



Design And Fabrication of Automated Multi Material Sorting System

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Abstract:-This paper presents the design and development of an automated three category material sorting system based on Arduino. The proposed system is designed to classify objects into metal, non-metal heavy(wood), and non-metal light(paper) categories. A metal sensor is used to identify metallic objects, while a load cell combined with an HX711 amplifier is used to determine the weight of non-metal objects. Arduino processes the sensor information and controls a conveyor and servo based sorting mechanism. Metal objects are directed to the metal collection bin without considering their weight. For objects identified as non-metal, the measured weight is compared with a predefined threshold to distinguish between heavy and light products. The proposed system provides a simple, low cost, and flexible approach to automated material segregation. The design

can be applied to small scale recycling, industrial material handling, and educational automation systems.

Keywords—Arduino, automated sorting, load cell, metal detection, material segregation, conveyor system, servo motor.

I. Introduction

Material segregation is an important operation in recycling, manufacturing, packaging, and waste management. Conventional sorting processes frequently depend on manual labor, which can be time consuming and may produce inconsistent results. Automation can improve sorting speed, reduce human effort, and provide repeatable operation.

developments in embedded systems have made it possible to construct low cost sorting machines using microcontrollers and sensors. Arduino platforms are particularly suitable for prototype development because they provide simple programming, multiple input and output interfaces, and compatibility with a wide range of sensors and actuators.

This work proposes an automated material sorting system that classifies products into three categories: metal, non-metal heavy, and non-metal light. The proposed system uses a metal sensor for material identification and a load cell for weight measurement. Arduino acts as the central controller and operates the sorting mechanism according to predefined decision conditions. Unlike systems that require several different material identification sensors, the proposed design focuses on two primary characteristics: metallic properties and weight. This makes the system relatively simple, economical, and suitable for small scale applications.

II. System Objectives

The main objectives of the proposed system are:

1. To develop an automated system for material segregation.
2. To detect metallic products using a metal sensor.
3. To measure the weight of non-metallic products using a load cell.
4. To classify non-metal products into heavy and light categories.
5. To control the sorting mechanism automatically using Arduino.



6. To reduce manual intervention during the sorting process.
7. To develop a low cost prototype that can be expanded for practical applications.

III. Proposed System

The proposed system consists of a conveyor mechanism, metal sensor, load cell, HX711 amplifier, Arduino controller, motor driver, DC motor, servo motors, and three collection bins.

The product is placed on the conveyor and transported toward the sensing section. The metal sensor first determines whether the product contains metal. If metal is detected, Arduino classifies the product as metal and activates the appropriate sorting mechanism. If the product is identified as non-metal, it is positioned on the load cell. The load cell measures the applied weight, and the HX711 module amplifies and converts the load-cell signal into a digital value. Arduino processes this value and compares it with a predefined weight threshold. Products above or equal to the threshold are classified as non-metal heavy, while products below the threshold are classified as non-metal light.

The three categories are therefore:

Category 1: Metal

Category 2: Non-metal heavy(wood)

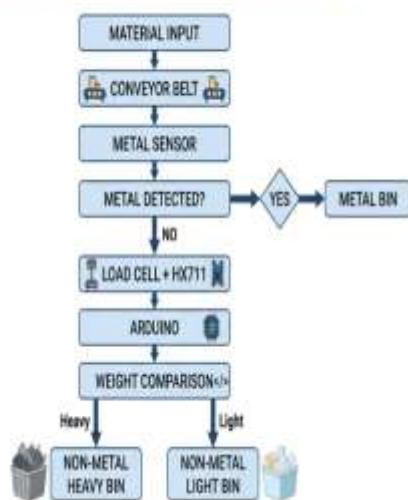
Category 3: Non-metal light(Paper)

IV. System Architecture

The overall operation of the system can be represented as:

Material Input → Conveyor → Metal Sensor → Arduino → Load Cell for Non-metal Products → Weight Classification → Servo Sorting Mechanism → Three Collection Bins

MATERIAL SORTING PROCESS DIAGRAM



The Arduino receives information from the metal sensor and HX711 module. Based on the sensor conditions, it generates control signals for the conveyor and servo motors.

The decision sequence is:

Metal detected → Metal

Metal not detected + weight $\geq$ threshold → Non-metal heavy

Metal not detected + weight $<$ threshold → Non-metal light

This decision hierarchy ensures that metal detection has priority over weight classification.

V. Hardware Components

A. Arduino Uno

Arduino Uno is used as the central processing and control unit. It receives sensor data, executes the sorting algorithm, and generates control signals for the motors and servo actuators.

