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Segregation of Plastic Wastes from Landfills from Infrared Imaging Using Deep Learning Approaches

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Abstract

Management of wastes is a great threat to environment protection. The waste composition may contain contaminated, assorted mixture of plastics making its segregation very challenging. Both manpower and time are needed more for sorting out the waste. They can be sorted out in enormous types of techniques. Here comes, Image processing which can be a very efficient way to process waste materials efficiently from the garbage. One of the prominent recent times deep learning algorithm could be convolution neural networks (CNN) that can effectively scrutinize the plastics from landfills and dumps. This paper provides an automated system using Infrared imaging and neural networks for detection and segregation of plastic waste. Previous researches have been more about single object recognition and classification. Thus the work proposed identifies plastics present in the mixture of wastes by analyzing the infrared images using Alex net. Hence the result can pave a way to address the shortcomings of current plastic sorting technologies in terms of reliability and efficiency..

Keywords; *Composition, Infrared Imaging, deep learning, Plastic Segregation*

I. INTRODUCTION

An alarming concern over time for the world which is adversely affecting the human lives and environmental conditions is the immense generation of waste. Plastic consumption in India increases at a faster pace year-on-year.

According to a survey in 2017, An Indian consumes 11kg plastic every year, which is threatening[4]. Not only in India, but also across the country, Over 1.43 lakh tons per day of solid waste are generated. Meanwhile, the rate of plastic usage has been increasing steadily. According to report of the Central Pollution Control Board (CPCB), which inferred statistics from 60 major cities, India generates around 25,940 tons of plastic waste per day.

In 2011, the Indian government notified the rules for managing plastic wastes[12][13][14] .The solution to India's complications with plastic waste can be addressed through besieged funds in reprocessing and ensuring sustained effort to cut down consumption. Predominantly a huge area of land is required for dumping all these wastes in landfills, the plastic consists of chemical constituents and energy that may be lost during this route of disposal. In countries where landfills are not properly disposed, plastic wastes can easily mix into sea water which leads to adverse effects. In addition, when plastics decompose in landfills, they may leak pollutants (phthalates and bisphenol A) into the soil that makes soil unfertile.

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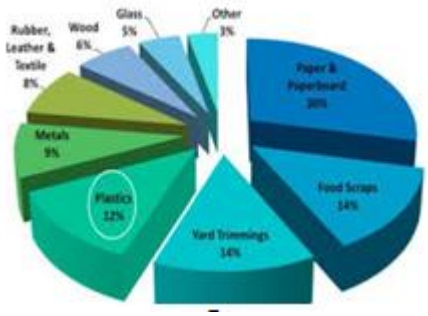

Figure1: percentage of plastic wastes disposed in a year

Figure 1 shows the percentage of plastic wastes disposed in a year. The sorting of plastics from various types of waste streams is a very essential step in waste management technique. Manual sorting of a mixture of wastes is applicable when plastic substances are present in large amount but it is a labor intensive process. Identification and classification of this waste is a major challenge in current waste management technologies. Thermography (IR thermal imaging), is a process of a contactless temperature measurement using a temperature-calibrated IR camera. Thermal energy perceived by IR cameras is not noticeable to the human eye, so the different temperatures in an IR image may be "plotted" to different colors for display using IR visualization software .The radiation range of various types of plastics are identified and captured using infrared imaging.

Convolutional neural network is a type of feed-forward artificial neural network where the distinct neurons are floored in such a way that they react to overlying regions in the perceptional field[9][10]. Convolutional networks were inspired by biological processes and are variations of multilayer perceptron's designed to use minimal amounts of preprocessing, computing matrices and data structures before application In cases where we cannot distinguish the inputs using a visible-range image, we need to find a type of input that makes the classification problem feasible In this paper, we are introducing the application of Infrared imaging and neural networks for detection and segregation of plastic waste for efficient disposal.

