Forest Fire Alert System

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Abstract. Recently, forest fire cases have often occurred in Indonesia. Besides efforts to prevent the forest fires, there is also a need for a good mitigation system. Mitigation is an effort made so that the impact of disasters can be minimized. In this research, a prototype of forest fire alert system will be built. This system will be based on IoT and focus on prediction of forest fire positioning. Temperature data as a basis prediction data obtained from the DHT11 temperature sensor which is transmitted by NodeMCU v3 towards Raspberry Pi 3B utilizes the Message Queuing protocol Telemetry Transport (MQTT) will be displayed on a webpage provided by Node-Red Dashboard. The webpage accessible to authorities to take actions needed to deal with forest fires.

Keywords: fire detection, temperature sensor, website

1. Introduction

In the past 10 years, cases of forest fires in Indonesia have continued to increase. Recorded data released by the National Agency for Disaster Management (BNPB) that the most cases of forest fires occurred in 2019, with a total of 3,276 incidents. While the worst case of forest fire occurred in 2015, the area of forest and land burned reached 2,611,411.44 hectares [1].

To overcome this the government has create various monitoring tools to prevent forest fires. However if the disaster is inevitable, the disaster mitigation process needs to be carried out [2]. In this research, a prototype for the mitigation process will be built with the aim of predicting the forest fire positioning. To build the mitigation system prototype a temperature sensor, wifi module, and a server are needed. This prototype system will work starting with receiving data in the form of forest temperature using a temperature sensor. The received data will be transmitted by the wifi module to a server. The data on the server will be processed to predict the fire position. Data that has been processed will be transmitted immediately to a webpage. On a webpage, the data will be presented and observed. The webpage accessible to authorities to take actions needed to deal with forest fires.

2. Method

In this research, a mitigation system prototype designed consist of three important parts, namely data retrieval and transmission, data processing and storage, and data presentation. Data retrieval and transmission (sensor node) consists of a DHT11 temperature sensor module, and NodeMCU ESP8266. DHT11 is a low-cost humidity and temperature sensor [3], [4] meanwhile NodeMCU ESP8266 is a low-cost, powerful, and simple to use microcontroller and wifi module [5], [6]. Data processing and storage consists of Raspberry Pi. Raspberry Pi can be used as a low-cost private server [7]–[9]. Data presentation consists of a webpage.

DHT11 sensor and NodeMCU ESP8266 operate using the same voltage sources which is equal to 3V. While the Raspberry Pi operates using 5V voltage source. Temperature data obtained by DHT11 sensors will be transmitted by NodeMCU ESP8266 utilizes MQTT. MQTT protocol is an application layer protocol that uses a topic-based publish-subscribe architecture [5], [10]. DHT11 sensor will act as publisher connected using MQTT. MQTT will pass data to subscriber namely Raspberry Pi. The data will be received by Raspberry Pi and Node-RED will store data on influxDB. Node-RED is open source tool to integrate hardware devices [4], [11]. InfluxDB
is an open source time series database [12], [13]. Data stored on InfluxDB will be processed again by Node-RED which later will be displayed on the webpage. Figure 1. shows block diagram of this system. In the meanwhile Figure 2 shows system implementation, red circle shows NodeMCU, yellow circle shows DHT11, and blue circle shows power cable.

There are two algorithms used in this research. In Figure 3.a. there is a flow chart related to the data retrieval program algorithm. While in Figure 3.b. there is a flow chart related to the data processing algorithm. In the data retrieval process, the program code uploaded to NodeMCU v3. NodeMCU v3 is directly connected to the temperature sensor using the MQTT. Retrieval data utilizes the DHT11 sensor library which can be used to set the data retrieval interval and the length of the data retrieval process. Data retrieval process will only stop if the sensor or NodeMCU has run out of power.

Meanwhile, data transmission process using the MQTT library. In this library we can determine the connection data transmission to be used, security protocols, messages delivered and much more. Like the data retrieval process, the data transmission process will not stop until all devices run out power.

