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Design and Fabrication of Automated Accumulator for Waste Management

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Abstract: ***In today's society, the escalating issue of improper waste disposal looms large. As population density swells, so does the volume of waste produced, straining landfill capacities, polluting the environment, and posing grave health risks. Traditional waste collection approaches fall short, proving costly, laborious, and inadequate in addressing the mounting problem. This underscores the urgent need for innovative solutions. Enter the automated accumulator: a pioneering system designed to revolutionize waste management by streamlining processes and boosting efficiency. Combining cutting-edge sensor technology, robotics, and data analytics, the automated accumulator redefines waste management efficiency. Through instantaneous waste identification and categorization, it revolutionizes resource distribution, slashes manual labor requirements, and curtails environmental pollution.***

This ambitious project endeavors to unveil an innovative solution poised to completely transform the landscape of waste management, targeting the mitigation of environmental and health risks associated with mishandled waste, thereby elevating the holistic well-being of communities. The urgent imperative driving this endeavor is crystal clear: we must pioneer a comprehensive solution that not only optimizes the intricate processes of waste collection and sorting but also prioritizes the well-being of sanitation workers by lightening their workload while simultaneously fostering a culture of environmental responsibility and sustainability. The creation and rollout of an automated accumulator mark a major advancement in waste management, addressing the pressing need for effective waste handling while supporting sustainability objectives through recycling promotion and environmental protection.

Key words: landfills, automated accumulator, waste management, waste identification and categorization.

I. INTRODUCTION

Waste management is a crucial aspect of modern life and environmental sustainability. The generation of waste has increased significantly, posing serious challenges to all ecosystems. Effective waste management is very essential to promote sustainable development. This report provides a comprehensive overview of various waste management strategies, technologies, and their implications for a sustainable future.

Waste can be broadly classified into two categories: solid waste and liquid waste. Solid waste includes household waste, industrial waste, and hazardous waste, while liquid waste comprises wastewater from domestic and industrial sources. Each type requires specific treatment methods to minimize its impact on the environment.

The waste management hierarchy outlines the preferred methods for dealing with waste, prioritizing reduction and recycling over disposal.

The hierarchy includes five key steps:

1) *Source Reduction:* Minimizing waste generation at the source through practices such as reusing products, reducing packaging, and promoting sustainable consumption.
2) *Reuse:* Encouraging the reuse of products or materials to extend their lifecycle, reducing the need for new resources.
3) *Recycling:* The process of converting waste materials into new products, reducing the demand for raw materials and energy.
4) *Recovery:* Extracting valuable materials or energy from waste through technologies like incineration or anaerobic digestion.
5) *Disposal:* The least preferred option, involving the safe disposal of residual waste in landfills or incineration facilities.

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Fig 1.1: Waste Management Hierarchy

II. LITERATURE REVIEW

Waste management is a critical aspect of environmental sustainability, with numerous studies exploring various dimensions of this complex issue. Waste management includes waste reduction strategies, recycling technologies, public awareness, the environmental and economic impacts. Studies, such as those by Wilson and Araba (2015), highlight the significance of waste minimization through sustainable consumption patterns and the promotion of the "reduce, reuse, and recycle" strategy. These works stress the need for proactive measures to reduce the generation of waste, emphasizing the role of individual and community behaviors in achieving sustainable waste management.

There are traditional waste management systems like periodic and routine clearing by the municipal corporation. But even though these routine maintenances are carried out we often come across overflowing garbage bins from which the garbage spills on to the streets. When trash vans/trucks come irregular to homes, many civilians empty their overloaded dustbins in open spaces. [1] Ineffective waste management leads to pollution. The pollution created by humans have become the major factor that caused destructions to the surrounding environment

Several designs and projects have been conducted throughout the world on waste management in the hope of reducing the waste generation especially the pollution [3]. It ranges from autonomous, mechanical, and human-based computation designs.

A few of the projects on waste management are:

Smart e- dustbin, a smart way of handling the garbage by using the IOT protocol for transmitting the dustbin status wirelessly, which can notify to the concerned person via emails to replace the filled dustbin.[1]

It focuses to develop a model of smart dustbin which can be effectively used at public places in smart cities. A smart city is incomplete without a smart waste management system.[4] Public awareness and education play a significant role in waste management strategies. These initiatives instill environmentally responsible habits among the population that encourage collective responsibility for waste reduction. Governments implemented regulations and policies to guide waste disposal practices, ensuring that industries and individuals adhered to responsible waste management guidelines.

