Evolution in Electrical and Electronic Engineering Vol. 1 No. 1 (2020) 333 - 341

EEEE

Homepage: http://penerbit.uthm.edu.my/ proceeding/index.php/eeee
e-ISSN : 2756-8458

Vision Based Traffic Control for Intelligence Ambulance Detection System

Ong Wei Yang[1], Nor Surayahani binti Suriani[1*]

[1]Faculty of Electrical and Electronic Engineering,
Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, MALAYSIA

DOI: https://doi.org/10.30880/eeee.2020.01.01.040
Received 15 July 2020; Accepted 06 September 2020; Available online 30 October 2020

Abstract: The increase in the number of vehicles brings the congestion problem to the road users especially the ambulance that stuck at the traffic junction and the simple traffic signal control system does not provide priority for the ambulance. To handle the problem faced, this paper presents the works in designing and developing a vision based traffic signal control system with priority for the ambulance and developed a traffic supervising system to synchronize the traffic condition to Firebase database and WhatsApp. The blob detection and colour detection method in the image processing technique is used to specify the size and colour of the ambulance required to be detected. Raspberry pi, webcams and LED traffic light module used to design a system model for prototyping the vision-based ambulance detection system and the system code is written in python language. Python IDE and Microsoft Visual Studio used to perform data analysis. In the system model, the sequence of traffic lights has been set to 3 seconds green light during normal conditions while 10 seconds green light during an emergency condition. Conclusively, the vision-based ambulance detection system was successfully designed and developed in which the system has provided an effective time response for the ambulance detected and works as a cloud-based monitoring system to synchronize the traffic condition to the database.

Keywords: Ambulance Detection System, Image Processing, Blob Detection Method, Colour Detection Method, Firebase Database, Whatsapp.

1. Introduction

The increase in the number of vehicles and the simple traffic signal control system is the main problem that is causing traffic congestion in the urban or highly populated area. This results in the ambulance cannot pass the traffic junction and forced to wait for green light during an emergency. To figure out the traffic congestion problem, the Singapore government has limited the number of vehicles on the road by increasing the cost of the vehicles [1]. In fact, it is not effective in reducing the congestion problem. In advanced science and technology, there are many techniques such as Radio Frequency Identification (RFID), Global Positioning System (GPS), wireless sensor networks and so on can be in the traffic signal control system to make it advanced in solving the congestion problem [2]. In this paper, a vision-based traffic signal control system has proposed using colour detection and blob detection method in the image processing technique. The intelligent traffic signal control system can recognize the ambulance on the road and give prompt instructions to the traffic in order to clear the lane for ambulances.

**Corresponding author: nsuraya@uthm.edu.my*

A simple traffic signal control system brings a negative effect on the efficiency of the ambulance to deliver emergency services. It cannot recognize the ambulance and will not provide priority to the ambulance during the emergency. Therefore, most of the ambulances used the emergency line or ran the red light. This will bring danger to the safety of other road users. Recent news reported that an ambulance that was sending a pregnant woman and involved in an accident at the traffic light intersection was caused by the lack of attention for the clearance of the emergency vehicles [3]. The other recent news reported an MPV driver failed to make way for the ambulance, which was on the way to sending the patient and both vehicles crash in Jalan Kulim-Bukit Mertajam [4]. Besides, a simple traffic signal control system operates at a fixed timing mechanism even when the road is congested. Recent news reported patients dying on the way to the hospital because of the ambulance stuck in traffic congestion [5].

The main objective of this project is to propose a traffic signal control system with priority for the ambulance. This project aims to design an ambulance detection system using an image processing technique [6], while develop a cloud-based supervising system [7] by synchronizing the traffic light condition in real-time to Firebase database and WhatsApp. Finally, able to evaluate the system accuracy in terms of ambulance localization and time response for the effective control of the traffic light system. A system model is designed using raspberry pi, webcam and traffic light model to demonstrate the vision-based traffic signal control system. When the vision-based ambulance detection system detected the ambulance, the ambulance detection system will send the instruction to the traffic light control system in order to change the traffic light green for the lane with an ambulance. Besides, the traffic light condition will be synchronized in real-time to Firebase database in Google Cloud Platform send a WhatsApp message when the ambulance is detected.

