Automated Data Driven Approach To Waste Management

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Abstract. This work follows a systematic approach based on the Software Development Life Cycle (SDLC) to design and develop a garbage collection application using TensorFlow Lite machine learning model in Java within the Android Studio environment. The application addresses waste management challenges by integrating computer vision, machine learning, and geolocation technologies. The project encompasses requirements gathering, where the application's objectives are established, enabling users to classify various types of trash, including plastic, glass, metal, and recyclable plastic. The Android device's camera captures trash images, processed through a TensorFlow Lite machine learning model. Development integrates the trained model into the Android app, offering an intuitive interface for trash classification. The app optimizes TensorFlow Lite for real-time trash detection. Geolocation features enhance waste management, identifying the user's location and guiding them to the nearest recycling trash can through mapping and step-by-step navigation. Real-time monitoring of trash can status enhances efficiency. Rigorous testing ensures reliable trash classification and geolocation. User feedback informs iterative development. Ultimately, the garbage collection application promotes waste segregation, recycling, and environmental sustainability.

Keywords: computer vision, waste management, trash classification.

1. Introduction

This work addresses the challenges of waste management through the use of cutting-edge technologies. Our proposed garbage collection application leverages machine learning, and geolocation features to revolutionise the way we handle trash.

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It follows a systematic approach based on the Software Development Life Cycle (SDLC) and is implemented using TensorFlow Lite machine learning model in Java within the Android Studio environment. Our goal is to develop an intuitive and user-friendly application that simplifies the process of waste classification and promotes responsible waste disposal practices.At the core of our application lies a powerful machine learning model implemented using TensorFlow Lite. This model is trained on a diverse dataset of labelled images, allowing it to accurately classify different types of trash, such as plastic, glass, metal, and recyclable plastic. Users can simply capture images of the trash using their Android device's camera, and our application takes care of the rest, swiftly processing the images and providing real-time classification results. To further enhance waste management practices, we have incorporated geolocation technology into our application. By leveraging the device's geolocation capabilities, our app determines the user's present location and identifies the nearest recycling trash can for the detected trash type. Users are then guided through step-by-step navigation instructions to effortlessly reach the designated recycling bin, reducing unnecessary travel and promoting efficient waste disposal.

Additionally, we understand the importance of real-time monitoring in waste management. Our application allows users to check the status of identified recycling bins, ensuring they are available and not already filled before users embark on their journey. This feature optimises the utilisation of recycling bins, streamlines the waste collection process, and contributes to a cleaner and more sustainable environment. Throughout the development process, we have conducted rigorous testing to ensure the accuracy, reliability, and usability of our application. Various test cases were designed and executed, and we eagerly gathered feedback from users and stakeholders, continuously improving and iterating upon our solution.

In conclusion, our garbage collection application represents a significant step forward in waste management practices. By harnessing the power of TensorFlow Lite machine learning model and geolocation technology, we simplify trash classification, guide users to the nearest recycling bins, and provide real-time updates on trash can availability. Together, let us embrace this technological advancement and work towards a greener and more sustainable future.

