

Safety Management in Construction Site by the Implementation of Image Processing on Raspberry Pi: Risk of Truck Collision Towards the Workers

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Abstract: The construction industry is one of the most important sectors that help in economic growth around the world. Generally, all construction sites consist of many equipment, truck, materials and variety of workers so there usually lead to accidents occurred mostly with the reasons of truck collisions towards the worker. This problem can be overcome by doing object detection and notify the workers when there is close truck towards them. The object detection process is for detecting the workers that close to the truck. Then, the speaker device will trigger audio sound as an alert tool for the workers to avoid the collision. Raspberry pi 4B with pi camera installed on it will be used as the main device to run the Node-RED flow based platform. Node-RED is flow-based programming development tool that will deploy object detection flow. Image processing is readily included in the pre-trained model of coco-SSD from Tensorflow.js to classify the image class before trigger the speaker. This system can help the workers to avoid collision with the trucks that close to them and on the future work this device may be used to measure between them and give alerts through the mobile phone or other devices.

Keywords: Safety Management, Construction, Raspberry Pi, Node-RED

1. Introduction

Construction industry is one of the most important sectors that help in economy's growth around the world included in Malaysia. The construction industry can be divided into two different types which is general construction and special trade work [1]. All construction sites consist of much equipment, truck, materials and variety of workers based on the type of construction as it is known as a complex development that usually make in outdoor place. One of the most challenging issues in the construction is about the safety on the site. The safety issue obviously related to the site workers and

other people that work in that area. The construction site is also agreed to be known as the most hazardous place in all countries that affects the life of the workers on the site [2]. There are several major safety issues or accidents that always happened in the construction site in Malaysia which is striking against or being struck by objects or equipment and falls [3]. The struck by object is happening when there is a moving object or equipment suddenly runs over the workers without they realize. This included the accident between trucks towards.

Based on the fatal accidents cases analysis in Malaysia, 34% come from struck by moving object or vehicles [4]. To overcome this problem a device that can program image processing such as Raspberry Pi 4B board will be used by implementing it with any camera. This device should detect presence of workers on the building construction site from the truck and notify the workers about the dangerous close to them by the speaker device. The performance of the device can be analysed by the image processing method applied through the machine learning platform such as Node-RED platform. By this study, the accidents at construction sites can be reduced by using the method of object detection process implemented through Raspberry Pi board.

2. Materials and Methods

2.1 System Overview

This device project development began with the recognizing the components and software development need to build the device function correctly. Both software and hardware are specializing based on the function required to fulfill the objectives. Figure 1 shows the flow chart for overall project.

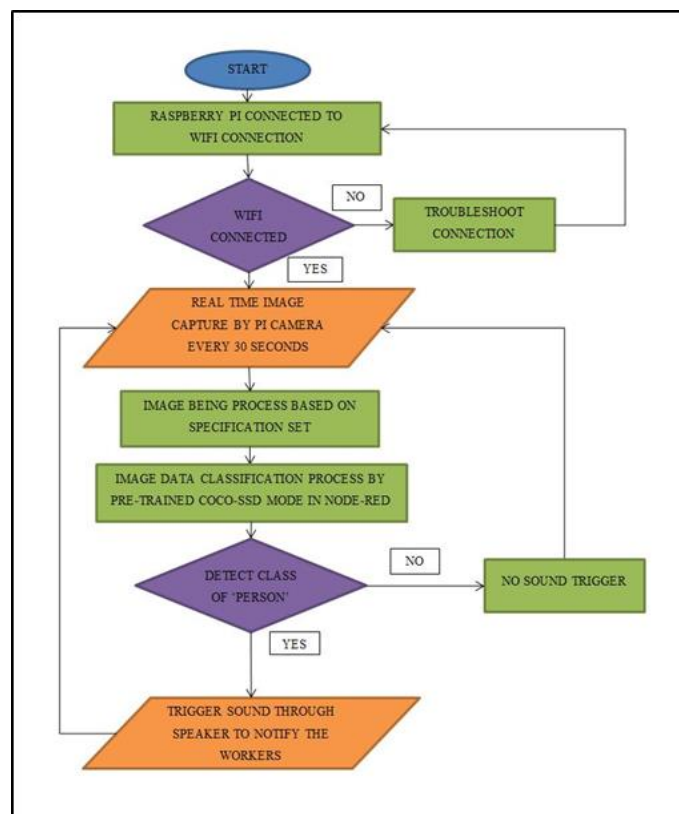


Figure 1: Flow chart for overall project

2.2 Software Development

There are several softwares and system configuration needed to develop the image processing of object detection, which is:

