Journal of Electrical Engineering and Automation (ISSN: 2582-3051)
www.irojournals.com/iroeea/

Smart Waste Segregation System using Convolutional Neural Networks

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Abstract

As the population increases, waste management has become difficult in today's world. It is estimated that, until now in India in the year 2022, the total amount of waste generated is 62millon tons, wherein nearly 43 million tons of waste is collected in which about 12million tons is treated and 31million tons is dumped in landfill. Moreover, segregation of waste also is a tough task for the workers. Since the waste may be hazardous and infectious for the human life, the segregation must be carried out without labor. This problem is majorly being faced in developing cities. To overcome this, a smart waste segregation system using CNN is proposed in this paper.

Segregation of waste from building itself brings about a large change in waste management. As the waste gets collected in a dumping area, it is identified using Open CV with the help of Pi camera. The captured image of waste is compared with default images using CNN algorithm, and segregation is done using robotic arm. Furthermore, the ultrasonic sensor present within the bin monitors the level of waste; when the waste level reaches the maximum, it alerts the authorized person with the help of GSM module. As the result, this keeps the buildings clean and supports the swatch Bharath mission. Existing waste segregation system use moisture sensor to differentiate between wet and dry waste ,even with small water droplets present on dry or metal waste detects it as wet which is a wrong identification.

Keywords: CNN algorithm, Pi camera, Robotic arm, Ultrasonic Sensor

DOI: https://doi.org/10.36548/jeea.2022.2.003
Received: 04.05.2022, received in revised form: 07.06.2022, accepted: 22.06.2022, published: 02.07.2022

1. Introduction

As the population is increasing at a disturbing rate, the country is heading towards the most terrible time for contamination which is toxic for living beings. Pollution or contamination can happen in any source like water, air, and soil. The current population of India is 145 crores; may be by 2030 many parts of the universe will be gigantically populated [1] including India because of which the amount of waste generated will also increase terribly. During covid19 lockdown, there were huge amount of waste generated from every house in the locality, due to the improper manner of waste disposal and different types of health issues were observed [2]. To avoid this, the proposed model informs the authorized person to collect the waste from the specific area like home, building and campus. To focus on waste management our honorable Prime Minister of India had launched the swatch Bharath mission on 2nd October 2014, which aims to keep villages districts, states, and union territories in India clean. In this regard 2 different dustbins are used to segregate wet and dry waste [3]. But people in this modern generation with busy schedule forget to separate in the flowing manner. Therefore, to overcome this problem, this proposed model segregates the waste into wet, dry, and metal automatically without human intervention. The waste collection may be door to door or indirect [4]. In both cases, the plan is to develop a system that would collect and segregate in a smart way. The system is designed by reducing unnecessary cost, and it provides good quality of service to the citizens. The proposed smart waste segregation system is developed to reduce the existing problems in the urban environment.

Nowadays there are many hardware and software resources available, and this has led to the increased enthusiasm in researchers and hobbyists to perform experiments using Machine learning Algorithm. Currently the waste management practice includes more human resources which is time consuming and results in health issues of workers. Dumping the waste materials everywhere can be injurious to plants and animals lives also; when the waste is segregated as wet, dry, and metallic in the initial stage, it will be helpful [5]. Waste is a big problem throughout the countries. Municipal authorities are facing problem in collecting huge amount of waste from different location and segregation in large scale. In the proposed system, CNN is used to segregate the waste without manpower with less time consumption. Machine learning is a function of intelligence where the system gets the ability to make decisions automatically without any help. CNN is neural network algorithm which is useful to classify the images. Input image is converted to matrix form, then extracts the features in

the image by applying filters; when it is applied to whole image, there will be an activation of that feature to detect. In the proposed model, the waste is discovered by using open CV. The waste is further segregated using robotic arm into respective section in the bin.

2. Related Work

Few recent papers are referred to identify the existing techniques of waste segregation system. Some new technologies have proved to be the best in this field. So, there is a need for public to implement this type of system which is significantly less in the current scenario [6].

