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Automatic Soil Irrigation and Soil Monitoring System

Rohan Patil[1], Himanshu Shukla[2], Pruthvit Kshirsagar[3], Soham Patil[4],
Mrs. Archana S. Jadhav[5] (Project Guide)
Department of Mechatronics[1-5]
Marathwada Mitra Mandal's Polytechnic, Pune, Maharashtra, India

Abstract: *The Automatic Irrigation and Soil Monitoring System is designed to automate the process of watering plants by using real-time data collected from sensors. The system continuously monitors soil moisture, temperature, and humidity to determine the water requirement of crops. When the soil moisture level falls below a predefined threshold, the system automatically activates a water pump to irrigate the field, and when the moisture level reaches the required*
value, the pump is turned off. The project utilizes an ESP32 microcontroller as the control unit, interfaced with a soil moisture sensor, DHT11 temperature and humidity sensor, and a relay module to operate the pump. The collected data is transmitted to an IoT platform such as Blynk or Thing Speak, enabling farmers to monitor environmental conditions remotely through a smartphone or computer. This system minimizes water wastage, reduces human effort, and ensures efficient irrigation, making it a cost-effective and eco-friendly solution for modern agriculture. The project demonstrates the potential of IoT-based smart farming technologies in promoting sustainable and precise agricultural practices.

Keywords: ESP 32, DHT11, IoT, Thing Speak

I. INTRODUCTION

Automation is widely used in modern industries to perform operations with minimum human intervention. It improves productivity, accuracy, and efficiency while reducing human effort and human errors. In industries such as manufacturing, packaging, and material handling, conveyor belt systems are commonly used for transporting objects.

Sorting of objects is an important process in these systems. Traditionally, sorting is done manually, which is time-consuming, less accurate, and dependent on human performance. This reduces overall efficiency and increases labor cost.

To overcome these limitations, automated sorting systems are developed. The present project, Automated Object Sorting Conveyor Belt System, is designed to automatically sort objects based on their colour and size (height) using sensors and motors. The system uses simple and cost-effective components, making it suitable for small-scale industrial and educational applications

II. BACKGROUND OF THE PROJECT

In traditional industrial setups, sorting operations are performed manually by workers. This method is not efficient for large-scale production and results in errors due to human limitations. Continuous manual work also causes fatigue, which further reduces efficiency.

With the advancement in automation, industries are shifting towards automatic systems that can perform sorting operations continuously and accurately. These systems use sensors for detection and motors for actuation.

In this project, sorting is performed based on two parameters: colour and size. Instead of using complex systems, simple sensors and motors are used to achieve automation.

The servo motor is used for colour-based sorting, where it diverts objects into different bins based on their colour. The stepper motor is used for size-based sorting, where objects are positioned or directed based on their height. This combination makes the system efficient and easy to implement.

III. METHODOLOGY

The methodology describes the systematic procedure followed for the design and development of the Automated Object Sorting Conveyor Belt System. It includes concept planning, component selection, mechanical design, electrical circuit design, programming, assembly, and testing.

A structured approach was followed to ensure proper coordination between sensing, control, and actuation components. The system integrates sensors and motors with a microcontroller to achieve automatic sorting of objects based on colour and size (height).

