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IOT-BASED FIRE AND THEFT DETECTION SYSTEM IN HOUSING

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Abstract. *The Internet of Things (IoT) system has become an object of research that is proliferating lately in various fields of life. Along with that, the concept of smart city is also promoted in many cities in the world. One part of the idea of smart city is the safety of the environment and society. Hence, this research will apply a home security system in the form of early detection of fire and theft in residential areas to create a prosperous and safe city. This research, manages two systems, namely the user side by installing several sensors such as smoke and temperature sensors, which detect fires, and PIR sensor and ultrasonic sensor, to detect theft. On the server-side, there is a Web-based monitoring system that can be used by security officials to monitor security conditions and the user himself when leaving home. Both of these systems communicate with each other with wireless networks. The result indicates that the system can work well. This system is built by integrating several sensors as input, Arduino Uno as data processing, Xbee for sending data to the server, and Ethernet shield for sending data to the Internet. Furthermore, monitoring results will be displayed on the website. Thus, the concept of smart city with the application of IoT for public safety can be applied in a housing to detect fires and theft.*
Keywords: Internet of Things (IoT), Fires, Theft, Sensors, Arduino Uno, Xbee, Ethernet shield, Website

1. **Introduction.** Regarding the development of IoT, research on smart city has been widely carried out, including the application of smart city concepts in a city, along with the rapid development of Internet-based monitoring systems. The smart city is a city area that has integrated information and communication technology in daily governance, with the aim to enhance efficiency, improve public services, and improve the welfare of citizens [1]. Also, research on the integration of information systems services for each domain, such as health, education, transportation, and electricity networks in a city that provides public services to citizens that can be accessed quickly and efficiently [2]. Adequate equipment is necessary to create these conditions, including physical devices, Internet networks, and application systems; therefore, infrastructure operations and public services can be integrated, such as buildings, transportation, electricity and water distribution, and public safety [3]. For public safety, especially in residential areas, many studies are conducted such as fire detection using a combination of sensors that not only detect smoke, but also distinguish different types of smoke to avoid false alarms by using wireless networks [4]. Other research on monitoring and warning of house fires uses Arduino Uno with the Global System Mobile (GSM) network [5]. Other research is also about early fire detection, but uses Zigbee wireless networks as a communication medium [6]. Besides, there is research about the development of fire detection devices that use wireless alarms using intelligent

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computer systems [7]. Whereas for research on burglar detection, PIR sensors can be used to detect human movements [8]. Another study is to add UGS (Unattended Ground Sensors) to increase the accuracy of theft detection in a home. The proposed method has the advantage of fast execution time and low memory requirements and potentially suitable for real-time implementation [9]. Other research is on the use of PIR sensors, temperature sensors, and cameras for theft detection [10]. More complex research is applying machine learning for fire detection [11], and image processing to increase the accuracy of detection between humans and animals [12].

Based on some of the literature above, the researcher will try to apply the concept of Smart City in IoT-based housing, which monitors the safety of homes against the danger of fire and theft. In addition, by assembling monitoring tools yourself from a practical point of view, it will certainly be much easier and cheaper. While from an academic perspective, it can increase knowledge and experience in building online monitoring systems. In this case the research is still on a prototype scale and is still devoted to a house, namely by installing several sensors such as temperature and smoke sensors that can detect fires as early as possible. And in terms of preventing theft, especially if the house is empty, before leaving the house, the owner can activate sensors that can detect when there is human movement. By activating two detection systems, the owner and a security officer can monitor the condition of a house, so fire prevention and theft can be handled as early as possible. To implement the wireless sensor network system in a residential, each house in the residential can use this system and send their respective data to the server [13,14]. Therefore, the application of IoT-based Smart City can be carried out, especially in terms of public safety.

2. Methodology.

2.1. General design. In this research, a monitoring system will be applied for early detection of the prevention of fire and theft in a house. Monitoring can carry out at the coordinator/server via the website through IoT networks. Details are shown in Figure 1.

