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Research Article

Realtime Monitoring and Analysis Based on Cloud Computing Internet of Things (CC-IoT) Technology in Detecting Forest and Land Fires in Riau Province

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Abstract

Forest and land fires in Riau are natural disasters that always repeat every time they enter the dry season. The solution of this research is to apply the leading technology of cloud computing internet of things (CC-IoT) to find out more quickly the existence of forest or land fires. This study uses Particle Argon (Photon) to connect to the internet and several IR Fire Detector sensors, DHT22 MQ2 and GPS Neo 6m. Particle Argon can receive input and perform processing so that it is connected using the CC-IoT concept to a web server so the users can monitor land conditions in real time. Based on the test results, it can be concluded that a fire detector using fire parameters (2000 = Normal and > 2000 = Danger) , temperature (≤37 = Normal, 38 – 45 = Alert, and 46 = Danger), humidity (≤50 = Dry, 51 = Humid) , smoke (≤ 1700 = Normal, > 1700 = Danger), and soil moisture can work well (> 3500 = Dry Moisture Content, 1500 to 3500 = Medium Moisture Content, and < 1500 = High Moisture Content). The fire detection tool developed can detect fires in real time and also has a fire early detection function that is useful for anticipating land conditions to prevent fires. The results obtained from the test are that the sensor can read indications of fire, smoke, soil moisture with a success rate of 93% and send location data and sensor values to the website. The use of sensors has their respective roles so that if there is a problem with one of the sensors, the tool has an alternative sensor and can continue to function.

Keywords: Cloud Computing Internet of Things (CC-IoT); Forest and Land Fires; Realtime Monitoring.

Introduction

Forest fires on peatlands often cause haze disasters that can disrupt the activities and health of the surrounding community. This is because forest fires on peat-lands produce carbon emissions, especially in the form of carbon monoxide (CO) and carbon dioxide (CO_2) in large quantities into the atmosphere to be the thick smoke [1]. Forest fires on peatlands are caused by 2 factors, namely natural factors and human-made factors. One of the natural factors that cause fires is the hot weather in the long dry season which makes the land dry, while the human-caused factors include land clearing, logging, and illegal burning [2],[3].

One of the solutions of this research is to design a forest alert system to be able to find out more quickly the signs of forest and land fires [4],[5]. The technology designed is a combination of several technological components that are packaged into one and placed into the forest or land [6],[7]. This system is designed to access remote and inaccessible areas of forest and land which is equipped with several sensors to detect forest fires before it starts and enables to send information to land owners as well as the Pekanbaru City Regional Disaster Management Agency (BPBD) [8],[9]. This system detects fires quickly and accurately before it spreads to hundreds of hectares and becomes out of control, so when a fire disaster occurs, the risk of fire spreading to a wider area can be handled quickly.

Internet of Things (IoT) is a very promising scientific development today [6]. The adoption of the IoT is a big issue, especially in the Internet world [10]. Internet of Things itself can also identify, find, track, monitor objects automatically in real-time [11]. The application of the Internet of Things has been carried out by several previous researchers such as monitoring air pollution [7],[8],[12],[13] and home security monitoring [9]. Besides IoT, the development of cloud computing technology is also very rapid and much helpful for systems with long distance

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storage media [14],[15]. Information collection and storage is periodically carried out by sensors and data is processed in cloud storage [16].

Several previous studies discussed early detection of forest fires as in the article [4] the system applied is still Short Message Service (SMS). The weakness of this system is the data cannot be monitored in real-time and needs to be developed and modified to overcome weather conditions because the sensor components which used are very susceptible to damage if prolonged exposure to heat. In another study, [5] the author also discusses research on the restful web service prototype for monitoring and early warning of natural disasters. However, this research still has a weakness where data is manually entered into the database using the POST method so the web service can process the data and share it with each client.

Based on the summary of the study results above, researchers have carried out some developments by implementing several combinations of sensor technology that increases the accuracy of the system in detecting fires. Research requires technology for the rapid dissemination and management of information using IoT technology and cloud computing so the data and information can be monitored by the public or the BPBD via mobile devices. Besides the use of Argon particle technology, a development board that has strong Wi-Fi capabilities, an IR Fire Detector (Infrared) sensor is also needed as a device that detects fire to identify the spectral patterns emitted by the fire. The application of the DHT22 Sensor to monitor air quality and humidity in measuring air quality levels is useful when air conditions are affected by fires and use a soil sensor to measure soil moisture as an indication of early fire detection. Meanwhile, to determine the location of forest or land fires, researchers use the Neo 6m GPS module, then apply a soil sensor to measure soil moisture levels. To measure the condition of smoke levels in the air, an MQ2 sensor is needed [17]. All device modules (sensors) are connected to one another. As result of, the tool can continue to work in the middle of the forest. Solar panel technology is needed for energy source, so all the tools keep working once the power goes out.