2.1 Literature Survey

Shamin.N et al., [7] proposed the implementation of KNN and surf algorithm for waste segregation. The system was based on IoT waste segregation which segregates the waste to the dustbin by the usage of sensor and when detected right away, the information goes to cloud via IoT which segregates the wastes into metal, biodegradable and non-biodegradable wastes.

Shinini Ray et al., [8] described the model of smart bin which manages the collection of waste in buildings. The system optimized the routine to clean up the bins regularly. They have derived only three timings to clean up the bins. The 3 cleanups showed a standard deviation of 37minutes, which showed that particular dustbin might be left unclean for maximum 37minutes. And also new dustbins were installed that reduced the standard deviation and range.

Krishangi Deka et al., [4] used IoT Platform RL78 series of micro controllers interfaced with other component, and low-cost sensor attached to it which made dustbins handy all the times. The usage of force restive sensor measured the weight in dustbin. They have given a approach to contribute to the smart city which address the government and private sector to utilize the resources in an efficient manner, and also address the public to make them understand the environment and the steps included in ‘recycle, reuse, reduce’ near them.

Himadri Nath Saha et al., [1] attached the ultrasonic sensor and DHT11 sensor to the dustbin. When the dustbin is full, the alert is sent to the user using GSM model. The main source of power supply was solar panels. RGB led lights were used to indicate the level of

waste in the dustbin. They have mainly concentrated to reduce the amount of petrol cost by detecting the shortest required route for the truck drivers when collecting waste.

Kishan Ps et al., [9] performed classification of garbage by using deep learning and CNN. It had different folders created having different images like glass, plastic, metal, and cardboard. Nearly 2500 default images were used, wherein 800 images of garbage and 300 images non garbage were trained using faster CNN. Robotic intervention was used to classify without human intervention and the accuracy attained was 85.52%.

2.2 Existing System

The previous existing system detects the level of the waste and sends message via GSM to the authorities. Separation is done only for metallic and non-metallic substances. Moisture sensor detects the waste as wet. Whereas the proposed system monitors, segregates the waste into wet, dry, and metal, into specific sections of dustbin using robotic arm. From the previous existing models, it is observed that KNN algorithm can only classify and do not segregate into different categories, and SURF algorithm has a low rate of efficiency (70-75%). Therefore the idea of implementing the model with the help of CNN algorithm has been implemented.

3. Proposed Work

This system focuses on developing a smart waste segregator that segregates waste into wet, dry, and metal. It begins with the detection of waste by using open CV. Then the Pi camera captures the image of the present waste and compares with the default trained images by using CNN algorithm. Later, the robotic arm that is present segregates the waste into different compartments of the smart bin according to its category (wet, dry, and metal). The level of the dustbin is measured by using level sensor i.e., ultrasonic sensor. When the dustbin is filled and less than 10mm space is available, immediately the information is sent in the form of message to the authorized person through GSM module. Existing waste segregation system use moisture sensor to differentiate between wet and dry waste, even with small water droplets present on dry or metal waste detects it as wet which is not a proper consideration. Initially the proposed model consists of a dumping area where the waste materials are dumped. The waste detection happens by using the Open CV. The Pi camera module is connected to raspberry pi which captures the images of the waste present. The captured images are sent to the raspberry pi which is the main part of the proposed model.

The raspberry pi controller compares the captured image of the waste with the previously stored images [10].

