DEXTEROUS TRASHBOT

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Introduction:
   Garbage segregation mechanism assembles a wide range of waste in an unsorted way by utilizing physical work. Segregation of this waste is repetitive, hazardous and tedious. The project aims to provide a novel solution to eliminate the redundant activity with the help of deep learning and robotics.
   The process of classification of waste is accomplished using the concept of deep learning. The model so obtained was trained on dataset comprising of images belonging to five categories namely, paper, plastic, cardboard, glass and metal. The classified waste is then segregated with the help of a robot which is equipped with a single axis robotic arm.

Objectives:
   - To obtain required datasets needed to be able to segregate garbage.
   - To applying deep learning to classify objects in real time.
   - To deploy the deployed deep learning model and classify the live image taken by making requests or API call.
   - To pick the corresponding object using the robotic arm.
   - To segregate the garbage into respective category.

Methodology:
Object Classification:
   The deep learning model was trained using Google Colab on the dataset. Pytorch was used as a tool to train the model. A CNN model was built initially and then transfer learning approach was used to come up with highly accurate models with the help of architectures like ResNet and Vgg. The model so obtained was then deployed using a “Flask” application on “render”. A POST request at the endpoint is used to predict the class image of garbage.

Object picking:
   - The image of the garbage is captured through the web camera.
   - The image so obtained is sent as a multipart-encoded file through a HTTP POST request to the desired endpoint for classification.
   - The garbage is classified from one of the five categories and the result is obtained by prediction from the deployed model.
• The robot then navigates to the desired object.
• The garbage is picked with the help of a robotic arm if feasible.
• Corresponding to the classification, the garbage is segregated into its respective category.

When the control program is started from the raspberry pi the robot will be slowly moved towards the target object from its initial position. Once the robot is in the vicinity of the object, it will be stopped. The control program then takes a picture of the target object and send a HTTP POST request to the deployed deep learning model. The trained deep learning model detects the waste object present in the picture and classifies it to the one of the categories mentioned above. The result of classification is sent back to the control program running in the raspberry pi. After obtaining the result, the robotic arm picks the waste object and travels backwards to its original position. Based on the result obtained from the deep learning model, the robot travels in one of the five directions and segregates the waste picked according to the category detected. In the control program a particular direction is mentioned for each of the five waste categories.

A single axis robotic arm with two degrees of freedom is designed to pick the waste object classified by the deep learning model. The robotic arm is made up of two servo motors to provide two degrees of freedom. The robotic arm can move up and down with the help of the servo motor attached to the base. The claw of the robotic arm opens and closes based on the movement of the second servo motor attached at the tip of the robotic arm. The arm is designed in L shape to easily pick the target object. Both the servo motors are controlled by raspberry pi. Angle to which the servo motor should rotate is specified by giving a signal with particular duty cycle.

Results And Conclusion:

The deep learning models developed using the concept of CNN and various known architectures have helped in achieving the objective of the project. The model producing the best results was used for deployment and serving on the cloud platform. A combination of metrics are used for comparing the models. These are:

1. Confusion Matrix
2. Accuracy
3. F1 – Score
Accuracy and F1-Score of Models

<table>
<thead>
<tr>
<th>Architecture</th>
<th>Accuracy</th>
<th>F1-Score</th>
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</thead>
<tbody>
<tr>
<td>ResNet-34</td>
<td>86.8201</td>
<td>86.7281</td>
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<tr>
<td>ResNet-50</td>
<td>89.1213</td>
<td>89.0312</td>
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<tr>
<td>Vgg-16</td>
<td>90.0962</td>
<td>90.0812</td>
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<tr>
<td>Vgg-19</td>
<td>89.5397</td>
<td>89.49214</td>
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</tbody>
</table>

Confusion Matrix of ResNet-34

Confusion Matrix of ResNet-50

Confusion Matrix of Vgg-19

Confusion Matrix of Vgg-16

It can be seen that Vgg-16 performs the best among the models. The models developed are dependent on the dataset which is a collection of images. In order to increase the accuracy of the model it is necessary to build a better dataset. Creating a cohesive dataset helps in improving the performance of the system.

Picking and segregating the classified waste
Scope For Future Work:

The project uses state-of-the-art technology to solve the problem of garbage segregation. However, it should be noted that the application developed is a classifier with only few classes. This is a limitation due to the dataset available. Also, the lack of computing resources prevents the possibility to use state-of-the-art object detection algorithms like SSD and YOLO. Building an autonomous robot with the capability to use the robotic arm, involves complex mechanisms like navigation, object avoidance during path traversal and feasibility to pick the objects. Also, the support for Kinect based services is stopped and finding 3-D coordinates to map real world scenarios is hard in real-time. Application deployment and accessibility is a concern and using third party cloud platform as service involves investment of money. This can be taken care by deploying on other established cloud computing platform services like AWS and Azure. The limitation to implement the same being inadequate support for the requisite libraries. Finally, while using the application, the images from real-time scenarios used for classification can be used to enrich the existing dataset in-order to create a cohesive dataset for image classification. This problem can be solved by reusing the same images and storing it in the dataset and re-training the model.

Thus, the project is a novel solution solving the purpose of segregation of garbage and has achieved the objectives.