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AI Powered Garbage Detection System

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ABSTRACT

The aim of this research is to develop a smart waste management system using TensorFlow based deep learning model. It performs real time object detection and classification. The bin consists of several compartments to segregate the waste including metal, plastic, paper. Object detection and waste classification is done in TensorFlow framework with pre-trained object detection model. This program classifies an input image as clean/unclean. This can later be used to automatically send alerts to respective authorities when a street is found to be unclean. Once a street is found to be unclean, it automatically sends an email alert to the respective authorities who can then take action. It is impossible to manually identify streets that require cleaning at a given time. With "CCTV Street Garbage Detection and Alert System", authorities can get updates about the streets that are unclean.

Keywords : Deep Learning Model, Tensor Flow Framework, Classification.

I. INTRODUCTION

Monitoring and cleanliness assessment of garbage area in urban scenes mainly rely on manual inspection and photographic record, which makes it a difficult and time consuming task. During the inspection process, human intervention and cumbersome problems often happen. The quality of sanitation work has been affected. Different from pedestrians, vehicles and other objects, garbage have no relatively clear definition. Due to the judgment of garbage always has certain subjectivity, in different situations, it will produce different judgment results. Since the diversity of scenes where garbage appears, accuracy of test results will be affected. With the development of smart city, we expect to provide an automatic detection method of urban garbage to help alleviate urban garbage problems. Before the development of deep neural networks, features were manually designed, then followed by a classifier. Some research focused on the classification and recycling of garbage a few years ago. For example, Sudha S et al. proposed a model for classifying objects as biodegradable and non-biodegradable. Although the traditional object detection already has some mature techniques, due to the morphological diversity, illumination diversity, background diversity and other factors of the target object, the detection precision for the unfixed form objects such as urban garbage is still a tough problem to solve. The past decade has witnessed a rapid development of massive data and high-performance computing systems such as graphics processing units

(GPUs).Now regionbased CNN detection methods have dominated many tasks of computer vision. It is such an exciting area that can extract the high-level features and the hierarchical feature representations of the objects. Girshick et al. introduced a region-based CNN (RCNN) for object detection, from 2014 to now, R-CNN, Fast R-CNN, Faster R-CNN, ION, HyperNet, SDP-CRC, YOLO, G-CNN, SSD and other increasingly fast and accurate object detection methods have emerged.

The scope of the project is Monitoring and cleanliness assessment of garbage area in urban scenes mainly rely on manual inspection and photographic record, which makes it a difficult and time consuming task. Traditional waste management system operates based on daily schedule which is highly inefficient and costly. The existing recycle bin has also proved its ineffectiveness in the public as people do not recycle their waste properly. With the development of smart city, we expect to provide an automatic detection method of urban garbage which makes it easy. This Machine Learning based program is built using tensorflow and classifies images from any CCTV camera to identify streets that are unclean. The model is trained with hundreds of images of clean and unclean images so as to let theprogram identify a new image as clean or unclean.

II. RELATED WORK

The cleanliness of city street is directly related to the city's public image. To maintain the streets clean, different methodologies have been developed in the past years. These methodologies can be classified into two directions: evaluating the street cleanliness, monitoring the waste. In order to evaluate the street cleanliness, Sevilla et al. proposed a clean index for measuring the level of cleanliness of the city streets, such that the quality and governance of public services can be evaluated. However, the process of measurement requires a lot of human intervention like collecting data and rating data. Lopez et al.developed an App to evaluate the street cleanliness and waste collection service. Specific methodologies for calculating and evaluating 21 indicators have been designed to give a true reflection of the level of city street cleanliness. Although this App can collect information from the user end and store information in the application database, it still needs users to fill the information manually in the App. Li et al.put forward a multi-level assessment system and showed how the cleanliness status of streets is collected by using mobile stations. The results are transmitted through city network, analyzed in the cloud and presented to city administrators online or on mobile. Regarding monitoring the waste, Rovetta et al. used sensors to monitor waste bins based on distributed sensor technology and geographical information systems. Begur et al. focused on illegal dumping problems in the City of San Jose. They proposed an innovative smart mobile-based service system, which supports real-time illegal dumping detection, altering, monitoring, and management. Alfarrarjeh et al. presented an automating geo-spatial classification approach to determine the level of street cleanliness. The experiments compared various combinations of classifier and image features, which show that SVM classifier based on CNN image features obtained good values on both precision and recall. Balchandani et al. proposed a deep learning framework for smart street cleaning, which aims at providing any city with an automated way to monitor the cleanliness of its streets. It is a good idea to use deep leaning technology to automatically detect and classify litter, but this paper only provided with a simple example about separating the street and the curb, and the performance of detection and classification was not discussed. The proposed approach in this paper is also based on recent advances in deep learning. Related work in deep learning is introduced in the next paragraph.

