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Waste Segregation using Convolutional Neural Network

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Abstract: ***Looking at the population increase in India, waste generation and segregation is a major issue in the current scenario. Tonnes of mixed waste is dumped without segregating it properly which leads to problem in decomposition. Due to this mixed waste several other problems arise over a period of time. To avoid this, waste segregation at least at the basic level is very much needed. We have implemented a system based on Convolutional Neural Networks. The basic idea is that when the waste is to be dumped in the garbage bin, the system will identify the type of waste and will open the dustbin of that category accordingly. Using this system, it becomes easier the segregate waste at the basic level. We have four categories in which waste will be segregated namely, glass, paper, plastic, metal. Four distinct dustbins along with servo motors will be used for the same.***
Keywords: ***Waste Segregation, Convolutional Neural Network, Machine Learning, Classification, Detection.***

I. INTRODUCTION

Segregation of waste is an important issue currently faced by the ever-growing population. For a sustainable society, segregation of waste is a must. Initially, segregation required use of hands for separating waste. This became tedious once the
amount of waste increased as population increased. We had to look for something which could automatically sort the waste. This will be more efficient since the employees or garbage pickers do not sort the waste 100 percent. The fine waste cannot be segregated manually.

Thus, it will not only enhance the surrounding environment but also reduce the pain of segregation manually.

Presently in India, about 960 million tonnes of solid waste is being generated annually. 350 million tonnes are organic wastes, 290 million tonnes are inorganic waste of industrial and mining sectors, 4.5 million tonnes are hazardous in nature.[1] Using the advancements in technology, the desired results can be obtained. Biodegradable (wet waste) and non-biodegradable (solid waste) is currently being separated using manual methods (putting solid and wet waste into separate bins). These methods can be effectively used for manures, fertilizers, etc. But this isn't the same for dry waste. Dry waste may contain useful waste materials like metal, glass, paper, etc. which can be efficiently recycled and reused. A traditional method of dry waste segregation includes incineration i.e. burning of the waste. The tedious task to separate waste manually is inefficient. Hence, dry waste should be segregated in the initial stages only so as to prevent the hassle afterwards.

We are using Convolutional Neural Networks along with Machine Learning to implement this project. Previous studies regarding the project and system were based on similar lines.

The initial use of conveyor belts for segregation proved to be futile when it came to large scale waste segregation. Using CNN along with the dataset which are regularly updated, the system can be used at a minimum level which will help separate the waste materials.

The idea is to identify the object in front of the bin, run it through the dataset available to the system and then open the dustbin for the required garbage object. The whole process takes place in a matter of seconds.

II. LITERATURE SURVEY

A. Conveyor Belt Method

Segregation of waste using conveyer belts was also implemented. Bulk elements such as plastic, metal, rocks, stones, etc were removed easily depending upon the weight of the objects. Such method was useful for heavier objects but
separating fine particles, sand, organic waste was a difficult job. To get rid of unhealthy environment and health hazards the solid wastages must be taken care of by sorted into various components and then handled separately at the disposal for reused or recycling site. In order to recycle the solid wastages, they need to be segregated into various constituents. So, in this study, a mechanical machine for sorting of mixed domestic solid waste into its various component is designed. The machine is designed with the major components being the belt conveyor, roller conveyor, air blower and a magnetic separation. [2]

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B. Micro Controller Based

An Automatic waste segregtor was proposed by Aleena V.J and team wherein they segregated the waste into three categories namely metallic, organic and plastic thereby making waste management more effective. They used ultrasonic sensors which were placed in the dustbins which gave the indication when the dustbin was near full to the micro controller. The micro controller will give the indication to the concerned authority. [3]

C. Using Object Recognition and Detection

The use of Machine learning and neural networks into waste segregation was introduced by CS299 project group Gary Thung and Mindy Yang where they used a support vector system (SVM) with SIFT along with Convolutional Neural Networks (CNN) to classify images of a single object and to identify they accordingly into six different categories, metal, paper, plastic, trash, glass and cardboard. They achieved a 63 percent accuracy using SVM and 22 percent accuracy using CNN. However, their implementation involved classifying a single object image as
opposed to a jumbled waste.[4]

III.PROPOSED METHODOLOGY

A. Objective

The main objective of the proposed system is:

1) To segregate the waste consisting of household, electronic, and general waste into their respective categories.

2) To apply machine learning and convolutional neural networks to make the segregation easier, faster and more efficient.

