Eco Kiosk: Self-Service Deposit and Refund System

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Abstract

This project is a smart and eco-friendly system designed to encourage people to recycle plastic bottles. The idea is simple: when a person adds a plastic bottle to the machine, the system checks the bottle using a small electronic tag (called an RFID tag) that is attached to it. If the bottle is valid, the system accepts it and gives some cash to the user as a reward. At the heart of this system is the Arduino Mega, a mini-computer that controls everything. It connects and manages all the parts of the system. The user interacts with the machine using a 2.4-inch touch screen display. This colorful screen shows instructions like "Please insert the bottle" or "Scan complete" and even has buttons that the user can touch to start or finish the process. When the bottle is inserted, an RFID Reader (RC522) scans the RFID tag on the bottle to identify it. If the tag matches the system's records, it sends a signal to the machine to move the bottle using a servo motor (MG90S). This small motor carefully rotates to pull the bottle inside the system. Once the bottle is accepted, the system activates a cash dispenser to give a small amount of money to the user. This makes the experience rewarding and motivates people to return plastic bottles instead of throwing them away. All the electronic parts are connected using a Printed Circuit Board (PCB) and jumper wires, which help the system work smoothly and keep everything organized. This smart recycling machine can be placed in public places like schools, malls, or parks to reduce plastic waste and promote recycling. It's a small step toward building a cleaner, greener, and smarter world.

Keywords: Smart Recycling, Plastic Bottles, RFID Technology, Arduino Mega, Eco-Friendly System, Touchscreen Interface, Servo Motor

INTRODUCTION

Plastic waste is one of the most pressing environmental issues facing the world today. Despite growing awareness, a significant portion of plastic bottles still end up in landfills or as litter, contributing to pollution and harming ecosystems. Recycling is a powerful solution, but public participation remains a challenge.

This project introduces a Smart and Eco-Friendly Plastic Bottle Recycling System aimed at making recycling more accessible, interactive, and rewarding. The system encourages users to recycle plastic bottles by offering small cash incentives. Built around the Arduino Mega microcontroller, the machine integrates several key technologies including RFID scanning, touchscreen interface, and automated mechanical control.

When a user inserts a tagged plastic bottle, the system scans it using an RFID reader. If the bottle is validated, a servo motor pulls it inside and a cash dispenser rewards the user. All interactions are guided through a 2.4-inch touchscreen display, providing clear instructions and feedback.

Compact and user-friendly, this system is ideal for placement in schools, shopping malls, parks, and other public areas, where it can help promote sustainable habits and reduce plastic waste. By combining technology with environmental responsibility, this project offers a scalable solution for cleaner communities and a greener future.

LITERATURE SURVEY

1. "RFID-Based Smart Waste Management System" – Jain et al., 2019

This paper explores the integration of RFID technology into waste bins to identify and sort garbage based on material type. RFID tags were used to uniquely label different waste items, while RFID readers helped automatically segregate items into appropriate categories. The system reduced human error, improved sorting accuracy, and promoted a more efficient recycling process. It served as a strong foundation for using RFID in recycling systems like the one proposed in this project.

2. "Reverse Vending Machine: A Smart Way to Reduce Plastic Waste" – Sharma & Patel, 2020

Sharma and Patel designed a Reverse Vending Machine (RVM) prototype that accepts plastic bottles and dispenses reward tokens. The study was based on behavioral economics—showing that people are more likely to recycle when they receive tangible incentives. It highlighted that RVMs placed in malls and campuses increased recycling rates significantly. The project validates the core concept of this system: reward-based recycling using automation.

3. "Arduino Mega Based Automatic Waste Segregator" – Kumar & Rani, 2020

This work implemented an automated waste sorting system controlled by an Arduino Mega 2560. The project used various sensors to detect and separate metal, wet, and dry waste. The authors emphasized Arduino Mega'sflexibility, multiple input/output support, and reliability for running real-time automation. This supports its use as the central controller in more complex systems, such as the plastic bottle recycling machine in this project.

4. "Development of Interactive User Interfaces for Smart Bins" – Ahmed et al., 2021

This paper discusses how adding a touchscreen display improves public interaction with smart recycling systems. The interface provided step-by-step instructions, feedback messages, and multilingual support. Findings indicated that a well-designed user interface helps users understand the recycling process better and increases proper usage. This reinforces the use of a 2.4-inch TFT touchscreen in your system for clear and simple communication with users.

5. "Smart Bins for Smart Cities: Integration of IoT and Renewable Energy" – Lee & Zhang, 2022

This study focused on building smart waste bins that could communicate with a central server via IoT and operate on solar power. It demonstrated how waste levels could be monitored remotely, and how bins could be powered sustainably. While the paper focused more on large-scale deployment, the principles of modularity, energy efficiency, and public space integration are directly applicable to your smart recycling project.

