customers can use this system since its user-friendly interface does not require any training. The modular structure supports scalability even though the design primarily serves dry granular materials. The project demonstrates advancement in automated retail operations which create independent stores capable of performing daily duties for consumers and businesses.

Acknowledgement

By completing this research project, I was able to gain valuable experience and technical skills regarding robotics application development. Hence, I would like to express my gratitude to everyone who helped me in completing this project.

First, I must mention that I am deeply grateful to our project supervisor, Mr. Supun Asanga, for providing us with guidance. His advice helped me to overcome the obstacles I faced throughout this project. I am also thankful to our esteemed course director, Mrs. Sandaruwani Pathirage, for her support and leadership throughout the project.

Then I would also like to thank the faculty members and technical staff of the School of Computing, National Institute of Business Management, for the support and the resources they provided. My heartfelt thanks also go to my colleagues. They supported me with their suggestions, and encouragement.

Finally, I am grateful to my family for providing support throughout this project work.

I am honored to have had all these supportive and motivating people behind me as I reach the end of this project.

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Chapter01–Introduction

Introduction to the Project

The retail industry demands quick processes and convenient customer experiences during the current fast-paced business environment. Many supermarkets today continue to have difficulties managing bulk products which include grains, flour and sugar. Such bulk processing typically demands staff members conduct manual measuring and packing activities which lead to time delays and inconsistent results. This peak-time operation produces traffic jams that extend queues and let the customers have a negative impact. These repetitive tasks handled through manual labor represent a waste of workforce capability by working on something which can be done automatically through a system rather than working where manpower is needed.

The solution involves developing an automated system which handles product measurement together with dispensing operations. The system removes the requirement for staff involvement because it enables customers to manage product quantity selection and dispensing automatically through the system. The solution enhances shopping simplicity through its easy-to-use input process and dependable dispensing technology which maintains proper measurements.

The system consists of three essential elements which include exact weight determination along with controlled distribution features alongside user-friendly interface design. The accurate measurement function depends on load cells and the dispensing process is managed by an Archimedes screw mechanism powered by a gear motor. The Arduino Uno functions as the main decision-making unit to connect the keypad display system with the mechanical parts. Customers achieve a smooth self-service transaction which lets them enter their required amount and observes the machine fill the precise measurement before they take possession of their items without waiting.

The system has additional effects on retail automation in addition to its current convenience benefits. The automated weighing process reduces both expenses for labor and decreases the probability of human mistakes. Even future enhancements can be made because the design features scalability which enables us to make connections between digital payment solutions, required product selection and smart packaging.

The project serves as a useful advancement which contributes to supermarket industry modernization efforts.

Aim

This project seeks to create an automated self-service dispenser that takes off staff dependency for measuring dry goods in supermarkets. The combination of precision mechanics, electronic sensors, and intuitive software controls helps the customers to independently get the exact quantities of products like grains with minimal error though the system. The priority of the integrated design goes to user-friendliness while focusing on some key retail challenges: measurement inaccuracies, long queues, and inconsistent shopping experiences for the customers - ultimately streamlining bulk product distribution through smart automation and making it convenient to the customer.

Objectives

- Developing a reliable system using an Archimedes screw and gear motor combination which effectively stores and distributes commodities perfectly.
- The system uses four precise 50kg load cells together with an HX711 amplifier module to measure dispensed weight with maximum accuracy.
- A user-friendly interface will contain a 4x3 keypad for input and a 16x2 LCD which uses I2C communication to display information clearly to allow untrained customers to operate the system to meet a good customer satisfaction due to better convenience.
- All system elements including the motor, display and keypad will operate smoothly through the Arduino Uno microcontroller which provides the necessary synchronization between these components.
- The system should include real-time monitoring capabilities through which users can activate and deactivate dispensing functions and reset system inputs and view visual feedback about all system activities.
- The system needs to maintain affordability while delivering durability and scalability which enables supermarkets and retail stores to adopt it easily without major expenses or complicated maintenance protocols.
- The system should reset itself automatically after completing every customer transaction, thus preparing for the next user without human assistance.