III. PROPOSED SYSTEM

Message Queuing Telemetry Transport (MQTT) MQTT is a lightweight and simple massaging protocol designed for constrained devices. MQTT protocol consists of 2 main parts is the server and the client. Client is then divided into 2 parts which is the sending communication machine and information feedback machine. In this project, the server is the 4 DoF robotic arm, and the sending communication machine is the camera. Also, the information feedback machine is the 3 trash bins. The reliability of MQTT is managed by 3 Quality of Service: level 0 is the massage is sent almost one and no acknowledgement of reception is required, level 1 is the massage is sent almost one and acknowledgement of reception is required, level 2 is a four-way machanism is used for the delivery of massages only one [12].

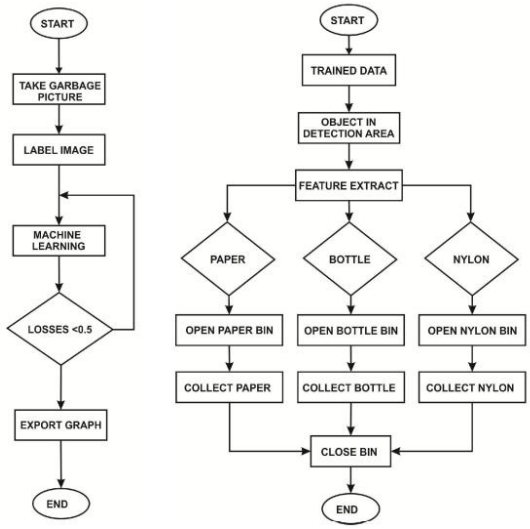

Fig 1(a). diagram of training Fig 1(b). diagram of testing

In our project, we have 2 parts for recognising and sorting. The first part is when we train the model by appling labelling images into the model (Fig 7a). The model will be stopped when the loss function reaches 0.5. For the sorting process, the robotic arm will be controlled to move and drop the garbage bottle, nylon or paper into the corresponding bin.

IV. RESULTS AND DISCUSSION

This section shows the evaluation of this method for garbage recognition and the analysis of loss function in detail. The results and discussions will be divided into parts: classification loss function, smooth L1 loss in regression loss, manual control of 4 DoF, and detection and classification results.

Cross-entropy in classification loss function:

For the trash dataset, the reported error was high until the 1000 iteration, then started to go down. However, at the start of the training, more and more feature of the images has been extracted by simple filters and therefore the loss function decrease dramatically. As more and more feature has been extracted, the object can then be identify and classify and because of that, the loss function decreases more slowly. The graph produces a trend therefore it can be recognised as the machine had found a solution. The final result after over 90000 steps, the loss value is 1.15

Figure 2. Classification loss graph

Smooth L1 loss in localization loss function

Localization is a special topic of SSD because this model of recognition can recognise large object accurately but this accuracy value decreases as the object gets smaller. As the machine learns at a greater amount of steps, the value of localisation loss decreases. This is because the predicting box at first mismatch a lot with the ground-truth bounding box (labelling box) leads to low value of IoU. As more and more kernels have been used to extract features, the

object is detected more accurately and the localisation loss decreases shown as in Fig 3.

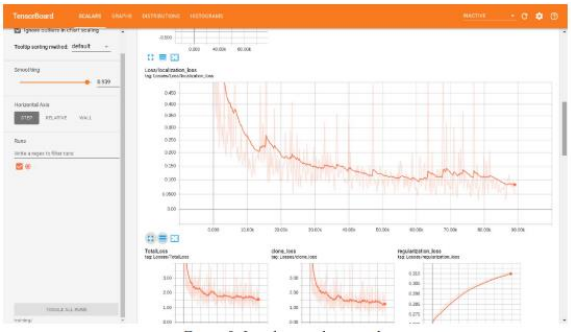

Figure 3. Localization loss graph

V. CONCLUSION

The recognition and classification of garbage based on convolution neural network for quickly and accurately was proposed. In this project, by using SSD-MobileNetv2, the server can identify and classify 3 type of garbage: bottle, nylon and scrap paper. All garbage has been labelled and the position is returned to the 4 DoF. 4 DoF can pick up and return the garbage to the correct trash bin. With SSD-MobileNetv2, the recognition and classification of garbage have achieved a high level of accuracy but the current author desires to seek for a better training methods.

The performence of the project can be improved by:

1. More and more models of training must be collected and investigated. This will improve the performance of the classification.
2. The region of labelling images must be carefully labelled for more accurate training.
3. Because the model can recognise 3 types of garbage, more type can be added to compare and evaluate the training model.

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