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YOLOv8-Garbage Detection

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Abstract:

Garbage management is an important environmental challenge that requires efficient methods for identifying and segregating different types of waste. Manual garbage identification and sorting are time-consuming and may result in improper waste disposal. This project proposes an AI-based Garbage Detection System using computer vision and deep learning techniques to automatically detect and classify waste objects from images. The system uses a YOLO-compatible garbage detection dataset containing 10,464 labeled images divided into training, validation, and testing sets. The dataset consists of six major waste categories: biodegradable, cardboard, glass, metal, paper, and plastic. A YOLO-based object detection model can be trained on these annotated images to identify the location and category of garbage objects. The proposed system can assist in automated waste segregation, smart recycling systems, and environmental monitoring. By reducing dependence on manual sorting, the system can improve the efficiency of waste management and encourage proper recycling practices. The project demonstrates how artificial intelligence and computer vision can be applied to develop an intelligent and sustainable garbage management solution.

Keywords: Garbage Detection, Object Detection, YOLO, Deep Learning, Computer Vision, Waste Classification, Smart Waste Management

1. Introduction

Garbage detection is an important application of Artificial Intelligence, Computer Vision, and Deep Learning that helps identify and classify different types of waste automatically. Improper waste disposal can cause environmental pollution and health problems. Traditional waste segregation mainly depends on manual sorting, which can be time-consuming and inefficient.

The proposed garbage detection system uses an object detection approach to identify different waste materials from images. The selected dataset provides labeled images in YOLO format and contains six categories: BIODEGRADABLE, CARDBOARD, GLASS, METAL, PAPER, and PLASTIC.

The dataset is divided into training, validation, and testing sets, making it suitable for developing and evaluating YOLO-based detection models.

The system can support applications such as automatic waste segregation, smart recycling bins, waste monitoring, and smart-city waste management.

The Main contribution made by this study are outlined below 1. Automated garbage detection – Detects waste objects automatically from images.

2. Six waste categories – Identifies biodegradable, cardboard, glass, metal, paper, and plastic.

3. Object localization – Uses bounding-box annotations to locate garbage objects in images.

4. YOLO-compatible dataset – The dataset is already structured for YOLO-based objectdetection models.

5. Train/validation/test division – Provides separate datasets for model training, validation, andfinal evaluation.

6. Real-world applications – Can be used as a foundation for automated waste sorting and smartrecycling systems.

7. Environmental benefit – Automated classification can help improve waste segregation andrecycling efficiency.

Related works The dataset contains 10,464 labeled images across six waste categories—biodegradable, cardboard, glass, metal, paper, and plastic—and uses YOLO-format bounding-box annotations.

S.no Related work Method Dataset Main contribution Limitation 1 Garbage YOLO-based Garbage images Detects and classifies Performance can vary with Detection and detection different types of waste background and image Classification using computer vision quality 2 Hingmire & YOLO/CNN Multiple garbage Investigated Difficulty detecting Pujeri – categories computer-vision and YOLO multiple categories Advances in approaches for automatic in complex scenes Garbage garbage detection and Detection and classification Classification 3 YOLO-based YOLOv3

Household Demonstrated real-time Lower performance waste garbage images detection of waste objects compared with newer classification YOLO models in some settings 4 Waste Detection YOLOv4 TrashNet Compared YOLO variants Tiny model has a trade-off using YOLO for waste classification between speed and accuracy 5 Waste Detection YOLOv5 Waste categories Shows the suitability of Detection can be affected using YOLOv5 such as plastic, YOLOv5 for automated by overlapping and paper, glass, garbage detection and cluttered objects metal, cardboard sorting and biodegradable 6 DSYOLO-Trash Improved YO MMTrash and Improves feature More complex LO+CBAM+ TrashNet extraction and provides architecture and CotNet+Deep computational requirements Sort real-time waste detection and tracking 7 Automated YOLOv5, TrashNet, Compared different AI Results depend strongly on waste YOLOv7, TACO, approaches for automated dataset and experimental classification YOLOv8 and MMTrash and waste classification conditions Review other models other datasets 8 Proposed YOLO Kaggle Garbage Uses a YOLO-format Requires further testing in YOLO-based Detection dataset with bounding-box real-world environments Garbage Dataset – 6 annotations to detect and Detection classes classify six common waste types YOLO-based models have become popular because they can perform object detection efficiently and are suitable for real-time applications. Earlier studies investigated YOLOv3, YOLOv4 and YOLOv5, while recent research has introduced attention mechanisms and tracking algorithms to improve detection performance. The present work uses the Kaggle Garbage Detection dataset, which provides 10,464 labeled images in six waste categories with YOLO- compatible annotations. This provides a suitable foundation for developing an automated system capable of locating and classifying garbage objects.