A Convolutional Neural Network (CNN or ConvNet) is a class of deep, feed-forward network that has been applied to analyse visual imagery.

B. CNN Works on Three Layers

1) *Layer 1: Convolutional Layer*: Convolution is the first layer to extract features from an input image. Convolution preserves the relationship between pixels by learning image features using small squares of input data. It is a mathematical operation that takes two inputs such as image matrix and a filter or kernal [5]

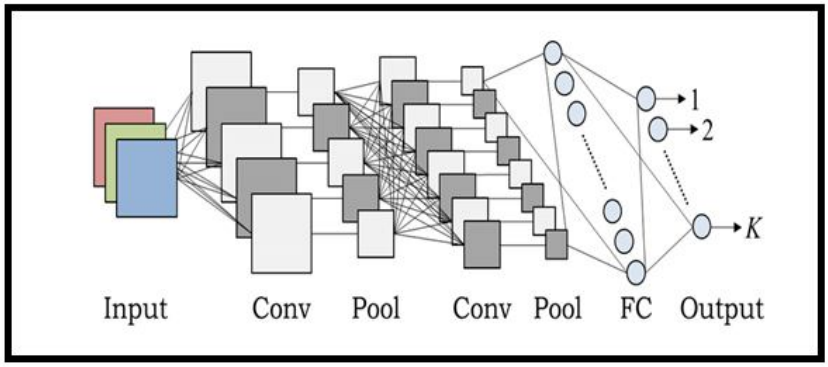


Figure 1: Example of CNN Architecture

2) *Layer 2: Pooling layer*: Pooling layers section would reduce the number of parameters when the images are too large. Spatial pooling also called subsampling or downsampling which reduces the dimensionality of each map but retains the important information. Spatial pooling can be of different types:

a) Max Pooling
b) Average Pooling
c) Sum Pooling

Max pooling take the largest element from the rectified feature map. Taking the largest element could also take the average pooling. Sum of all elements in the feature map call as sum pooling. It does the two main things:

i) It reduces the number of parameters within using down sampling
ii) It generalizes the result from a convolutional filter. [6]

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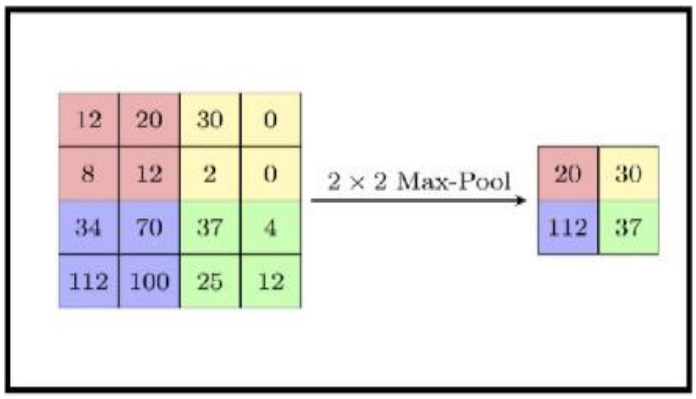


Figure 2 : Max Pooling

C. *Layer 3: Fully Connected Layer:* The layer we call as FC layer, we flattened our matrix into vector and feed it into a fully connected layer like neural network. In the above diagram, feature map matrix will be converted as vector (x1, x2, x3, …). With the fully connected layers, we combined these features together to create a model. Finally, we have an activation function such as softmax or sigmoid to classify the outputs as cat, dog, car, truck etc.

