Smart Recycling Bin

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***Abstract*— With more plastic bottles and metal cans being thrown away every day, waste management is a major global issue. Therefore, this project aims to reduce waste by making the recycling process easier for the consumers as well as raising awareness, starting at The American University of Kuwait (AUK). To achieve this goal, this project implements advanced sensing, sorting, and controlling technologies to speed up the recycling process and promote a more sustainable environment. The project also aims to provide a quality-of-life upgrade in terms of providing ease of mind when recycling. This is important due to many occurrences where the discarded waste is disposed of into the incorrect receptacle slot. The project also ensures that time is saved from the lack of needing to do so. This type of identification capability will also provide a starting point for many future invaders in terms of upgradability and features. Those may include automation and visual aids calibrated with the identification sensor.**

To raise awareness, there will be an award system integrated into the smart bin. This system will use a special chip to allow the user to scan and collect points. After a certain number of points collected, the user will be able to redeem the points for various gift card rewards as an incentive to be mindful of the environment and that doing so is not only rewarding for the planet but rather, for the individual as well.

Keywords*— Awareness, Smart bin, Technologies, Waste management*

I. BACKGROUND

The idea for smart recycling containers originated from the increasing challenges that traditional trash management approaches posed. Growing urbanization and an increasing worldwide population have led to previously unheard-of quantities of trash production. As a result, there is an increasing need for original and practical solutions to the problem of waste accumulation and its consequences on the environment. Consequently, technology has been used to enhance waste collection and recycling processes through the creation of intelligent recycling containers.

A range of cutting-edge features are used by smart recycling bins to optimize recycling procedures and boost productivity. Compaction systems to maximize the bin's capacity, sensors to detect the amount of waste within, and connectivity options to enable real-time data collecting and monitoring are common examples of these characteristics. Utilizing these technological advancements, smart recycling bins aim to solve several significant problems with conventional recycling techniques, including ineffective garbage collection, contaminated recyclables, and a lack of data-driven insights into recycling behaviors.

Smart recycling bins are also part of a larger trend that incorporates technology into many parts of urban infrastructure to make cities smarter and more sustainable. By implementing smart bins, municipalities can save operating expenses, streamline trash management procedures, and improve citizen engagement to promote recycling habits. The extensive use of smart recycling bins has the potential to have a positive environmental impact since it can increase recycling rates, reduce the amount of waste dumped in landfills, and support a more resource- and circular-efficient economy [1].

In addition to the environmental advantages, smart recycling bins also offer the opportunity to gather valuable data and insights related to consumer behavior and waste generation patterns. This data can be leveraged to inform targeted recycling education initiatives, optimize waste collection routes, and support evidence-based policymaking aimed at promoting sustainable waste management practices [2]. Ultimately, the integration of smart technology into recycling bins has the potential to revolutionize the approach to waste management, fostering a more environmentally conscious and resource-efficient society.

II. PROBLEM STATEMENT

The conventional waste management system is plagued by numerous challenges, including inadequate collection of waste, contaminated recyclables, and a lack of real-time data to facilitate decision-making. Higher operating costs, an increase in the quantity of landfills used, and negative environmental effects are the results of these challenges. Smart recycling bins offer state-of-the-art technological solutions that will revolutionize waste management and enhance sustainable recycling practices. Utilizing sensors, connectivity, and data analytics, smart recycling bins maximize waste collection, minimize contamination, and provide valuable insights into recycling behaviors [2]. Through this approach, smart recycling bins aim to significantly reduce the environmental impact of waste while fostering a more efficient and informed approach to recycling.

III. AIMS OF THE PROJECT

The Smart Recycling Bin project intends to transform trash management by boosting recycling's resilience, efficiency, and environmental benefits using cutting-edge

technology. The project uses cutting-edge components like sensors, networking, and data analytics to try and achieve the following goals:

- Improve waste collection: The project's goal is to reduce operational expenses and boost overall efficiency by streamlining waste collection procedures. Sensors to monitor fill levels and compaction devices to maximize bin capacity will be incorporated.
- Reduce contamination: By offering consumers real-time feedback and assistance, promoting appropriate disposal techniques, and improving the quality of recycled materials, the Smart Recycling Bin seeks to minimize contamination of recyclable materials.
- Deliver real-time data: To help governments and organizations make data-driven decisions and maximize their waste management strategies, the project aims to collect important data on recycling behaviors, waste generation trends, and bin fill levels.
- Promote sustainable behavior :The initiative intends to engage and educate communities about sustainable recycling practices, fostering improved awareness ,using connectivity features and participation in recycling efforts.
- Assist to a greener future: The Smart Recycling Bin seeks to eventually contribute to a more environmentally conscious society by reducing landfill usage, increasing recycling rates, and supporting a circular economy.