The controller performs the following operations:

- Reads the metal sensor output.
- Receives weight information from the HX711.

- Compares measured weight with the threshold.
- Controls conveyor movement.
- Operates the sorting servo mechanism.
- Repeats the sorting sequence for subsequent products.

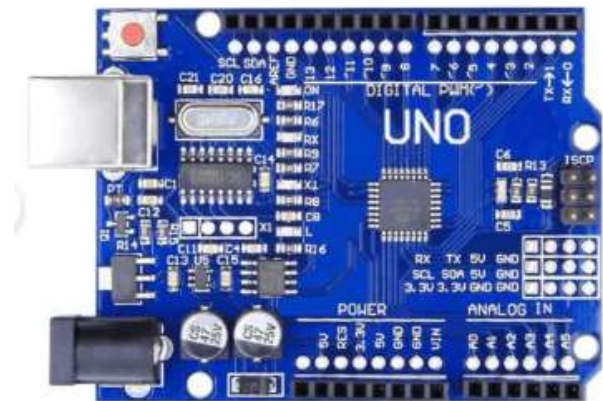


Fig .0.1 Arduino Uno

B. Metal Sensor

The metal sensor is responsible for detecting metallic objects. When a product enters the detection region, the sensor produces an electrical output corresponding to the presence or absence of metal.

If the sensor detects metal, the Arduino immediately assigns the product to the metal category. This avoids unnecessary weight-based classification of metallic objects.



Fig.0.2 metal sensor

C. Load Cell

The load cell is used to measure the weight of non-metal products. When a product is placed on the load-cell platform, mechanical force causes a small electrical signal to be generated. The magnitude of this signal corresponds to the applied load. Proper calibration is required to convert the sensor output into a meaningful weight value.

D. HX711 Module

The HX711 is a precision amplifier and analog-to-digital converter designed for load-cell applications. It amplifies the small electrical signal from the load cell and provides digital data that can be read by Arduino.

The combination of the load cell and HX711 allows the system to obtain weight measurements suitable for the sorting algorithm.

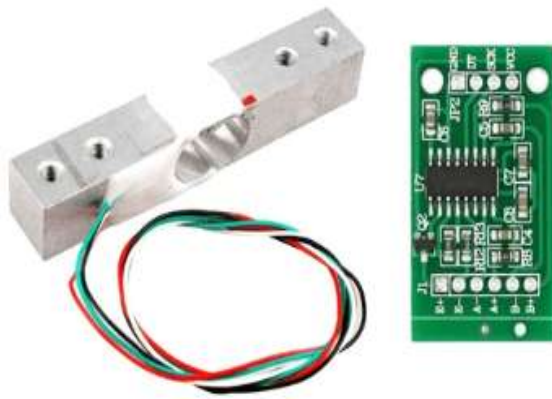


Fig.0.3 Load cell

E. Stepper Motor System

A stepper motor is used to move and position the material accurately during the sorting process. The motor is controlled by Arduino through a suitable stepper motor driver. It provides precise rotational movement, allowing the product to be positioned correctly at the metal sensor, load-cell, and sorting sections. The stepper motor can be programmed to move a specific number of steps and stop at predetermined positions, improving the accuracy and repeatability of the sorting operation.

F. Servo Motor

Servo motors are used to operate the sorting gates. According to the category determined by Arduino, the corresponding gate is moved to direct the product into the appropriate collection bin.

VI. Methodology

The operation of the proposed system consists of the following stages.

A. Product Feeding

A product is placed on the conveyor belt. The conveyor transports the product toward the metal detection area.

B. Metal Detection

The metal sensor checks the product.

If the sensor output indicates metal, the Arduino selects the metal sorting path.

If the sensor does not detect metal, the product continues toward the load-cell section.

C. Weight Measurement

The non-metal product is positioned on the load cell. The load-cell output is processed through the HX711 module. Arduino obtains the corresponding weight measurement.

D. Weight Classification

The measured weight is compared with a predetermined threshold, represented by (W_T).

The classification can be expressed as:

$$C = \begin{cases} \text{Metal,} & M = 1 \\ \text{Non-metal heavy,} & M = 0 \text{ and } W \geq W_T \\ \text{Non-metal light,} & M = 0 \text{ and } W < W_T \end{cases}$$

where (M) represents the metal sensor state, (W) is the measured weight, and (W_T) is the selected weight threshold.

E. Sorting

After classification, Arduino sends a control signal to the corresponding servo motor. The sorting gate moves to guide the product into the selected bin.

