Water Cleaning Bot with Waste Segregation Using Image Processing

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Abstract. Dumping of waste into water bodies has become a major threat to the environment. Removal of these floating waste such as plastic, paper, cardboard etc. is a biggest challenge. This paper proposes a 'Water cleaning bot' along with a waste segregating mechanism to remove the waste from the water surfaces. It also includes an automated waste classification system using Convolution Neural Network (CNN) algorithm, a Deep Learning based image classification model used to classify objects into bio and non-biodegradable, based on the object recognition accuracy in real-time. The hardware part consist of ESP32 and Raspberry pi as the core module. The waste collection mechanism is established through a belt conveyor mechanism.

Keywords: CNN · Waste detection · Waste sorting · Web analysis · Bot control mechanism

1 Introduction

The main objective of our project is removal of floating waste from water surface. If we collected the waste from water there is no method to separate without any manual control. So here we propose an efficient method to collect and separate waste from water using image processing. It will definitely create a break through on the society and government organizations. The main concept is that a remote controlled bot which will moves through the water surface collects waste and separates the wastes into biodegradable and non biodegradable by using image processing. Waste is detected using Convolution Neural Network. Once the waste is detected the conveyor start working and the waste will comes to the collection unit. Once waste reaches the conveyor image processing is done with the help of Raspberry pi and the waste is separated in to two categories biodegradable and non biodegradable, for that a wiper is used.

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2 Bot Design

2.1 Block Diagram of Overall System

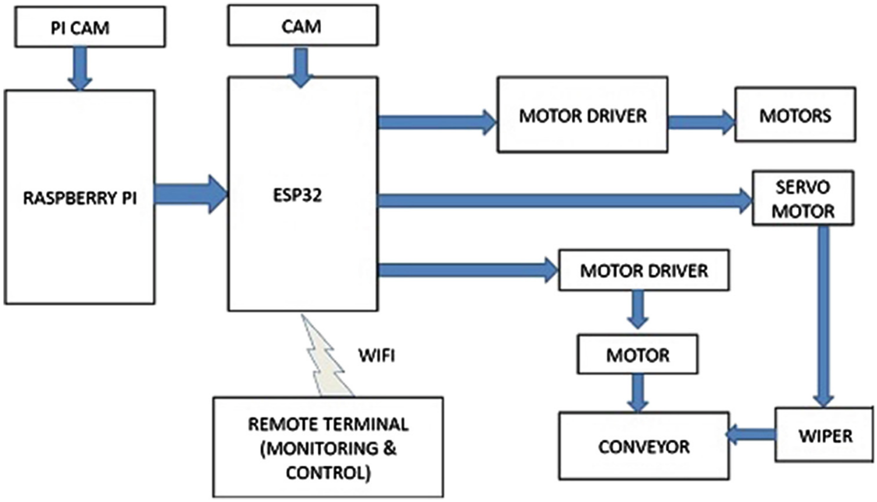


Fig. 1. Bot structure

Figure 1 Shows the basic block diagram of the system. The major components are ESP32, Raspberry Pi, Motor drivers, Motors, Conveyor and Wiper. Here ESP32 is used as the main control of the bot, cam on it will capture the images and transmit them to the destination (Remote terminal) for the detection. Manual control and manual triggering is done through the WiFi network.

Waste is collected using a conveyor belt and to drive this conveyor a dc geared motor is used and to energize this motor a motor driver (L293D) is also used. Once the waste is detected the conveyor start working and the waste will come to the collection unit. At that time the waste is separated in to two categories biodegradable and non-biodegradable for that a wiper is used. A servo motor is used to control this wiper. The thrust provided to control the bot is given by a geared dc motor and a motor driver is used to control it. Once waste reaches the conveyor image processing is done with the help of Raspberry pi, the pi cam is used to capture these images and these images are used for further classification and decides to which category it belongs to, this decision is transferred to ESP32 and the wiper takes action accordingly.

2.2 Data Set Collection

Data set is a collection of data used for training and testing of a network. The data set used for training is collected from trash net. The floating waste classification data set contains 1400 images from 3 categories:- plastic (500), paper (400), cardboard (500) (Fig. 2).