The Indian government has implemented several initiatives and schemes to address the challenges of waste management in the country. One of the prominent programs is the Swachh Bharat Abhiyan, launched in 2014 with the aim of making India clean and open defecation-free. This mission focuses on proper waste disposal and has significantly contributed to raising awareness about the importance of cleanliness.



Fig 2.1: Public awareness campaign



Fig 2.2: Swachh Bharat Abhiyan

To specifically target the issue of solid waste management, the government introduced the Solid Waste Management Rules in 2016. These rules emphasize waste segregation at the source, encouraging citizens to separate biodegradable and non-biodegradable waste.

III. PROBLEM STATEMENT

Day by day as the population is increasing and the waste produced is also increasing which in turn resulting of landfills and causing diseases to living beings and it pollutes the land. Another major problem is that to provide the basic necessities of the growing population we require various types of materials and resources but due to mixing of different waste is leading to wastage of material which cannot be recovered to the recycling facilities. The existing waste management practices practiced in dump yards pose a significant health and environmental problems. This is due to lack of effective waste segregation system. In dump yards the waste of industries, household, and hazardous waste are mixed together which in result hinders the potential of material recovery which leads to losing of valuable material in dump yards.

A. Proposed Solution

The objective of this paper is to address the mentioned problem by constructing an automated accumulator for collecting and sorting of waste. The main objective if this system is to do the waste management with minimum human intervention, making the process more automated and beneficial to society. The main tasks performed by this system id to automated collection of waste and automated sorting of waste. This system can be used to clean up the dump yards and landfills and provide the recyclable waste to recycling stations. This innovation not only contributes to cleaner environment but also for better waste management.

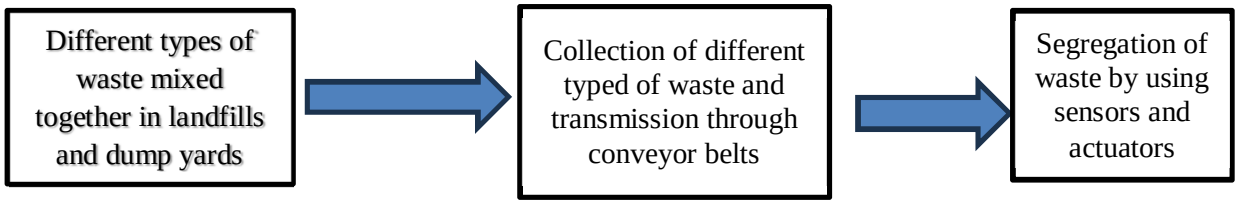


Fig 3.1: Basic working of the accumulator

The accumulator gathers the different waste and transmits the waste by using conveyors after the collection mechanism it goes to segregation unit where the waste is segregated by using sensors and actuators.

IV. METHODOLOGY

The process of waste management is highly complicated and which consists of various hard tasks which can't be achieved automatic. The system is designed with a high mechanism which performs various tasks to achieve a nice waste management. The tasks combined is to achieve efficient waste management. The tasks are the basic steps for segregation of waste. The following are the tasks performed by accumulator.

1) Collection of waste
2) Transmission of waste
3) Segregation of waste

A. Collection of Waste

The initial and crucial step for waste management is collection of waste. To sort the waste and to achieve the further goals with the waste we need to collect the waste to achieve this we need a sophisticated mechanism so that we can collect different types of waste. In dump yards and landfills the waste is scattered everywhere and the different wastes are mixed. It is a hard task to collect the waste. To achieve this, we need a well built and quick mechanism which can collect degradable waste, recyclable waste, and metal waste. After the collection of waste, the waste is sent to the further processes.

B. Transmission of Waste

The next step is to transmission of waste it is the crucial step where the waste is transferred from stating point of the system to ending point. The main components for transmission are conveyor belts, with the help of the conveyor belts the waste is sent from collection unit to segregation unit. We used different conveyors depending on the tasks as to send waste from lower to upper places we use stepped conveyors, to make sure that waste reached to segregation unit in a single order we use spiral conveyor. At the end of the system to send waste into dustbin we use conveyor belts.