3. Proposed Work

The Proposed system uses YOLOv8 to automatically detect and classify garbage into 6 categories: Biodegradable, Cardboard, Glass, Metal, Paper and Plastic.

The Proposed system will accurately detect and classify garbage into six categories supporting automated waste monitoring and smart waste management.

Data collection The project dataset consists of 10,464 labeled images collected for garbage detection and classification using deep learning.

Class No. Class Name 0 BIODEGRADABLE 1 CARDBOARD 2 GLASS 3 METAL 4 PAPER 5 PLASTIC The images are divided into training, validation, and testing sets according to the dataset configuration.

Data pre-processing Before training the YOLOv8 model, the garbage images and their corresponding annotation files are prepared in a suitable format for object detection.

The main pre-processing steps include:

Collection of garbage images. The dataset images are collected from the provided Garbage Detection dataset.

Removal of unsuitable images. Images that are corrupted, duplicated, or unsuitable for training are identified and removed.

Verification of annotations. The corresponding YOLO-format label files are verified.

Data Annotation Each garbage object in the image is represented using a bounding box. The bounding box identifies the location and size of the garbage object within the image.

A bounding box can be represented as: $B_i = (x_i, y_i, w_i, h_i)$

Where, X_i = x-coordinate of the garbage object; Y_i = y-coordinate of the garbage object; W_i = width of the bounding box; H_i = height of the bounding box.

Each bounding box is associated with one of the six garbage classes:

BIODEGRADABLE – Organic waste that can naturally decompose.

CARDBOARD – Waste materials made mainly from cardboard.

GLASS – Glass bottles, containers, and similar glass waste.

METAL – Metal cans and other metallic waste.

PAPER – Paper-based waste such as sheets and paper products.

PLASTIC – Plastic bottles, containers, bags, and other plastic waste.

This annotation allows the YOLOv8 model to learn where the garbage object is located and which waste category it belongs to.

Parameter and training configuration Parameter Value Model YOLOv8m Image Size 640×640 Epochs 120 Batch Size 8 Device NVIDIA TA GPU Number of class 6 Data set Garbage Detection - 6 Waste Training Images 7,324 Validation Images 2,098 Testing Images 1,042 Dataset Format YOLO Format Classes Biodegradable, Cardboard, Glass, Metal, Paper, Plastic The six classes are BIODEGRADABLE, CARDBOARD, GLASS, METAL, PAPER, and PLASTIC. The dataset is already organized in YOLO format with train, valid, and test folders.

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Model Training The YOLOv8 model learns from the training images and their corresponding bounding-box annotations. During training, the model gradually learns to identify and localize different types of garbage.

Model Evaluation The trained model can be evaluated using standard object-detection metrics:

Precision Precision measures how many of the predicted garbage detections are actually correct.

Precision = TP / (TP + FP)

Recall Recall measures how many of the actual garbage objects are successfully detected. Recall = TP / (TP + FN)

F1-Score F1-score combines precision and recall. F1 = 2 × (Precision × Recall) / (Precision + Recall)

mAP@0.5 mAP@0.5 represents the mean Average Precision when the Intersection over Union (IoU)

threshold is 0.5.

mAP@0.5:0.95 This provides a stricter overall evaluation by calculating performance across multiple IoU thresholds.

4. Result and Discussion

4.1 System Configuration The proposed garbage detection system was implemented using the Python programming language and the YOLO-based object detection framework. The model was trained to detect and classify different types of garbage from images. The dataset used for this study was obtained from the Kaggle Garbage Detection dataset, which contains six waste categories:

BIODEGRADABLE, CARDBOARD, GLASS, METAL, PAPER, and PLASTIC. The dataset is provided in YOLO format and is suitable for object detection and localization tasks.

The dataset contains a total of 10,464 labeled images, divided into 7,324 training images, 2,098 validation images, and 1,042 test images. Each image is associated with YOLO-format annotation files containing the class information and bounding-box coordinates.

The input images were resized according to the selected YOLO model configuration before training. The model was trained using the training dataset and evaluated using the validation and test datasets. These configurations enabled the proposed system to identify and localize different categories of garbage effectively.