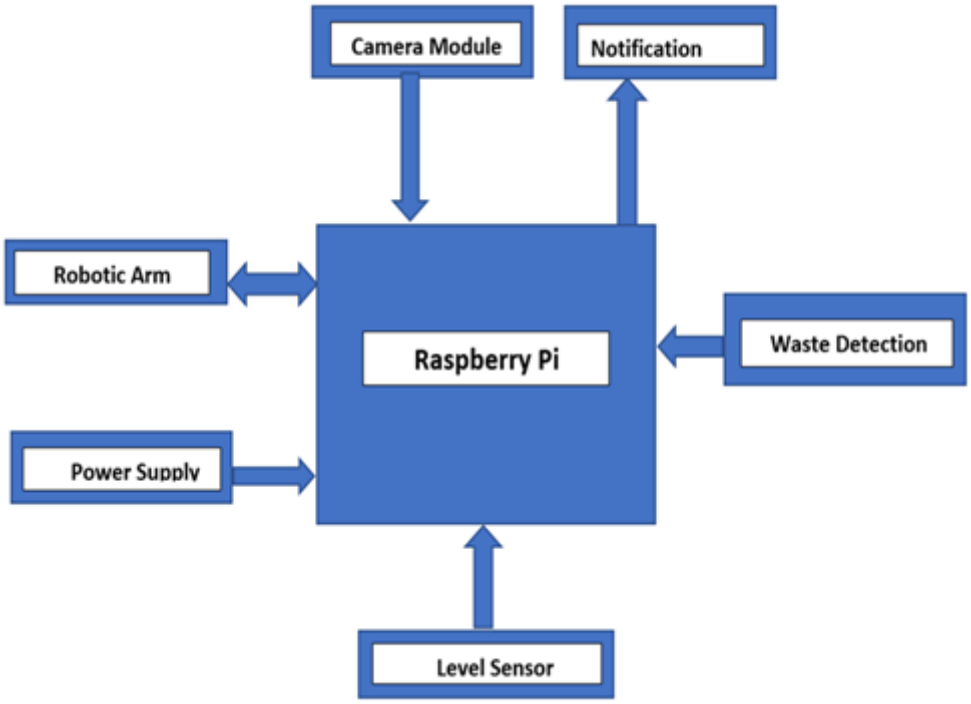

Figure 1. Block Diagram of Proposed Model

The convolutional Neural Network Algorithm is used for comparing the captured and the default images. About 92 images are used to train the system. Immediately after the identification of the waste material as Wet, Dry or Metal waste, robotic arm is used to pick and place the waste that is identified into the specific section of the dustbin like dry, wet, and metal. Power supply is used for the system to run during the working. External power supply is used that takes 5Volts for Raspberry Pi, 12Volts for DC drivers, and 5Volts for Ultrasonic Sensor. For monitoring whether the dustbin is filled or not, the ultrasonic sensor is used. When the dustbin is full, a notification is sent to the authorized person using Twilio trial. This Twilio uses the amazon web service to host the communication via APIs (Application Programming Interface). It uses a customized markup language that is TwIML which allows direct interaction with the services and exchange its documents via HTTP Webhook.

3.1 CNN Algorithm

CNN is convolutional neural network, which is used for classification of image, and widely used in image recognition and object detection. This process goes through several

layers like convolution layer, max pooling, and fully connected layers. Convolution layers consist of many filters that extract the features which are applied to the whole image.

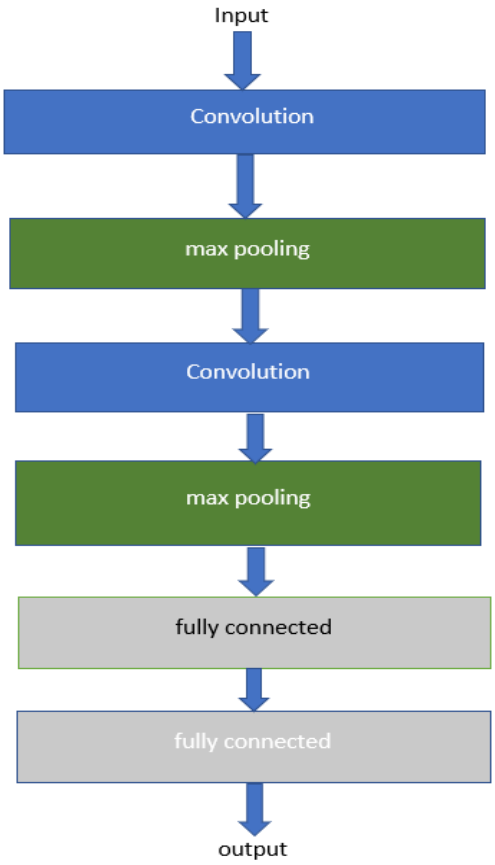

Figure 2. CNN algorithm

The purpose of filter is to extract the specific feature from the input image [11]. The max pooling layer reduces the size of the image compared to the convolution layer; this process continues until all the features are extracted. At last, it goes to the fully connected layer which consists of waits and bias. Then the sum of dot products of input goes to the activation function that is Relu activation which decides the neuron for the specific situation. This results in comparison of images of waste in the proposed model.