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C. Segregation of Waste

The last step to segregate the waste, the segregation of waste means dividing the waste into their respective categories. In present situation in many dump yards this segregation process is done by using robotic arms, hand picking method, magnetization method where all the processes involve most human intervention. In this system the sorting of waste is done in automatic way by using sensors and actuators. We use different sensors which are used to detect the different wastes and send the electrical signal to Arduino and the signal is sent to servomotor. The servo motor is connected to rotating dustbin where it is divided into 3 parts to collect recycled waste, bio degradable waste and metal waste.

D. Mechanism

The overall mechanism of the system is that at first, we use rotating flaps to pick up the waste from the ground. The flaps push the waste towards the stepped conveyor belt with help of dustpan. The waste is carried through the stepped conveyor which is kept slant. From the slant conveyor belt the waste is sent to spiral conveyor. The spiral conveyor task is to send the waste one by one to the segregation unit. The segregation unit is placed on the last conveyor belt. The sensors are placed on the conveyor belt to the side of conveyor belt. Sensors are connected to Arduino board. When the sensors send signals to their connected pins the Arduino board sends the signals to servo motor to make the degrees of rotation. The servomotor is connected to dustbin as shown in the figure. The dustbin is divided into 3 equal parts where each parts contains their respective type of wastes like degradable waste, metal waste and dry waste.

To make the system semi-automatic we used RC controlled system as we connected wheels on the chassis and fixed motors and motor drivers, this motor drivers are connected to Arduino. With the help of Bluetooth module that is connected to Arduino, it pairs with the Bluetooth devices and controls the movement of the accumulator. Finaly, we have successfully built the working model of the system where we have done some changes to make sure the system performs the various tasks and overcome the different problems.



Fig 4.1: Side view



Fig 4.2: Top view

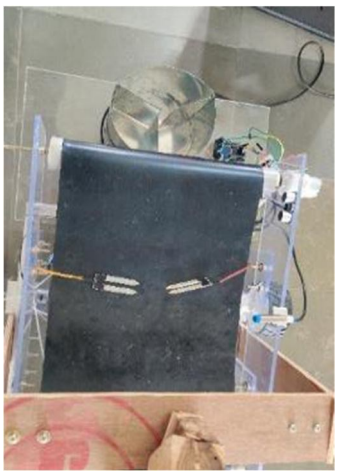


Fig 4.3: Segregation unit



Fig 4.4: Final assembly

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V. HARDWARE COMPONENTS

A. Aluminum Extrusions

Aluminum extrusions are used to build chassis. The aluminum extrusions are used to carry the load of the components and other parts and distribute the weight on each wheel equally. We have used aluminum extrusions of dimensions 20*20 mm. Aluminum extrusions are used because it contains T shape slots which can be used to fit bolts head so that we can fix the motor clamps, other aluminum extrusions etc.



Fig 4.1: Aluminum extrusions

B. Rubber Sheets

Rubber sheets play crucial role in transmission system. Rubber sheets are used for conveyor belts. Due to nature of rubber the friction produced on the contacting surfaces produces motion and it can restrict the motion of the waste particles present on it. It is high tensile strength and flexibility.



Fig 4.2: Rubber sheets

C. Acrylic Sheets

Acrylic sheets, also known as plexiglass or acrylic glass, are transparent thermoplastic panels made from polymethyl methacrylate (PMMA). They're popular due to their clarity, durability, and versatility. Acrylic sheets are lightweight, impact-resistant, and offer excellent optical clarity, often surpassing glass. Overall, acrylic sheets offer a combination of transparency, durability, versatility, and ease of fabrication, making them a popular choice for a wide range of applications across various industries.