II. RELATED WORKS

In the last two decades the usage of plastics has grown exponentially. Moreover, non-biodegradable plastic types have invaded the market extensively. Hence to limit their damage on environment many algorithms and techniques have been proposed in the recent years[4]. Ali Mohammad Tehrani [2], analyzed a technique to combine hyper spectral imaging and neural networks for identification and separation of plastic wastes (e-wastes).The results have been achieved using Artificial Neural Networks(ANN) algorithm and hyper spectral imaging of plastic signatures. In W.H.A.M. van den Broek [15], analysed the accuracy of plastic identification using a remote sensing spectroscopic near infrared (NIR) system. It has been installed in a trial workshop setup for plastic identification. The identification of waste items is performed in two steps. First, spectroscopic image data is acquired .Second, a non-linear conversion is achieved by a neural network for supervised classification of images. But, this identification system needs to be evaluated for its performance.

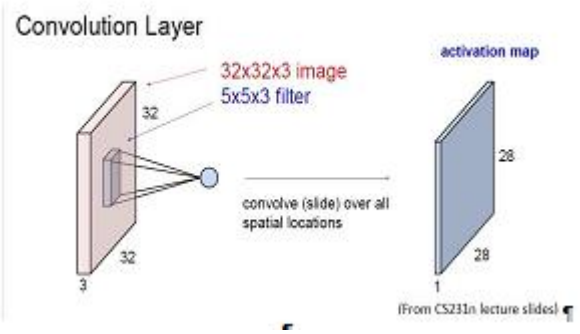

Figure 2: Convolution Layer

AdhithyaPrasanna, M [1], describes a method that sorts the possessions of reflecting surfaces. The surfaces used are metal, plastic and paper. Their algorithm efficiency shows the outcomes for arbitrary geometry surfaces. This absorbs the correlations between surface reflectance and the data computed from an observed image is done by the

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reflectance algorithm. Mohammed Rafeeq [7], proposes an Automation of Waste material Segregation in scrap industry. This method provides an easy and simple solution of segregation of three types of wastes. The proposed system is intended to categorize the garbage into metallic, plastic and glass waste which is ready for the next process. This method also uses inductive sensors metallic articles, and capacitive sensors to differentiate between them and dry waste. Figure 2 shows the convolution layer in a CNN algorithm.

RafatSiddique [8], presents a detailed review about waste and reprocessed plastics, waste managing choices, and study issued on the outcome of reprocessed plastic. The upshot of recycled and waste plastic on various aspects has been conversed thoroughly in this paper. HamedMasoumi [3] gave an idea for an automated system for recognition and isolation of plastic resins constructed on near infrared reflectance spectroscopy. For identification and segregation among the type of resins, the method used is Two-Filter Identification. The shortcomings of the above listed papers have been identified and analysed in the upcoming proposed methodology. This has been taken into consideration in the proposed model. The proposed approach rectifies the limitations in cost effective manner.

PROPOSED METHODOLOGY

In the proposed system, we use image processing technique and deep learning approach to detect and identify plastics in dumps. The workflow diagram and block diagram for the proposed system is given as below:

WORKFLOW DIAGRAM

The workflow diagram represents the flow of activities:

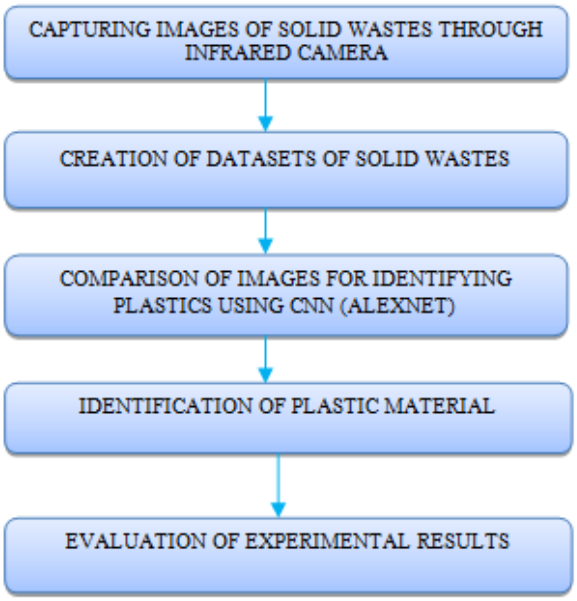

Figure 3: Workflow diagram of proposed system

In Fig (3), initially images of solid wastes are captured through Infrared camera. Then the captured IR images are processed for comparison. A deep learning algorithm Alex net (CNN) is used for identification of plastic material. Alex net compares the input image with its available training dataset, classifies and predicts the presence of plastic in the dump.

