International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 04 | April - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

IOT based Waste Segregation Using Deep Learning

[1]Atharv Dahale, [2]Sayali Kadus, [3]Vaishnavi Shinde, [4]Gayatri Ajabe, [5]Prof. Nita Gade

[1,2,3,4]Students, Shri Chhatrapati Shivaji Maharaj College of Engineering,

[5]Ass.Prof, Shri Chhatrapati Shivaji Maharaj College of Engineering,

[1]Department Of Computer Engineering,

[1]Shri Chhatrapati Shivaji Maharaj College of Engineering, Ahmednagar, India

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Abstract :

In the rapidly urbanizing world, effective waste management is crucial to maintain environmental sustainability. This project presents an innovative solution utilizing Internet of Things (IoT) technology and deep learning Convolutional Neural Networks (CNN) algorithm for automated waste segregation. We propose a smart waste segregation system equipped with sensors to detect the level of waste in bins. The system utilizes a CNN model trained using Deep Learning to classify waste items into different categories, ensuring proper segregation.

When a bin reaches its full capacity, the IoT sensors trigger an alert mechanism, sending real-time notifications to the concerned authorities or waste management personnel. This proactive approach not only optimizes waste collection but also promotes recycling by ensuring the segregated waste reaches the appropriate recycling facilities. The integration of IoT devices and deep learning algorithms enhances the efficiency of waste management processes, reducing environmental pollution and promoting a sustainable future.

Key Words: **IoT, waste management, deep learning, CNN algorithm, waste segregation, environmental sustainability, real-time monitoring, sensor technology, recycling, smart cities, automation.**

I.INTRODUCTION

IoT based waste segregation using Deep learning Project aims to revolutionize waste management through an innovative IoT-based solution coupled with deep learning technology. We have developed a smart waste segregation system that utilizes sensors to classify waste items into different categories. Deep learning algorithms, specifically convolutional neural networks (CNNs), are employed to enhance the accuracy of waste recognition. When bins reach their capacity, real-time data is transmitted via the Internet of Things (IoT) to alert waste collectors. This automated system not only optimizes waste segregation but also ensures timely and efficient waste collection, reducing environmental pollution and promoting recycling. The integration of cutting-edge technologies like IoT and deep learning facilitates a sustainable and eco-friendly approach to waste management, contributing significantly to a cleaner and greener environment.

IMPACT OF IMPROPER WASTE SEGREGATION

Improper waste segregation has several negative impacts on the environment, public health, and the economy. Some of the key consequences include:

1. **Environmental Pollution:**

   Mixing different types of waste can contaminate the environment. For instance, when organic and inorganic waste are combined, it can lead to the generation of harmful gases and leachate in landfills, polluting soil and groundwater.

2. **Increased Landfill Usage**

   Inefficient waste segregation results in more waste going to landfills, which can quickly fill up and require additional land for disposal. Expanding landfill sites can lead to habitat destruction and increased greenhouse gas emissions.

3. **Health Risks:**

Mixed waste can attract pests, such as rodents and insects, which can carry diseases and pose health risks to the community

4. **Air and Water Pollution:**

Improperly disposed of hazardous materials, such as batteries and chemicals, can contaminate the air and water, posing risks to human and environmental health.

5. **Increased Energy Consumption:**

Incineration and waste-to-energy processes are less efficient when waste is not properly segregated, leading to higher energy consumption and increased greenhouse gas emissions.

6. **Economic Costs:**

Inefficient waste management systems result in higher disposal and recycling costs. Local governments and municipalities may need to allocate more funds for waste management, which can strain public budgets.

7. **Loss of Recycling Opportunities:**

Without proper waste separation, recyclable materials are often contaminated and cannot be reused, reducing the overall efficiency of recycling programs.

OBJECTIVES:

1 .Implement an automated waste segregation system using deep learning and IoT technology.

2. Develop a robust deep learning algorithm to classify waste items into distinct categories.

3. Integrate real-time monitoring and IoT connectivity to keep users informed of bin fill levels.

4. Promote efficient waste disposal and management by sending timely alerts when bins are full.

5. Reduce the environmental impact of waste management by enhancing waste segregation and recycling.

6. Contribute to the development of sustainable, cleaner, and more environmentally friendly urban areas through improved waste management practices.

7. Reduce waste management costs for municipalities and local governments, ensuring a more cost-effective approach to waste collection and recycling.

II..RESEARCH METHODOLOGY

Waste classification has become one of the most popular research topics because of the increasing amount of unprocessed waste around the world. For classifying waste, many research works have been done using various types of datasets and machine learning techniques.

So, in this work, a method is proposed to automatically classify waste into four categories. For this, a dataset named OrgalidWaste is prepared by collecting images from four other waste datasets. The prepared dataset contains around 5600 images with four classes including one organic waste class and three solid waste classes (glass, metal, and plastic). On this dataset, several CNN architectures including 3-layer CNN, VGG16, VGG19, Inception-V3, and ResNet50 have been implemented for training. Among them, VGG16 outperforms other models with 88.42% accuracy. It is believed that this work will be greatly beneficial in the waste management sector.[1].