Limitations

The first version of this automated dispersion system has a lot of advantages but as with the first version this also has some limitations.

- **Product Type Restriction:**

  This system mainly designs dry products like grants like rice, dhal, and wheat etc. It may not be optimized for liquids, sticky materials, or extremely fine powders without optimizing system physical design.

- **Capacity Constraints:**

  the scaler created using 4*50kg load cells.so the system maximum holding capacity is 200kg.if need more capacity, need to replace scaler load cells with higher-capacity load cells.

- **Slight Over-dispensing Possibility:**

  While dispersion process, possibility to have the small amount of commodities over-dispensing. because process of stopping the Archimedes screw but that over dispersion has been minimized over smart controlling logics.

- **User Interface Simplicity:**

  in this first version has been used simple Metrix 4*3 keypad and 16*2 lcd display for user interface. But present days have lack of advanced features such as touch screens and voice commands.

- **Manual Refilling Requirement:**

  Once the store is empty the staff need to fill it manually. But that can develop another unit for automatic refilling to minimize human participation.

- **Single Product Handling:**

  This first version is optimized for a single product handle so it need one complete unit for each commodity. There can be an increase in the system buyers' cost.
  That can improve handling multiple commodities.

Apart from these limitations, the system meets its focused goal by providing the customers with a very user-friendly, comparatively fast and reliable way for the customers to measure and collect the required quantity of commodities they need without any staff involvement. Based on these limitations, future implementations can be done expanding based on real-world testing and feedback.

Chapter 02 - Literature Review

To understand the current development process of automated measurement and dispersion system, several articles are studied for understanding how the work of some sensors and components below,

L298N motor driver
hx711 load cell sensor
keypad
display

1. “Interface L298N DC Motor Driver Module with Arduino”
    a. This article discusses all about L298N motor driver like pins, example code, how to use limitations etc.… in this project use one gear motor and need to control it using motor driver. That makes it easier to control motor ether direct controlling.
2. “50kg Load Cells with HX711 and Arduino. 4x, 2x, 1x Diagrams.”
    a. This article is about 50kg load cells and HX711 module and discusses the different ways of arranging load cells, wiring and how they work of hx711 module. In this project, the scaler is used for measurement and dispersion processes so need to create high-capacity scalers so take resources using that article.
3. “Interface 4×3 & 4×4 Membrane Keypad with Arduino”
    a. The keypad has been used to take user input in this project so that article is used to go through how the 4*3 keypad works such as row pins, col pins and library.
4. “I2C Liquid Crystal Displays”
    a. This article is about 16*2 lcd display integrating with I2C module. That also discusses how it works with full detail. In this project, the display is used to interact with users and needs to reduce Arduino pin usage so that need to use I2C module for that purpose.

Chapter 03 – Methodology

System overview

This automated measuring and dispersion system has 3 main units and 2 supportive units. There are,

Main:

dispersion unit

This is the main mechanical part that is responsible for dispersion process. Includes store, Archimedes screw for push out items, gear motor for rotate Archimedes screw as we wish in low RPM.

control unit

This is a control unit like as brain. Main responsibility is executing logics controlling by all sensors and devices. That includes keypad for taking user inputs, display for display system process, L298N for control gear motor as system wish, 2 buck converters for 5v out for sensors and 11v out for Arduino power-up and Arduino-uno board for integrating all sensors and devices.

scaling unit

This is used to measure wight changing of the system. This is also one of the main parts of the system. Includes 4*50kg load cells for sense weight and HX711 for reading sensors and communication with Arduino.

Supportive:

power control unit

This is reducing voltage that is capable with control unit voltage usage.

power supply unit

This is supplying continues power for a system using AC current.

Important Components and Their Functions

Component	Purpose/Function
Plastic Barrel	Stores the product (e.g., wheat).
Archimedes Screw	Mechanically push out the product out when rotated.
Gear Motor (100 RPM)	Drives the Archimedes screw for dispensing.
L298N Motor Driver	Controls the direction and speed of the gear motor.
Load Cells (4 x 50kg)	Measures the weight of the dispensed material.
HX711 Module	Amplifies the load cell signals and sends weight data to Arduino.
Arduino Uno	Main controller that handles motor control, reading sensors, and user input.
4x3 Keypad	Takes the quantity input from the user.
16x2 LCD Display with I2C Module	Displays system status, inputs, and outputs to the user.
Down buck convertors LM2596	Adjectabale power reducing.