BLOCK DIAGRAM

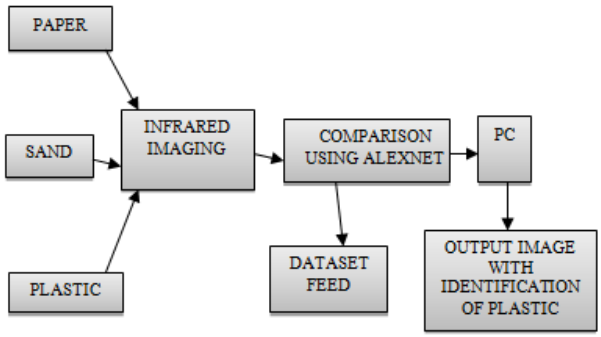

Figure 4: Functional diagram of proposed system

Figure 4., showcases the block diagram of the proposed system.IR image of a mixture of wastes are fed using the deep learning network in Alex net which classifies and identifies whether plastic materials are present in the given input image.

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MODULE DESCRIPTION

In the proposed system, we use image processing technique and deep learning approach to detect and identify plastics in dumps.

IMAGE ACQUISITION

Image processing is the process of retrieving an image for a hardware-based source processing. In this module, an Infrared camera captures images of solid waste mixture. Here the image is acquired using an Infrared Camera, and then given for processing.

The image that is acquired is completely unprocessed. The garbage mixture may consists of paper, covers, cardboard, biodegradable waste etc. The infrared imaging is used here in order to capture the night images also and make the process of segregating the dumps even more effectively. It aims at creating real time computer vision.

The IR image captured is enhanced and the pixel intensity of objects are analysed. Since different shades of the same material show different signatures due to the change in the intensity of reflection, the spectral data needs to be normalized so that objects can be distinguished solely based on their spectral details, and not based on the intensity level. The image acquired by an infrared camera, looks like as shown in figure [5].

COMPARISON OF IMAGES USING ALEXNET

Classification is a crucial stage in image processing. There are many methods applicable for comparing datasets of images and one of these methods based on pixels sorting is Convolution Neural Network. CNN is a deep learning algorithm which is used to dissect the datasets. The CNN algorithm consents us to mine unique qualities from the image and then classify it into determined classes.

The CNN algorithm is not the same in a number of ways when associated to the standard artificial neural network algorithm. But, the basics like training, testing, back propagation, error reduction are the same. The algorithm is divided largely into

Three layers –Convolutional Layer, Max pooling Layer and the fully connected layer.

The three layers of the algorithm are described in detail:

Convolution Layer:

Convolution layer works as follows-it receives some input volume, in this case an image which is a mixture of plastic and other materials. There are filters which are actually matrices prepared with arbitrary numbers at first. For RGB the Filters will have depth 3, for Grey scale, the Filters will have depth 1.The Filter is convolved over the input dataset. This produces activation maps for the input dataset.

The dot product is calculated in the following manner –

$$WTx + b \qquad (1)$$

Where W = Filter x = the input image b = bias

Max Pooling:

The activation function is

$$F(x) = \max(0, x) \qquad (2)$$

Max pooling is fundamentally sampling of activation maps. Alternative method of max pooling is average pooling, in which the average of the sub matrix is conserved for the subsequent layer.

Fully Connected Layer:

The Fully Connected layer takes the dimensions as input at the end. It has neurons for calculating class scores and they are fully connected to the complete input dataset, similar to a normal Neural Network. The CNN algorithm generally works in a two phases, the forward pass and back propagation. Throughout the forward pass, the input dataset is delivered to each of the layers and the output is

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calculated. The projected output is matched with the actual output. The back propagation phase is used in aggregation with optimization techniques such as gradient decline to mitigate the miscalculation as much as possible.

Alexnet is a Convolution Neural Network (CNN) which is pre-trained that consists of billions of images from ImageNet database. This network is about 8 layers deep and it can classify images to around 1000 objects from wood to plastics.The Alex net network has rich feature representations of a wide category of images. This network takes the input image and labels the output image based on the object categories. In the 8 layers, first 5 are convolution layers and last 3 are fully connected layers. In between there are pooling and activation layers. The organization of Convolutional and pooling layers shrinks the amount of input image dataset features to about 1024 before transferring them to the fully connected layers.

