Comparison on Cloud Image Classification for Thrash Collecting LEGO Mindstorms EV3 Robot

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Abstract—**The world today faces the biggest waste management crisis due to rapid economic growth, congestion, urban planning issues, devastating negative symptoms and political affairs. In addressing this waste management problem, many methods of solving waste management have proven not to be as planned. In this high technology era, the innovation of humanoid robots is found to be helpful to support the everyday human life. The industry is gearing towards automation to increase productivity at the same time will improved quality of life to local communities. Therefore, in this paper Thrash Collecting Robot (TCR) is proposed to help provide automatic control in thrash collection. The TCR, built on the LEGO Mindstorm EV3 robot, can distinguish between static and dynamic barriers, and can move according to the programming that has been created. TCRs are basically composed of sensors designed according to different requirements in order to detect dynamic barriers. TCR is one type of Cloud Robot that implements image processing techniques to identify the type of waste that has been collected. The concept of image processing built in TCR by using Cloud Representational State Transfer (REST API). This concept has been applied by Google Cloud API and Sighthound. This cloud services used machine vision techniques to identify and classify the type of thrash images; whether it is plastic, metal or paper. Experiment results show that SightHound gives accurate result compared to Google Cloud in classifying thrash types.**

Keywords—Image processing; LEGO Mindstorm EV3 robot; Cloud Robot; Google Cloud API and SightHound.

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I. INTRODUCTION

Machine vision provides the technology on image analysis applications, for example in classification, identification, and robot guidance which usually use in industry. Image processing is one of the element which provides the algorithm such as in edge detection[1] in order to obtained accurate localisation on image[2]. Machine vision plays an important role in robotic applications.

Robots are human like machines that are capable of doing what they are programmed to do. They have shown significance in decreasing human workloads; especially in industry. In manufacturing tasks, speed and efficiency have historically been improved upon by robotic systems. Robots have replaced humans in many industries; especially in repeated or dangerous situations. A line follower robot is generally a robot that tracks and follows a pre-defined black line or path on a white surface [3]. The importance of the robotics field has been acknowledged by researchers since machine development first began, because it provides a useful tool for environment detection and decision-making during automation processes. Drawbacks of robotic operations include extra hours needed for programming and they are limited to certain predefined operations that cause rigid automation. One solution to improve system adaptability is to integrate image processing and make it open to other potential applications. For example, work by [4] aimed to imitate human behaviour in sketching human facial portraits. There are 10 types of new robotic trends, which are bio inspired robots, micro-nano-femtorobots, walking machines, toy robots, ubiquitous robots, household robots, cloud robots, flying robots, autonomous driving vehicles and modular self-reconfiguring robots.

Trash management becomes serious problem for citizens in the world and environment. People might not be realise it, but the world is now facing big problems when it comes to waste management. However, nowadays many people are unable to work as cleaner as they could only get low salary by doing that job. In the future with the development of robotic and artificial intelligence areas, all routine work collecting and separating garbage will be assisted by robots and humans will only be supervisors . So, there's possible market for government to purchase the robot to solve the trash problems. Therefore, this TCR was build and designed to solve this problem as it would not only be collecting trash but also categorise the trash to the type of object accordingly. So, in this case, people might purchase this TCR where it can be used to educate people to recycle but not only throw the rubbish inside the trash bins.

TCR is a smart robot that can collect garbage and put it in place. TCR distinguishes waste material and puts it in suitable containers. This robot helps people clean the area without monitoring it. Problems with traditional systems require a lot of labour to do cleaning work. The ideal solution for reducing the workforce to do the same work repeatedly is to use a smart cleaning agent that can clean the city in a more effective way.

TCR can be categorized as a household robot. The smart bin robot was designed to focus on selecting the type of rubbish by using a blob detection algorithm, which enabled it to open and close its lid automatically [5]. The clean-up task, designed in [6], uses a more unstructured procedure, within which the robot needs to clean a table and categorize trash accordingly, after cooking is completed. Even though the robot can finish its task, it still depends on a processor to classify trash image types, which can be quite difficult.

Cloud robots are said to be exciting possibilities in the near future, because of their reduced requirements for on-board processing, which can increase efficiency in performing complex tasks [7]. A Google researcher claimed that cloud computing could make robots smaller, cheaper, and smarter. Calling this approach 'cloud robotics,' it allows the robot to offload computer-intensive tasks, like image processing. Cloud robotics could make that possible by expanding the robot's knowledge beyond its physical body [8].

