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Development of a Deep Learning Based Automatic Garbage Classification System

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Abstract: ***The escalating global waste production has given rise to significant environmental challenges, encompassing pollution and health risks. Effective waste management hinges on the essential process of garbage categorization. Nonetheless, manual sorting proves to be arduous, error- prone, and time-intensive. To address this, automated garbage classification powered by deep learning has emerged as a promising remedy. This project introduces a garbage classification framework leveraging convolutional neural networks (CNNs) to achieve remarkable precision in distinguishing various garbage types. Comprising pre-processing, feature extraction, and classification stages, this system holds the potential to curtail the necessity for manual intervention in waste management operations. This, in turn, can enhance the efficiency and precision of garbage segregation procedures.***

Keywords**:** ***Image Processing, Feature Extraction, Machine Learning Algorithms, predictions, Classification.***

I. INTRODUCTION

A machine learning algorithm, was utilized to create the model for this investigation. The dataset used for the study contained photos of trash. For image identification and classification applications, convolutional neural networks (CNNs) are a prevalent form of ML technique. In this study, CNNs have been used to separate out various sorts of trash from photographs. A collection of photos of different trash categories, including paper, plastic, metal, glass, and organic garbage, is used to train the CNN model. The model is skilled at correctly categorize each image into one of these groups. This technology guarantees the best possible waste management and will also expedite and more precisely complete the segregation process. Overall, this project aims to provide a solution to the problem of waste management by using CNN-based garbage classification system. This system can be implemented in various waste management facilities, including recycling plants, waste collection centres, and landfills.

II. LITERATURE SURVEY

The research paper[1], The leading method for image recognition at the time was the convolutional neural network (CNN) model, such DenseNet121, which enhanced the conventional image recognition technology. The effectiveness of the CNNs was assessed using the well-known benchmark dataset TrashNet, which consists of a total of 2527 photos divided into six different waste types. The data augmentation approach might be used to improve the accuracy of CNN-driven trash categorization, but it was never applied to fine- tune the fully-connected hyper-parameters of the CNNs. In order to improve the classification accuracy of DenseNet121 on TrashNet and propose the optimized DenseNet121, this work also seeks to use a genetic algorithm (GA) to optimize the fully-connected layer of DenseNet121. And in research paper[2], In the realm of Deep Convolutional Neural Network (DCNN) and image processing, the research suggests a machine that can divide garbage into its various components with the aid of a smart object detection algorithm and ConvoWaste. In this study, the waste is precisely classified using deep learning and image processing techniques, and the discovered waste is then deposited within the appropriate bins using a servo motor-based system. Using the ultrasonic sensors put in each bin and the dual-band GSM-based communication technology, this machine has the capability to alert the responsible authority regarding the waste level of the bins and the time to throw out the bins full with rubbish. The entire system is controlled remotely through an android app in order to dump the separated waste in a desired place by its automation properties.

III. PROPOSED WORK

The proper management of garbage will be aided by the suggested rubbish categorization system's high accuracy in identifying various forms of waste. The system has the ability to cut down on the time and labor needed for manual garbage sorting and classification, increasing the effectiveness of waste management procedures.

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The proposed garbage classification system based on CNN employs a large-scale garbage dataset for training and testing. The system consists of three main stages: pre-processing, feature extraction, and classification. The pre-processing stage involves resizing, normalization, and augmentation of images. The feature extraction stage uses a pre-trained CNN model to extract high-level features from garbage images. Finally, the classification stage employs a multi-layer perceptron (MLP) to classify garbage into different categories based on the extracted features.

IV. METHODOLOGY

A large-scale garbage dataset is collected and pre-processed to remove noise and normalize the images. The dataset contains various types of garbage, such as plastic, glass, project, metal, and organic waste. Using a pre-trained CNN network, advanced characteristics are extracted from low-resolution photos. The deep neural network with 16 layers used in this study, known as VGG16, produced state-of-the-art performance on the ImageNet dataset. Using a multi-layer perceptron (MLP), the garbage is divided into various groups based on the retrieved attributes. A softmax layer that produces probability outputs for each category follows three fully connected layers that incorporate dropout regularization in the MLP.

The modules used in proposed system are as follows:

1) *Recycle Plant Manager:* The Recycle Plant Manager of the recycling plant has the responsibility of overseeing the training phase of the application. Once logged in successfully, the Plant Manager can upload the training dataset, initiate the training process using the CNN algorithm, create a model, and view the training results through graphical representations.
2) *Quality Control Inspector:* The Quality Control Inspector of the recycling plant has the responsibility of overseeing the evaluation phase of the application. Once logged in successfully, the Quality Control Inspector can upload the test dataset and view the test results through graphical representations.
3) *Waste Management Analyst:* The Waste Management Analyst of the recycling plant has the responsibility of segregating the waste by using the application. He has to first register with his details. After successful login, he can upload a garbage image and classify the type of waste from the image accordingly.