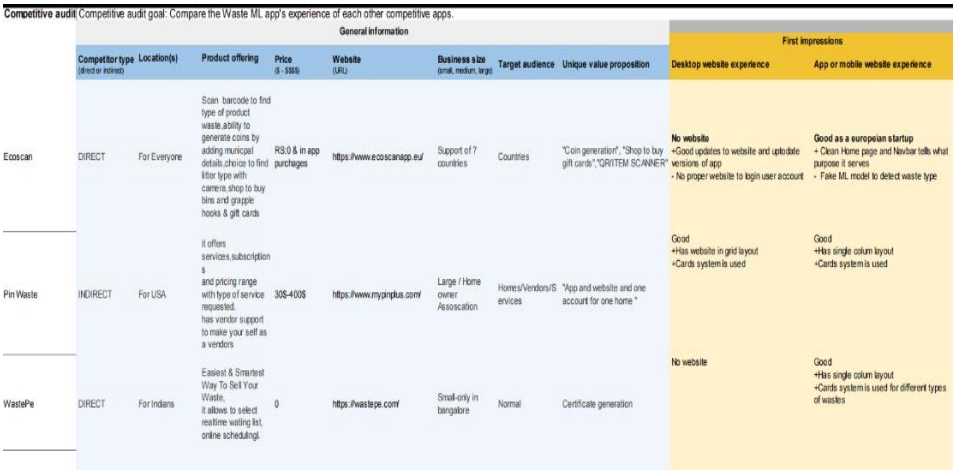
2. Related work

It is indeed disheartening to witness a growing environmental crisis, exemplified by the increasing levels of waste mismanagement across India. Reports indicate a surge in improper disposal and inadequate recycling practices, contributing to severe pollution and ecological harm. This alarming trend emphasizes the immediate need for innovative solutions to address these waste management challenges. In response, our "Automated

Data-Driven Approach to Waste Management" app has been meticulously developed, drawing from extensive research and knowledge acquisition to provide a comprehensive and data-driven solution that promotes responsible waste disposal and contributes to a cleaner and more sustainable environment in India.[15]. In comparison to the Ecoscan app, the "Automated Data-Driven Approach to Waste Management" app excels in several key aspects. Our app employs cutting-edge machine learning techniques for advanced waste classification, enabling users to distinguish between a broader range of waste materials accurately. It integrates real-time monitoring, IoT technology, and navigation, offering users not only the capacity status of nearby trash bins but also step-by-step directions to the nearest recycling facilities. Our user-centric interface enhances accessibility and usability, while the app's environmental impact is heightened by its focus on promoting precise waste disposal and sustainability. These unique strengths collectively position our app as a superior solution for waste management, catering to a wide range of user needs and making it an invaluable tool for waste reduction and environmental preservation.In comparison to the WastePe app, our "Automated Data-Driven Approach to Waste Management" offers several notable advantages. While the WastePe app primarily focuses on waste pickup and disposal scheduling, our application goes beyond by implementing advanced machine learning models for precise waste classification, providing users with detailed insights into the types of waste they are dealing with. Furthermore, our app integrates IoT technology for real-time monitoring of trash bin capacity, making waste management more efficient and environmentally sustainable. With user-friendly navigation features and a strong emphasis on promoting recycling and waste reduction, our app offers a comprehensive waste management solution that empowers users with valuable information and resources for responsible waste disposal and environmental preservation. These distinctive strengths collectively position our app as a superior choice for addressing waste management challenges, contributing to more effective waste reduction and environmental sustainability.Another application worth mentioning Pin Waste app, our "Automated Data-Driven Approach to Waste Management" offers several distinctive advantages. While the Pin Waste app primarily focuses on waste bin location services, our application goes beyond by implementing advanced object detection and waste classification using machine learning models, providing users with detailed insights into the types of waste they are dealing with. Additionally, our app incorporates IoT technology for real-time monitoring of trash bin capacity and navigation to the nearest recycling facilities, making waste management more efficient and environmentally sustainable. With a user-friendly interface and an emphasis on promoting recycling and waste reduction, our app stands out as a comprehensive waste management solution, addressing not only location-based needs but also empowering users with valuable information and resources for responsible waste disposal and environmental preservation.

Compared to the RecycleNation app, our "Automated Data-Driven Approach to Waste Management" excels with advanced features. While RecycleNation focuses on locating

