



GRANULATED RCNN AND MULTI-CLASS DEEP SORT FOR BIODEGRADABLE AND NON-BIODEGRADABLE SOLID WASTE DETECTION

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ABSTRACT:

Solid waste management (SWM) is a major problem for many urban local bodies (ULBs) in India, where urbanization, industrialization, and economic growth have resulted in increased municipal solid waste (MSW) generation per person. Waste management reduces greenhouse gas emissions and improves the quality of air and water, and the condition of any area affected by the waste. This can be overcome by separating the solid waste into two separate medium. The first one will collect the biodegradable waste such as paper, vegetable and fruit waste which can be converted in to energy by using Biomethanation plant. The second one will collect non-Biodegradable waste such as plastic, can, bottles which can be used for recycling purposes. The Biodegradable and Non-Biodegradable wastes separation should be implemented in automatic manner by applying granulated RCNN (G-RCNN) and multi-class deep SORT (MCD-SORT) to predict the type of waste item in accurate manner. The waste material detection has two stages: waste object or material localization (region of interest ROI) and classification. In deep convolution neural network, the G-RCNN is an improved version of the well-known Fast RCNN and Faster RCNN which helps to extract RoIs by incorporating the unique concept of granulation. Granulation with spatio-temporal information enables more accurate extraction of RoIs (waste object regions) in unsupervised mode. Compared to Fast and Faster RCNNs, G-RCNN uses (i) granules (clusters) formed over the pooling feature map, instead of its all feature values, in defining RoIs, (ii) only the positive RoIs during training, instead of the whole ROI-map, (iii) videos directly as input, rather than static images, and (iv) only the objects in RoIs, instead of the entire feature map, for performing waste object classification. All these lead to the improvement in real-time detection speed and accuracy. MCD-SORT is an advanced form of the popular Deep SORT. In MCD-SORT, the searching for association of objects with trajectories is restricted only within the same categories. This increases the performance in multi-class tracking.

KEYWORDS:

BIOMETHANATION PLANT, RCNN, MCD-SORT, ROI, BIODEGRADABLE.

INTRODUCTION

The objective of this paper is to predict the waste item category by capturing image and collects in separate chambers. The camera placed inside the dustbin will capture the image of the waste item. The Raspberry pi helps to compare the image with the dataset in the cloud. The Artificial Intelligence concept is applied to train itself to find the captured waste item category. The image classification algorithm is applied using Tensor Flow in executing digital image processing to find the corresponding chambers for waste collection. The Tensor Flow is a Python friendly open source library for numerical computation that makes machine learning concepts in an efficient manner. The algorithm will be trained with all types of waste material and thus while throwing the waste into the dustbin, it get predicted and as per the prediction the corresponding chamber opens to collect waste. The project helps in collecting waste in different chambers by detecting biodegradable and non biodegradable waste. The manual collection of waste can be overcome therefore the collection of waste can be computerized and accuracy level will be more. This will

decrease the percentage of non biodegradable waste into land which increases the land water and overcome the pollution. The waste management places a vital role in Smart city and Clean India mission that can be achieved by separating the solid waste into two medium and make use of those waste effectively for recycling and energy production.

PROBLEM STATEMENT

Most recyclable waste ends up in a dump yard due to the lack of efficient waste management. Waste management rules in India are based on the principles of "sustainable development", "precaution" and "polluter pays". These principles mandate municipalities and commercial establishments to act in an environmentally accountable and responsible manner—restoring balance, if their actions disrupt it. The increase in waste generation as a by-product of economic development has led to various subordinate legislations for regulating the manner of disposal and dealing with generated waste are made under the umbrella law of Environment Protection Act, 1986

(EPA). Specific forms of waste are the subject matter of separate rules and require separate compliances, mostly in the nature of authorisations, maintenance of records and adequate disposal mechanisms.

With rapid urbanisation, the country is facing massive waste management challenge. Over 377 million urban people live in 7,935 towns and cities and generate 62 million tonnes of municipal solid waste per annum. Only 43 million tonnes (MT) of the waste is collected, 11.9 MT is treated and 31 MT is dumped in landfill sites. Solid Waste Management (SWM) is one among the basic essential services provided by municipal authorities in the country to keep urban centres clean. However, almost all municipal authorities deposit solid waste at a dump yard within or outside the city haphazardly. Experts believe that India is following a flawed system of waste disposal and management.