Method

A forest fire detection system or forest alert applying the leading technology of the IoT is to find out the signs of forest or land fires faster. The application of IoT technology is needed in sending information to land owners and the Pekanbaru City BPBD [18],[19]. In addition, in distributing data to the server, the proposer utilizes cloud computing as data storage and distribution. In supporting the application of this technology, several sensors is used according to the parameters that is generated. Particle Argon is a technology used in IoT as a development board and has strong Wi-Fi capabilities.

On the other hand, the application of the DHT22 Sensor is used as a monitoring of air quality and humidity in measuring the level of air quality that useful during air conditions caused by fires [20]. Meanwhile, to determine the location of the forest or land fire, the researcher uses the Neo 6m GPS module [21] and to measure soil moisture levels by applying the soil sensors [22],[23]. In measuring the condition of smoke levels in the air, an MQ2 sensor is required [24]. All device modules (sensors) are connected to one another. **Figure 1** shows a plan for installing sensors and elements used to build a fire detection system.

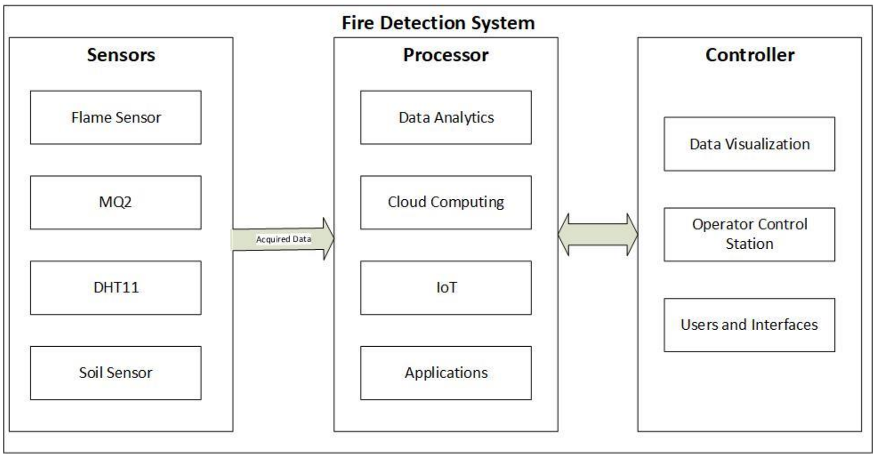

Figure 1. Fire Detection System Element

Several monitoring points are installed in several samples of forest and land in Riau Province which quite vulnerable to forest and land fires.

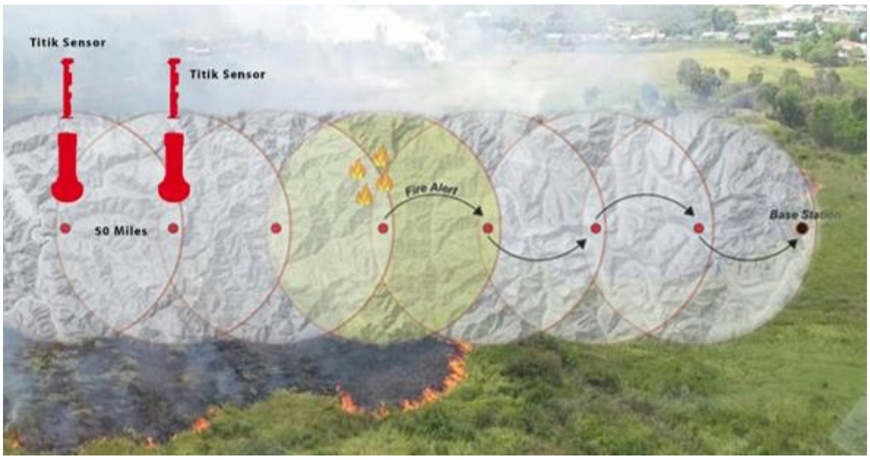

Figure 2. Sensor point placement

Cloud computing and IoT technologies are used for monitoring in real time and send data and forward it to the database/server through several points or spots [25],[26],[27]. The Pekanbaru City BPBD and the community can monitor in real time through website and mobile-based applications. Every electronic device used in the design of a fire detection device requires an electric power supply because the fire detector placed in the forest and land is likely to be far from the power supply and required to work continuously. Consequently, the tool requires a solar panel system and battery so the system can continue to run. Since this tool is placed in an open field, the physical tool is packaged for resistant to weather such as heat and rain. **Figure 3** shows the proposed infrastructure development plan for forest and land fire detection systems.