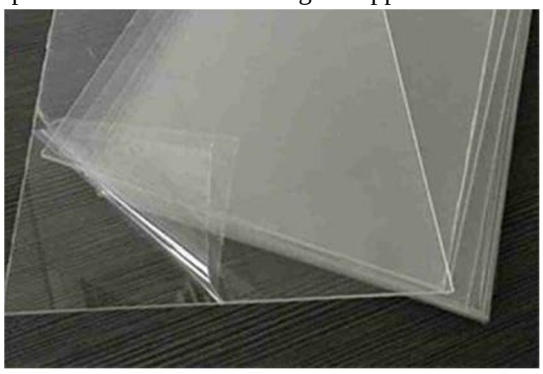


Fig 4.3: Acrylic sheets

D. Motors

1) *D.C Motors:* We used 12V dc motors to perform rotation of conveyor belts, spiral conveyor, flaps to collect the waste.
2) *Jhonson Motors:* 12V Jhonson motors are used to carry heavy loads so they are used for wheels for the accumulator.
3) *Servo Motor:* Servomotors are used to make degree of rotations as per the signal given by the microcontroller. In this system servo motors are used for rotating the dustbin.

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Figure 4.3: Motors

E. L298 Motor Driver

The L298 motor driver is a popular integrated circuit (IC) used to control DC motors and stepper motors. It's commonly utilized in robotics, automation, and hobbyist projects due to its simplicity and versatility. Key features of the L298 motor driver include its ability to handle high currents (up to 2 amperes per channel) and a wide input voltage range, typically from 5 to 35 volts. It also has built-in protection diodes to prevent damage from back EMF (electromotive force) generated by the motors during deceleration.

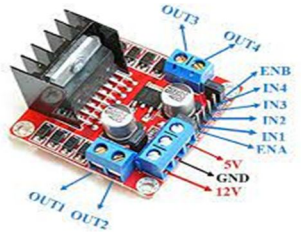


Fig 4.4: L298 Motor driver

F. Relay

Relays are used to control high-power or high-voltage circuits with a low-power signal, making them essential components in many electrical systems for switching, controlling, and protecting circuits. They provide isolation between the control circuit and the load circuit, ensuring that sensitive control electronics are not directly exposed to high voltages or currents. We used 4 module relays.

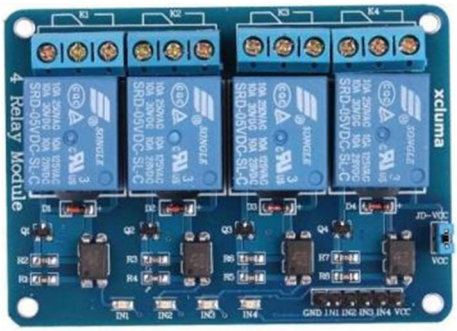


Fig 4.5: Relay

G. 12V, 3.3AH Lead Acid Battery

Batteries are portable energy storage devices that convert chemical energy into electrical energy through electrochemical reactions. They are essential power sources for a wide range of applications, from small electronic devices to electric vehicles and grid-scale energy storage systems.



Fig 4.6: 12V, 3.3AH lead acid battery

H. Bluetooth Module

Bluetooth module is a small electronic device which enables wireless communication between electronic systems. Bluetooth module enables wireless data transmission without any loss of data. Bluetooth module consists of a Bluetooth radio transmitter, microcontroller etc. are packed in to a compact module. Bluetooth modules are commonly used in wireless transmission system, smarts home devices, wearable technology, IoT (Internet of Things), and in industrial automation. The Bluetooth module is shown in figure 4.7.

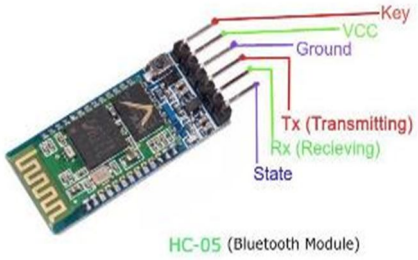


Fig 4.7: Bluetooth module

I. Arduino

Arduino is an open-source electronics platform based on easy-to-use hardware and software. It consists of a family of microcontroller boards and an integrated development environment (IDE) for programming these boards. Arduino boards are designed to be versatile, accessible, and user-friendly, making them popular among hobbyists, educators, artists, and professionals alike.



Fig 4.8: Arduino

J. Sensors

1) *Soil Moisture Sensor:* Soil moisture sensors, or soil moisture meters, are devices used to measure the moisture content of soil. They provide valuable information about soil water levels, helping farmers, gardeners, and researchers make informed decisions about irrigation, crop management, and water conservation. This sensor is used to detect the biodegradable waste by humidity and water levels in the waste.
2) *Ultrasonic Sensor:* Ultrasonic sensor is used to detect if an object is present in front of the sensor. They are mainly used for obstacle detection is automatic guided vehicles.
3) *Inductive Proximity Sensor:* Inductive proximity sensor is used to detect metals and plastic materials. When a material passes in front of the inductive proximity sensors it will detect the material type mainly metal by electromagnetic energy. It is a non-contact type sensor.