2. System Design

The ambulance detection system will process the recorded traffic videos by using colour detection and blob detection method [8]. When the ambulances are located and tracked from image sequences, the Raspberry pi will receive the signal in order to turn the traffic signal green for the ambulance to pass the traffic junction and stop the vehicles from other traffic junction. Besides, Raspberry pi will synchronize the road condition to the Firebase database in Google Cloud Platform [9], which acts as a cloud-based monitoring system, and it will send a WhatsApp message to the emergency department. It allows the hospital staff to monitor and make the preparation earlier. Figure 1 shows the overall system block diagram of the intelligent traffic signal control system.

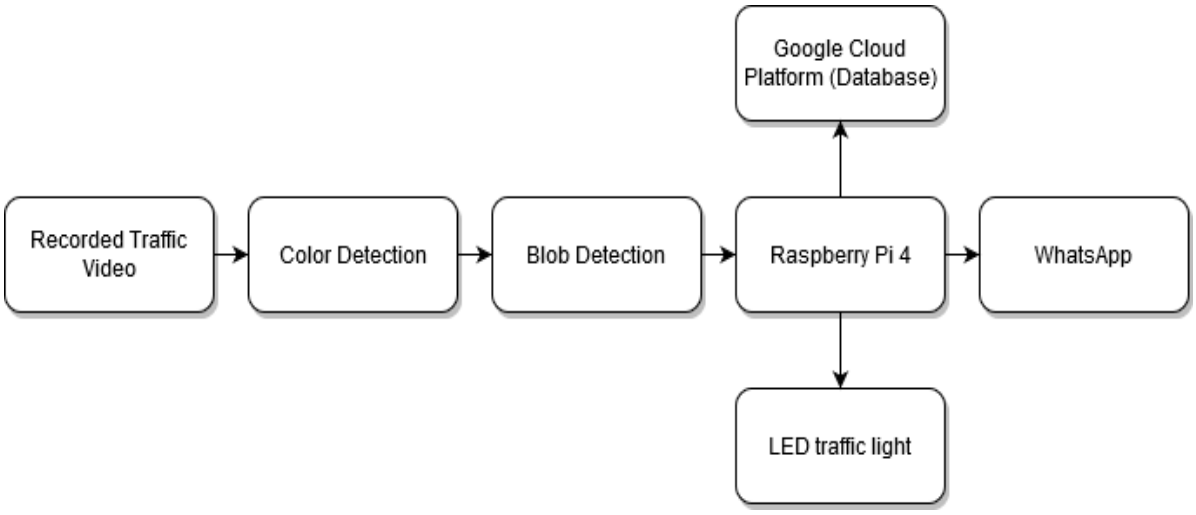


Figure 1: Overall system block diagram

The specification of the materials and equipment used are listed for implementing the ambulance detection system. The Raspberry pi 4 is a credit-card size computer that provides General Purpose Input/Output (GPIO) and USB ports to allow the LED traffic light module and USB webcams connected to it. The LED traffic light module has three different signals, which are red, yellow and green. The

USB webcam with 8-megapixels used to record the traffic condition. Thonny Python IDE platform and Microsoft Visual Studio allow users to debug and develop the program regarding the image processing technique used in the ambulance detection system. Firebase database and WhatsApp as a cloud-based monitoring system that synchronizes the data in real-time.

Image processing [10] is a set of methods and algorithms used to process a digital image or video to detect the ambulance. It consists of the conversion of a physical image into a corresponding digital image by applying various methods or algorithms. In the project, there are two types of methods used to detect the ambulance, which is colour detection and blob detection method. The colour detection method used to detect a specific colour in the image by using RGB to HSV conversion. RGB (Red, Green, Blue) defines the colour in term of a combination of primarily colour while HSV (Hue, Saturation, Value) defines colour similarity to human eyes that tend to perceive colour. It can set the range of a specific colour, any colour that out of the specified range will be ignored. Besides, blob detection method are used to detect the regions (x, y) in a digital image or video. RGB to Grayscale conversion used to reduce the complexity from a 3D pixel value to 1D value. By using blob detection method, the size of blobs (w, h) is taken into consideration in which any vehicles that larger than or smaller size than the fixed size of blob for ambulance will be ignored.

