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An Illegal Dumping Detection System Based on Image Processing in OpenALPR

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Tipping or depositing large waste onto land using unauthorized and unlicensed methods are considered as illegal dumping. The increasing rate of illegal dumping becomes a crucial nation issue because this activity causes negative impacts to social, economy and environment. Thus, study on detecting the dumping activities is conducted to control the illegal dumping activities in Malaysia. Raspberry Pi with Python language is used as the microprocessor and a Raspberry Pi camera module with a microwave radar sensor are interfaced to it to capture the image of any vehicles entering the illegal dumping site. The image is captured to recognize the license plate of the vehicle. The method in this study is by using Open Automatic License Plate Recognition (ALPR), Open Computer Vision (CV) libraries and Optical Character Recognition (OCR) to detect the character of the plate registration number. The outcome of the study consists of recognition of Malaysia vehicles' plate number and the automatic real time email notification on the illegal dumping case. The detection system can be used for case monitoring since the plate number recognition is done in real time. The system can be upgraded to ensure its sustainability in the harsh and isolated environment.

Keywords: vehicles detection; license plate recognition; OpenALPR; OpenCV; OCR

I. INTRODUCTION

Malaysia involves in many industrial sectors such as construction, manufacturing, mining and agriculture which introduces hazardous wastes. The waste management is not properly done leading to a bad impact on social, economy, and environment. Noor Atika H *et al.* (2019) and Mohd Rodzi (2019) have done an overview and analysis on waste management and solid waste generation, respectively. Uncontrolled activities of illegal dumping cause many environmental problems. Illegal waste dumping can possibly place people at health risk in multiple ways (Rahim *et al.,* 2017). Illegal dumping usually occurs because people are avoiding fees and cost to landfill the waste. They believe that the cost to landfill bulky waste is too high and the profit margins can be increased if legal disposal fees are avoided (Nell, 2014). Therefore, an illegal dumping detection system is important to control illegal dumping activities.

Recent research (Begur *et al.,* 2017a) implemented edge-based smart mobile service system for illegal dumping detection and monitoring. A smart edge-based mobile service system, which supports illegal dumping detection, altering, monitoring, and management services was introduced. The system proposed a machine learning technique to automatically detect the illegal dumping object based on collected trained images. The system also applied mobile service communication protocol and framework for smart cities.

Automatic license plate recognition using Raspberry Pi is implemented using Optical Character Recognition (OCR) in which the character on the image of license plate of a vehicle is read using Raspberry Pi processor. The image of the license

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plate is captured and processed by character segmentation. The different angles of the license plate image can contribute to less clear image that affects the image processing process. However, multiple instances and partial occlusion of the license plate may also contribute to the difficulties of the image processing task (Agrawal & Pardakhe, 2017). The image processing of recognition vehicle number plate works in four steps: (1) image acquisition, (2) license plate extraction, (3) license plate segmentation, and (4) character recognition. Optical Character Recognition (OCR) is the process which converts the image into text (Owhal *et al.,* 2018).

The application of license plate recognition technology is not limited to only in transportation system but also applied in many areas such as parking, tracking things and security system. For security system, the matched template techniques are mostly applied for access control. For example, the technology has widely been used in many huge companies to grant access only to authorized personnel vehicle. The vehicle number plate is recognized by template matching technique using a normalized cross correlation algorithm and phase correlation algorithm (Sharma, 2018).

Current studies on plate recognition system are quite complicated and expensive where the applications focus more on speed detection and vehicle monitoring at parking spaces (Dalarmelina *et. al.*, 2019; Akila *et. al.,* 2019; Ezhilarasi *et al.,* 2019). Intelligent parking system, Smart Parking Service (SPANS) was proposed previously to check the availability of the parking slot (Dalarmelina *et al.,* 2019). Meanwhile, automated license plate recognition has been developed using computer vision where the vehicle plate number can be recognized by various layers of digital image processing (Akila *et al.,* 2019). There is also a study done on damage vehicle plate recognition (Ezhilarasi *et al.,* 2019). Thus, the purpose of the study is to develop a simple, yet reliable system that would help the government to detect the illegal dumping activities on the targeted dumping site using vehicle plate recognition system. The objective of the system is to collect data of culprit at a prone area of illegal dumping site. The system recognizes the plate number from the captured image of the vehicles which enter the illegal dumping site.

