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Waste Segregation system

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Abstract - Effective waste management is a critical challenge in modern urban environments due to the exponential growth in population, consumption, and industrial activity. This project report presents the design, development, and implementation of an automated Waste Segregation System aimed at improving efficiency in waste disposal and recycling processes. The proposed system integrates mechanical and electronic components, including sensors, microcontrollers (such as Arduino or Raspberry Pi), and conveyance systems to automatically segregate waste into biodegradable, non-biodegradable, and recyclable categories.

The system utilizes moisture sensors, Infrared sensors, and inductive sensors to identify different types of waste materials based on their physical and chemical properties. Once identified, the waste is directed into the appropriate bin using mechanical arms or conveyor-based diverters. This reduces human intervention, minimizes health risks, and promotes cleaner and safer environments

This project also addresses the socio-environmental impact of poor waste management practices and emphasizes the importance of sustainable urban development. The implementation of this system in residential complexes, institutions, and municipalities can significantly reduce landfill accumulation, increase recycling rates, and support eco-friendly initiatives. In conclusion, the Waste Segregation System represents a scalable and intelligent solution to one of the most pressing urban challenges, with promising implications for environmental conservation and resource optimization.

INTRODUCTION

We proposed the design and development of Waste Segregation system. The increasing global concern for environmental sustainability has prompted the development of ennovative technologies aimed at optimizing waste management processes . In this context , the Waste segregation based smart Dust-Bin emerges as a ground breaking solution, leveraging electronics hardware to enhance recycling practices.

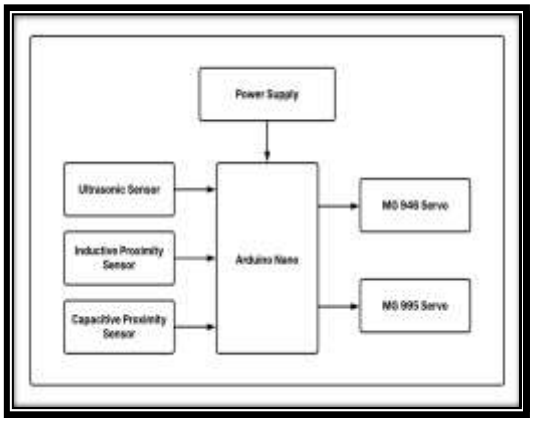
The nation and world is facing a huge problem today is disposal , segregation , and recycling of solid waste and dangerous to human health and ecological system. There is a rapid increase in capacity and categories of solid waste and as a result of urbanization , constant economic growth , and industrialization.

Global Waste management Market reported that the amount of waste generated worldwide produced is 2.02 billion tones . ―Wastes are not always waste if it is segregated as it was‖. The economic value of waste is best comprehended when it is segregated. Currently there is no such system employed of segregation of glass , plastic and metallic wastes at industrial level.

This method is easy and simple solution of segregation of four type of wastes metal can , plastic bottle, paper and plastic ball. It is designed to sort the trash into metallic waste , plastic waste and paper waste ready to be processed separately for the next process of operation .The method uses inductive sensors metallic items and capacitive sensors to distinguish between and dry waste . Experimental result shows that the segregation of waste into metal can , plastic bottle, paper and plastic ball waste has been successfully implemented using the Automation of material segregation (AMS) method.

LITERATURE SURVEY

Block



Artificial Intelligence in Automated Sorting in Trash Recycling

Author: Eduardo A. Soares, IBM Research

A computer visions approach to classify garbage into recycling categories could be an efficient way to process waste. This project aims to take garbage waste images and classify them into four classes: glass, paper , metal and plastic etc.

Recyclable Waste Classification using SquezeeNet and XGBoost Author: Anton Satria Prabuwano, King Abdulaziz University

This phenomenon poses a substantial threat to both the ecological system and human welfare. To tackle this problem, the current study proposes the implementation of machine learning technologies to automate the sorting of waste.

Automation of plastic , Metal & Glass Waste Materials Segregation using Arduino in Scrap Industry

Author: Mohammed Rafeeq International Islamic University Malaysia The three material found mostly in solid waste are metal, glass and plastic . These are the materials that can be recycled and the first step towards recycling is segregation . There are numerous benefits of recycling the waste materials.