3.2 Raspberry PI

It is a small card size board that can be inserted to the computer, TV etc. In the micro-SD card slot, 8GB SD card is used to store the default images and the code. It has 40 general purpose input output port, 2 USB ports, Ethernet port, audio Jack, camera connector, HDMI audio video connector, and power source which consumes 3 Watt of power for the working purpose.

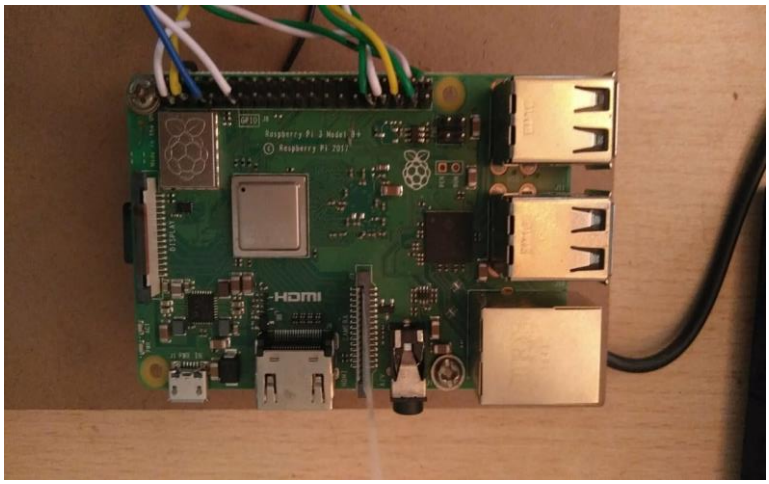

Figure 3. Raspberry pi

GPU is a Broadcom bcm2835 System made up of ARM Central Processing Unit (CPU). The CPU helps with all the computational work done in computer and GPU takes care of graphics output. GPIO are the General-Purpose Input-Output pins for the connection needs, RCA Jack allows connection of any analog TV, and Audio out Jack allows connection of audio output devices like speakers, headphone etc.

LED-Light Emitting Diodes are used for indication purpose, USB is a common connection port for devices of all types, HDMI connects to the high definition television using HDMI cable, and Power has 5Volts USB power connector to which power supply can be connected. An SD card installed with (Rasbian OS) is inserted and booting of the device is required. Ethernet is used for wired network access [12].

3.3 External Power Supply

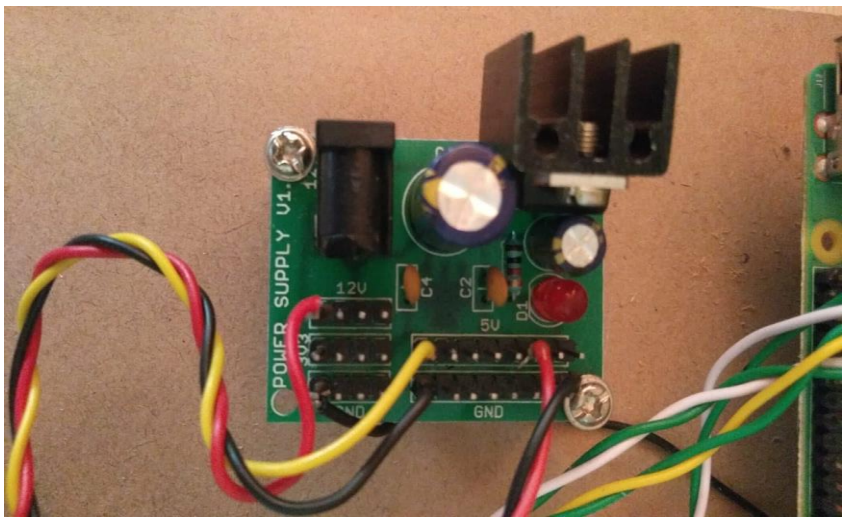

Figure 4. External Power supply

Fig 4 represents the External power supply. External power supply converts Direct Current to Alternative Current (DC to AC). As raspberry pi consumes 5 volts of current and the DC drivers requires more voltage, the external power supply is used, which is of 12 volts. It contains two types of capacitors (ceramic,electrolyte). LED for indication purpose, filter to remove the noise, heat dissipater to take up the heat caused during work, and Resistor which resist the current during short circuit conditions and protect the board have been used.