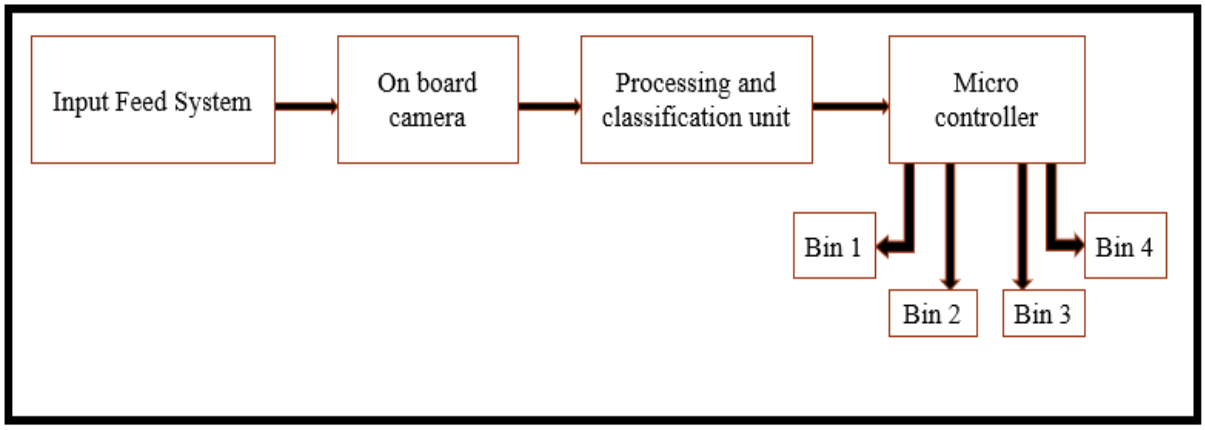


Figure 3 : Block Diagram

IV. IMPLEMENTATION OF PROPOSED SYSTEM

The first and foremost step is to train the images in the dataset for very accurate results. Large number of images are considered or given as a dataset.

A. *Hardware Components*

1) *Node MCU*: The below is of Node MCU. NodeMCU is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The term ”NodeMCU” by default refers to the firmware rather than the development kits. The firmware uses the Lua scripting language. Here it is used to interface servo motor which will be required to open the dustbin.
2) *Servo Motor*: A servo motor uses servo mechanism, which is a closed loop mechanism that uses position feedback to control the precise angular position of the shaft. Controlling servo is an easy task and needs no hardware as such.
3) *Camera*: A webcam is a video camera that feeds or streams its image in real time to or through a computer to computer network. When ”captured” by the computer, the video stream may be saved, viewed or sent on to other networks travelling through systems such as the internet, and e-mailed as an attachment. Here the web camera is used to take the input image from the user which will be processed and compared with the data set for a match.

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B. Recognition and Detection of Image

Flow of how the image is recognised and detected:

1) Put the waste in front of the camera.
2) The lens of the camera captures the image of the waste object and sends to the system.
3) Tensor flow system identifies the object.
4) CNN algorithm detects and classifies the object. Thus, CNN will result the waste into the four categories.
5) Detection of the waste is done by the CNN algorithm. Array of pixels is taken as input.
6) The filter values are multiplied with pixel images.
7) Summation of output values is done and entire process is repeated for the whole image.
8) Further the output is max pooled, which has the maximum value in particular window by reducing the parameters and generalizes the convolution layer.
9) It then determines the features which most correlates to a particular class (dataset). Thus, the waste will be classified.
10) The result of classification will be given to NodeMCU.
11) NodeMCU will be programmed so that it instructs the servo motor to open the desired bin and dump the classified waste into the respective bins. [7]

C. Software Algorithm

The following figure 5 shows how the data is send to the Firebase from the system. Go to firebase.google.com and sign up with your email-ID. Next go to Console. A dashboard appears click on : Database. Here, you will find your host url. Then from the NodeMCU the data is sent to firebase through an application.



Figure 5: System to Firebase

The following figure 7 show how the data is fetched from the Firebase to Node MCU. Firebase data is retrieved by either a one time call to Get Value Async() or attaching to an event on a Firebase Database reference. The event listener is called once for the initial state of the data and again anytime the data changes.

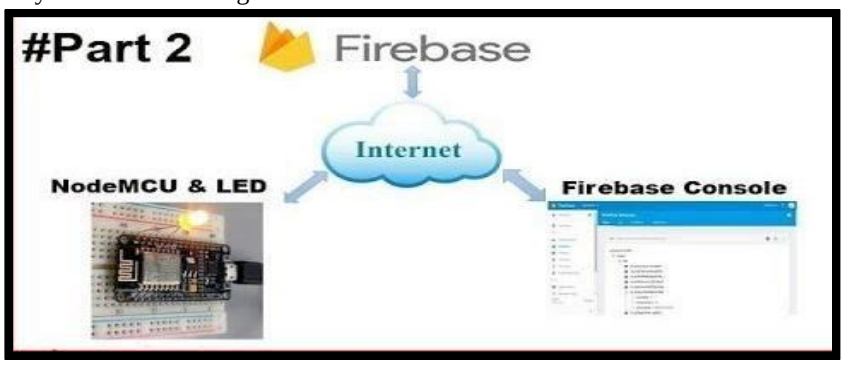


Figure 6: Firebase to NodeMCU

After the whole process of sending and fetching the data, trashcan will open according to the desired waste product. The servo goes to 50 degrees and hits the upper lid of the bin, so that the upper lid is opened, waits for three seconds, then automatically turns to 160 degrees and thus the upper lid gets closed. Hence we would see an auto open/close trash-bot.