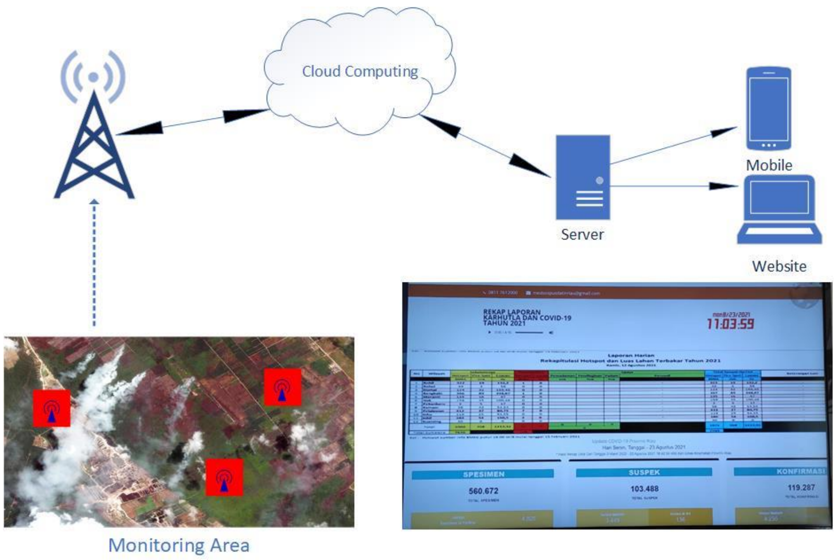

Figure 3. Fire Monitoring System Infrastructure Plan

The data generated from several fire detectors located in several spot points of land and forest areas is stored in a local database using IoT and cloud computing technology forwarded to the server and processed so the recording and monitoring data can be carried out. The Pekanbaru City BPBD, the community and other authorities can monitor online and in real time through a website-based application that can be used as a reference in making decisions. By using a mobile-based fire monitoring and detection application that can be installed on a smart phone enabling users can monitor forest and land fires from anywhere and anytime.

In an effort to prevent the occurrence of the Karhutla disaster, it is necessary to implement management in handling the Karhutla disaster. The use of fire detection technology has been designed to be used side by side with the management of forest and land fires. This technology used is harmonized with carrying out a Focus Group Discussion (FGD) to manage forest and land fires by producing a policy plan with the application of technology.

The framework consists of seven stages, which are described as in **Figure 4**.

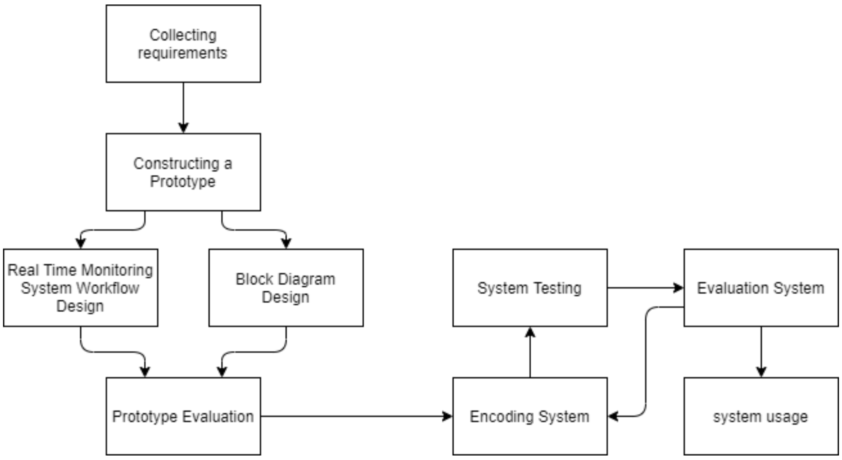

Figure 4. Study Framework

- *Collecting Requirements*

  The method used in this paper to collect data is literature study which involves studying and reading theories about fire systems that support this writing as well as references from other journals that supports the discussion [28].

- *Constructing a Prototype*

  Build prototyping by designing a fire system according to existing data based on the stages set in the data collection stage [29].