recycling centers and materials, our app integrates cutting-edge machine learning for precise waste classification and real-time trash bin capacity monitoring via IoT technology. This promotes efficient waste management and responsible disposal. With an intuitive interface and a strong commitment to waste reduction and recycling, our app goes beyond basic location services, offering valuable insights and resources for a sustainable and eco-friendly waste management approach. These strengths make our app the superior choice for addressing waste management challenges and promoting a cleaner, more environmentally responsible world.Compared to the Earth911 app, our "Automated Data-Driven Approach to Waste Management" offers significant advantages. While Earth911 focuses on locating recycling centres, our app goes further by using advanced machine learning for precise waste classification and integrating real-time IoT-based trash bin capacity monitoring, thus promoting efficient waste management and responsible disposal. With an intuitive user interface and a strong commitment to waste reduction and recycling, our app provides a comprehensive solution, offering valuable insights and resources for an eco-friendlier waste management approach. These strengths position our app as a superior choice for addressing waste management challenges and contributing to a cleaner, greener environment.After conducting a comprehensive review of existing applications, including those mentioned above, it becomes evident that while several serve a similar purpose, they often lack certain essential features. For instance, some apps in the waste management domain provide basic location services but do not offer advanced real-time monitoring or detailed waste classification. These observations have inspired the development of our "Automated Data-Driven Approach to Waste Management" application, which integrates all these crucial features to ensure a comprehensive and effective approach to addressing waste management challenges and promoting responsible disposal practices.



Competitive audit Competitive audit goal: Compare the Waste ML app's experience of each other competitive apps.

	General information							First impressions	
	Competitor type (direct or indirect)	Location(s)	Product offering	Price ($ - $$$$)	Website (URL)	Business size (small, medium, large)	Target audience	Unique value proposition	Desktop website experience	App or mobile website experience
Ecoscan	DIRECT	For Everyone	Scan barcode to find type of product waste,ability to generate coins by adding municipal details,choice to find litter type with camera,shop to buy bins and grapple hooks & gift cards	RS:0 & in app purchages	https://www.ecoscanapp.eu/	Support of 7 countries	Countries	"Coin generation", "Shop to buy gift cards","QRITEM SCANNER"	**No website** +Good updates to website and uptodate versions of app - No proper website to login user account	**Good as a europeian startup** + Clean Home page and Navbar tells what purpose it serves - Fake ML model to detect waste type
Pin Waste	INDIRECT	For USA	it offers services,subscription s and pricing range with type of service requested. has vendor support to make your self as a vendors	30-400	https://www.mypinplus.com/	Large / Home owner Assosciation	Homes/Vendors/Services	"App and website and one account for one home "	Good +Has website in grid layout +Cards system is used	Good +Has single colum layout +Cards system is used
WastePe	DIRECT	For Indians	Easiest & Smartest Way To Sell Your Waste, It allows to select realtime waiting list, online scheduling).	0	https://wastepe.com/	Small-only in bangalore	Normal	Certificate generation	No website	Good +Has single colum layout +Cards system is used for different types of wastes

Fig. 1. Competitor analysis Waste Management ML app.

UX *(rated: needs work, okay, good, or outstanding)*

Interaction				Visual design	Content	
Features	Accessibility	User flow	Navigation	Brand identity	Tone	Descriptiveness
OK + Good quality code + Good initiative to join local municipal - No crop selection for picture of QR code	**Outstanding** + Users can access all functions from home and bottom bar - NO feature to show nearest dustbin location to dump waste	**On Point** + Straight forword user flow + Coin and ordering are clean and efficent processes - Can skip login as guest user	**Needs work** + Bottom bar with labels made their work lot easier but lac of proper ml model gets them in drawback of being not accurate in tracing type of waste - No proper top bar for user profile	**Needs work** - Minimal brand identity - App is simple - Uses few colors + Brand identity matches website	Formal and informative	**Outstanding** + Short and to the point + Focused on info relevant to target audience. + Descriptive
GOOD + Good quality code + Good White space - Not relate to our primary use case.	**Outstanding** + Users can access all functions from home and bottom bar - NO feature to show vendors location and its all automated no contact services	**On Point** + Straight forword user flow - No proper skip login as its all paid app and needs us citizen location for adress	**Needs work** + Bottom bar with labels - No proper top bar for user profile shows your address only	**Good** + Brand identity matches website	Formal and informative	**Outstanding** + Short and to the point + Focused on info relevant to target audience. + Descriptive
GOOD + Good quality code + Good White space - OTP doesnt work well.	**Notgood** - NOT good mockup images - Pricing changes - One star ratings in google play store	No proper userflow	Needs work	Not good	Not discriptive	**Failed** -No proper userflow and price changes from page to page

Fig. 2. Competitor analysis to Waste Management ML app.