Fig 4.9: Soil moisture sensor, ultrasonic sensor, inductive proximity sensor

VI. FLOW CHART

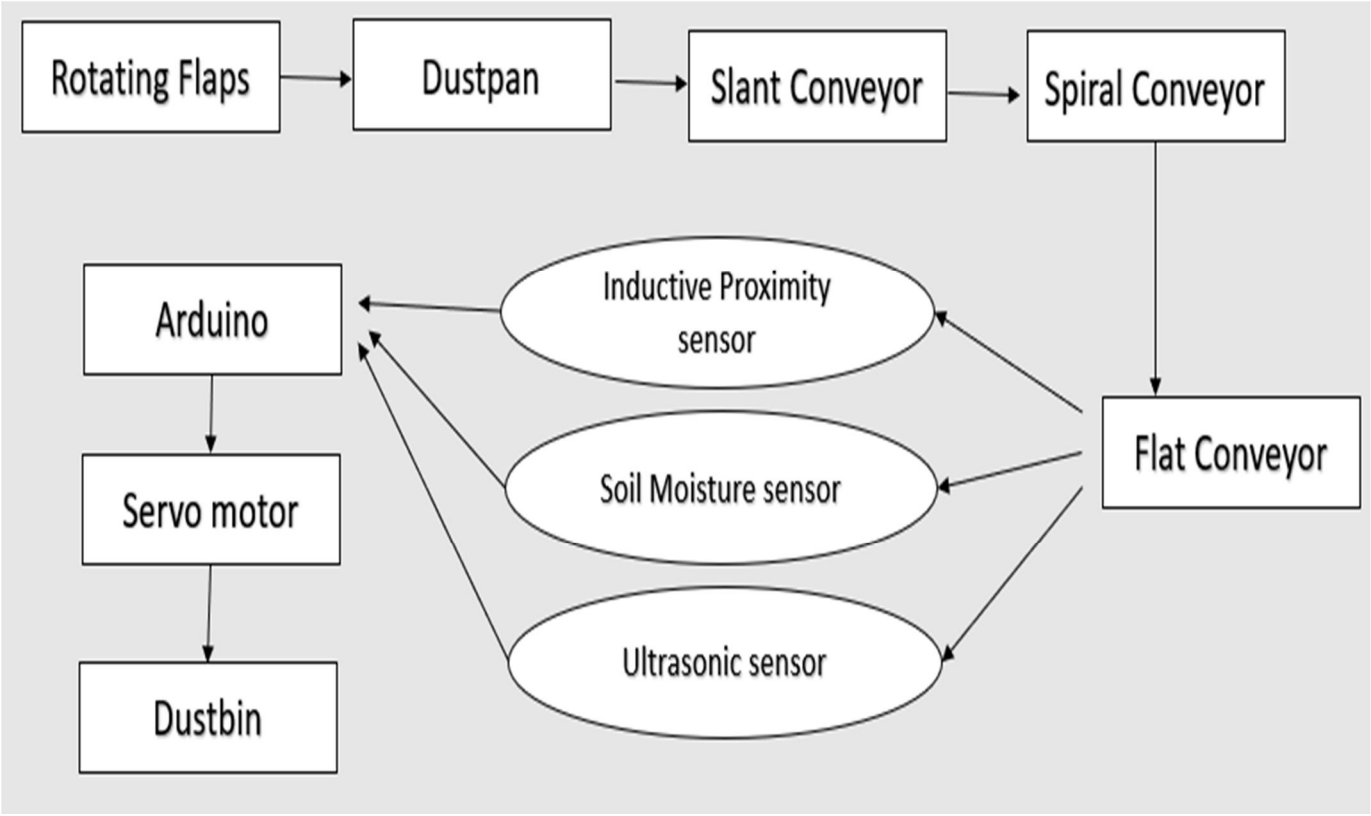


Fig 5.1: Flow chart

VII. RESULTS AND DISCUSSIONS

The automatic waste segregator system demonstrates promising results in effectively sorting and segregating waste materials based on their composition, thus aiding in the efficient management of solid waste. Through the integration of sensors, actuators, and machine learning algorithms, the system accurately identifies and separates different types of waste such as plastic, glass, metal, and organic matter. This technology not only reduces the burden on landfills by facilitating recycling and proper disposal but also promotes environmental sustainability by minimizing the release of harmful substances into the ecosystem. Furthermore, the automatic waste segregator enhances the overall waste management process by streamlining collection, sorting, and recycling operations, thereby contributing to the conservation of resources and reduction of pollution. However, challenges such as scalability, cost-effectiveness, and integration with existing waste management infrastructure require further research and development to maximize the system's efficiency and adoption on a larger scale.



Fig 6.1: Final assembly

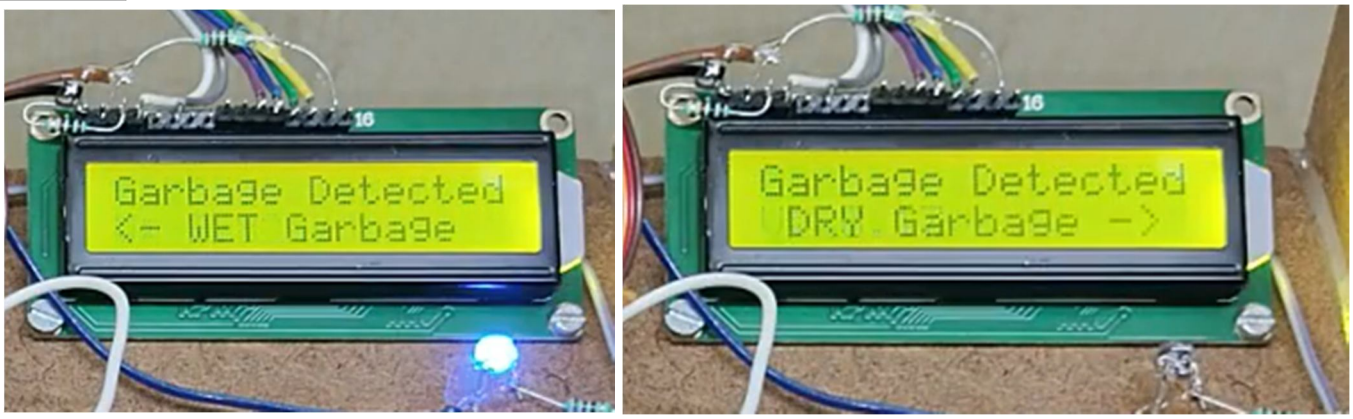


Fig 6.2: Different garbage detection (display)

A. Efficiency

