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Smart Segregation of Dry and Wet Waste Using Arduino

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Abstract- — ***This project suggests an automatic system to segregate dry waste and wet waste which are sensed through embedded system technology. The purpose of this system design is to decrease human interaction while handling wastes and enhances cleanliness from source level. Ultrasonic sensor detects the presence of waste and soil moisture sensor will sense the moisture percentage present in the waste. Sensor values are then fed into Arduino Uno microcontroller. Dry or wet threshold values are pre-stored in the microcontroller which further classifies wastes into dry or wet categories. Servo motor is operated using Arduino to drop the waste into respective bins. Sensor values and system outputs are viewed in serial monitor which can be used for monitoring or troubleshooting purpose. Based on the prototype build and the experimentation with the system, it can be concluded that it successfully does the primary waste segregation of dry and wet waste which can be implemented in small spaces such as home, schools etc. It can also be said that the system efficiently does the primary automated waste management which is effortless and cost-effective.***

Index Terms- Automatic Waste Segregation System, Arduino Uno, Ultrasonic Sensor, Moisture Sensor, Embedded Technology, Smart Waste Management.

I. INTRODUCTION

Rapid urbanization and population growth have significantly increased the amount of waste generated in cities. This rise has created serious challenges in managing waste effectively. Improper disposal and the lack of waste segregation at the source lead to environmental pollution, health hazards, and reduced recycling efficiency. In many regions, waste is still sorted manually, which is labor-intensive, unhygienic, and prone to human error. These issues highlight the need for an automated system capable of segregating waste at the point of disposal [1].

To address these challenges, this project proposes an automatic waste segregation system based on an embedded system approach. The system classifies waste into wet and dry categories using real-time sensor data.

An ultrasonic sensor detects the presence of waste, while a soil moisture sensor measures the moisture content to determine whether the waste is wet or dry. The sensor data is processed by an Arduino Uno microcontroller, which controls a servo motor to direct the waste into the appropriate bin [2], [3].

Segregating waste at the source improves recycling efficiency and promotes environmentally friendly practices such as composting. The proposed system is cost-effective, compact, and suitable for small-scale applications such as homes, schools, and public spaces. Furthermore, the design is flexible and can be upgraded with advanced sensors and IoT integration to support smarter waste management solutions in the future [4], [5].

In conclusion, this system provides a practical and economical solution to reduce manual labor, enhance cleanliness, and encourage sustainable waste management practices.

II. LITERATURE SURVEY

[1] Automatic Waste Segregation System Using Arduino and Sensors, 2019 IEEE International Conference on Computing, Communication and Automation (ICCCA) IEEE.

[2] Sensor-Based Smart Waste Segregation for Sustainable Environment, 2020 IEEE International Conference on Smart Systems and Inventive Technology (ICSSIT) IEEE .

[3] Embedded System Design for Smart Waste Management Applications, 2018 IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT) .

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III. EXISTING SYSTEM

Urban solid waste management practices across the world depend largely on manual labour and the source segregation of solid waste at the point of generation after it has already been collected. The current practices require large amount of labour and therefore spend large amount of time for sorting solid waste, which is further accompanied with unhygienic conditions. The sanitation workers (municipal solid waste collectors) have to spend a significant part of their working hours manually handling the solid waste for segregation. This is accompanied with high chances of error, worker's overload and increased likelihood of health risks due to manual segregation of mixed solid waste.

Mixed solid waste cannot be recycled if the waste at the source cannot be sorted. Non-recyclable objects such as soil, sand, leftovers, etc. can pollute the recyclables, affecting the efficiency of the recycling process. After the solid waste is contaminated, it is difficult to be recycled or will increase the amount of landfill waste and cause environmental pollution.

Unlike most current smart waste bins and conventional waste bins/recycling bins available in the market, the waste bin and recycling system of the present invention is a real time monitoring device with an automatic sorting system. Unlike other conventional waste bins and recycling systems in the market, the current waste bins and recycling systems do not offer real time monitoring, and is limited to only a basic collecting function, as it highly depends on segregation of waste by human hand. Most of the smart bins in the market is only able to open its lid by using motion sensor technology, and there is no separation of liquid waste and solid waste.