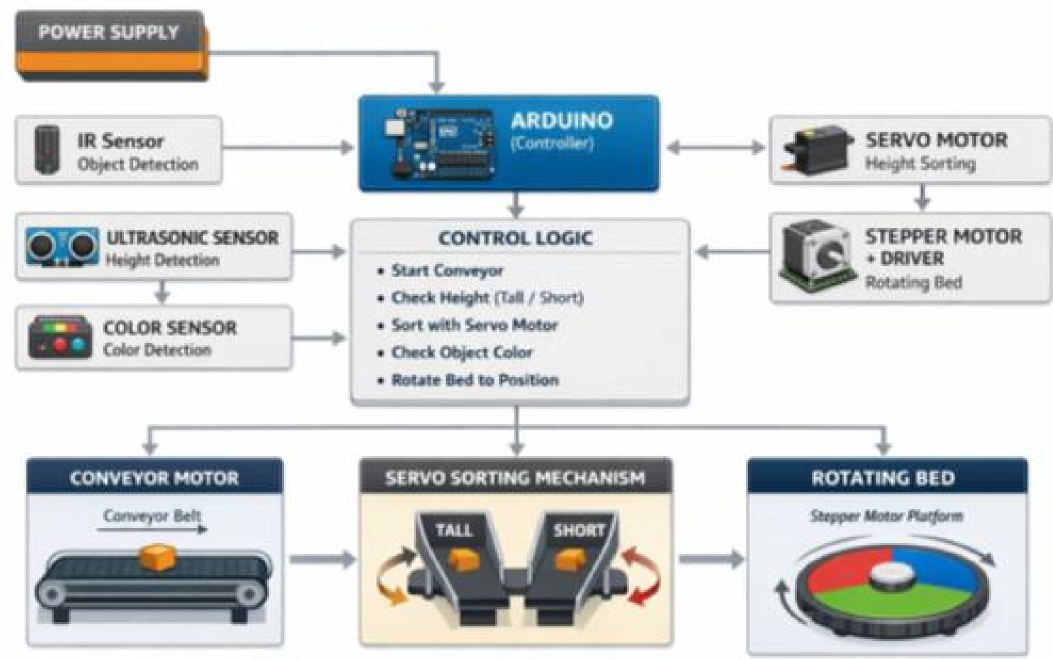

Fig 1: Functional Block Diagram of Object Sorting Conveyor System

- Step-by-Step Working

1. System Start: The system is switched ON and all components start working.
2. Conveyor Movement: The DC motor runs the conveyor belt and moves the objects forward.
3. Object Detection: The IR sensor detects the object on the conveyor and sends a signal to Arduino.
4. Height Detection: The ultrasonic sensor measures the height of the object and sends data to Arduino.
5. Color Detection: The color sensor detects the color of the object.
6. Processing (Arduino): The Arduino processes all inputs (color + height) and decides how to sort the object.
7. Color Sorting (Servo Motor): The servo motor rotates to a specific angle and directs the object based on its color.
8. Height Sorting (Stepper Motor): The stepper motor moves to position the object according to its height.
9. Final Output: The object is dropped into the correct bin.
10. Repeat Process: The system continues the same process for the next object.

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IV. SYSTEM DESIGN APPROACH

The system is divided into two main parts:

Mechanical System

The mechanical system includes the conveyor structure, motor mounting, sorting mechanism, and bins.
The design ensures:

- Proper alignment of conveyor belt
- Smooth movement of objects
- Accurate positioning for sorting
- Stable mounting of motors and components Main

Mechanical elements include:

- Conveyor belt driven by DC motor
- Frame structure for mounting components
- Sorting bins for collecting objects
- Servo-based diverter mechanism
- Stepper motor-based positioning system

Electrical and Control System

The electrical system includes sensors, controller, motor drivers, and power supply. The control system is responsible for:

- Receiving input from sensors
- Processing data using Arduino
- Controlling motors based on logic
- Executing sorting operations

It ensures proper synchronization between all components.

Selection of Components:

The components were selected based on simplicity, availability, cost, and compatibility. The main components include:

1. **Arduino Uno** – used as the control unit
2. **IR Sensor** – used for object detection
3. **DC Motor** – used to drive the conveyor belt
4. **Servo Motor** – used for color-based sorting
5. **Stepper Motor** – used for size-based sorting
6. **Motor Driver (L298N or equivalent)** – used to control DC and stepper motor
7. **Power Supply (12V DC Adapter)** – used to provide power
8. **Buck Converter** – used for voltage regulation

Mechanical Design and Fabrication

The mechanical structure was designed to support all components and ensure proper functioning. A layout was prepared to define:

- Position of conveyor belt
- Placement of sensors
- Mounting of motors
- Location of sorting bins

The structure was fabricated using lightweight materials such as acrylic or plywood. The system includes:

1. Base platform for mounting components
2. Conveyor belt system driven by DC motor
3. IR sensor positioned for object detection
4. Servo motor attached to a diverter arm
5. Stepper motor connected for size-based positioning
6. Sorting bins placed at output

Proper alignment and secure mounting were ensured for smooth operation.

Electrical Circuit Design:

The electrical circuit was designed to ensure safe and proper functioning of all components. The system is powered using a 12V DC power supply. The power is distributed as follows:

1. DC motor and stepper motor are powered through the motor driver
2. Arduino and servo motor require 5V supply
3. Buck converter is used to step down voltage from 12V to 5V

Connections include:

- IR sensor connected to Arduino input pin
- Motor driver connected to Arduino digital pins
- Servo motor connected to PWM pin
- Stepper motor connected via motor driver

All components are connected to a common ground to ensure proper circuit operation.