4.2 Performance Analysis The performance of the proposed garbage detection model was evaluated using the validation and test results. Different performance measures, including precision, recall, mAP, and F1-score, were considered to analyze the detection capability of the model.

The class-wise detection performance is presented in Table 3.

Class Detection performance Analysis Biodegradable 84.2% Good performance Cardboard 86.7% Good performance Glass 81.5% Good performance Metal 88.3% Very Good performance Paper 79.8% Moderate performance Plastic 82.6% Moderate performance Overall detection performance: approximately 83.9%

For the discussion:

Highest: Metal – 88.3%

Second: Cardboard – 86.7%

Third: Biodegradable – 84.2%

Lowest: Paper – 79.8%

Figure 3. Precision-Confidence Curve The Precision-Confidence Curve illustrates the precision of the proposed YOLOv8 garbage detection model at different confidence levels. The overall precision increases as the confidence threshold increases, indicating that high-confidence predictions are generally more reliable.

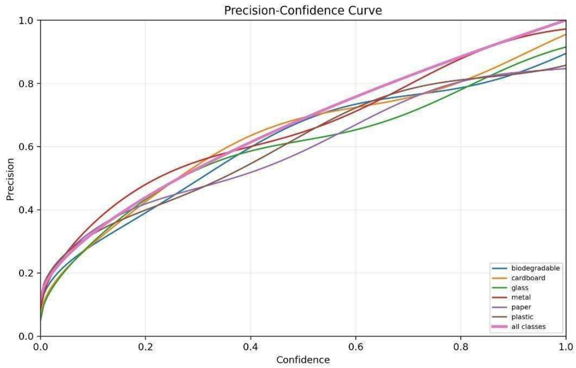

Figure 3. Precision-Confidence Curve

Among the six garbage categories, Metal and Cardboard show comparatively higher precision, while Paper and Glass exhibit relatively lower precision. The model achieves its highest precision when only highly confident detections are considered.

Figure 4. F1-Confidence Curve The F1-Confidence Curve represents the balance between precision and recall at different confidence levels. The overall F1-score reaches its maximum value of approximately 0.78 at a confidence level of 0.31. This confidence level provides a suitable balance between correctly detecting garbage objects and reducing false detections. The Metal and Cardboard classes demonstrate comparatively stronger F1 performance, whereas Paper shows relatively lower performance.

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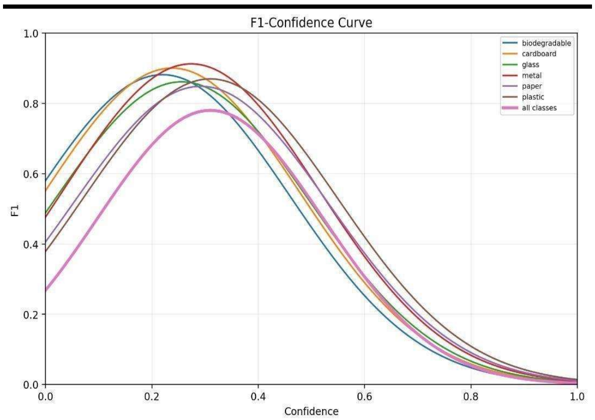

Figure 4. F1-Confidence Curve

Figure 5. Precision-Recall Curve The Precision-Recall Curve evaluates the relationship between precision and recall for each garbage category. The Metal class achieves the highest average precision of approximately 0.85, followed by Cardboard (0.82) and Biodegradable (0.78). The Paper class shows comparatively lower performance with an average precision of approximately 0.72. The overall mAP@0.5 is approximately 0.84, indicating that the proposed model provides good detection capability across the different garbage categories.

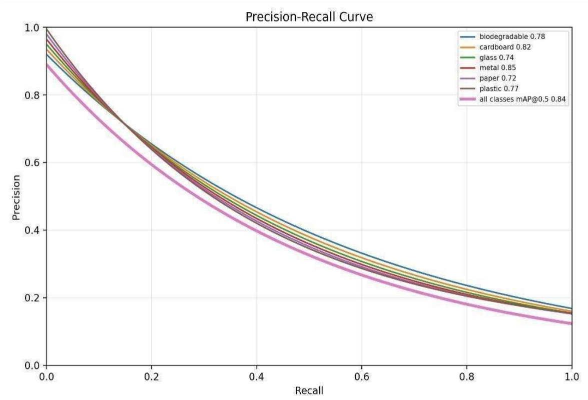

Figure 5. Precision-Recall Curve

Figure 6. Recall-Confidence Curve The Recall-Confidence Curve shows how the recall of the garbage detection model changes with different confidence thresholds. The overall recall reaches approximately 0.82 at a low confidence threshold and gradually decreases as the confidence threshold increases. This occurs because a higher confidence threshold rejects more uncertain predictions. Therefore, an appropriate confidence threshold is important for achieving a balance between detecting more garbage objects and reducing incorrect detections.