- Raspberry Pi Operating System (OS)
- Node-RED platform
- Tensorflow.js Library

Raspberry Pi OS or formerly known as the Raspbian is a Debian-based operating system for Raspberry Pi. The Raspbian can add custom tools and software to it [5]. File of Raspbian had been installed directly from the Raspberry Pi official website through the Raspberry Pi. The Raspbian makes the use of Raspberry Pi easier to install any programming platform such as Node-RED in this research. After the installation of Raspbian into the SD card, it then inserted into the Raspberry Pi and applied to the monitor that used for this project. Next, the configuration of Raspberry Pi was setup through the monitor.

Node-RED is a flow-based programming development tool that originally developed by IBM's Emerging Technology Services team. Several functions of Node-RED is part of Internet of Thing (IoT) [6] is for connecting hardware devices, Application Programming Interface (API) and online services. The using of Node-RED require internet connection as it need to be configure by a web browser-based flow editor that able to create the function of JavaScript. The flows created can be saved or shared to other device or user. In the workspace flows, all the functions and elements are created and labelled in the nodes. JSON is the place where the flows program created in Node-RED being saved. In this project Coco SSD pre-trained model from Tensorflow JavaScript models had been used for object detection. Coco SSD is one of Tensorflow.js models that can be applied to any program that related to object detection.

Tensorflow.js used as library for machine learning in JavaScript that has many types of models that can be used to any program related to the models' program. In this project, Coco SSD model has been used to do object detection on the image as it was trained to identify and localize multiple objects in a single image includes the person [7]. Coco SSD model class image contains 90 different classes included person. Because of that there is function node created to decide which class of image needs detected will be chosen to trigger the speaker alarm.

2.3 Hardware Development

There are several softwares and system configuration needed to develop the image processing of object detection which is:

- Raspberry Pi 4B
- Pi Camera 5MP
- Charger Plug
- LCD 3.5 inch TFT with Cooling Fan
- Mouse and Keyboard
- Speaker
- SD card

Raspberry Pi 4B is a minicomputer that has a fast processor to run the program of object detection. This small CPU device needs to connect with the monitor to display the interface of the system. Keyboard and mouse are required for the configuration or do any programming. This Raspberry Pi 4B was built with four USB ports so it can directly connect with external devices without need of any extension for the USB port. SD card is the crucial item as the operating system is installed in it. This project needs power supply to start the system. When it was being used to set up the program, the charger will power up the Raspberry Pi 4B But, on the real construction site this charger power supply can be replaced with power pack or power bank.

Pi camera with 5MegaPixels (5MP) used as external camera that install on the CSI camera port on the Raspberry Pi.4B This pi camera will capture the image and send it to the Node-RED system to process the input image. The LCD 3.5 inch with TFT cooling fan important to monitor the Raspberry Pi at the construction site. Then, if there any human figure being detect, speaker will play a file sound selected in the Node-RED system. The flow chart is shown in Figure 1.

2.4 Node-RED Flows

Figure 2 shows the Node-RED flows for object detection. Every Node in the Node-RED is a basic block for the flow. The Nodes were connected by the flows. The terms of flow also represent as a tab within the editor workspace. The Nodes will be trigger by receiving a message from previous nodes or gain from external event. The input is generated either from the image file or pi camera. For using on construction site, the image captured by pi camera will be used as input image to be applying the image processing and object detection.

