EcoSort: A Mobile Application for Accurate Waste Segregation Using Image Recognition Technology

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1 Background of the Study

Waste management has been acknowledged since ancient times, as demonstrated by early cities like Rome and Athens. Nevertheless, this mainly focuses on removing the waste rather than recycling or segregation. With time, especially during industrialization and city growth processes, there was an increase in quantities of waste leading to more systematic waste management approaches. It was only at the end of the 20th century that waste categorization emphasizing biodegradable, non-biodegradable, and recyclable materials became important hence transitioning towards recycling and usability in modern waste management systems.

In today's world, waste management has become a critical global issue due to the rapid increase in urbanization, industrialization, and population growth. Especially in the Philippines, where it has been reported by **statista2022waste<empty citation>** to increase by more than 59.24 thousand tons per day in 2022, Poor waste segregation, contributes much to environmental degradation through soil and marine pollution. Various policies have been implemented to encourage proper waste disposal. However, public awareness and participation in proper segregation practices are still at a minimal rate.

Since mobile phone technology is increasingly becoming part of people's lives, it can provide a way to address such practical issues like waste management. This research proposes that a mobile application that will use image recognition technology for sorting waste into biodegradable, non-biodegradable, and recyclable categories should be developed to

help improve waste segregation practices. Through technology usage, this research aims to encourage people to segregate their waste and create environmentally conscious behaviors properly.

Previous studies have explored various waste management approaches, such as manual classification, recycling programs, and automated sorting systems. However, research on mobile applications for real-time waste classification using image recognition is limited. For instance, a study by **Malik2022<empty citation>** demonstrated the potential of using Convolutional Neural Networks (CNNs) for classifying waste materials through images, showcasing the effectiveness of deep learning models in waste sorting. Despite these, a comprehensive waste classification system integrating real-time image recognition, particularly for mobile devices, is still lacking. Additionally, a study by **AhmadFaudzi2023<empty citation>**, demonstrates that effective user experience and interaction design in mobile applications could enhance user engagement and positively influence behavior change. Building on these insights, this study aims to address this existing gap by developing an educational and practical mobile application that incorporates real-time image recognition for daily waste segregation purposes.

2 Statement of the Problem

Waste management plays a crucial role in environmental sustainability, it involves the collection, processing, recycling, and disposal of waste materials. A key factor that makes the waste management process more effective is waste segregation. Waste segregation is the process of sorting waste into categories like recyclable, biodegradable, and non-recyclable materials to improve recycling efficiency and reduce landfill impact. The increasing volume of improperly segregated waste has a significant impact on pollution, health, and environmental damage. By utilizing technology and modernization, the problem of improper waste segregation can be solved.

The traditional approach of waste segregation involves manual sorting that depends on people's knowledge which often leads to error, inefficiency, and unreliability. This study

addresses the problem of the lack of a reliable and efficient waste segregation tool that assists users in segregating waste more accurately. Specifically, this study aims to develop a mobile application that utilizes image recognition and machine learning algorithms to automatically identify and sort waste into their proper categories.

By offering a user-friendly and accessible method for waste segregation, the mobile application aims to contribute to improved waste management practices, enhancing environmental sustainability and educating users as well on proper waste disposal methods.

3 Objective of the Study

3.1 General Objective

The primary purpose of this study is to develop a mobile application that will assist users in accurately classifying waste materials into biodegradable, non-biodegradable, and recyclable using Image Recognition Technology and Machine Learning Model.

3.2 Specific Objective

- To develop an image recognition model, developers will utilize Google's AI training platform to accurately classify waste items into biodegradable, non-biodegradable, or recyclable classes by training the model with uploaded images of various waste materials that users encounter daily.
- To design a user-friendly mobile application interface, developers will use Android Studio, which will simplify the process of creating the app and designing its User Interface.
- To evaluate the performance and accuracy of the trained model under various real-world conditions such as lightning and background interference.
- To assess the app's impact on users' environmental awareness and waste segregation behavior through feedback and usability testing.

- To provide a foundational study that can serve as a guide or inspiration for future developers working on related projects, such as automated waste sorting machines or other waste management innovations.

4 Significance of the Study

The proposed system holds significant potential to address environmental challenges through technological innovation. By developing a system capable of accurately categorizing waste as biodegradable, non-biodegradable, or recyclable, the study aims to enhance waste sorting practices and contribute to effective waste segregation. The following sections detail the benefits of the system:

- **Contribution to Knowledge:** The systems uses a machine learning model to enhance the classification of waste materials into biodegradable, non-biodegradable, and recyclable categories. This makes a valuable contribution to the technological sector by offering an innovative solution to real-world waste management problems. The use of image recognition powered by machine learning not only fills a gap in existing waste segregation technologies but also advances the field of environmental science by integrating AI techniques for better accuracy and efficiency.
- **Practical Implications:** The system's features can assist users in more accurately classifying waste, potentially leading to:
  - Improved waste segregation, which enhances waste collection, disposal, recycling, and composting practices.
  - Increased environmental awareness and better segregation practices within households.
  - Integration into educational institutions for teaching proper waste management, thereby enhancing student engagement.
  - Benefits to government authorities and waste management professionals by improving waste sorting, recycling programs, and overall waste management systems.