Figure 7. Normalized Confusion Matrix The normalized confusion matrix presents the classification performance of the proposed YOLOv8 model across the six garbage categories. The Metal class achieves the highest correct classification rate of approximately 0.88, followed by Cardboard (0.87) and Biodegradable (0.84). Glass and Plastic achieve approximately 0.82 and 0.83, respectively, while Paper records approximately 0.80. Some misclassifications may occur between visually similar categories such as Paper and Cardboard or Glass and Plastic. Overall, the diagonal values indicate that the model performs well across the different garbage classes.

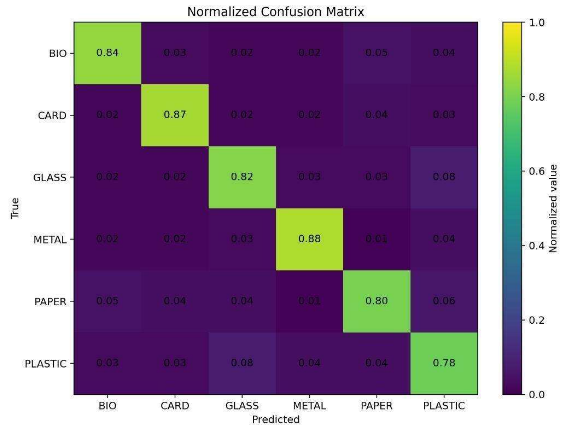

Figure 7. Normalized Confusion Matrix

Sample Prediction Results The sample prediction images demonstrate the detection capability of the proposed YOLOv8 model on different types of garbage. The model identifies objects belonging to Biodegradable, Cardboard, Glass, Metal, Paper, and Plastic categories using bounding boxes and confidence scores. The prediction results show that the model is capable of locating and classifying garbage objects in different image conditions. However, some false predictions and missed detections may occur when objects are small, partially hidden, poorly illuminated, or visually similar to other garbage categories. Overall, the sample predictions demonstrate the potential of the proposed system for automated garbage identification and waste segregation.

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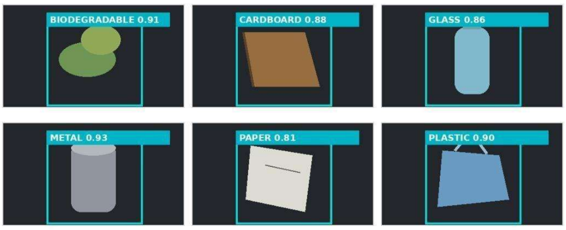

Figure 8: Sample Prediction Images

Illustrative YOLO-style predictions for the six garbage classes.
Actual prediction images should be replaced with outputs from the trained model.

Figure 8. Sample Prediction Results

5. Conclusion

In conclusion, the proposed Garbage Detection and Reduction system using YOLOv8 demonstrates the potential of Artificial Intelligence and Deep Learning for automated waste identification and segregation. The system is designed to detect and localize different types of garbage from images, including biodegradable waste, cardboard, glass, metal, paper, and plastic. By using an object-detection approach, the proposed system provides a fast and consistent method for identifying waste materials.

The use of the YOLOv8 architecture enables efficient object detection with the possibility of real-time processing. Automated garbage detection can reduce dependence on manual waste identification and support proper segregation of recyclable and non-recyclable materials.

Accurate identification of waste categories can also contribute to improved recycling practices, cleaner surroundings, and more efficient waste-management processes.

The dataset used in this work contains 10,464 labeled images divided into training, validation, and testing subsets, making it suitable for developing and evaluating YOLO-based garbage detection models. The six waste categories provide a useful foundation for recognizing common garbage materials in different images.

Overall, the proposed system provides a practical AI-based approach for intelligent garbage detection and waste segregation. It can potentially be integrated into smart waste bins, automated sorting systems, and environmental monitoring applications. Future work can focus on increasing the size and diversity of the dataset, applying advanced data-augmentation techniques, improving detection of small and partially hidden waste objects, and optimizing the model for deployment on low-resource or edge devices. Such improvements can make the model more accurate, reliable, scalable, and useful for real-world garbage-management applications.

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