The traffic light control system is designed to provide a timing sequence for each traffic junction. The Raspberry pi will process the video frame and examine the condition of traffic. If there was an ambulance on the road, it would send the commands to change the timing of the traffic signal to allow the ambulance to pass the traffic and stop the vehicles on other traffic junction. Google Cloud Platform (GCP) allows individuals or enterprises to build and run the software via the Internet, allowing them to store or review the data from the platform. Firebase database is one of the features in GCP that can synchronize the traffic condition and acts as a monitoring system for the hospital staff to review the conditions. Besides, the system will send a WhatsApp message to the medical staff to make earlier preparation to face the emergency.

3. Results and Discussions

A prototype model of 4-way traffic junction is designed to demonstrate the vision-based ambulance detection system in order to evaluate the system accuracy in terms of ambulance localization and time response for effective control.

3.1 Prototype

Four (4) USB webcams and LED traffic light modules are connected to the raspberry pi, which the raspberry pi is placed at the bottom of the model. The timing sequence of a traffic light is set 5 seconds for green and 2 seconds for yellow light during normal traffic conditions. Figure 2 shows the prototype model of a 4-way traffic junction.

Figure 2: Prototype of 4 way traffic junction

3.2 System model simulator

When there is no ambulance, the traffic light system will operate with the timing sequences of 5 seconds for green and 2 seconds for the yellow light. Figure 3 shows the output of video streaming using Thonny Python IDE and the Thonny Python IDE will update synchronously with the traffic condition for every turns.

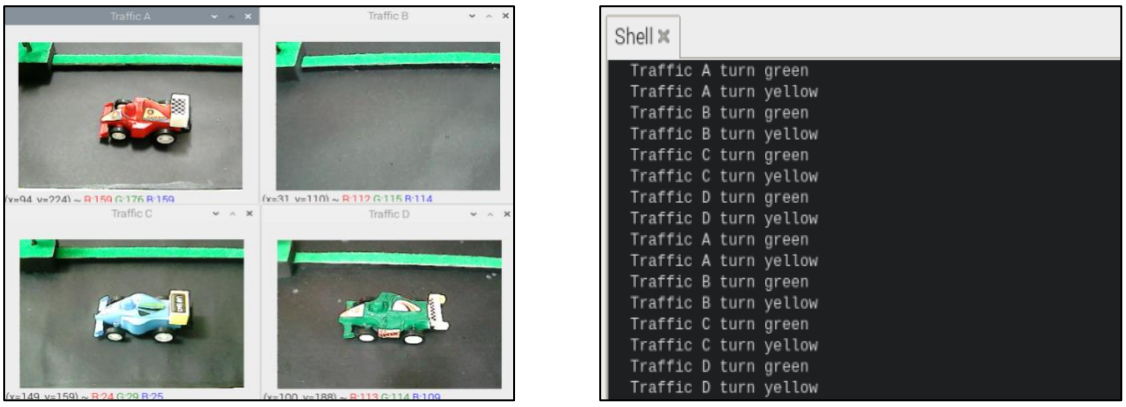


Figure 3: Left: output of video streaming, right: traffic condition updated by thonny python IDE

3.2.1 Emergency traffic condition

In Figure 4, the ambulance detection system detected the ambulance in the video streaming of webcam A and the Thonny shell will update synchronously with the emergency condition when the total amount of ambulances that were detected. The system provided a clearance lane for Traffic A by extending the timing sequences of the traffic light A to 10 seconds green light. After 10 seconds, the green light will turn to the red light, and the system will continue searching for the ambulance. When there was no ambulance was detected, the system will switch back to normal traffic conditions.

Figure 4: Left: ambulance detected in video streaming of webcam a, right: ambulance detected at traffic an updated by thonny shell

3.2.2 Traffic monitoring system

In order to enhance the performance of the ambulance detection system, the traffic monitoring system was implemented with the ambulance detection system in this project. The traffic monitoring system used to synchronize the road condition in real-time to the Firebase database. Besides, the relevant authorities such as the hospital emergency department or ministry of transport also will be received a WhatsApp message when the ambulance detected.

The timing sequences of a traffic light for every turn will update and highlight in the database. In Figure 3.4, the traffic light D turned to "Red" while the traffic light A turned to "Green" at the same time. After 5 seconds of green for the traffic light A, it turned to "Yellow," and the timing sequences were continuing to update and looping until the emergency condition occurs.