3. Proposed system

The "Automated Data-Driven Approach to Waste Management" app offers a comprehensive solution for efficient waste management and responsible disposal. The system is designed to address various waste management challenges, encompassing the following key components.

3.1 Object Detection and Waste Classification Module:

The core functionality of the system involves a sophisticated object detection module that employs machine learning models. This module allows users to capture images of waste items using their device's camera. These captured images are then processed through a waste image classifier model, which accurately identifies the type of waste. The system classifies waste items as "Plastic" or "Organic" based on the classifier's findings.

3.2 Real-Time Monitoring and IoT Integration:

The system is equipped with IoT technology, including an Arduino Uno with a Wi-Fi module and an HC-SR04 Ultrasonic sensor. This integration enables real-time monitoring of trash bin capacity. [1,2,3].The Wi-Fi module establishes a connection with the cloud to transmit capacity data, reflecting the current remaining capacity of trash bins. The HC-SR04 sensor provides accurate data on trash bin capacity, ensuring timely and data-driven waste collection.

3.3 Geolocation and Navigation Module:

To enhance waste management, the system incorporates geolocation features. It identifies the user's location using GPS and utilizes mapping services.When a user accesses the app, the system employs a Map module in Java to pinpoint the user's location. It overlays nearby trash bin locations on the map and enables users to view pins representing these bins. [1,7,13]

Users can select a nearby trash bin pin of their choice, and the system initiates navigation via the Google Cloud Map API. Step-by-step instructions are provided, guiding the user to the selected trash bin's location, promoting efficient waste disposal.[9]

3.4 User Feedback and Iterative Development:

The system encourages user feedback, enabling users to report issues, suggest improvements, and provide valuable input to enhance the application's features.

This iterative development approach ensures that the app continually evolves to meet users' needs and deliver an optimal waste management experience.

The "Automated Data-Driven Approach to Waste Management" app offers a user-friendly interface, empowering users to make informed decisions about waste disposal and recycling. By combining advanced machine learning, real-time monitoring, geolocation services, and user feedback mechanisms, this system provides a holistic solution for efficient waste management, waste segregation, and environmental sustainability.

3.5 Automated Waste Classification

In the "Automated Data-Driven Approach to Waste Management" app, the user utilizes the integrated object detection ML model, using the device's camera, to capture live images of waste items. These images are then processed through a waste image classifier model to determine if the waste is "Plastic" or "Organic."[4,8,10] Based on the classifier's findings, the system assigns labels as either "Plastic" or "Organic." Subsequently, the labels are combined, and the resulting classification information is presented on the user's screen, enabling informed waste management decisions.[6]

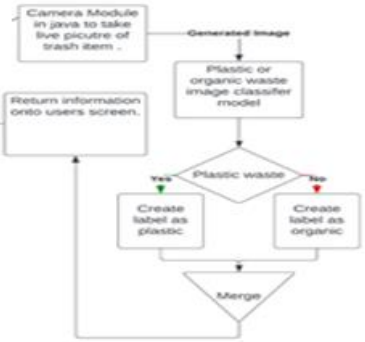


Fig. 3. Automated Waste Classification of Waste Management ML app.

3.6 Empty Trash Bin Detection and Navigation Module

In the context of the "Automated Data-Driven Approach to Waste Management" app, a user leverages an Arduino Uno equipped with a Wi-Fi module and an HC-SR04 Ultrasonic sensor [2,4,10]. The Wi-Fi module establishes a connection with the cloud to transmit capacity data, reflecting the current trash bin's remaining capacity. Simultaneously, the HC-SR04 Ultrasonic sensor provides accurate capacity information [10]. This data is subsequently used to determine the location of the trash bin, enabled by the Arduino Uno. When the user accesses the app, the system employs a Map module in Java to pinpoint the user's location and overlay nearby trash bin pins on the map. The user can then select a nearby trash bin pin, triggering the initiation of navigation via Google Cloud Map API, facilitating efficient navigation to the selected trash bin's location.

