GARBOGO: REVOLUTIONIZING WASTE DISPOSAL PRACTICES

PROJECT PHASE II - REPORT

submitted by

Dhaheen Rahman P	**IDK20CS025**
Shibin K K	**IDK20CS056**
Vinoy Raj J S	**IDK20CS062**
Vyshnav K K	**IDK20CS063**

to
the APJ Abdul Kalam Technological University
in partial fulfillment of the requirements for the award of the degree
of
Bachelor of Technology
in
Computer Science & Engineering

Department of Computer Science & Engineering
Government Engineering College Idukki
685603

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DECLARATION

We undersigned hereby declare that the main project report **GarboGo: Revolutionizing Waste Disposal Practices** submitted for partial fulfillment of the requirements for the award of degree of Bachelor of Technology of the APJ Abdul Kalam Technological University, Kerala, is a bonafide work done by us under the supervision of Prof. Philumon Joseph. This submission represents our ideas in our own words and where ideas or words of others have been included, We have adequately and accurately cited and referenced the original sources. We also declare that we have adhered to ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in my submission. We understand that any violation of the above will be a cause for disciplinary action by the institute and/or the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not been previously formed the basis for the award of any degree, diploma, or similar title of any other University.

Dhaheen Rahman P	Shibin K K
Vinoy Raj J S	Vyshnav K K

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

Government Engineering College Idukki

Idukki

685603

CERTIFICATE

This is to certify that the report entitled **GarboGo: Revolutionizing Waste Disposal Practices** submitted by **Dhaheen Rahman P , Shibin K K, Vinoy Raj J S, Vyshnav K K** to the APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Computer Science & Engineering is a bonafide record of the main project work carried out by them under our guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

Prof. Philumon Joseph
(Project Guide)
Assistant Professor
Dept.of Computer Science & Engg.
Govt. Engineering College Idukki

Dr. Sunil K S
(Project Coordinator)
Assistant Professor
Dept.of Computer Science & Engg.
Govt. Engineering College Idukki

Dr. Unnikrishnan K

Associate Professor and HoD

Dept.of Computer Science & Engg.

Government Engineering College Idukki

Date:

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Dhaheen Rahman P

Shibin K K

Vinoy Raj J S

Vyshnav K K

B. Tech. (Computer Science & Engineering)

Department of Computer Science & Engineering

Government Engineering College Idukki

ABSTRACT

GarboGo is a comprehensive waste management app designed to transform the way we interact with our environment and manage waste. This multifaceted app combines public bin and recycling location services, real-time sensor alerts, illegal dumping reporting, navigation to recycling centers, a rewards and loyalty program, statistical analysis for urban planning, a donation and exchange platform, local cleanup initiatives, and household waste pickup services, all with the goal of creating a cleaner, greener, and more sustainable world.

The app connects users to the nearest public bins and recycling centers, promoting responsible waste disposal. Smart sensor technology alerts authorities when bins are nearing capacity, ensuring bins are never overly full or neglected, reducing litter and encouraging timely disposal. Illegal dumping is reported with ease through the app, facilitating rapid response and enforcement. The navigation system directs users to the nearest recycling centers or bins, simplifying the process of responsible waste disposal. GarboGo offers a rewards and loyalty program, recognizing and rewarding users for their recycling efforts and reporting of illegal dumping. Users can see how their actions affect the environment and their community. It's not just about handling trash; it also helps city planners make better decisions about waste and sustainability.

Along with all these, the app offers household waste pickup services, streamlining waste collection and ensuring that waste is properly handled and recycled.

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Chapter 1
INTRODUCTION

The world is evolving rapidly, driven by population growth and development. Consequently, waste generation is increasing, posing significant challenges for effective waste management. Current strategies are inadequate, often leading to littered streets and environmental pollution. To tackle these issues, innovative solutions are essential. By leveraging technology and community involvement, we can improve waste management efficiency. Garbogo aims to address these limitations by introducing user-friendly technology to manage waste effectively. Key features include optimized waste collection schedules, reporting illegal dumping, and providing information about recycling centers to promote recycling. Ultimately, the goal is to create a cleaner, healthier, and more sustainable environment by integrating technology and waste management practices.

1.1 MOTIVATION

The force driving this project emerges from the multifaceted and escalat- ing challenges that urban areas face in the realm of waste management. With the global urbanization trend, the issue of illegal dumping has became a serious issue, posing substantial threats to the health of both communities and the environment. The urgent need to address this challenge has lead to putting effort in exploring innovative and efficient solutions. The project's motivation is underscored by a commitment to developing a sophisticated system capable of swiftly and effectively identifying and managing illegal dumping sites in urban landscapes. At the core of this endeavor is the integration of technologies which offer a potent tool for local governing authorities. By using the capabilities of these technologies, the project seeks to empower authorities with real-time insights, enabling quick responses to illegal dumping. In urban areas, managing waste is a significant challenge due to the increasing population and the rise of illegal dumping, which poses serious threats to public health and the environment. This project is driven by the urgent need to address this issue by exploring innovative solutions. By integrating advanced technologies, we aim to empower local authorities with real-time insights to swiftly detect and manage illegal dumping sites. Ultimately, our goal is to contribute to the creation of cleaner and healthier urban environments by catalyzing a shift towards more sustainable waste management practices worldwide. In essence, the motivation driving this project is deeply rooted in the aspiration to contribute to the creation of cleaner, healthier environments. By helping local authorities with a robust and technologically advanced tool for the quick detection and management of illegal dumping sites, the project aims to catalyze a shift towards more sustainable and responsive waste management practices in urban settings worldwide.

1.2 PROBLEM DEFINITION

The prevailing waste management systems are degraded by inefficiencies in waste collection, unhygienic environments resulting from illegal dumping, limited awareness, and inadequate infrastructure for waste disposal. Addressing these challenges requires the development of a comprehensive platform that not only resolves current issues but also enhances the effectiveness of existing waste management methods

1.3 OBJECTIVES OF THE PROJECT

To integrate IoT concepts into waste management, facilitating efficient waste disposal. Establishing a framework for proper waste disposal practices while promoting the ’Reuse’ concept to mitigate waste generation. Conducting statistical analyses to inform strategic improvements in existing waste management methodologies.

1.4 CONCLUSION

In conclusion, as urbanization accelerates and populations grow, the challenges surrounding waste management become increasingly pressing. Current strategies are proving insufficient, leading to littered streets and environmental harm. To address these issues, innovative solutions are necessary. Garbogo aims to tackle these limitations by introducing user-friendly technology to efficiently manage waste. By optimizing waste collection schedules, reporting illegal dumping, and promoting recycling through accessible information about recycling centers, Garbogo aims to create a cleaner, healthier, and more sustainable environment. Additionally, the project is motivated by the urgent need to address illegal dumping, leveraging advanced technologies to empower local authorities in identifying and managing dumping sites proactively. By integrating IoT concepts, promoting waste reduction through reuse, and conducting strategic analyses, the project seeks to enhance waste management practices, ultimately contributing to cleaner and healthier urban environments worldwide.

Chapter 2
LITERATURE SURVEY

2.1 OVERVIEW OF LITERATURE SURVEY

The introduction of technology, especially through the addition of sensor-based alarm systems represent a possible revolution in the ever changing setting of modern waste management. The study looks at how technology can be used to report and handle instances of illegal dumping, navigate to recycling facilities, and evaluate loyalty and reward programs that encourage responsible trash management. It explores the use of statistical evaluations for urban planning, investigates platforms facilitating donations and exchanges, and highlights the role of technology in promoting and organizing local cleanup initiatives.

One notable development in the field of Internet of Things-based public trash cans is the incorporation of Infrared (IR) sensors, especially when it comes to the ability to determine the complete state of the bins. For this reason, traditional methods frequently used ultrasonic sensors, as described in previous study [1]. However, because of their unique benefits, recent research have introduced and promoted the use of IR-based sensors [2]. The capacity of infrared sensors to provide equivalent accuracy to ultrasonic sensors as a more affordable substitute is what makes them unique [3]. The envisioned ”IOT based public bins” system, inspired by the innovative waste container design detailed in the referenced paper [3], combines several key features for effective waste management. Drawing inspiration from the advancements in IoT-based waste management systems [5], the integration of geospatial technology, particularly GPS as expounded in [6], assumes a pivotal role. Expanding on the technological underpinnings underscored in [4], the envisioned applications transcend the boundaries of conventional data presentation.Inspired by the success story of an IoT-based smart garbage collector [6], the proposed system not only seamlessly integrates recycling centers into its functionality but envisions an active role for users in sustainable initiatives.

The paper [7] focuses on the design and evaluation of a low-cost position tracking system using off-the-shelf GPS modules.Technology has advanced significantly in the field of waste management, particularly with machine learning applications that automate procedures, as covered in the publications that are cited [8].The integration of solar energy into microcontrollers marks a revolutionary concept that not only enhances the appeal of solar power but also enables direct clean energy charging. This innovation, as demonstrated in the referenced paper [9], utilizes high-efficiency nanophotocatalysts to capture solar energy and store it in batteries. However, these applications have primarily focused on large-scale electricity generation, leaving room for innovative approaches at the microcontroller level. The paradigm shift presented in [9] revolves around integrating solar energy into rechargeable batteries designed for microcontrollers.

The study presented in [10] adds a valuable dimension to the discourse on solarpowered sensor networks. Drawing inspiration from the ideas presented in the referenced papers [11] and [12], the importance of credible data for waste management planning be comes evident. Paper [11] emphasizes the need for reliable waste generation statistics, suggesting that weighing waste samples at generator sites is a key method for developing sustainable local databases. Furthermore, paper [12] provides a real-world example from Gujarat, India, showcasing the challenges posed by inadequate waste disposal facilities in metropolitan areas.

In our statistical analysis, we will leverage data-driven insights to identify areas with the highest and lowest waste generation rates. This approach aligns with the recommendations of the cited papers, emphasizing the significance of accurate waste generation data for effective waste reduction strategies. By understanding the dynamics of waste generation in different locations, we can tailor bin sizes and waste collection schedules to match the specific needs of each area, thereby optimizing the overall waste management process.

2.2 CONCLUSION

In conclusion, the literature survey underscores the transformative potential of technology in modern waste management practices. From sensor-based alarm systems to IoT-based public trash cans with infrared sensors, innovative solutions are emerging to address challenges like illegal dumping and promote responsible waste management. Advances such as low-cost position tracking systems using GPS modules and the integration of solar energy into microcontrollers offer promising avenues for enhancing efficiency and sustainability. Additionally, the importance of reliable data, highlighted in studies on waste generation statistics and challenges in waste disposal facilities, emphasizes the need for data-driven approaches in waste management planning. By using data to understand things better, we can make waste management plans that fit each place, using resources better and helping to reduce waste more effectively.

Chapter 3
SOFTWARE REQUIREMENTS

3.1 FRONT END

The front end of our IoT-based waste bin locating project features a user-friendly web interface, allowing users to visualize bin locations on a map and monitor their fill levels in real-time. With intuitive controls and informative displays, the interface enables efficient waste management by providing insights into bin statuses and optimizing collection routes.

3.1.1 XML

XML (Extensible Markup Language) is a simple and widely used language for creating structured documents, including user interfaces (UI) for Android apps. In Android Studio, XML serves as the frontend language for designing app layouts and specifying how elements like buttons, text fields, and images are arranged and displayed on the screen. Using XML, developers can easily define the visual structure and appearance of their app's UI components, such as defining the size, color, and position of elements. It is easy for developers to create attractive and responsive user interfaces for their Android apps because of to the combination of visual design and XML code.

3.2 BACK END

At the backend of a waste bin locating IoT-based system, data collected from sensors installed in bins is processed and analyzed. This data is used to optimize waste collection routes, monitor bin fill levels, and generate insights for efficient waste management practices, ensuring timely pickups and reducing operational costs. Additionally, the backend facilitates integration with mapping systems and databases to provide real-time updates and historical data for informed decision-making.

3.2.1 Kotlin

Kotlin is like a modern programming language that makes writing code for Android apps easier and faster. It's simpler than Java, the language most Android apps are written in. Kotlin helps developers write less code, fewer chances for mistakes and bugs. It also has features that make sure your app runs smoothly and safely, without crashing unexpectedly.We can use Kotlin right inside Android Studio, the main tool for building Android apps. This makes it really convenient for developers to learn and use Kotlin without much hassle.

3.2.2 Firebase

Firebase offers a powerful and user-friendly backend solution for mobile and web applications, serving as both a real-time database and a comprehensive development platform. Its seamless integration with Android Studio, facilitated through Firebase SDKs and plugins, allows developers to easily link their applications to the Firebase database, enabling real-time data synchronization and offline capabilities, Offering a robust backend solution that improve development and simplifies database management.

3.3 PLATFORMS USED

The project for a waste bin locating and IoT-based bin management system typically utilizes platforms like Arduino, Android Studio for hardware integration. These platforms enable sensor connectivity to monitor waste levels and location tracking, while cloud platforms facilitate data storage, analysis, and remote management, enhancing efficiency in waste collection and management processes.

3.3.1 Android Studio

Android Studio is the premier integrated development environment (IDE) designed specifically for Android app development, developed and maintained by Google. It provides an extensive collection of tools designed to make the whole app development process more efficient. Its supports multiple programming languages, including Java and Kotlin, providing features such as code completion and syntax highlighting for efficient coding. The built-in emulator facilitates thorough testing by simulating diverse Android devices and versions. Additionally, the IDE includes a performance profiler for optimizing app performance and seamless integration with version control systems like Git for efficient collaboration. Overall, Android Studio empowers developers to create high-quality Android apps with ease and efficiency.

3.3.2 Google Cloud

A wide range of cloud computing services, such as platform, infrastructure, and software-as-a-service options, are provided by Google Cloud. The Google Maps Platform is a well-known product that offers application programming interfaces (APIs) for incorporating location-based services, dynamic and static maps, and geospatial data analysis into apps. With the help of these APIs, developers can easily incorporate geolocation services, interactive maps, route optimisation, and geocoding features into their web and mobile apps. By using these APIs, developers can produce mapping experiences that are user-friendly and customised to meet their specific requirements.

