An Early Warning Elephant Intrusion Integrated with IoT

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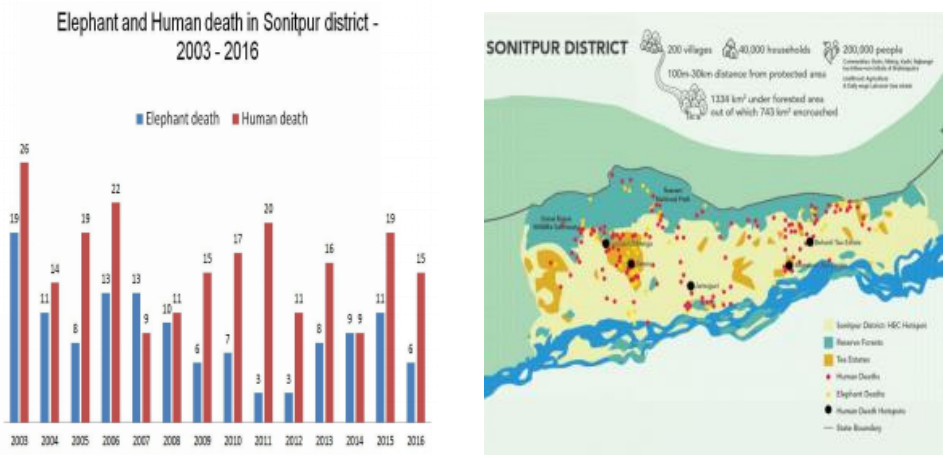
1. Introduction

Human–animal conflict (HEC) is one of the main issue in the forest border areas where herds of wild elephants straying into human habitation. Another issues is that the elephant start to raid the villager's plantation. The main idea of this project is to design a prototype of an early warning detection and prevention system that prevent elephant intrusion at the same time alerts the villagers. The system also be able to integrate with Internet of Things (IoT). In this proposed system, a Passive Infrared (PIR) sensor or motion detection sensor being used to capture the movement of the elephant. The prevention mechanism is conducted by Arduino Uno R3 ATMega328P as microcontroller and later communicate with the other microcontroller via nRf2401 modules. The system is connected with cloud database using Favoriot platform. The platform communicate with Arduino Uno ATMega328P via NodeMCU ESP8266 Wi-Fi to obtain the Wi-Fi signal for uploading the data of intrusion events. The average of uploading time for the data for Favoriot platform is within 10 seconds until 15 seconds. The systems able to alerts the local villagers and triggers prevention mechanism at the same time when the elephant intrusion event occurs. The data intrusions is uploaded to Favoriot platform on regular bases and specifically extract the data making into real time analysis.

2. Recent Incidents of Elephant Intrusion Worldwide

According to paper [1] there are only 50 countries in the world that can be considered as natural habitats for wild elephants. From that, only 13 of these countries are in Asia while rest are from the African continent. As for today, only a total of 51,000 to 66,000 elephants are living in Asia, and of these elephants only 35,000 to 50,000 are living in their natural habitats [2].

In the worldwide, the North-East India shows the highest human-elephant conflict (HEC). The particular area that hot in elephant intrusion is Sonitpur District in Assam province. The statistics in Figure 1 (a) shows the elephant and human death in Sonitpur District during (2003–2016) with the highest human loss is 26 people and elephant loss is 19. Figure 1 show the map of Sonitpur District with the region of hotspot of HEC conflict occurs. This conflict most occur at night and usually September to February coinciding with the cropping cycle when elephants are often attracted to the fresh paddy.



(a) (b)

Fig. 1 - (a) Elephant and human deaths in; (b) the map of Sonitpur District Sonipur District [3]

As in Figure 1, the bar chart tends to fluctuate from year to year which mean the conflict still not have a right solution. In the following year, the number of victims from this conflict may increase. Therefore, early detection of elephants can prevent surprise encounters and give people more time to choose the best response to prevent escalation into conflict.