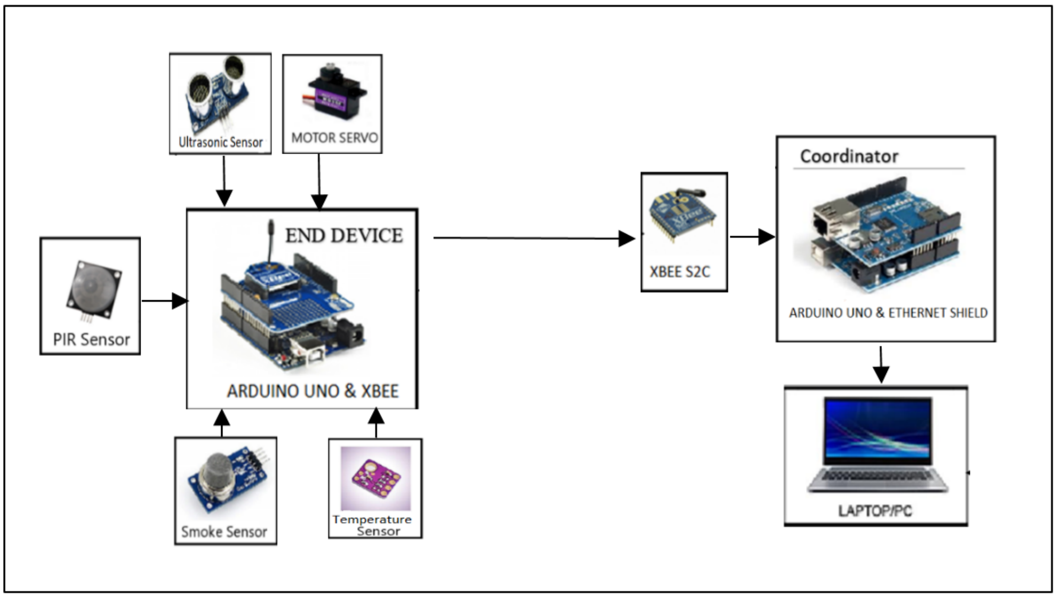

FIGURE 1. Block diagram design

The working principle of this system is using four sensors as input, namely ultrasonic sensor, PIR sensor, temperature sensor, and smoke sensor. The application of each sensor is as follows.

a) Theft detection; a PIR sensor is used to detect any movement in the house, and an ultrasonic sensor (HCR sensor), which is driven by a radar servo, is used to determine the position of a moving object.
b) Fire detection used temperature sensor (SHT31 sensor) and smoke sensor (MQ-2 sensor) for detecting temperature and smoke in the room.

Furthermore, the four sensors connect to the Arduino Uno microcontroller controller circuit, which is also connected to the Xbee S2C (end device) as a data sending module to the coordinator/server. Furthermore, the coordinator/server displays data on a PC or Laptop monitor. Monitoring is designed by a website-based interface. The design of a Web-based fire and theft monitoring system consists of hardware design, which includes designing input/output circuits and microcontroller circuits. Besides that, a software design is also implemented in the microcontroller and interface design to display monitoring results on the website.

2.2. **Hardware design.** This system is divided into two parts which are sender/end device and receiver/coordinator, as follows.

2.2.1. *Sender/end device circuit.* This hardware design covers the design of input and output circuits. The input circuit includes the HCR sensor, the PIR sensor, the MQ-2 sensor, the SHT31 sensor connected to the microcontroller, and the output circuit, the Xbee module for sending data. In order to work more optimally and be able to reach a larger coverage area, the ultrasonic sensor is paired with a moving servo motor like a radar with a motion detection range up to 180°.

