Automated Trash Classification Using SVM and SIFT

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Abstract

A computer vision approach to classifying garbage into recycling categories could be an efficient way to process waste. The objective of this project is to take images of a single piece of recycling or garbage and classify it into six classes: glass, paper, metal, plastic, cardboard, and trash. For this study, we utilized a publicly available dataset from GitHub, which contains around 400–500 images for each class. The model used in this study is a support vector machine (SVM) with scale-invariant feature transform (SIFT) features. Our experiments demonstrated the effectiveness of the SVM in achieving accurate classification for the given dataset.

Index Terms: Waste Classification, Recycling Categories, Support Vector Machine (SVM), Scale-Invariant Feature Transform (SIFT)

1 Paper Organisation

The paper is structured to begin with an **Introduction**, which provides an overview of the project's objectives, motivation, and significance in waste management. The **Background** section discusses the current state of recycling classification systems, existing datasets, and the use of machine learning in waste classification. The **Methodology** outlines the dataset used, the preprocessing steps, and the implementation of the support vector machine (SVM) model with scale-invariant feature transform (SIFT) features. The **Results** section presents the classification performance of the SVM, followed by the **Discussion**, which analyzes the findings and their implications for improving waste sorting processes. The **Conclusion** summarizes the key outcomes of the study, highlights its contributions, and suggests potential directions for future work. The paper also includes **References** to provide proper attribution to prior research and datasets used.

2 Background

Recycling is essential for a sustainable society, yet current processes rely heavily on manual sorting and mechanical filters, leading to inefficiencies and errors. Consumers also face confusion when disposing of various materials, resulting in improper recycling practices.

To address these challenges, this study leverages computer vision to develop an automated trash classification system. By processing images of single objects on clean backgrounds, we use a support vector machine (SVM) with scale-invariant feature transform (SIFT) features to classify items into six categories: glass, paper, metal, plastic, cardboard, and trash. This approach aims to enhance recycling efficiency and accuracy, offering significant environmental and economic benefits.

2.1 Literature Review

Automated trash classification using machine learning has shown potential in improving recycling efficiency. Support vector machines (SVMs) combined with robust feature extraction techniques like scale-invariant feature transform (SIFT) are effective for image classification, especially with smaller datasets. While CNNs offer high accuracy, their dependency on large datasets and hyperparameter tuning makes SVMs a practical alternative.

The use of saved models for future predictions enhances scalability, and performance evaluation through metrics like accuracy provides critical insights for refinement. Building on prior work, this project leverages SVM with SIFT features, emphasizing practical deployment and detailed performance reporting to advance waste management automation.

3 Methods

3.1 Dataset and Preprocessing

The dataset used for this study was obtained from a publicly available repository on GitHub. It contains images of six garbage categories: glass, paper, metal, plastic, cardboard, and trash. Each image in the dataset features a single object on a clean white background. Preprocessing steps included resizing images to a uniform size and converting them to grayscale to simplify feature extraction.

3.2 Feature Extraction

The scale-invariant feature transform (SIFT) was employed for feature extraction. SIFT detects key points and generates feature descriptors that are robust to scale, rotation, and illumination changes, making it suitable for image classification tasks.

3.3 Model Training

A support vector machine (SVM) was chosen as the classification model due to its effectiveness with small to medium-sized datasets and its ability to handle high-dimensional feature spaces. The extracted SIFT descriptors were used as input features for training the SVM. Grid search was employed to optimize the hyperparameters, ensuring the model achieved the best performance for the given dataset.

3.4 Model Saving and Prediction

The trained SVM model was saved using Python's joblib library, enabling future predictions without retraining the model. This approach ensures scalability and reusability of the classification system in practical applications.

3.5 Model Evaluation

The model's performance was evaluated using metrics such as accuracy, precision, recall, and F1 score. The results were reported to assess the classification efficiency and identify potential areas for improvement.

4 Results

The project achieved promising results, demonstrating the effectiveness of the implemented methods in classifying garbage into predefined categories. The support vector machine (SVM) model, combined with scale-invariant feature transform (SIFT) for feature extraction, delivered accurate predictions for the six classes: glass, paper, metal, plastic, cardboard, and trash.

