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Detection of Organic and Inorganic Waste Using Mobile Phone Camera

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Abstract

This study aims to develop a dataset of organic and inorganic waste images using a mobile phone camera as the foundation for an automatic detection system. Data collection was carried out in the Binjai area by utilizing a smartphone as the primary image acquisition device. The waste was categorized into two main groups, namely organic (such as food waste, leaves, and fruit peels) and inorganic (such as plastic bottles, cans, and styrofoam). The research method involved image collection, manual labeling, and dataset storage in a structured format. The results produced an initial dataset that can be utilized for the development of machine learning-based classification systems. This dataset is expected to contribute to technology-based waste management efforts at the local level.

Keywords: *Dataset, Inorganic, Organic,Smartphone Camera,Waste*

1. Introduction

Waste is one of the environmental problems that continues to increase in various cities, including Binjai. Population growth and high levels of public consumption have triggered a daily increase in waste volume. According to data from the Ministry of Environment and Forestry, the total national waste generation has reached more than 60 million tons per year. Most of this waste is still not properly separated between organic and inorganic types, which hinders recycling and processing efforts. This condition highlights the need for innovations in waste detection and management.

One of the fundamental issues is the lack of automated systems that can assist in sorting waste quickly and accurately. At present, most waste separation is still carried out manually by workers, requiring considerable time and effort. In fact, image recognition technology can be applied to distinguish types of waste based on their visual characteristics. Unfortunately, there are still very few locally available datasets that can be used to train waste detection models specifically adapted to regions such as Binjai.If this problem is not addressed promptly, unsegregated waste piles will increasingly burden the Final Disposal Sites (TPA) and contribute to greater environmental pollution. The use of simple technology such as mobile phone cameras for waste image acquisition can serve as an initial, low-cost, and easily implementable solution. This study is important to provide initial data that can be utilized by developers of AI-based detection systems as well as waste management stakeholders.

Several previous studies have examined the use of image recognition technology for waste detection. For example, Rad et al. (2017) developed the TrashNet dataset, which includes various types of waste. However, that dataset mostly consists of waste collected from developed countries and does not sufficiently represent waste conditions in tropical regions such as Indonesia. This reveals a research gap in the creation of local datasets that align with specific environmental characteristics.

The novelty of this study lies in the development of an organic and inorganic waste image dataset using mobile phone cameras in Binjai. The dataset is structured with clear formats and labels, making it ready for use in artificial intelligence training models. This study also emphasizes simple image acquisition methods, making the approach easily replicable by both researchers and the general public.
The situation in Binjai indicates that waste separation is still far from optimal. In traditional markets as well as residential areas, organic waste such as vegetable and fruit residues is often mixed with inorganic waste such as plastics and beverage bottles. This condition complicates further waste processing. The present study seeks to provide an initial solution in the form of a dataset that reflects real conditions in the field.Based on this background, this research focuses on the creation of an organic and inorganic waste image dataset using mobile phone cameras in Binjai. This dataset is expected to serve as the foundation for the development of automatic detection systems that can facilitate waste sorting processes more quickly and efficiently.

2. Research Method

2.1. Research Approach

This study uses an experimental approach with the aim of developing a primary dataset in the form of organic and inorganic waste images taken using a smartphone camera. This dataset is prepared as a basis for developing an automatic detection system based on machine learning. The research objects consist of two main categories, first organic waste, including fruit peels, dry leaves, and food waste.second inorganic waste, including plastic bottles, used cans, and styrofoam packaging. The main equipment used includes first a Samsung A06 smartphone camera.second a laptop for storage, annotation, and dataset management. third labeling software such as LabelImg or LabelMe.

2.2. Location and Time of Research

The research was conducted in Binjai City, North Sumatra, with sampling conducted in traditional markets and residential areas. Data acquisition took place from May to July 2025.

2.3 Research Stages

2.3.1. Data Collection (Image Acquisition)

Image collection was conducted using a Samsung A06 smartphone camera with a 12 MP resolution. Each image was taken at a distance of ±30 cm from the object, with natural lighting and a neutral background to minimize visual disturbances. Image data was obtained from various types of organic and inorganic waste found in market and residential areas. Each image capture was accompanied by basic metadata, including the date, time, and lighting conditions.

2.3.2. Object Grouping

After acquisition, images are grouped into two main folders: Organic and Inorganic. This grouping ensures an organized dataset structure from the outset, facilitating labeling, annotation, and further processing.

2.3.3. Data Storage in JPG Format

All images are saved in JPEG (.jpg) format to maintain compatibility with various devices and deep learning frameworks. The original camera resolution is maintained to ensure optimal visual detail.
File names use a standardized format:
category_subcategory_location_date_number.jpg
Example:
-organik_daun_binjai_20250701_001.jpg
-anorganik_botol_binjai_20250701_002.jpg

2.3.4. Manual Labeling (Labelling)

The labeling process is carried out using Label Img software to mark objects and embed category labels. The main labels consist of two classes, namely Organic and Inorganic. For flexibility, additional labels are also given to sub-categories, for example dry leaves, fruit peels, used cans. Annotations are stored in Pascal VOC (XML) format for integration with TensorFlow-based models and COCO (JSON) for integration with YOLOv8 and PyTorch.