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V. RESULT

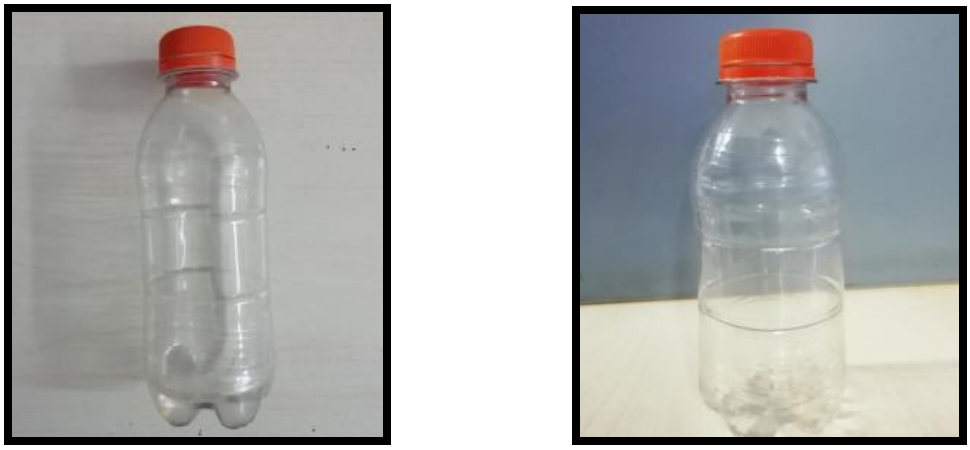


Figure 7: Input image of plastic waste bottle

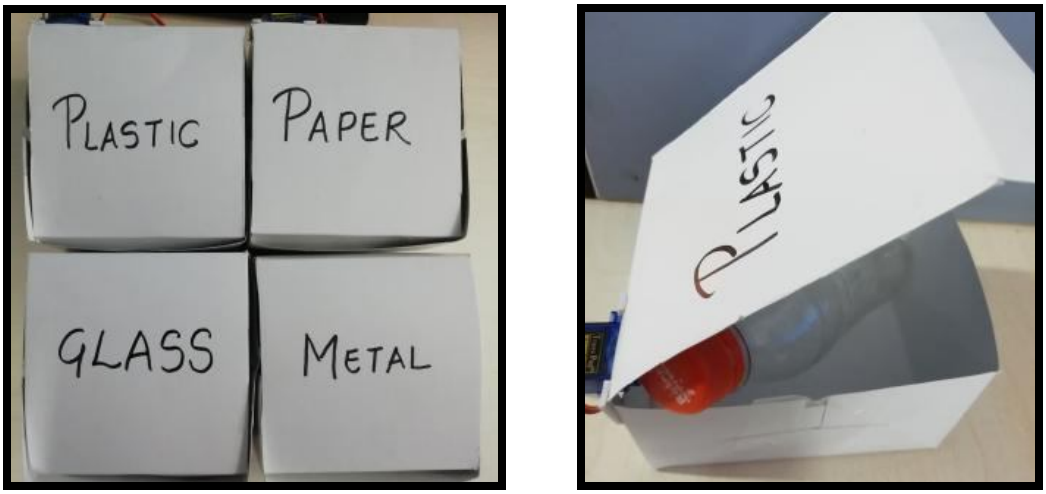


Figure 8: Dustbins of 4 categories connected to the servo motor

Figure 7 shows a plastic bottle considered as garbage whose image is taken as input through a camera. This image is compared with the available dataset through CNN. According to the algorithm it gives the desired probability of respective waste in given image.
Figure 8 shows the four categories of waste and their respective dustbins. Each dustbin is connected to a servo motor which is interfaced with NodeMCU. Here the input image is plastic hence the algorithm runs and the servo attached to plastic labelled bin opens.

