Group 14 Progress Report: Municipal Waste Image Classifier

Sunny Yao, Second Author, Third Author
{yaoh24,macid2,macid3}@mcmaster.ca

1 Introduction

The rapid increase in municipal solid waste has become a major global issue, contributing to landfill overflow, environmental pollution, and the depletion of natural resources. Effective waste management plays a vital role in addressing these challenges by promoting recycling, conserving resources, and reducing the overall environmental footprint. However, traditional methods of waste sorting are often manual, time-consuming, and error-prone, limiting the efficiency and scalability of recycling systems.

This report presents the development of a Municipal Waste Image Classification system that applies deep learning techniques to automate the identification and categorization of waste materials. The system is designed to classify common waste types such as plastic, paper, glass, metal, and organic matter based on image data. By automating the classification process, the project aims to improve recycling efficiency, streamline waste management operations, and support environmental sustainability efforts.

The main challenge of this project lies in the variability and complexity of real-world waste images. Factors such as lighting conditions, object overlap, background noise, and material degradation can make accurate classification difficult. Overcoming these challenges requires the use of robust machine learning models capable of handling diverse input data while maintaining high accuracy and efficiency. The success of this project would demonstrate the potential of artificial intelligence to transform waste management practices and contribute to the creation of more sustainable and environmentally responsible cities.

2 Related Work

Here, talk about the related work you encountered for your approach. Cite at least 5 references. Refer to item 2. No one has done exactly your task? Write about the most similar thing you can find. This should be around 0.25-0.5 pages.

3 Dataset

You should write about your dataset here, following the guidelines regarding item 1. This section may be 0.5-1 pages. Depending on your specific dataset, you may want to include subsections for the preprocessing, annotation, etc.

4 Features

The dataset used in this project consists of labeled images of municipal waste categorized into classes such as plastic, paper, glass, metal, and organic waste. Each image is organized within a directory structure, where each subfolder represents one waste category. A custom GarbageDataset class was developed to efficiently load the data by reading image paths and their corresponding labels, returning (image, label) pairs suitable for use in PyTorch data loaders.

Before being fed into the model, all images undergo a series of preprocessing steps using torchvision.transforms. These include resizing the images to a uniform size, converting them into tensors, and normalizing pixel values to ensure consistent scale and distribution across the dataset. This preprocessing helps improve training stability and ensures that the model can handle variations in lighting, background, and image quality.

The model itself is a Convolutional Neural Network, which is particularly well-suited for image classification tasks. Unlike traditional approaches that rely on manual feature engineering, the CNN automatically learns to extract hierarchical visual features directly from raw image data. Early convolutional layers capture low-level features such as edges, colors, and textures, while deeper layers identify higher-level patterns like shapes and ob-

ject structures. The network then uses these learned embeddings to classify each image into its corresponding waste category.

All feature extraction and classification are performed within this single end-to-end neural network pipeline. By leveraging the CNN's ability to learn rich spatial representations, the system avoids manual feature selection and instead learns robust, generalizable features directly from data. This approach enhances classification accuracy and makes the model more adaptable to real-world waste sorting applications, where visual variability is common.

5 Implementation

Describe your model and implementation here. Refer to item 4. This may take around a page.

6 Results and Evaluation

How are you evaluating your model? What results do you have so far? What are your baselines? Refer to item 5. This may take around 0.5 pages.

7 Feedback and Plans

For the remainder of the project, our primary focus will be on improving the accuracy, robustness, and generalization ability of our CNN-based waste classification model. We will also explore other CNN based models to look at their techniques and see if we can incorporate them into our own model.

8 Template Notes

You can remove this section or comment it out, as it only contains instructions for how to use this template. You may use subsections in your document as you find appropriate.

8.1 Tables and figures

See Table 1 for an example of a table and its caption. See Figure 1 for an example of a figure and its caption.

8.2 Citations

Table 1 shows the syntax supported by the style files. We encourage you to use the natbib styles. You can use the command `\citet` (cite in text) to get "author (year)" citations, like this citation to a paper by Gusfield (1997). You can use the command `\citep` (cite in parentheses) to get "(author, year)" citations (Gusfield, 1997). You can use the command `\citealp` (alternative cite without parentheses) to get "author, year" citations, which is useful for using citations within parentheses (e.g. Gusfield, 1997).

