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High Sensitivity Prototype Kit with IoT System for Fire Detection in a Peatland Swamp Forest Area

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Abstract: Smoke sensor of the photoelectric type is often used in indoor fire detection system. It is very sensitive to fire smoke and will trigger a fire alarm quickly when the presence of smoke is detected. By making a small innovation, this sensor can be implemented outdoors by means of IoT as used in the forest fire early detection system. However, the typical use of the sensor without any modification causes the sensitivity of the system to be very low such as failing to identify the actual presence of smoke. To increase the sensitivity of systems that use this type of sensor, the developed system is equipped with an automatic reclosing operation that is able to distinguish real smoke or not. The system has been designed to trigger cloud servers only after detecting smoke for ten seconds or beyond. System equipped with automatic reclosing operation show better response by not triggering cloud servers when detecting temporary smoke from car, motorcycle or nearby factory. When comparing the system before and after using this operation is, it was found that the system no longer sends smoke notification message to the user via Telegram channel when this temporary smoke is detected

Keywords: Sensor node, smoke sensor, high sensitivity system, Telegram channel

1. Introduction

Peatland swamp forest reserve fires in Malaysia have damaged the wildlife ecosystem in it and also harmed the lives of humans living around it. Apart from that, the country also suffered a loss of millions of ringgit due to large cost

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was required to repair the burned area and this effort took a long time to restore it to its original condition. Every year fires occur repeatedly involving large areas of the peatland swamp forest. The data of the Ayer Hitam Muar forest reserve, Johor, Malaysia from 2011 to 2021 shows that many areas in the compartment were destroyed because the fire failed to be detected at an early stage while the effort to put out the fire took a long time. It is seen as an unfortunate occurrence as these fires occur in the digital age as technology can be employed to help humans overcome this problem. In this case, early fire detection work is essential to prevent more severe fires. The use of smoke sensor is an appropriate method for early detection of forest fires using Internet of Things (IoT) technology as shown in Fig. 1. The figure shows how the sensor can detect fire smoke and subsequently trigger a cloud server to send a detected fire message to the authorities such as rangers, firefighters or enforcement agencies.

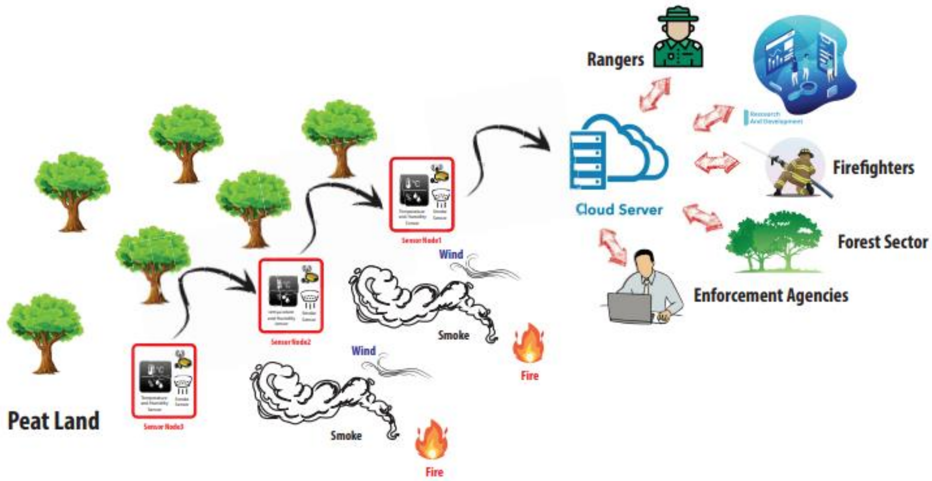

Fig. 1 - Illustration of the proposed sensor node that detects the smoke in a peat swamp forest

Although smoke sensors are widely used indoors to detect the onset of fires, by making small innovations such as using waterproof casings they can be used in outdoor environments effectively [1]- [2]. In addition, the use of this sensor has many advantages such as its effectiveness in detecting the presence of smoke has been proven, easy to integrate with IoT, reasonable price, simple and practical. However, if the smoke sensor is used directly, it may cause the fire detection system to be low sensitivity due to the system fails to distinguish real smoke or non-real smoke. This will cause an error when the system sends a notification message of a forest fire to the user as shown in Fig. 2. The figure shows that the system will detect the smoke, measure the temperature and humidity of the surrounding area. The flowchart presents that when the smokes are detected by the sensor nodes, the system immediately trigger the cloud server to send the notification message to the user through the Telegram channel.