This method does not provide adaptive sorting function or automatic waste sorting, which is not beneficial for resource- efficient recycling of waste and sustainability. Thus the waste management systems provided by this method does not provide intelligent waste sorting and real time support required for efficient and clean handling of waste.

A. Existing System Disadvantage

Today's solid waste management systems have some drawbacks such as not being able to sort the waste automatically and not having a systematic method for separating them. Wet solid waste discrimination using moisture sensors and smart systems for identifying wet and dry solid waste are not used in today's systems.

The inadequate separation of solid waste from each other results in the failure of the recycling process and the occurrence of environmental pollution [16], [5].

Current waste collection and sorting practices have many disadvantages such as high labor costs, and the fact that manpower needed for collection and sorting of waste is highly exposed to health risks and accidents. An intelligent waste collection system necessarily needs waste detection technologies, sorting performance evaluation and real time fill grade level measurement for recycling bins.

Although many advanced waste management systems

and techniques have been developed over the years they are many times highly technical, expensive and therefore not feasible to be applied in the home, school or public domain level [14].

Waste sorting is a process that, like many others, has its shortcomings. Today, there is no sensor system in the world literature that is able to measure the waste properties such as moisture content at the disposal point unambiguously, and therefore appropriate waste sorting cannot be provided and consequently the efficiency of the waste and materials cannot be processed at the maximum efficiency of composting and recycling.

The Solid Waste Management (SWM) sector is currently facing a series of global challenges. Most of them are due to lack of efficiency, because of a very manual and non-proprietary way of disposing of solid waste. For this reason, efficient waste separation is urgently needed, by means of compact, affordable and automated sorters that are capable of selectively sorting solid waste in real time at the source of generation, thus leading to a higher level of sanitation, efficiency and sustainability in waste management practices.

IV. PROPOSED SOLUTION

A. System Architecture

- The system consists of sensors, a microcontroller, and a mechanical component that work together to perform automatic waste segregation.
- The ultrasonic sensor detects the presence of waste in the input area.
- Once waste is detected, the moisture sensor measures the moisture content of the material.
- The Arduino Uno processes the sensor data and determines whether the waste is wet or dry.
- Based on this decision, the servo motor rotates and directs the waste into the appropriate bin.

B. Components Used

- Arduino Uno – Acts as the central controller of the system.
- Ultrasonic Sensor – Detects the presence of waste within a specific range.
- Moisture Sensor – Measures the moisture level of the waste.
- Servo Motor – Rotates to guide waste into the correct bin.
- Breadboard and Jumper Wires – Used for proper circuit connections.
- Power Supply – Provides stable power to all system components.

C. Working Procedure

- The ultrasonic sensor continuously monitors the waste input area.
- When waste is detected, the moisture sensor measures its moisture content.
- The measured value is sent to the Arduino Uno for processing.
- The controller compares the value with a predefined threshold.
- If the moisture value is below the threshold, the waste is classified as dry.
- If the moisture value is above the threshold, the waste is classified as wet.
- The servo motor rotates accordingly to drop the waste into the correct bin.
- After disposal, the servo motor returns to its initial position and waits for the next cycle.

D. Pre-processing and Control Logic

- Sensor calibration is performed to ensure accurate readings.
- Small delay functions are included to reduce sensor noise.
- The system is programmed using Embedded C in the Arduino IDE.

A simple decision-making logic ensures smooth and automatic operation

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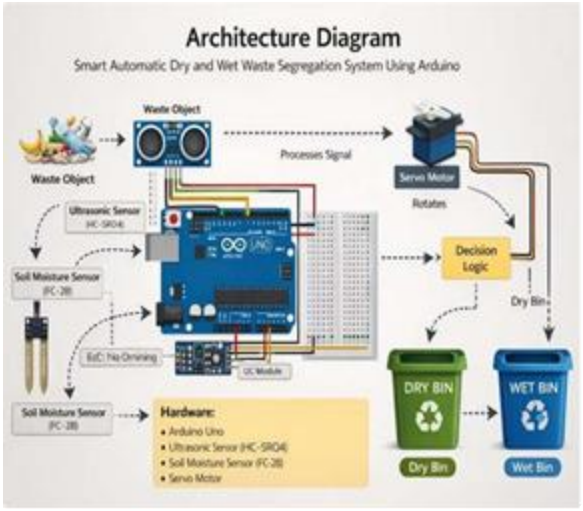