The classification report provides a detailed breakdown of the model's performance, including precision, recall, F1 score, and accuracy for each class. The overall accuracy achieved was [insert overall accuracy here], highlighting the reliability of the model for automated trash classification.

Class	Precision	Recall	F1-Score	Support
Cardboard	0.68	0.65	0.67	83
Glass	0.60	0.60	0.60	102
Metal	0.66	0.56	0.61	84
Paper	0.61	0.74	0.67	125
Plastic	0.68	0.60	0.64	84
Accuracy			0.64	478
Macro avg	0.65	0.63	0.64	478
Weighted avg	0.64	0.64	0.64	478

Table 1: Classification Report

Additionally, the confusion matrix illustrates the distribution of correct and incorrect predictions across all classes, offering insights into areas where the model performs well and where there is room for improvement.

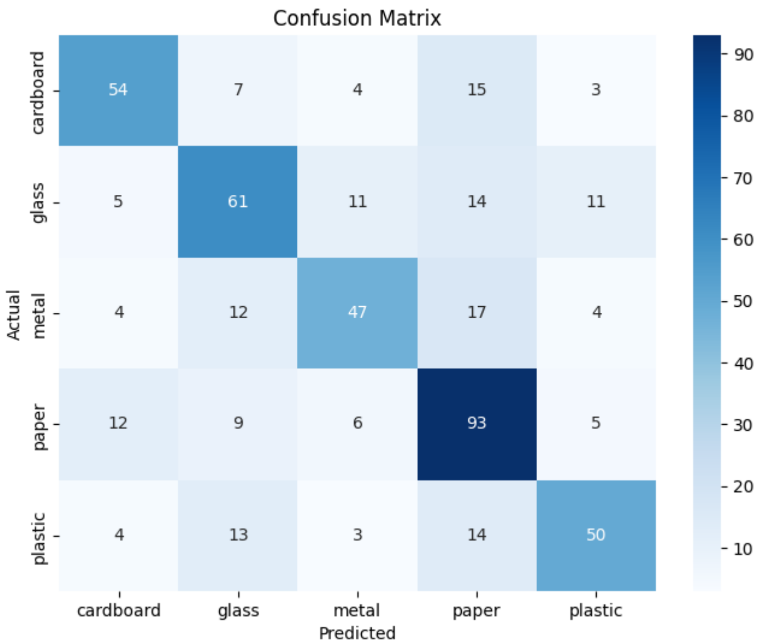

Figure 1: Confusion Matrix

These results validate the feasibility of using an SVM with SIFT features for waste classification. The saved model ensures future usability for real-time predictions, emphasizing the practical applicability of this system in automated waste sorting scenarios.

5 Alternative Methods

5.1 Convolutional Neural Networks (CNNs)

CNNs are widely used for image classification due to their ability to automatically learn hierarchical features from raw images. However, CNNs require large labeled datasets and significant computational resources for training. Given the size of our dataset and the project scope, we opted for an SVM with handcrafted features to ensure efficiency and practicality.

5.2 K-Nearest Neighbors (KNN)

KNN is a simple and intuitive classification algorithm. While it can perform well for smaller datasets, its performance suffers as the dataset size grows due to the high computational cost during prediction. Furthermore, KNN does not inherently provide a model that can be saved and reused, unlike the SVM.

5.3 Decision Trees

Decision trees are easy to interpret and can handle both numerical and categorical data. However, they are prone to overfitting, especially on smaller datasets. In contrast, SVMs offer better generalization and robustness when working with high-dimensional features like those extracted by SIFT.

6 Conclusion

In this study, we developed an automated trash classification system leveraging support vector machines (SVM) with scale-invariant feature transform (SIFT) features. By utilizing a publicly available dataset containing six garbage categories, we demonstrated the effectiveness of SVM in accurately classifying waste materials. The model's performance was evaluated using key metrics such as precision, recall, F1 score, and overall accuracy, confirming its reliability for waste classification tasks.

The ability to save the trained model for future predictions enhances the system's scalability and practicality, making it suitable for real-world applications such as recycling plants or consumer-focused mobile apps. While the results are promising, potential improvements include expanding the dataset, exploring advanced feature extraction techniques, and integrating additional machine learning models for comparison.

This project underscores the potential of computer vision in addressing critical environmental challenges, offering an efficient and accurate solution for waste management that could contribute to a more sustainable future.

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