Efficiency in waste segregation systems is usually measured by the area covered, but for our prototype, we focused on time. Although our system operates in a small area, the time required for waste segregation is similar to larger systems. Our prototype's efficiency is between 55-60%, meaning it correctly segregates more than half of the waste within the given time frame. This is a good result for a prototype, showing promise for future scaling.

B. Efficiency Calculation

General efficiency = Σ(P*WAGR)
P = Total population of the particular area.
WAGR = Waste amount generation rate.

VIII. CONCLUSION AND FUTURESCOPE

The Automatic Waste Segregation System, integrated within the accumulator, represents a groundbreaking advancement in waste management. Its innovative mechanism not only automates the collection of waste but also meticulously segregates it into distinct categories, namely metal, dry, and wet waste. The system's uniqueness lies in its ability to detect the surrounding waste automatically, enabling a seamless and proactive waste management process. The incorporation of sensors, intricately connected to a control unit, empowers the system to identify and categorize waste types accurately. This not only enhances the overall efficiency of waste segregation but also underscores the system's adaptability to diverse waste materials. By automating both collection and segregation, this system stands as a testament to its effectiveness and forward-thinking design, offering a more sustainable and technologically advanced solution to modern waste management challenges. In essence, the Automatic Waste Segregation System within the accumulator heralds a new era in waste management, aligning with the imperative for smarter, more efficient, and environmentally conscious solutions.

