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DEEP LEARNING-BASED CLASSIFICATION OF BIODEGRADABLE AND NON-BIODEGRADABLE MATERIALS USING CNN

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Abstract

Numerous ecosystems are under threat from plastic waste and carbon emissions. One proposed solution involves the use of biodegradable plastics, which are designed to break down quickly through microbial assimilation, thus mitigating climate change, microplastic pollution, and littering. Nonetheless, biodegradable plastics make up only a small percentage of the global plastics market and necessitate additional research and commercialization endeavors. A range of considerations must be taken into account, including the environmental and socio-economic consequences, governmental policies, standards and certifications, physico-chemical attributes, and analytical techniques. When non-biodegradable and toxic substances are involved, improper waste disposal may result in increased pollution, global warming, and health hazards, underscoring the importance of appropriate waste disposal methods. One innovative approach to streamlining waste classification involves deep learning and convolutional neural networks (CNNs). An image dataset is utilized to train the CNN, and several visualization methods are employed to distinguish waste types based on color and texture. The model is deployed via the Django web framework. Collectively, these efforts demonstrate the potential of advanced technology to address environmental challenges.

Keywords: Deep learning, CNN.

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1. Introduction

Biodegradable materials, such as bacteria, fungi, ultraviolet rays, ozone, oxygen, and water, can decompose naturally by breaking down complex organic materials into simpler units, enriching the soil with various nutrients. These materials are generally non-toxic and do not cause harm to the environment over extended periods, making them less hazardous to the ecosystem. Examples of biodegradable materials include products made from natural sources such as plants or animals.

In contrast, non-biodegradable materials cannot decompose naturally and persist in the environment for extended periods. Plastic, polyethylene, scrap metals, aluminum cans, and glass bottles are examples of non-biodegradable materials that can pose hazardous problems and damage the ecosystem. Non-biodegradable metallic substances, in particular, can pollute natural waters and soils.

To reduce the harm caused by non-biodegradable materials, developing countries are increasingly emphasizing the use of biodegradable materials. A deep learning study was conducted to classify materials as biodegradable or non-biodegradable. The dataset comprised visual representations of various items, and pre-trained networks were employed for classification. The study evaluated the success criteria of the classification. The second section of the study examined the existing literature, while the third section described the materials and methods used. The fourth chapter summarized the experimental analysis results, and the fifth chapter presented the study's conclusions.

2.Related works

JIM YU, YU SU, And MARGARET H. DUNHAM (2018):

proposed a novel method for predicting biodegradability of compounds, which is crucial for understanding their impact on the environment and public health. Unlike traditional regression analysis using structural relationships, this method employs neural networks and physical, chemical, and thermodynamic data. The method demonstrated higher prediction accuracy compared to some existing methods.

In a 2021 study by Ipek Atik, the categorization of materials as recyclable or non-recyclable was discussed, based on whether they are biodegradable or non-biodegradable. Biodegradable materials, such as food, plants, and fruits, can naturally break down with the help of microorganisms, while non-biodegradable materials, like plastics and metals, cannot decompose naturally.To classify materials as biodegradable or non-biodegradable, the study employed deep learning methods, specifically Convolutional Neural Network (CNN), using a dataset of 5430 images.The performances of four different algorithms (AlexNet, ShuffleNet, SqueezeNet, and GoogleNet) were evaluated, and the results can aid in the identification, sorting, and processing of waste materials.

ABHANG And RATHOD (2017):

proposed a mechanism to raise awareness among users about photo sharing and involve them in the decision-making process. Their approach involved the use of a facial recognition system (FR) that would be used by all individuals in the photo. This would allow for greater control over who sees the photo and enable users to make more informed decisions about photo sharing.

E. RORIJE, F. GERMA, B. PHILIPP, B. SCHINK, and D.B. BEIMBORN (2013):

This paper presents a project that aims to develop a structure-activity relationship for biodegradation. The objective is to create a set of structural rules that govern the potential microbial degradability of classes of chemicals. These rules will serve as tools to consider the biodegradation aspects of a product, including all precursors in the production process, early in the product development phase.

The project focuses on imidazole derivatives, and specific rules have been derived for this class of chemicals. A model degradation mechanism has been proposed, based on the urocanate-hydratase mechanism from histidine metabolism. The ultimate goal of this project is to contribute to the development of sustainable and environmentally friendly products by enabling early consideration of biodegradation aspects in the product development process.

JOÃO RICARDO AFONSO PIRES, VICTOR GOMES LAURIANO SOUZA, PABLO FUCIÑOS, LORENZO PASTRANA, AND ANA LUÍSA FERNANDO (2022):

Our society is in a transition phase where sustainable alternative materials are replacing traditional petroleum-based polymers. To consider these bioproducts as more viable options, it is essential to ensure that they are fully biodegradable or compostable, and no hazardous compounds are released during degradation. Legislation needs to adapt to establish consistent data to design a coherent labeling system. This review aims to identify standards for characterizing biodegradation profiles of biopolymers in different environments and laboratory methodologies adopted for the same purpose. Gaps in existing standards were identified to establish new validation criteria to boost the sustainable progress of this rising industry.