3.3.3 Arduino IDE

The Arduino IDE (Integrated Development Environment) is a versatile platform widely used for programming microcontrollers like the ESP8266, enabling seamless control over various IoT (Internet of Things) devices. With its user-friendly interface and extensive library support, developers can easily write and upload code to ESP8266 modules, leveraging its Wi-Fi capabilities to connect and manage IoT devices. Through Arduino's intuitive programming environment, users can create applications to monitor sensors, control actuators, and exchange data with other connected devices, facilitating the development of smart and interconnected systems for diverse IoT applications.

3.3.4 Visual Studio Code

Microsoft made Visual Studio Code (VS Code), which is a powerful but simple program for writing code. It's famous for being easy to customize and having lots of extra tools can add. VS Code is a programming language and framework supporter that offers a user-friendly interface along with cutting-edge capabilities like Git integration, debugging, and Intellisense code completion. Cloud apps and web development are only two of the many projects that developers choose it for because of its large extension marketplace and customisable layout. Modern programmers can expect a seamless development experience using Visual Studio Code, regardless of the complexity of the software solution they're building or how quickly they're producing scripts.

3.3.5 Google Colab

Google Colab stands as a versatile platform for various projects, including IoT-based solutions like smart waste management. Offering a cloud-based Jupyter notebook environment, it enables efficient development and execution of Python code, crucial for tasks such as image processing in your project. With free access to GPU resources, Colab enhances computational capabilities, expediting tasks like model training and analysis. Its collaborative features streamline team collaboration and sharing, fostering productivity and innovation across diverse domains. Whether for machine learning projects, data analysis, or software development, Google Colab provides a user-friendly and accessible platform for diverse applications, making it a valuable asset for numerous industries and projects.

3.4 CONCLUSION

In conclusion, Garbogo requires both front-end and back-end components for efficient waste management. The front end utilizes a user-friendly web interface powered by XML for visualizing bin locations and monitoring fill levels. Kotlin simplifies code development for Android apps, while Firebase provides a robust backend solution for real-time data synchronization. Additionally, we utilize platforms like Arduino, Android Studio, Google Cloud, and Visual Studio Code for hardware integration and data management. Overall, our software requirements aim to optimize waste management processes through seamless and user-friendly solutions.

Chapter 4
SYSTEM DESIGN

The GarboGo initiative emerges as a light of innovation in the complex environment of waste disposal and recycling. This chapter goes into the design details, revealing the inner workings of GarboGo, its system design, and the visual representation of its operation using sequence and use case diagrams. This chapter discusses the details of the methodology adopted for the implementation of the project. The actual details of the implementation are discussed in the next chapter.

4.1 FEASIBILITY STUDY

Market analysis helped to identify and analyze the target market for GarboGo. Understand the current waste management landscape, existing competitors, and potential user demographics. Also helped to evaluate the demand for a waste management app, considering environmental awareness, government regulations, and societal attitudes toward recycling. Technical requirements for developing GarboGo, including app development, sensor integration, and data management were assessed. The availability of technology infrastructure, such as reliable internet connectivity and smartphone penetration, to ensure widespread accessibility was considered. Estimated the initial development costs, including app design, sensor implementation, server setup, and marketing. Projected operational costs, such as maintenance, server hosting, and potential updates. Evaluated revenue streams, including app purchases, subscription models, partnerships, or advertisements. Investigated legal requirements and regulations related to waste management and data privacy in the target locations. Ensured that GarboGo complies with relevant laws, obtaining necessary permits and approvals. Assessed the practicality of

GarboGo's day-to-day operations, including waste pickup scheduling, sensor data management, and user support. Evaluated the feasibility of collaborating with waste management agencies, recycling centers, and other stakeholders. Analyzed the potential positive impact of GarboGo on the community and the environment.
Considered how the app can encourage sustainable waste management practices and contribute to reducing environmental impact. Identified potential risks, such as technological challenges, market competition, user adoption hurdles, or unforeseen regulatory issues.Strategies were developed to reduce these risks and ensure the app remains strong. Conducted surveys or focus groups to gauge potential users' interest in and acceptance of GarboGo. Analyzed user feedback and preferences to enhance the app's user experience. Developed a realistic timeline for the development, testing, and launch of GarboGo. Created a project plan outlining key milestones, responsibilities, and timelines. Summarized the findings of the feasibility study, highlighting strengths, weaknesses, opportunities, and threats. Provided a recommendation on whether to proceed with the development of GarboGo, suggesting potential modifications or enhancements based on the study's outcomes.

4.2 USE CASE DIAGRAM

In the GarboGo project, the use case diagram is crucial to the complete documentation and system architecture. Use cases are a term used to describe how particular features or functionalities are tied to actors, who represent different entities such as users, external systems, or other components. These examples capture various aspects of how the system functions. The connections between actors and use cases illustrate the complex network of linkages, demonstrating how many entities work together to accomplish particular goals. The system's boundaries are shown in the diagram, which also separates the system's internal parts from external entities.

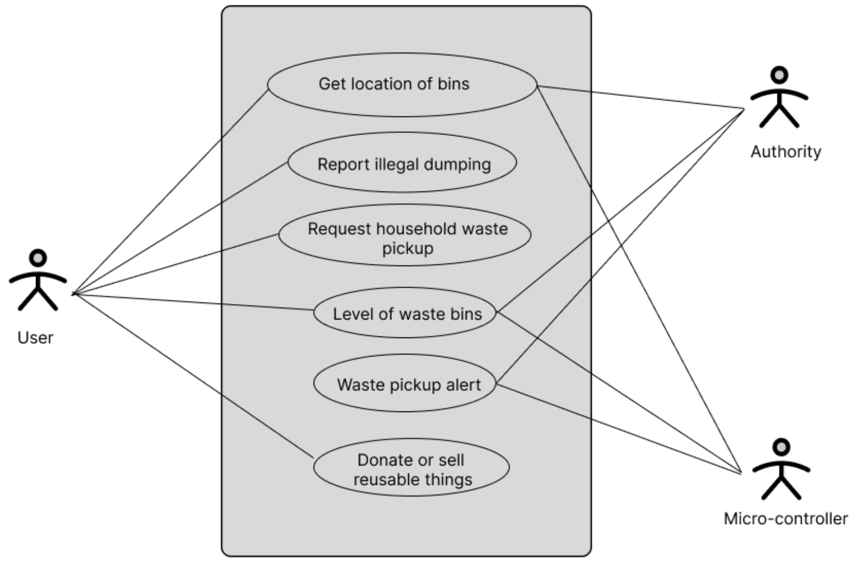


Figure 4.1: Usecase diagram.

4.3 SEQUENCE DIAGRAM

The sequence diagram in the GarboGo project plays a pivotal role in elucidating the dynamic aspects of the system's behavior by showcasing the chronological order of interactions between various components and actors. This visual representation goes beyond the static view provided by use case diagrams, offering a detailed insight into the temporal sequence of events and the messages exchanged during these interactions. The sequence diagram in the GarboGo project goes beyond a mere chronological depiction of events; it serves as a dynamic and insightful tool for system analysis, enabling the identification of potential improvements, bottlenecks, and areas of contention.

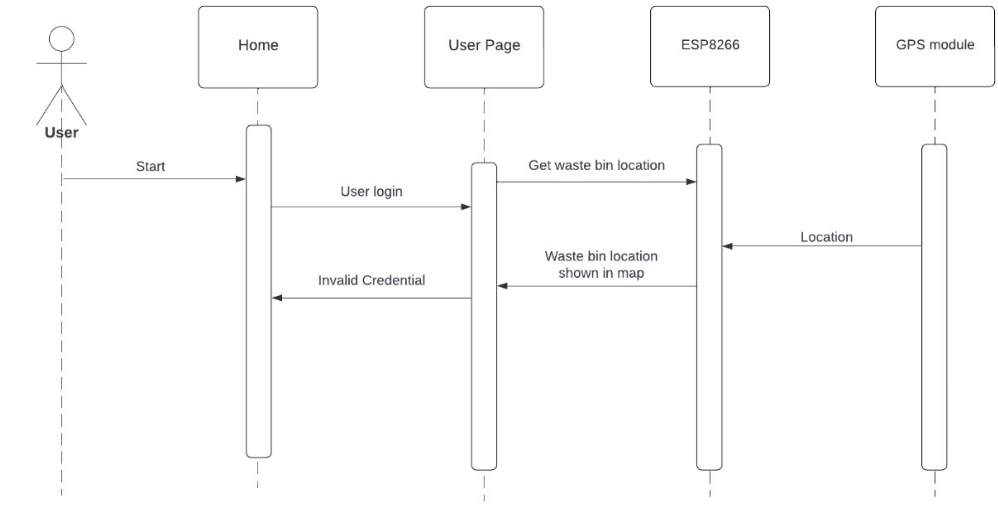


Figure 4.2: Locate nearby bins.

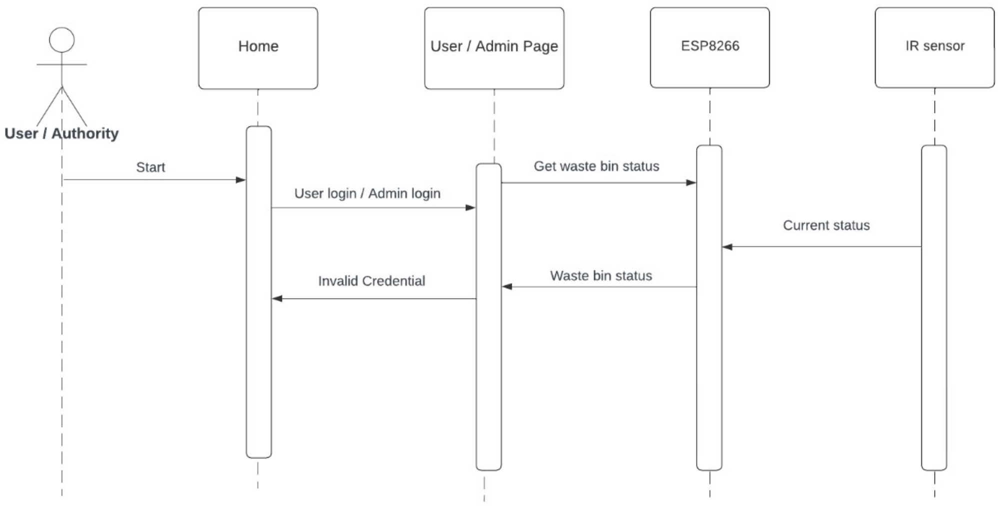


Figure 4.3: Waste bin level.

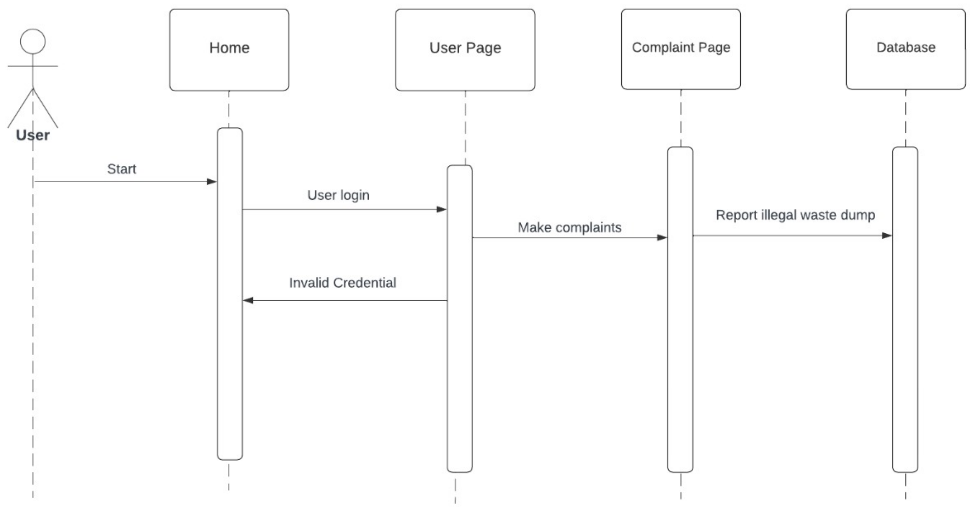


Figure 4.4: Report Illegal Waste dump.

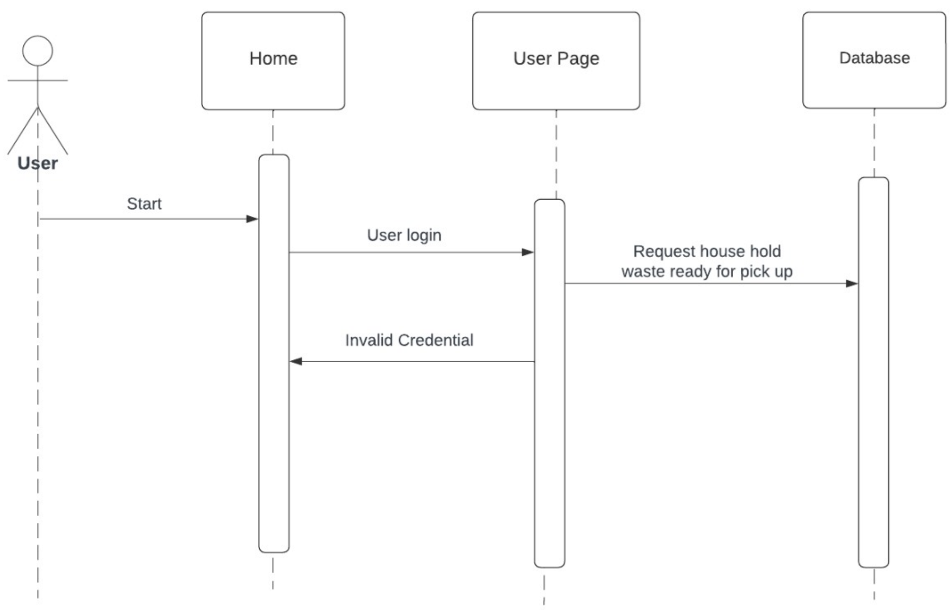


Figure 4.5: Household Waste pickup request.