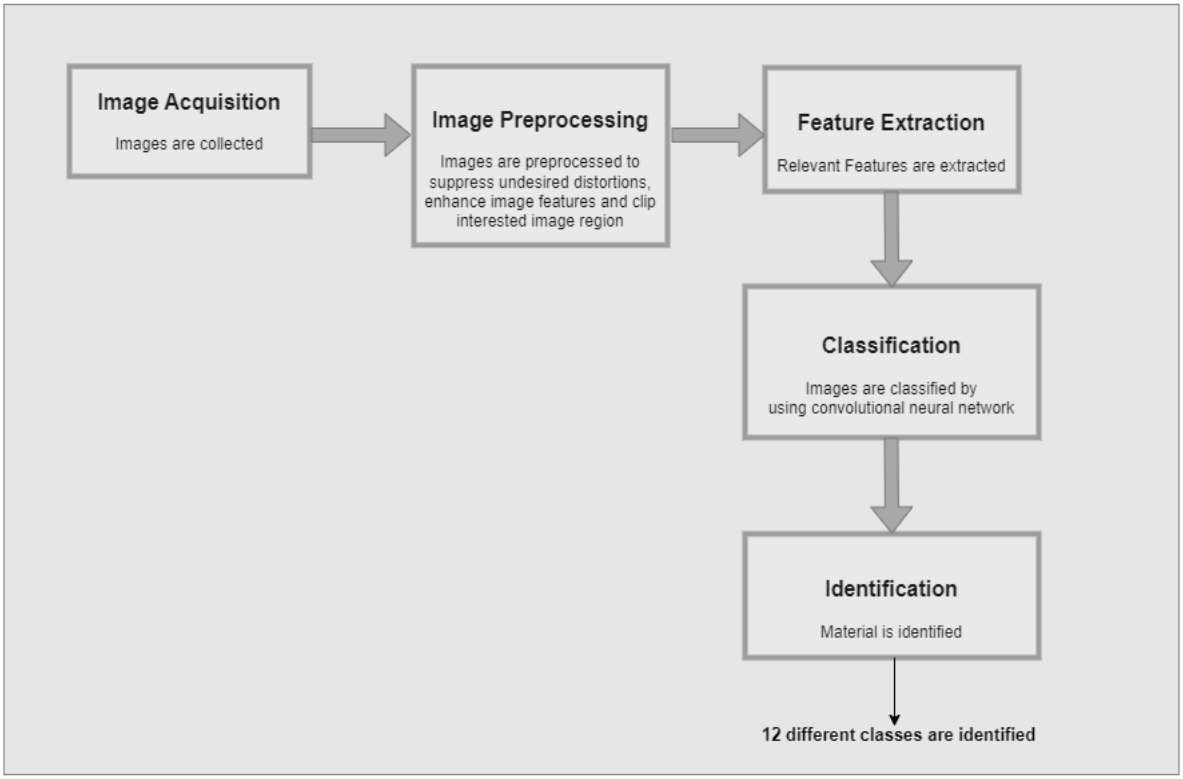


Fig. 1 Overview of the Proposed system

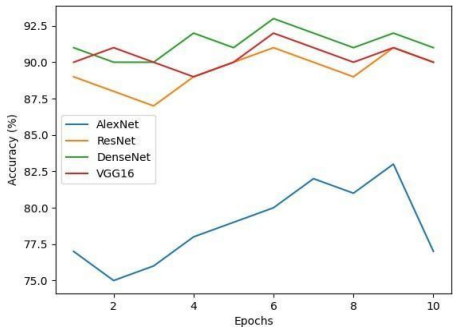
V. RESULT ANALYSIS

Here is a summary of the results for all four models: VGG16, ResNet-50, AlexNet, and DenseNet-169. Remember that these studies are based on the typical benefits and weaknesses of each design. Depending on your training configuration, preprocessing, and dataset, your specific results may vary. The accuracy graph shows how well the models are learning from the training data over each epoch (training iteration). The x-axis represents the number of epochs, while the y-axis represents the accuracy achieved by the models.

Table 1 Accuracy Comparison

Model	Accuracy
VGG16	91.86%
ResNet-50	90.65%
AlexNet	82.52%
DenseNet-169	92.69%

Fig. 2 Accuracy Graph



The above figure 2 shows the screenshot of the garbage class prediction and classification into biodegradable and non-biodegradable waste.

