

INTELLIGENT PLASTIC SORTING SYSTEM

Mr. Harsha C J¹, Mr. Kiran Paul T², Mr. Bineesh Biju³, Mr. Kelvin Shaju⁴, Mr. Linto Mathew⁵

¹ Assistant Professor, Dept. of ECE, Yenepoya Institute of Technology, Moodbidri, India - 574225

^{2,3,4,5} Students, Dept. of ECE, Yenepoya Institute of Technology, Moodbidri, India - 574225

Abstract - Plastic waste generation is very harmful to the mother Earth. Recycling and reusing of plastic is the solution for controlling this issue. But not all plastic can be recycled or reused. The proposed project is to control the quantity of plastic materials, which is going to be considered as waste, by checking whether it is reusable or recyclable before putting it to waste bin and from there to waste pits and water bodies, and thus reducing the amount of plastic wastes. This project is able to classify plastic wastes into three classes namely; reusable plastic, recyclable plastic, and neither reusable nor recyclable plastic. This can also separate metal waste from a bunch of solid wastes. This plastic sorting system will help to reduce the plastic waste generation rate. This project has major importance in industrial and commercial than domestic areas. It can thus reduce the harmful effects due to improper plastic waste segregation.

Key Words: Plastic sorting, Image processing, Raspberry Pi, Waste management, Metal detection

1. INTRODUCTION

Effective waste management is an inevitable need, since inappropriate waste disposal affects the healthy condition of people and environment in a very bad manner. A lot of experts have proven over the years that inappropriate waste disposal has a lot of detrimental effect to the people all over the world^[6]. The increase in rate of population and urbanization has led to growth in annual waste generation rate, and it is expected to be more again in the upcoming years. Therefore, in such a scenario the threats and harms caused by solid wastes, especially from plastics, which is a non-biodegradable solid waste, is not inevitable.

We cannot say that plastic should be prohibited. Without plastic, our life wouldn't have this easy. We use plastic in computers, mobile phones, cars, and in almost everything in our daily life. So we would think about a better way to control the usage of plastic in an incredible way, where it results only good effects to the Earth. The fact is that, the production is directly proportional to consumption.

The terms recycle and reuse has great role in this view of analysis. If we realise the plastic products which can be used again, why should we produce it again. It is also a fact that the recycling and reusing of any product is inversely proportional to generation of waste. But it is said the not all type of plastics can be recycled or reused^[7]. This characteristics depends on the composite materials which plastic is made of.

The intention of this project is to control the quantity of plastic materials, which is going to be considered as waste, by checking whether it is reusable or recyclable before putting it to waste bin, and thus reducing the plastic wastes. For our objective to be achieved, we are proposing an intelligent plastic sorting system. In our project, we classified plastic materials into; reusable, recyclable and those type of plastics can neither be reusable nor recyclable. For this classification we are considering the ASTM (American Society for Testing and Material) standards for plastics, where plastics are classified into 7 types^[9]. Managing waste effectively and recycling efficiently, a nation can ahead one step forward.

This system is an embedded type of system which is combined of few sensors, camera, conveyor belt^[2], and image processing algorithms. The classification of plastic is done using digital image processing technology. Previously defined databases of recyclable plastic, reusable plastic, and neither reusable nor recyclable plastics are the classes used for this classification.

2. METHODOLOGY

The methodology used for the proposed project is combined of both hardware and software. The entire system can be divided into five main units. They are; sensor unit, image processing unit, robotic unit, power supply unit, and processing unit.

The sensor unit consists of an Infrared sensor, metal sensor, and sensor drivers. Image processing unit has USB camera

module, and image processing algorithms, and database for plastic classification. Robotic unit consists of 12V DC motors for conveyor belts and arms, motor drivers and 5V servo motors. The processing unit is the brain of the system. It has the main processor which manages all other units. We are using Raspberry Pi 3B+ as the main processor of the system^[4]. The power supply unit is designed in a way that it is capable of providing 5V and 12V DC.

The sensor unit needs an additional LM324 sensor driver IC for interfacing IR and Inductive sensors with Raspberry Pi. This is used because the Raspberry will take only digital inputs at the normal GPIO pins on the board. LM324 will thus acts as an ADC. Interfacing of two sensors is possible using one LM324 IC. Similarly on the output side of the processor, it needs an additional LM293D motor driver to control the DC motors used for conveyor belt. This motor driver IC is required to prevent the back EMF send from motor to processor, and also to control the direction of rotation of motors.

The status area shown in the Fig-2 consists of two LEDs and a buzzer. The purpose of this on the system is for indication purposes. It is used to indicate or inform the statuses like metal is detected, object on conveyor belt is detected, the power supply is proper, etc.