J SRIDHAR And D VIVEK (2021):

addressed the challenge of detecting cancer in hematological diseases. Manual identification of cancer cells from microscopic images is difficult and depends on factors such as the lack of images and precise measurement. Automated identification of cancer cells from microscopic images can improve diagnosis and treatment. The authors focused on detecting white blood cell cancer using image processing techniques, including enhancement, segmentation, and classification. They proposed a method that uses Gaussian Feature Convolutional Visual Recognition (GFCVR) to classify different types of white blood cells. The proposed approach achieved better results than existing methods in terms of time complexity, accuracy, recall, perception, and false classification ratio.

3.Methodology

A Convolutional Neural Network (CNN) is an Artificial Neural Network that includes one or more convolutional layers. These networks are widely used for processing images, performing tasks such as classification, segmentation, and more. Prior to training a CNN model, the dataset is preprocessed by reshaping and resizing images and converting them to arrays. Similarly, any test image is also preprocessed in a similar way.

The dataset used in CNN models typically consists of four different types of images, Biodegradable and Non-Biodegradable, from which any image can be chosen as a test image. Each convolutional layer in a CNN model has a set of convolutional kernels or filters, which are matrix arrays of integers applied to a subset of input pixel values of the same size as the kernel.

The convolution process involves multiplying each input pixel value by its corresponding kernel value, and then adding up the resulting products to generate a single value that represents a pixel in the output channel or feature map. By repeating this process across multiple layers, the CNN model can identify patterns and features in the input images, which can be used for tasks such as image recognition and classification.

The training dataset is used to teach the CNN model to recognize and classify the test image as either Biodegradable or Non-Biodegradable. The CNN model comprises several layers, including Dense, Dropout, Activation, Flatten, Convolution2D, and MaxPooling2D. After successful training and preprocessing, the model can accurately classify the images in the dataset. To classify a test image, it is compared to the trained model, and the model predicts whether the image is Biodegradable or Non-Biodegradable.

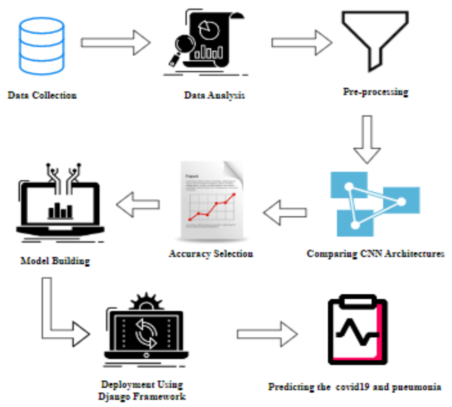

Fig.3.1.Detailed System Architecture

4.Proposed System

Our proposed approach involves developing a deep learning algorithm to classify images into one of three categories: Biodegradable, Non-Biodegradable, or normal, using the Convolutional Neural Network (CNN) algorithm. To achieve this, we conducted a thorough analysis of the dataset and employed various CNN architectures using the Tensorflow and Keras packages in Python. We hypothesized that integrating additional feature extraction methods would enhance the accuracy of the CNN model's classification results. We assessed the performance of multiple architectures and selected the best-performing model based on accuracy metrics. Once we identified the most accurate model, we saved it for future use. Finally, we employed the Django Framework to deploy the model for user interface purposes.

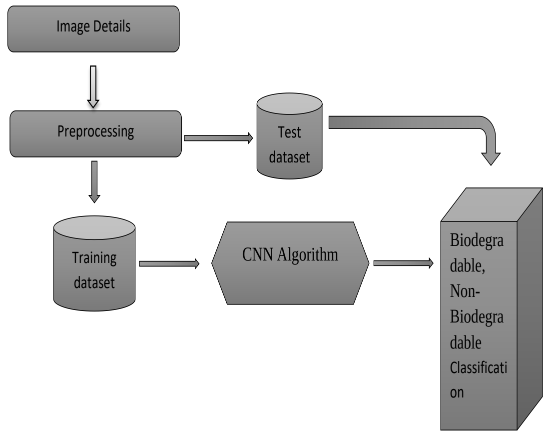

Fig.4.1. Proposed system architecture

5. Results and future scope

The primary objective of this project is to devise a deep learning model utilizing the Convolutional Neural Network (CNN) algorithm to classify Biodegradable and Non-Biodegradable waste. The ultimate aim is to attain optimal accuracy levels by carefully analyzing and comparing various CNN architectures.

Fig5.1.Interface of the webpage

The system we have developed can be effectively utilized on a large scale for the treatment of waste in biodegradable and non-biodegradable bins as well as large garbage bins. The automated model training through Lobe application can also be extended to classify other types of waste such as medical waste, industrial waste, etc. The use of Convolutional Neural Networks (CNN) and Deep Learning techniques enables efficient and accurate segregation and treatment of waste, which ultimately leads us towards a safer, cleaner, and greener environment.

Fig.5.2.Final result after uploading image

6. Conclusion

The purpose of this project was to investigate and compare different Deep Learning methods for classifying biodegradable and nonbiodegradable materials. The researchers aimed to determine the most effective approach for accurate classification. The study concluded that the use of Convolutional Neural Network (CNN) based architectures for classification provided highly accurate results. The researchers suggested that deep learning techniques offer great potential for achieving accurate image classification, especially for complex datasets such as those related to biodegradable and nonbiodegradable materials. These findings are significant given the growing concerns regarding the environment and the need to identify sustainable materials to reduce waste generation. By utilizing deep learning techniques, researchers can speed up the development of biodegradable materials and improve their classification accuracy, leading to a more sustainable future.

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