II. MATERIALS AND METHOD

The system implements Raspberry Pi 3 as the microprocessor and its camera module and sensors as the controller. Raspberry Pi is a low price, credit-card sized yet very powerful single board computer which has the capability to capture clear images and videos with some simple algorithm. In this process, OpenALPR and OpenCV are the main libraries involved as well as OCR technology. The study is conducted in early January 2020 for 6 months and has a collaboration with Solid Waste Corporation (SWCorp) Malaysia, a government link agency that responsible to manage the solid waste and mitigate the illegal dumping issues in Malaysia.

A. Approached Methodology

The system works as it detects the vehicle that passes through the sensor range and an image would be captured from the movement of the vehicle by using the camera. The system automatically sends the image of the presence vehicle of possible illegal dumping activities at the site as an alert to the authorities. For further actions, the captured image is processed to recognize the plate number of the vehicle if there is any plate region found in the image. The processed output can become a good evidence for the law action against the offence. The system is in 'sleep' mode if no vehicle passes the sensor and the captured image will not be processed if no plate region found. The proposed system design function is shown by the flow chart of the system as in Figure 1. The end process of the flow chart occurs when the system does not detect any illegal dumping activities. The system is proposed to continuously work when activities is detected, and only idle when no activities detected. It will only stop when it receives no power to operate, or the battery is running out.

B. Hardware Components

Raspberry Pi and NoIR camera are used to control the system and capture the image during day and night vision, respectively. The NoIR camera module for Raspberry Pi is custom-designed as an add-on for the board that it is designed without "IR cut-filter". Unlike the other regular camera, the NoIR camera can capture and record video at night vision. Both camera can be interfaced to Raspberry Pi board using the same method. The camera is suitable for

illegal dumping detection because it can capture image during night.

Other component is RCWL-0516 microwave radar sensor, which is a mini doppler radar sensor module, equipped with microwave induction technology-based chip designed with supporting DC voltage in a wide range of 4V to 28V. When the sensor is connected to Raspberry Pi, microwave radar sensor can measure in a range as accurate as 1 cm to 700 cm (0.01 m – 7.0 m). The sensor continuously gives high level signal output when there is motion (Elecrow n.d.). The high-level signal triggers the camera function to capture the image of the illegal dumping activities.

We design a rectangular box which is small in size yet very easy to handle. It is a design that is compatible and suitable for outdoor use and small enough to be placed in any hidden area. Figure 2 shows the surface area of the rectangular box with its proposed design.

The material used for the box is a waterproof acrylic sheet size of 2 mm thick. The acrylic sheet is cut using laser for an accurate size. The front part is designed with many circles for IR LEDs placement and camera lens. The small rectangular space is designed for the radar sensor placement. The Raspberry Pi 3, power bank of 20000 mAh, NoIR pi camera module with IR LEDs and the microwave radar sensor are placed in the box. The prototype of the system is shown in Figure 3. The 7 IR LED is used due to limited space of the prototype. Thus, there is no limitation to use less or more 7 IR LED for the system.