Smart Recycle Bin: A Conceptual Approach of smart waste management with integrated wed based system□

Author : Razali Tomari , Universiti Tun Hussein Onn Malaysia Smart recycle bin that caters for recycling glass ,paper and aluminium can, plastic products that automatically evaluate the value of the wastes thrown accordingly.

METHODOLOGY

1. Trash Items (Metal Can ,Other & Glass): - Represents the various recyclable materials that users dispose of into the recycling bin.
2. Microcontroller: - Serves as the central processing unit that coordinates the actions of the system based on the outputs from the audio classifier. It communicates with other components to initiate appropriate responses.
3. Power Supply: - Provides the necessary electrical power to all components, ensuring continuous and reliable operation of the system.
4. Rotating Base: - A mechanical component that facilitates the rotation of the recycling bin. When triggered by the system, it rotates the bin to allow the categorized items to move towards specific partitions for further sorting
5. Trapdoor: - Located at the bottom of the recycling bin, the trapdoor opens based on the classification results. It allows the sorted items to move to the next stage of the sorting process.
6. Partition: - Divides the interior of the recycling bin into sections corresponding to different types of recyclable materials. Each partition directs items to the appropriate collection area.
7. Trash Parts (Separated Bins for Metal, Other & Glass): - Represents the separate compartments or bins where each type of recyclable material is collected after being sorted. Users can easily retrieve sorted items from these dedicated bins. The process begins with users disposing of items into the recycling bin. The audio classifier identifies the material based on the sound it produces. The microcontroller processes this information, and the edge software triggers the rotation of the base. The trapdoor opens, allowing the sorted items to move to the designated partition, directing them to the appropriate trash part for further collection,

System architecture

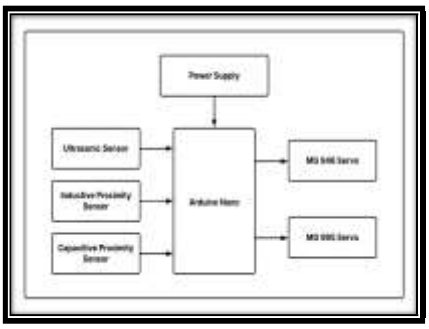


Fig. Waste Segregation System

List of Components

Sr. No	Resources Used	Specification	Quantity
1	Arduino Nano	IC328p	1
2	Power Supply	12v/3 Amp	1
3	Servo Motor	Mg946r	1
4	Capacitor	1000uf	1
5	Transistor	BC547	1
6	Resistor	Current limiting	2
7	Inductive Proxymity Sensor	Sensing object(metal)	1
8	Capacitive	Sensing object (glass)	1

	Proxymity Sensor		
9	Ultrsonic Sensor	Object detection	1
10	AC to DC buck converter	12v to 5v	1
11	PCB	General purpose	1
12	Connecting Wires	-----	----

Component Information

1. Arduino Nano

Fig. Arduino Nano

The Arduino Nano is a small, compact microcontroller board based on the ATmega328P. It's a popular choice for DIY electronics projects, robotics, and IoT applications.

□ Features :

1. Microcontroller: ATmega328P
2. Operating Voltage: 5V
3. Input Voltage: 6-20V
4. Digital I/O Pins: 14 (6 PWM)
5. Analog Input Pins: 8
6. Flash Memory: 32KB
7. SRAM: 2KB
8. Clock Speed:16 MHZ

8. EEPROM: 1KB

2. Inductive Proximity sensor

- What is an Inductive Proximity Sensor?

An inductive proximity sensor is a type of sensor that detects the presence or absence of a metal object within its detection range. It works on the principle of electromagnetic induction, where a coil of wire generates a magnetic field that induces a voltage in the presence of a metal object.

- How Does it Work?

The sensor consists of:

1. Coil: A coil of wire that generates a magnetic field.
2. Oscillator: An oscillator circuit that generates a high-frequency signal.
3. Detector: A detector circuit that senses changes in the magnetic field.