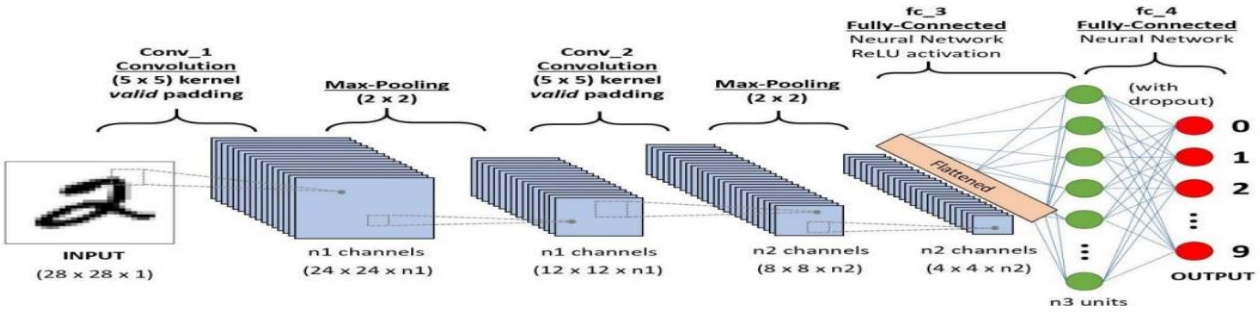
The proposed garbage classification algorithm is based on ResNet-34 algorithm, and its network structure is further optimized by three aspects, including the multi feature fusion of input images, the feature reuse of the residual unit, and the design of a new activation function. Finally, the superiority of the proposed classification algorithm is verified with the constructed garbage data. The classification accuracy of the proposed algorithm is enhanced by 1.01%. The experimental results show that the classification accuracy is as high as 99%, the classification cycle of the system is as quick as 0.95 s.[2].

The aim of this research is to develop a smart waste management system using LoRa communication protocol and TensorFlow based deep learning model. LoRa sends the sensor data and Tensorflow performs real time object detection and classification. The bin consists of several compartments to segregate the waste including metal, plastic, paper, and general waste compartment which are controlled by the servo motors.[3].

This paper proposes a machine to segregate the waste into the different parts with the help of smart object detection algorithm using ConvoWaste in the field of Deep Convolutional Neural Network (DCNN), and image processing technique. In this paper, the deep learning and image processing techniques are applied to classify the waste precisely and the detected waste is placed inside the corresponding bins with the help of a servo motor-based system.[4].

ALGORITHM:

CNN - CNN stands for Convolutional Neural Network, a type of deep learning algorithm designedspecifically for processing grid-like data, such as images and videos. CNNs are powerful tools for image recognition, image generation.



Step 1: Input Layer

The process begins with the input layer, where the network receives the raw data. In thecontext of image analysis, this could be a pixel values of an image.

Step 2: Convolutional Layer

In this step, the input data undergoes a series of convolutions with learnable filters (alsoknown as kernels). Each filter scans a small portion of the input data at a time.

Step 3: Pooling Layer

Pooling (subsampling or down-sampling) reduces the dimensionality of each feature map but retains essential information. A common technique is max-pooling, where the maximum value in a small rectangular neighborhood is selected, and the rest are discarded. Pooling helps in making the detection of features invariant to scale and orientation changes.

Step 4: Flattening

After several convolutional and pooling layers, the high-level reasoning in the neural network is done through fully connected layers. To connect these layers, the dimensions of the data are flattened into a vector. This flattening step prepares the data for input into the neural network's hidden layers.

Step 5: Fully Connected (Dense) Layers

In these layers, the neural network learns to associate specific features from the previous layers to the output classes. Each neuron in a fully connected layer is connected to every neuron in the previous layer. This stage is where the network learns to classify the features extracted by the previous layers into the appropriate class labels.

Step 6: Output Layer

The final fully connected layer produces the output of the network. In the case of classification tasks, it usually employs a softmax activation function, which converts the raw scores from the previous layer into class probabilities. The class with the highest probability is the predicted output of the network.

Step 7: Loss Calculation and Backpropagation

During training, the network's output is compared to the actual labels, and a loss (error) is calculated. The goal of training is to minimize this loss. This is typically done using a loss function like categorical cross-entropy for classification problems. After the loss is calculated, backpropagation is used to adjust the network's weights and biases, minimizing the error.