3.4 DC Motor Drive

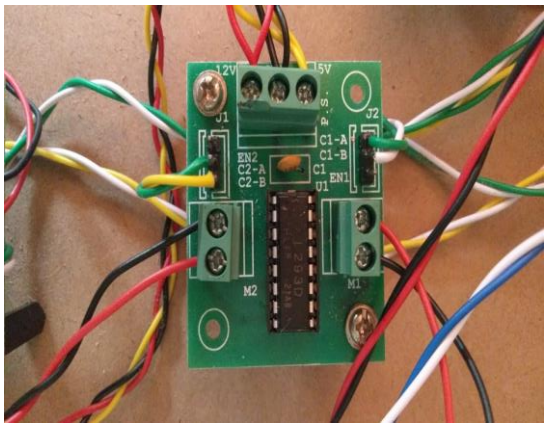

Figure 5. DC motor drive

A DC drive supplies voltage to motor to run at a specific speed. It is the amplifier that integrates between controller and DC motor. It converts AC to DC to run the DC motor. It is used to control the speed, acceleration, and direction of the DC motor. An H bridge is an electronic circuit which supplies current in 2 directions. As shown in Figure 5, L293D is a H bridge with 2 outputs. H bridge is one of the commonly used motor driver circuits. L293D is dual H bridge motor drive. It contains 16 pins that can drive motor in anti-clockwise and clockwise directions. Pin descriptions for L293D are: 1,9 are enable pins, 2,7,10,15 input pins, 3,6,11,14 output pins, 4,5,12,13 are the ground pins, and 8,16 pins are for VCC. Enable pin is connected to 5volts for the motor drive to operate. Enable 1,2 drive the H bridge circuit on left side and Enable 3,4 drive the H bridge on Right side.

3.5 DC Motor

Electric motors are of 2 types: DC motor, and AC motor. In this proposed model, DC motor of 5 volts is used. A DC motor takes electrical energy and converts into mechanical energy. It runs on direct current power. DC motors are used for the rotation of robotic arm and dustbin. It is rotatory electrical machine which contains 2 key components as stator and

armature. Stator is a stationary part, while the armature is the rotatory part. A coil of wire has current running in it to generate electromagnetic field with center of the coil. The above Fig. 6 represents the DC motor.

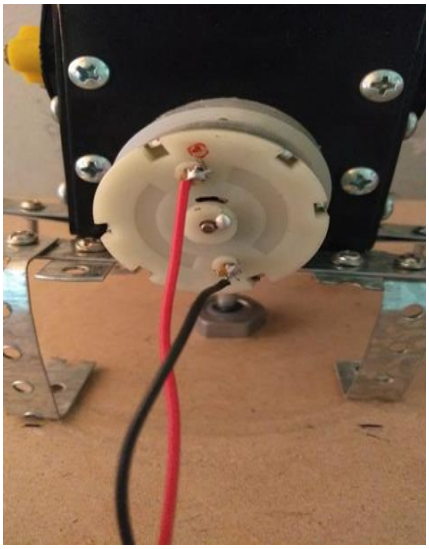

Figure 6. DC motor

3.6 Ultrasonic Sensor

Figure 7. Ultrasonic sensor

Figure 7 represents Ultrasonic Sensor used to check the dustbin if it is filled or not. Usually, it has a frequency range of 30 to 500khz. Ultrasonic sensor is device that measures the distance of object by emitting the ultrasonic waves that gets reflected and converted into electrical signal. Ultrasonic waves travel faster than the speed of sound. There are 2 pins that are: Trigger which is used to trigger the ultrasonic sound pulse and Echo which produces pulse when the signal is transferred and reflected. It has 2 components: transmitters which emits the sound and the receiver that receives the sound after reaching the target.