3. Development of the Elephant Intrusion System

The key success of the system is based on sensorial parts and the networks. M. S. Nakandala et al. [2] proposed an early warning system which can act as a virtual barrier covering elephant corridors or villages which consists of PIC microcontroller, Infra-red (IR) sensors, Passive Infra-red (PIR) sensors and wireless communication module. The basic detection is explained which when the both IR and PIR sensor triggered simultaneously then warning signal is send. For the sending the warning, the system using a GSM modem as this necessary and important to alert all the people in the village. In this study, the main sensor is Passive Infrared (PIR) sensor and the system using the wireless network which related to this project. Ms. Gayathri. R et al. [4] presented an automated system for identification of elephant where the system consists of three consecutive layers and by using piezoelectric vibrating sensor, the sensor is sensed the vibration created when obstacles or elephants enter as shown in Figure 2.

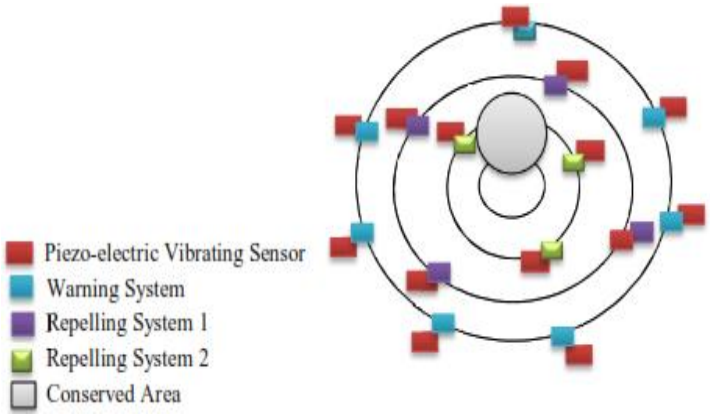


Fig. 2 - Sensor deployment [4]

Inspired by this work, here the proposed system will be using the same modus operation which consists of consecutive of layers. This layers acts as the virtual barriers covering the border of the plantations. E. Kanniga et al. [5] presented an enhanced target detection and classification performance by fusion of seismic and PIR sensor signals. This system presents a fusion of seismic and PIR sensor which shows the PIR sensor can give more credibility in detection system. Therefore, this give more reasons to select the PIR sensor as main sensor in this project.

The previous works focus on the network system and the sensorial approach while provide the alternatives for the elephant intrusion detection system. From there, it was decided to use PIR sensor and multilayer sensor as virtual barriers in this project. Fig. 3 shows the architecture of proposed system. This project is developed with wireless network system which the data information may be uploaded into Internet of Things (IoT) platform and the platform is able to alert the local villagers by sending the notification. From the data uploaded, the IoT platform can bring the analysis results as reference in the future.