IV. OBJECTIVES OF THE PROJECT

The Smart Recycling Bin project addresses significant waste management concerns and promotes sustainable recycling habits through the following objectives:

- Utilization of advanced technology: To build an intelligent and adaptable recycling infrastructure, use state-of-the-art technologies such as sensors, compaction systems, and networking features.
- Optimize waste collection and management: Utilizing real-time data on fill levels and recycling patterns, waste collection may be made more efficient by maximizing collection routes, cutting down on operating expenses, and minimizing overflow problems.
- Reduce contamination of recyclable materials: Educate and guide users on proper waste disposal practices to minimize contamination and enhance the quality of recycled materials, thereby contributing to a more efficient recycling process.
- Real-time monitoring and data collection: Gather and analyze real-time data on waste generation, recycling habits, and bin fill levels to inform evidence-based decision-making, policy development, and targeted recycling initiatives.
- Promote sustainable behavior: Utilize connectivity features to engage and educate communities about the importance of sustainable recycling practices, encouraging increased participation and awareness.
- Environmental impact: Reduce the environmental impact of waste by increasing recycling rates, minimizing landfill usage, and contributing to a more circular and resource-efficient economy.

V. SIGNIFICANCE, SCOPE AND DEFINITION

The Smart Recycling Bin project holds significant potential in revolutionizing traditional waste management practices and fostering environmental sustainability. By harnessing advanced technology, real-time data, and user engagement, these bins offer several critical advantages. They optimize waste management processes, enhancing efficiency, reducing operational costs, and minimizing environmental impact through informed decision-making. Additionally, they contribute to pollution reduction by lowering contaminants in recyclable materials, resulting in higher-quality output and decreased processing costs. These bins also facilitate long-term psychological change and awareness, fostering community involvement, promoting sustainable recycling behavior, and raising environmental consciousness. Moreover, the incorporation of cutting-edge technologies such as sensors, connectivity features, and data analytics fuels innovative solutions to waste management problems, advancing sustainable infrastructure development.

The scope of the Smart Recycling Bin project encompasses various essential factors. It involves technological integration through sensor-equipped bins, compaction systems, connectivity features, and data analytics to facilitate data-driven insights, effective garbage collection, and real-time monitoring. Environmental effects play a crucial role, encouraging sustainable waste management practices to reduce landfill consumption, enhance recycling rates, and mitigate waste generation. Furthermore, the project emphasizes customer engagement and behavior change, aiming to raise awareness, educate communities, and promote sustainable recycling methods. Additionally, the project considers policy and regulatory factors, ensuring compliance with waste management legislation, addressing privacy concerns related to data collection, and navigating bureaucratic processes for successful implementation.

Understanding key definitions associated with the Smart Recycling Bin project is crucial. The term Smart Recycling Bin refers to a garbage container equipped with cutting-edge technology, including sensors and data analytics, aimed at real-time tracking and facilitating environmentally friendly recycling methods. Contamination pertains to the addition of non-recyclable or hazardous substances to the recycling stream, impacting the quality and usability of recycled products. Circular Economy signifies an economic system focused on recycling, reusing, and reducing dependency on finite resources to maximize resource utilization and minimize waste. User Engagement involves interactive projects and awareness campaigns to empower communities in adopting sustainable behaviors. Finally, Data-Driven Decision-Making entails using analytics and real-time data to guide operational and strategic waste control efforts effectively.

VI. SYSTEM ARCHITECHURE

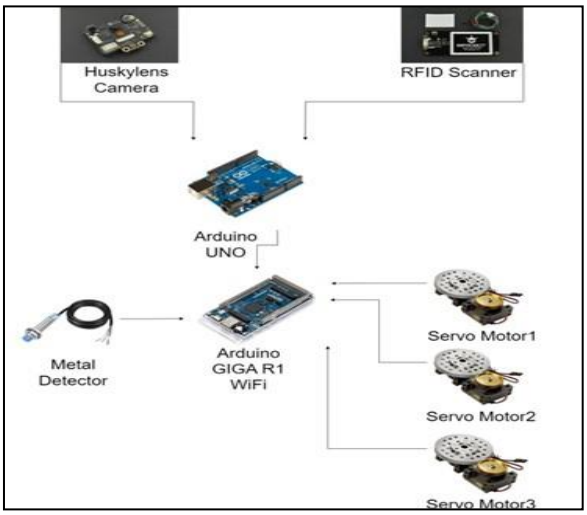

Figure VI.1 System Architecture

The system architecture of the Smart Recycling Bin is explained briefly in figure 3.2 showing the Arduino GIGA R1 Wi-Fi and the Arduino UNO and how our components such as the metal detector, HuskyLens camera, RFID scanner and servo motor will be connected to them. Also, our system architecture shows how the components interact to achieve specific goals or functionalities such as the Smart Recycling Bin.