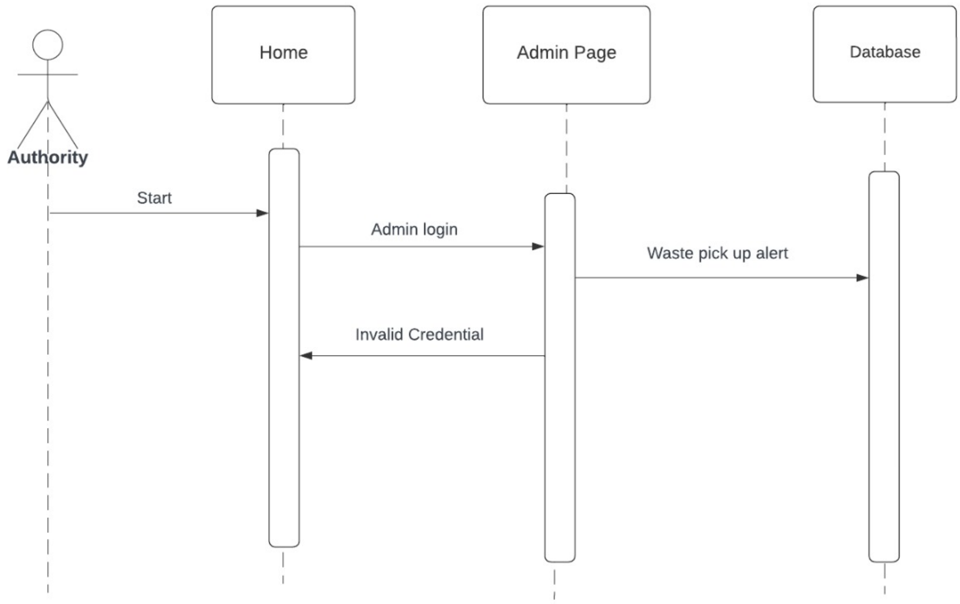


Figure 4.6: Authority pickup notification.

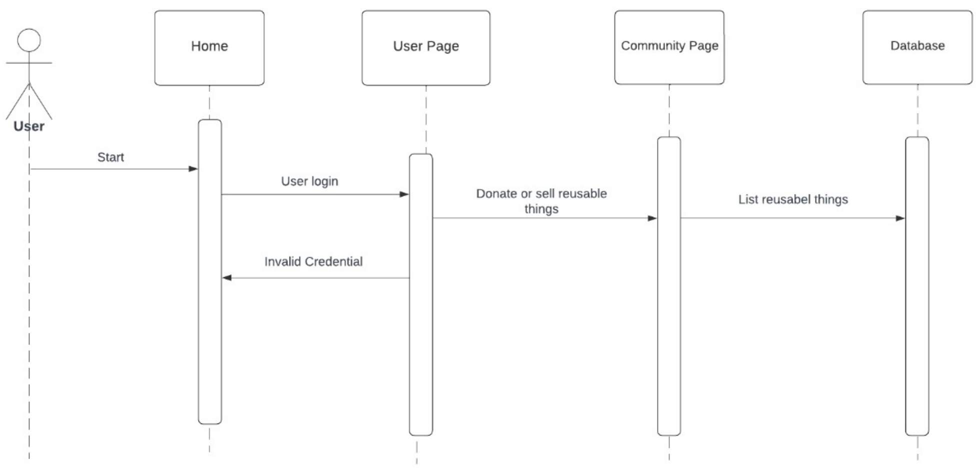


Figure 4.7: Donation and exchange platform.

4.4 CONCLUSION

By concluding the System Design chapter, we've journeyed through the inner workings of GarboGo, an innovative waste disposal and recycling solution. We delved into a thorough feasibility study, considering market dynamics, tech requirements, and legal aspects. Strategies were crafted to tackle potential hurdles, and user feedback was a key influencer in refining the app's design. The visual aids, such as use case and sequence diagrams, offered a clear picture of the system's structure and dynamic behavior. In a nutshell, this chapter sets a strong groundwork for GarboGo's development, ensuring a well-informed and thoughtful path forward as we move into the implementation phase.

Chapter 5
IMPLEMENTATION

This chapter explains how to turn your ideas into something that actually works in the real world. Here, we will explore the workings, key components, and the estimation of costs involved in bringing GarboGo to life. It will provide a detailed breakdown of the working mechanisms that underpin GarboGo. We will elucidate how the app navigates through waste collection schedules, leverages sensor data for real-time alerts, facilitates recycling through user-friendly interfaces and engages users through rewards and loyalty programs. To really get how GarboGo works as a whole, it's super important to know how each little piece works too.

5.1 WORKING

The project primarily focuses on proper waste disposal management. It includes a waste bin equipped with a sensor that continuously gives the status of the waste content in the bin. Thus the authorities such as municipalities or other authorized organizations can know which waste bins are ready for pick up based on the status information they receive. The waste bin status information will be obtained through the application. The entity of the application is those who put the waste into the bin. The users can find and navigate to the nearest waste bin location using the app. The users can also report complaints regarding improper waste disposal which is harmful to the environment. The authority can identify the vulnerable areas from where a majority of complaints come and strategically place cameras in those places. By monitoring the image taken by the camera the system will give the information about severity of the waste disposal.

The app users can inform the municipality when the household waste is ready for pick up through the app consequently the authority can know to which homes or areas they should go for collecting waste. The app has the feature that it connects to the community where the sellers can find the buyers who are searching for the same thing, thus the app supports the maximum re-usability of an object. The things that are considered as a waste by some people can be useful things to other individuals or organizations.

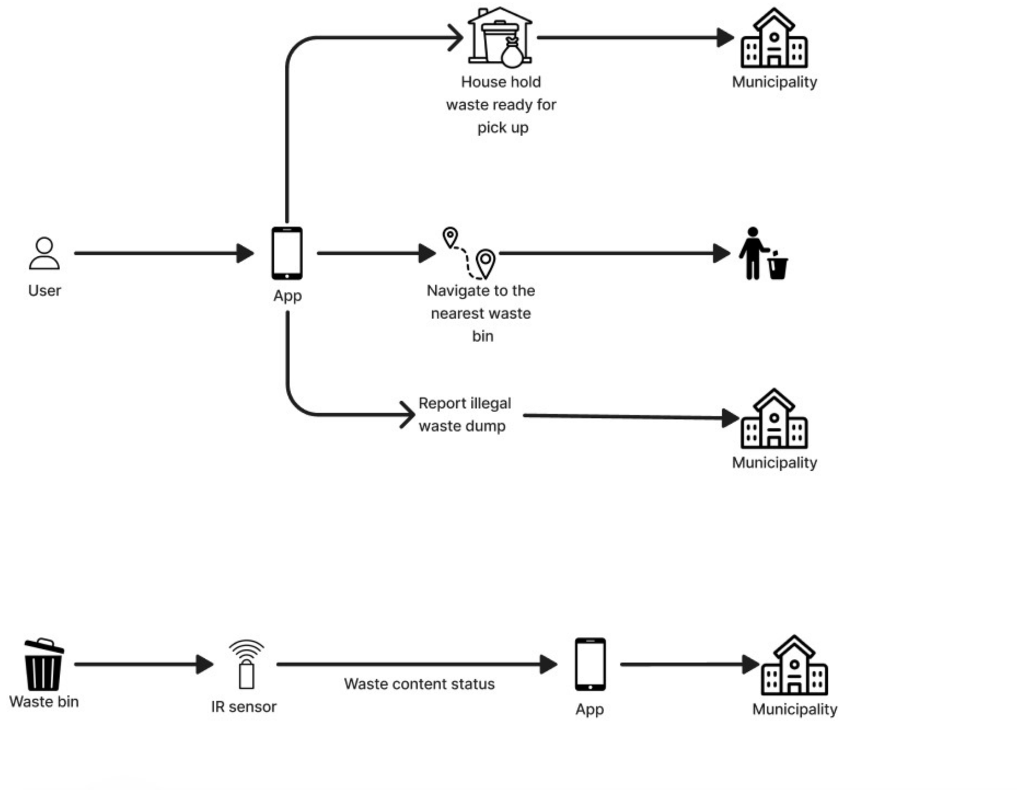


Figure 5.1: General working.

5.1.1 Data Retrieving

To retrieve data from the waste bins equipped with IR sensors and GPS modules, the system employs a two-tiered approach. Positioned strategically within the bins, two IR sensors are utilized: one located at the middle and the other at the top. This arrangement enables precise detection of the waste level, categorizing it as less than half, more than half, or full. The IR sensors continuously monitor the fill level, transmitting real-time data to the central processing unit. Concurrently, the GPS module provides location-based information, ensuring accurate bin identification and tracking. Through seamless integration of these technologies, the system retrieves comprehensive data on waste levels and bin locations, facilitating efficient waste management and enhancing user experience.

5.1.2 Real-time Update

The system enables real-time updates of bin statuses on the user application by seamlessly integrating Arduino sketches with a server. As the status of the bins changes, whether they are categorized as less than half, more than half, or full based on IR sensor readings, this information is swiftly transmitted to the server. Through the utilization of a real-time database, such as Firebase, these updates are instantaneously stored and made accessible to users and relevant authorities. Moreover, the system allows for efficient reporting and scheduling of waste pickups directly from the application, with these actions also being recorded in the real-time database for immediate access by authorized personnel. This ensures that users and authorities have up-to-date information regarding waste levels and collection schedules, facilitating effective waste management practices.

5.1.3 Waste Classification based on Severity using CNN

CNNs are widely used for image classification tasks due to their ability to automatically learn hierarchical features from images. In this implementation, the CNN likely takes an image of the waste dump as input and outputs a severity score or classification indicating the level of severity of the waste. The model is trained on a dataset containing images of waste dumps along with their corresponding severity labels, allowing it to learn patterns and features associated with different levels of waste severity.

The CNN architecture typically consists of multiple layers including convolutional layers for feature extraction, pooling layers for dimensionality reduction, and fully connected layers for classification. During training, the model learns to adjust its parameters to minimize the difference between the predicted severity scores and the ground truth labels using techniques such as gradient descent optimization. Once trained, the model can be deployed in the mobile application's backend to predict the severity of waste dumps captured by users.

In the project implementation, the CNN model is integrated into the mobile application's backend. When a user captures an image of a waste dump and submits it along with details about the waste, the image is passed through the CNN model to predict its severity. The severity score is then used to prioritize the listing of reported requests in the authority login, ensuring that waste dumps with higher severity are listed at the top. This functionality enhances the efficiency of waste management by enabling authorities to quickly identify and address severe waste dumping incidents.

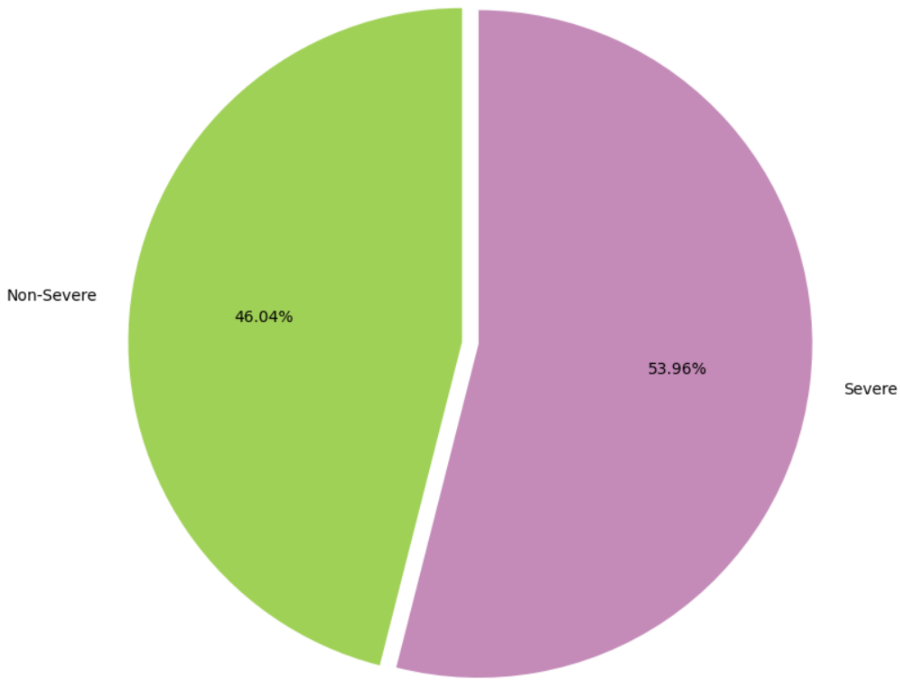


Figure 5.2: Chart Representing Size of Dataset

5.2 CIRCUIT DIAGRAM

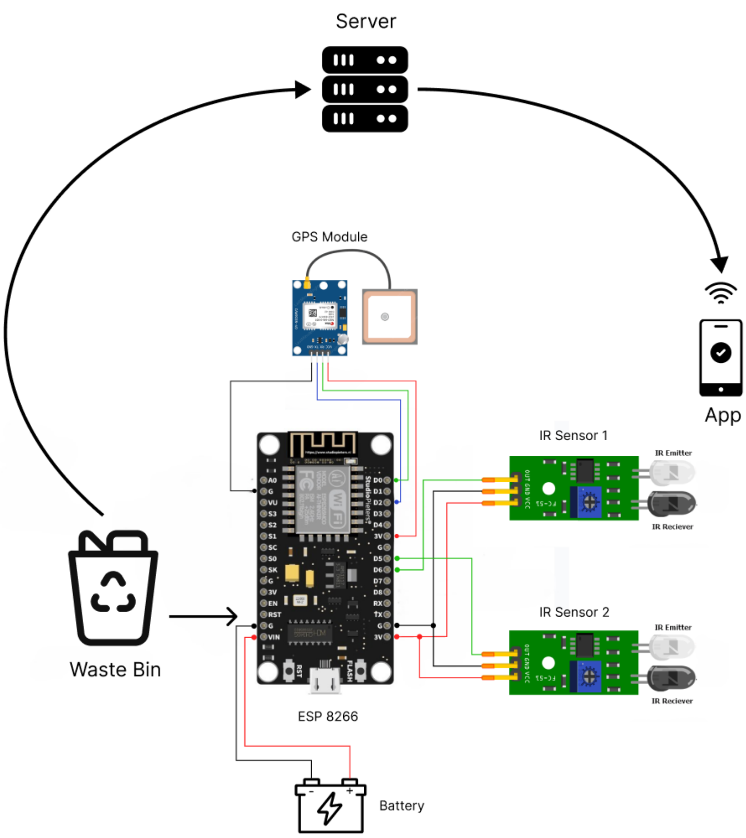


Figure 5.3: Circuit for GarboGo.