VI. CONCLUSION AND FUTURE SCOPE

We have successfully implemented the project where it detects the waste object and classifies it into categories namely glass, paper, metal, plastic. After classifying the object it also opens the respective bin of that category.
The project has a wider scope in future considering the idea behind the project is very practical and is in dire need of such applications in garbage segregation. There are various ways in which the project can be further improvised at a large scale level:

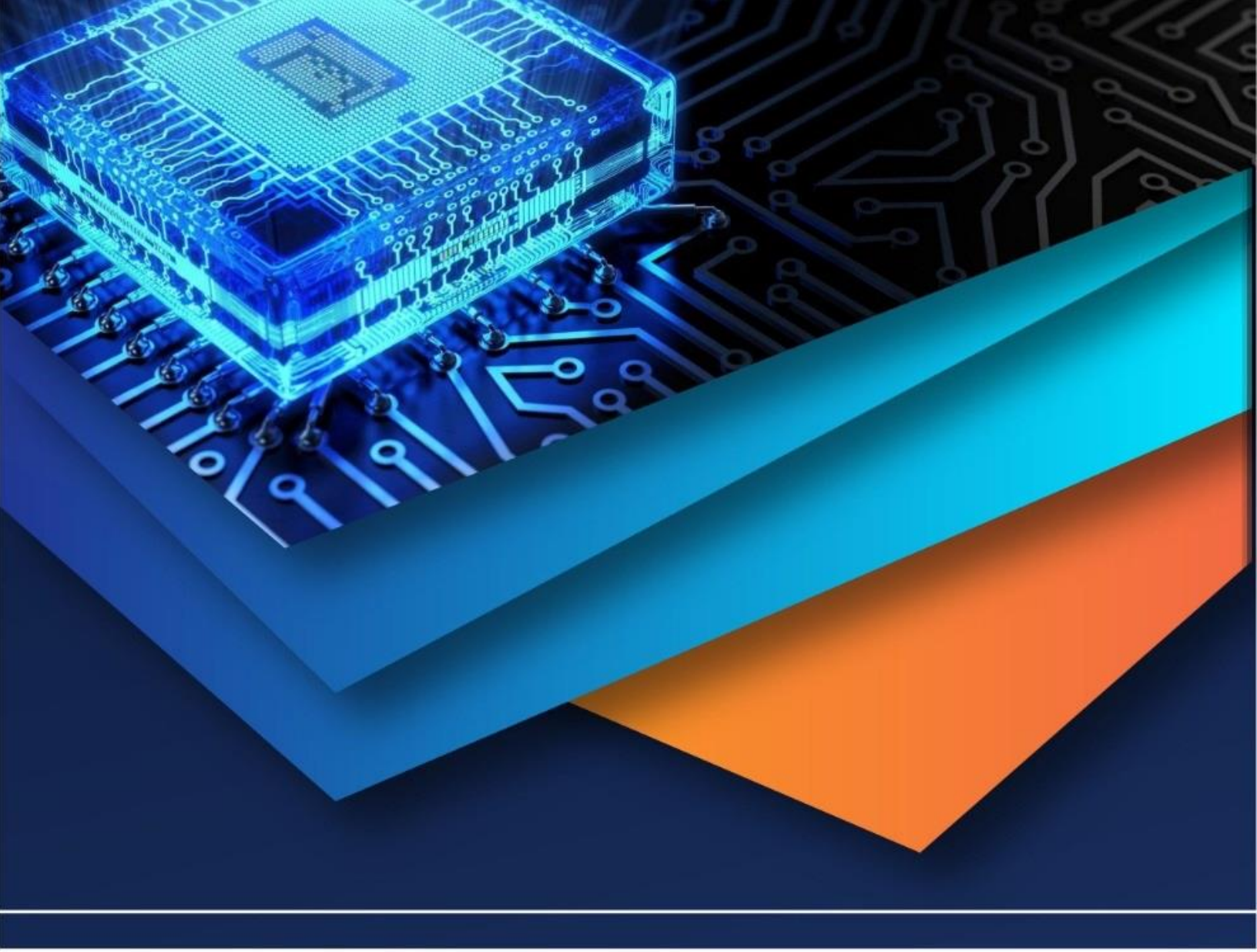
A. The garbage collected in the bin will be near full at a certain time. Using wifi module or an application and sensors, this data can be sent to the janitor or concerned authority who will be intimidated to come and clear the bin.
B. Another application can be to convert the bin into a robot and train it to dump itself after the bin is full. This could be implemented on single floor basis where collecting garbage from every room becomes a hassle. The bot can be programmed accordingly.

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