Fig. 3 illustrates the problem in the previous product [1]- [2] in which the sensor node has detected the smoke from unknown sources such as smoke from vehicles and nearby factories carried by the wind so that it can reach around the sensor node. The figure depicts a sensor node that has been installed at the study location. The node is located on the side of the main road that is used by a motor vehicle user such as motorcycles and cars. A factory is also situated not far from the place which will produce smoke. This causes the user to receive an incorrect message.

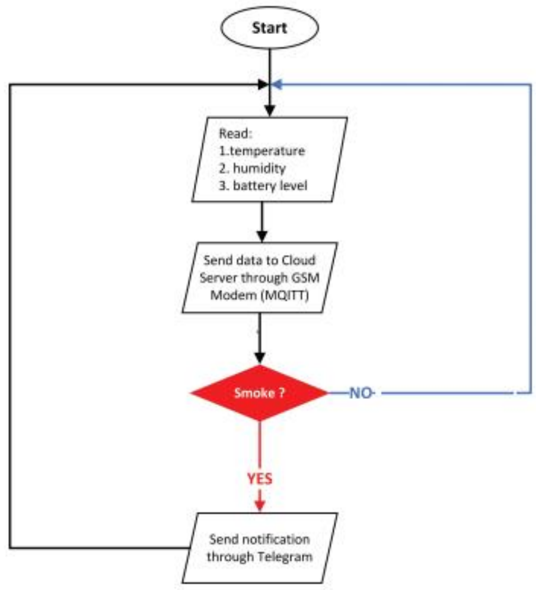

Fig. 2 - The overall system operation in [1]- [2]

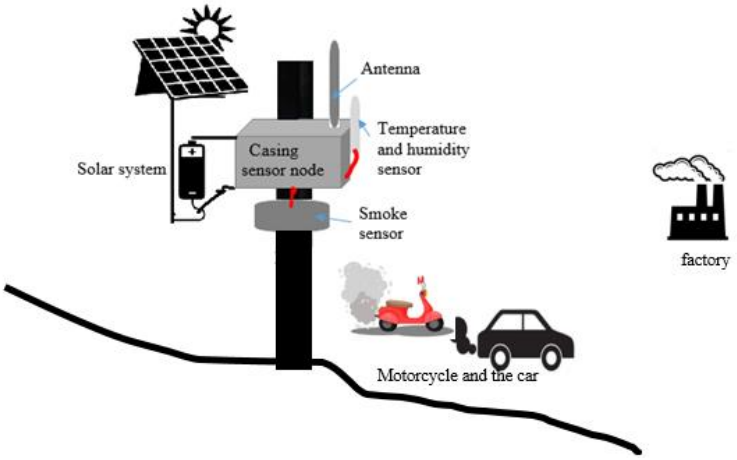

Fig. 3 - Illustration of the smoke from the car, motorcycle and the factory nearby

To overcome this problem, the smoke detector system developed is equipped with automatic reclosing operation that can increase the sensitivity of the system. Among the advantages of the prototype developed in this article is that it can distinguish the actual or non-actual fire smoke based on the period given for the decision-making system to trigger cloud servers to send smoke notifications that have been detected by node sensors.

Many studies use smoke sensors for forest fire detection systems as reported in the reference [3]-[8]. These systems were developed using gas sensors or recorded smoke images. The system developed in [3] uses a smoke sensor to detect the gas content during normal conditions and the presence of smoke (fire). However, the sensor used is not industry based which is definitely low sensitivity, not durable, cannot last long and limited capabilities. The prototype produced also did not take into account the real environmental factors such as extreme weather and only involves the work in the laboratory only. This certainly gives inaccurate smoke detection results if it were used to detect forest fires. In [4], gas sensors were used to measure CO_2 and CO gases. Although the system was able to operate well, it was still low sensitivity, complicated with high power consumption. In [5], gas sensors were used to detect hydrocarbon gases and CO_2 while detecting fires. This developed prototype operated well and the readings from this sensor gas were used to distinguish the occurrence of fire or not. However, the sensitivity of the system was still low because it cannot distinguish between the real and non-real fire smoke. MQ-2 type gas sensor was used in [6] to detect smoke in the developed system. However, there was no work to optimize the ability of the system to detect smoke which causes the sensitivity of the system was low. In [7], an MQ-7 type gas sensor was used in the built-in system. The system was equipped with a conditional gas level for the received gas to trigger the system when the fire occurred. However, the system did not able to distinguish real smoke or temporary smoke (not real smoke). So, the sensitivity of the system was low. QM-6 and TGS 2600 smoke sensors were used in [8] to produce early fire detection system. This developed system was limited to initial testing of the sensor response when detecting smoke such as distance and response time. In addition, the usage of video cameras to detect fire smoke was a frequently used method and not just limited to smoke sensors. Yet the system require high-resolution cameras and smoke images from these cameras were used to detect fire as reported in [9].

