A Step towards Sustainable Development using Neural Network

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***Abstract*— The United Nations has come up with 17 problem statements to achieve sustainable development goals. These goals need to be completed to achieve a better and more sustainable future for all.**

This project proposes a solution for the 12th problem statement: Responsible Consumption and Production. It segregates plastic into recyclable and non-recyclable depending upon the RICs(Resin Identification codes).The robotic arm will pick one bottle at a time followed by a camera which will click the pictures of the base/sides of the bottle then identify the RIC number using Deep Learning and will dump the bottle into the respective container. After segregation, the waste will be sent to the industry for further process.

The whole system is automated, hence reducing the human interference and errors along with replacement of rag pickers to machines.

Keywords:- Sustainable Development Goals, Resin Identification Code, Deep Learning, TensorFlow API.

I. INTRODUCTION

Plastic, as we know, is everywhere in water, in animals, even in our food. A new report indicates that it's accelerating global warming. If this continues, then our earth will go extinct till 2030 [8]. Some severe actions need to be taken on these issues.

A. Sustainable Development Goals

SDGs, also known as the Global Goals, were adopted by United Nations in 2015 as a universal call to end poverty, protect the planet and to spread peace and prosperity by 2030. The SDGs are designed to reduce poverty, hunger, waste and discrimination against women and many other issues [8].

B. Need for segregating the plastic waste

Every day, tons of waste is generated, thus causing a major problem to various cities and their municipal authorities due to the shortage of landfill to dump such waste. In addition, the toxic hazardous materials among the waste cause severe health problems and damage to the environment. Plastic bottles are a major part of the municipal waste. They have special importance because they are non-biodegradable and consume a large volume in the landfill. Therefore, plastic bottles can cause a serious environmental problem [1].

The only way to address this problem is to recycle the plastic waste material and reuse it. Recycling is becoming an important issue with the shortage of the landfill. The sorting stage is the essential part of the recycling process and therefore the need for an automated sorting system can be considered for high throughput rate and accuracy.

C. Categories of Plastic Bottles

Plastic bottles can be classified into seven categories based on its material. This classification is within the requirement of plastic recycling industries [3]. The following is a brief description of seven types of plastic bottles.

- *Polyethylene Terephthalate (PET No. 1)*
  These plastics are commonly used for beverages such as mineral water and soda beverages [9].
- *High Density Polyethylene (HDPE No. 2)*
  These plastic containers are of rigid or soft type. Rigid HDPE containers are generally opaque, and can be used for manufacturing oil containers, household cleaning solution bottles, etc. Soft HDPE containers are generally semi-transparent and are used in juice and milk bottles [9].
- *Polyvinyl Chloride (PVC No. 3)*
  They include translucent or opaque bottles. Typical products are vegetable oil, floor polish, mouthwash, and some translucent pharmaceutical bottles [9].
- *Low Density Polyethylene (LDPE No. 4)*
  LDPE is mainly used for purposes such as agricultural covering, food industry wrap and garbage bags, etc.
- *Polypropylene (PP No. 5)*
  These types of plastics are used in battery cases, medical containers, some dairy tubs, bottle labels, caps, combs and snack wraps [9].
- *Polystyrene (PS No. 6)*
  Plastic containers used in yogurt cups, tubs, cookie tray and vitamin bottles. Foamed polystyrene, are used in trays, egg cartons, and carry out containers [9].
- *Other Plastics (Other No. 7)*
  All plastic products made of other than the six listed above, are included under this category. Examples are microwavable serving ware, 'brick pack' juice boxes, water cooler bottles and squeezable bottles used for ketchup, condiments and syrups [9].

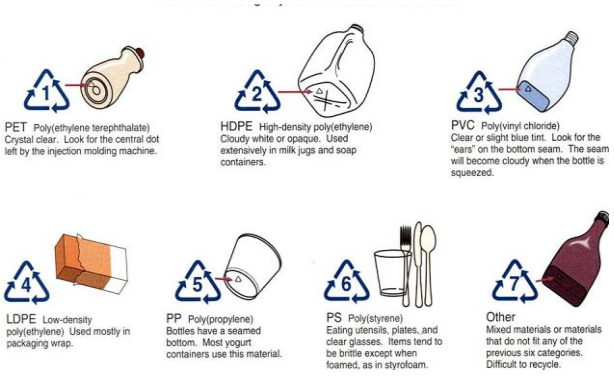

Fig.1 Types of Resin Identification Code [12]

Almost all the plastic bottles have a Figure printed inside a triangular recycling symbol that is printed at the bottom of the bottle [2]. Fig. 1 illustrates this recycling symbol code.

II. LITERATURE SURVEY

As per the survey done, India generates approximately 26000 tones of plastic waste every day, which makes it the 15th biggest plastic polluter in the world [7]. Thus yearly, almost 96000 tons of plastic waste ends up being piled in the ocean, sea or landfill. If we compare the countries having best waste management systems, India does not even lie within top 30 [6]. Countries like Germany, Singapore, South Korea use various techniques such as NIR Spectroscopy to segregate the waste wherein in India; waste is still segregated with the help of rag pickers.

