Waste Classification System Using Deep Learning

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July 29, 2023

Introduction

- Waste classification is the categorization of waste based on its physical, chemical, and biological characteristics.
- The project uses a pre-trained deep learning model(CNN) to classify waste materials from a video source.
- The system works by capturing frames from the video source, resizing the image, and passing it through the pre-trained model to get a prediction.
- The waste classification system is a Computer Vision project.

Motivation

- Real-time processing: The system can quickly process images, making it ideal for waste-sorting plants or public spaces where fast decisions are necessary.
- Easy to use: The system is easy to use and does not require any special training or skills.
- Reduce: It reduces environmental pollution, improves waste management efficiency, and increases the recovery and reuse of valuable resources.

Literature Review

References	Approach	Paper Type	Description
Olugboja Adedeji et al. [1]	Deep CNN	Journal	Developed specifically to work with images and other grid-like data, such as audio signals and time series data..
H. I. K. Fathurrahman et al. [2]	Deep Learning	Journal	Aims to create a mobile-based application that can select the type of garbage and enter the garbage data into a database.
S. Zhang et al. [3]	Computer Vision	Journal	They propose a two-stage algorithm based on Computer vision for waste recognition and retrieval, to classify waste materials accurately and efficiently.

Table 1: Literature Review

References	Approach	Paper Type	Description
N. Ramsurrun et al. [4]	Computer Vision, Deep Learning	Journal	Mainly for classifying recyclable waste materials.The approach utilizes a CNN for image classification and achieves promising results.
D. Ziouzios et al. [5]	CNN	Journal	This is for recycled materials using CNN.The proposed algorithm achieves high accuracy and performance in identifying and categorizing recycled materials.

Table 2: Literature Review

Gaps Identified

1. Lack of transparency: The paper does not provide detailed information about the CNN model architecture, hyperparameters, and other technical details.
2. Limited applicability: The proposed system is designed specifically for detecting and classifying garbage in real-time using a mobile device. It may not be applicable or suitable for other waste management applications, such as waste disposal or recycling.
3. The paper primarily focuses on identifying and classifying pre-segmented waste objects,not classifying all wastes.
4. which is the need for an efficient and accurate system for classifying recyclable waste using computer vision and deep learning.
5. Traditional methods of recycling material detection and classification can be time-consuming and rely on human labor, which can lead to errors and inefficiencies.

Problem Statement

"To develop an automated waste classification system using AI and machine learning techniques. The system will be designed to accurately identify the type of waste, such as plastic, metal, paper, or glass".

Objectives

1. To achieve this goal, here Deep learning technique is used to classify the waste materials. This Deep learning model will predict the waste type and thereby we can classify the waste materials accordingly.
2. If the system accurately predicts the type of waste, the model will display the waste type and the respective category the waste belongs to.
3. However, if the system fails to identify the waste type, the model will not display the waste category, and thereby we cannot get the proper identification and their class.

Methodology

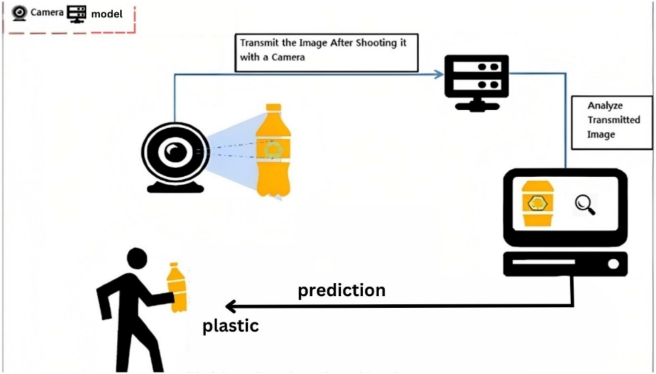

Figure 1: Methodology

Methodology

- Gather waste datasets and compile a new dataset using the best available dataset for each classes.
- Preprocessing techniques are appiled images of new dataset.
- The system is trained using the newly compiled dataset of labeled waste images,where each image is annotated into different classes as plastic,metal,glass,paper,food and electronic wastes.
- Adjustments are made to the model based on the analysis post-training.
- After training an interface is developed to predict the type of waste and its confidence level in real time.