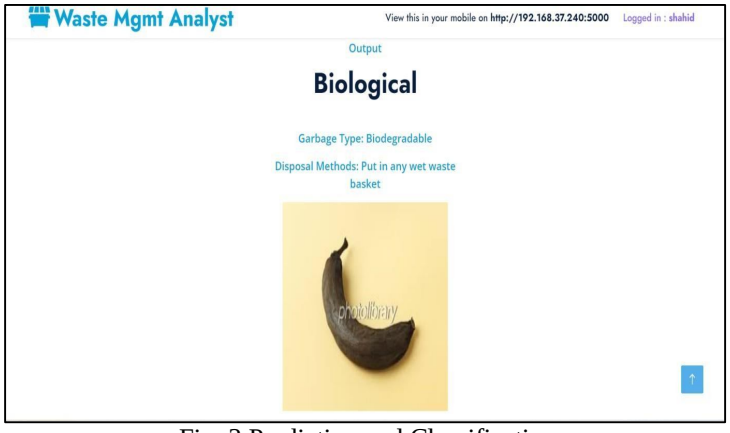


Fig. 3 Prediction and Classification

VI. CONCLUSION

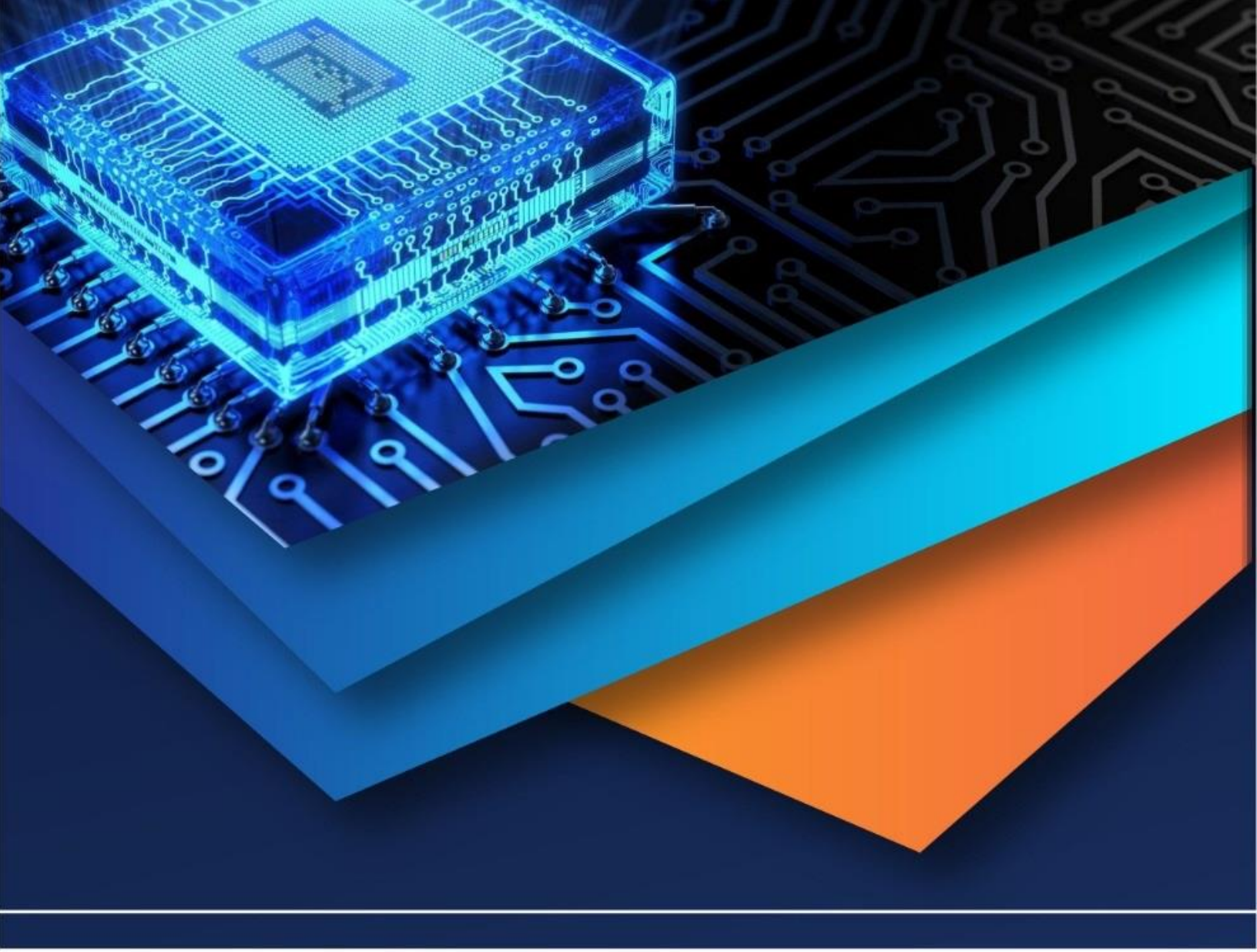
With its superior accuracy and efficiency in trash sorting and classification, the CNN-based rubbish classification system has the potential to radically alter the waste management industry. Better quality recyclable materials and less contamination of waste streams may result from the system's potential to lessen reliance on human labour and enhance the uniformity of trash sorting and categorization. Waste management workers, recycling plant operators, and municipal governments may all benefit from using the established system. In conclusion, the CNN-based rubbish categorization system offers a potentially game- changing approach to better waste management and more effective sustainability.

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