After the product has been sorted, the mechanism returns to its initial position and the next sorting cycle begins.

VII. Control Algorithm

The control algorithm can be summarized as follows:

1. Initialize Arduino and all connected devices.
2. Start the conveyor.
3. Detect the incoming product.
4. Check the metal sensor.
5. If metal is detected, select the metal bin.
6. If metal is not detected, measure product weight.
7. Compare the measured weight with the threshold.
8. If weight is greater than or equal to the threshold, select the non-metal heavy bin.
9. If weight is below the threshold, select the non-metal light bin.
10. Activate the corresponding servo.
11. Allow the product to enter the selected bin.
12. Return the servo to its initial position.
13. Repeat the process.

VIII. Experimental Setup

A prototype can be constructed using an Arduino Uno mounted on a supporting frame. The conveyor belt is driven by a DC motor through a motor driver. The metal sensor is positioned near the conveyor to detect metallic products.

The load cell is installed at a dedicated weighing position. The HX711 module connects the load cell to the Arduino. Servo-operated gates are placed near the end of the conveyor so that products can be directed into three separate bins.

Before testing, the load cell should be calibrated using known reference weights. The weight threshold should then be selected according to the intended application.



Fig.0.4 Prototype of the developed automated material sorting system

For experimental evaluation, products representing all three categories can be repeatedly introduced into the system. The actual category determined by the operator can be compared with the category selected automatically by the system.



IX. Results and Discussion

The proposed system provides a straightforward method for three category material segregation. The metal sensor enables the controller to distinguish metallic objects from non-metallic objects. Once a product is classified as non-metal, the load cell provides the second decision parameter based on weight.

The performance of the system depends on several factors, including sensor calibration, conveyor speed, load-cell stability, metal sensor sensitivity, and servo response time. Mechanical vibration should be minimized during weight measurement because vibration can cause fluctuations in load-cell readings.

The weight threshold is another important parameter. An inappropriate threshold may cause a heavy product to be classified as light or vice versa. Therefore, the threshold should be determined experimentally according to the products being sorted.

A suitable evaluation can use the following parameters:

Sorting Accuracy

The sorting accuracy is calculated as the percentage of products correctly classified by the proposed system.

$$\text{Sorting Accuracy} = \frac{\text{Number of correctly sorted products}}{\text{Total number of tested products}} \times 100$$

Sorting Error

The sorting error represents the percentage of products that are incorrectly classified by the system.

$$\text{Sorting Error} = \frac{\text{Number of incorrectly sorted products}}{\text{Total number of tested products}} \times 100$$

The relationship between sorting accuracy and sorting error is:

$$\text{Sorting Accuracy} + \text{Sorting Error} = 100\%$$

These parameters can be used to evaluate the performance and reliability of the automated three-category material sorting system.

X.

Advantages

The proposed system has several advantages:

- Simple system architecture.
- Low-cost electronic components.
- Automatic material classification.
- Reduced requirement for manual sorting.
- Adjustable weight threshold.
- Easy Arduino programming and modification.
- Three separate output categories.
- Suitable for prototype development and educational applications.
- Can be expanded with additional sensors and actuators.

XI. Limitations

Although the proposed system provides an effective prototype approach, several limitations should be considered.

First, the accuracy of weight classification depends on load-cell calibration and mechanical stability. Conveyor vibration can introduce errors in the weight measurement. Second, metal detection depends on the type, size, and distance of the metallic object from the sensor. Third, the system classifies non-metal products only according to weight and therefore cannot distinguish between different non-metal materials having similar weights.

The sorting speed is also limited by the time required for stable weight measurement and servo operation. These limitations can be addressed through improved mechanical design, sensor selection, signal filtering, and optimized control algorithms.

XII. Applications

The proposed sorting system can be applied in:

- Small-scale recycling systems.
- Waste segregation systems.
- Manufacturing material handling.
- Packaging and production lines.
- Educational automation laboratories.
- Prototype industrial sorting machines.
- Material collection and segregation systems.

XIII. Future Scope

Several improvements can be incorporated into future versions of the system.

A color sensor can be added to identify products based on color. Additional material sensors can be introduced to distinguish plastic, glass, paper, and other materials. An LCD or other display can be used to show the measured weight and detected category. Internet of Things connectivity can also be incorporated for remote monitoring and data collection. The number of products in each category could be automatically recorded and transmitted to a monitoring system.

For industrial applications, a higher-speed conveyor, industrial sensors, pneumatic actuators, and more advanced controllers could be used. Machine-learning techniques could also be explored for more complex material identification.