Fig.01.Architecture of smart automatic wet and dry waste segregation system using arduino

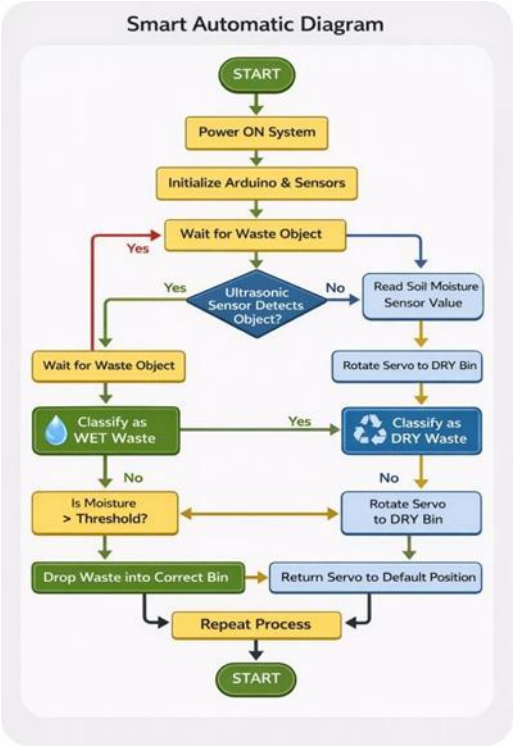

Fig.02.Work flow of the smart waste segregation system

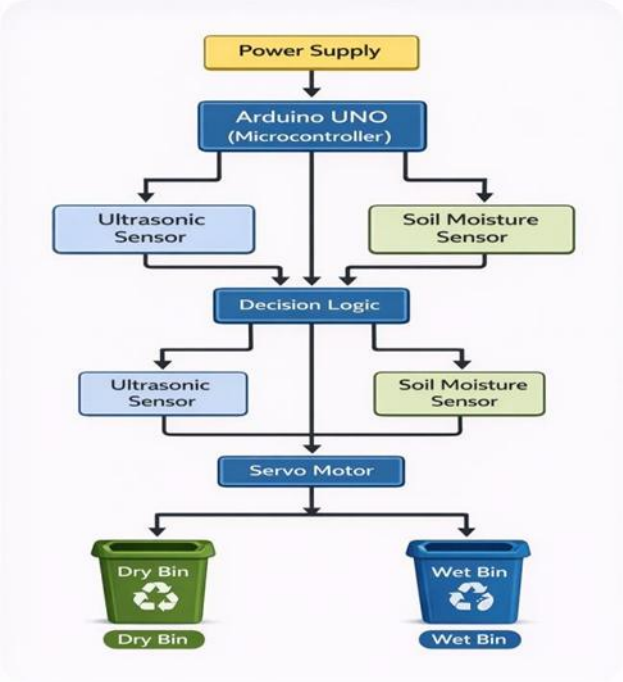

Fig.03.Working block diagram of waste segregation system

V. SYSTEM IMPLEMENTATION

A. Hardware Components

1) Arduino Uno

The Arduino Uno acts as the main controller of the system. It is responsible for managing all the connected components and processing the data received from the sensors. Whenever waste is placed in front of the system, the Arduino first checks for detection and then reads the moisture value. Based on this value, it decides whether the waste is wet or dry. According to the result, it sends a signal to the servo motor to rotate in the required direction. The entire program is developed using Embedded C in the Arduino IDE, which ensures smooth and real-time functioning of the system.

2) Ultrasonic Sensor (HC-SR04)

The ultrasonic sensor is used to sense the presence of waste. It works by transmitting ultrasonic waves and calculating the time taken for the reflected waves to return. If an object is detected within a certain distance, the sensor sends a signal to the Arduino to begin the segregation process. This makes the system fully automatic and reduces the need for manual

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handling.

3) Soil Moisture Sensor (FC-28)
The soil moisture sensor is used to determine whether the waste is wet or dry. It measures the moisture content present in the waste material. If the moisture level is above a predefined value, the waste is identified as wet; otherwise, it is considered dry. The sensor continuously sends this information to the Arduino for decision-making.

4) Servo Motor
The servo motor plays an important role in physically separating the waste. After receiving instructions from the Arduino, it rotates to a particular angle so that the waste is directed into the correct bin. Once the waste is dropped, the motor returns to its original position and waits for the next detection cycle.