Representational State Transfer (REST) is designed to bring dominance advantages of current protocols. REST can be used for nearly all existing protocols. It helps developers without installing libraries or additional software. REST data doesn't depend on any techniques or resources and has the ability to handle various types of calls, return different data formats and alter structures with proper hypermedia implementation. There are two 'Clouds' that claim to use the REST concept, namely Google Cloud API and SightHound. These Clouds allow developers to understand computer visions in image content by enabling a powerful machine learning model to classify images, detect objects and read printed words contained within images. These Cloud API were used in [9]–[12].

This paper proposes a trash collecting robot that can classify trash and insert it into corresponding bins. Here, a comparison between two cloud services for image processing, Google Cloud API[13] and SightHound [14], will be executed.

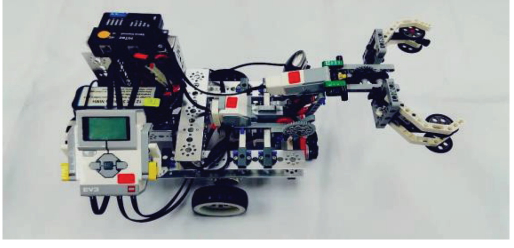
II. TRASH COLLECTING ROBOT (TCR)

The proposed robot use image processing to identify the type of recyclable trash and allocation to different recycling bins. For image processing, cloud services are used to identify the content of the captured image[15]. Fig. 1 presents the TCR robot design from different views.

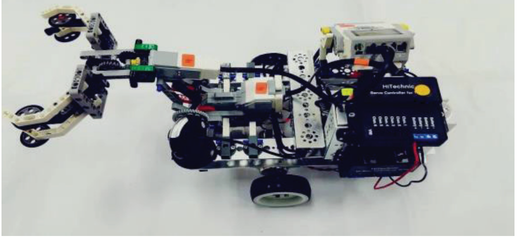
The method used for our research testing phase is rapid prototyping. The robot is tested from phase to phase; each phase tests whether the robot can achieve the project objective or not. Rapid prototyping has been used primarily to test robot functionality. The people involved during this testing phase are the group members (who will develop and test the robot) and the supervisor (who will supervise the entire project). The first phase tests the movement of the robot i.e., whether the robot can move forwards smoothly, in order to test the functionality of the motor.

During the second phase, we test the functionality of the ultrasonic sensor; which helps the robot to judge distances and "see" where objects are located. The sensor can detect an object and measure its proximity in inches or centimetres. This sensor is implemented in the TCR and to stop movement when an obstacle is detected at a certain distance (in this case, 75 cm for image capture and 12cm to pick the object up).

In the third phase, we test the functionality of the colour sensors. The colour sensors enable the robot to detect colour for 'line following' and the colour of the relevant trash bin. We used black and red sticky tape to make the line on the map. The robot will follow the black line for straight movement and stop when it reaches a red line. It will then follow the red line to go to the designated bin. We also used blue, orange and green coloured paper for trash bins; to differentiate between types of material i.e., tin cans, bottles and paper; based on the captured image (see Fig. 2).

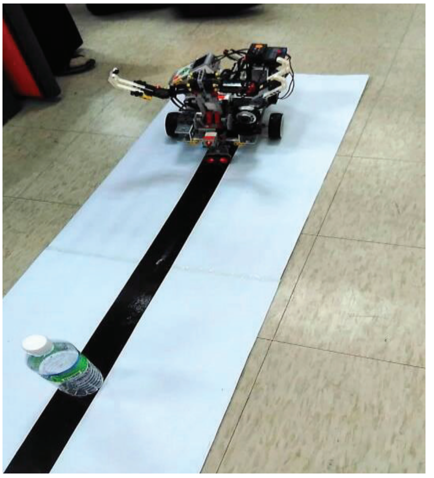


(a)

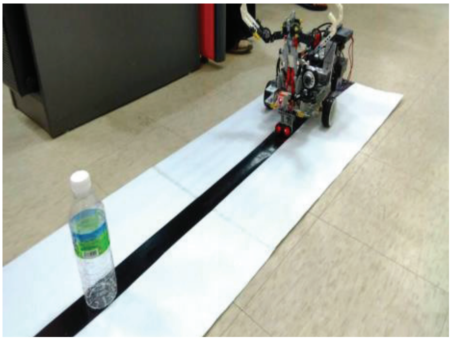


(b)

Fig. 1. (a)Right and (e) left view of the TCR robot

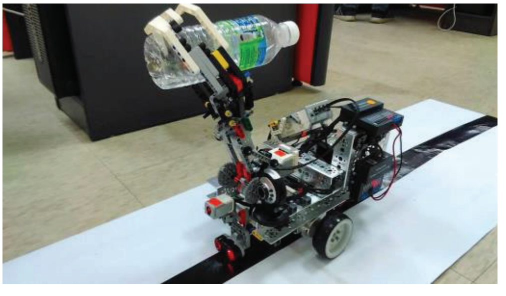


(a)