5.3 COMPONENTS REQUIRED

In this project, we put Infrared (IR) sensors on public waste bins to revolutionize waste management. These little sensors are strategically placed in the bins to monitor how full they are. As soon as a bin reaches its limit, an automatic alert is generated and sent to the people in charge so that it can be emptied. Doing this means we are ensuring that all of our resources are being used efficiently and promptly. Inside sits a powerful ESP8266, which is a versatile Wi-Fi-enabled microcontroller that acts as the central control unit. We had to make sure our system could work without harming the environment too much, so we incorporated mini solar panels into it for a continuous energy supply for both the ESP8266 and IR sensors. We have a GPS module attached to bins, which will give us real-time tracking and show us exactly where each waste bin is located. Combining all of these smart tools optimizes waste collection and contributes to a cleaner city environment.

- **Infrared (IR) Sensor :** An IR (Infrared) sensor is a device that detects and measures infrared radiation to sense the presence or motion of objects by their emitted or reflected heat. It is placed in the waste bins to monitor their fill levels.

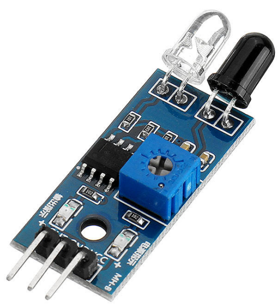


Figure 5.4: Infrared Sensors[1]

- **ESP8266 Micro-controller :** The ESP8266 is a versatile Wi-Fi-enabled microcontroller responsible for processing and communication within the system.

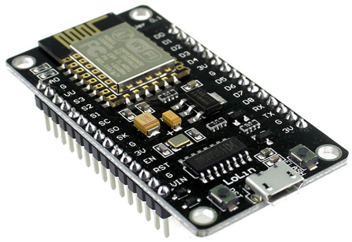


Figure 5.5: ESP8266 Micro-controller[1]

- **GPS Module :** A GPS module, placed on waste bins, receives signals from global positioning system (GPS) satellites to determine and provide accurate location information such as latitude and longitude coordinates for tracking purposes.

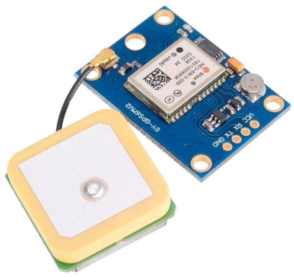


Figure 5.6: GPS Module
Source : https://probots.co.in/gps-module

- **Mini Solar Panel :** A 5V mini solar panel is a compact photovoltaic device utilized to generate electrical power for components such as ESP8266 and IR sensors by harnessing sunlight energy.

Figure 5.7: Solar Panel
Source: https://images.app.goo.gl/MU7RCAwAdMtxZGzRA

5.4 ESTIMATION OF COSTS

The cost of components is a critical factor that significantly influences overall manufacturing expenses. These components encompass electronic parts, processors, memory modules, sensors, and other specialized components depending on the nature of the product. The cost of these parts can change depending on things like how much people want them, how easy they are to get, new technology, and how hard they are to make. The expected expense associated with hardware components as required for the implementation is given below:

Table 5.1: Estimated price of components

Name	Price (in Rs)
ESP8266 Micro-controller	350
IR sensor	30
Mini solar panel 6V	100
NEO-6M GPS module	250
Total Cost	730

5.5 CONCLUSION

To sum it up, this waste recycling app, with all the features we discussed, could change how we handle waste and care for our environment. It can help with waste collection, recycling, and raising awareness about the environment. The app can empower individuals, communities, and local authorities to work together for a cleaner and greener future. It can also reduce waste contamination, stop illegal dumping, and encourage recycling and reusing items. Additionally, it provides valuable data for city planning and offers convenient waste pickup services. By using technology and community involvement, this app moves us closer to a more eco-friendly world where everyone can help make our planet healthier for future generations.

Chapter 6

RESULTS AND CONCLUSIONS

In summary, the GarboGo app we've envisioned transcends the conventional notions of waste management. Its comprehensive suite of features promises a transformative impact on how we interact with and contribute to our environment. At its core, the app is not merely a tool for waste collection and recycling; it is a multifaceted solution that addresses critical issues and advocates for a sustainable future. By streamlining waste collection and recycling processes, the app aims to alleviate the burden on individuals and communities, making environmentally responsible practices more accessible and convenient. Beyond its practical functionalities, the app serves as a beacon of environmental awareness, educating users and fostering a sense of responsibility towards the planet.

Empowerment is a key theme woven into the fabric of this app. Individuals are empowered to take active roles in waste management, communities are empowered to collectively strive for a cleaner future, and local authorities are empowered with valuable data for informed decision-making in urban planning. The app's potential impact extends far beyond the reduction of waste and the promotion of recycling. It is a potent tool in the fight against illegal dumping, acting as both a deterrent and a reporting mechanism. By encouraging the reuse of items through donation and exchange platforms, the app promotes a culture of sustainability that goes beyond traditional recycling efforts.

Moreover, the app embraces the digital age, leveraging technology not only for waste management but also for community building. Its rewards and loyalty program not only incentivizes eco-friendly practices but also fosters a sense of shared responsibility. The app's integration of sensor-based technology not only optimizes waste collection but also provides real-time data for responsive decision-making.

As we navigate toward a more eco-friendly world, this waste recycling app represents a pivotal step. It's a convergence of technology and community involvement, a synergy that propels us toward a future where sustainable practices are not just encouraged but effortlessly integrated into our daily lives. This app, with its visionary features, has the potential to be a cornerstone in the collective effort to make our planet healthier, more resilient, and more vibrant for the generations to come.

6.1 SOCIAL RELEVANCE AND APPLICABILITY

GarboGo, our revolutionary waste recycling app, is deeply rooted in social relevance and widespread applicability. It transcends traditional waste management boundaries, engaging communities and fostering environmental consciousness. With its intuitive interface, GarboGo ensures inclusivity, making waste management accessible to everyone. By providing real-time alerts and educational resources, it raises awareness and inspires eco-friendly habits. GarboGo actively prevents illegal dumping, empowering users to safeguard their neighborhoods. It serves as a powerful tool for local authorities, offering valuable data for efficient urban planning. Beyond waste collection, GarboGo promotes recycling, donation, and item exchange, encouraging a circular economy. Leveraging technology, including sensor-based alerts, GarboGo is not just a local solution; it's globally relevant, adaptable to diverse contexts. In essence, GarboGo is a social and environmental catalyst, propelling communities toward a cleaner, greener future.

Chapter 7

FUTURE DIRECTIONS

In the future, the waste management and recycling project has several exciting directions to explore. Integrating artificial intelligence (AI) and machine learning (ML) technologies can enhance the automation system. Data analytics can provide valuable insights into user behavior, resource usage patterns, and system performance.

leveraging machine learning algorithms for image processing can improve the accuracy and efficiency of illegal dumping detection, enabling swift response and enforcement actions. Collaborating with local authorities and waste management agencies can promote community engagement and support, driving adoption and sustainability initiatives. Continuous refinement based on user feedback and technological advancements will be essential, ensuring the smart bin project evolves to meet evolving needs and challenges in waste management and environmental conservation.

Continuous improvement is crucial, with user feedback playing a vital role in identifying areas for enhancement. By actively addressing usability issues and concerns.

REFERENCES

[1] **S. Murugaanandam, V. Ganapathy and R. Balaji** *"Efficient IOT Based Smart Bin for Clean Environment,"* 2018 International Conference on Communication and Signal Processing (ICCSP), Chennai, India, 2018.

[2] **A. Premgi, F. Martins and D. Domingos***"An infrared-based sensor to measure the filling level of a waste bin,"* 2019 International Conference in Engineering Applications (ICEA), Sao Miguel, Portugal, 2019.

[3] **Samann, Fady EF.***"The design and implementation of smart trash bin."* Academic Journal of Nawroz University 6, no. 3 (2017):141-148.

[4] **Joshi, Sonali, Uttkarsh Kumar Singh, and Sahil Yadav.** *"Smart dustbin using GPS tracking."* International Research Journal of Engineering and Technology (IRJET) 6.06 (2019).

[5] **Harisha, A. N. L.** *"IOT BASED GARBAGE COLLECTIOR."*, 2023 Research Journal on Indian Institution of Industrial Engineering(IIIE), Volume 52(2023).

[6] **Shyam, K., Reddy, S.M., Reddy, A.M., Sri, G.L. and Charan, P.S.,** *"IOT-BASED SMART BIN MANAGEMENT WITH LOCATION ALERT USING NODEMCU",* 2023 Research Journal Indian Institution of Industrial Engineering(IIIE), Volume 52(2023)

[7] **Bujang, S. H., Suhaimi, H., and Abas, P. E.***"Performance of low cost Global Positioning System (GPS) module in location tracking device. In IOP Confer-*

ence Series: Materials Science and Engineering"(Vol. 991, No. 1, p.012137) 2020.

[8] **Adhikari, J., Jumale, A., Pittalwar, L., Joshi, M., Khan, F. and Samund, N.** *"AUTOMATED WASTE CLASSIFICATION VIA IMAGE PROCESSING BASED ON DEEP LEARNING"*, 2023 International Research Journal of Modernization in Engineering Technology and Science(IRJMETS),Volume5(2023)

[9] **Li, Qi, Yang Liu, Shaohua Guo, and Haoshen Zhou***"Solar energy storage in the rechargeable batteries."*, Nano Today 16 (2017): 46-60.

[10] **T. Voigt, H. Ritter and J. Schiller***"Utilizing solar power in wireless sensor networks"* 28th Annual IEEE International Conference on Local Computer Networks, 2003. LCN '03. Proceedings., Bonn/Konigswinter, Germany, 2003, pp. 416-422.

[11] **Chowdhury, Moe.***"Searching quality data for municipal solid waste planning."* Waste management 29, no. 8 (2009):2240-2247.

[12] **Kartik Sharma, Deepshikha Sharma.***"Statistical Analysis of Solid Waste Generation and Challenges Faced in Solid Waste Management in Navsari City."* Department Of Civil Engineering, Chhotubhai Gopalbhai Patel Institute Of Technology, Uka Tarsadia University, Bardoli, Gujarat, India. November-2021.

APPENDIX I: SAMPLE CODE

1. Login.xml

```
<?xml version="1.0" encoding="utf-8"?>
<androidx.constraintlayout.widget.ConstraintLayout xmlns:android="http://schemas
    xmlns:app="http://schemas.android.com/apk/res-auto"
    xmlns:tools="http://schemas.android.com/tools"
    android:layout_width="match_parent"
    android:layout_height="match_parent"
    tools:context=".MainActivity">

    <ImageView
        android:id="@+id/imageView"
        android:layout_width="610dp"
        android:layout_height="893dp"
        app:layout_constraintBottom_toBottomOf="parent"
        app:layout_constraintEnd_toEndOf="parent"
        app:layout_constraintHorizontal_bias="0.502"
        app:layout_constraintStart_toStartOf="parent"
        app:layout_constraintTop_toTopOf="parent"
        app:srcCompat="@drawable/_d23d6fa_0b96_4950_8590_88917646980a" />

    <TextView
        android:id="@+id/loginText"
        android:layout_width="match_parent"
        android:layout_height="wrap_content"
        android:layout_marginTop="232dp"
        android:text="Login"
        android:textAlignment="center"
        android:textColor="@color/white"
```

```
    android:textSize="30sp"
    android:textStyle="normal"
    app:layout_constraintEnd_toEndOf="parent"
    app:layout_constraintHorizontal_bias="0.0"
    app:layout_constraintStart_toStartOf="parent"
    app:layout_constraintTop_toTopOf="parent" />

<EditText
    android:id="@+id/username"
    android:layout_width="360dp"
    android:layout_height="60dp"
    android:background="@drawable/custom_edittext"
    android:drawableLeft="@drawable/ic_baseline_person_24"
    android:drawablePadding="8dp"
    android:hint="Username"
    android:textColorHint="@color/lw"
    android:padding="8dp"
    android:textColor="@color/white"
    app:layout_constraintBottom_toBottomOf="parent"
    app:layout_constraintEnd_toEndOf="parent"
    app:layout_constraintHorizontal_bias="0.487"
    app:layout_constraintStart_toStartOf="parent"
    app:layout_constraintTop_toTopOf="parent"
    app:layout_constraintVertical_bias="0.448" />

<EditText
    android:id="@+id/password"
    android:layout_width="360dp"
    android:layout_height="60dp"
    android:background="@drawable/custom_edittext"
```

```
    android:drawableLeft="@drawable/ic_baseline_lock_24"
    android:drawablePadding="8dp"
    android:hint="Password"
    android:textColorHint="@color/lw"
    android:padding="8dp"
    android:inputType="textPassword"
    android:textColor="@color/white"
    app:layout_constraintBottom_toBottomOf="parent"
    app:layout_constraintEnd_toEndOf="parent"
    app:layout_constraintHorizontal_bias="0.487"
    app:layout_constraintStart_toStartOf="parent"
    app:layout_constraintTop_toTopOf="parent"
    app:layout_constraintVertical_bias="0.576" />

<TextView
    android:id="@+id/textView"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_marginTop="16dp"
    android:layout_marginBottom="24dp"
    android:text="Forgot?"
    android:textSize="18sp"
    android:textColor="@color/lw"
    app:layout_constraintBottom_toBottomOf="@+id/password"
    app:layout_constraintEnd_toEndOf="parent"
    app:layout_constraintHorizontal_bias="0.897"
    app:layout_constraintStart_toStartOf="parent"
    app:layout_constraintTop_toTopOf="@+id/password"
    app:layout_constraintVertical_bias="0.0" />
```

```
<Button
    android:id="@+id/loginButton"
    android:layout_width="360dp"
    android:layout_height="61dp"
    android:backgroundTint="@color/grey"
    android:text="Login"
    android:textSize="18sp"
    app:cornerRadius="10dp"
    app:layout_constraintBottom_toBottomOf="parent"
    app:layout_constraintEnd_toEndOf="parent"
    app:layout_constraintHorizontal_bias="0.526"
    app:layout_constraintStart_toStartOf="parent"
    app:layout_constraintTop_toTopOf="parent"
    app:layout_constraintVertical_bias="0.737" />

<TextView
    android:id="@+id/textView2"
    android:layout_width="205dp"
    android:layout_height="31dp"
    android:text="Don't have account?"
    android:textSize="19sp"
    app:layout_constraintBottom_toBottomOf="parent"
    app:layout_constraintEnd_toEndOf="parent"
    app:layout_constraintHorizontal_bias="0.199"
    app:layout_constraintStart_toStartOf="parent"
    app:layout_constraintTop_toTopOf="parent"
    app:layout_constraintVertical_bias="0.948" />

<TextView
    android:id="@+id/textView3"
```

```
        android:layout_width="173dp"
        android:layout_height="31dp"
        android:text="Create new"
        android:textColor="@color/white"
        android:textSize="19sp"
        android:textStyle="bold"
        app:layout_constraintBottom_toBottomOf="parent"
        app:layout_constraintEnd_toEndOf="parent"
        app:layout_constraintHorizontal_bias="1.0"
        app:layout_constraintStart_toStartOf="parent"
        app:layout_constraintTop_toTopOf="parent"
        app:layout_constraintVertical_bias="0.948" />

</androidx.constraintlayout.widget.ConstraintLayout>
```