**Figure 1.** Block diagram of the system

**Figure 2.** System implementation

Data processing occurs at the Raspberry Pi. After Raspberry Pi receives data from the sensor, the data will be stored using program code on Node-RED to the database on InfluxDB. Database can be available after the initialization process. After the data is stored in InfluxDB, the code continues to read stored data and carry out data processing. The data processing conducted to determine whether the temperature data stored can be identified as fire category or not. Fire characterized by temperature data that exceeds 45°C. If the code identified a fire, it will send a message to the webpage to display temperature data and fire symbol. Meanwhile if there is no fire, the program will send a message to display only temperature data on a webpage. Figure 3. shows the webpage result.
3. Results and Discussion

In this research, a fire alert system prototype has been built. There were 5 sensor nodes used. In Figure 4, there is a map as if a sensor nodes had been placed as a forest fire detector. There are five sensor nodes positioned along the x-axis, with sensor-1 at coordinate x = 1, sensor-2 at coordinate x = 3, sensor-3 at coordinate x = 5, sensor-4 at coordinate x = 7, and sensor-5 at coordinate x = 9. Data retrieval process obtained temperature from each sensor each second. There is an example of cases that was tested in this research, namely the fire source detected on sensor1. Obtained data listed in table 1.

![Figure 4. The webpage result](image-url)
Figure 5. showed an example of webpage for a case where the source of fire detected on sensor 1. On this webpage, temperature of each sensors dispalyed together with position of each sensor. Data will be displayed in the form of measured temperature of the sensor in real time. Sensors indicating the presence of fire will display a fire symbol under the word sensor. In this example, fire image displayed under the word sensor-1. This indicated position of the forest fire equal to position of sensor-1 at coordinate x = 1.

![Figure 5](image)

Figure 5. The result of fire identification

Corresponding temperature of sensor-1 can be seen in table 1. In this table, it can be seen temperature from t = 1 s to t = 10 s with interval of 1 second. Temperature during those 10 s reach more than 45°C so that it categorized as fire. Those temperature data achieved by bringing a candle closer to sensor-1. The results obtained are similar to the existing mitigation webpage [14].

| Time | Temperature (°C) | ∆t (s) |
|------|------------------|--------|
|      | Sensor-1 | Sensor-2 | Sensor-3 | Sensor-4 | Sensor-5 |
| 1    | 45.6     | 40.1     | 33.8     | 28.4     | 27.2     | 1.0     |
| 2    | 46.1     | 40.2     | 33.6     | 28.0     | 27.4     | 1.0     |
| 3    | 46.3     | 40.6     | 34.3     | 28.3     | 27.7     | 1.0     |
| 4    | 46.8     | 41.6     | 34.9     | 29.0     | 28.5     | 1.0     |
| 5    | 47.3     | 42.1     | 35.7     | 30.1     | 28.6     | 1.0     |
| 6    | 47.9     | 42.1     | 35.8     | 30.8     | 29.2     | 1.0     |
| 7    | 48.5     | 43.2     | 36.5     | 31.3     | 29.9     | 1.0     |
| 8    | 49.1     | 43.9     | 37.2     | 31.7     | 30.1     | 1.0     |
| 9    | 49.4     | 44.2     | 37.4     | 31.9     | 30.5     | 1.0     |
| 10   | 50.2     | 44.5     | 38.2     | 32.9     | 31.1     | 1.0     |

4. Conclusion

Based on the results obtained, the prototype of forest fire alert system has been successfully built. This is marked with the process of data retrieval, data transmission, processing and data storage, as well as data display on the webpage is successfully done. Another result is positioning the fire was determined by processing each temperature data sensor. In this case a fire source occurred in sensor-1. Fire identified by using minimum temperature, the minimum temperature equal to 45°C. Temperature above minimum temperature will be categorized as fire. In the
future, we will increase the number of temperature sensors. It will be equipped with supporting sensors others such as smoke sensors. In addition, we will predict the distribution of fire in the x-axis and the y-axis.

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