5) Power Supply
A regulated 5V power supply is provided to operate the Arduino board, sensors, and servo motor. A stable power source is necessary to ensure proper and uninterrupted working of the entire system.

B. Software Description
The system software is developed using the Arduino IDE and programmed in Embedded C. The working of the system is based on a simple decision-making logic. The ultrasonic sensor continuously monitors the presence of waste. Whenever waste is detected, the Arduino reads the moisture value from the soil moisture sensor. This value is then compared with a predefined threshold to determine whether the waste is wet or dry. Based on the result, the Arduino sends a signal to the servo motor to rotate towards the appropriate bin. After the waste is dropped into the selected bin, the servo motor returns to its initial position, and the system becomes ready to process the next input.

VI. RESULTS AND DISCUSSION

The proposed system was tested using various samples of dry and wet waste, including paper, plastic wrappers, vegetable peels, and leftover food. The ultrasonic sensor reliably detected the presence of waste within the specified range, triggering the segregation process.The moisture sensor produced low readings for dry waste materials and high readings for wet waste materials. Based on these readings, the Arduino Uno accurately classified the waste type and controlled the servo motor accordingly. The servo motor response was smooth and consistent, with minimal delay.Multiple test cycles were conducted to evaluate system reliability. The results showed a high success rate in correct waste classification under controlled conditions. Minor deviations were observed due to sensor sensitivity and environmental factors; however, these did not significantly affect overall performance.The experimental analysis confirms that the proposed system is effective for basic waste segregation and suitable for small-scale real-world application

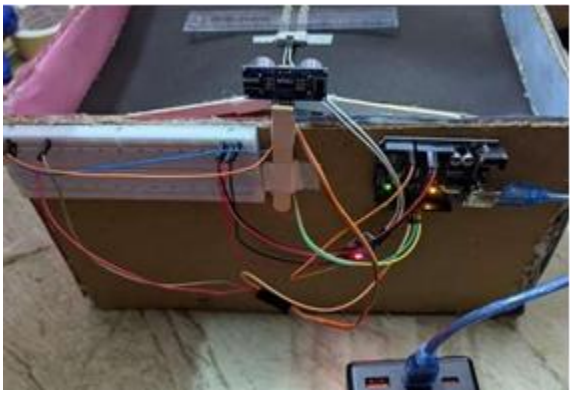

Fig.04. Hardware prototype of smart Automatic wet and dry waste segregation system

VII. CONCLUSION AND FUTURE SCOPE

The Smart Dry and Wet Waste Segregation project was created to address the common issue of improper waste separation at the source. In many places, waste is mixed together, which makes recycling and disposal difficult. To solve this problem, the system uses an ultrasonic sensor to detect when waste is placed in front of it and a moisture sensor to check whether the waste is wet or dry. The entire operation is controlled by the Arduino Uno microcontroller. Based on the readings from the sensors, the system automatically decides the type of waste and moves it into the appropriate bin using a servo motor.

From the testing results, it was observed that moisture-based classification works effectively for basic segregation. The system minimizes human effort and reduces direct contact with waste, thereby

maintaining better hygiene. Since the components used are simple and affordable, the system can be easily implemented in households, educational institutions, offices, and public spaces.

There is also good scope for improving the system in the future. More sensors, such as metal or gas sensors, can be added to classify waste into additional categories like metal, plastic, biodegradable, or hazardous waste. This would make the system more advanced and suitable for larger waste management setups.

The project can also be integrated with IoT technology to make it smarter. By connecting the system to the internet, the level of waste in each bin can be monitored remotely. This would help municipal authorities or maintenance teams know when a bin is full and schedule timely collection.

To further enhance accuracy, machine learning techniques can be introduced. Instead of depending only on moisture level, the system could analyze multiple factors before making a decision. A camera module with image processing features could also be included to identify different types of waste more accurately.

For large-scale or industrial use, the system can be designed with conveyor belts to handle higher volumes of waste efficiently and reduce manual labor. In addition, using solar power can make the system more energy-efficient and suitable for outdoor installations.

Overall, this project has strong potential to be developed into a smart waste management solution for future smart cities. It can contribute to cleaner surroundings, better recycling practices, and reduced environmental pollution.

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