The main module of the whole proposed system is about comparison of images .This process is done by the comparison of values from the image i.e. actually obtained using the IR camera at real time and the pixel values obtained from the image at that is already trained using Alexnet. When there is any comparison, and if the pixel value matches then it is portrayed that plastic is present in the mixture. If there is no match in the pixel values present in the training dataset and the values of the segmented images then it indicates that there is no presence of plastic in the dump like mixture. This comparative analysis gives out the result whether there is a presence of plastic or not and if present it would be identified.

III. INTIMATION AND DETECTION

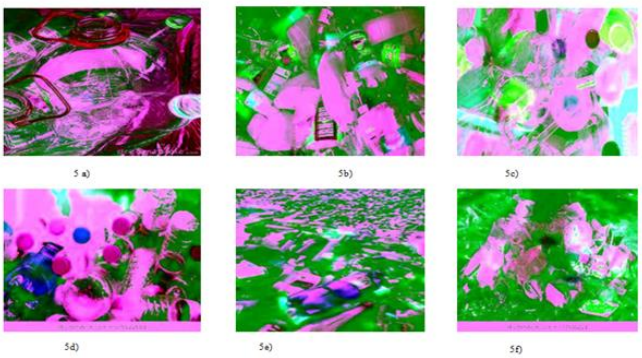
The final module of the proposed system is the detection of plastic and it's Intimation. After the comparison of both the dataset are finally arrive at the place, where the plastics are present in the mixture. It can be detected and intimated in the system (PC) on a clear note. The detection of plastics from a mixture of dumped wastes is very tedious. Our proposed system has acquired a better accuracy in detecting plastics from landfills. The intimation of the presence of plastics would be highlighted in the PC are displayed outright. The final comparison between the acquired image and the image set we have already collected and trained for the system intimates and detects the presence of plastics. Thus the PC shows the output image with the identification of plastic present in it.

The experimental results and performance evaluation of the proposed system are discussed which in detail explains the input images that are being acquired from the infrared camera, the Alex net training images and the final results with plastic identification

IV. EXPERIMENTAL RESULTS

The experimental results of the proposed system are given as follows. Fig 5 represents the different Infrared images of solid wastes captured by IR camera. The IR image captured is enhanced and the pixel intensity of objects are analysed. The IR input image should be in the size 227*227.The captured Infrared Images are processed and enhanced. Leninishaet. al.,[5][6] developed enhanced water flow approach for road network extraction with junctions, sample approach utilized for analyzing the pulp nectrotic tooth growth. In future, same methodology will be utilized for analyzing plastic categorization in the infra red imaging.

Image Acquisition



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Training Image Dataset

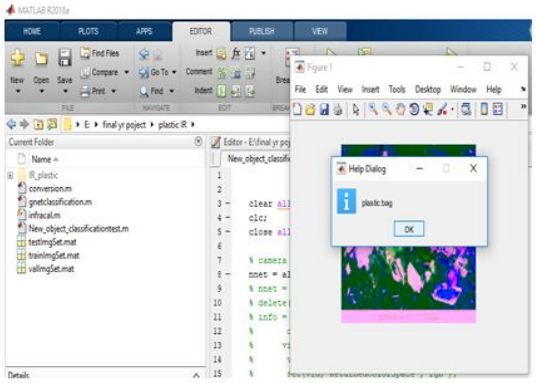
Comparison is an essential stage in image processing. There are many methods used for training datasets of infrared images and one of the famous and popular methods is Convolution Neural Network (CNN). Alex net has millions of pre-trained images that can be used to compare the given input image. These pre-trained image datasets are convenient to compare and identify the plastic material in the given input image.

Segregation of landfills by human operator is a tedious process, even though produces good result. Thus, this research proposed that automating the plastic segregation with hazardous conditions using thermal (infrared) imaging camera and the experiment results shows that it is able to identify plastic items in untidy conditions. The thermal imaging camera provides the temperature values of the objects include plastic wastes. With the reference of training dataset, we can detect the plastics by comparing the thermal values of acquired images.