When a metal object enters the detection range, it disturbs the magnetic field, causing a change in the oscillator's frequency. The detector circuit senses this change and outputs a signal indicating the presence of the metal object.

□ Applications in Waste Segregation Systems

1. Metal Detection: Inductive proximity sensors can detect metal objects, such as cans, foil, or other metal contaminants, in the waste stream.
2. Sorting: Sensors can be used to sort waste into different categories based on the presence or absence of metal objects.

3. Quality Control: Sensors can monitor the waste stream for metal contaminants, ensuring that the waste meets quality standards.

□ Benefits

1. High Accuracy: Inductive proximity sensors provide high accuracy in detecting metal objects.
2. Reliability: Sensors are robust and reliable, withstanding harsh environments.
3. Low Maintenance: Sensors require minimal maintenance, reducing downtime and costs.

□ Challenges

1. Interference: Electromagnetic interference (EMI) can affect sensor accuracy.
2. Metal Object Size: Sensors may not detect small metal objects or objects with complex shapes.
3. Environmental Factors: Temperature, humidity, and vibration can impact sensor performance.

3. capacitive proximity sensors:

Fig. Capacitive Proximity Sensor

□ What is a Capacitive Proximity Sensor?□

A capacitive proximity sensor is a type of sensor that detects the presence or absence of an object within its detection range. It works on the principle of capacitance, where a change in capacitance occurs when an object enters the detection range.

□ How Does it Work?□

The sensor consists of:

1. Electrode: A conductive plate or surface that acts as one plate of a capacitor.
2. Dielectric: The air or material between the electrode and the object being detected.
3. Object: The object being detected, which acts as the second plate of the capacitor. When an object enters the detection range, it changes the capacitance between the electrode and the object. This change in capacitance is detected by the sensor's electronics, which output a signal indicating the presence or absence of the object.

□ Applications

1. Object Detection: Detect presence or absence of objects in various applications.
2. Level Detection: Detect liquid or solid levels in tanks or containers.
3. Proximity Detection: Detect proximity of objects to machinery or equipment.
4. Touchless Switching: Used in touchless switching applications, such as lighting or HVAC control.

□ Benefits

1. High Sensitivity: Capacitive proximity sensors offer high sensitivity and accuracy.
2. Non-Contact: Sensors detect objects without physical contact.
3. Low Power Consumption: Sensors typically consume low power.
4. Compact Design: Sensors are often compact and lightweight.

□ Challenges

1. Environmental Factors: Temperature, humidity, and vibration can impact sensor performance.
2. Object Material: Sensor performance can be affected by the material properties of the object being detected.
3. Interference: Electromagnetic interference (EMI) can affect sensor accuracy.

Ultrasonic Sensor :

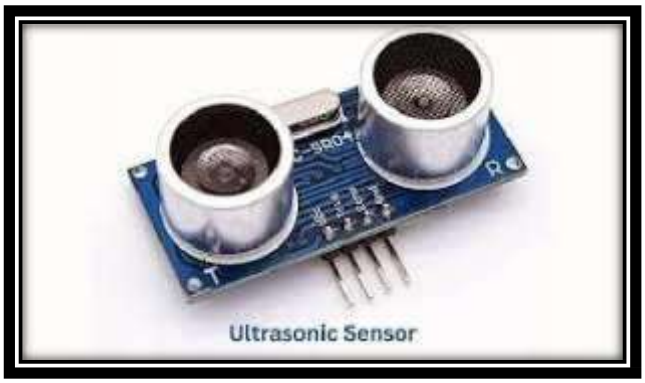


Fig.Ultrasonic Sensor

- What is an Ultrasonic Sensor?

An ultrasonic sensor is a device that uses high-frequency sound waves to detect objects, measure distances, and sense levels.It is specially used for object sensing in our project. To detect it the waste in pipe is exist or not.

- How Does it Work?

1. Transducer: The ultrasonic sensor has a transducer that converts electrical energy into ultrasonic sound waves.
2. Sound Waves: The sound waves are emitted towards the target object.
3. Echo: The sound waves bounce back from the target object and return to the sensor.
4. Detection: The sensor detects the echo and calculates the distance, level, or presence based on the time-of-flight and amplitude of the echo.