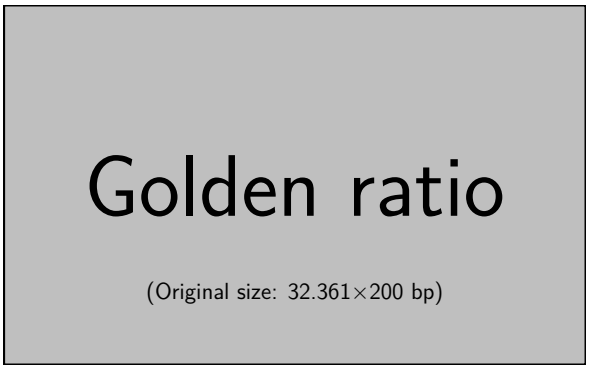

Figure 1: A figure with a caption that runs for more than one line. Example image is usually available through the `mwe` package without even mentioning it in the preamble.

8.3 References

Many websites where you can find academic papers also allow you to export a bib file for citation or bib formatted entry. Copy this into the `custom.bib` and you will be able to cite the paper in the LaTeX. You can remove the example entries.

8.4 Equations

An example equation is shown below:

$$A = \pi r^2 \tag{1}$$

Labels for equation numbers, sections, subsections, figures and tables are all defined with the `\label{label}` command and cross references to them are made with the `\ref{label}` command. This an example cross-reference to Equation 1. You can also write equations inline, like this: $A = \pi r^2$.

Team Contributions

Write in this section a few sentences describing the contributions of each team member. What did each member work on? Refer to item 7.

References

Rie Kubota Ando and Tong Zhang. 2005. A framework for learning predictive structures from multiple tasks and unlabeled data. *Journal of Machine Learning Research*, 6:1817–1853.

Galen Andrew and Jianfeng Gao. 2007. Scalable training of L1-regularized log-linear models. In *Proceedings of the 24th International Conference on Machine Learning*, pages 33–40.

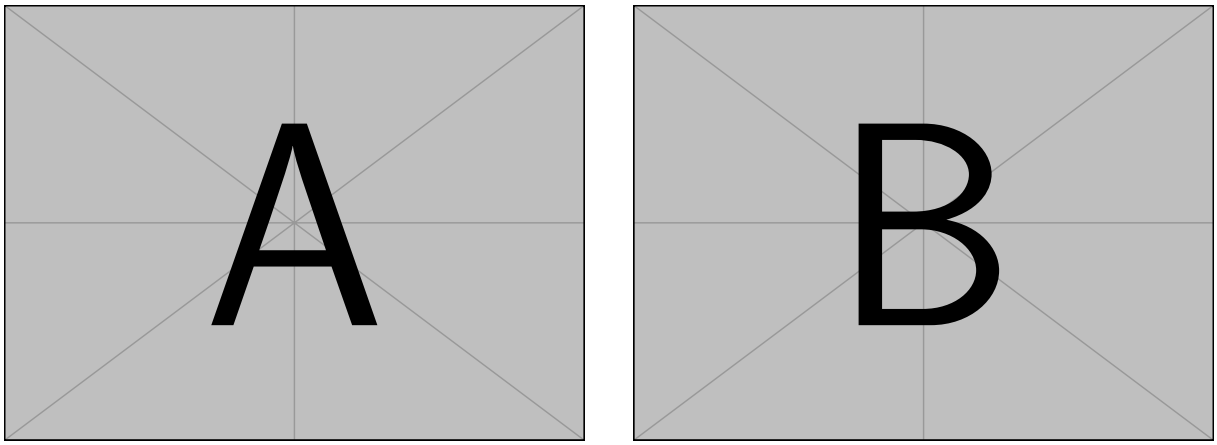

Figure 2: A minimal working example to demonstrate how to place two images side-by-side.

Output	natbib command	ACL only command
(Gusfield, 1997)	`\citep`	
Gusfield, 1997	`\citealp`	
Gusfield (1997)	`\citet`	
(1997)	`\citeyearpar`	
Gusfield's (1997)		`\citeposs`

Table 1: Citation commands supported by the style file.

Dan Gusfield. 1997. *Algorithms on Strings, Trees and Sequences*. Cambridge University Press, Cambridge, UK.

Mohammad Sadegh Rasooli and Joel R. Tetreault. 2015. Yara parser: A fast and accurate dependency parser. *Computing Research Repository*, arXiv:1503.06733. Version 2.