All those wastes can be used almost 99 % in an effective manner without ends up in landfills. This can be achieved by separating the waste into two different medium as recycle and energy generated. This research is focused on this area to make India as a success in Smart City mission and Clean India. In Tamil Nadu more than 59 % of waste ends up in landfills that contaminate the soil, ground water and emit dangerous green house gases. Manual separation of biodegradable and non biodegradable wastes can't succeed.

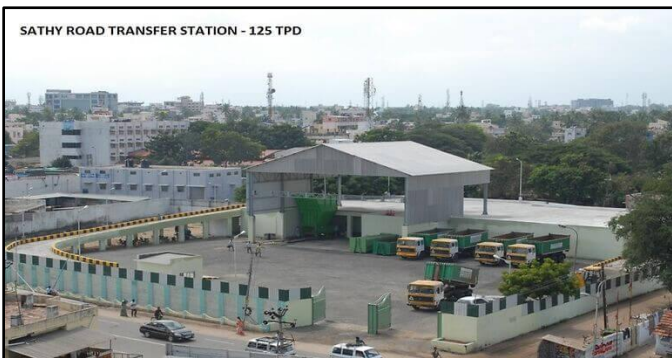


FIG. 1 BIOMETHANATION PLANT AT COIMBATORE

The TN government constructs Biomethanation Plant to generate energy from Biodegradable waste constructed at Bharathi Park, Coimbatore which generates 150 – 170 Unit of electricity per day. The main problem is that the unit can't get biodegradable waste in proper manner.

DESIGN AND IMPLEMENTATION

WORKING OF G RCNN

1. The method takes an image as input and extracts around 2000 region proposals from the image(Step 2 in the above image).
2. Each region proposal is then warped(reshaped) to a fixed size to be passed on as an input to a CNN.
3. The CNN extracts a fixed-length feature vector for each region proposal(Step 3 in the above image).
4. These features are used to classify region proposals using category-specific linear SVM(Step

4 in the above image).

5. The bounding boxes are refined using bounding box regression so that the object is properly captured by the box.

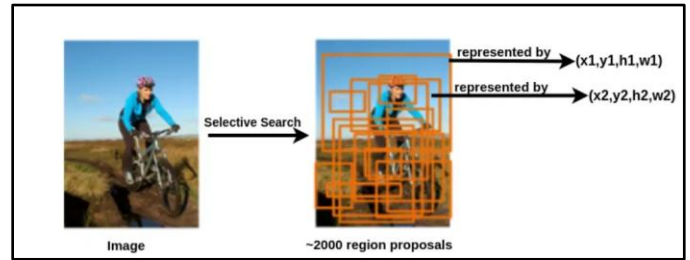


FIG. 2 G RCNN WORKING

CALCULATING REGION PROPOSALS

Region proposals are the bounding boxes that may contain an object. These are represented by a tuple of 4 numbers(x,y,h,w). The (x,y) are the coordinates of the centre of the bounding box and (h,w) are the height and width of the bounding box respectively. These region proposals are calculated by an algorithm called selective search. For an image, approximately 2000 region proposals are extracted.

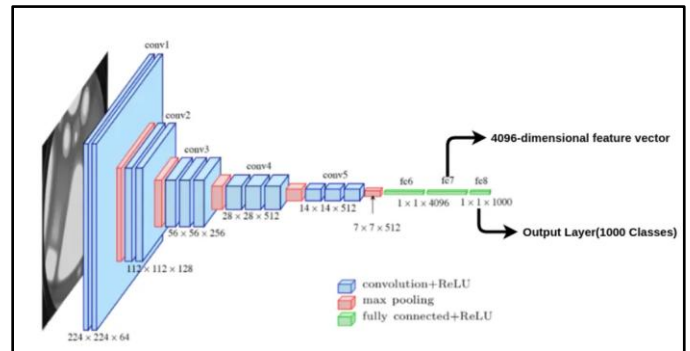
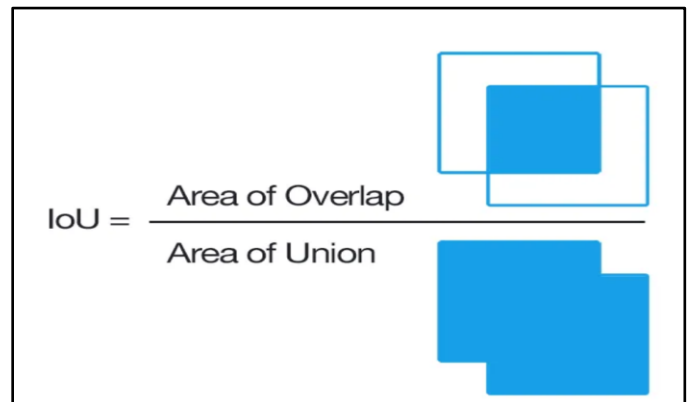


FIG. 3. G RCNN TO CALCULATE OBJECT REGION

TRAINING G RCNN FEATURE EXTRACTOR

To measure the performance of a classification model, we generally use metrics like accuracy, recall, precision etc. But how to measure the performance of object detection. In object detection we have to evaluate two things:



The IoU score measures how close the predicted box is to the ground truth. It is the ratio of the area common to

ground truth and predicted box to the total area enclosed by both the boxes.