Programming and Control Logic

The system is controlled using a program written in Arduino IDE. The control logic includes:

1. Reading input from IR sensor
2. Detecting object presence
3. Processing sorting conditions
4. Controlling servo motor for color sorting
5. Controlling stepper motor for size sorting
6. Maintaining proper timing and synchronization

1) Sequence of Operation:

1. Conveyor belt starts moving
2. Object reaches detection point
3. IR sensor detects object
4. Arduino processes object data
5. Servo motor rotates to sort based on colour
6. Stepper motor activates for size-based sorting
7. Object is placed into the correct bin
8. System repeats for next object

Assembly and Integration

All components were assembled to form the complete system. The process included:

1. Mounting DC motor and conveyor belt
2. Fixing IR sensor at detection point
3. Installing servo motor for sorting mechanism
4. Mounting stepper motor for size sorting

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5. Connecting all electrical components
6. Organizing wiring properly

Proper insulation and secure connections were ensured to avoid faults.

Testing and Troubleshooting

The system was tested to verify its performance and reliability. Testing involved:

1. Checking power supply and voltage levels
2. Verifying IR sensor operation
3. Testing DC motor and conveyor movement
4. Checking servo motor rotation
5. Testing stepper motor control
6. Verifying sorting accuracy
7. Ensuring proper sequence of operation

Any issues found were corrected through:

- Wiring adjustments
- Program modification
- Component alignment

V. DETAIL OF DESIGN, WORKING AND PROCESSES

The system is designed as a compact automation model that includes conveyor mechanism, sensing unit, control unit, and sorting section.

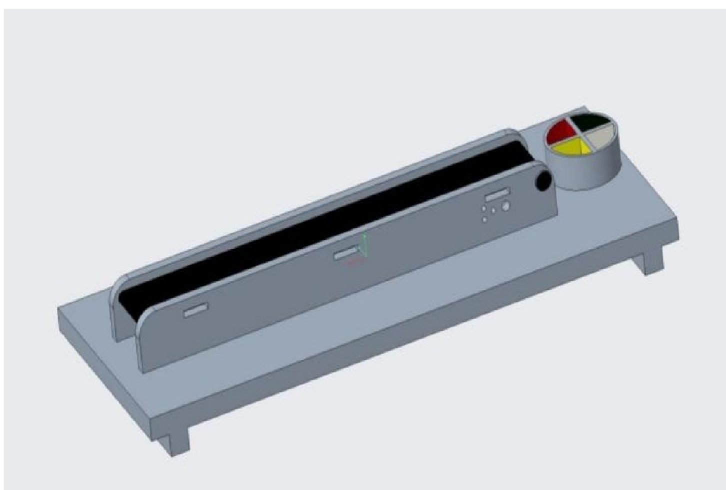

Fig 2. 3D Model of the system.

The main components used in the system are:

- Conveyor belt driven by DC motor
- IR sensor for object detection
- Color detection arrangement
- Arduino Uno microcontroller
- Servo motor for color-based sorting

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- Stepper motor for size-based sorting
- Sorting bins for collection

The objects are placed on the conveyor belt and move forward. During movement, the sensors detect the object and send signals to the controller. Based on the programmed logic, the object is sorted into the correct bin.

Fig 3. (Top view of real model).

Mechanical Design

The mechanical design is important for smooth and continuous operation of the system.
The mechanical structure consists of:

- A wooden base frame to support the system
- Conveyor belt mounted on rollers
- DC motor connected to pulley for belt movement
- Supporting structures for sensors and sorting mechanism
- Sorting bins placed at the end

The conveyor belt is properly aligned on rollers to reduce friction and ensure smooth motion. The DC motor rotates the pulley, which drives the belt continuously.
A servo motor is attached near the sorting section to divert objects based on color. A stepper motor is used to control size-based sorting. The structure is simple, stable, and easy to maintain.

Electrical Design and Components

The electrical system controls the working of all components.