Figure 3.5 shows the data updated in the database in which the ambulance was detected at the Traffic A. Therefore, the traffic monitoring system will automatically update the condition of Traffic A to "Yes" which means the ambulance detected, and the emergency condition occurs at the stated road and "No" for the road without the ambulance. At the same time, the traffic light A will turn to "Green" immediately and operate for 10 seconds. After the ambulance passes the traffic junction, the traffic monitoring system will continue updating the timing sequences which operate at normal traffic condition. Even when the ambulance was detected at any other lane, the database will also update the condition for the road with the ambulance.

Figure 3.6 shows the ambulance detection system sent the WhatsApp messages with the content "Ambulance detected at Traffic A" to the relevant authorities when there was an ambulance detected which located at the Traffic A. There were several messages will be sent due to the fps of the video streaming. Besides, the ambulance detection system also sent alert messages to the emergency department when the ambulance was detected at any roadway of the traffic junction.

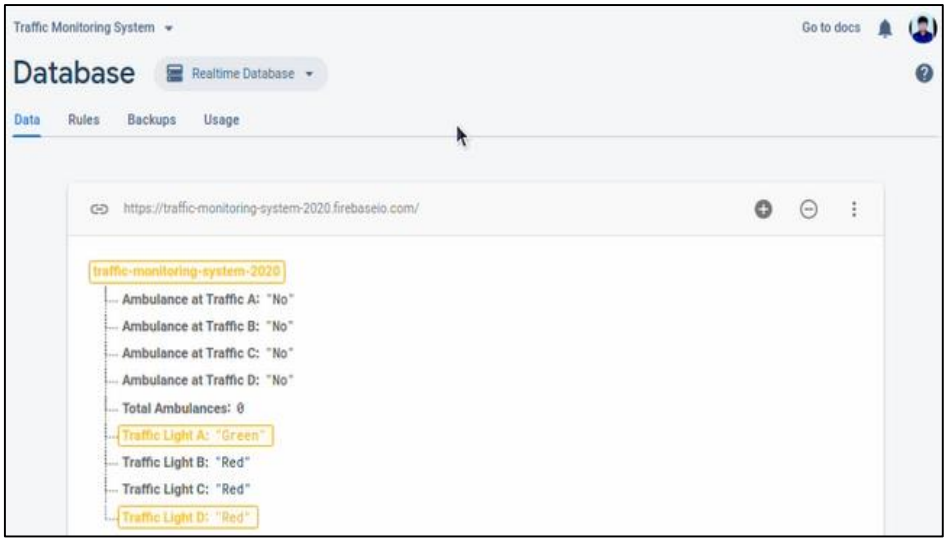


Figure 3.4: Data updated for traffic A and traffic D

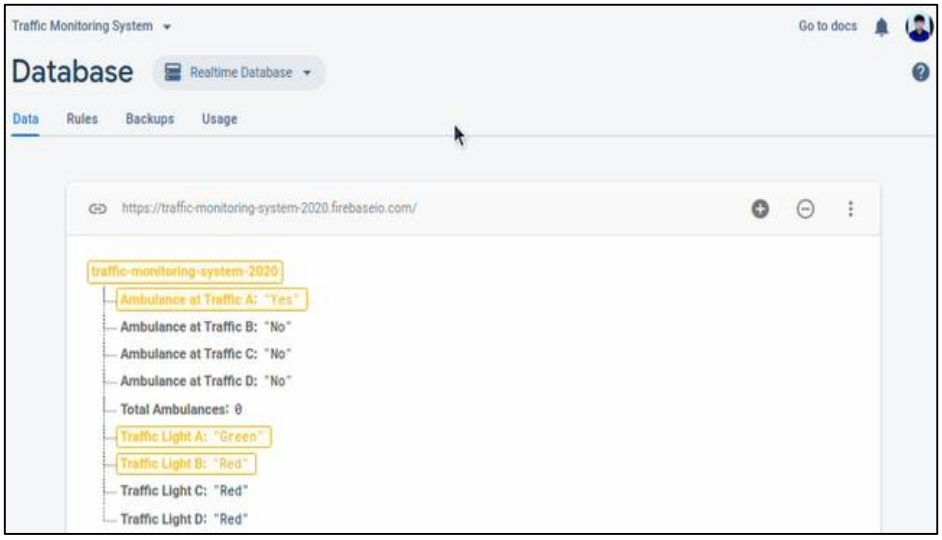
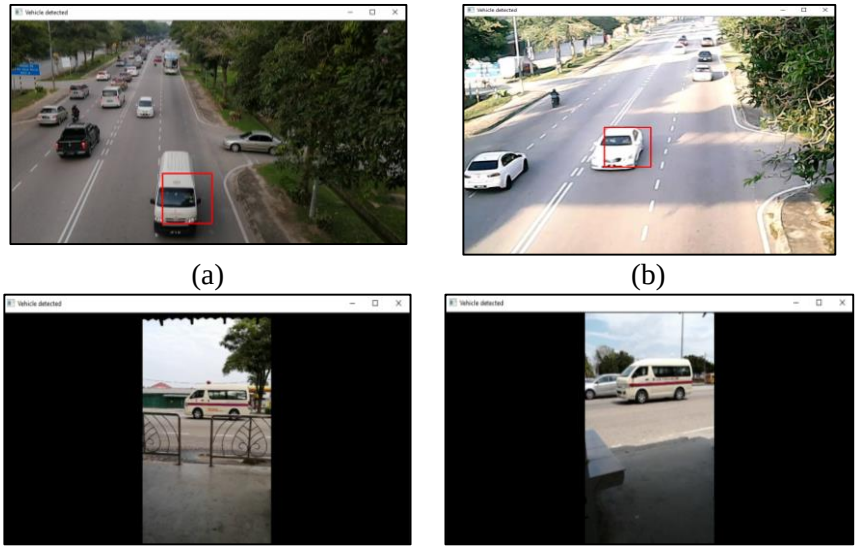