2.3 Waste Detection

Step *1:- Creating the Network head

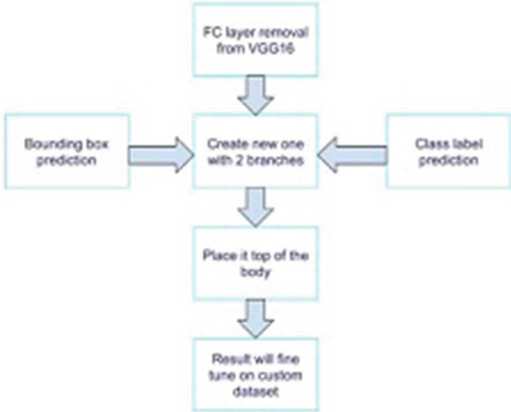
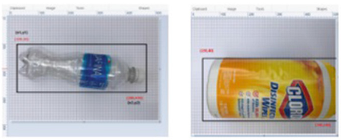


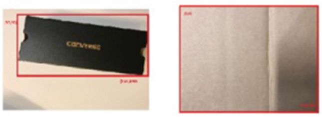
Fig. 2. .

Step *2:- Classification of Data set collection
Step *3:- Creating Regression box



images	X1	Y1	X2	Y2
plastic 1	0	380	410	395
plastic 2	10	350	410	390

images	X1	Y1	X2	Y2
paper 1	70	30	430	330
paper 2	0	40	440	385



images	X1	Y1	X2	Y2
cardboard 1	50	0	510	380
cardboard 2	0	0	510	390

Fig. 3. Regression box

Step *4:- Training: The flowchart shows the steps of training process.

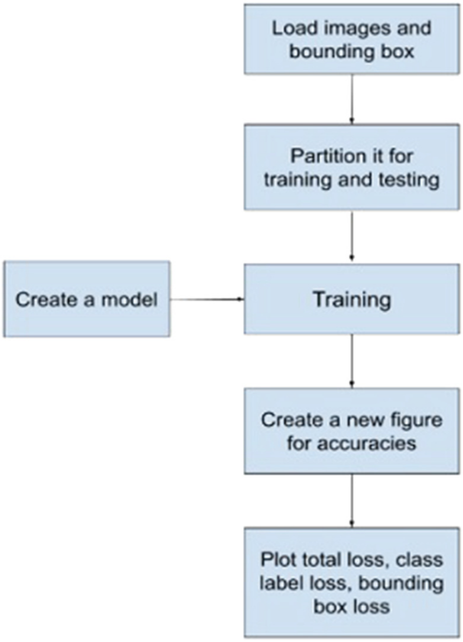


Fig. 4. Training flowchart

- First is to initialize the list of data and also load the input images and bounding box.
- After updated the loaded data convert the data to numpy arrays and scaling the input pixel.
- Then split the data into training and testing.
- Creating a model which is FC layer removal and new one is created. Then train the network and plot the accuracy and loss plot.

Step *5:- Testing (Figs. 3 and 4).
Determine the input file type, by loading image path in the testing file and load input image from disk (Figs. 5, 6 and 7).

- Preprocess the loaded image and predict the object along with the class label.
- Then load the input image (in OpenCv format).
- Mark the predicted bounding box and class label on the image.