- *Block Diagram Design*

  This block diagram represents the overall sequence of fire detection devices used in this study. Real Time Monitoring System Workflow Design

- *Prototype Evaluation*

  Researchers conduct this evaluation to determine whether the prototyping that has been built is in accordance with the wishes. Step 4 is taken if it is appropriate. Otherwise, the prototyping will be revised by repeating steps 1 through 3 [30].

- *Encoding System*

  At this stage, the agreed-upon prototyping is translated into the appropriate programming language.

- *System Testing and Evaluation*

  Once the fire system is ready for use, it must be tested. All structured specifications must be tested, both in terms of hardware and software as a whole. At this point, the completed system is put through its paces. This trial process is required to ensure that the system created is correct in accordance with the specified characteristics and free of errors.

Results and Discussion

System Design

The system built is a website-based system that is useful for online and real-time monitoring of forest and land fires from anywhere and anytime. The circuit is depicted in **Figure 5**.

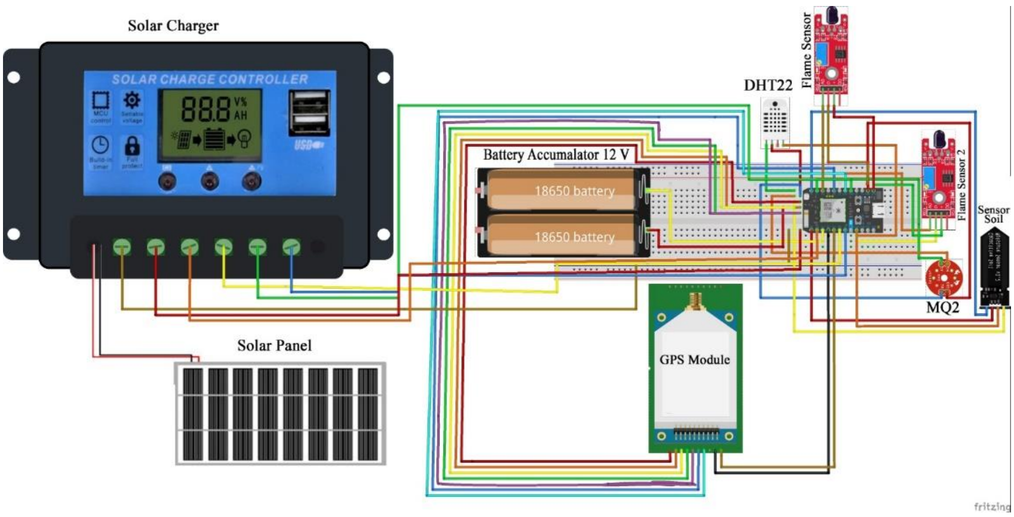

Figure 5. Block Diagram Design

The display design is intended to display a prototype of the forest and land fire system tool to be able to find out the signs of forest or land fires more quickly. Below is an explanation of how the forest and land fire system tools work:

1. How this hardware works, where this tool works by detecting temperature, humidity, soil moisture, smoke, and fire around it.
2. The sensor works if there is a forest and land fire by sending the Location Point for the occurrence of forest and land fires.
3. This system works in real time by utilizing cloud computing internet of things (CC-IOT) technology.
4. This system works with a power voltage of 5 volts.

The system built is a website-based system that is useful for online and real-time monitoring of forest and land fires from anywhere and anytime. The system design used is as follows **Figure 6**.

Figure 6. Monitoring Dashboard Design

The fire and smoke sensor parameters show the "danger" status if the sensor detects fire and smoke points. If the fire and smoke parameters have been detected, it is likely that a fire has occurred in the land. Temperature, humidity, and soil moisture are only early detection of fires which means that these parameters serve as early warning indicators before a fire occurs. If the sensor detects that it reaches certain predetermined indicators, the authorities can anticipate that a fire will not occur. The location menu will detect the coordinates of the GPS embedded in the device, and display it via google maps and send the coordinates to telegram in the event of a fire.

The real-time fire detection monitoring system works as follows in **Figure 7**. The diagram depicts the system flowchart, in which the fire and smoke sensor values are used to determine whether or not a fire occurs. If a fire is detected in the form of hotspots or smoke, the system will send a warning to the website as well as the coordinates via a telegram message. The temperature and humidity sensor in the soil sensor component serves as an early detection of fire and send data on air humidity, temperature, and soil moisture content. Those some parameters can be used as a reference in anticipating the possibility of a fire.