Figure 3.5: Data updated for emergency condition at traffic A

Figure 3.6: WhatsApp messages with content "ambulance detected at traffic A"



(a) (b)

(c) (d)

Figure 3.7 a) Ambulance detected in CAM1, (b) white vehicle detected at 4th second of CAM2, (c) no vehicle detected in CAM3, and (d) no vehicle detected in CAM4

3.3 Discussion

From the analysis of the recorded traffic video, the ambulance detection system operated at normal weather condition and has successfully detected the ambulance in the traffic video 1 (CAM1) but failed its performances when analyzing the traffic video 2 (CAM2), traffic video 3 (CAM3) and traffic video 4 (CAM4). This is because CAM1 has recorded by using the smartphone with a high specification of camera (48-Megapixels) which recorded the video without indistinct. Nonetheless, CAM3 and CAM4 also recorded using a smartphone, but the ambulance detection system failed to detect the ambulance in the recorded traffic videos. This may occur due to the location of the traffic video recorded that affected the blob size of the ambulance where CAM1 was recorded at the footbridge while CAM3 and CAM4 were recorded at the bus stop. The distance between the footbridge to the road is more than 10 m in CAM1 which captured the ambulance within 200 to 1000 pixels while the distance between the bus stop to the road was less than 10 m in CAM3 and CAM4 which makes the larger blob size for the ambulance that was out of the range and caused the ambulance detection system failed to detect the ambulance.

Besides, the white colour is the preset colour in the ambulance detection system. As a result, the white colour ambulance in CAM1 has been detected while the system failed to recognize and detected the yellow-brown colour ambulance in CAM3 and light yellow colour ambulance in CAM4 which both colour are not in the specified range.

In addition, CAM1 and CAM2 have recorded at the footbridge, and the ambulance detection system successfully detected the ambulance at CAM1 but failed its performance by accidentally detected the normal white vehicles in CAM2. This may due to the traffic video recorded using a low specification of USB webcam, which was only 8 Megapixels and caused the indistinct in the video. The traffic video recorded using the webcam easily affected by the illuminance, which increased the intensity or the HSV value of the frames. Therefore, the ambulance detection system using a high specification of a camera and implemented at the footbridge will provide a higher accuracy on detecting the ambulance.