2. Illegal.kt

```
    package com.example.garbogo

import android.Manifest
import android.app.Activity
import android.content.ContentValues
import android.content.Intent
import android.content.pm.PackageManager
import android.graphics.Bitmap
import android.graphics.ImageDecoder
import android.net.Uri
import android.os.Build
import android.os.Bundle
```

```kotlin
import android.provider.MediaStore
import android.widget.Button
import android.widget.ImageButton
import android.widget.Toast
import androidx.annotation.RequiresApi
import androidx.appcompat.app.AppCompatActivity
import androidx.core.app.ActivityCompat
import androidx.core.content.ContextCompat
import com.google.firebase.firestore.FirebaseFirestore
import com.google.firebase.storage.FirebaseStorage
import java.io.ByteArrayOutputStream
import java.util.*

class Illegal : AppCompatActivity() {

    private lateinit var imageButton: ImageButton
    private lateinit var submitButton: Button
    private val REQUEST_IMAGE_CAPTURE = 1
    private var imageUri: Uri? = null

    override fun onCreate(savedInstanceState: Bundle?) {
        super.onCreate(savedInstanceState)
        setContentView(R.layout.activity_illegal)

        imageButton = findViewById(R.id.imageButton)
        submitButton = findViewById(R.id.submit)

        imageButton.setOnClickListener {
            dispatchTakePictureIntent()
        }
```

```
        submitButton.setOnClickListener {
            uploadImage()
        }
    }

    private fun dispatchTakePictureIntent() {
        if (ContextCompat.checkSelfPermission(this, Manifest.permission.CAMERA)
            ActivityCompat.requestPermissions(this, arrayOf(Manifest.permission
        } else {
            openCamera()
        }
    }

    private fun openCamera() {
        val values = ContentValues()
        values.put(MediaStore.Images.Media.TITLE, "New Picture")
        values.put(MediaStore.Images.Media.DESCRIPTION, "From the Camera")
        imageUri = contentResolver.insert(MediaStore.Images.Media.EXTERNAL_CONT
        val cameraIntent = Intent(MediaStore.ACTION_IMAGE_CAPTURE)
        cameraIntent.putExtra(MediaStore.EXTRA_OUTPUT, imageUri)
        startActivityForResult(cameraIntent, REQUEST_IMAGE_CAPTURE)
    }

    override fun onRequestPermissionsResult(requestCode: Int, permissions: Arra
        super.onRequestPermissionsResult(requestCode, permissions, grantResults
        if (requestCode == REQUEST_IMAGE_CAPTURE) {
            if (grantResults.isNotEmpty() && grantResults[0] == PackageManager.
                openCamera()
            } else {
```

```
            Toast.makeText(this, "Camera permission denied", Toast.LENGTH_SI
        }
    }
}

@RequiresApi(Build.VERSION_CODES.P)
override fun onActivityResult(requestCode: Int, resultCode: Int, data: Inter
    super.onActivityResult(requestCode, resultCode, data)
    if (requestCode == REQUEST_IMAGE_CAPTURE && resultCode == Activity.RESUI
        val bitmap: Bitmap = ImageDecoder.decodeBitmap(ImageDecoder.createSo
        imageButton.setImageBitmap(bitmap)
    }
}

private fun uploadImage() {
    if (imageUri != null) {
        val storageRef = FirebaseStorage.getInstance().reference
        val imageName = UUID.randomUUID().toString() + ".jpg"
        val imageRef = storageRef.child("images/$imageName")

        imageRef.putFile(imageUri!!)
            .addOnSuccessListener { taskSnapshot ->
                imageRef.downloadUrl.addOnSuccessListener { uri ->
                    val imageUrl = uri.toString()
                    saveImageUrlToFirestore(imageUrl)
                }.addOnFailureListener { exception ->
                    Toast.makeText(this, "Failed to get image URL: ${excepti
                }
            }
            .addOnFailureListener { exception ->
```

```
                Toast.makeText(this, "Image upload failed: ${exception.messa
            }
        } else {
            Toast.makeText(this, "No image selected", Toast.LENGTH_SHORT).show(
        }
    }

    private fun saveImageUrlToFirestore(imageUrl: String) {
        val firestore = FirebaseFirestore.getInstance()
        val imagesCollection = firestore.collection("images")

        val imageData = hashMapOf(
            "url" to imageUrl
        )

        imagesCollection.add(imageData)
            .addOnSuccessListener { documentReference ->
                Toast.makeText(this, "Image uploaded successfully", Toast.LENGT
            }
            .addOnFailureListener { exception ->
                Toast.makeText(this, "Failed to save image URL to Firestore: ${
            }
    }
}
```

3.Arduino Sketch

```
    #include <TinyGPS++.h>
#include <WiFiClient.h>
#include <SoftwareSerial.h>
#include <ESP8266WebServer.h>
```

```
#include <ArduinoJson.h>
#include <ESP8266WiFi.h>

const char* ssid = "Tenda";
const char* password = "S!S@S#S$";
const char* serverAddress = "192.168.0.108"; // Replace with your server’s IP ac
const int serverPort = 3000;

const int irSensorPin1 = 12;  // Replace with the actual pin number for IR senso
const int irSensorPin2 = 14;  // Replace with the actual pin number for IR senso

TinyGPSPlus gps;
SoftwareSerial SerialGPS(4, 5);

float Latitude , Longitude;
String LatitudeString , LongitudeString;

WiFiClient client;
bool dataSent = false; // Flag to track if data has been sent
String prevIrStatus; // Variable to store previous IR status

int prevIrSensorValue1 = LOW;  // Assuming HIGH as the default state
int prevIrSensorValue2 = LOW;  // Assuming HIGH as the default state

// const int ledPin = D4; // Define the pin connected to the LED

void setup() {
  Serial.begin(115200);
  SerialGPS.begin(9600);
```

```
  // pinMode(ledPin, OUTPUT); // Set the LED pin as an output

  Serial.println();
  WiFi.begin(ssid, password);
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println("");
  Serial.println("WiFi connected");

  pinMode(irSensorPin1, INPUT);
  pinMode(irSensorPin2, INPUT);
}

void loop() {
  // GPS data collection
  while (SerialGPS.available() > 0) {
    if (gps.encode(SerialGPS.read())) {
      if (gps.location.isValid()) { // Check if GPS data is valid and data hasn
        if(!dataSent) {
          Latitude = gps.location.lat();
          LatitudeString = String(Latitude , 6);
          Longitude = gps.location.lng();
          LongitudeString = String(Longitude , 6);

          // Print latitude and longitude to serial monitor
          Serial.print("Latitude: ");
          Serial.println(LatitudeString);
          Serial.print("Longitude: ");
```

```
  Serial.println(LongitudeString);
}



// IR sensor data collection
int irSensorValue1 = digitalRead(irSensorPin1);
int irSensorValue2 = digitalRead(irSensorPin2);

// Determine IR sensor status
String irStatus;
if (irSensorValue1 != prevIrSensorValue1 || irSensorValue2 != prevIrSens
// If there's a change in IR sensor readings

  if (irSensorValue1 == HIGH && irSensorValue2 == HIGH) {
    irStatus = "Waste level less than half";
  } else if (irSensorValue1 == LOW && irSensorValue2 == HIGH) {
    irStatus = "Waste level more than half";
  } else if (irSensorValue1 == LOW && irSensorValue2 == LOW) {
    irStatus = "Waste bin is full";
    Serial.println("#######################################################
  }

  // Update the previous state
  prevIrSensorValue1 = irSensorValue1;
  prevIrSensorValue2 = irSensorValue2;
}



// Check if IR status has changed and send data to server
if (irStatus != prevIrStatus) {
```

```
          sendToServer(LatitudeString, LongitudeString, irStatus);
          prevIrStatus = irStatus;
          Serial.print("IR Status changed: ");
          Serial.println(irStatus);
        }

        dataSent = true; // Set flag to true to indicate that data has been sent
      }
    }
  }
}

void sendToServer(String latitude, String longitude, String irStatus) {
  Serial.print("Connecting to ");
  Serial.print(serverAddress);
  Serial.print(":");
  Serial.println(serverPort);

  StaticJsonDocument<200> doc; // Adjust the size as per your message size
  doc["Lat"] = latitude;
  doc["Lng"] = longitude; // Add GPS coordinates to JSON object
  doc["IR_Status"] = irStatus; // Add IR sensor status to JSON object

  // Serialize JSON object to string
  String jsonString;
  serializeJson(doc, jsonString);

  if (client.connect(serverAddress, serverPort)) {
    Serial.println("Connected to server");
    client.println("POST /arduino-data HTTP/1.1");
```

```
    client.println("Host: 192.168.0.108:3000"); // Change to your server's IP ar
    client.println("Content-Type: application/json");
    client.print("Content-Length: ");
    client.println(jsonString.length());
    client.println();
    client.println(jsonString);
  } else {
    Serial.println("Connection failed");
  }
}
```

4.Server

```
    const express = require('express');
const bodyParser = require('body-parser');

const app = express();
const port = 3000;
const host = '0.0.0.0';
let bin_data;
// Parse JSON bodies
app.use(bodyParser.json());

app.post('/arduino-data', (req, res) => {
  const data = req.body;
  if (data.IR_Status !== '') { // Check if IR status is not empty
    bin_data = data;
    console.log('Received data from Arduino:', data);
  }
  res.send('Data received successfully');
});
```

```
let dh = {
  Lat: '9.853989',
  Lng: '76.948151',
  IR_Status: 'Waste level less than half'
};

app.get('/waste-bin-status',(req,res) => {
    res.json(bin_data);
    // console.log(bin_data);

    // res.json(dh);
})

// Start the server
app.listen(port,host, () => {
  console.log(`Server is running on http://${host}:${port}`);
});
```

5.Waste Classification using CNN

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import skimage.io
import tensorflow
import tqdm
import glob
import os

from tqdm import tqdm

from skimage.io import imread, imshow
```

```
# from skimage.transform import resize

from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.applications.vgg16 import VGG16
from tensorflow.keras.applications import InceptionV3
from tensorflow.keras.layers import GlobalAveragePooling2D
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import InputLayer, Dense, Flatten, BatchNormalizat
from tensorflow.keras.callbacks import EarlyStopping, ModelCheckpoint
from tensorflow.keras.preprocessing.image import load_img, img_to_array
# from keras.utils.vis_utils import plot_model
from tensorflow.keras.utils import plot_model
from sklearn.metrics import confusion_matrix
import seaborn as sns

# %matplotlib inline

from google.colab import drive
drive.mount('/content/drive')

drive_path = '/content/drive/MyDrive/ML'

import cv2  # Add this line
from tqdm import tqdm
from glob import glob

train_path = os.path.join(drive_path, 'TRAIN')
test_path = os.path.join(drive_path, 'TEST')

x_data = []
```

```
y_data = []

# Iterate over the TRAIN folder
for category in ['N', 'S']:
    # Define the path to the current category folder
    category_path = os.path.join(train_path, category)
    # Iterate over the images in the current category folder
    for file in tqdm(os.listdir(category_path)):
        # Check if the file is not a "Thumbs.db" file
        if not file.endswith('.db'):
            # Construct the full path to the image file
            file_path = os.path.join(category_path, file)
            # Read the image using cv2.imread
            img_array = cv2.imread(file_path)
            # Check if the image was successfully loaded
            if img_array is None:
                print("Failed to read image:", file_path)
                continue
            # Convert BGR image to RGB
            img_array = cv2.cvtColor(img_array, cv2.COLOR_BGR2RGB)
            # Append the image and label to the lists
            x_data.append(img_array)
            y_data.append(category)

            data=pd.DataFrame({'image': x_data,'label': y_data})

from collections import Counter
print("Number of images for each category:")
print(Counter(y_data))
```

