Garbage Classification - Based on Rules of Shanghai Garbage Classification System

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# **1. Introduction**

## *1.1 Problem*

An inevitable consequence of intense human activities is the rapid increase in the amount of waste that is produced, and it is the way these waste are handled, stored, collected, and disposed of, which can pose risks to the environment and to public health. At the heart of waste disposal is reasonable waste classification. ①**Although different countries/cities may have proposed the details for garbage classification, it is not realistic for people to classify them without intelligent tools.** As an increasingly detailed understanding of the different degrees of environmental, social, and economic risks associated with managing various types of ‘waste’ has developed, a variety of systems have been established to differentiate between materials. ②**However, most available systems do not accept pictures as input, which makes it difficult for citizens to inquire about waste types.**

## *1.2 Motivation*

Our algorithm model and solution therefore complements the gap between legislation and practice by developing an image-based waste sorting system, which assists users to understand the characteristics of waste so that it can be managed and monitored appropriately in a manner that protects human health and the environment. Based on the optimal model among MLP, CNN, and ANN, users can get quick and accurate judgments on the waste types, improving the garbage classification quality. Also, a simple front-end layer is included in our solution that allows users to interact easily.

# **2. Task description**

Fetch the images of garbage by designing our scrawler and modify their labels like *Recyclable - Glasses* to adapt our multi-class garbage classification model. Based on deep learning technology, design an image classification model to solve the garbage classification problem. MLP is set as the baseline, while CNN and ANN are considered to improve it. Finally, based on the classification model, design a simple front-end layer for user interaction.

# **3. Data sources**

*3.1 Waste types*

[Shanghai Waste Classification System](https://trash.lhsr.cn/sites/feiguan/trashTypes_3/TrashQuery.aspx) is valuable to provide waste-type information for thousands of items. It categorizes items into four main types: *recyclable waste*, *hazardous waste*, *wet waste*, and *dry waste*. Since this platform communicates in Chinese, we also need to use [Baidu Translation API](https://api.fanyi.baidu.com) to get the corresponding English labels.

3.2 *Waste images*

Based on item labels, the waste image URLs are crawled through [Flickr API](https://www.flickr.com/services/apps/create/). It displays identifiers for users, photos, photo albums, and other uniquely identifiable objects. Then, a simple python script is written, which fetches all the images available on a web page by giving a web page URL.

# **4. Methodologies**

## *4.1 Data pre-processing*

Data preprocessing includes data verification, data cleaning, data selection, and data augmentation. 1) Data verification: refers to the process of basic judgment and verification of data availability. 2) Data cleaning: refers to the process of de-drying, error correction, or completion of data. On the basis of data verification, the data is checked for consistency, and some invalid values are processed. 3) Data selection: refers to the process of selecting a subset of data from the full amount of data. There are many bases for selecting data, which can be selected according to some similarity or deep learning algorithm. 4) Data augmentation: refers to directly or indirectly increasing the amount of data through scaling, cropping, transforming, synthesizing, and other operations to further improve the training accuracy of the model. We will perform some of the methods to ensure the validity of the data

## *4.2 Models*

We discover three of the recommended models suitable for image classification, including MLP, CNN, and ANN. 1) MLP is chosen as a baseline. We will explore the performance of different numbers of layers, whether a linear activation is used, and try to find the optimal learning rate and the number of hidden layer nodes. In addition, MLP is prone to problems such as weight disappearance or explosion. We will also try to use Genetic Algorithm instead of gradient descent to optimize model parameters. 2) CNN owns the property of translation invariance, with sparse local connections using fewer parameters, which is more suitable for image processing. Starting from the most basic CNN, we will consider small improvements such as batchnorm layer and dropout, and consider feature reuse improvements such as Resnet and Densenet. Finally, transfer learning will be used to improve accuracy, providing a comprehensive analysis. 3) ANN: Attention mechanism is a means to quickly screen out high-value information from a large amount of information using limited attention resources. The emergence of attention is for two purposes: one is to reduce the computational burden of processing high-dimensional input data, and to reduce the data dimension by structurally selecting a subset of the input; another point is that it let the task focus more on finding the useful information that is significant in the input data and related to the current output, thereby improving the quality of the output.

*4.3 Interactive front-end layer*

Using Gradio, we only need to add a few lines to the original code and get an interactive front-end layer so that the user can upload or draw the waste image and get the predicted waste type based on the optimized model. At the same time, it also supports the generation of links that can be accessed from external networks, which allows others to experience our algorithm.

# **5. Project schedule**

## *5.1 Tasks for each member*

| Name | Tasks |
| --- | --- |
| An Yuhong | Majorly working on attention network such as transformer. Helping dataset acquisition & preprocessing and model training work |
| He Wenbin | Majorly working on MLP & CNN models and evaluation & interpretation. Develop a suitable front-end layer for solution. Summarize content and integrate reports |
| Li Guoshen | Majorly working on using class activation map for neural network interpretability, incorporate attention block in CNN, and help model training. Helping and advising on data pre-processing work |

## *5.2 Time schedule*

| Tasks | Week 9 | Week 10 | Week 11 | Week 12 | Week 13 | Week 14 |
| --- | --- | --- | --- | --- | --- | --- |
| Dataset acquisition |  |  |  |  |  |  |
| Data cleaning |  |  |  |  |  |  |
| MLP model training |  |  |  |  |  |  |
| CNN model training |  |  |  |  |  |  |
| ANN model training |  |  |  |  |  |  |
| Report finalize |  |  |  |  |  |  |
| Slide & video finalize |  |  |  |  |  |  |