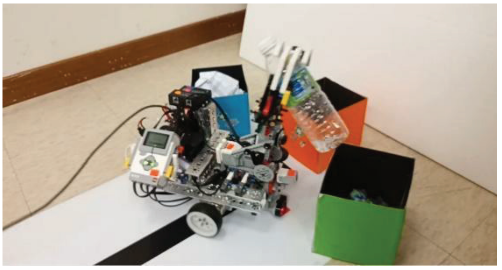


(b)

(c)



(d)



(e)

Fig. 2. (a) Robot at starting point, successfully moving forward (b) robot at 75 cm to capture the image and process it (c) robot is 12 cm from the object and ready to pick it up (d) pick up process and (e) the object is put into the appropriate coloured bin based on trash type

III. EXPERIMENT AND RESULT

TCR is an intelligent cloud robot agent. It identify trash and place it the designated container. Object recognition application with image processing in EV3 Robot will be apply to precisely identify type of waste material such as aluminium, paper, glass, iron and others, TCR is able to move on a smooth track. LEGO Mindstorms EV3 is used as the 'brain' for processing all commands and TETRIX set is used as the 'brawn' to support the architecture because its aluminium elements make it an ideal way to construct a robot with stable body structure. By integrating Python with the ev3dev library platform, it is much easier to collaborate with the APIs provided by Google Cloud API and SightHound in order to perform image processing and results will be obtained via the internet. Ev3dev is a Debian Linux-based operating system that runs on LEGO Mindstorms compatible platforms and create a new software platform to program robot. TCR is also able to pick-up objects once their presence is sensed, and takes a picture using the wireless camera to distinguish their type via Google Cloud Vision API and Sighthound. TCR is then able to identify the type of object that has been collected. It will then categorise them by colour. Sixty thrash images are used in these experiments which consist images from different angle. Fig. 3 shows an image processing procedure of the trash images that have been involved in the Google Cloud Vision API and Sighthound.

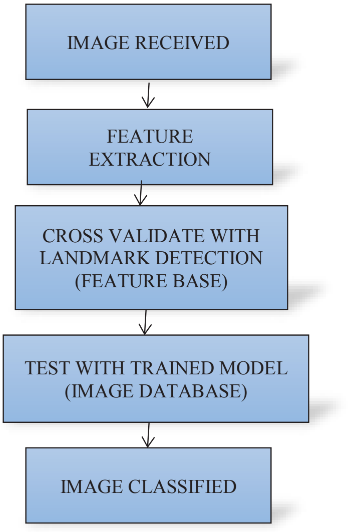


Fig. 3. Image processing procedure been involved in the Google Cloud Vision API and Sighthound

The measurement procedures for the results is as follow:

$$\text{Accuracy (\%)} = \frac{\text{Correctly classified Images}}{\text{Total Images}} \times 100. \qquad (1)$$

where, each type of thrash images accuracy will be calculated. Fig. 4 present the accuracy of waste material identification, based on the captured image, using Google API Cloud Vision and Sighthound. It clearly shows that by using SightHound, TCR can determine the type of waste material more efficiently than Google API Cloud Vision.

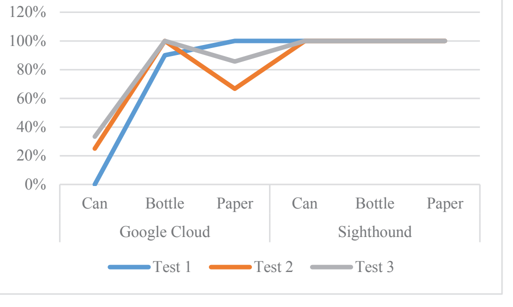


Fig. 4. Image processing procedure been involved in the Google Cloud Vision API and Sighthound

IV. CONCLUSION

As a conclusion, humanoid robot will improve the quality of human life. All the repetitive works will be done by them and supervised by human. In the future people will become more innovative to create product that can solve daily live task. Cloud robotics as TCR, based on the LEGO Mindstorm EV3 robot, has been built to assist in providing automatic collection of waste materials that really help waste management company. An image processing system was integrated into TCR and two cloud vision services which are Google Cloud Vision API and SightHound was compared. From the experiments, it was found that SightHound could identify the type of waste material images more efficiently than the Google Cloud Vision API. In the future, we propose that large scale processing works, such as image processing, needs to be done in an environment with better processing power. To achieve this, the robot should be equipped with a wireless camera and a network card. The wireless camera will capture the image of an object and the metadata of that image will be sent to a server for image processing. All of the heavy processing work will be done at the server. The results will then be returned, and the robot will be able to identify the type of trash.

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