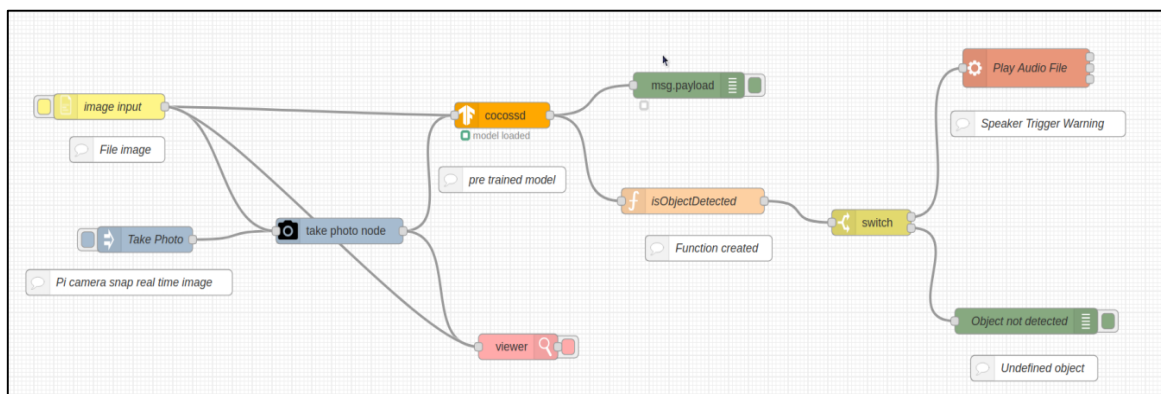


Figure 2: Node-RED flows for object detection

3. Results and Discussion

3.1 Results of Object Detection

Node-RED platform is deployed to run the program. Image data is inserted with different measurement. The Node-RED flow with image input workspace is shown in Figure 3. The Raspberry Pi 4B device with readily connected to the speaker to trigger the audio file.

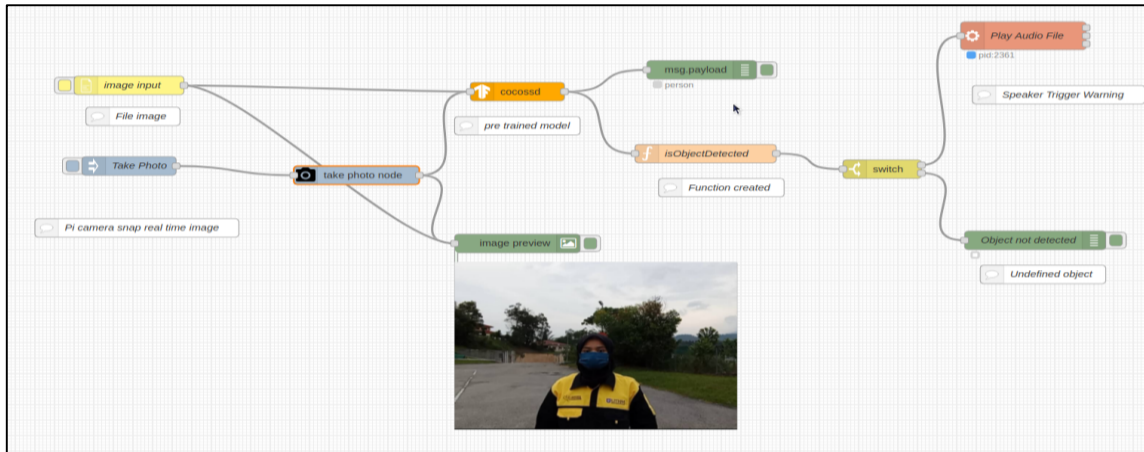


Figure 3: Node-RED workspace flow with image input

The success detection of human figure had been shown when there is ‘person’ class in nodes of msg.payload’s message. Figure 4 shows that message output stated ‘person’ class. Then, the audio file will automatically play the audio file as there is human detected.



Figure 4: Person class shown on node’s output message

3.2. Result of Detection with Different Distance

There are several distance measurements tested to see the availability of the object detection of the device. Table 1 shows the result of object detection with different distance measurement.

Table 1: Analysis of object detection with different distance measurement

Distance (m)	Input Image	Class of image detected	Speaker trigger sound
0.5	Image 1	Person	Yes
1.0	Image 2	Person	Yes
1.5	Image 3	Person	Yes
2.0	Image 4	Person	Yes
2.5	Image 5	Person	Yes

Based on Table 2, it shows the full results of distance measurement test with sample images. The ‘person’ class was detected for each image. If there is no human figure appears on the camera view, the system will not trigger any sound then directly continue the looping as shown in the flowchart in Figure 1 for next image capture after 30 second.