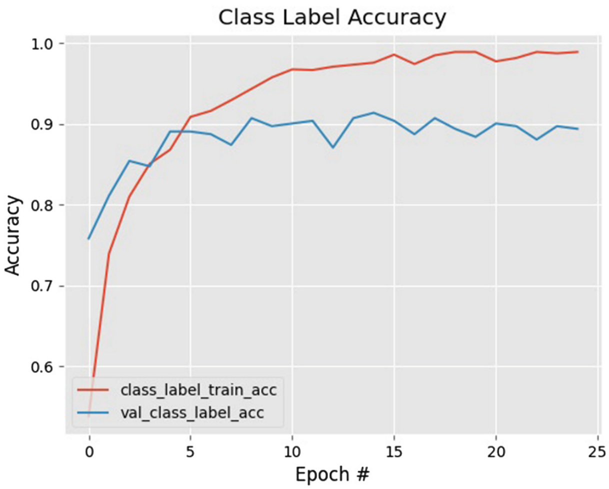


Fig. 5. Class label accuracy

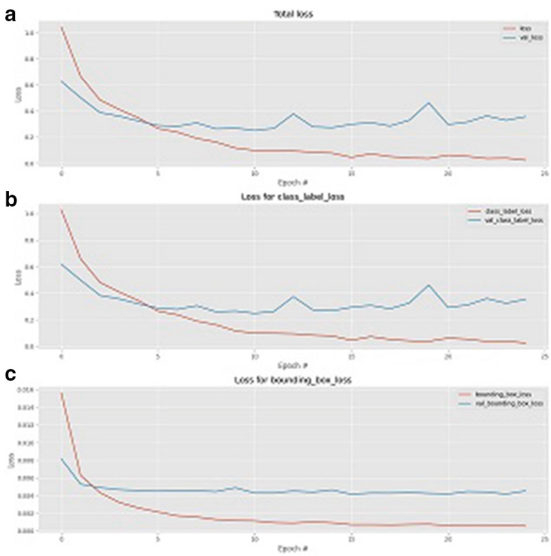


Fig. 6. (a) Total loss (b) Class label loss (c) Bounding box loss

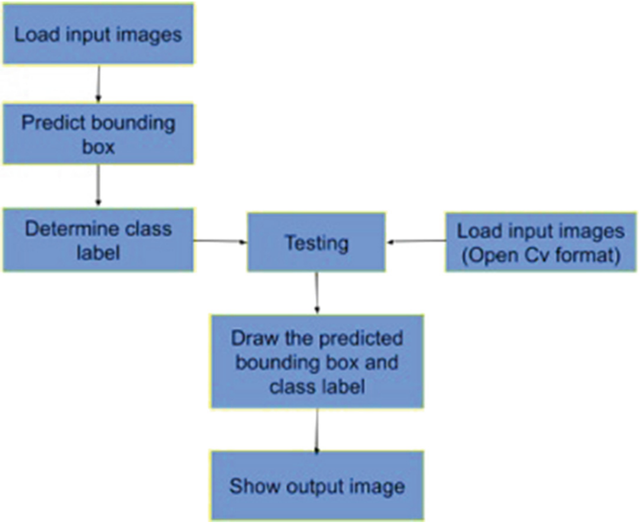


Fig. 7. Testing flowchart

Fig. 8. Detection output

2.4 Waste Classification

*Training Process steps:- Initialize the number of epochs to train for, initial learning rate, batch size, image dimensions, data and labels (Figs. 8, 9 and 10).

- Grab the image paths and randomly shuffle them loop over the input images.
- Scale the row pixel intensities to range [0,1] and binarize the labels and partition the data and construct image generator for augmentation.
- Creating a model then train the network and save the model to disk and plot the training loss and accuracy.

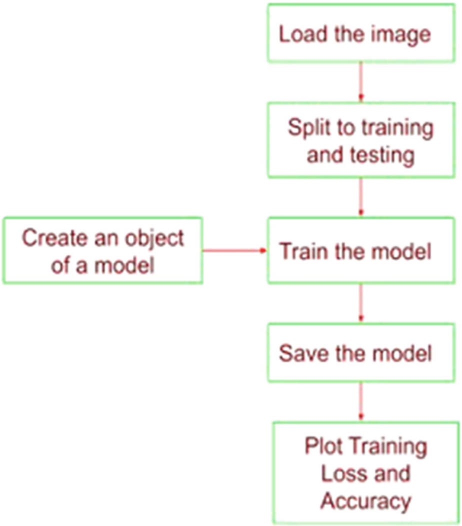


Fig. 9. Classification training flowchart

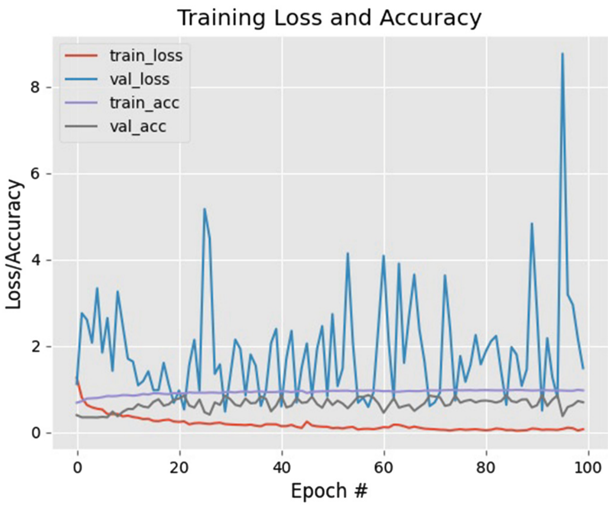


Fig. 10. Training loss and accuracy

*Testing Process steps:-

- Load the image and preprocess the image for classification.
- Then load the trained CNN and classify the input image.
- Mark the prediction of the input image filename contains the predicted label text and build the label.
- Draw the label on the image and show the output image.