Network Architecture

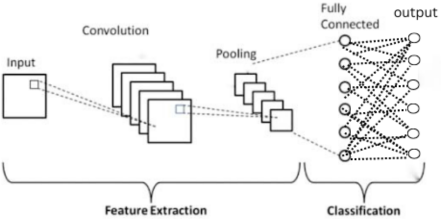

Figure 2: Architecture Diagram

Network Architecture

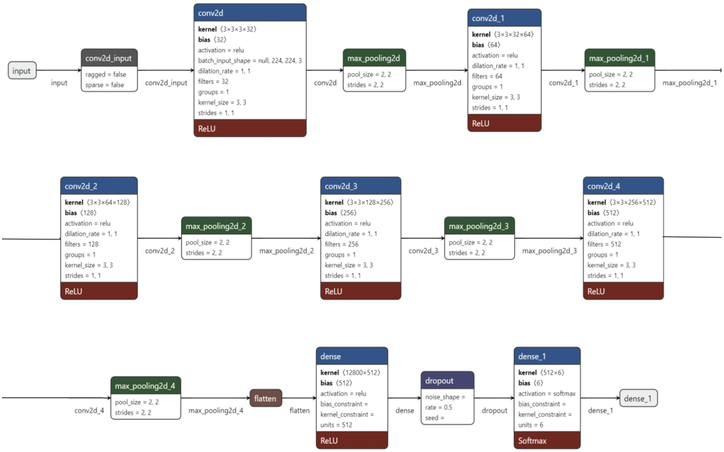

Figure 3: CNN Layer Details

Dataset

- Waste Classification PI [6]
- Waste Classification Dataset [7]
- Food-101 Dataset [8]
- Electronic Waste images are taken from [7], Food Waste images are taken from [8] and rest are taken from [6]

	Name	**Image Count**
1	Electronic Waste	228
2	Food Waste	2194
3	Glass	568
4	Metal	424
5	Paper	594
6	Plastic	486

Table 3: Dataset

Source:Kaggle, Avg Size: 3518Kb

Sample Images

Figure 4: Types of waste

Dataset Size

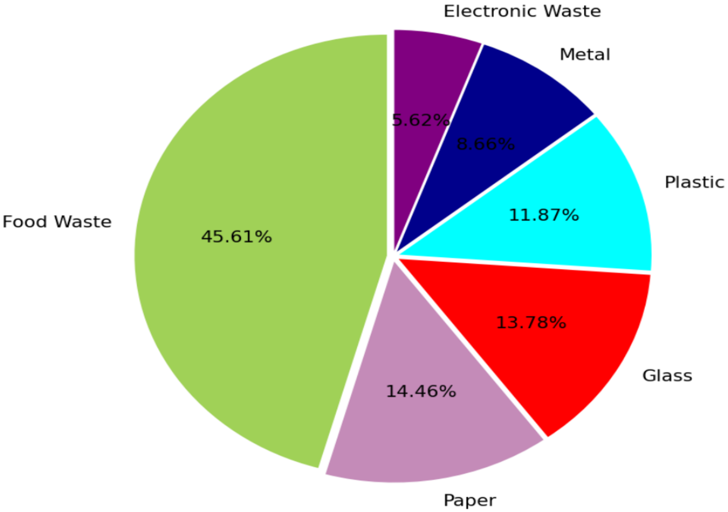

Figure 5: Classwise Distribution

Software Requirements

- Software Requirements
  - Pycharm IDE
  - Python 3
  - Deep Learning Libraries(Keras,Tensorflow,OpenCV)
  - Google colaboratory
  - Tkinter module

Implementation Details

Model Details:

- Filter size: 3x3
- Numbers of filters: 32, 64, 128, 256, 512
- MaxPooling2D size: 2x2

Training Settings:

- Optimizer: Adam
- Batch size: 32
- Epochs: 82
- Loss function: Categorical Cross Entropy.

Result and Discussion

- After training the model for 82 epochs, the model achieved a training loss of 0.2291 and a training accuracy of 91.59%.
- The validation loss at the end of the training was 0.2682, with a validation accuracy of 92.32%.