2.3.5. Dataset Preparation

The dataset was divided into three subsets:
-Training set: 70% – 80%
-Validation set: 10% – 15%
-Testing set: 10% – 15%
To increase dataset diversity, data augmentation techniques such as rotation, flipping, zooming, and brightness/contrast adjustments were used. These techniques have been shown to effectively improve the detection accuracy of the YOLOv8 and ResNet50 models [7]

2.3.6. Metadata Storage

Metadata is stored in a structured manner in CSV and JSON formats. The recorded information includes the image file name, main and sub-category labels, date and time of capture, device used, lighting conditions and location, and the name of the person responsible for data collection.

Table 1: Metadata

File Name	Category	Sub-Category	Date	Device	location
organic_leaf_binjai_20250701_001.jpg	Organik	Dried leaves	01/07/2025	Samsung A06	Binjai market
inorganic_botol_binjai_20250701_002.jpg	Inorganic	Plastic bottle	01/07/2025	Samsung A06	Binjai market

2.4. Dataset Validation

The dataset was manually validated to ensure image quality, label consistency, and format consistency. Blurred, duplicated, or mislabeled images were excluded before model training.

3. Results and Discussions

The waste detection system was tested using a 12 MP mobile phone camera integrated with a machine learning-based detection application. The dataset consisted of 500 images of organic waste and 500 images of inorganic waste, collected from various locations such as markets, beaches, and residential yards. Each image underwent preprocessing steps including resizing to 224×224 pixels and pixel value normalization to match the model input format.

The testing process was conducted by capturing waste images directly in the field. The system then automatically classified the images into two categories: organic or inorganic. Based on 200 test image captures, the system correctly classified 188 images, while 12 images were misclassified. Misclassifications generally occurred with organic waste that had shapes and colors similar to inorganic waste, such as brown plastic bags folded in a way that resembled dried leaves.

In this study, the dataset used consisted of 500 images of organic waste and 500 images of inorganic waste. Organic waste images were collected from objects such as banana peels and banana leaves, while inorganic waste images were obtained from objects such as plastic packaging, Aqua bottles, and disposable lunch boxes.

As an illustration, examples of the dataset images used in this research are presented below:

Fig.1: Example of organic waste image: banana peel

Fig. 2: Example of inorganic waste images: plastic, Aqua bottle, and disposable lunch box

Each image collected in this study was documented through metadata to ensure consistency and ease of use in subsequent stages. The recorded metadata included the file name, waste category, object description, image acquisition location, date, and the device used.

For example, organic images were sequentially named from organic_001.jpg to organic_500.jpg, while inorganic images were labeled from inorganic_001.jpg to inorganic_500.jpg. In the organic category, the objects captured included banana peels and banana leaves commonly found in market areas and residential environments. Meanwhile, the inorganic category consisted of plastic packaging, Aqua bottles, and disposable lunch boxes collected from beach areas and local markets in Binjai.

The metadata documentation was carried out consistently. For instance, the file organic_001.jpg contained an image of a banana peel taken at Binjai Market on June 12, 2025, using a Samsung A06 smartphone camera. Similarly, the file inorganic_002.jpg contained an image of a disposable plastic lunch box captured at Binjai Market on June 13, 2025, with the same device.

Table 2: Metadata of Organic and Inorganic Waste

File Name	Category	Object Description	Location	Date	Device
organic_001.jpg	Organic	Banana peel	Binjai Market	June 12, 2025	Samsung A06

organic_002.jpg	Organic	Banana leaf	Residential Area	June 12, 2025	Samsung A06
inorganic_001.jpg	Inorganic	Plastic Aqua bottle	Residential Area	June 13, 2025	Samsung A06
inorganic_002.jpg	Inorganic	Disposable plastic lunch box	Binjai Market	June 13, 2025	Samsung A06

The testing achieved an accuracy of 94%, with an average precision of 93% and a recall of 94%. This high level of accuracy indicates that the system has strong capability in distinguishing between the two types of waste, although certain cases still present challenges.

The analysis of method advantages shows that the use of a mobile phone camera provides high flexibility, as the device can be easily carried to various locations without the need for specialized equipment. In addition, the integration with machine learning allows the classification process to be performed quickly, requiring less than two seconds per image. However, there are limitations under conditions of low lighting or cluttered backgrounds, which may affect the classification results.

Overall, this detection system is effective in supporting waste sorting in the field in a fast and practical manner. Nevertheless, improvements can still be made, such as increasing dataset variation, applying data augmentation techniques, and optimizing the algorithm to enhance robustness against variations in lighting conditions and image capture angles.

4. Conclusion

Based on the results of this study, the organic and inorganic waste detection system using a mobile phone camera demonstrated satisfactory performance with an accuracy level of 94%. This method was able to classify waste quickly and practically in the field, making it a potential solution to support waste sorting programs within communities. The flexibility of using a mobile phone camera allows the system to be easily implemented in various environments without the need for expensive specialized equipment.Nevertheless, this study has several limitations. Misclassifications still occurred, particularly with objects that shared similar shapes and colors between the organic and inorganic categories. Lighting conditions and complex backgrounds also influenced the system's performance. Therefore, enhancing the quality and diversity of the dataset is essential to ensure greater robustness under varying image capture conditions.

Future development suggestions include expanding the number and types of images in the dataset by incorporating different scenarios such as low lighting, complex backgrounds, and varying angles of capture. In addition, the application of data augmentation techniques and the use of more advanced deep learning algorithms are expected to improve both accuracy and the generalization capability of the system. Integration with mobile applications based on cloud computing may also be considered, enabling faster data processing and direct sharing of classification results for educational purposes as well as waste management.With proper development, this mobile phone camera-based waste detection system has the potential to become an environmentally friendly technological innovation that can assist communities in sorting waste independently and sustainably.

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