Some countries have come up with revolutionary ideas like in Columbia, ECOBOTS are placed in public areas and every time a citizen deposits a PET bottle, they receive a coupon which can be used at restaurants or malls. In Indonesia, a city named Malang generates 55000 tons of waste everyday while it was observed that people staying there did not have health insurances. These may seem to be two different scenarios but a doctor there came up with an idea of Garbage Clinical Insurance. Here people have to deposit trash to the clinic which is sold to recycling plants and the money collected from it is used to give basic health insurances to people. Hence encouraging the citizens to actively take initiative in the drive [8].

Sweden, on the other hand has run out of trash and they are exporting the waste from other countries in order to keep their recycling plants running. The country burns all the waste and the energy generated from it is given to heat up the homes and protect them from the freezing Swedish winters. Another example is of Semakau landfill in Singapore which got converted into a bio-diversity hotspot and is now home to birds, mangroves and marine life [8].

Hence the survey concludes that leading waste management countries in the world prefer to reuse and recycle their waste. Hence, to eradicate the production of new plastic, segregation and recycling of waste need to be done.

III. IMPLEMENTION

A. What Is Deep Learning?

Deep learning is a subset of machine learning which in turn a subset of artificial intelligence. Deep learning is used in self driving cars, face detection, medical sector and many more because of its ability to imitate the human brain. It processes large datasets using forward and backward propagation along with activation functions. This allows it to take complex decisions such as detection of face of dogs even from different breeds. Deep learning has been derived from the human neural network made up of neurons [2].

Initially a dataset of 700 images was created which consist of bottles having RIC codes with different shapes, sizes, colours, dimensions, orientations and backgrounds. A neural network with N number of hidden layers is created with random weights assigned to each perceptron of every layer. An image will pass through this network and a probability of matching will be calculated and closed value will be assigned to it. This is called as forward propagation. But the weights are assigned randomly hence it can give a wrong predication; backward propagation will help in solving this problem [2].

The goal of the back propagation algorithm is to adjust weights at the input side so that the network will produce a higher value if it is shown that picture again. To do this, the back propagation algorithm starts by examining the inputs to the neuron in the output layer. Each input value has a weight variable. The back propagation algorithm will adjust each weight in a direction that would have produced a higher value. The larger an input's value, the more its weight gets increased [2].

B. Robotic Arm

The Robotic Arm used in this system is controlled by Arduino UNO Board. The central processing unit of the board is ATmega328P. It has fourteen GPIOs (general purpose input output) to which the servo motors are connected. This arm works with the help of six motors out of which three are

Tower Pro MG995R and remaining three are SG90 servo motors. Each servo motor is given a supply of 5V externally with the help of power supply. The arm has a five Degree of Freedom and is programmed with the help of Arduino IDE Software. Every part of the Robotic Arm is designed individually and printed with the help of a 3D printer.

The main purpose of the arm is to perform pick and hold operation. It collects bottles one by one and drops them bottle into their respective containers depending upon the RIC codes printed on it.

C. Feature Extraction

In this technique, the objects are classified on the basis of their features, wherein the system detects a particular shape or colour of the object and matches it with the database. Since the triangle containing the Resin identification code is discontinuous as shown in the Fig. 1, feature extraction can't be used to detect RICs, though it can be used for distinguishing the bottles based on its size and colour.

D. Template Matching

Template matching is a technique for finding areas which are similar to that of the template images. For this, databases of template images need to be created. The major drawback of this technique is that the orientation of the template image and source image should match otherwise it won't give desired output. The database required for this method should be large and it should already contain an image of the source. So to make this process simpler, deep learning using tensor flow can be used.

E. Object Detection using TensorFlow and COCO Pre-Trained Models

The TensorFlow Object Detection API can construct, train and deploy object detection models. It is an open source framework. TensorFlow detection model zoo provides a variety of models which are pre-trained on several datasets. Some models have an architecture that allows for faster detection but with less accuracy, while some models give slower detection but with more accuracy. For this project,

Faster RCNN Inception V2 model is used [11]. The following steps explain its working.

Procedure for training the model

- Download and install Anaconda with Python 3.6/3.7 and create a virtual environment.
- Install TensorFlow.
- Install the other necessary packages by issuing the following commands such as Protocol Buffers, Pillow, LXML, Cython, Jupiter, Mat plot, Pandas, Open-CV.
- Download a pre-trained object detection model.
- Add the dataset in train and test folders and label them using LabelImg tool. For each image, an xml file will be created which contains labelled data. The file is saved in two folders namely Test and Train folder.
- Create PYTHONPATH variable in Anaconda Virtual environment and install it.
- Generate Training and Test Data
- Generate .tf record.
- Create Label Map.
- Configure Training.