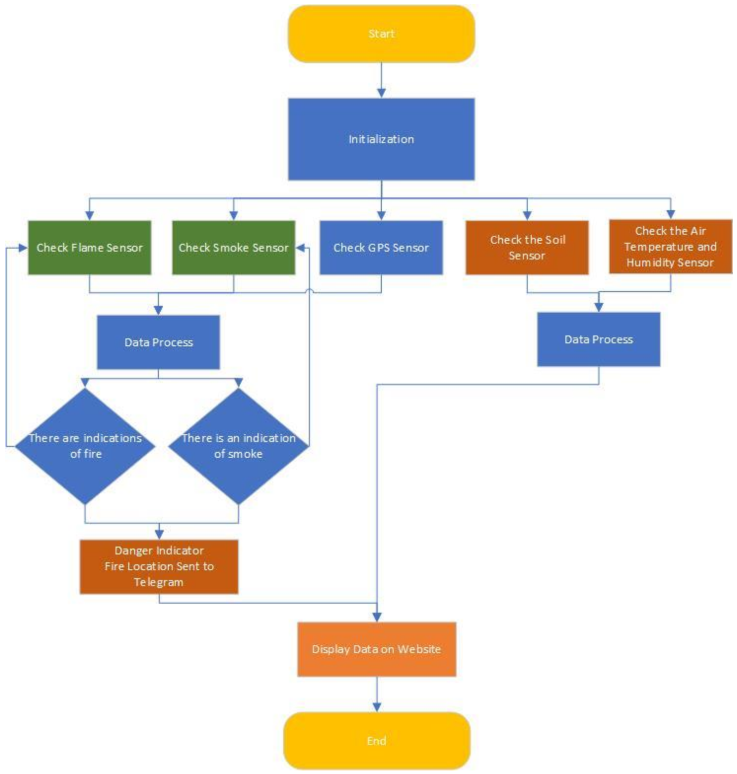

Figure 7. System Works

Figure 8 and **Figure 9** is a display of fire detection tools and website pages that are used to monitor the state of the land in real time.

Figure 8. Display of a Fire Detector

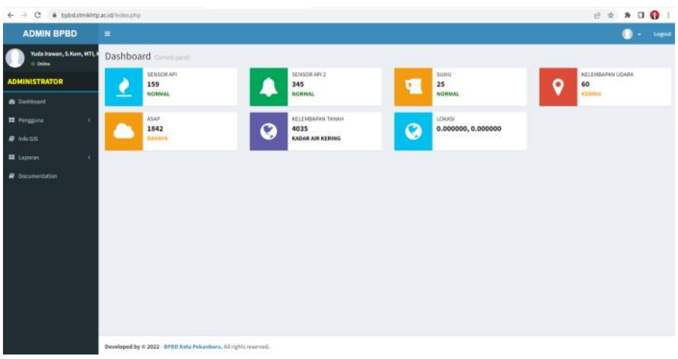

Figure 9. Display of Realtime System Monitoring

Priming Test

The research team initially evaluated a number of electronic components, including photons, GPS, and sensors. The purpose of photon testing is to ascertain how the photon is programmed and integrated. Photon has the benefit that it can be configured and programmed online through the particle.io website, in contrast to offline coding performed by the Arduino uni kit. According to the photon test found that transferring computer devices when coding could present challenges. Researchers encountered challenges when trying to reset photon devices to switch between Wi-Fi and PC connections. To solve this issue, researchers substituted the particle argon for photons, and results of successful trials of switching Wi-Fi devices and PCs. Another issue arose while using the tiny shield GPS; the GPS could not be connected to particle argon; therefore, the researchers chose to use the Neo 6M GPS as a workaround. The connection between the Neo 6m GPS and particle argon has been evaluated, and the test was deemed a success. GPS can test the system by sending coordinates to it through telegram. After undergoing tests, soil, DHT22, and MQ2 sensors as well as fire sensors have all been deemed effectively integrated and capable of receiving input data. Web-based monitoring system testing goes over without a hitch and the system can show sensor input through web-based Apps. After undergoing tests, soil, DHT22, and MQ2 sensors as well as fire sensors have all been deemed effectively integrated and capable of receiving input data. Web-based monitoring system testing goes over without a hitch, and the system can show sensor input through web-based apps. After undergoing tests, soil, DHT22, and MQ2 sensors as well as fire sensors have all been deemed effectively integrated and capable of receiving input data. Web-based monitoring system testing goes over without a hitch and the system can show sensor input through web-based apps.

Testing

Testing of the IoT based fire detection system with a particle argon device was carried out to test that the fire sensor, smoke sensor, soil sensor, air temperature and humidity sensor, and GPS could work according to expectations and the information that had been processed could be displayed via the website in real time by carrying out tests carried out within a period of 1 week with testing 30 times in burning waste in the area around the tool.