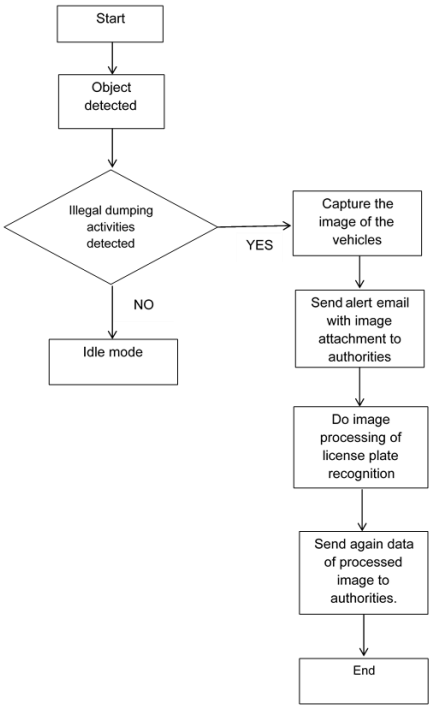

Figure 1. The proposed design system function

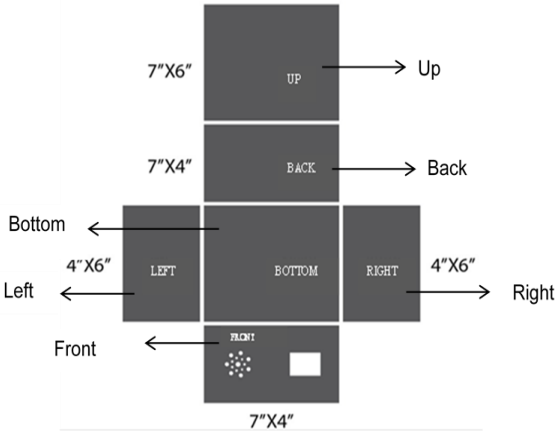

Figure 2. Design of Illegal Dumping Detection Device Box

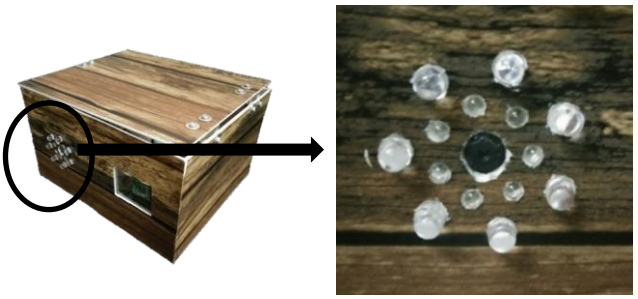

Figure 3. The prototype of the system with the camera and IR LED

C. Software Libraries and Programming Language

We use OpenALPR with OpenCV and Tesseract OCR. OpenCV is an open-source computer vision and machine learning software library used to analyze image by computer vision. OpenCV has interfaces for multiple of programming languages, like C/C++, Python and Java. It is usable on a variety of operating systems (O.S.) including Windows, Android and Unix-like ones (Buhus *et al.,* 2016). For recognition of license plate number, the OpenALPR is integrated to python language. OpenCV is used as a platform for Optical Character Recognition (OCR) using Tesseract. Tesseract is a very popular OCR engine developed by Hewlett Packard in the 1980s. Tesseract library is available in Raspberry Pi and works well when binding with Python. It converts the text image into string data type in Python (Adrian Rosebrock, 2017). OpenALPR works in pipeline. The stages of working pipeline of the OpenALPR are visualized in Figure 4.

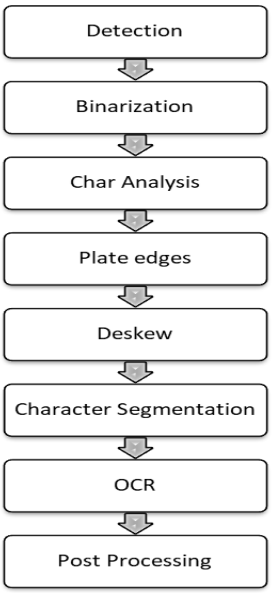

Figure 4. OpenALPR pipeline operation

OpenALPR is a country specific software library, thus, the implementation of the device need to be within the country supported by the software libraries. Otherwise, the OCR library of the OpenALPR requires training to improve the accuracy of plate recognition.

D. Sending Email Notification

For the detection system, the email notification will be sent over a Gmail service. The email contains an image captured by the camera when the system is triggered. Smtplib native library is used for sending an email using python through SMTP protocol. The email can be delivered using Python script whereby in the script, the senders' and receivers' email addresses are declared so that once the system is running on, the output can be sent to the correct address. In order to send the email, the application device should be allowed to access the Gmail account, therefore the password is declared in the script as well. Every mail server has their own port number, port 587 is used for Gmail service through SMTP protocol and this port must be correctly declared inside the codes.

III. RESULTS AND DISCUSSION

The illegal dumping detection system involves license plate recognition, an image processing technology that mainly used to identify vehicles by their number plates. When the image is given as an input to the OpenALPR, it automatically detects the region of plate and gives out the confidence of possible plate characters. Figure 5 shows Malaysia vehicle's plate number tested as an input image.

Figure 5. Malaysia's plate number tested as an input image

In the case of this input image, the result obtained from Raspberry Pi processor is shown in Figure 6 and described in Table 1. The results show an increasing number of confidences which give more accurate result.