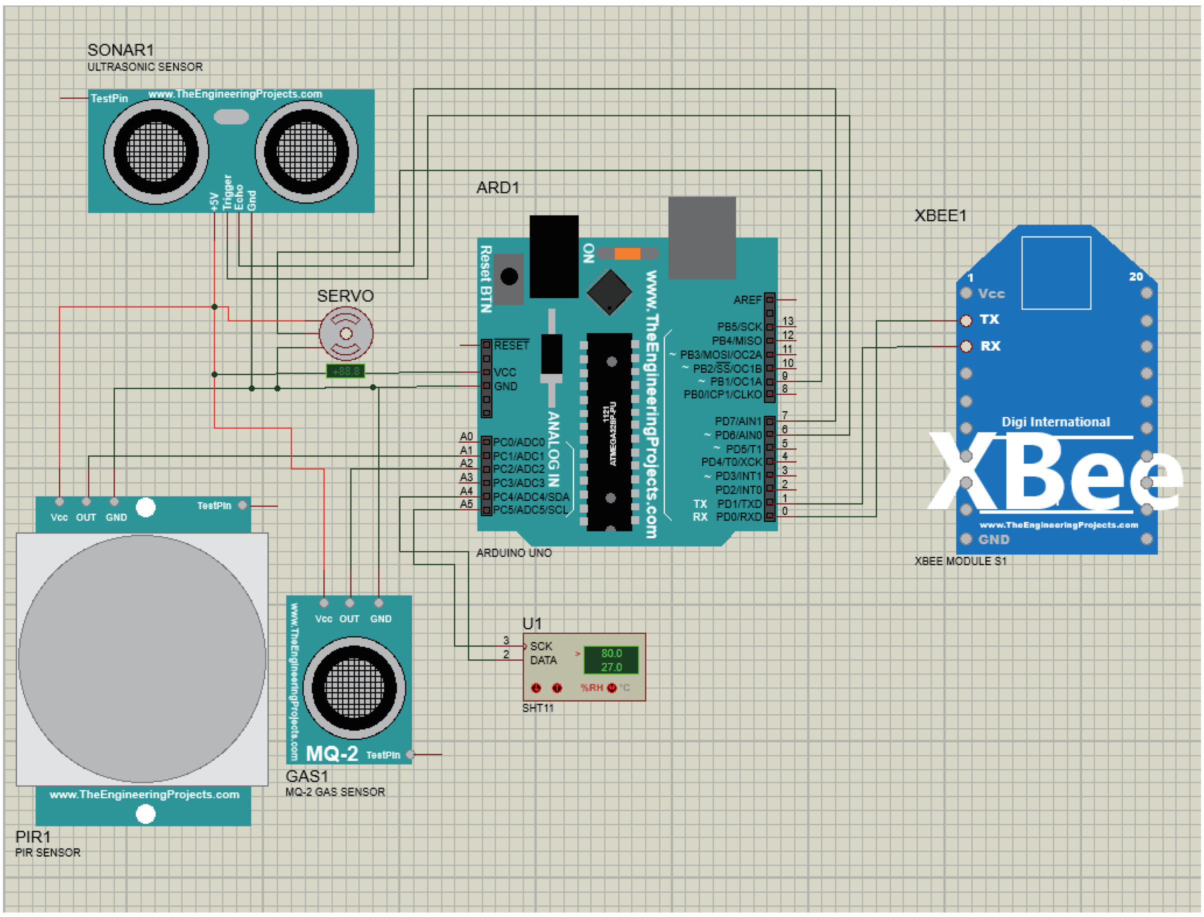

FIGURE 2. System schematic circuit of end device

2.2.2. *Receiver/coordinator circuit.* The coordinator module circuit uses an Arduino and Xbee with the addition of an Ethernet shield (ENC28J60) to send data to the Internet. For connecting with Arduino, the RX and TX pins on Xbee are connected with pin0 and pin1 on Arduino, as shown in Figure 3.