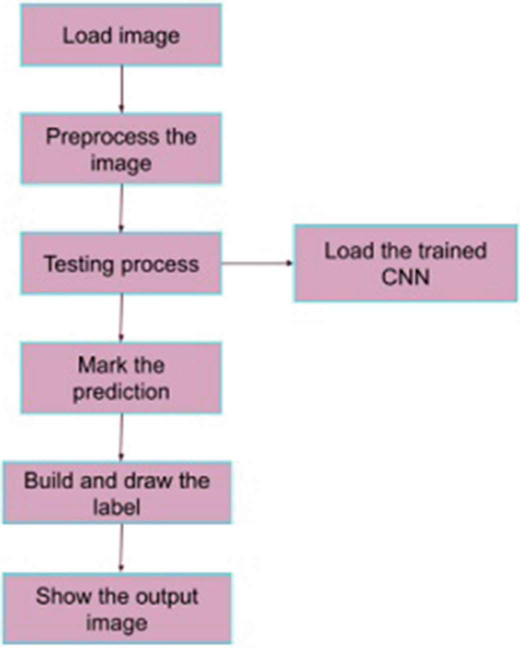


Fig. 11. Classification testing

Fig. 12. Classification output

2.5 Web Analysis

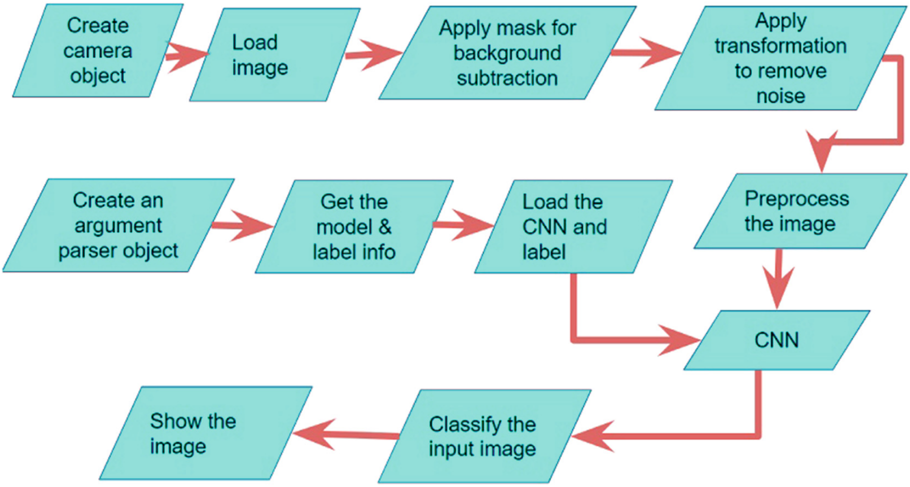
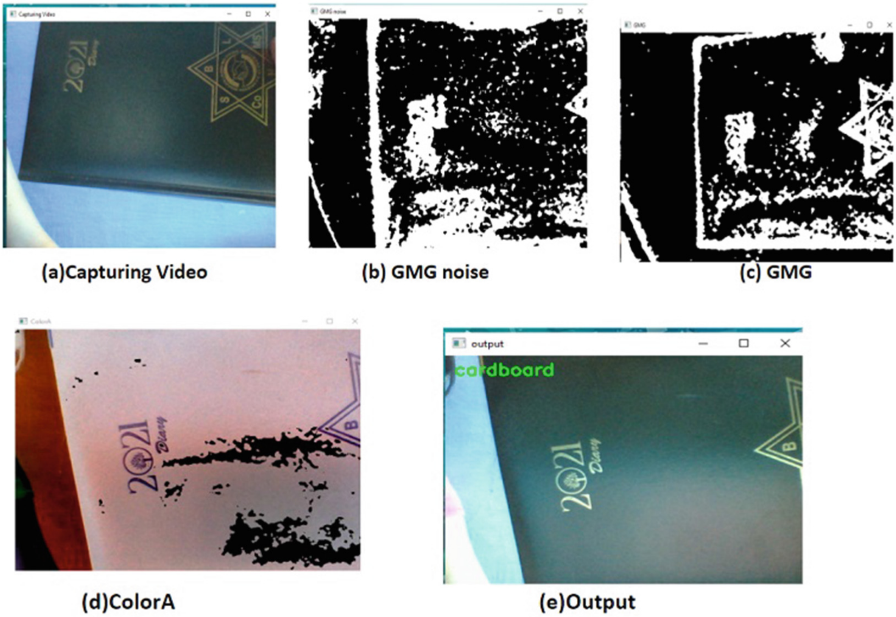


Fig. 13. Web analysis flowchart

2.6 Bot Control

Flow chart shows the working of motors. Here the data is giving through a virtual terminal for the motion of motors. If data is "f" the 2 dc motors move forward, if it is "b" move backward, "r" and "l" for right and left movements. And "s" for stop. "C" and "c" is given to start and stop of conveyor. The servo motor work according to the input, it rotate 180° (Figs. 11, 12, 13 and 14).