3.7 Pi Camera

Figure 8. Pi Camera

Fig. 8 shows the image of the Pi camera. It is transportable light wait camera. It captures the image of waste and transfers it to the system for the comparison with the default image for identification of waste. It is used in image processing and machine learning. It can be used as normal USB Webcam with computer. The features of the camera are 5mp camera module, supports raspberry pi, lightweight and portable, and night vision. It is basically a ribbon cable that is connected to the camera serial interface port of the raspberry pi board which is found near HDMI port.

3.8 Robotic Arm

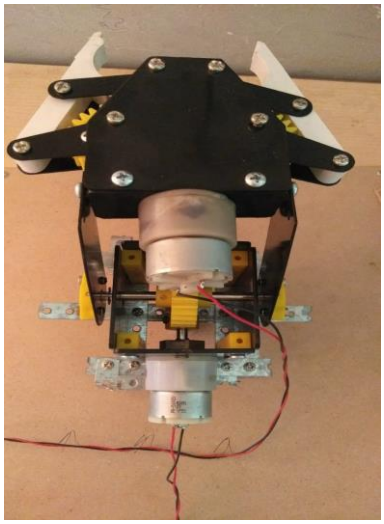

Fig. 9(a)-Top view of the Robotic arm

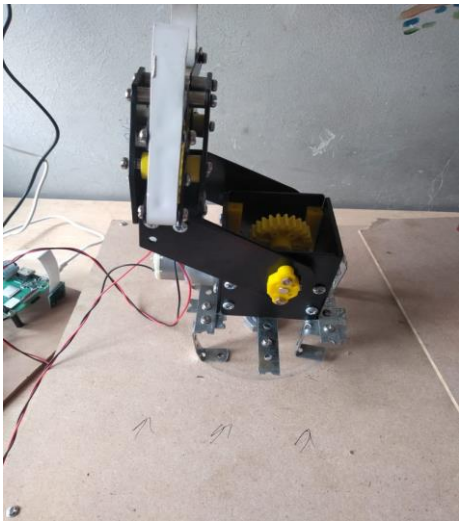

Fig. 9(b)-Side view of the Robotic arm

Figures 9 (a) and (b) represent the proposed model of the robotic arm. It is a simple pick and place robot which has two rigid bodies on a moving base which are connected with a rotatory joint. Rotatory joint provides rotation in 360 degrees, around any axis. 1st rigid body is fixed and supports the 2nd rigid body which has the end effector. The 2nd rigid body has the movement in all 3 axis and 3 degrees of freedom, and is connected to the first rigid body with the help of rotational joint which is used to pick and place the waste into the specific section of the dustbin (dry, wet, and metal) [13]. It is connected with the DC motor for the movements like clockwise, anticlockwise, up and down.

The flowchart of the proposed system has been depicted in the below figure. The top view and the side view of the proposed system are shown in figures 11 (a) and (b). Pi camera, external power supply, DC motor drivers, DC motors, Robotic arm and Dustbin have been depicted. The compartments are made in dustbin to show the separate areas for wet, dry, and metal waste. The dustbin rotates with the help of the DC motor present below it.