Circuit Implementation

All wirings are carefully connected. **Pin configurations are clearly mentioned in code implementation**.

Control unit:

L298N motor controller single motor connected to Arduino and make output for motor and implement two buck convertors one for 5V for power up display and HX711(via 5v out ports) second one for power up Arduino board.

main power supply fist connected with L298N and then distribute power to buck converters parallelly.

Keypad connected to digital pins and display connected via I2C protocol using Arduino SCL and SDA pins.

ports:

- 14v power in
- 12v motor power out
- 5v power out
- scaler data in and clock in

Scaler:

Scaler created using 4*50kg load cells and hx711 amplifier module. Load cells are connected in Wheatstone bridge arrangement. Then it connected to amplifier inputs and module out connected to output ports (+, -, data, clock).

Ports:

- 5v +
- Ground
- Data
- clock

Dispersion unit:

Dispersion unit have Archimedes screw, and it connected to gear motor and motor connected to motor driver.

Libraries Used (Header Files)

HX711_ADC.h

used for reading data from hx711 amplifier module. This provides useful and stable functions for reading hx711.

LiquidCrystal_I2C.h

used for controlling the 16*2 lcd display via I2C adaptor, minimizing wiring.

Wire.h

I2C needs this to communicate with Arduino.

Keypad.h

Used for reading signals from 4*3 matrix keypad.

Algorithm and Logic Flow

The system logic can be divided into clear steps:

Step 1:

User enters the required weight through the keypad.

- Input is displayed on the LCD screen for confirmation.
- User can press * to reset the input or # to confirm.

Step 2:

After confirmation:

- The current total weight (including the barrel) is tared to zero using the load cells.
- This ensures that only the dispensed product is measured.

Step 3:

Dispensing starts:

- The motor is activated, rotating the Archimedes screw to push the wheat out.
- If the target weight <= 600g then last 200g pulse delay is 20ms and the commodities before last 200g pulse delay is 80ms.
- If the target weight is > 600g, then motor continuously rotates when current weight meets last 400g and toggle it into prediction mode. And this also last 200g pulse delay is 20ms and the commodities before last 200g pulse delay is 80ms.

Step 4:

Real-time Monitoring:

- Arduino continuously reads the weight from the load cells while dispensing.
- If the current dispensed weight equals or exceeds the input quantity, the motor is immediately stopped.

Step 5:

After completing the dispensing:

- The system displays the final dispensed quantity and a "Thank you" message.
- After a 5-second delay, the system resets automatically and becomes ready for the next user.