 Advantages

1. Non-Contact: Ultrasonic sensors detect objects without physical contact.
2. High Accuracy: Ultrasonic sensors provide high accuracy and reliability.
3. Low Maintenance: Ultrasonic sensors require minimal maintenance.

 Limitations

1. Environmental Factors: Ultrasonic sensors can be affected by environmental factors like temperature, humidity, and air pressure.
2. Object Surface: Ultrasonic sensors require a smooth, reflective surface to accurately detect objects.
3. Noise Interference: Ultrasonic sensors can be affected by noise interference from other ultrasonic sources.

 Applications

Industrial Automation: Ultrasonic sensors are used in industrial automation for object detection, level measurement, and distance measurement.

1. Robotics: Ultrasonic sensors are used in robotics for obstacle detection and navigation.
2. Medical Devices: Ultrasonic sensors are used in medical devices for imaging and diagnostics.4. Automotive Systems: Ultrasonic sensors are used in automotive systems for parking sensors, collision avoidance, and blind spot detection.

5. Power Supply :

12v ,1 Amp –Adapter

Specifications

- Input Voltage: 100-240V AC (universal input)
- Output Voltage: 12V DC
- Output Current: 1A (1000mA)
- Power Rating: 12W
- Efficiency: Typically 80-90%
- Protection Features: Overcurrent protection, overvoltage protection, short-circuit protectin.

6. AC to DC buck convertor :

Fig.AC to DC Buck Converter

- What is an AC-to-DC Buck Converter?

An AC-to-DC buck converter is a type of power converter that converts an alternating current (AC) input voltage to

a lower direct current (DC) output voltage. It is used in our project for Protect the device from high voltage because due to high voltage may causes to burn or damage the system. It is harmful for the system.

- How Does it Work?□

The AC-to-DC buck converter works by:

1. Rectification: The AC input voltage is first rectified to a pulsating DC voltage using a bridge rectifier or a switching rectifier.
2. Filtering: The pulsating DC voltage is then filtered to reduce the ripple and noise.
3. Switching: The filtered DC voltage is then switched on and off at a high frequency using a power electronic switch, such as a MOSFET or an IGBT.
4. Inductor: The switched voltage is then applied to an inductor, which stores energy during the switching cycle.
5. Output: The output voltage is taken across the inductor and is filtered to produce a smooth DC output voltage.

□ Advantages

1. High Efficiency: AC-to-DC buck converters can achieve high efficiency, typically above 90%.
2. Compact Design: The converters can be designed to be compact and lightweight.
3. Low Noise: The converters can produce low noise and ripple.
4. High Power Density: The converters can achieve high power density.

□ Disadvantages

1. Complexity: AC-to-DC buck converters can be complex to design and implement.
2. Cost: The converters can be more expensive than other types of power converters.
3. Switching Losses: The converters can experience switching losses, which can reduce efficiency.

□ Applications

1. Power Supplies: AC-to-DC buck converters are widely used in power supplies for electronic devices.
2. Renewable Energy Systems: The converters are used in renewable energy systems, such as solar and wind power systems.
3. Electric Vehicles: The converters are used in electric vehicles to convert the AC voltage from the grid to DC voltage for charging the battery.
4. Industrial Power Systems: The converters are used in industrial power systems, such as motor drives and power supplies.

7. Servo motor Mg946r :

Fig. AC to DC buck convertor

□ Working Principle:□

1. Command Signal: A command signal is sent to the servo motor from a microcontroller or other control device.
2. Control Circuitry: The control circuitry interprets the command signal and determines the desired position of the motor.
3. Motor Activation: The control circuitry activates the DC motor, which begins to rotate.
4. Gearbox: The gearbox reduces the speed of the motor while increasing the torque to 12kg.
5. Potentiometer Feedback: The potentiometer provides feedback on the motor's position to the control circuitry.
6. Position Adjustment: The control circuitry adjusts the motor's position based on the feedback from the potentiometer.
7. Holding Position: Once the motor reaches the desired position, the control circuitry holds the motor in place.