METHODOLOGY

The methodology for developing the Smart and Eco-Friendly Plastic Bottle Recycling System was divided into several key stages: design, component selection, hardware integration, software development, testing, and deployment. The project began with the conceptual design of a system that could identify plastic bottles using RFID tags, verify their authenticity, and reward users upon successful verification. An Arduino Mega 2560 microcontroller was selected as the main control unit due to its large number of input/output pins and compatibility with multiple modules.

Essential hardware components were selected based on their functionality, cost-effectiveness, and ease of integration. These included the RC522 RFID reader for scanning bottle tags, RFID cards for bottle identification, an MG90S servo motor to pull bottles into the machine, a 2.4-inch TFT touchscreen display for user interaction, and a cash dispenser to provide monetary rewards. All components were connected using a combination of jumper wires and a custom PCB, with the Arduino powered by a regulated power supply to ensure stable operation.

The software was developed using the Arduino IDE. The program logic starts with the system initializing all modules, followed by a user tapping “Start” on the touchscreen. Once a bottle is inserted, the RFID reader scans the tag and compares the ID against a list of valid entries. If the tag is recognized, the servo motor activates to move the bottle into the collection compartment, and the cash dispenser is triggered to release a small reward. Throughout the process, the touchscreen provides clear instructions and confirmation messages to guide the user.

Thorough testing was carried out to ensure system reliability. The servo motor was calibrated for precise movement, RFID scanning was tested for speed and accuracy, and the cash dispenser was fine-tuned for timing and control. The user interface was also tested with volunteers to ensure clarity and ease of use. The final system is suitable for deployment in public places such as malls, schools, and parks, with safety considerations like proper casing, insulated wiring, and user labels included to make the system safe and accessible for everyone.

OBJECTIVE

1. The system aims to automate plastic bottle collection through technology. It will use a combination of RFID and mechanical components. The goal is to simplify and promote recycling in public spaces.
2. Each bottle will have an RFID tag for unique identification. The system will scan these tags to verify the bottles before accepting them. This ensures only valid recyclables are processed.
3. Users will receive a small cash reward for each valid bottle they recycle. The incentive aims to motivate more people to recycle. This approach encourages positive environmental behavior.
4. A 2.4-inch touchscreen will guide users through the process. It will display clear instructions, such as "Insert Bottle" or "Scan Complete." This provides a seamless interaction for all users.
5. Arduino Mega serves as the main controller of the system. The RFID reader scans bottles, the servo motor moves them inside, and the cash dispenser rewards users. All components work together to automate the recycling process.
6. The system is designed for use in high-traffic areas like malls, schools, and parks. It will encourage people to engage in recycling while offering an easy and rewarding experience. The aim is to reduce plastic waste in public spaces.

7. By integrating technology with incentives, the system aims to build long-term recycling habits. It seeks to change behaviors by making recycling both easy and rewarding. The ultimate goal is to create a cleaner, more sustainable community.

PROBLEM DEFINATIONS

Plastic waste, especially bottles, continues to be a major environmental issue, with many bottles ending up in landfills or oceans due to inefficient recycling systems. Existing recycling methods often lack convenience and immediate rewards, leading to low public participation. The need for an automated, easy-to-use recycling system with incentives is critical to encourage higher recycling rates. This project aims to address these challenges by creating a smart recycling system that uses RFID technology to verify bottles and provide cash rewards, making recycling more accessible and engaging for everyone.

DATA FLOW DIAGRAMS

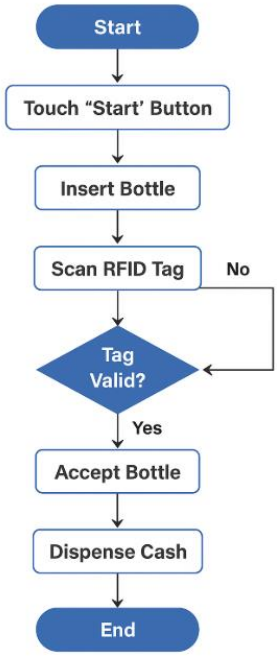


Figure: Data Flow Diagram

FUCTIONAL REQUIREMENTS

1. The Smart Plastic Bottle Recycling System is designed to promote recycling by offering users a reward for returning plastic bottles. Upon interaction, users will insert their bottles into the machine, which will be identified using an RFID reader.

2. Each bottle contains a unique RFID tag that the system scans. Once the bottle is inserted, the system checks the RFID tag data against the Bottle Records Database to validate whether the bottle is eligible for recycling.

3. Once a valid bottle is identified, the servo motor activates to move the bottle into the internal collection compartment.