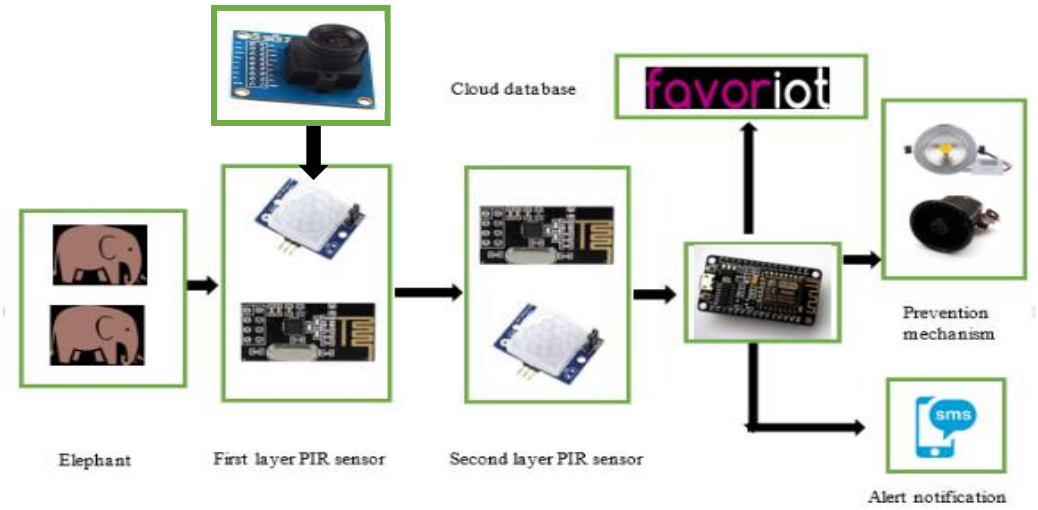


Fig. 3 - Illustration of overall flow of the system

4. Realisation of the Prototype

The prototype have two parts which is first layer and second layer detection sensor. Figure 4 shows the setup of the prototype. The first layer of detection sensor is connected with the second layer via nRF24L01 modules that communicate using radio frequency (RF). The Internet of Things (IoT) which Favoriot platform is communicated with the prototype using NodeMCU ESP8266 Wifi board. To monitor the connection between the first and second layer, the prototype is connected to the computer. The prototype has been testing in the outdoor location at Lorong Baitul Manisah in Parit Bengkok's area. The prototype is installed at the parking's pillar to act as the tree because it more convenient to see the prototype working properly. Figure 5 shows the first and second layer of the detection system are installed at the pillars. While, Figure 6 shows the both layer of the detection system.

Fig. 4 - The setup of the prototype

(a) (b)

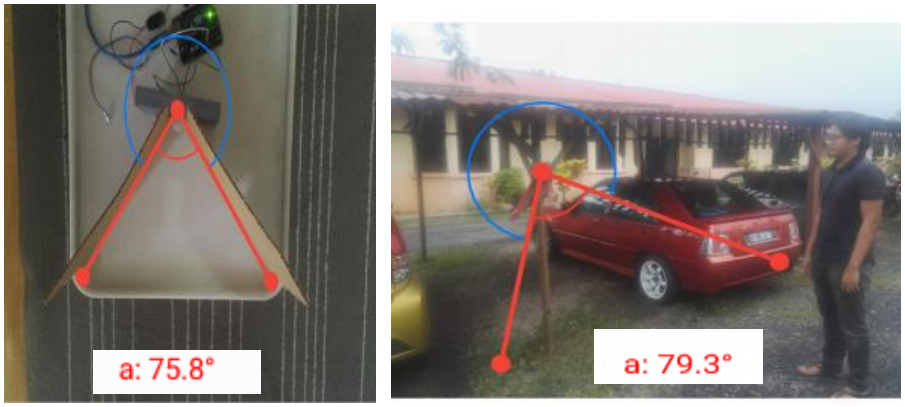
Fig. 5 - (a) First layer of detection system; (b) second layer of detection system

Fig. 6 - Both of layer in detection system

The system is conducted by using a person to walk beside the first layer until the second layer to see the working prototype. This is to indicate when the elephant passing by the system. The camera module is ready to capture any images of the passing intruders. When the first layer detect the motion, the message is sending to the second layer for ready and light up the first defense mechanism which is spotlight or lamp. For the intrusion happened, the elephant need to pass the second layer as the motion sensor ready. As the person walk through, the second layer detect the motion and this trigger the second defense mechanism which is an alarm. In the same time, the alert warning is sending to the villagers and data of intrusion is uploaded to the Favoriot platform via NodeMCU ESP8266 wifi board. The alert sending to the villagers using email. From the platform, data analysis are recorded and discussed.

5. Performance of the System

The angle of beam from the PIR sensor is analyzed. From the datasheet, angle from the top view for the sensor is 90° degrees. The indoor and outdoor testing for the actual angle is done by using mobile application which is Angulus. Figure 7 shows the indoor angle is 75.8° degrees while the outdoor angle is 79.3° degrees. From the both testing, the side range of sensor is less than the expecting angle of beam from the sensor which is 90° degrees. The sensitivity of the PIR sensor to detect an object movement which may represent an elephants is analyzed. It also absorved that the workability distance for the system is up to 5 meter. This distance can be increased if the sensitivity of the sensor is adjusted.