In this article, the use of automatic reclosing operation as a technique to increase the sensitivity of the system by distinguishing the real or non-real fire smoke is the main objective of the study. Basically, the principle of automatic reclosing operation is simple. When an error is detected, the system can correct it once the actual smoke is detected successfully. This technique brings obvious advantage such as the notification regarding the correct smoke detected at the sensor node.

2. Proposed Prototype

Fig. 4 shows the overall flow chart of the system. Initially the system reads the temperature, humidity, battery level and smoke to detect weather heat, humidity, battery readings on each node and smoke around the nodes. These data will be sent to the cloud server within 30 seconds while the smoke data will be sent to the server at a digit value of 1 or 0 which indicates the sensor node detects the presence of smoke. The system is equipped with an automatic reclosing operation where the smoke data will be sent to the server after the smoke detected for 10 seconds or more. If smoke is detected during this period, the microcontroller will trigger the cloud server (digit 1) and the server will send a message of smoke detected on the sensor node to the user via Telegram channel. The total number of node sensors built in this research work is three while testing the system has started from April 2021 until now. A complete description of the system operation such as graphene software, node-RED software, ID system and database can be found in [2].

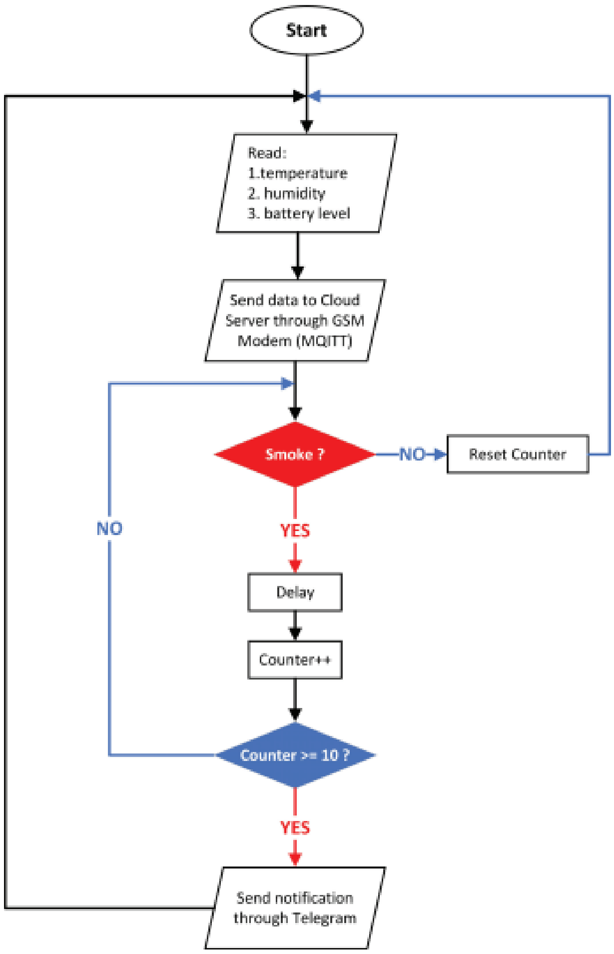

Fig. 4 - Flowchart of the overall system

In this work, smoke detector method is used to detect fire. Figs. 5, 6 and 7 show the smoke sensor, the operating flow of the machine state and the prototype image, respectively. Fig. 5 shows the sensor of the smoke used in this work.