□ Technical Specifications:

1. Torque: 12kg/cm
2. Speed: 0.24 sec/60°
3. Operating Voltage: 4.8-6.0V
4. Current Draw: 1.5A (idle), 3.5A (stall)

5. Pulse Width: 900-2100 µs

6. Rotation: 180°

Servo motor used to rotate the rotating base in 0 to 180 degree rotation angle on result given by a Arduino nano controller

SYSTEM DESIGN

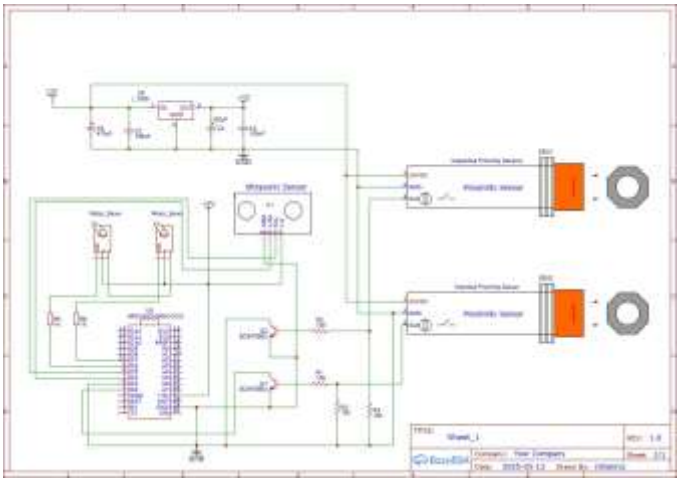


Fig . System architecture

Experimental setup

Working:

Sorting wastes of different sizes and shapes is possible, but the performance is better with objects of cylindrical shape or cubic shape with limitations of the size (in terms of height) of a Coca- Cola Cans (waste should be limited to a maximum of 1kg).

The restrictions are due to the design constraints of our waste sorting machine, modifying the size of the sorting machine (e.g. Gate, Pipe diameter) will make it more adaptable to different shapes, sizes and weight of the wastes.

The capacitive sensor is very sensitive in detecting plastic waste, anything inside/around the plastic object affects the accuracy of the sensor.

As a microcontroller board we have used the Arduino UNO which is based on the ATmega328P. The Arduino Uno has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button.\

Inductive proximity sensors have been used to detect metal objects. We have used a larger sensor, based on our requirement of having a larger sensing range.

Capacitive sensors can sense any object within their sensing range. When the target approaches the face of the sensor, the capacitance increases, resulting in an increase in amplitude of the oscillator.

Then the solid state output switch detects the increase in amplitude and based on that it is turned on or off.

There are different types of Capacitive Sensors. In our project we have used Capacitive Sensors with a compensation adjustment. The capacitive sensor sensitivity depends on the material dielectric constant. Plastic, in fact, has a lower dielectric constant than glass. We have adjusted our sensor in such a way that it can "see through" the objects of plastic nature (to not detect plastic), and glass is detected by the capacitive sensor alone.

Larger sensors have a larger range of detection. We have used servo motors for both gate and pipe, specifically, we have used TowerPro MG946R servo motors.

CONCLUSION

This project has been done during the academic year 2022-2023 as part of the Mechatronics course, in the Brussels Faculty of Engineering; a joint Master's program of the Vrije Universiteit Brussel (VUB) and Université Libre de Bruxelles (ULB). The project was challenging. The requirement was to do an automatic machine to be able to sort minimum two different types of waste. As a team we managed to meet these requirements and developed a machine that sorts three types of waste.

ACKNOWLEDGMENT

We would like to express our sincere gratitude to all those who contributed to the successful completion of this project. First and foremost, we extend our heartfelt thanks to our guide and mentor **Prof. V B bhiungadefor** their

continuous support, valuable insights, and guidance throughout the development of the **Waste Segregation System**.

We also wish to thank our institution, **ATS sanjay bhokare group of institutes** , for providing the necessary infrastructure and resources. Special thanks to our faculty members and lab staff for their encouragement and assistance.

Lastly, we are grateful to our peers, friends, and family members who supported us throughout this journey with their motivation and belief in our work

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