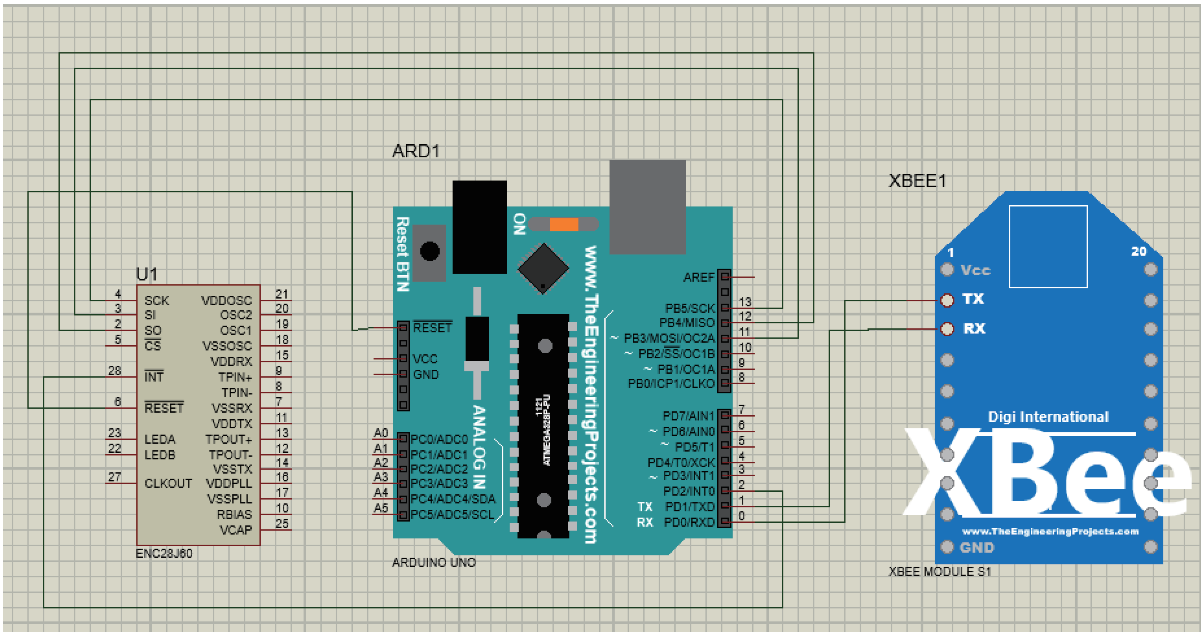

FIGURE 3. System schematic circuit of coordinator/server

2.3. **Software design.** The flowchart of the software design of this research is shown in Figure 4.

The program starts by initializing the PIN on the device module; then, the tool will read data on the sensor, and then it will be sent via the Xbee module. If the receiving module does not receive data, the process is repeated until the data is sent to the receiving module. Therefore, the data will be processed by the receiving module. After the data is processed in the receiver module, the data will be displayed on the website. Software design divides into the design of the sender/end device and the receiver/coordinator and website design interface.

2.3.1. *Software design on end device and coordinator.* This program is designed as a data input module consisting of data received from sensors processed by Arduino Uno. The program created, stored with the extension [*.ino] due to the Arduino Uno, is part of the Arduino microcontroller, which has its compiler called the Arduino IDE. This file is then compiled and then uploaded to the microcontroller using a USB cable so that the microcontroller can work as a system controller regarding the desired performance. In designing this module, the data on the microcontroller is displayed in the form of a serial monitor, which will be sent to the coordinator module to be processed. In this program design, XbeeAddress addr64 on the Arduino program is the serial data output from Arduino that will be sent using the Xbee S2C radio module. Design of the end device module on Arduino Uno using the Arduino IDE can be seen in Figure 5. In designing the program in the coordinator, the IP address is determined to connect to the Internet and ZBRxResponse, which means that the data received is from the Xbee end device. The design of the coordinator module on Arduino Uno using the Arduino IDE can be seen in Figure 6.