Fig. 5 - Smokes sensor

The operating of the sensor node to detect smoke is shown in the operating flow chart of the entire system (Fig. 4). The node sensor will detect smoke as follows. If smoke is detected, the node sensor will wait up to one second, then will go through the counting process. If smoke is detected within ten seconds (smoke status starts from C1 to C10) or more, the system will trigger a cloud server to instruct the server to send a smoke notification message detected at the sensor node to the user via Telegram channel. If smoke is not detected within ten seconds, the countdown period will be reset to its original state. The complete operation of the smoke detection method is shown by the Mealy state machine in Fig. 6.

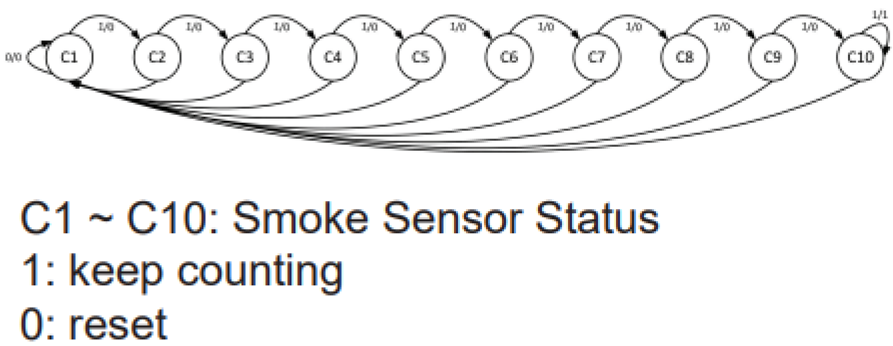

Fig. 6 - Mealy state machine

Fig. 7 shows a photograph of the developed prototype. It consists of solar PV, antenna, sensors, waterproof casing and poles. The prototype produced has some interesting features such as low power and data consumptions, low cost, green technology, IR 4.0 technology, unlimited coverage, follow industry regulation, high reliability and low maintenance cost. It uses 84 mW power, 3.4 MB of data, IoT technology, can access anywhere with internet coverage, industry-based sensors and the prototype has been tested for four months' duration.

No	Item
1	Solar PV
2	Antenna
3	Smoke sensor
4	Water proof casing box
5	Sensors (temperature/humidity, voltage)
6	pole

Fig. 7 - Prototype image

3. Results and Discussion

In this section, a discussion of the results is made involving the original system of low sensitivity [1]- [2] and the repaired system with high sensitivity as proposed in this article. The Telegram message was received by the user via smartphone as shown in Fig. 8(a)-(c). This data was dated from 18 July 2021 to 10 August 2021 for system with low sensitivity. The system sends a message to trigger the cloud server when it detects smoke. Fig. 8(a) shows a smoke message detected at node 4 on 18 August 2021. Node 1, 4 and 5 also detected smoke on the 28, 30 July 2021 and 10 August 2021 as shown in Fig. 8(b). Fig. 8(c) shows that node 2, 4 and 5 also detected smoke on the 16 August 2021. This smoke came from the wind-carried smoke either from vehicle exhaust or a nearby factory as mentioned earlier. After the system is equipped with automatic reclosing operation (refer to Fig. 3), all sensor nodes are no longer detecting any smoke from the specified sources. The product in this article has managed to distinguish between the real or non-real smoke. Therefore, messages like this are no longer sent to the users after this date.

Fig. 8 - Message notification in Telegram channel (a) at 18 July 2021; (b) at 28, 30 July, 4, and 10 August 2021 and; (c) 10 and 16 August 2021

4. Conclusion

This product successfully detects smoke and sends notification messages to users via Telegram channel using IoT technology that meets the objective of the work. The system has been tested from April 2021 until now and is capable of operating during bad weather and can even send data consistently. Furthermore, the product developed in this work has high-sensitivity and able to distinguish between real smoke or non-real smoke. The system is equipped with an automatic reclosing operation where the sensor will send a signal to the trigger cloud server when smoke is detected for a period of ten seconds or more. After implementing this operation, the user is no longer receives a smoke message detected from the specified sources indicating that the system is capable of operating properly. The state-of-art of the product in this work is capable to help the authorities monitor early peatland swamp forest fires more effectively. In the future, the system will be equipped with a digital camera to verify the smoke detected through smoke images from the camera.

Acknowledgement

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