Block Diagram

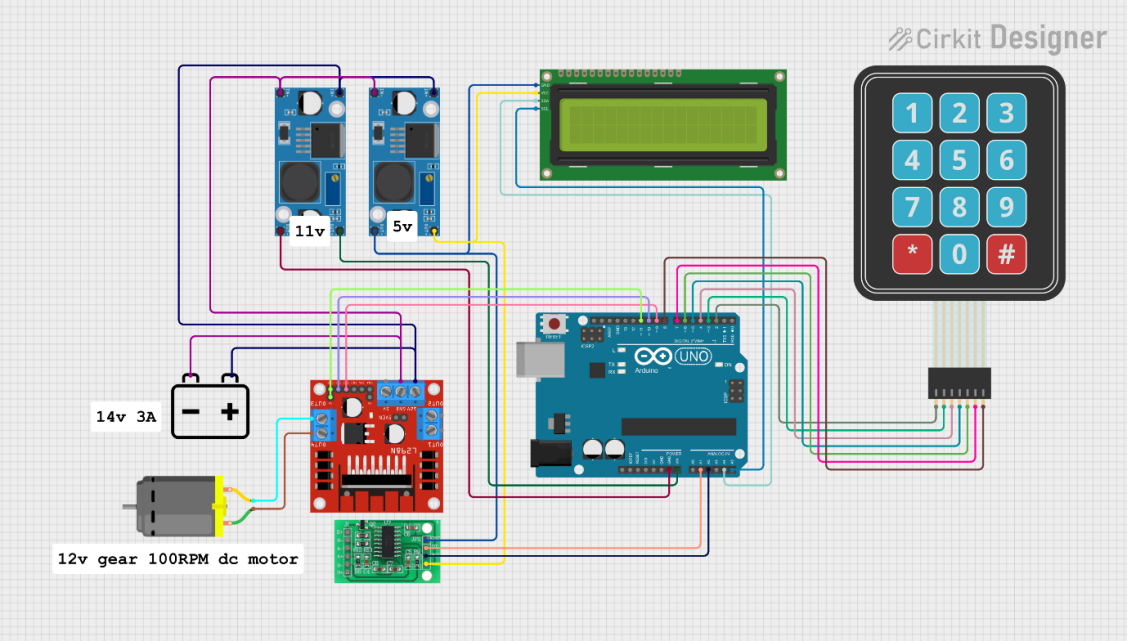

Figure 1circuit diagram

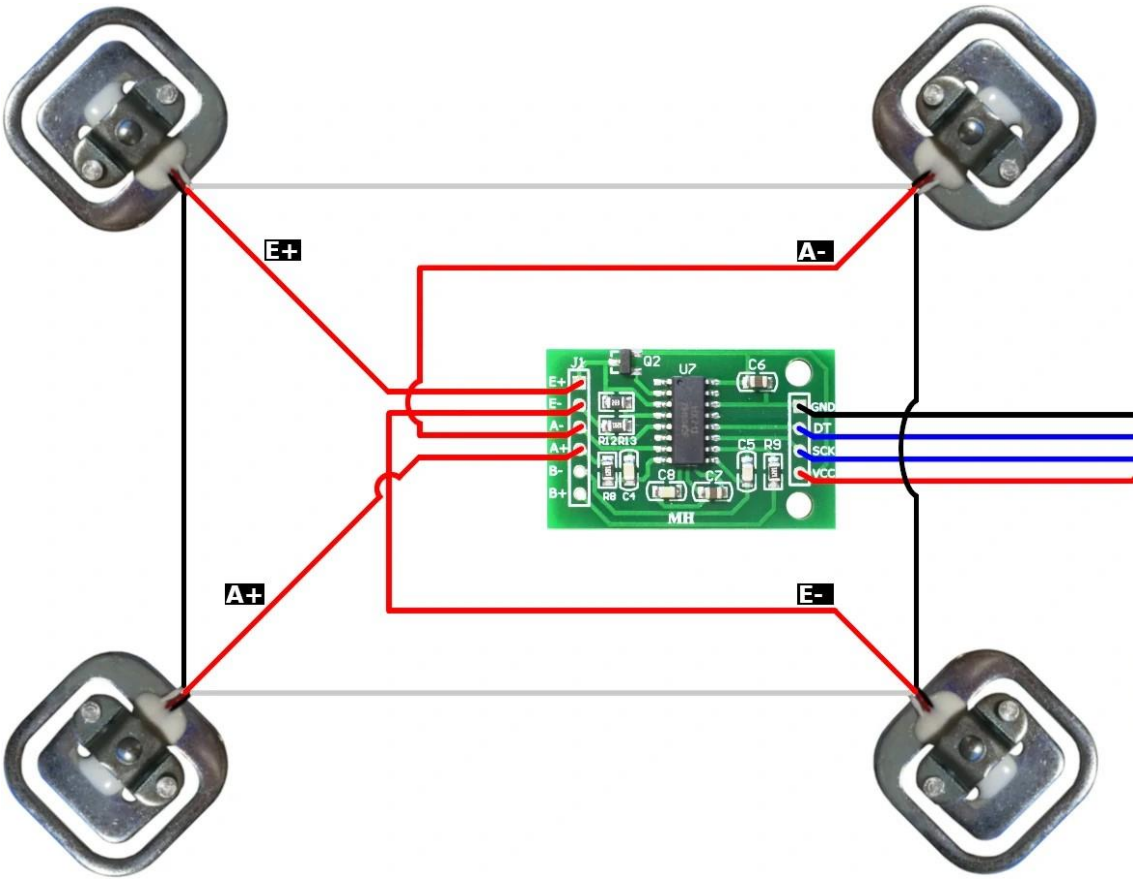

Figure 2 scaler diagram

Chapter 04 – Discussion

Problems Faced During the Project

- What is the best mechanism for pushing out commodities well controlled and reliable.
    - There is have lot of mechanisms to push commodities horizontally.so need to choose best way to that case.
- Screw blockage with screw casing.
    - Had to face screw blockage. The screw is touching it's casing when its rotating.so it's made extra friction.
- minimize friction between the screw and its casing connecting point.
    - Had to face large friction both of connecting points between crew axel and casing.
- The motor load power is not much for rotate screw.
    - Had faced unexpected behavior in gear motor, the first motor power is not much for rotating motors with high load.
- The motor is not connected well(stable) with storing bucket.
    - While rotating the screw using the motor, the motor had deviation of small amount from center.
- faced unexpected behavior with scaler readings.
    - While testing the scale had to face unexpected and unnatural readings.
- 5v, 11v and 14v power sources need to power up the system.
    - Lcd display and scale need 5v, motor controller needs 14v and Arduino needs to 11v.
- Unfortunately use damage jumper wires for wiring.
    - Had face unexpected behavior with keypad cause of using damaged jumper wires.

Solutions Implemented

- Choosing the best mechanism for push commodities
    - Choose Archimedes screw for that purpose. because it is repairable and accurate and easy to use.
- Reducing fraction between screw and casing
    - Had grind sharp then was able to remove 100% reaction between casing and screw.
- Reducing fraction between screw and casing connecting point.
    - Used two boll bearings to minimize fraction between connecting points.
- Choosing high powerful gear motor
    - Choose gear motor with high toque. The new motor is DC 12v 100RPM 3A motor. Its power is much for rotate screw without any disturbance.
- Stabilizing the motor.
    - The motor is tight using 4*4inch nut and bolt then it is stabilized.
- Solving unexpected behavior of scale