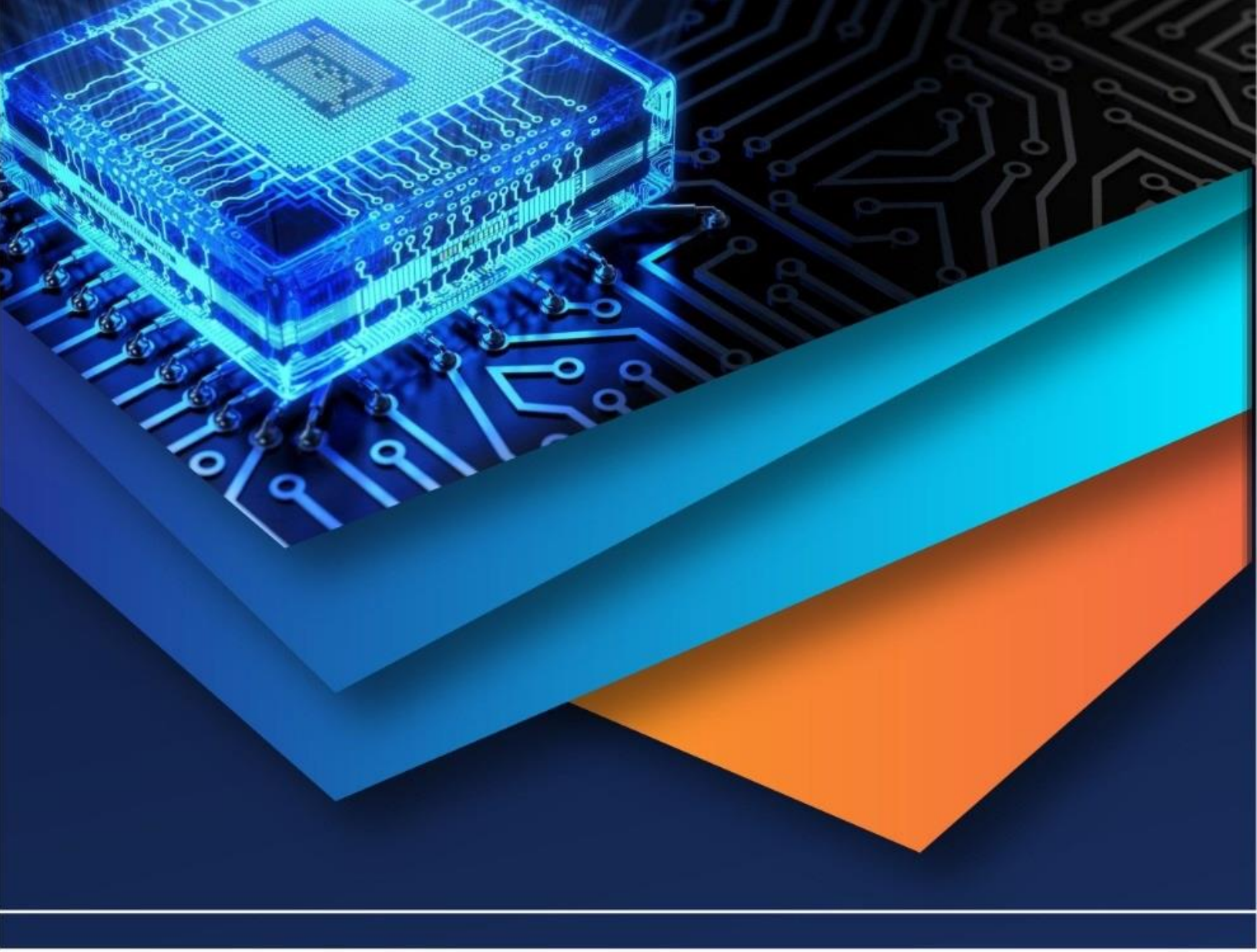
A. Future Scope

1) Advanced sensor technology enables precise detection and identification of diverse materials, significantly improving the efficiency of waste segregation systems.
2) Seamless connection to urban infrastructure for optimized waste management.
3) Utilizes renewable energy and efficient components to reduce carbon footprint.
4) AI optimizes sorting, predicts waste patterns, and improves efficiency.
5) Educates users on proper disposal and tracks recycling contributions.
6) Reduced costs and savings enhance broader adoption and implementation.

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