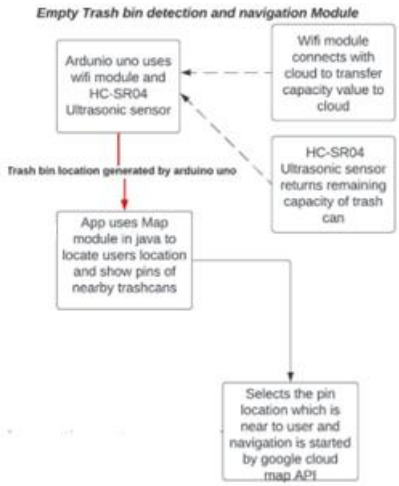


Fig. 4. Empty Trash Bin Detection and Navigation Module of Waste Management ML app.

4 Output/result

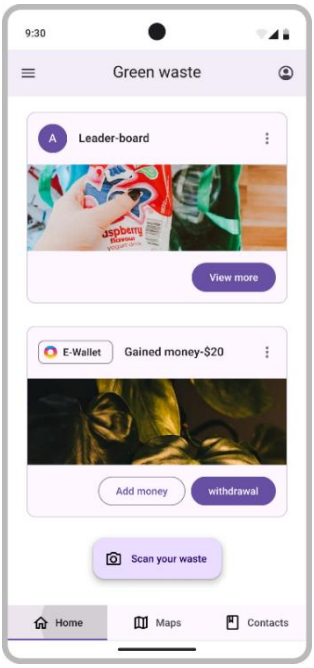


Fig. 5. HOME PAGE "Automated Data-Driven Approach To Waste Management" app.

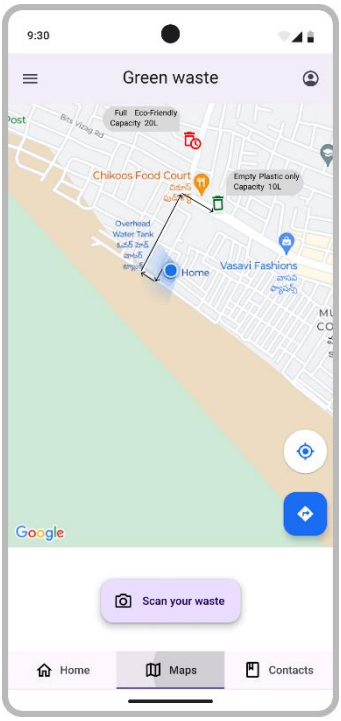


Fig. 6. NAVIGATION PAGE OF "Automated Data-Driven Approach To Waste Management" app.

5 Conclusion and Future scope

The "Automated Data Driven Approach to Waste Management" project successfully developed a garbage collection application using TensorFlow Lite machine learning model in Java within the Android Studio environment. The application addresses waste management challenges by utilizing computer vision, machine learning, and geolocation technologies. By leveraging the Android device's camera module and TensorFlow Lite, the application allows users to classify different types of trash in real-time. The app incorporates geolocation features to identify the nearest recycling trash can for each trash type and provides step-by-step navigation instructions to guide users to the designated bin. Real-time monitoring of trash can status ensures efficient utilization of recycling bins and reduces unnecessary travel.It followed rigorous testing procedures to ensure the accuracy, reliability, and usability of the trash classification and geolocation functionalities. User feedback and stakeholder inputs were incorporated into the iterative development process. The "Automated Data Driven Approach to Waste Management" application contributes to environmental sustainability efforts by promoting proper waste segregation and recycling.

The future scope involves continuous improvement in waste classification models, enhanced IoT optimization, and integration with municipal waste management systems. Additionally, advanced geolocation services, smart notifications, and global market expansion aim to make the app a comprehensive, user-centric tool for promoting responsible waste disposal practices on a global scale.

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