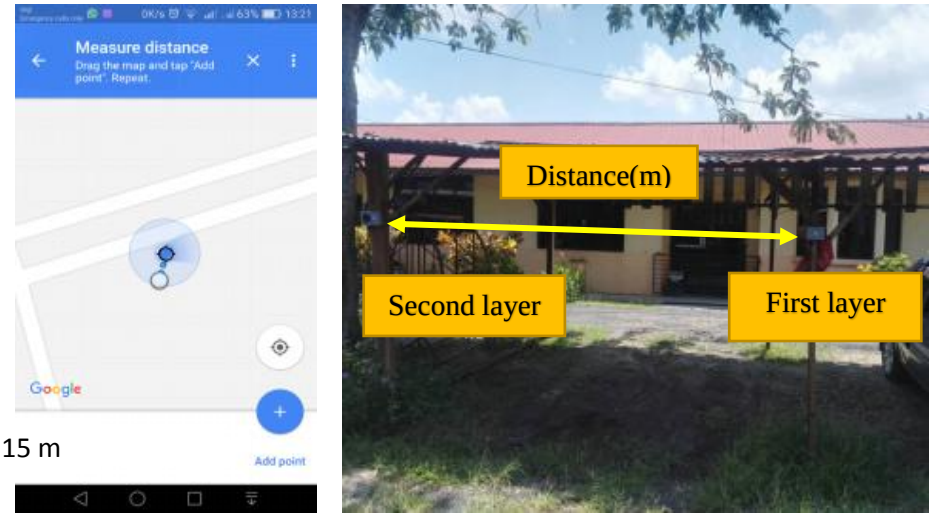
(a) (b)

Fig. 7 - (a) Indoor testing; (b) outdoor testing

The ability of the PIR sensor to detect a movement across the sensor is analysed. The speed is measured by time taken of average walking at constant distance. From here we may observe the slowest and the farthest movement the PIR sensor can detect. The average speed of the elephant walking is 0.8 m/s while average of human walking is 1.4 m/s. The testing shows the PIR sensor can detect a movement as slow as 0.33 m/s. The sensitivity of the PIR sensor can be adjusted using the potentiometer. An increased sensitivity can be beneficial for when using a PIR for long range detection, which up to 6 meters or more. While, the decreased sensitivity is good for a short range, as the half of the maximum range or up to 4 meters. This can be dependent on how the data taken and measured.

Based on the project application, the sensor sensivity is more suitable to be on the lower side because the speed of elephants in moderate speed. Therefore, the detection of elephant should be closer to the sensor as for the short range detection. If using the long range detection, it may indicate a false alarm.

The distance between the first layer and second layer is tested. This is to ensure the elephant intrusion to the plantation and avoid false alarm whereas only first layer detect motion but not the second layer. The alert be triggered after the both layer of sensor is detected the motion. This testing is done using line of sight (LOS) and obstructed sight between the first and second layer. The obstructed sight indicated the trees and by using application Maps, the distance can be measured and recorded. The starting point is located at 1.88453914, 103.0795110, Parit Bengkok as shown in Figure 8. It is shown that that the distance between the first and second layer of sensor can be achieved up to 18 m with line of sight (LOS) while obstructed sight is 15 m.