XIV. Conclusion

This paper presented the design of an automated three category material sorting system using Arduino, a metal sensor, and a load cell. The proposed system classifies products into metal, non-metal heavy, and non-metal light categories.

Metal detection is performed first, giving priority to the identification of metallic products. For non-metal products, a load cell and HX711 module are used to measure weight. Arduino compares the measured weight with a predefined threshold and controls the sorting mechanism accordingly.

The proposed approach provides a simple, economical, and flexible solution for automated material segregation. Its modular architecture allows additional sensors, communication systems, and advanced control techniques to be incorporated in future developments.

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References

- [1] M. Margolis, B. Jepson, and N. R. Weldin, Arduino Cookbook: Recipes to Begin, Expand, and Enhance Your Projects, 3rd ed. Sebastopol, CA, USA: O'Reilly Media, 2020.
- [2] Arduino, "Arduino UNO Rev3," Arduino Documentation. [Online]. Available: [Arduino UNO Rev3 Documentation](https://www.arduino.cc/en/Reference/ArduinoUNORev3)
- [3] Arduino, "Arduino UNO Rev3 Technical Specifications," Arduino Official Store. [Online]. Available: [Arduino UNO Rev3 Technical Specifications](https://www.arduino.cc/en/Reference/ArduinoUNORev3)
- [4] Avia Semiconductor, "HX711 24-Bit Analog-to-Digital Converter (ADC) for Weigh Scales," Datasheet, Avia Semiconductor.
- [5] J. Fraden, Handbook of Modern Sensors: Physics, Designs, and Applications, 5th ed. Cham, Switzerland: Springer, 2016.
- [6] R. S. Pressman and B. R. Maxim, Software Engineering: A Practitioner's Approach, 9th ed. New York, NY, USA: McGraw-Hill Education, 2019.
- [7] A. S. Sedra and K. C. Smith, Microelectronic Circuits, 7th ed. New York, NY, USA: Oxford University Press, 2014.



- [8] J. W. Nilsson and S. A. Riedel, Electric Circuits, 10th ed. Boston, MA, USA: Pearson, 2015.
- [9] R. C. Dorf and J. A. Svoboda, Introduction to Electric Circuits, 9th ed. Hoboken, NJ, USA: Wiley, 2014.
- [10] J. J. Craig, Introduction to Robotics: Mechanics and Control, 3rd ed. Upper Saddle River, NJ, USA: Pearson Prentice Hall, 2005.
- [11] M. P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 4th ed. Upper Saddle River, NJ, USA: Pearson, 2015.
- [12] K. Ogata, Modern Control Engineering, 5th ed. Upper Saddle River, NJ, USA: Prentice Hall, 2010.
- [13] B. K. Bose, Modern Power Electronics and AC Drives. Upper Saddle River, NJ, USA: Prentice Hall, 2002.
- [14] R. H. Bishop, Ed., The Mechatronics Handbook, 2nd ed. Boca Raton, FL, USA: CRC Press, 2007.
- [15] W. Bolton, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, 6th ed. Harlow, U.K.: Pearson, 2015.

- [16] S. Monk, Programming Arduino: Getting Started with Sketches, 2nd ed. New York, NY, USA: McGraw-Hill Education, 2016.
- [17] M. Banzi and M. Shiloh, Getting Started with Arduino: The Open Source Electronics Prototyping Platform, 3rd ed. Sebastopol, CA, USA: Maker Media, 2014.
- [18] M. A. Mazidi, S. Naimi, and S. Naimi, The AVR Microcontroller and Embedded Systems: Using Assembly and C. Upper Saddle River, NJ, USA: Pearson, 2011.
- [19] S. S. Rattan, Theory of Machines, 4th ed. New Delhi, India: McGraw Hill Education, 2017.
- [20] R. K. Jain, Production Technology: Manufacturing Processes, Technology and Automation, 17th ed. New Delhi, India: Khanna Publishers, 2018.
- [21] P. N. Rao, Manufacturing Technology: Metal Cutting and Machine Tools, 4th ed. New Delhi, India: McGraw Hill Education, 2013.
- [22] S. K. Saha, Introduction to Robotics, 2nd ed. New Delhi, India: McGraw Hill Education, 2014.
- [23] M. P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, 6th ed. Hoboken, NJ, USA: Wiley, 2019.
- [24] R. Isermann, Mechatronic Systems: Fundamentals. London, U.K.: Springer, 2005.
- [25] Texas Instruments, "HX711 24-Bit Analog-to-Digital Converter for Weigh Scales," Texas Instruments, Dallas, TX, USA, Datasheet.