  - Utilization by environmentalists for awareness campaigns and promoting environmental responsibility.
- **Theoretical Implications:** The development of this system may contribute to new theories or models in AI-enhanced waste management and human-computer interaction. It can provide insights into how technology influences human behavior and supports the evolution of personal-level waste management systems.
- **Policy Implications:** The successful implementation of this application could prompt local governments to revise waste collection policies, incorporating pre-collection waste separation. Such changes could include imposing penalties on those who do not adhere to waste segregation guidelines.
- **Social and Economic Impact:** The system has the potential to alter individual behaviors regarding waste management, increase environmental awareness, and inspire communities to adopt cleaner environmental policies. Economically, it could lead to increased recycling rates, reduced landfill waste, and the production of natural composts beneficial for agricultural use.
- **Future Research Directions:** The system may inspire future researchers to advanced technological solutions for environmental sustainability. Future developments may include features for classifying additional types of waste and integrating more sophisticated models into broader waste management systems.

5 Scope and Limitations

5.1 Scope

- **Research Focus**: The study aims to develop and evaluate a mobile application designed to assist users in waste segregation by recognizing and categorizing waste as biodegradable, non-biodegradable, or recyclable. The app will utilize image recognition technology alongside a comprehensive database of waste items for the model to accurately classify the object. Additionally, the effectiveness of the user interface in guiding users and enhancing environmental awareness through educational content will

be assessed.

- **Geographical Scope and Time Frame**: The study will be conducted in the Philippines, focusing on waste items commonly encountered in daily life across different regions. Over one year, the app will be tested with real-world waste data collected from various locations within the country, ensuring that the model is trained with waste types that users in the Philippines typically interact with. Upon completion, the app will be made accessible to a broader audience through the Google Play store, extending its practical implication beyond the study's local scope.
- **Population and Sample**: The app will be initially distributed online, allowing a broad range of users across the Philippines to interact with it. By gathering feedback from users through online reviews, insights into the app's functionality and usability will be gained. This feedback will be crucial in refining the app before its eventual release.
- **Variables and Concepts**: The key variables include the accuracy of the app's image recognition model in correctly classifying waste into their categories as well as its usability and impact on users' behavior regarding waste segregation. The app's educational features will be evaluated for their influence on increasing environmental awareness. The concept of environmental awareness will be explored to evaluate how the app's education content influences users' understanding and concern about waste management. Technological reliability will be measured by the app's performance under various real-world scenes particularly such as lighting and background noise.
- **Methodology**: This study will develop and evaluate a mobile application for waste segregation using image recognition technology. The application will be designed with a user-friendly interface in Android Studio and will integrate a machine learning model trained with a vast amount of waste images collected from daily user interactions in the Philippines. The model is trained in Google's AI platform, to ensure that it will correctly classify waste into biodegradable, non-biodegradable, and recyclable. Evaluation of the app's effectiveness will involve usability testing and assessments under various real-world conditions such as lightning and background noise. User feedback will collected through online surveys to refine the app based on practical

usage. Additionally, the study will measure changes in waste segregation behavior and environmental awareness to assess the app's impact on users and its contribution to improved waste management practices.

5.2 Limitation

- **Methodological Limitations**: The image recognition technology may face challenges in accurately classifying waste items that are damaged, dirty, or unrecognizable. This could result in incorrect classifications and recommendations, potentially affecting the overall effectiveness of the app.
- **Sample Size and Selection**: Since the app will be released broadly and not tested on a controlled sample. This may limit the ability to generalize findings based on the feedback received from a diverse user base.
- **Data Availability**: The app's database of waste items may initially be incomplete, potentially leading to misclassification of new or uncommon items. Additionally, accurate and comprehensive information from local recycling facilities is necessary to ensure that the app's recommendations align with local recycling practices and policies
- **External Factors**: Changes in local or national waste management policies during the study could affect the app's recommendations, leading to inconsistencies. Moreover, factors such as users' access to waste segregation resources, like appropriate bins and facilities, may influence how effectively users can implement them.
- **Time Constraints**: The one-year timeframe for this study may limit the depth of testing and refinement. This constraint might impact the app's ability to fully develop its database and enhance image recognition accuracy, potentially affecting the final version's performance and completeness.
- **Single Image Limitation**: The app may only allow users to take one picture of each item for classification, which could affect the accuracy of the image recognition process. While multiple images or angles could provide better context for accurate classification, addressing this feature may be a lower priority due to the project's timeframe and design constraints.