Figure 10. Testing by Burning Waste

Table 1 shows the test results of each sensor used in this study. Testing in the field was carried out 30 times in detecting fire by sensors. Based on the analysis of the forest and land fire system testing, it works very well.

Table 1. Sensor Test Results in 30 times Experiments

Platforms	**Component**	**Test**			
		Calibration	***Response***	***Number of Successes***	***Results***
Sensor	Temperature	37 = Normal	Respond to Temperature	28	Success
		38 – 45 = Standby	Respond to Temperature	28	Success
		46 = Danger	Respond to Temperature	28	Success
	Air Humidity	50 = Dry	Responds to Air Humidity	27	Success
		51 = Moist	Responds to Air Humidity	27	Success
	Soil Moisture	>3500 = Dry Moisture Content	Responding to Soil	27	Success

Platforms	Component	Test			
		Calibration	***Response***	***Number of Successes***	***Results***
		1500 to 3500 = Medium Moisture Content	Responding to Soil	27	Success
		< 1500 = High Water Content	Responding to Soil	27	Success
	Smoke	1700 = Normal	Responds to smoke levels	28	Success
		> 1700 = Danger	Responds to smoke levels	28	Success
	Fire	2000 = Normal	Not Responding to fire	27	Success
		> 2000 = Danger	Responding to fire	27	Success
GPS Module	GPS Location Delivery Test	Longitude and Latitude Data Delivery Test	GPS Connect	26	Success
Telegram	Fire Location Point Delivery Test	Fire Site Delivery Test	Sent Location Point	27	Success
Cloud Server	Data delivery interconnect	Check Connection	Connect	27	Success
	Data Storage	Test save data	Stored	27	Success
Web/Mobile Apps	Connection with cloud server	Check connection	Connect	28	Success
	Data management information from cloud server	Data retrieval test	Information successfully displayed	28	Success
Solar Panel	Charging Connection	Charge test to battery	Battery successfully charged	28	Success
Internet Modem	Internet connection	Connection Test	Internet Connection Successful	28	Success

From the test results **Table 1**, it can be concluded that the prototype product is running well, and the system logic is running correctly according to the conditions for entering the values from each sensor. When charging, the battery continues to be charged using solar panel technology so that all devices can continue to run on the ground. The results obtained are that the sensor can read indications of fire, smoke, soil moisture with a success rate of 93% and send location data and sensor values to the website. By utilizing a match pointed at the sensor in the room, the fire sensor is tested. The sensor can now read fires and provide information to the website as a result. The MQ2 sensor's ability to successfully interpret smoke is tested in the following test. According to test results, the smoke sensor successfully detects the smoke and transmits information to the system after researchers burning paper to produce smoke. From the testing of smoke and fire sensors, GPS was able to deliver the telegram and website with the fire's coordinates.

The DHT11 sensors' s temperature and humidity sensor is tested next. According to the test results, the sensor can accept input of room temperature and humidity and provide data through the website. The test is conducted by raising the temperature around the sensor.

By dipping the soil sensor into the soil, the soil sensor is put through its paces to measure soil moisture. Water is poured into the soil to conduct the test. According to test results, the sensor can effectively receive information whether the soil is damp or dry. Researchers tested solar panels' ability to recharge dry batteries as well. The device is taken outside for the test, where the solar panel is exposed to direct sunshine. According to the test findings, the battery is charged by the solar panel. The sensor can accept input of room temperature and humidity and provide data through the website. The test is conducted by raising the temperature around the sensor.

Conclusion

Based on the results of the research that has been carried out, it can be concluded that a fire detector using the parameters of fire, temperature, humidity, smoke, and soil moisture can work well. Particle Argon can receive input and perform processing so that it is connected using the IoT concept to a web server so the users can monitor land conditions in real time. The fire detection tool developed can detect fires in real time and has a fire early detection function that is useful for anticipating land conditions, so fires do not occur. The results obtained from the test are that the sensor can read indications of fire, smoke, soil moisture with a success rate of 93% and send location data and sensor values to the website. The use of sensors has their respective roles so that if there is a problem with one of the sensors, the tool has an alternative sensor and keep continue to function. The next research is to combine it with image processing methods, namely the use of Convolutional Neural Network (CNN) to detect fires using images, thereby increasing the accuracy of the system in detecting fires.