Image processing technology is used for classification purpose^[1]. The basis of classification used in image processing is based on basic principles computer neural network and few deep learning algorithms. For performing classification, a clearly defined dataset of images are required. For creating the database of objects, colour images of objects were taken, and images will be undergoing a training using one of the neural network model for extracting features of images^[8]. Each feature of image will be represented using an integer value. The same features might be presented in different images, based on the characteristics such as shape or colour. Thus each image will obtain a weight or reference vector value based on its features. Thus the database for the classification will be holding these reference values. The arrangement will be in such a way that, a group of reference values or say vector representation is considered as a main class with a range of values. This integer value will be representing the type of the class. Once this database is created, when the next time a new image is analysed, the weight of the image is calculated and compare with previously stored weights. The predefined dataset have images of reusable plastic objects, recyclable plastic object, and neither reusable nor recyclable plastic waste object.

Here, the comparison will be between the weight or probability of previously defined type of class and weight or probability of newly taken image of object. If the value of newly taken image came in range of probability of any particular class, the object will considered as that particular type of class. Then, depending on the output of image processing unit, each object will be displaced to appropriate class's bin using servo motor controlled arms.

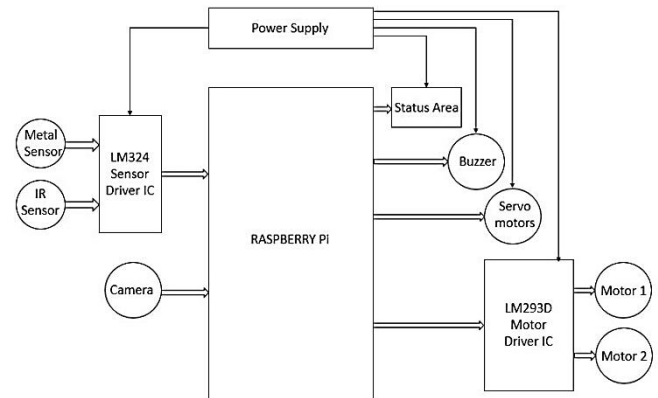


Fig-2: Block diagram of intelligent plastic sorting system

In software session, the language used is Python, and the IDE used is Python IDLE. It is a simple IDE for beginners. The Raspberry Pi supports Python. The algorithms used in the image processing unit is also written using Python.

3. PROCESS FLOW

The process flow can be explained as in following steps.

1. Keep the conveyor belt in off state.
2. Read the IR sensor status.
3. If object detected, increment the count and start the conveyor for some delay. If no object detected, keep checking the IR sensor status.
4. If inductive proximity sensor detects metal object, stop the conveyor belt, and enable the robotic arm to displace the object. Read the IR status again^[5].
5. If inductive proximity sensor detects no metal object, move the conveyor belt for some delay as it reaches to camera module, then stop the belt.
6. If the image of object matched with a particular class in the database, robotic arm will displace the object to appropriate bin for that particular class. Read the IR sensor output again.
7. If the image of object doesn't matched with any of the class in database, move the conveyor belt for some delay and stop^[4], so that object will be fall to a

waste bin which is kept directly below the conveyor belt end. Read the IR sensor output again.

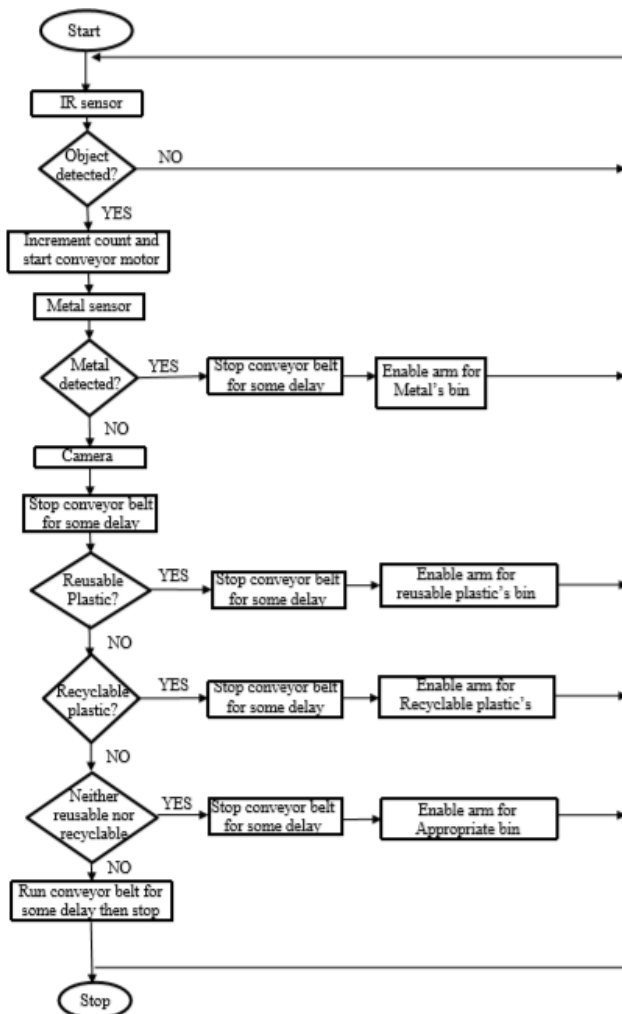


Fig -3: Flow diagram of the processing unit

4. COMPUTER NEURAL NETWORK FOR IMAGE CLASSIFICATION

The convolutional neural network (CNN) is a class of deep learning neural networks^[8]. CNNs brought a large breakthrough in image identification. They are most commonly used for visual analyzing and frequently used in image classification.