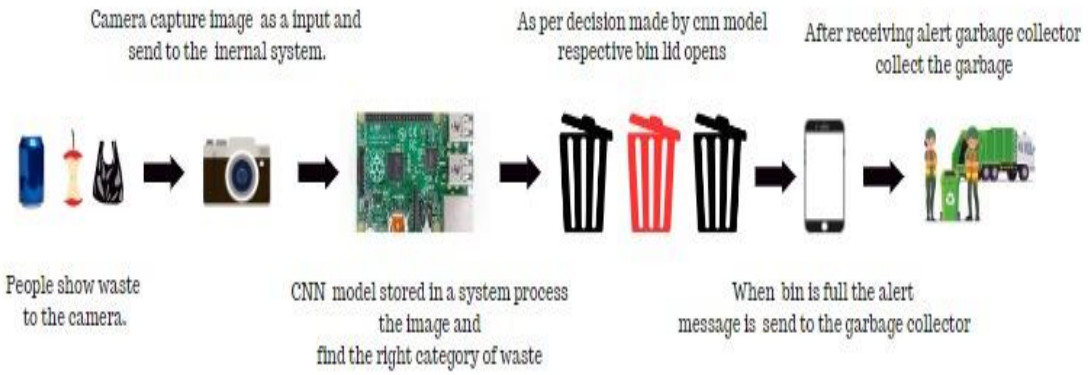
Step 8: Training

The entire process (steps 2-7) is repeated multiple times (epochs) on the training dataset. Each pass helps the network to learn weights and improve its ability to make accurate predictions.

Step 9: Testing and Prediction

Once the network is trained, it can be tested on new, unseen data to evaluate its performance. The network's ability to accurately classify or predict unseen data is a measure of its generalization ability.

III. ARCHITECTURE



1.Data Collection and Preprocessing:

Data from the camera is collected and pre-processed. This step involves cleaning and formatting the data for input into the deep learning model. To train the deep learning model, a dataset of labelled waste images is required. This dataset should include a variety of waste items, representing the different categories of waste that need to be sorted.

2. Deep Learning Model:

The core of system is a deep learning model. For this model we are going use Convolutional Neural Network (CNN) which is widely used for image recognition and classification. The model is trained to identify and classify different types of waste such as plastic, paper, glass, metal, and organic waste.

3.. Decision Making Module:

The deep learning model makes predictions on the type of waste detected by the sensors. Based on these predictions, it instructs the waste segregation system on how to sort the waste. This module decides which bin or container each piece of waste should go into.

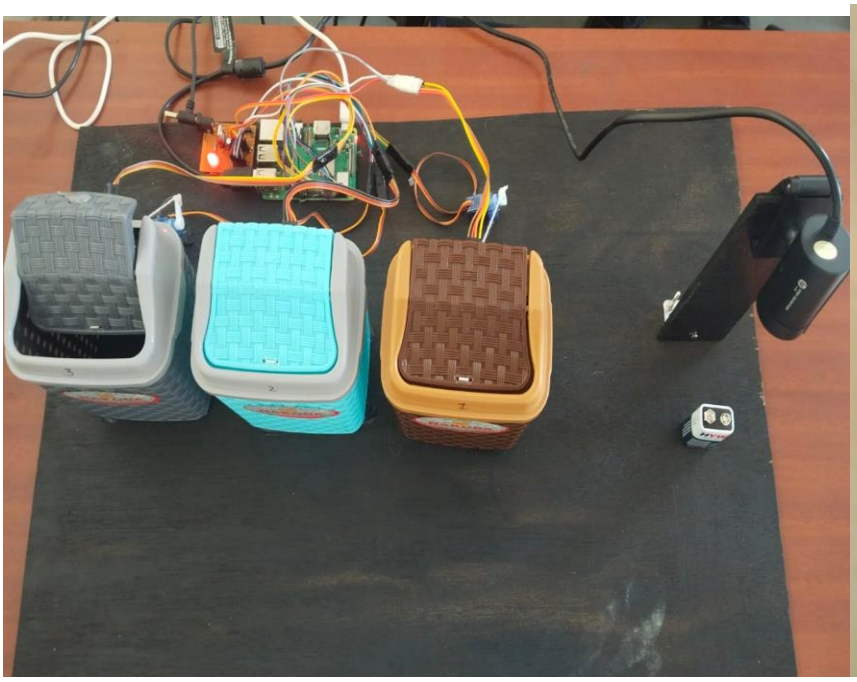
4. Sensors moule:

IoT sensors are used to detect and collect data about waste materials. These sensors can include cameras, ultrasonic sensors, weight sensors, and RFID tags. They collect information about the waste's type, weight, and other relevant attributes.

5. Alert Module:

This module will send an alert to garbage collectors when waste bins are about to fill. For this ultrasonic sensor will be used to calculate level of waste from bottom of dustbin.

IV.RESULT AND DISCUSSION :



V.CONCLUSION

The increasing amount of unprocessed waste around the world imposes more danger to the environment and nature. For the waste recycling process to be more effective, categorizing waste is very important. By using the CNN Algorithm and Raspberry pi we can implemented the IoT based Waste segregation using Deep Learning. The IoT-based waste segregation system using deep learning represents a promising solution for addressing the growing challenges associated with waste management. This innovative approach combines the power of the Internet of Things (IoT) with deep learning techniques to enhance the efficiency and effectiveness of waste segregation. In this conclusion, we will highlight key findings and benefits of this system.

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