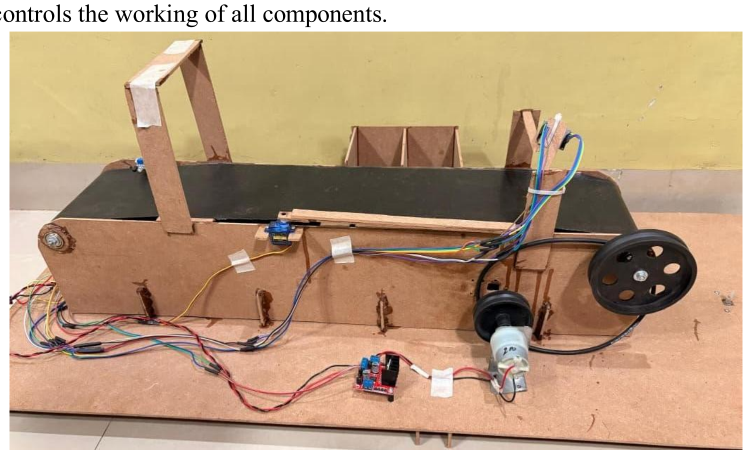

Fig 4. (Side view with wiring and components).

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The main electrical components are:

- **Arduino Uno** – acts as the main controller
- **IR sensor** – detects object presence
- **L298N motor driver** – controls DC motor and stepper motor
- **DC motor** – drives the conveyor belt
- **Servo motor** – used for color sorting
- **Stepper motor** – used for size sorting
- **Power supply (5V/12V)** – provides required voltage

The IR sensor sends signals to the Arduino when an object is detected. The Arduino processes the signal and controls motors using the motor driver.
The servo motor is controlled using PWM signals, while the stepper motor is controlled using step sequence signals.
Proper wiring and connections ensure smooth and safe operation of the system.

Working Principle

The system works automatically based on programmed instructions in the Arduino. The working steps are as follows:
The conveyor belt starts moving using a DC motor
Objects are placed on the belt

1. The IR sensor detects the presence of an object
2. The sensor sends a signal to the Arduino
3. The system identifies the color of the object
4. The servo motor rotates to a specific angle
5. The object is diverted into the corresponding bin
6. The size of the object is checked
7. The stepper motor adjusts the sorting position
8. The object is finally collected in the correct bin

This process continues automatically for all objects placed on the conveyor.
Program

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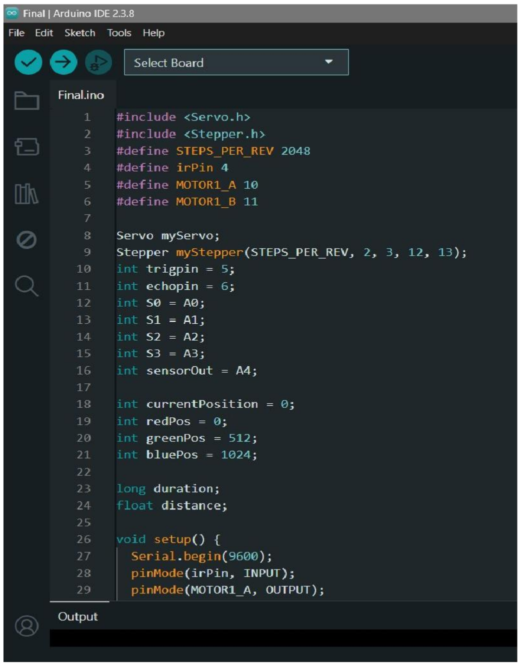