Image classification is the process of taking an image as an input to a system, and outputting a class, which that particular inputted image belongs to. The output can be a class name or a probability value that the input is particular class. For example, the input can be a picture of a dog, and output can be like 'there is 90% probability that input is dog'. For this classification, a database of images or its feature's

reference vectors are required. It is possible for the computer by using a computer neural network. CNN

The CNN has other applications too. That is the input to the CNN need not be images, it can take text, sound, etc. as an input but in a translated form. A CNN has many layers between the input and output layers. A CNN convolves learned features with input data and uses 2D convolutional layers. Thus this type of network is ideal for processing 2D images. Compared to other image classification algorithms, CNN can learn the filters while in other algorithms go with extraction depends on characteristics of images instead of learning how to extract. Thus we say that CNNs use very little preprocessing.

CNNs have an input layer, and output layer, and hidden layers. The hidden layers is the intermediate layer between input and output layer, and it holds all the computational processes in the network. This computations in CNNs usually consists of convolutional layers, ReLU (Rectified Linear Unit) layers, pooling layers, and fully connected layers. The CNN follows a hierarchical model which works on building a network. Convolutional layers apply a convolution operation to the input. This passes the information on to the next layer. Pooling combines the outputs of clusters of neurons into a single neuron in the next layer. Fully connected layers connect every neuron in one layer to every neuron in the next layer^[8].

A CNN works by extracting features from images. The CNN learn these features by train the set of 2D images. Thus such models has high accuracy, even if it is little much complex. Each time of learning, a new layer will added for convolution. Each layer increases the complexity of the learned features. Thus the final layer final output layer will be having highest accuracy. The final value will usually between 0 and 1, which represents the probability of the class.

5. TEST AND DISCUSSION

The dataset taken for the testing of image processing unit is retrained with the support of Inception v3, which is created by Google. Inception V3 is an architecture combined of so many complex layers. ImageNet database was created by Google with 1 million training images. Inception V3 takes the images of objects from those imageNet dataset images. Inception V3 is the third version of Google's inception CNN. Inception V3 was trained using a dataset of 1,000 classes.

Transfer learning allows us to retrain the final layer of an existing model. Transfer learning helps to decrease training time significantly. The size of the dataset required is also get reduced by using transfer learning. One of the most famous models that can be used for transfer learning is Inception V3. As mentioned above, this model was originally trained on 1,000 classes on some very powerful machines. Being able to retrain the final layer means that you can maintain the knowledge that the model had learned during its original training and apply it to your smaller dataset, resulting in highly accurate classifications without the need for extensive training and computational power.

We have taken the images of waste materials from the college cafeteria to retrain the existing Inception v3 dataset. The classes created were; reusable plastic, recyclable plastic, and neither reusable nor recyclable plastic.



Fig -5: Examples of (a) Reusable plastic, (b) Recyclable plastic, (c) Neither reusable nor recyclable plastic classes

Hence the designed system consists of image processing unit and sensor unit is capable of sorting the waste and collecting it into four containers, container for including metal waste. The training of neural network has been done for different types of material and the system is capable of distinguishing between the different types of plastic waste. In order to reduce the power consumption, the system will not start processing (including the start of conveyor belt motor) until we put waste into it. The testing result shows that an accuracy of 99% is achieved with detection of reusable plastic, 96% detection of recyclable plastic and 98% detection of neither reusable nor recyclable plastic.

In the testing of inductive sensor, it is found that it can detect metals in a range from 0.8cm to 1.1 cm. The IR sensor provides a detection range near to 2cm. The working of power supply unit also has verified at the points where the 5V DC and 12V DC are supplied. The motor used for conveyor belt is of 30 rpm, which will provide a satisfactory speed of rotation.

In addition we would say that, more time should have been spent researching mechanical design of our conveyor system. Overall the design prototype looks satisfactory with

optimization point of view and our system will be in future will be capable of sorting into more type of waste and complex algorithm will be implemented. Also in future the number of objects that the camera recognizes may be increased by adding more objects to the image database. This process may be automated, and a user friendly GUI-based application may be created to achieve this functionality.