```
data.shape

from collections import Counter

# Calculate the counts of severe and non-severe labels
label_counts = Counter(y_data)

# Define the labels and corresponding colors
labels = ['Non-Severe', 'Severe']
colors = ['#a0d157', '#c48bb8']

# Plot the pie chart
plt.pie(label_counts.values(), startangle=90, explode=[0.05, 0.05], autopct='%0
        labels=labels, colors=colors, radius=2)
plt.show()

plt.figure(figsize=(20,15))
num_samples = len(data)
num_plots = min(9, num_samples)  # Limit the number of plots to 9 or the number

for i in range(num_plots):
    index = np.random.randint(num_samples)
    plt.subplot(3, 3, i+1)
    plt.title('This image is of {0}'.format(data.label[index]), fontdict={'size
    plt.imshow(data.image[index])
    plt.tight_layout()

plt.show()

import glob
```

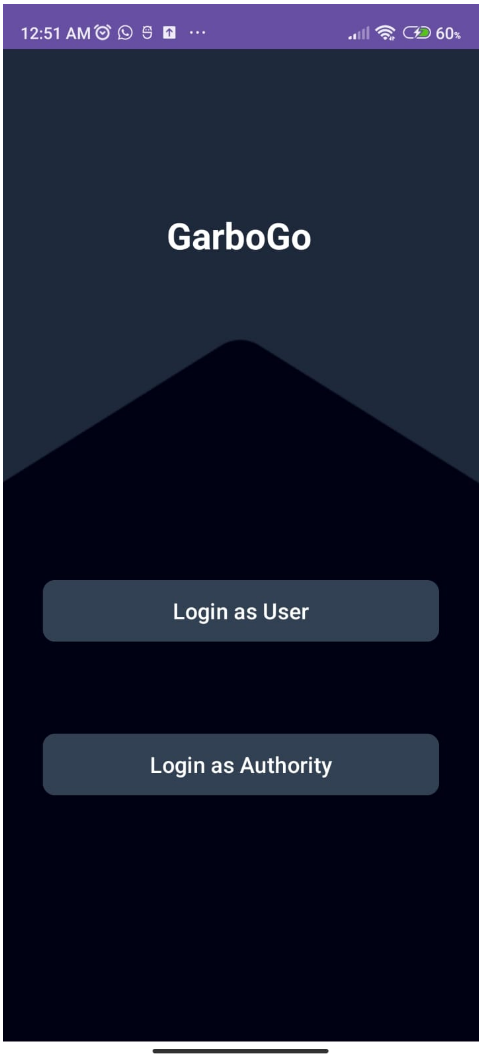
```
className = glob.glob(train_path + '/*' )
numberOfClass = len(className)
print("Number Of Class: ", numberOfClass)

model = Sequential()
model.add(Conv2D(32,(3,3),input_shape = (224,224,3)))
model.add(Activation("relu"))
model.add(MaxPooling2D())

model.add(Conv2D(64,(3,3)))
model.add(Activation("relu"))
model.add(MaxPooling2D())

model.add(Conv2D(128,(3,3)))
model.add(Activation("relu"))
model.add(MaxPooling2D())

model.add(Flatten())
model.add(Dense(256))
model.add(Activation("relu"))
model.add(Dropout(0.5))
model.add(Dense(64))
model.add(Activation("relu"))
model.add(Dropout(0.5))
model.add(Dense(numberOfClass)) # output
model.add(Activation("sigmoid"))

model.compile(loss = "binary_crossentropy",
              optimizer = "adam",
```

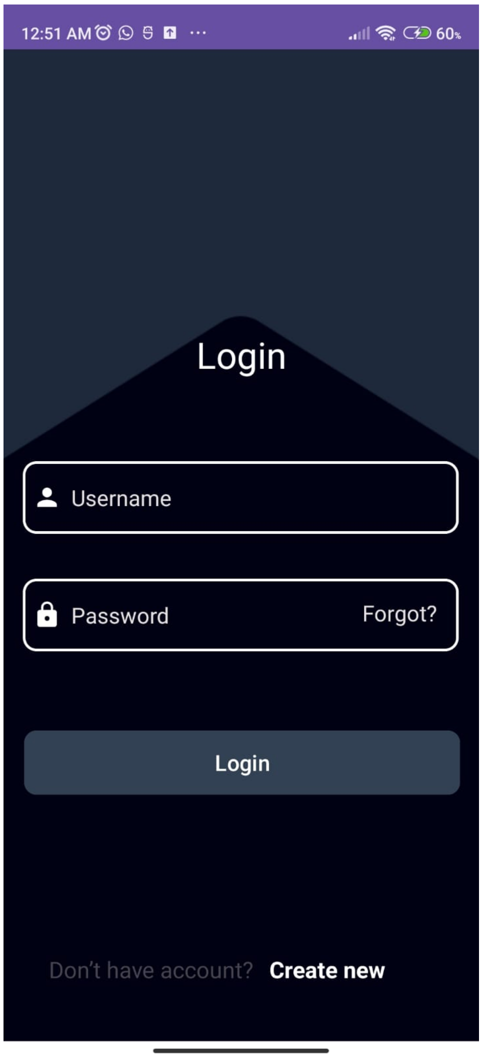
```
              metrics = ["accuracy"])

batch_size = 256

plot_model(model)

train_datagen = ImageDataGenerator(rescale= 1./255)

test_datagen = ImageDataGenerator(rescale= 1./255)

train_generator = train_datagen.flow_from_directory(
        train_path,
        target_size= (224,224),
        batch_size = batch_size,
        color_mode= "rgb",
        class_mode= "categorical")

test_generator = test_datagen.flow_from_directory(
        test_path,
        target_size= (224,224),
        batch_size = batch_size,
        color_mode= "rgb",
        class_mode= "categorical")

hist = model.fit_generator(
        generator = train_generator,
        epochs=2,
        validation_data = test_generator)

def predict_func(img):
```

```
    plt.figure(figsize=(6,4))
    plt.imshow(cv2.cvtColor(img, cv2.COLOR_BGR2RGB))
    plt.tight_layout()
    img = cv2.resize(img, (224, 224))
    img = np.reshape(img, [-1, 224, 224,3])
    result = np.argmax(model.predict(img))
    if result == 0: print("\033[94m"+"This image -> Non Severe"+"\033[0m")
    elif result ==1: print("\033[94m"+"This image -> Severe"+"\033[0m")

test_img = cv2.imread("/content/drive/MyDrive/ML/TEST/N/N100.jpg")
predict_func(test_img)

test_img = cv2.imread("/content/drive/MyDrive/ML/TEST/S/S126.jpg")
predict_func(test_img)

accuracy = model.evaluate(test_generator)
print("Loss:", accuracy[0])
print("Accuracy:", accuracy[1])

test_img = cv2.imread("/content/drive/MyDrive/S512.jpg")
predict_func(test_img)

test_img = cv2.imread("/content/drive/MyDrive/images.jpeg")
predict_func(test_img)