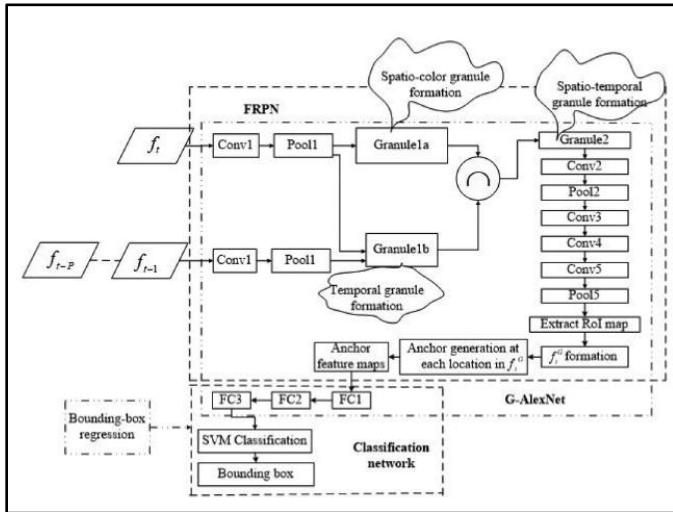


FIG. 4 G-RCNN ARCHITECTURE

SORT AND DEEP-SORT EVALUATION

The proposed WM data association cost matrix formulation requires the selection of three constant values (weights) to control the influence of each data association cost matrix. Table 2 shows the evaluation performed on the MOT17 dataset with different weight value combinations of the WM cost matrix. Based on the achieved results, the highest MOTA value was attained using: $\lambda_{IoU}=710$, $\lambda_{DE}=210$ and $\lambda_R=110$. The aforementioned weight configuration has the minimum number of FP and IDs, despite the higher number of FNs. Furthermore, it has the minimum number of FM by a large amount. Therefore, throughout the following evaluations, the aforementioned values were used for the WM cost matrix.

An evaluation of SORT and Deep-SORT, where the data association threshold is modified, was also performed on the MOT17 dataset. As expected, as the threshold value increased, the MOTA score decreased for the majority of the cost matrices. As observed, no threshold value was found to be suitable for all evaluated cost matrices. Hence, the best results were obtained using a threshold value of 0.3, which was thereafter used for all the evaluations.