6. ADVANTAGES

By using this proposed intelligent plastic sorting system, classification of plastic waste can be done automatically. Implementation of this project in manufacturing industries will increase the rate of plastic recycling. Dumping of metal and non-metal waste in separate is possible using this project. Since robotic arms are implemented, human labor requirement can be reduced and it helps to avoid direct contact with solid waste including metals and non-metals.

7. FUTURE SCOPE

The proposed project aims to develop an intelligent plastic sorting system for effective plastic waste management. By implementing this kind of effective system to sort the plastic waste, we can efficiently control the increase in plastic waste generation in future. As plastic is an inevitable factor in many various fields like industrial, commercial as well as domestic workplaces, this intelligent plastic sorting system has large scope.

Also more sensors and supporting technologies can be added to it to make it more advanced in future days. We can add sensors to detect poisonous or toxic substances contained in plastic materials to collect those to separate category. Also sensors to differentiate among wet and dry plastics can also be added to this system. By using more cameras and efficient algorithms, classification of plastic from a heap of waste might be possible.

8. CONCLUSION

This plastic sorting system will help to reduce the plastic waste generation rate. This project has major importance in industrial and commercial than domestic areas. It can thus reduce the harmful effects due to improper plastic waste segregation.

This project is able to classify plastic wastes into three classes namely; reusable plastic, recyclable plastic, and

neither reusable nor recyclable plastic. This can also separate metal waste from a bunch of solid wastes. Also the production of plastic products can also be reduced as we enhance the reusing and recycling rate. This will be helpful for human as well as other living beings on earth in one or the other way.

REFERENCES

- [1] Edgar Scavino, Dzuraidah Abdul Wahab, Aini Hussain, Hassan Basri, and Mohd Marzuki Mustafa - "Application of automated image analysis to the identification and extraction of recyclable plastic bottles", Faculty of Engineering, University Kebangsaan Malaysia, May 2, 2009.
- [2] Zol Bahri Razali and Gunasegaran - "An Application of Image Processing for Automated Mixed Household Waste Sorting System", School of Mechatronics Engineering University Malaysia Perlis, February 2012.
- [3] Mahmudul Hasan Russel¹, Mehdi Hasan Chowdhury¹, Md. Shekh Naim Uddin¹, Ashif Newaz¹, Md. Mehdi Masud Talukder² - "Development of Automatic Smart Waste Sorter Machine", Department of Electrical and Electronics Engineering¹, Department of Mechanical Engineering² Chittagong University of Engineering and Technology (CUET), International Conference on Mechanical, Industrial and Materials Engineering 2013 (ICMIME2013), 1-3 November, 2013, RUET, Rajshahi, Bangladesh.
- [4] M. Kamalakannan¹ K. Devadharshini² - "Controlling the Speed of Conveyor Belt using Python Raspberry Pi 3B+", College of Fisheries Engineering, Tamil Nadu, Dr. J. Fisheries University, Nagapattinam, India¹. College of Fisheries Engineering, Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Nagapattinam, India², July 2019, Orient. J. Comp. Sci. & Technol., Vol. 12(2), 57-64 (2019).
- [5] Ranjitha C, Sarga V, Sreelakshmi P K, Vishnu Suresh, Arya Paul - "Real time waste segregation", UG Scholar, Assistant Professor Department of Electronics and Communication Engineering AdiShankara Institute of Engineering and Technology, May 2018, National Conference on Recent Trends in VLSI, Communication and Networks 2018 (RTVCN2K18), ISSN: 2454-4248, Volume: 4, Issue: 5.
- [6] Syeda Madiha Samreen¹, Dr. Baswaraj Gadgay², Veeresh Pujari³, Pallavi B.V⁴ - "Automatic Metal, Glass and Plastic Waste Sorter", ¹PG Student Dept. Of VLSI Design & Embedded Systems VTU PG Centre Kalaburagi, ²Research Guide & Professor VTU PG Centre Kalaburagi, ^{3,4}Assistant Professor VTU PG Centre Kalaburagi, Karnataka, Volume 5 Issue VI, June 2017
- [7] 7 Things You Didn't Know About Plastic (and Recycling), National Geographic, Site URL: <http://nationalgeographic.org/2018/04/04/7-things-you-didnt-know-about-plastic-and-recycling/>
- [8] Computer neural network and image classification, Annie Bonner, site URL: <https://towardsdatascience.com/wtf-is-image-classification-8e78a8235acb>
- [9] Inception v3 deep learning architecture for classifying, Intel, site URL: <https://software.intel.com/content/www/us/en/develop/articles/inception-v3-deepconvolutional-architecture-for-classifying-acute-myeloidlymphoblastic.html>
- [10] 7 different types of plastics, Site URL: <https://www.acplasticsinc.com/informationcenter/r/7-different-types-of-plastic-and-how-they-are-used/>