Each step of training reduces the loss with the help of Forward and Backward Propagation. For an optimum model, the loss should be below 0.05[11].

IV. PROCEDURE

The system consists of two parts, hardware and software part. The hardware consists of robotic arm and the software part is the image recognition. Initially, the robotic arm will pick a plastic bottle from the unsorted container (which consists of a mixture of all types of plastic bottles) and will place the bottle in front of the camera. The camera will click a picture of the base of the bottle and with the help of deep learning it will identify the RIC code. Once the code is recognized, the system will send a signal to the robotic arm with the help of PyCharm Software. Depending upon the signal received, the arm will dump the bottle into the respective container as shown in Fig. 2 [4].

Fig.2 Schematic Diagram of the setup

V. RESULT AND DISCUSSION

By observing the results shown in Fig. 3 to Fig. 10, it can be concluded that this system gives an overall efficiency of about 85%. The dataset contains only 700 images and in order to increase the efficiency of the system we can increases the dataset and retrain the model. The system is currently having a delay of up to 5 sec. To overcome this delay, a graphic card is needed while training the model.

By using this system, many challenges of segregation can be overcome. No more rag pickers will be required and the system is also completely harmless to the environment. The following images show that the system can give output even with the busy and noisy background.

Fig.3 RIC 1

Fig.4 RIC 2

Fig.5 RIC 3

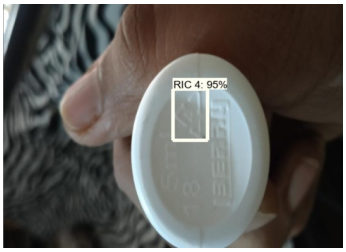

Fig.6 RIC 4

Fig.7 RIC 5

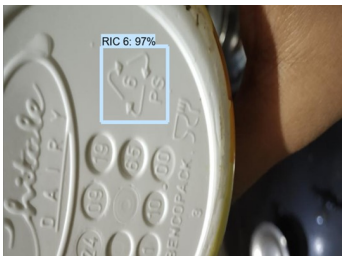

Fig.8 RIC 6

Fig.9 RIC 7

Fig.10 Mix RICs

CONCLUSION

Hence, by using the Template Matching technique one can get an accuracy of 85% but only when orientation of predefined templates and sample image matches. With the help of Deep Learning, one can have an accuracy of 95% without any predefined templates or orientation. Therefore, to meet an accuracy of 100%, we can use a GPU or cloud computing. This system provides an alternate option for NIR Spectroscopy.

A majority of the problems like health issues, increasing amount of waste, air pollution, man power and related economic issues will be solved by implementing this system, leading to an eco-friendly lifestyle.

FUTURE SCOPE

The more efficient method to increase the productivity is by using Conveyor Belt as the hardware instead of robotic arm. Frequency of bottles/containers can be increased. In this method, the bottles will be placed in the hopper through which the bottles will fall on the conveyor belt one at a time. It will move forward and with the help of the cameras located on either side of the belt RIC code will be captured. The bottle will then be dumped into its respective container depending upon the RIC code printed on it. The schematic diagram of the hopper and conveyor belt will be as shown in Fig. 11 and Fig. 12.

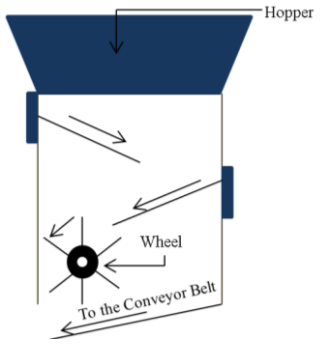

Fig.11 Schematic diagram of hopper

The slider is connected to a Servo motor which helps in the motion of slider. It is at initial position and can be rotated at 30° right or 30° left. It will turn to right for recyclable bottles and to left for non-recyclable bottles [3]. All the three hardware are designed to be in synchronization.

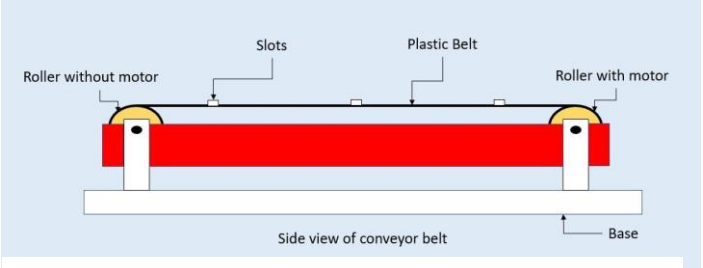

Fig.12 Schematic Diagram of Conveyor Belt

For capturing the picture of base of the bottle, two cameras of mobile phones will be used because of their higher resolution than laptop camera. The live feed from these phones will be directed to the laptop using a mobile application named IP webcam [4]. Using this application any feed can be recorded, directed or captured which make use of Internet Protocol.

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