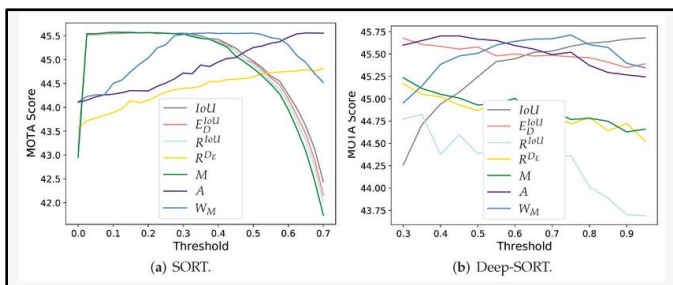


FIG. 5 TRACKING TO PREDICT WASTE MATERIAL

IMPLEMENTATION

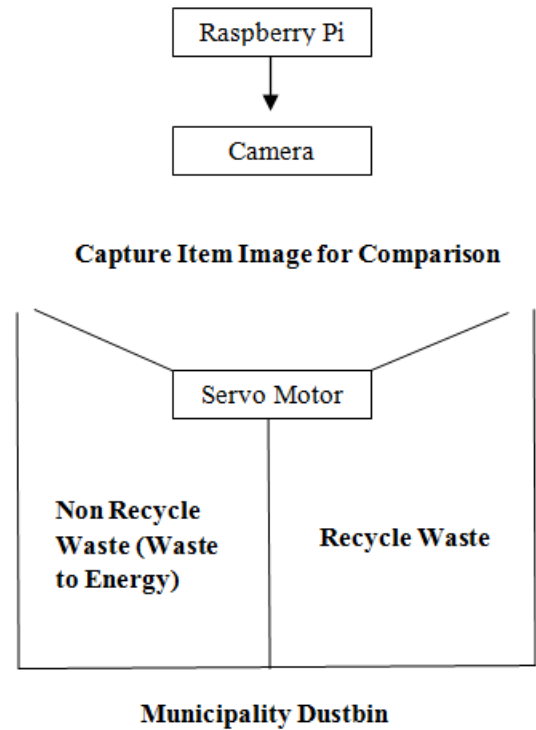


FIG. 6 IMPLEMENTATION WORK FLOW

AI TO PREDICT TYPE OF WASTE

The camera attached in the dustbin will capture the image of object thrown into the dustbin. The API will be trained by MS COCO dataset (Common Object in Context) which will be compared with the captured image to predict level of waste medium.

- Medium 1 - Waste for recycle (plastic, metal, glass)
- Medium 2 - Waste for producing energy by using WtE (Waste to Energy) project.

The camera attached with the Raspberry pi is used to capture the waste item image which gets compare to find the medium for waste collection.



FIG.7 RASPBERRY PI TO SUPPORT PYTHON TOOL



FIG. 8 CAMERA MODULE TO CAPTURE WASTE OBJECT IMAGE

OPERATE SERVO MOTOR

The servo motor attached in the dustbin will operate as per the degree to collect the waste in two different separations as per the medium. The value of degree for servo motor to open is as follows.

- 30 degree – to open recycle waste collection door
- -30 degree – to open non recycle waste collection door

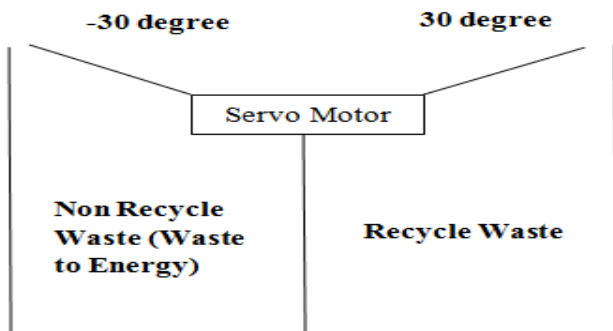


FIG. 9 SERVO MOTOR TO OPERATE DUSTBIN DOOR

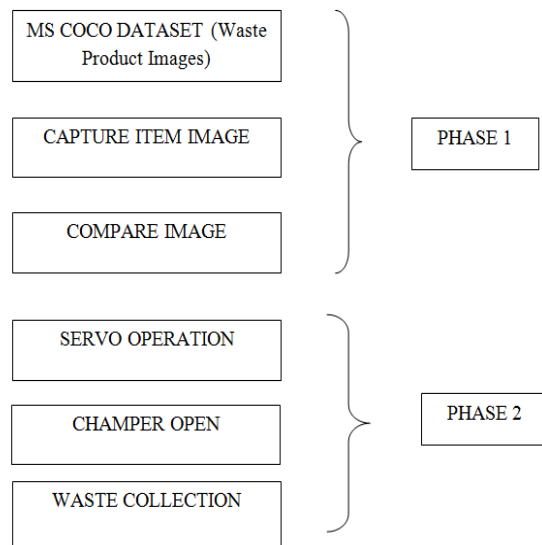


FIG. 10 CLASSIFICATION BLOCK DIAGRAM

PROGRAMMING RASPBERRY PI

LOAD A (WASTE) TENSORFLOW MODEL INTO MEMORY

```
detection_graph = tf.Graph()
with detection_graph.as_default():
od_graph_def = tf.GraphDef()
with tf.gfile.GFile(PATH_TO_CKPT, 'rb') as fid:
serialized_graph = fid.read()
od_graph_def.ParseFromString(serialized_graph)
tf.import_graph_def(od_graph_def, name="")
```