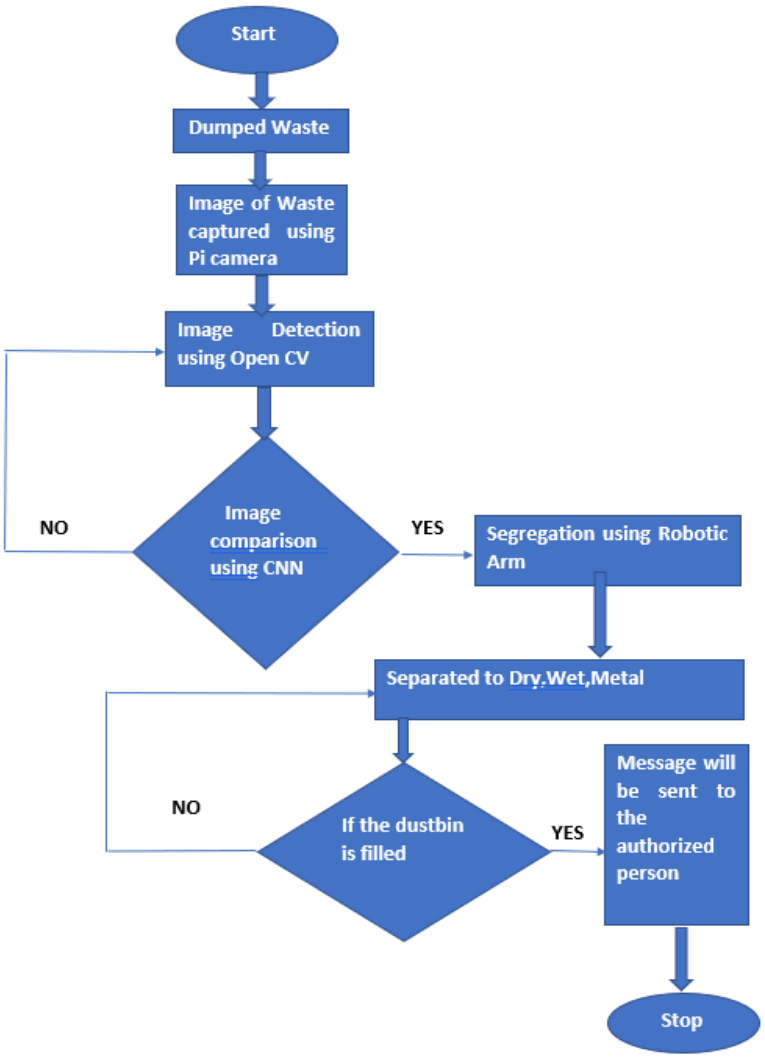

Figure 10. Flowchart of the proposed system

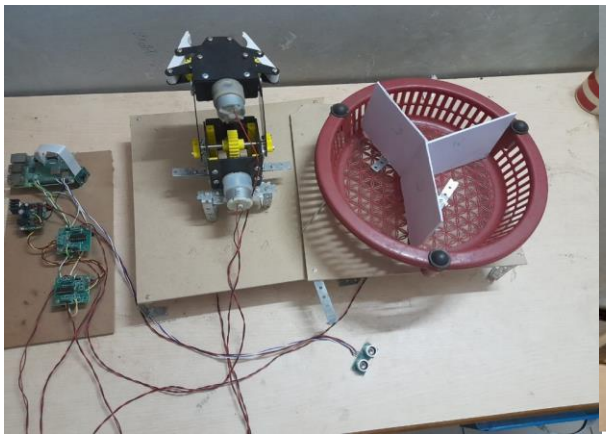

Fig. 11(a) Top view of the proposed system

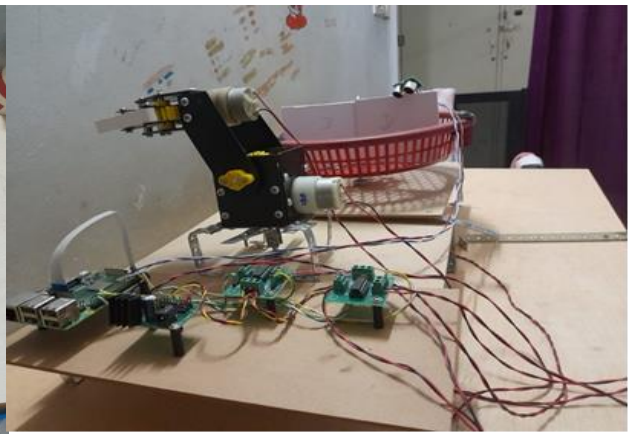

Fig. 11(b) Sideview of the proposed system

4. Results and Discussion

The ultrasonic sensor when placed in the top of the smart bin, detects whether the dustbin is filled or not, and the message is sent to the authorized person when it is full. The Robotic arm segregates the wastes and put into specific compartment of the dustbin like (Dry, Metal, and Wet).

Table 1. Segregation of waste

Type of waste	Dry	Wet	Metal
Banana, apple	No	Yes	No
Knife, scissors	No	No	Yes
Bottle, mug	Yes	No	No

The accuracy of the working model is found to be 90-95%. It is observed that the existing systems were identifying the substances as wet, even with little amount of moisture content present on them due to the usage of moisture sensor [14][15]. However, this proposed system works with the image comparison technique using CNN algorithm, which identifies the correct waste material even with the presence of moisture.