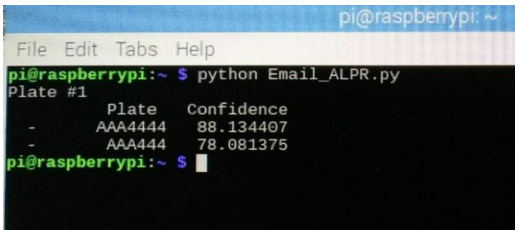

Figure 6. Result of plate number recognition for the tested input image

Table 1. Output data result with degree of confidence

Epoch Number	Number of plates being detected	Confidence on scale of 100
1	AAA444	78.081375
2	AAA4444	88.134407

The process of recognizing the plate number involves multiple sequence methods in which it firstly detects the location where the plate number presents in the images. This is a challenging task because of the variability that might present in the images. The poor resolution image usually occurs because of the image is taken too far away from the camera or a low quality camera. The captured image may also be blurry particularly caused by the motion of the vehicles. Poor lighting and low contrast due to reflection and shadow may also create a problem to the plate number recognition process. Any object that obscures the plate or part of it such as dirt on the plate could also be one of the difficulties of this process.

The captured image at the illegal dumping site will be automatically sent to the authorities when the sensor is triggered. Figure 7 depicts the email notification received by the authorities. When the plate region appears in the image, the processing image proceeds, and the second email will be sent with the result of the processed image.

When the sensor is triggered by motion passed through the sensor range, it triggers the camera module. As the camera captures the image, it will send the updated alert email to the authorities. Meanwhile, when there is no motion or specifically no illegal dumping activities detected, the sensor is in relax mood where the system will be in sleep mode.

The prototype also shows that the less complex proposed method is able to detect and recognize plate numbers as good as complicated methods proposed by Dalarmelina *et al.* (2020), Akila *et al.* (2019) and Ezhilarasi *et al.* (2019). Another approach is by using machine learning and image processing to detect people who do the dumping waste where the system can recognize various dumped wastes (Hedge *et al.*, 2020). A simpler method leads to easy execution and less prone to system's fault. Therefore, it is preferable specifically in illegal dumping cases, where systems can be widely deployed to prevent illegal activities.

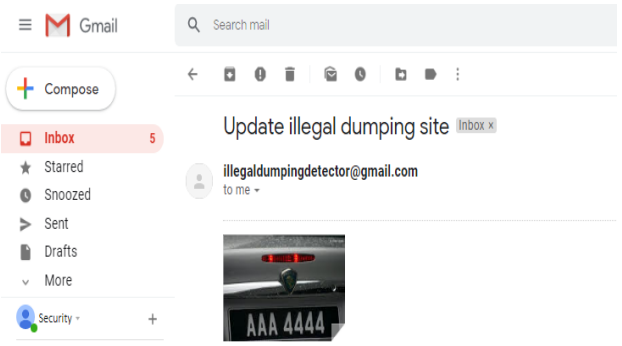

Figure 7. Alert notification email is sent automatically

IV. CONCLUSION

A simple electronic approach to monitor illegal dumping activities in Malaysia is introduced. The prototype consists of Raspberry Pi 3 as the single board controller (SBC) where the open-source software libraries OpenALPR based with OpenCV and Tesseract OCR are installed, NoIR Pi camera module for image acquisition with a radar sensor as the input signal for the camera function. To provide an amount of light to the NoIR camera for night vision, the camera lens is surrounded with a number of IR LEDs. The system is used to detect illegal dumping activities at the illegal dumping site at both day and night vision. The camera captures the image of illegal dumping activities occurred at the site and an email notification will be sent to the authorities as an alert of the case. The OpenALPR processes the image if the captured image contains license plate region. Then, an email will be sent again to the authorities to provide the license plate recognized from the image. The system with phone message notification will be developed by using global system for mobile communication (GSM) module. The study has developed a real-time plate number recognition and detection system using less complexity approach. The research output shows that the performance of the proposed method is as good as complex methods. However, considering the application in dumping case, more

experiments related to illuminating environments are to be conducted to verify the output. In future, the output can be further improved by implementing more reliable and sustainable devices so that the system can be used in isolated and tough environments.

V. ACKNOWLEDGEMENT

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