DETECTION OF WASTE ITEM IMAGE

```
with detection_graph.as_default():
with tf.Session(graph=detection_graph) as sess:
while True:
# Read frame from camera
ret, image_np = cap.read()
# Expand dimensions since the model expects images to have
shape: [1, None, None, 3]
image_np_expanded = np.expand_dims(image_np, axis=0)
# Extract image tensor
image_tensor =
detection_graph.get_tensor_by_name('image_tensor:0')
# Extract detection boxes
boxes =
detection_graph.get_tensor_by_name('detection_boxes:0')
# Extract detection scores
scores =
detection_graph.get_tensor_by_name('detection_scores:0')
# Extract detection classes
classes =
```

```
detection_graph.get_tensor_by_name('detection_classes:0')
# Extract number of detectionsd
num_detections = detection_graph.get_tensor_by_name(
'num_detections:0')
# Actual detection.
(boxes, scores, classes, num_detections) = sess.run(
[boxes, scores, classes, num_detections],
feed_dict={image_tensor: image_np_expanded})
# Visualization of the results of a detection.
vis_util.visualize_boxes_and_labels_on_image_array(
image_np,
np.squeeze(boxes),
np.squeeze(classes).astype(np.int32),
np.squeeze(scores),
category_index,
use_normalized_coordinates=True,
line_thickness=8)
```

STEPS IN DETECTION THE OBJECT IN MUNICIPALITY DUSTBIN

- Gather & Label object pictures
- Generate Training Data
- Train Object Detector
- Export inference graph
- Implement Algorithm (R-CNN)
- Test object detection

GATHER & LABEL OBJECT PICTURES

The dataset is trained by 225 different biodegradable and non biodegradable waste images and labeled. This dataset is used to compare with the current captured image, to predict the waste category.

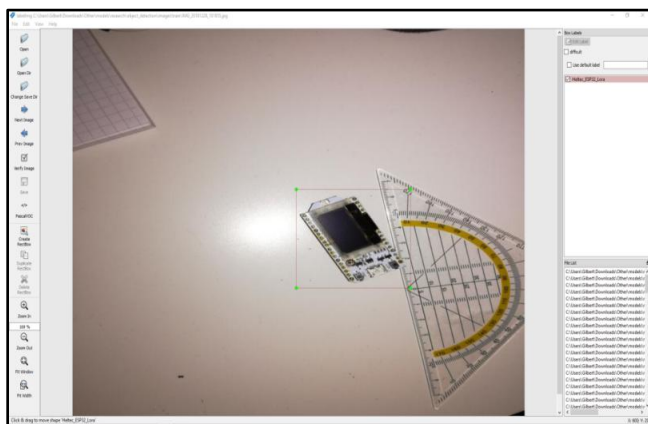


FIG. 11 LABEL WASTE MATERIAL

GENERATE TRAINING DATA

The dataset separated into 20 % as Testing Data and 80 % as Training Data to predict accuracy level. The training data generates the fields such as image width, height,

waste type, x and y values. This trained data helps to predict the type of product in accurate manner.

Filename	width	height	class	xmin	ymin	ymax	ymax
1 cam_image2.jpg	960	540	biodegradable	312	30	485	249
2 cam_image2.jpg	960	540	biodegradable	514	24	694	245
3 cam_image2.jpg	960	540	biodegradable	305	263	489	519
4 cam_image2.jpg	960	540	biodegradable	515	267	704	523
5 cam_image4.jpg	960	540	non biodegradable	297	18	459	237
6 cam_image4.jpg	960	540	non biodegradable	479	0	603	233
7 cam_image4.jpg	960	540	non biodegradable	287	270	457	535
8 cam_image4.jpg	960	540	non biodegradable	488	263	688	510
9 cam_image5.jpg	960	540	non biodegradable	739	166	899	403
10 cam_image5.jpg	960	540	non biodegradable	562	145	733	367
11 cam_image5.jpg	960	540	biodegradable	365	150	550	399
12 cam_image5.jpg	960	540	biodegradable	150	174	358	434
13 cam_image5.jpg	960	540	biodegradable	309	46	476	257
14 cam_image5.jpg	960	540	biodegradable	495	37	663	249
15 cam_image5.jpg	960	540	biodegradable	308	285	478	518
16 cam_image5.jpg	960	540	biodegradable	499	37	663	249
17 cam_image5.jpg	960	540	biodegradable	307	32	478	243
18 cam_image6.jpg	960	540	non biodegradable	504	32	676	243
19 cam_image6.jpg	960	540	non biodegradable	300	272	462	518
20 cam_image6.jpg	960	540	non biodegradable	504	272	693	518
21 cam_image6.jpg	960	540	non biodegradable	266	12	217	177
22 cam_image7.jpg	960	540	non biodegradable	450	0	629	234
23 cam_image7.jpg	960	540	biodegradable	260	272	426	528
24 cam_image7.jpg	960	540	biodegradable	444	273	632	528
25 cam_image8.jpg	960	540	biodegradable	212	15	383	238
26 cam_image8.jpg	960	540	biodegradable	407	13	578	236
27 cam_image8.jpg	960	540	non biodegradable	205	270	385	520
28 cam_image8.jpg	960	540	non biodegradable	412	267	506	517
29 HMC_23A3.jpg	378	504	non biodegradable	97	136	276	368
30 HMC_23A3.jpg	378	504	biodegradable	135	203	250	327
31 HMC_23A3.jpg	378	504	non biodegradable	709	167	249	349

FIG. 12 WASTE PREDICTION DATASET

TRAIN OBJECT DETECTOR

The tensor flow is used to train the data and its coordinate details. This helps to find the similarity of objects and predict the type of waste object with more accuracy.