test_img = cv2.imread("/content/drive/MyDrive/download.jpeg")
predict_func(test_img)
```

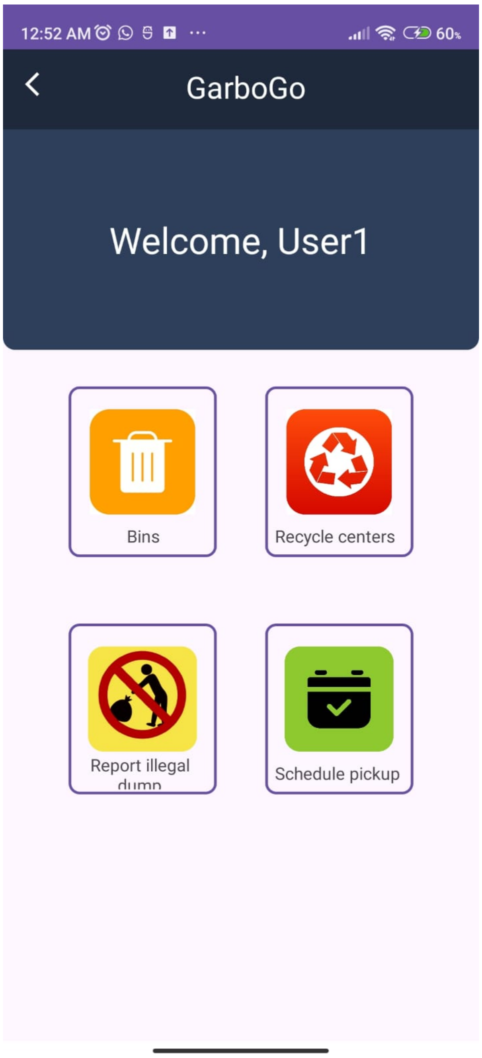
APPENDIX II: SCREENSHOTS

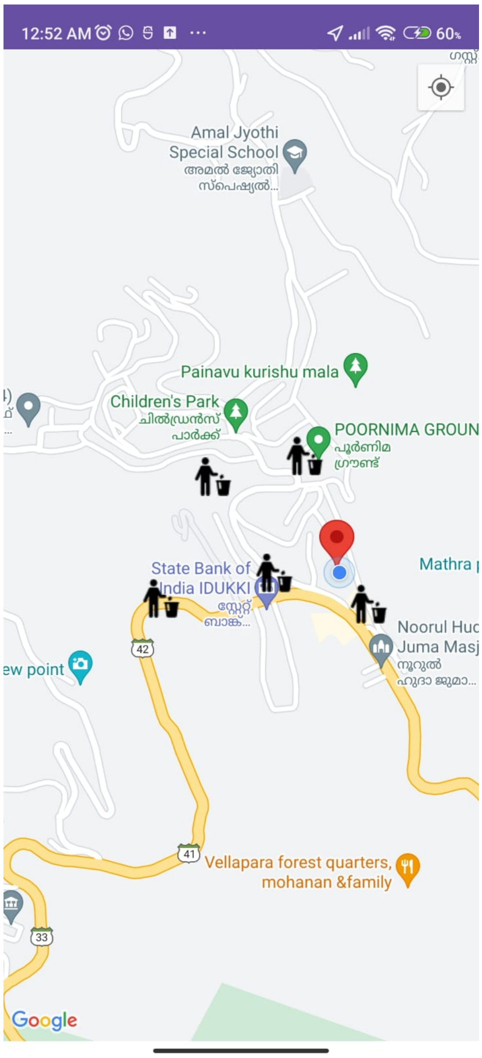
1. Login Page



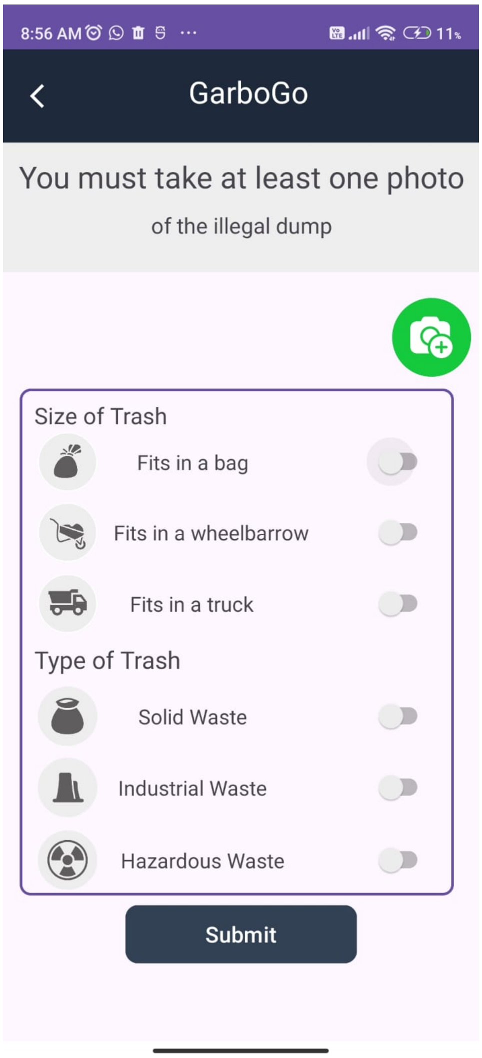


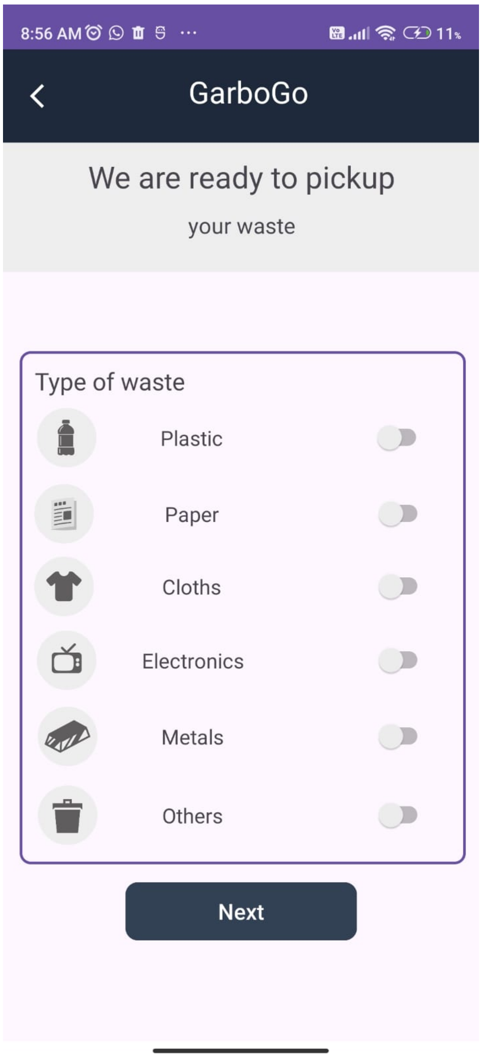
2. User Home and Bins



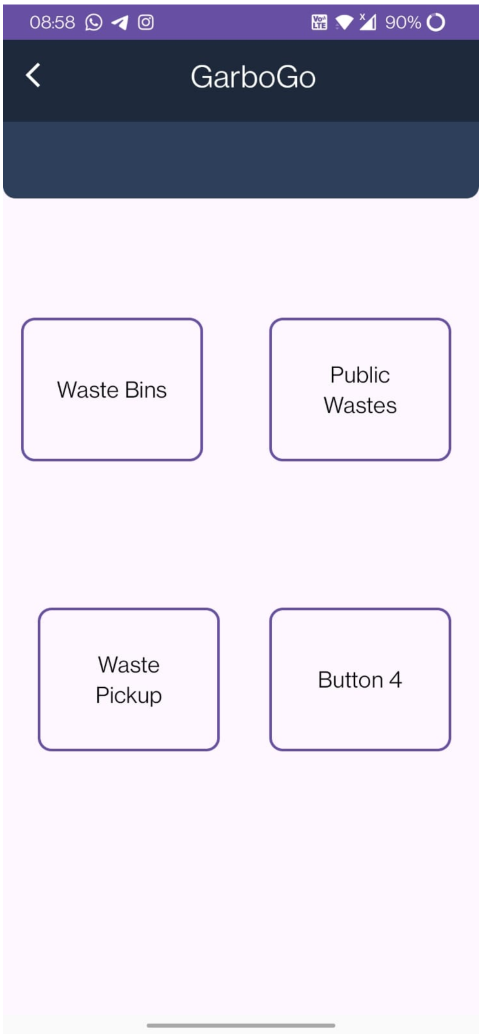


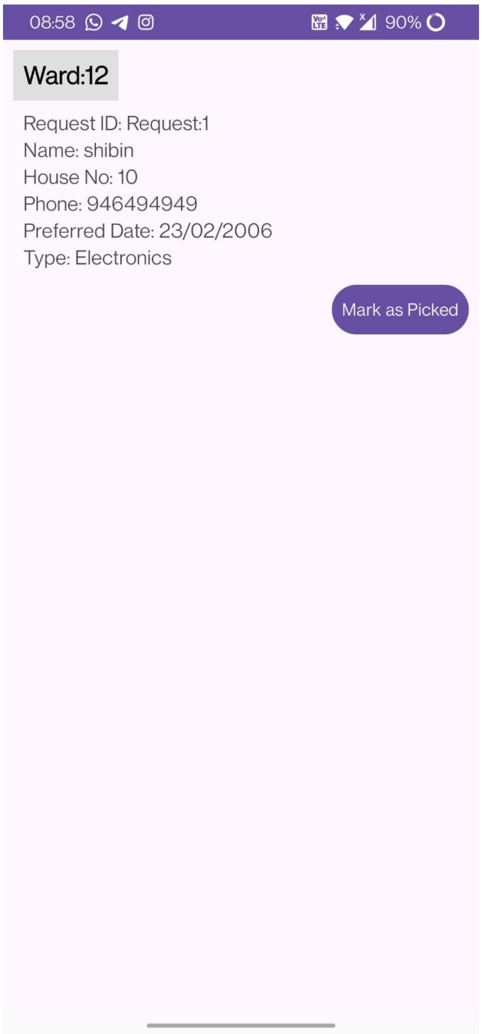
3. Illegal Dump and Schedule Pickup





4. Authority Login and Request List





APPENDIX III: PRESENTATION

GarboGo

Dhaheen Rahman P- IDK20CS025
Shibin K K - IDK20CS056
Vinoy Raj J S - IDK20CS062
Vyshnav K K- IDK20CS063

Guide : Prof Philumon Joseph

Overview

Introduction

- Population is rising rapidly so as the resource consumption, which will leads to increased rate of waste generation.
- Current techniques are not capable to handle huge volume of wastes in an efficient manner.
- GarboGo is a solution for handling this issue by bringing efficient changes that can enhance the quality of existing waste management techniques.

Aim and Objectives

- To bring IoT(Internet of Things) concepts in waste management.
- To create a scenario for proper waste disposal.
- To create a platform for promoting the 'Reuse' concept in order to reduce waste generation.
- To conduct statistical studies for bringing changes in existing strategies.

Problem Statement

- Current waste management systems suffer from issues like inefficient waste collection, unhygienic streets due to illegal dumping, lack of awareness and inadequate infrastructure for waste disposal.
- In order to properly handle these concerns, a platform that both mitigates present issues and improves the efficiency of current waste management approaches must be created.

Literature Survey

Sl No.	Paper	Author	Content
1	Utilizing solar power in wireless sensor networks,28th Annual IEEE International Conference on Local Computer Networks(2003).	T. Voigt, H. Ritter and J. Schiller.	• Focus on making solar-powered sensors. • Adopted the idea of solar-powered micro-controllers.
2	Searching quality data for municipal solid waste planning, Waste management 29, no. 8(2009).	Chowdhury, Moe	• Emphasises the importance of accurate local databases that store the details regarding waste collection. • Aims to enhance waste collection statistics for better waste management strategies.

Literature Survey Cont.

Sl No.	Paper	Author	Content
3	Solar energy storage in the rechargeable batteries, Nano Today 16 (2017).	Li, Qi, Yang Liu, Shaohua Guo, and Haoshen Zhou.	• Talks about using solar-powered rechargeable batteries. • Explore different ways in which we can use solar-powered batteries and discuss the challenges also.
4	The design and implementation of smart trash bin, Academic Journal of Nawroz University 6, no. 3 (2017).	Samann, Fady EF.	• Presents a low-cost smart waste container for small-scale use. • Utilize Arduino Nano, Ultrasonic sensor, GSM module for SMS alerts.

Literature Survey Cont.

Sl No.	Paper	Author	Content
5	Efficient IOT Based Smart Bin for Clean Environment, International Conference on Communication and Signal Processing (ICCSP),(2018).	S. Murugaanandam, V. Ganapathy and R. Balaji.	• Proposes a IoT based garbage and waste collection bin leveraging GPS and IoT technologies for real-time monitoring. • The system automates monitoring using sensors to track bin levels and weight, triggering alerts for timely collection.
6	An infrared-based sensor to measure the filling level of a waste bin, International Conference in Engineering Applications (ICEA), Sao Miguel, Portugal(2019).	A. Premgi, F. Martins and D. Domingos.	• Presents a low-cost sensor prototype for determining waste bin filling levels, using IR light beams as opposed to traditional methods like Ultrasonic sensors or imaging technologies. • Aims to cover maximum space inside the bin with minimal sensors offering a cost -effective solutions.

Literature Survey Cont.

Sl No.	Paper	Author	Content
7	Smart dustbin using GPS tracking, International Research Journal of Engineering and Technology (IRJET) 6.06 (2019).	Joshi, Sonali, Uttkarsh Kumar Singh, and Sahil Yadav.	• Introduces a smart waste management system using IoT and real-time monitoring for efficient waste disposal • Comprises of smart waste bins and a cloud-based platform, employs techniques like GPS and NodeMCU reducing manual efforts and costs.
8	Performance of low cost Global Positioning System (GPS) module in location tracking device. In IOP Conference Series: Materials Science and Engineering (Vol. 991, No. 1, p. 012137). IOP Publishing, (2020).	S H Bujang, H Suhaimi and Pg E Abas.	• Explores a cost effective GPS tracking system using existing GPS modules. • Results demonstrate minimal average error distances, making it suitable for tracking bin locations.

Literature Survey Cont.

Sl No.	Paper	Author	Content
9	Statistical Analysis of Solid Waste Generation and Challenges Faced in Solid Waste Management in Navsari City. 1Department Of Civil Engineering, Chhotubhai Gopalbhai Patel Institute Of Technology, Uka Tarsadia University, Bardoli, Gujarat, India,(2021).	Kartik Sharma,Deepshikha Sharma.	• Discusses serious waste management challenges in Navsari township, Gujarat. India. • Points out urgent need for changes in local authorities to improve waste management strategies.
10	IoT Based Garbage Collector, Research Journal on Indian Institution of Industrial Engineering(IIIE), Volume 52(2023).	A N L Harisha, B.Harshitha, G.V.D.Prasad, E.Pavani, B.Venkatesh babu	• Proposes an IoT-based Garbage and Waste Collection System using GPS and ultrasonic sensors. • Aims to improve waste management by providing real-time information on garbage bin levels.

Literature Survey Cont.

Sl No.	Paper	Author	Content
11	IoT-Based Smart Bin Management With Location Alert Using NODEMCU", Research Journal Indian Institution of Industrial Engineering(IIIE), Volume 52(2023)	K. Shyam, , S. Mounika Reddy,A. Manikanth Reddy, , G. Lasya Sri,P. Sai Charan.	• Proposes an IoT-based Smart Garbage Monitoring System using GPS and ultrasonic sensors to enhance waste management. • The system offers real-time data on garbage bin levels, alerting the central office and assigned truck driver when a bin is full.
12	Automated Waste Classification Via Image Processing Based on Depp Learning, International Research Journal of Modernization in Engineering Technology and Science(IRJMETS), Volume 5(2023).	Adhikari J, Jumale A, Pittalwar L, Joshi M, Khan F and Samund N.	• Focuses on real-time garbage identification and categorization. • The system uses object detection, and image processing for waste classification using some libraries.

Features

- **Real-Time Sensor Alerts**: Smart sensors that alert authorities when bins are reaching capacity, ensuring timely disposal and reducing litter.