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References

[1] A. Yusuf, H. Hapsoh, S. H. Siregar, and D. R. Nurrochmat, “Analisis Kebakaran Hutan Dan Lahan Di Provinsi Riau,” *Din. Lingkung. Indones.*, vol. 6, no. 2, p. 67, 2019, doi: 10.31258/dli.6.2.p.67-84.

[2] E. Kumalawati, Rosalina. Dianita Anjarini, “Penyebab kebakaran hutan dan lahan gambut di kabupaten barito kuala provinsi kalimantan selatan,” *Pros. Semin. Nas. diselenggarakan Pendidik. Geogr. FKIP UMP*, vol. 1, no. 1, pp. 263–275, 2019.

[3] A. Molina-Pico, D. Cuesta-Frau, A. Araujo, J. Alejandre, and A. Rozas, “Forest Monitoring and Wildland Early Fire Detection by a Hierarchical Wireless Sensor Network,” *J. Sensors*, vol. 2016, 2016, doi: 10.1155/2016/8325845.

[4] R. A. Setyawan, U. Suryadianto, and R. Nalandari, “Rancang Bangun Pendeteksi Dini Kebakaran Hutan Berbasis SMS (Short Message Service) Gateway,” vol. 02, no. 02, pp. 1–4, 2020.

[5] I. Sopiandi, “Protoype Restfull Web Service Guna Memonitoring Dan Peringatan Dini Bencana Alam,” *Infotech J.*, vol. 4, no. 1, p. 236706, 2018.

[6] A. Junaidi, “Internet Of Things, Sejarah, Teknologi Dan Penerapannya : Review,” *J. Ilm. Teknol. Inf.*, vol. 1, no. 3, pp. 62–66, 2015.

[7] Y. L. Zheng, H. Lin, and X. L. Su, “Design and implementation of the CNC monitoring system based on Internet of Things,” *Adv. Mater. Res.*, vol. 945–949, no. August, pp. 1552–1557, 2014, doi: 10.4028/www.scientific.net/AMR.945-949.1552.

[8] S. Chang and K. Jeong, “A mobile application for fine dust monitoring system,” *Proc. - 18th IEEE Int. Conf. Mob. Data Manag. MDM 2017*, pp. 336–339, 2017, doi: 10.1109/MDM.2017.55.

[9] K. J. S. Novian Patria Uman Putra, Aji Akbar Firdaus, Winarno, Alim Prasaja, “The Home Security Monitoring System with Passive Infrared Receiver , Temperature Sensor and Flame Detector Based on Android System,” *INTEGER J. Inf. Technol.*, vol. 6, no. 1, pp. 81–89, 2021.

[10] J. Toledo-Castro, P. Caballero-Gil, N. Rodríguez-Pérez, I. Santos-González, C. Hernández-Goya, and R. Aguasca-Colomo, “Forest Fire Prevention, Detection, and Fighting Based on Fuzzy Logic and Wireless Sensor Networks,” *Complexity*, vol. 2018, 2018, doi: 10.1155/2018/1639715.

[11] S. K. Bhoi *et al.*, “FireDS-IoT: A Fire Detection System for Smart Home Based on IoT Data Analytics,” *Proc. - 2018 Int. Conf. Inf. Technol. ICIT 2018*, pp. 161–165, 2018, doi: 10.1109/ICIT.2018.00042.

[12] A. Hidayat *et al.*, “Designing IoT-Based Independent Pulse Oximetry Kit as an Early Detection Tool for Covid-19 Symptoms,” *2020 3rd Int. Conf. Comput. Informatics Eng. IC2IE 2020*, pp. 443–448, 2020, doi: 10.1109/IC2IE50715.2020.9274663.

[13] Y. Irawan, R. Wahyuni, M. Muhardi, H. Fonda, M. L. Hamzah, and R. Muzawi, “Real Time System Monitoring and Analysis-Based Internet of Things (IoT) Technology in Measuring Outdoor Air Quality,” *Int. J. Interact. Mob. Technol.*, vol. 15, no. 10, pp. 224–240, 2021, doi: 10.3991/ijim.v15i10.20707.

[14] Y. Choi and Y. Lim, “Optimization Approach for Resource Allocation on Cloud Computing for IoT,” *Int. J. Distrib. Sens. Networks*, vol. 2016, 2016, doi: 10.1155/2016/3479247.

[15] A. Rojas, “Smart Agriculture IoT with Cloud Computing,” *Rev. Hist. América*, no. 29, pp. 37–66, 2015.

[16] D. A. Sungheetha and D. R. Sharma R, “Real Time Monitoring and Fire Detection using Internet of Things and Cloud based Drones,” *J. Soft Comput. Paradig.*, vol. 2, no. 3, pp. 168–174, 2020, doi: 10.36548/jscp.2020.3.004.