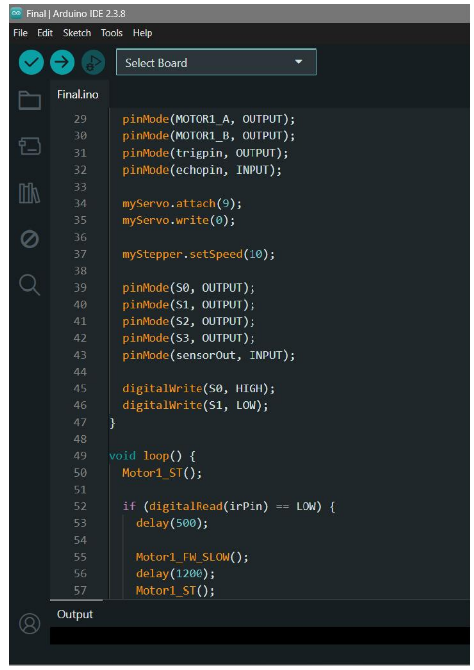

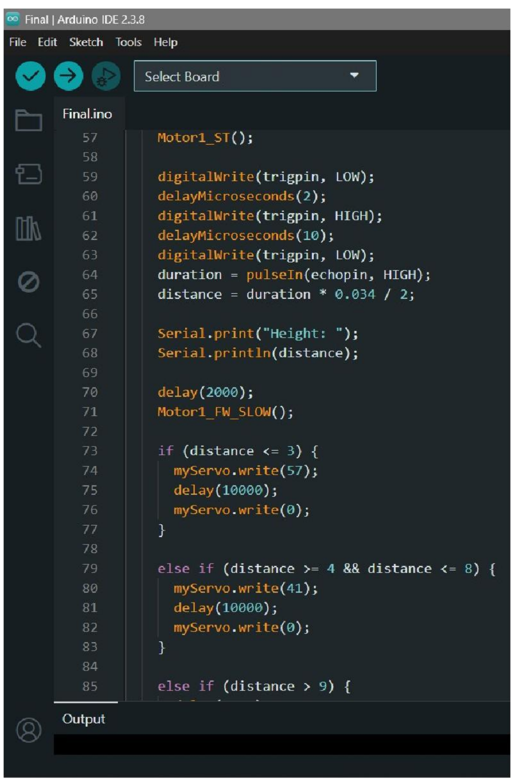

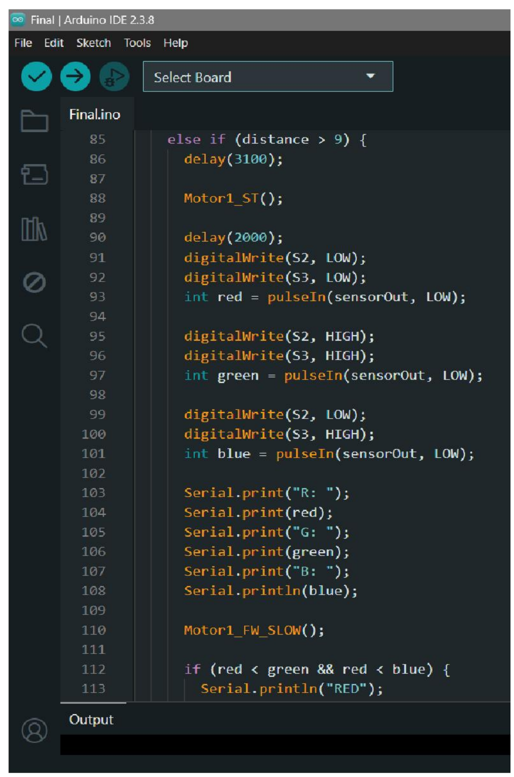

Colour-Based Sorting Mechanism

Colour sorting is performed using a servo motor mechanism.

Each color is assigned a specific angle of rotation. When the color is detected, the servo motor rotates to that angle and diverts the object.

Example:

- Red object → Servo rotates to 0° → Bin 1
- Green object → Servo rotates to 90° → Bin 2
- Blue object → Servo rotates to 180° → Bin 3

A small flap or guiding plate attached to the servo motor pushes the object into the correct bin. This method is fast, simple, and accurate.

Size-Based Sorting Mechanism

Size-based sorting is done using a stepper motor.

Objects are classified based on their size (small or large). The stepper motor rotates in fixed steps and adjusts the position of a gate or platform.

Example:

- Small objects → Allowed to pass directly
- Large objects → Diverted to another path

The stepper motor provides precise control, which improves accuracy in sorting.

Role of Sensors

Sensors play a key role in automation.

IR Sensor:

- Detects the presence of an object
- Sends signal to Arduino
- Helps in timing and synchronization

Sensors help in reducing human effort and improving system efficiency.

Control System and Programming

The control system is based on Arduino programming. The Arduino performs the following functions:

- Reads input signals from sensors
- Processes the sorting logic
- Sends output signals to motors
- Controls servo motor using PWM
- Controls stepper motor using step sequence

The program ensures proper coordination between conveyor movement, detection, and sorting.