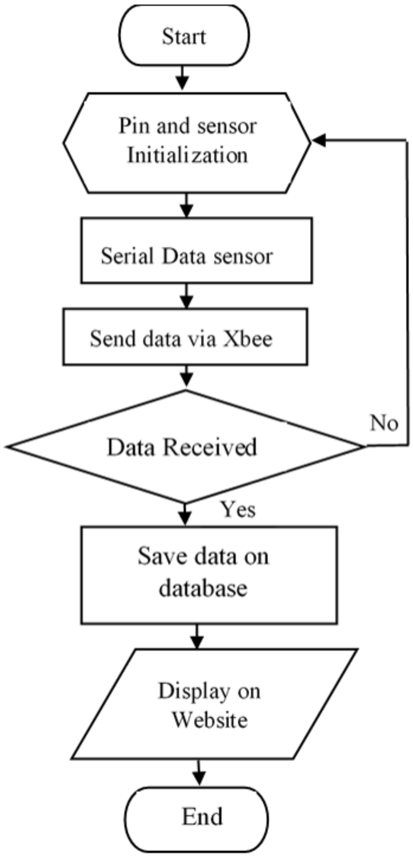

Figure 4. Software system flowchart

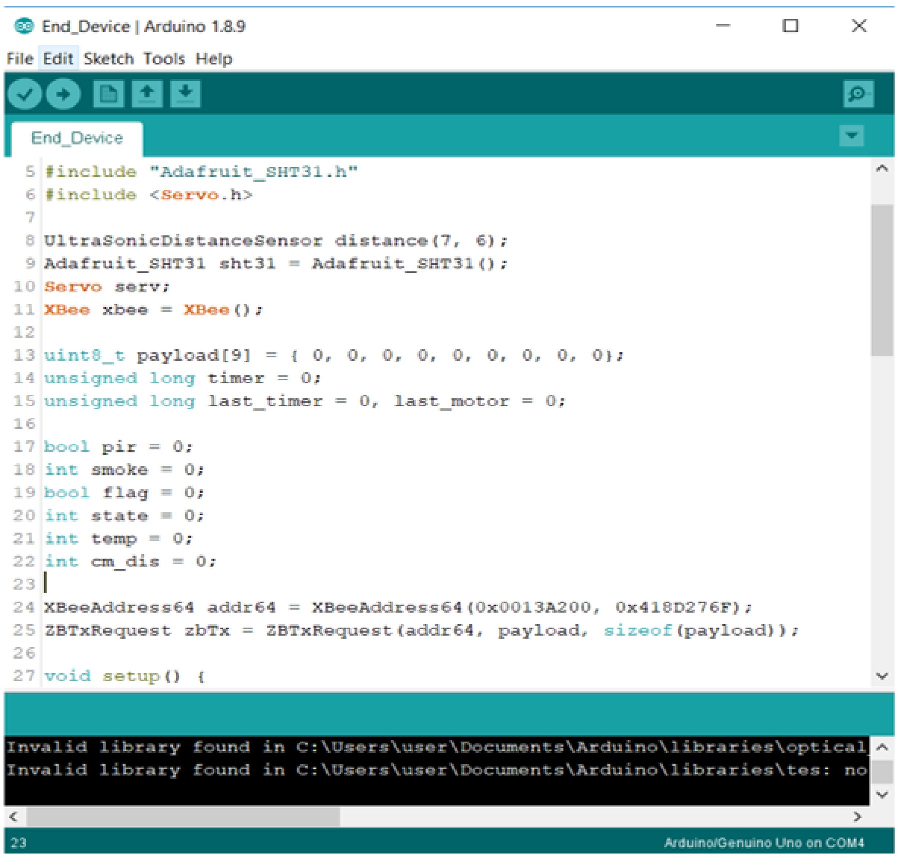

Figure 5. End device program on Arduino IDE

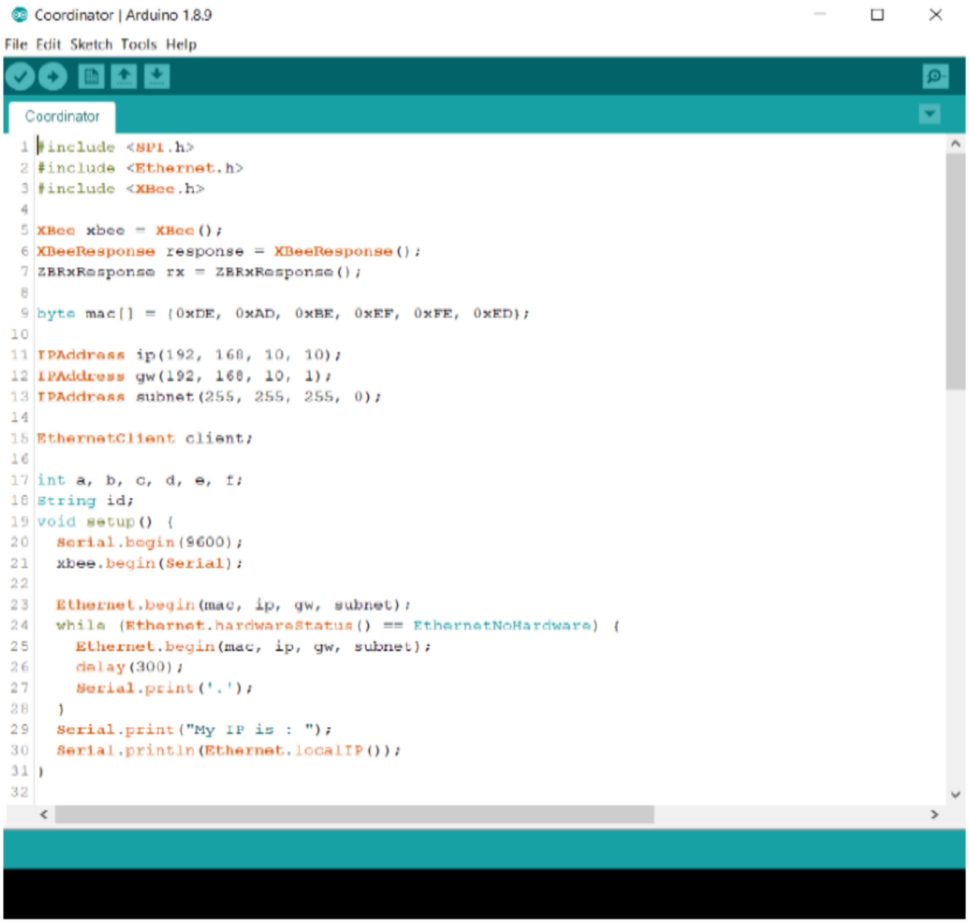

FIGURE 6. Coordinator program on Arduino IDE

2.3.2. *WEB interface design.* This design aims to display the results of detection and data transmission in real time, so that the user and security officers can access the state condition of the house. This design uses the HTML programming language in building website interfaces, which include PHP, CSS, JavaScript, and MySQL script.