    - Used separate power sources to Arduino and scale in testing environment there for occur that unexpected behavior. Solution is making common ground. That project connected scaler power source ground to Arduino ground pin.
- Handling power supply.
    - Used two separate buck converters for 5v and 11v and take direct 14v power to motor controller and then distribute power to buck convertors parallelly. So, using that have able to use single power source to power up the system.
- Solving wiring issue
    - All jumper wires checked using multimeter and then used.

Future Implementations

The present software satisfies basic supermarket requirements, but our future versions will introduce various compelling enhancements:

- Automatic Refill Alert:
    - A sensor system monitors wheat supply levels which triggers automatic staff alerts when the barrel requires refilling.
- Multi-product Handling:
    - A single machine must have the capabilities to contain multiple products while a user menu should allow selection of desired products.
- Touchscreen Interface:
    - The latest improvement transforms keypad interfaces into touchscreen panels that provide users with contemporary experience with easy operation.
- IoT Connectivity:
    - The system will use integrated Wi-Fi or Bluetooth modules to transmit product usage information and maintenance notifications directly to supermarket management.
- Improved Motor Control:
    - The replacement of gear motors with stepper motors provides better screw rotation control which enhances the overall dispensing precision operation.
- Eco-Friendly Build:
    - The unit's environmental sustainability increases through the substitution of recycled material containers in place of plastic barrels.

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Gantt chart

		week 1 (March 4)	week 2	week 3	week 4	week 5	week 6	week 7	week 8 (April 28)
Planning									
Implementation	Architecture design and circuit design								
	Code development								
Testing									

Appendix

Budget:

https://docs.google.com/document/d/1DaOAFT8bQvEzSwUqmQyisoYYA060ICEjH8NpNxVbs-0/edit?usp=sharing

circuit diagram:

https://app.cirkitdesigner.com/project/1ef32f10-1c7f-408f-af8e-330d7ac19076

code:

https://github.com/AshenKavinda/Robotic_Arduino