Process Flow

The overall process of the system is:

- System starts
- Conveyor belt turns ON
- Object is placed on belt
- IR sensor detects object

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- Color is identified
- Servo motor activates
- Size is detected
- Stepper motor activates
- Object is sorted into bin
- Process repeats

Conclusion

The Automated Object Sorting Conveyor System is successfully designed and implemented. It can sort objects based on color and size using sensors and microcontroller. The system is efficient, reliable, and demonstrates practical application of automation. It can be further improved for industrial use by adding advanced sensors and high-speed mechanisms.

VI. RESULT AND APPLICATIONS

The automated sorting system was successfully designed, assembled, and tested. The system performed all the intended operations according to the programmed logic in the Arduino controller.

During testing, the following results were observed:

1. The conveyor belt operated smoothly using the DC motor without jerks
2. The IR sensor accurately detected the presence of objects on the conveyor
3. Objects moved continuously and reached the sorting section properly
4. The Arduino controller processed input signals correctly and executed the sequence without delay
5. The servo motor successfully sorted objects based on color by rotating to predefined angles
6. The stepper motor effectively separated objects based on size (height)
7. Objects were directed into the correct bins with proper coordination
8. The system was able to perform repeated operations continuously without failure
9. The synchronization between conveyor movement and sorting mechanism was maintained

These results confirm that the system successfully achieved its objective of automatic sorting of objects based on multiple parameters.

Performance Analysis

The performance of the system was analyzed based on different parameters such as response time, accuracy, smoothness, and stability.

Sensor Performance:

The IR sensor showed reliable performance in detecting objects. It responded quickly and provided accurate signals to the Arduino. Proper positioning of the sensor ensured consistent detection without missing any object.

Conveyor System Performance:

The DC motor-driven conveyor belt provided continuous and uniform motion. The system ensured that objects moved steadily without slipping or stopping. The alignment of the belt played an important role in maintaining smooth operation.

Servo Motor Performance (Color Sorting)

The servo motor performed efficiently by rotating to precise angles required for color-based sorting. It successfully directed objects into different bins based on their color. The motion was smooth and consistent across multiple cycles.

Stepper Motor Performance (Size Sorting)

The stepper motor provided accurate and controlled movement for size-based sorting. Its step-by-step operation allowed precise positioning, ensuring correct separation of objects based on height.

Control System Performance

The Arduino-based control system worked effectively as the central unit. It processed sensor inputs and controlled all motors in a synchronized manner. The programmed sequence was executed correctly without any interruption or error.

Power System Performance

The power supply system provided sufficient and stable power to all components. The use of a buck converter ensured proper voltage regulation for sensitive components like Arduino and servo motor. No major fluctuations or failures were observed.

Overall, the system showed stable, reliable, and repeatable performance, which is suitable for a prototype-level automation project.

Limitations

Although the system performed successfully, some limitations were observed due to its prototype design:

1. The system is limited to sorting based only on color and size parameters
2. It cannot identify objects with complex shapes or materials
3. Accuracy may vary depending on sensor calibration and environmental conditions
4. The system operates on a fixed program and cannot adapt to changing inputs
5. It is suitable only for small-scale applications
6. The conveyor speed is limited and not suitable for high-speed industrial use
7. The mechanical structure supports only lightweight objects
8. External factors such as light intensity and dust may affect sensor performance

These limitations are expected in a small-scale model and provide scope for future improvements.

VII. APPLICATIONS

The developed system is a prototype, but its concept is widely used in real-world industrial applications. With further improvements, it can be applied in various fields.

Some important applications include:

1. Packaging Industries: Used for sorting products based on size, color, or type
2. Manufacturing Industries: Used in material handling and automated production lines
3. Food Processing Industries: Used for grading and sorting fruits and vegetables
4. Recycling Plants: Used for separating materials such as plastic, metal, and paper
5. Assembly Line Automation: Used for sorting and distributing components
6. Warehouse Automation : Used for organizing and managing goods
7. Educational and Training Systems: Used for learning automation, robotics, and mechatronics

The project demonstrates basic automation principles that can be applied to advanced industrial systems.

VIII. CONCLUSION

The project successfully demonstrates the design and implementation of an automated object sorting system using a microcontroller-based control approach. The integration of sensors, conveyor mechanism, and motor-driven sorting units resulted in a functional system.

The system achieved its objective by accurately sorting objects based on color and size. It provided practical knowledge of automation, sensor usage, and motor control.

Although the system has certain limitations, it serves as a strong foundation for further development. With improvements such as advanced sensors and controllers, the system can be upgraded for real industrial applications

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