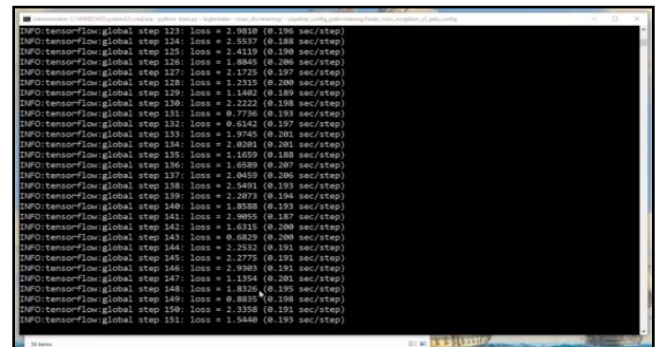


FIG. 13 TRAIN DATASET USING G-RCNN

EXPORT INFERENCE GRAPH

The inference graph shows the level of data trained. Here the level reaches 67 % after 5 hours of comparison

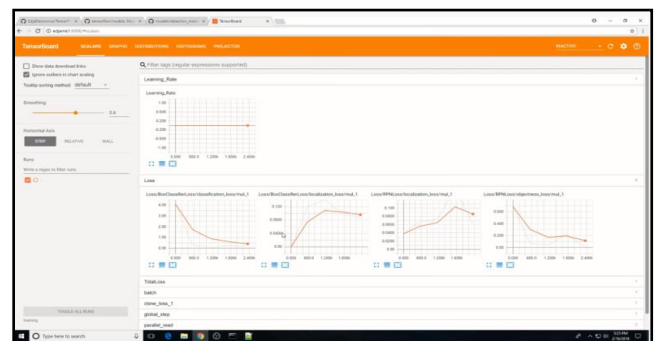


FIG. 14 GRAPHICAL VIEW OF TRAIN DATA

IMPLEMENT ALGORITHM (G - RCNN)

PROBLEM FACED

Different objects or even the same kind of objects can have different aspect ratios and sizes depending on the object size and distance from the camera.

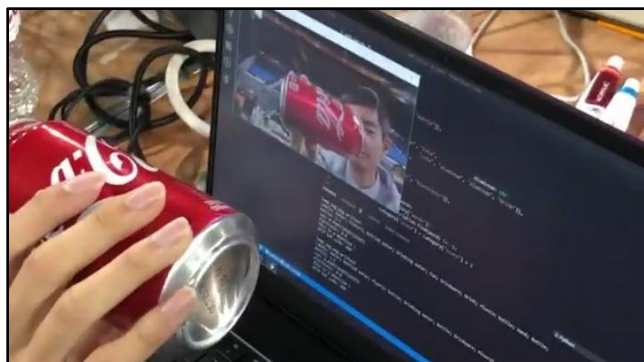
SOLUTION

To overcome this problem R - CNN Algorithm is used to

slit image into various boundary box. Instead of matching overall image, each boundary get matched therefore prediction will be high and accurate

RESULT

The overall waste images are trained and form a dataset. The camera opens to capture the image and compared with the dataset to predict the type of waste.



DETECT BIODEGRADABLE & NON BIODEGRADABLE WASTE BY CAMERA CAPTURING

The servo motor attached with the dustbin will open the corresponding chamber to collect the biodegradable and non biodegradable waste. The dustbin can be computerized and thus the waste can be used in an effective manner for both energy production and recycle.



COLLECT BIODEGRADABLE & NON BIODEGRADABLE WASTE IN CORRESPONDING CHAMBER

CONCLUSION

This implementation helps in collecting biodegradable and non biodegradable in different chambers in effective manner. The biodegradable waste can be used to generate methane gas that helps to produce electricity. The Non biodegradable waste can be recycled. Therefore the 59 % of waste ends up in landfills can be reduced more than below 5 %.

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