Figure 6.Training image dataset

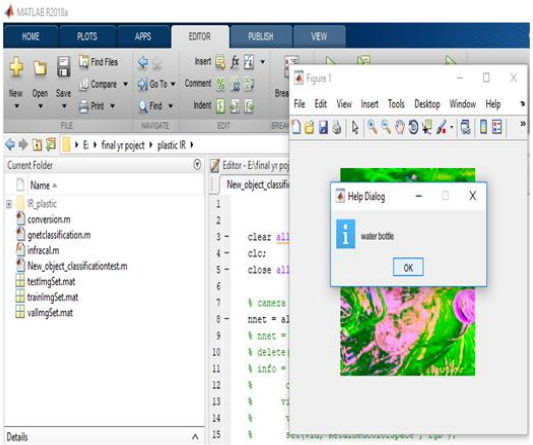
Output WithIdentification of Plastics

The final module of the proposed system is the identification of plastic. By comparing both the dataset, the results are predicted whether plastics are present in the mixture. It can be detected and intimated in the system (PC) on a clear note. The below figure shows the output of the input IR images given to the system. The output indicates the type of plastic material that is present in the input image.



7a)

Figure 7a) indicates the presence of plastic bag in the given input image.



7b)

Figure 7b) indicates the presence of plastic water bottle in the given input image.

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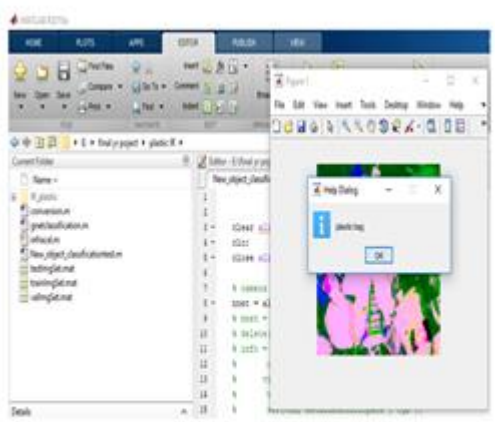
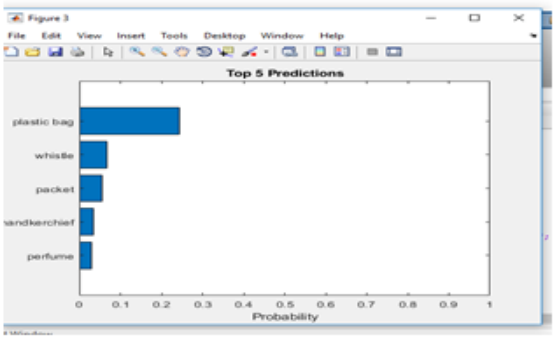


Figure 7c) indicates the presence of plastic bag in the given input image

V. PERFORMANCE EVALUATION

The figure (8a) indicates the top 5 probability of objects present in the input composition. The percentage of plastic material present is indicated in the figure (8b).The success rate obtained is around 75-80%.



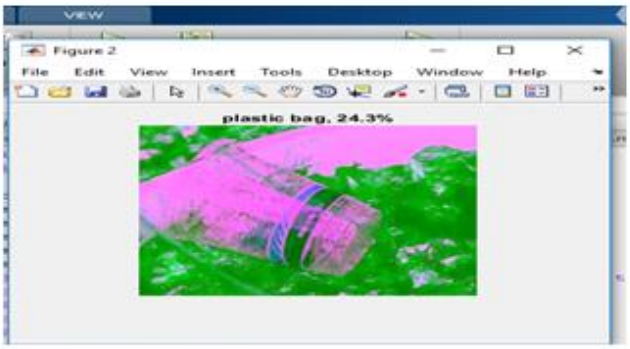


Figure 8. Probability of occuring the plastic in percentage

Since, the unique strength of infra red images is it can be utilized in night vision also, thus the proposed system increases the accuracy of identifying plastic materials even in night vision.

VI. CONCLUSION AND FUTURE WORK

There is an increase in awareness of waste management and environment-related issues that has led to future progress in the utilization of waste/by-products like plastics. The present work uses Infrared imaging and neural networks for detection and segregation of plastic waste efficiently. Infrared cameras can be used to capture images even at night with high accuracy. Convolution Neural Networks is considered to play a very important role in the process of object recognition and classification. This deep learning algorithm is deployed to identify the location of plastics in the dump based on the IR images comparison. Previous researches have been more about single object recognition and classification .Thus the work proposed segregate plastics present in the garbage landfills and dumps. Thus the proposed system enhances the way to give an effective solution to the current plastic waste management problems

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