Table 1: Traffic video recorded using different devices at a different location

Device	Traffic Video (CAM)			
	CAM1	CAM2	CAM3	CAM4
Type	Huawei smartphone	USB webcam	Huawei smartphone	Huawei smartphone
Pixel (MP)	48	8	48	48
Screen Resolution	1920x1080	640x480	1920x1080	1920x1080
View (angle)	45°	45°	90°	90°
Camera mode	Landscape	Landscape	Portrait	Portrait
Distance	>10 m	>10 m	<10 m	< 10 m
Location	Footbridge at Taman Intan, Parit raja	Footbridge at Taman Intan, Parit raja	Bus stop, KFC Parit Raja	Bus stop, right front of UTHM
Blob detected	Success	Fail	Fail	Fail

4 Conclusion

The system model of vision-based traffic signal control for the ambulance detection system had been successfully designed and developed with priority for the ambulance. During an emergency, the ambulance detection system will send the instructions automatically or without any human intervention to the traffic signal control system in order to provide 10 seconds green light for the lane with an ambulance. Besides, the vision-based traffic signal control system works as the cloud-based monitoring system by synchronizing the traffic road condition to the Firebase database, and there is no time delay and no limited customizability when the data updated to Firebase database. Also, WhatsApp message was sent to notify the relevant company when the ambulance detection system detected the ambulance.

From the data analysis, the ambulance detection system has successfully detected the white ambulance in CAM1 but failed its performance when analyzing CAM2, CAM3 and CAM4 due to the condition of CAM1 is most suitable to be implemented by the ambulance detection system. The specification of the devices used to record the video prefer in high specification so that to record the video clearly. The video recorded should have a distance more than 10 m so that it would not affect to the preset blob size for the ambulance. In addition, the white colour ambulance was in the specified range so that the system can detect the ambulance in CAM1 but not CAM3 and CAM4.

The future research directions for enhancing the vision-based traffic control for intelligence ambulance detection system was discussed. First of all, we will improve the accuracy of the system on detecting the ambulance by replacing it with a high-speed camera with the frames rate of exceeds 250 fps which can capture the moving vehicles clearly on the road. Last but not least, we will improve the feature of the system by adding the night vision feature, which allows the ambulance detection system to capture the ambulance at night.

Acknowledgement

The authors would also like to thank the Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia for its support.

References

[1] D. Shane, “Singapore slaps limit on the number of cars on its roads,” CNNMoney, 24-Oct-2017. [Online]. Available: https://money.cnn.com/2017/10/24/news/singapore-car-numbers-limit/index.html. [Accessed: 17-Oct-2019]

[2] P. Gupta, G.N. Purohit and A. Dadhich, "Approaches for Intelligent Traffic System: A Survey", International Journal on Computer Science and Engineering, ResearchGate, 2012, vol.4, pp. 1570-1578

[3] S. Ling, "Ambulance carrying pregnant woman overturns in accident with 4WD vehicle," The Star Online, 26-Feb-2019. [Online]. Available: https://www.thestar.com.my/news/nation/2019/02/26/ambulance-carrying-pregnant-woman-overturns-in-accident-with-4wd-vehicle. [Accessed: 17-Oct-2019]

[4] Z. Hashim, "MPV fails to give way to ambulance, both collide head-on," NST Online, 14-Sep-2018. [Online]. Available: https://www.nst.com.my/news/nation/2018/09/411305/mpv-fails-give-way-ambulance-both-collide-head. [Accessed: 19-Oct-2019]

[5] AFP, "Patients dying as Manila traffic jams block ambulances," NST Online, 09-Sep-2019. [Online]. Available: https://www.nst.com.my/world/2019/09/519863/patients-dying-manila-traffic-jams-block-ambulances. [Accessed: 19-Oct-2019]

[6] "Digital Image Processing Introduction," tutorialspoint, 2018. [Online]. Available: https://www.tutorialspoint.com/dip/image_processing_introduction.htm

[7] M. Rouse, "What is cloud computing? - Definition from WhatIs.com," SearchCloudComputing. [Online]. Available: https://searchcloudcomputing.techtarget.com/definition/cloud-computing. [Accessed: 19-Oct-2019]

[8] N. Yadav, "Color-based Blob Detection," 1nine.com, 2020. [Online]. Available: https://1nine.com/color-based-blob-detection/

[9] K. Keshari, "What is Google Cloud Platform (GCP)?-Introduction to GCP Services &GCP Account," edureka, 22-May-2019. [Online]. Available: https://www.edureka.co/blog/what-is-google-cloud-platform/#WhatisGoogleCloudPlatform?

[10] F. Andronicus and Maheswaran, "Intelligence Ambulance Detection System," International Journal of Science, Engineering and Technology Research (IJSETR), 2015, vol 4, Issue 5, pp 1462-1466