The main problem of existing system is when human does the waste sorting, they take lot of time. But the proposed system entire work can be automated so there is no need of any kind of skilled workers. It is user friendly. The second problem is the waste is highly contagious and harmful as it contain bacteria, virus which may lead to bad health of people working in the waste sorting process. The third problem of existing system is very costly. The proposed system initial and maintenance cost is low. Bot can be constructed using cheap materials so the initial cost can be reduced. It is applicable to reduce water pollution in rivers, canals and ponds. It does not harm the aquatic animals (Fig. 15).



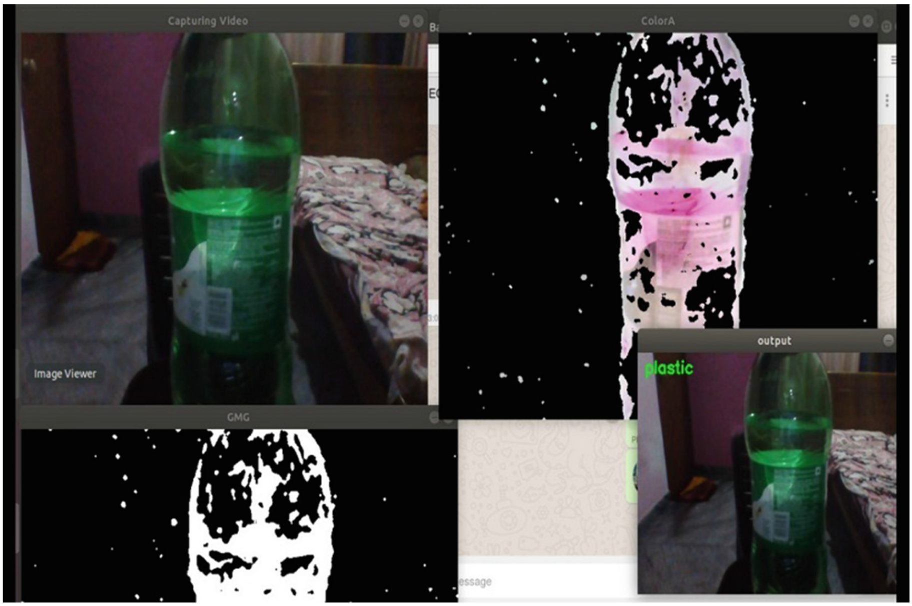


Fig. 14. Web analysis output

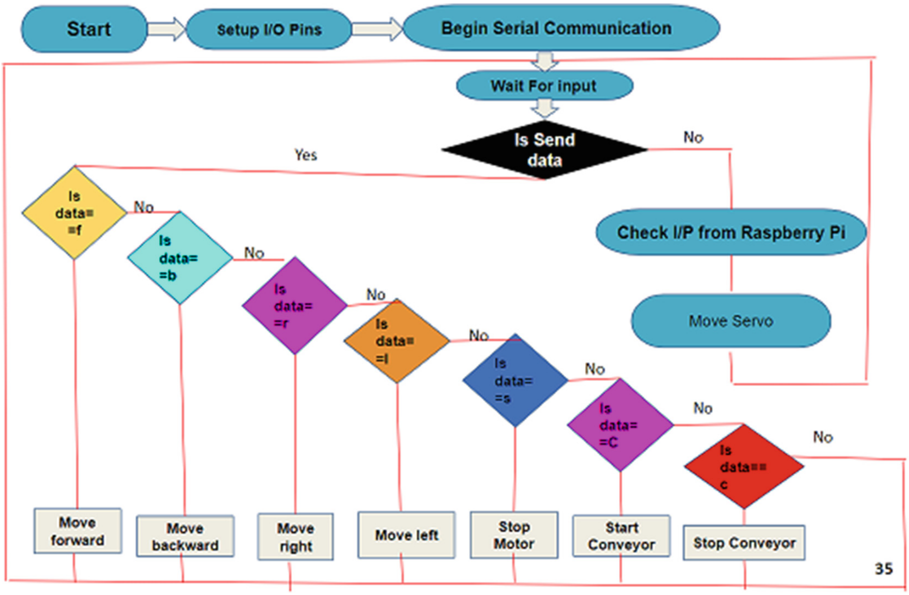


Fig. 15. BOT control

3 Conclusion

The primary objective of our project is to collect floating waste and to reduce human labour. The framework consists of two parts, one of which is the hardware platform with Raspberry Pi and ESP32 as the core module and the other is the software platform using CNN algorithm. The experimental result demonstrate that our system has 90 percentage average accuracy rate. In the long term, we will evaluate various feature extraction algorithms and classifiers to realize higher image classification accuracy.

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