5. Conclusion

This paper proposes an automatic waste segregation model. The present images of the waste materials are compared with the stored images by using CNN, and by the usage of robotic arm, the wastes are segregated to different categories into the sections of smart bin. This proposed system works with the image identification by image comparison using CNN

algorithm rather than using moisture sensor as in the existing methods, the exact waste material is identified by the image even with the presence of moisture on it. After extensive working with the present system, it is found to achieve more than 90-95% success rate in segregating wet, dry, and metal wastes in different forms. This system will defiantly contribute to a larger extent in managing waste, thus supporting the Swatch Bharath mission.

References

[1] Himadri Nath Saha,Souray Gon, Anne-Marie Nayak, bSamabrita kundu, Sumandrita Moitra:"IoT Based Garbage Monitoring and Clearnce Alert System".(,IEMCON,IEEE 2018) 204-208Pg

[2] Avery, E.; Park, S. Perceived Knowledge as Protective Power: Parents' Protective Efficacy, Information-Seeking, and Scrutiny during COVID-19. Health Commun. 2020, 36, 81–88. [CrossRef] [PubMed]

[3] Sharma Narayan, Singha Nirman, Dutta Tanmoy: Smart Bin Implementation for Smart Cities, International Journal of Scientific & Engineering Research, Volume 6, Issue 9, September-2015. ISSN 2229-5518.

[4] Krishangi Deka, Krishan Goswami and Sagarika :"IoT-based Monitoring and Smart Planning of Urban Solid Waste Management" Springer Nature Singapur pte Ltd vol 462,895-905Pg,2018 may

[5] Balagugan,Raja S,Maheswaran .T,Savitha .S:"Implementaion of automated waste segregator at house hold level"(IJIRSET,vol 6,issue 10,oct 2017) 20839-20847Pg

[6] D. O. Olukanni and C. O. Nwafor, "Public-private sector involvement in providing efficient solid waste management services in Nigeria," Recycling, vol. 4, no. 2, p. 19, 2019.

[7] N Shamin; Fathimal, P. Mohamed; R, Raghavendran; Prakash, Kamalesh: "Smart Garbage Segregation & Management System Using Internet of Things(IoT) & Machine Learning(ML)". (ICIICT),2019.

[8] Shining Ray, Satan Tapadar, Suhrid Krishna Chatterjee, Robin Karlose, Sudipta Saha, Dr.Himadri Nath Saha :"Optimizing Routine Collection Efficiency in IoT based Garbage Collection Monitoring System".(,CCWC,IEEE 2018) 84-90Pg

[9] Kishan Ps ,Snehal Shah, Jitendra jaiswal:"Garbage Classification and Detection for Urban Management" (IJCTT,vol 69,Issue 9,2021),17-26Pg

[10] Saravana kannan G, Sasi kumar S, Ragavan R, Balakrishnan M "Automatic Garbage

Separation RobotUsing Image Processing Technique" 2017

[11] H. Jiang and E. Learned-Miller, "Face detection with the faster RCNN," in 2017 12th IEEE international conference on automatic face & gesture recognition (FG 2017), 2017, pp. 650-657: IEEE

[12] Ruveena Singh, Dr. Balwinder Singh, "DESIGN AND DEVELOPMENT OF SMART WASTE SORTING SYSTEM", IJRECE, Volume 3, Issue 4, October December 2015

[13] Gowri Shankar M1, Aravindh V2, Deeban G2, Divakar T2 " Degradable and non degradable waste separation using pick and place robot."

[14] Md. Wahidur Rahman Rahabul Islam Arafat HasanNasima Islam BithiMd. Mahmodul HasanMohammad Motiur Rahman "Intelligent waste management system using deep learning with IoT"(JKSUS,vol 34,issue 5,may 2022) 2072-2087Pg

[15] Rijwan Khan, Santhosh Kumar,Akilesh Kumar ,Srivastava, Niharika Dhingra ,Mahima Gupta ,Neha Bhati, Pallavi Kumari "Machine learning and IoT based waste management model"(Aritcal ID 5942574,vol 2021,Aug 2021)

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