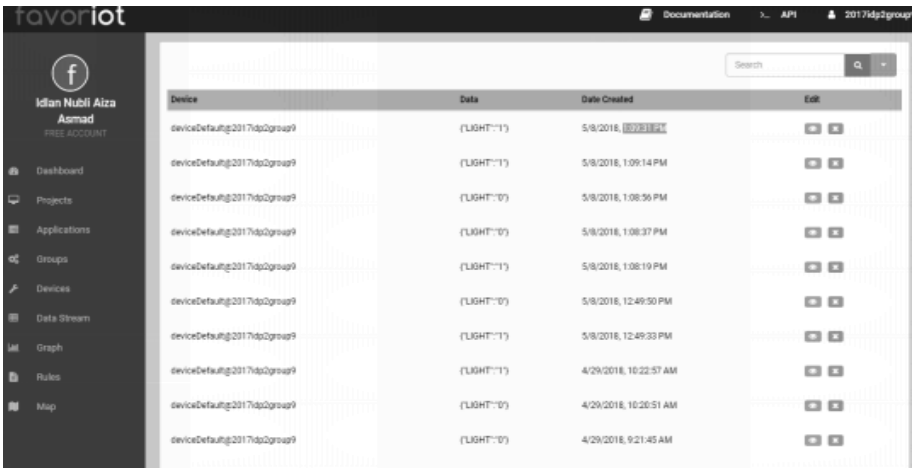


(a) (b)

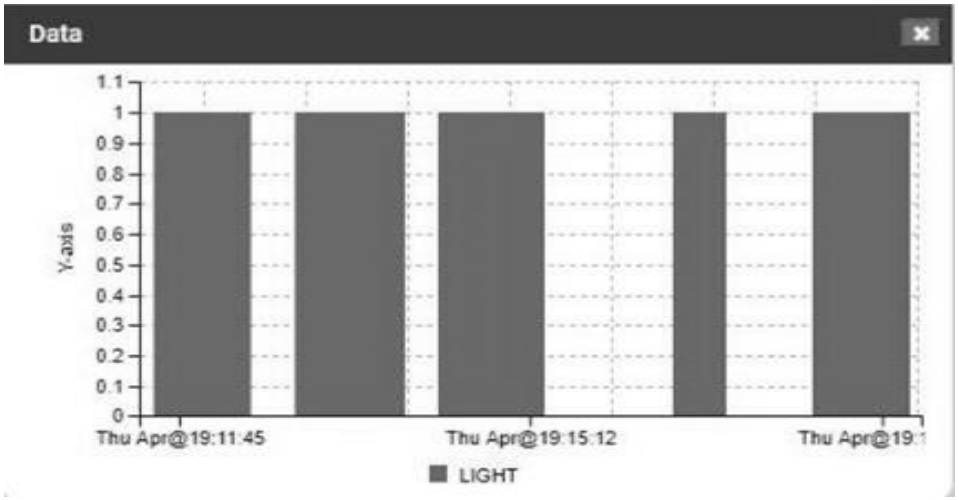
Fig. 8 - (a) Distance in Maps, and; (b) distance between the first layer and second layer

The captured images is taken by OV7670 camera module. The camera is able to capture and save the images into SD card. The restriction that occur is the camera module cannot able to send the images to the cloud platform which is Favoriot platform.

The data uploaded into Favoriot platform is taken and analyzed. For every motion detected and alert sending, the data is uploaded and analyzed into bar graph. This graph is detailed the data stream into the time of intrusion happened and the date which called real time data. The data from the graph can be analyzed into how the frequent of intrusion and hot areas where the intrusion occurs. Figure 9 shows data stream uploaded and bar graph in the Favoriot platform. From the Table 1, the date and time is recorded for the future analysis. It is observed that the time uploading to Favoriot platform may delay between 10-15 seconds. This time different does not affected the time for react to the intrusion.



(a)



(b)

Fig. 9 - (a) Data stream in Favoriot platform and; (b) bar graph in Favoriot platform

Table 1 - Recorded result of uploading time for Favoriot platform

No. of motion detect	Date	Time
1.	8/5/2018	1:09:31 pm
2.	8/5/2018	1:08:37 pm
3.	8/5/2018	12:49:50 pm
4.	29/4/2018	10:22:57 pm
5.	29/4/2018	10:20:51 pm
6.	29/4/2018	9:21:45 pm

6. Conclusion

From the results, it shows that an early warning elephant intrusion system integrated with internet of things (IoT) is successfully done. The system able to detect and react by using defense mechanism. Moreover, it is able to alert the villagers and keep the data of intrusion into Favoriot platform. The conclusion and recommendation of this project are discussed in detail for next chapter.

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