[17] Y. Irawan, A. W. Novrianto, and H. Sallam, “Cigarette Smoke Detection and Cleaner Based on Internet of Things (Iot) Using Arduino Microcontroller and Mq-2 Sensor,” *J. Appl. Eng. Technol. Sci.*, vol. 2, no. 2, pp. 85–93, 2021, doi: 10.37385/jaets.v2i2.218.

[18] R. Wahyuni, Herianto, Ikhtiyaruddin, and Y. Irawan, "IoT-Based Pulse Oximetry Design as Early Detection of Covid-19 Symptoms," *Int. J. Interact. Mob. Technol.*, vol. 17, no. 3, pp. 177–187, 2023, doi: 10.3991/ijim.v17i03.35859.

[19] A. R. Abidin, Y. Irawan, and Y. Devis, "Smart Trash Bin for Management of Garbage Problem in Society," *J. Appl. Eng. Technol. Sci.*, vol. 4, no. 1, pp. 202–208, 2022.

[20] F. Margret Sharmila, P. Suryaganesh, M. Abishek, and U. Benny, "Iot Based Smart Window using Sensor Dht11," *2019 5th Int. Conf. Adv. Comput. Commun. Syst. ICACCS 2019*, no. Icaccs, pp. 782–784, 2019, doi: 10.1109/ICACCS.2019.8728426.

[21] R. Muzawi, Y. Irawan, D. Akhiyar, and D. Setiawan, "Pattern Lock and GPS-Based Motorcycle Security System," *Int. J. Eng. Trends Technol.*, vol. 70, no. 3, pp. 185–194, 2022, doi: 10.14445/22315381/IJETT-V70I3P221.

[22] Y. Irawan, E. Sabna, A. F. Azim, R. Wahyuni, N. Belarbi, and M. M. Josephine, "Automatic Chili Plant Watering Based on Internet of Things (Iot)," *J. Appl. Eng. Technol. Sci.*, vol. 3, no. 2, pp. 77–83, 2022, doi: 10.37385/jaets.v3i2.532.

[23] Susilawati *et al.*, "Growth and Yield of Several Red Chilli (Capsicum Annuum L.) Peat-Strains on Peat Soil," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 995, no. 1, p. 012049, 2022, doi: 10.1088/1755-1315/995/1/012049.

[24] A. M. Anika, M. N. Akter, M. N. Hasan, J. F. Shoma, and A. Sattar, "Gas Leakage with Auto Ventilation and Smart Management System Using IoT," *Proc. - Int. Conf. Artif. Intell. Smart Syst. ICAIS 2021*, pp. 1411–1415, 2021, doi: 10.1109/ICAIS50930.2021.9395774.

[25] B. B. P. Rao, P. Saluia, N. Sharma, A. Mittal, and S. V. Sharma, "Cloud computing for Internet of Things & sensing based applications," *Proc. Int. Conf. Sens. Technol. ICST*, pp. 374–380, 2012, doi: 10.1109/ICSensT.2012.6461705.

[26] Y. Irawan *et al.*, "Design of library noise detection tools based on voice pressure parameters," *Ilk. J. Ilm.*, vol. 14, no. 3, pp. 237–244, 2022, doi: 10.33096/ilkom.v14i3.1191.237-244.

[27] S. Purwanti, A. Febriani, M. Mardeni, and Y. Irawan, "Temperature Monitoring System for Egg Incubators Using Raspberry Pi3 Based on Internet of Things (IoT)," *J. Robot. Control*, vol. 2, no. 5, 2021, doi: 10.18196/jrc.25105.

[28] U. Rahmalisa, A. Febriani, and Y. Irawan, "Detector leakage gas LPG based on telegram notification using wemos D1 and MQ-6 sensor," *J. Robot. Control*, vol. 2, no. 4, pp. 287–290, 2021, doi: 10.18196/jrc.2493.

[29] R. Muzawi and A. Fauzan, "Prototype Pengontrolan Titik Fokus Panel Surya Terhadap Energi Matahari Secara Otomatis," *Inovtek Polbeng*, vol. 3, pp. 1–9, 2018.

[30] Y. Irawan and R. Wahyuni, "Electronic Equipment Control System for Households by using Android Based on IoT (Internet of Things)," *J. Phys. Conf. Ser.*, vol. 1783, no. 1, p. 012094, 2021, doi: 10.1088/1742-6596/1783/1/012094.