Training Details

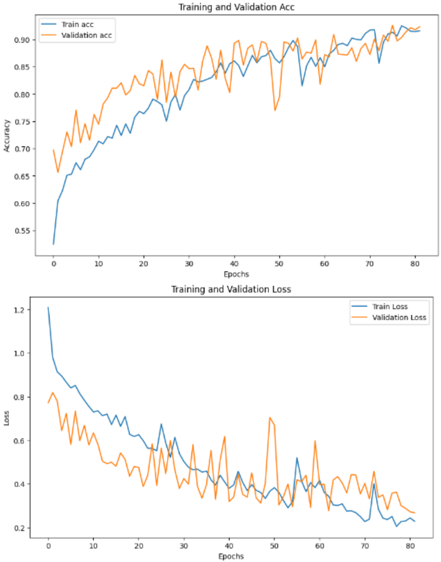

Figure 6: Training Curve

Result

Class	Precision	Recall	F1-Score	Support
Electronic Waste	0.78	1.00	0.88	39
Food Waste	0.99	0.99	0.99	661
Glass Waste	0.80	0.85	0.82	105
Metal Waste	0.90	0.73	0.80	133
Paper Waste	0.92	0.85	0.88	108
Plastic Waste	0.75	0.87	0.80	87

Table 4: Classification Report

Result

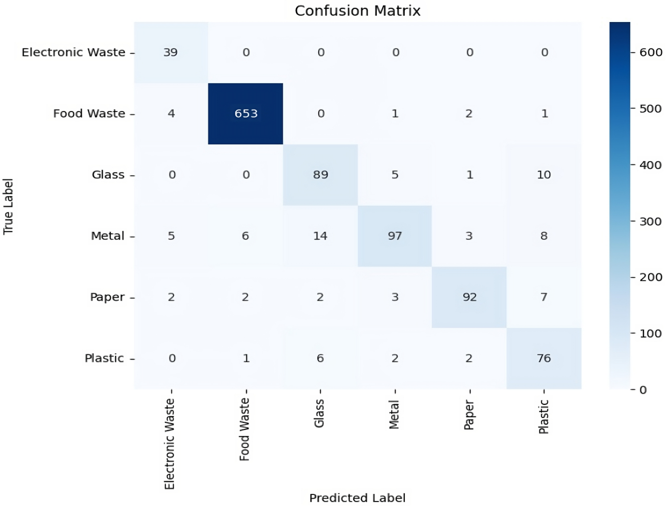

Figure 7: Confusion Matrix

Conclusion

- The overall aim of our topic is to classify the waste material according to their types and also thereby reduce pollution.
- Deep learning technique is used to classify different types of waste material, like paper, glass, metal, food, plastic, and electronic wastes.
- Deep learning models demonstrate strong performance in accurately categorizing different types of waste, enabling automated sorting processes and reducing human error.

Future Scope

- Hyperparameter tuning: Fine-tune the hyperparameters of your model to optimize its performance. This includes parameters such as learning rate, batch size, optimizer, regularization techniques, and dropout rates. Use techniques like grid search or random search to efficiently explore the hyperparameter space.
- Class imbalance handling: If the dataset has class imbalance, where some classes have more examples than others, consider employing techniques to handle this issue. You can explore oversampling techniques like SMOTE (Synthetic Minority Over-sampling Technique) or undersampling techniques like RandomUnderSampler.
- Model architecture exploration: Experiment with different variations of the CNN model architecture. You can try different numbers of layers, layer sizes, activation functions, or even explore advanced architectures like residual networks (ResNet) or convolutional neural networks (CNNs) with attention mechanisms.

References I

[1] O. Adedeji and Z. Wang, "Intelligent waste classification system using deep learning convolutional neural network," *Procedia Manufacturing*, vol. 35, pp. 607–612, 2019.

[2] H. I. K. Fathurrahman, A. Ma'arif, and L.-Y. Chin, "The development of real-time mobile garbage detection using deep learning," *Jurnal Ilmiah Teknik Elektro Komputer dan Informatika (JITEKI)*, vol. 7, no. 3, p. 472, 2022.

[3] S. Zhang, Y. Chen, Z. Yang, and H. Gong, "Computer vision based two-stage waste recognition-retrieval algorithm for waste classification," *Resources, Conservation and Recycling*, vol. 169, p. 105543, 2021.

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[5] D. Ziouzios, N. Baras, V. Balafas, M. Dasygenis, and A. Stimoniaris, "Intelligent and real-time detection and classification algorithm for recycled materials using convolutional neural networks," *Recycling*, vol. 7, no. 1, 2022.

[6] "Waste classification pi." https://www.kaggle.com/datasets/alveddian/waste-classification-data.

[7] "Waste classification dataset." https://www.kaggle.com/datasets/shubhamdivakar/waste-classification-dataset.

[8] "Food-101." https://data.vision.ee.ethz.ch/cvl/datasets_extra/food-101/.

THANK YOU