- **Timely Waste Collection**: Authorities can avoid collection of partially filled bins and also avoid overflowing bins.
- **Locate Nearby Bins and Recycling Centers**: Provide users with information on the location of nearby public bins, recycling centers and disposal points.

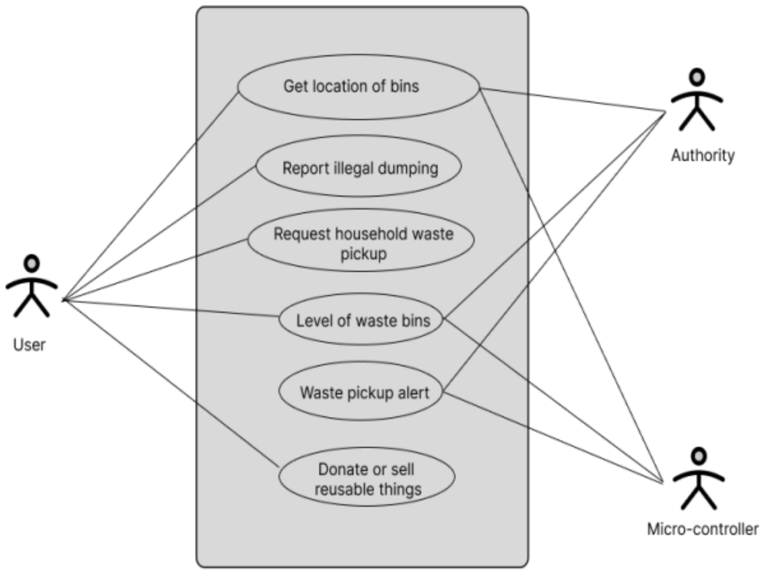
Features Cont.

- **Report Illegal Dumps**: Allow users to easily report instances of illegal dumping along with images through the app, facilitating rapid response by the authorities.
- **Severity based Alerts**: Illegal dumps are shown to authorities sorted according to severity of dump.
- **Household Waste Pickup Services**: Enable users to request flexible household waste pickup services whenever the waste is ready to be picked up.

Features Cont.

- **Statistical Analysis**: Gather data on waste collection and bin full status which can help in making changes in size or count of bins if needed.
- **Donation and Exchange Platform**: Offer a platform for users to donate items they no longer need or exchange goods for reducing waste generation.

Use case diagram



Sequence Diagram

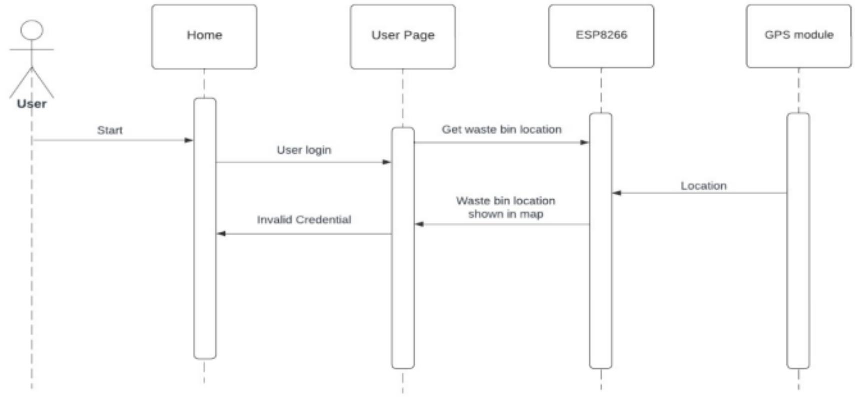


Figure: Locate nearby bins.

Sequence Diagram

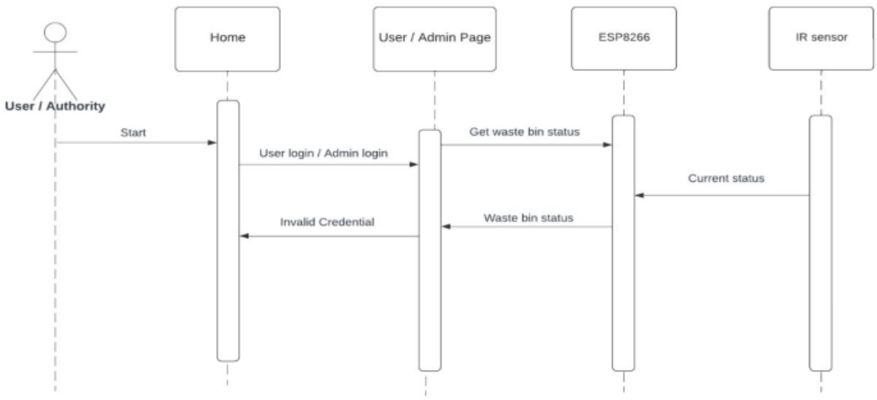


Figure: Waste bin levels.

Sequence diagram

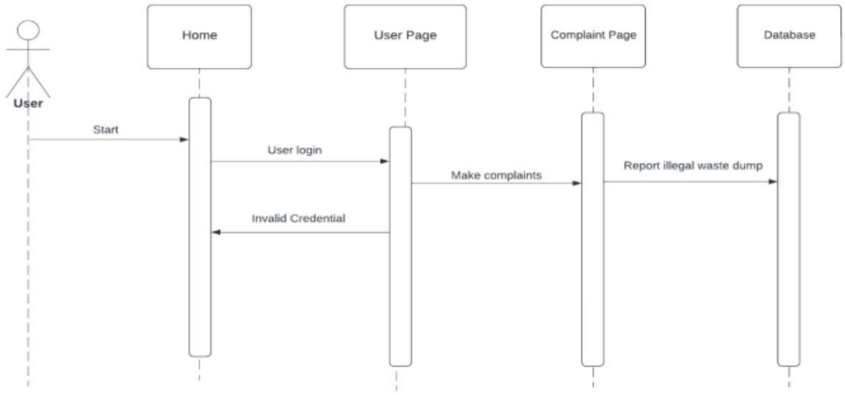


Figure: Illegal dump reporting.

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Sequence diagram

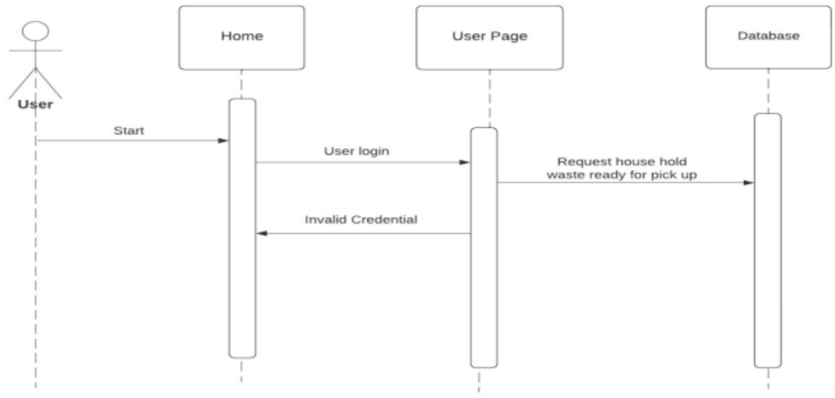

Figure: Household Waste pickup request.

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Sequence diagram

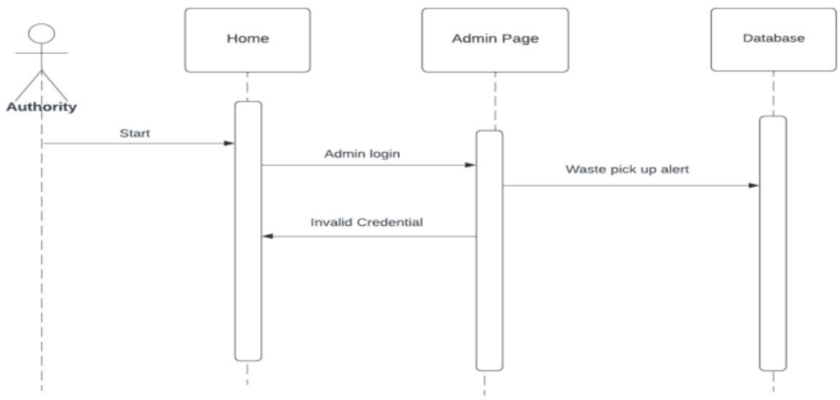

Figure: Authority pickup notification.

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Sequence diagram

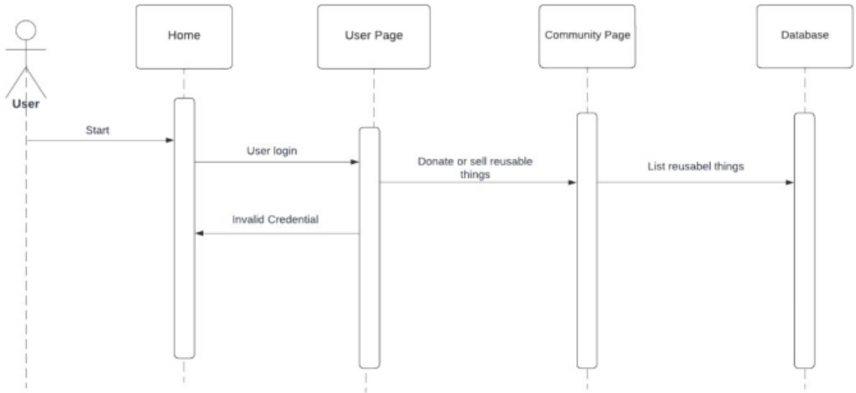

Figure: Donation and exchange platform.

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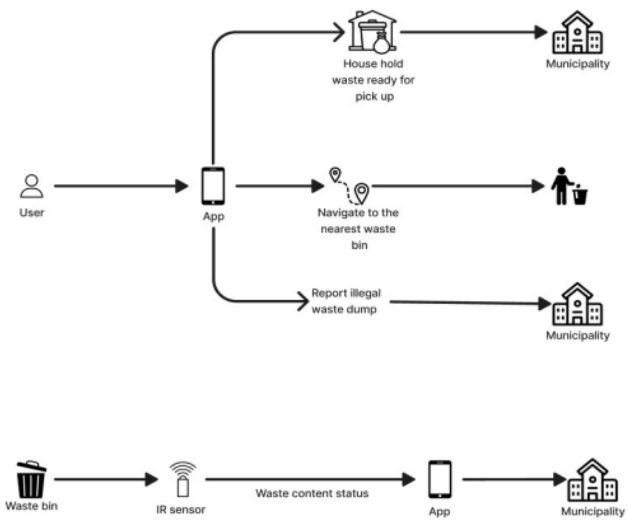
Working



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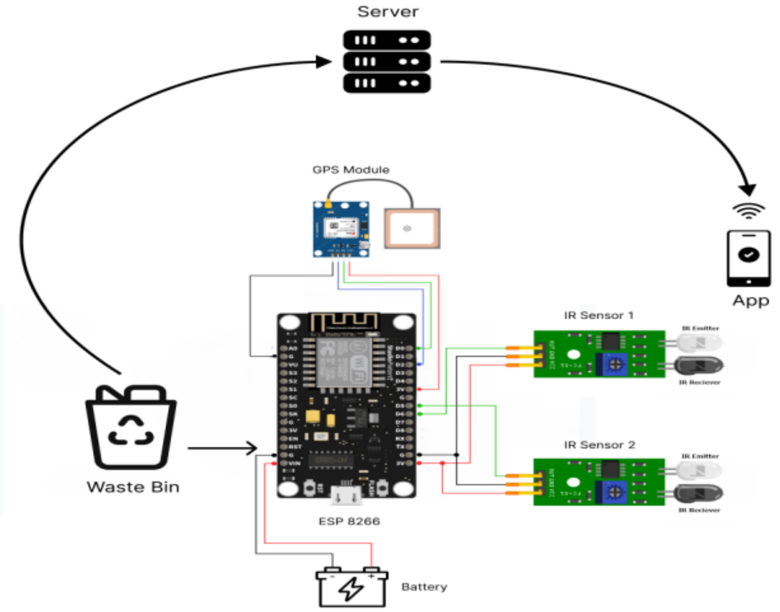
Circuit Diagram



Requirements

- Hardware
  - Infrared (IR) Sensor.
  - ESP8266 Micro-controller.
  - GPS Module.
  - Mini Solar Panel.
  - Rechargeable Battery.
- Software
  - Android Studio
  - Arduino IDE
  - Figma
  - Python

Implementation

- Collection of data through IoT devices
  - The data like real time waste level and location of waste bin is fetched using IR sensors and GPS module.
- Fetching data from server
  - The data collected from IoT devices are sent to server as json object.
  - The data from server is extracted and fetched to mobile app.
- Illegal dump reporting and waste pickup request issuing.
  - User enter the details of request and submit it.
  - These details are pushed into real-time database.
  - These are fetched at authority login and displayed to authorities.

Results

- Users can access waste-bin locations, direction to waste-bins and real time bin status updation via mobile application.
- Illegal waste dump can report to authority using app and authority will notified based on the severity of dump.
- Users can schedule waste pickup and authority will notified and pickup household wastes.

Estimated Price of Components

Table: Estimated price of components

Component	Price (in Rs)
ESP8266 Micro-controller	350
IR sensor	30
Mini solar panel 6V	100
NEO-6M GPS module	250
Rechargeable Battery	80
Total	810

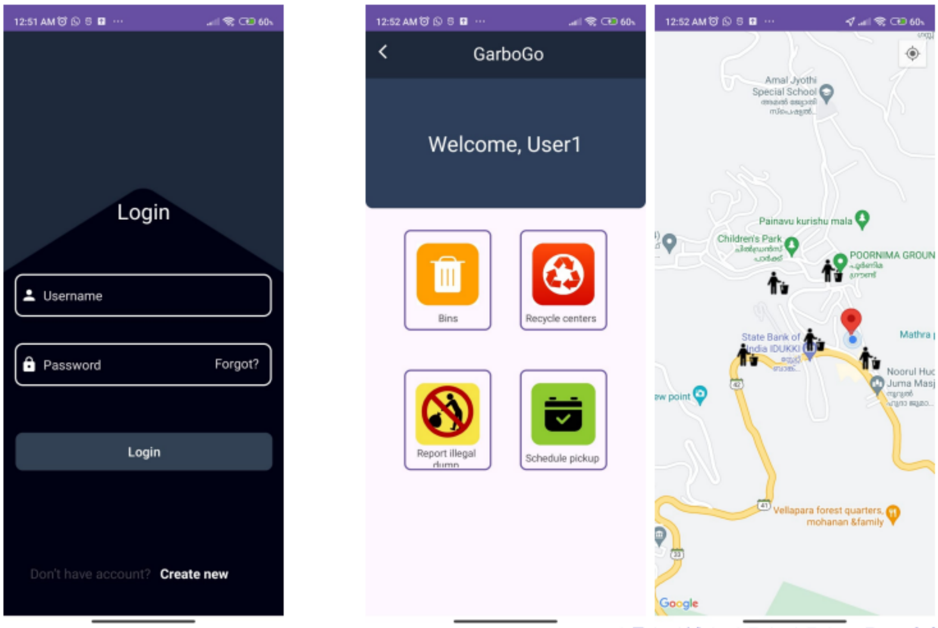
Future Scope

- In the future, our waste management project will explore exciting avenues.
- Integrating AI and ML can automate processes, while analytics offer insights into user behavior.
- Machine learning algorithms will enhance illegal dumping detection, bolstering enforcement efforts.
- Collaboration with authorities and continual refinement based on feedback will drive sustainability initiatives forward.

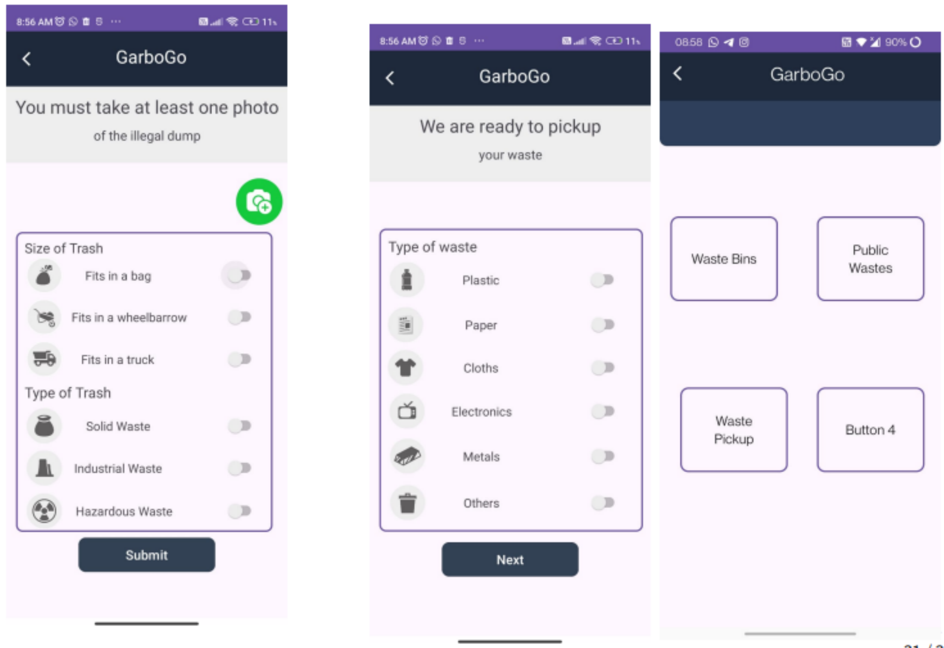
Conclusion

- GarboGo improves the handling of waste by using IoT and combining easily with current infrastructure.
- It offers a waste management solution that is both cost-effective and focuses on financial benefits for users and authorities.
- It also promotes environmental awareness and responsible waste disposal practices.

Screenshots



Screenshots Cont.



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References

- **S. Murugaanandam, V. Ganapathy and R. Balaji** *"Efficient IOT Based Smart Bin for Clean Environment,"* 2018 International Conference on Communication and Signal Processing (ICCSP), Chennai, India, 2018.
- **A. Premgi, F. Martins and D. Domingos***"An infrared-based sensor to measure the filling level of a waste bin,"* 2019 International Conference in Engineering Applications (ICEA), Sao Miguel, Portugal, 2019.
- **Samann, Fady EF.***"The design and implementation of smart trash bin."* Academic Journal of Nawroz University 6, no. 3 (2017):141-148.
- **Joshi, Sonali, Uttkarsh Kumar Singh, and Sahil Yadav.** *"Smart dustbin using GPS tracking."* International Research Journal of Engineering and Technology (IRJET) 6.06 (2019).

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References

Harisha, A. N. L. *"IoT based Garbage Collector."*, 2023 Research Journal on Indian Institution of Industrial Engineering(IIIE), Volume 52(2023).

Shyam, K., Reddy, S.M., Reddy, A.M., Sri, G.L. and Charan, P.S., *"IoT-Based Smart Bin Management with Location Alert using NodeMCU"*, 2023 Research Journal Indian Institution of Industrial Engineering(IIIE), Volume 52(2023)

Bujang, S. H., Suhaimi, H., and Abas, P. E.*"Performance of low cost Global Positioning System (GPS) module in location tracking device. In IOP Conference Series: Materials Science and Engineering"*(Vol. 991, No. 1, p.012137) 2020.

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References

Adhikari, J., Jumale, A., Pittalwar, L., Joshi, M., Khan, F. and Samund, N. *"Automated Waste Classification via Image Processing based on Deep Learrning"*, 2023 International Research Journal of Modernization in Engineering Technology and Science(IRJMETS),Volume5(2023)

Li, Qi, Yang Liu, Shaohua Guo, and Haoshen Zhou*"Solar energy storage in the rechargeable batteries."*, Nano Today 16 (2017): 46-60.

T. Voigt, H. Ritter and J. Schiller*"Utilizing solar power in wireless sensor networks"* 28th Annual IEEE International Conference on Local Computer Networks, 2003. LCN '03. Proceedings., BonnKonigswinter, Germany, 2003, pp. 416-422.

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References

Chowdhury, Moe."*Searching quality data for municipal solid waste planning.*" Waste management 29, no. 8 (2009):2240-2247.

Kartik Sharma, Deepshikha Sharma."*Statistical Analysis of Solid Waste Generation and Challenges Faced in Solid Waste Management in Navsari City.*" Department Of Civil Engineering, Chhotubhai Gopalbhai Patel Institute Of Technology, Uka Tarsadia University, Bardoli, Gujarat, India. November-2021.

ThankYou