4. The motor's operation is crucial as it must handle the bottle carefully, ensuring it is properly placed in the compartment. After the bottle is safely moved, the system triggers the cash dispenser, which gives the user a reward in the form of cash.

5. The dispenser must ensure accurate cash delivery to encourage recycling participation. Each transaction, including details about the bottle, user, and reward dispensed, is logged into the Transaction Log Database, ensuring the system maintains proper records for future reference.

6. The system interacts with users through a 2.4-inch touchscreen display that shows important messages and feedback, such as instructions for inserting the bottle, processing the scan, or dispensing cash.

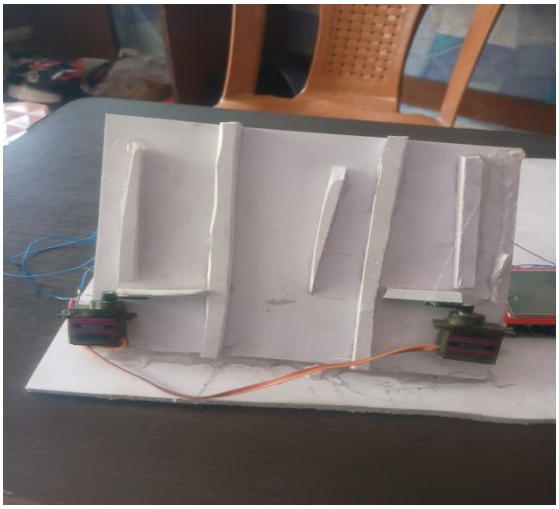
7. The touchscreen provides real-time feedback, notifying the user about the success or failure of their transaction. If the transaction is successful, it will display "Bottle Accepted" and "Cash Dispensed". If the bottle is rejected, it will display an error message like "Invalid Bottle".

NON FUCTIONAL REQUIREMENTS

1. The system must also be scalable, able to handle a large volume of transactions without significant performance degradation.
2. As more users interact with the system, it should be able to process multiple bottle submissions efficiently and record the data in the Transaction Log Database without delay.
3. The database should support high throughput and quick access to transaction data, ensuring that the system can handle increased traffic over time as more recycling stations are added.
4. Another critical non-functional requirement is usability. The system should be user-friendly, ensuring that even people with limited technical knowledge can operate the machine without difficulty.
5. The touchscreen interface must be intuitive, with clear instructions and feedback to guide users through each step of the process. The design should be simple and engaging to encourage widespread participation in recycling.
6. Performance is also important, particularly the response time of the system. The RFID scanning process should be fast enough to avoid user frustration.
7. The bottle should be validated and the transaction processed within a few seconds. Similarly, the cash dispensing mechanism should work smoothly and deliver the correct reward without any noticeable delay.
8. The system should have a high level of security to protect user data and transaction logs. Data encryption must be used to secure any sensitive information, and access to system records should be restricted to authorized personnel only.
9. The Admin should have password-protected access to the Bottle Records Database and Transaction Log Database, ensuring that no unauthorized modifications can be made.

RESULTS

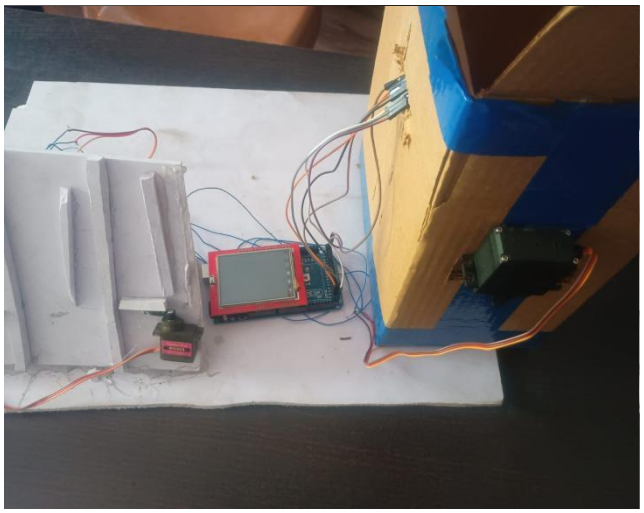
(Fig. 1)



(Fig. 2)

(Fig. 3)

(Fig. 4)



(Fig. 5)

CONCLUSION

In conclusion, the Smart Plastic Bottle Recycling System presents an innovative and eco-friendly solution to promote responsible waste disposal and environmental sustainability. By using RFID technology, an Arduino-based control system, and a user-friendly touchscreen interface, it encourages people to recycle plastic bottles in exchange for monetary rewards. The system not only simplifies the recycling process but also motivates users through instant incentives. Its integration of automation, real-time feedback, and secure data logging ensures efficiency, reliability, and ease of use. Overall, this project contributes to a cleaner environment while fostering eco-conscious behavior in communities.

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