VII. BLOCK DIAGRAM

In the block diagram there are two microcontrollers, and it is the Arduino GIGA R1 Wi-Fi and the Arduino UNO and the connection between them will be serial communication. Our microcontrollers will be connected to different sensors and devices that the team will be using in the project. The metal detector will be connected to the Arduino mega Wi-Fi through digital signal. A digital signal is information represented by a digital signal as discrete elements or values, usually using binary code. And the RFID Scanner and the HuskyLens camera will be connected to our Arduino through serial communication. The meaning of serial communication is that it transfers data sequentially, one bit at a time, via a single wire or pair of wires. Finally, the Servo Motor will be connected through PWM Signal. The acronym PWM denotes Pulse Width Modulation. This technique is used to encode data as a pulsating signal.

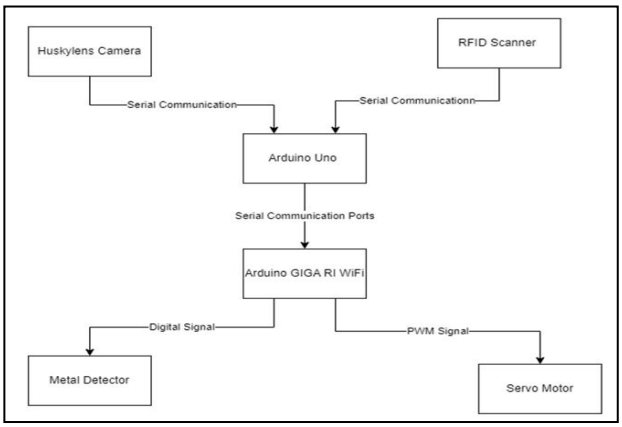

Figure VII.1Block Diagram

VIII. BUDGET

The table below show the budget table of all the components used with their quantity and price.

Table 1. Budget

#	Component	Qty	Price
1	HuskyLens Camera	1	$54.90
2	RFID Scanner	1	$29.90
3	Servo Motor	3	$359.97
4	Metal Detector	1	$3.27
5	Arduino GIGA R1 Wi-Fi Development Board	1	$72.90
6	Servo Power Distribution Board	1	$12.99
7	Lead	1	$1.99
8	Arduino Uno	1	$23.99
Total Price			$559.91

IX. HARDWARE AND SOFTWARE IMPLEMENTATION

The project works on two microprocessors: Arduino uno and giga. These two microprocessors act as master and servant respectively. The RDIF where you scan your tag and the HuskyLens camera are connected to the Arduino uno, they act as the master, where once they receive a signal the uno will communicate with the giga where it will perform the tasks we mentioned before. All motor servos are connected to the Arduino giga acting as servants once they receive signal from the uno. The two microprocessors communicate serially.

As you can see, we have added a bus to help connect extra wires that can't all fit on the Arduino board. For example, we have attached many wires to ground since there is only two ground pins available on the board. This helps all servo motors to be connected to ground which is an essential thing.

In addition, on the bus we have connected two wires for serial communication between Arduino uno and giga. SDA and SCL that connects the three: Arduino uno, second from Arduino giga, third is from the camera.

An important addition we added to the design is a Servo power distribution board where it is connected to the servo motors. It provides the required power for the motors to work. You can see it is connected to a power socket to provide enough power to generate properly.

For the software implementation two source files were created in C language to program the two microprocessors, servo motors, camera and the RFID scanner. The programmed code contained simple instruction that allows the two microprocessors to communicate serially, and instructions for servo motors to open and move to the right trash bin from the incoming signals.

Figure IX.1 Prototype

X. FUTURE WORKS

In the future the project can improve in many ways and could be used to improve the environment. Here are some ways to improve it:

- Add one more camera inside the funnel to better detect the shape of the object
- Add level detector to the trash bin to identify their level capacity
- Add wight detector to calculate the weight of the object for additional estimation of the object disposed
- Create a user-friendly application for reward system to encourage recycling

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