Table 2: Image data for distance measurement testing

No.	Distance Measure (m)	Input image	Class of object detected	Speaker trigger sound
1	0.5		Person	Yes
2	1.0		Person	Yes
3	1.5		Person	Yes
4	2.0		Person	Yes
5	2.5		Person	Yes

3.2 Temperature analysis of Raspberry Pi 4B for 1 hour operation

Figure 5 shows the graph of Raspberry Pi 4B's temperature after 1 hour. The average temperature of the Raspberry Pi 4B for every 5 minutes is 51.2°C. This shows that the project successfully can be run for an hour properly. This is because a cooling fan installs with the LCD screen so it can cool down the temperature.

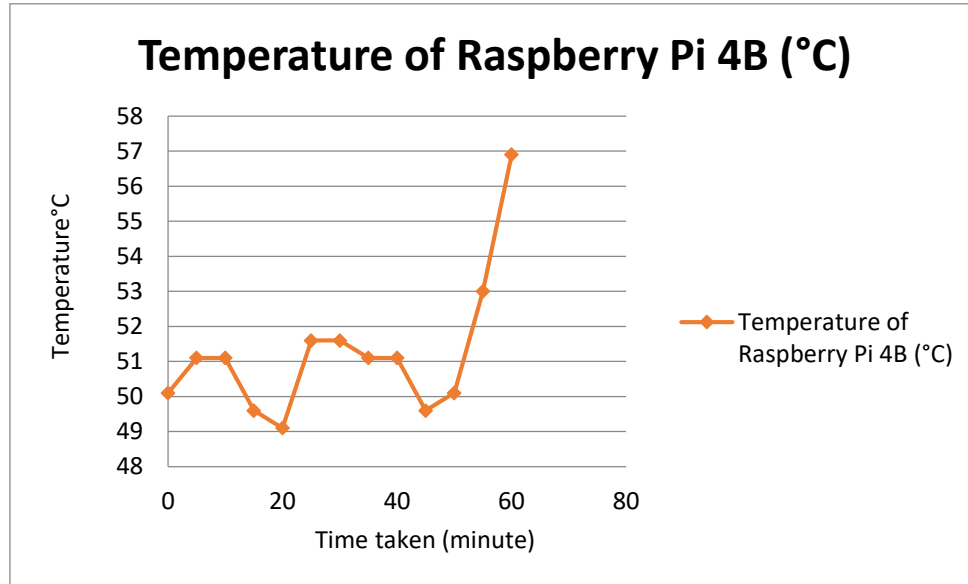


Figure 5: Graph analysis of Raspberry Pi 4B's temperature after 1 hour

3.3 Discussions

Based on the result Figure 3, the Node-RED able to detect a human figure from the input image by do the image processing using pre-trained coco SSD dataset from TensowFlow.js as the audio file is played when there is image class of 'person'. The detection also successfully working good with different measurement distance between the object and the device as result shown in Table 1. From Figure 5, the performance of the Raspberry Pi 4B based on the temperature average is great as it still in the normal temperature rate of Raspberry Pi 4B.

3.4 Limitation

This project device basically should be tested on the actual construction site as it needs to be on the specific construction truck as it is a safety device for the construction workers. Unfortunately, because of the pandemic of COVID-19 this project cannot directly test on the construction site as all Malaysian need to obey the movement control order (MCO) restrictions promulgated by the Prime Minister. Because of that, this project device was tested indoor with television monitoring and on the regular car on the wide area to get the result of the human detection based on different distance analysis.

4. Conclusion

In conclusion, the researches able to develop a device that can detect workers or human figure at by using the Raspberry Pi and object detection method. This could be observed by the Node-RED flows and the speaker triggered the sound when the human detected on the image captured by the pi camera. The sound was used to notify the worker that located too close to the truck or any vehicle on the construction site. The device's performance had been analysed by the temperatures reading taken for an hour.

Based on the observation and analysis, this project successfully reaches the target of the project's objectives. The first objective is to detect the presence of workers on building construction site from the truck. Next, notify the workers about the dangerous close to them by speaker device on the construction site. Lastly, this project must be analyse performance of the system of this project based on image processing method. The image processing was ready implemented in the Node-RED platform that contains machine learning and JavaScripts libraries.

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