3. **Results and Discussion.**

To find out the performance of this system, each sensor will be tested, namely the temperature sensor, smoke sensor, PIR sensor, ultrasonic sensor and testing of the overall system.

3.1. **SHT31 temperature sensor and the MQ-2 smoke sensor.**

SHT31 sensor testing aims to determine the ability of the sensor in room temperature reading by comparing it with other temperature reading devices. Testing the MQ-2 smoke sensor is done by burning a paper material so that the sensor can detect smoke/CO levels in the room. If CO levels have reached 200 ppm, a fire has been suspected. When the room is full of smoke, the sensor output voltage is a maximum of 5 volts. From Table 1, it can be concluded that the sensor detects the temperature accurately, and the MQ-2 sensor detects the presence of smoke by producing a voltage. The results obtained that the voltage generated is directly proportional to the value of CO level (ppm).

3.2. **PIR sensor and ultrasonic sensor.**

PIR sensor testing aims to determine the ability of sensors to detect human movements. The result is obtained by placing the sensor in a place that is usually passed by humans, if there is movement, then the PIR sensor reads it, as in Figure 7.

Ultrasonic sensor testing aims to determine the ability of sensors to detect the distance from objects-testing by comparing the data obtained by the sensor to the measurement

Table 1. Testing data of MQ-2 sensor and SHT31 sensor

No	Thermometer (°C)	Sensor SHT31 (°C)	Value CO (ppm)	Vout sensor (V)
1	40	40	0	0
3	37	37	50	3.0
4	34	34	150	3.4
5	32	32	200	3.6
6	31	31	300	3.8
7	30	30	400	4.0
8	28	28	500	4.2

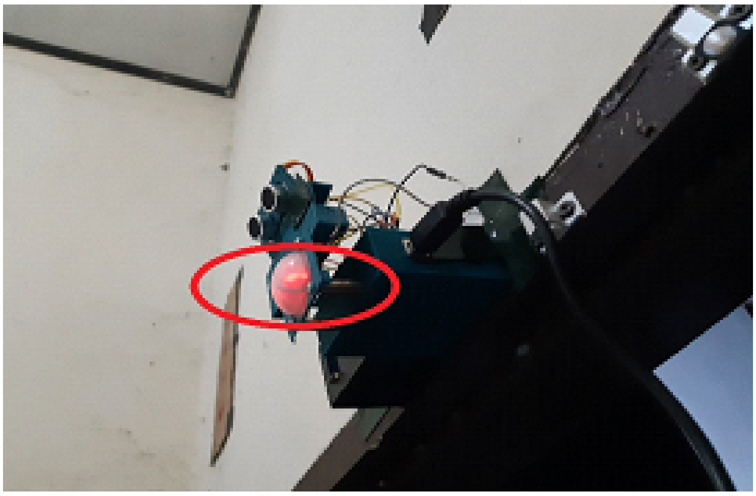

Figure 7. PIR sensor testing

Table 2. Ultrasonic sensor testing results

No	Ruler (cm)	Sensor (cm)	Percentage error (%)
1	9	10	11
2	14	14	0
3	20	20	0
4	30	30	0
5	40	40	0
6	50	50	0
7	60	60	0
8	70	70	0
9	80	79	1.25
10	100	98	2
11	200	198	1
Mean			1.38

using meter, as shown in Table 2. The sensor reading results are almost the same as the measurement results tracing the meter. With a small error percentage of 1.38%, hence, the sensor is working properly.

3.3. **Overall test.** Overall system testing is done with two scenarios. First, testing by integrating smoke sensors and temperature sensors to detect fires. This test aims to determine the performance of the system in detecting and sending information when a fire occurs. The second test integrates the PIR sensor and ultrasonic sensor, which is driven by using a moving servo motor like a radar to reach a wider area. This test aims to determine the presence of humans in the room. If the PIR sensor detects a human movement, it will automatically send a notification to the web. Similarly, if the temperature sensor and smoke in the room exceed the threshold of 37°C and 200 ppm, then the notification will automatically be displayed on the Web as shown in Figure 8.

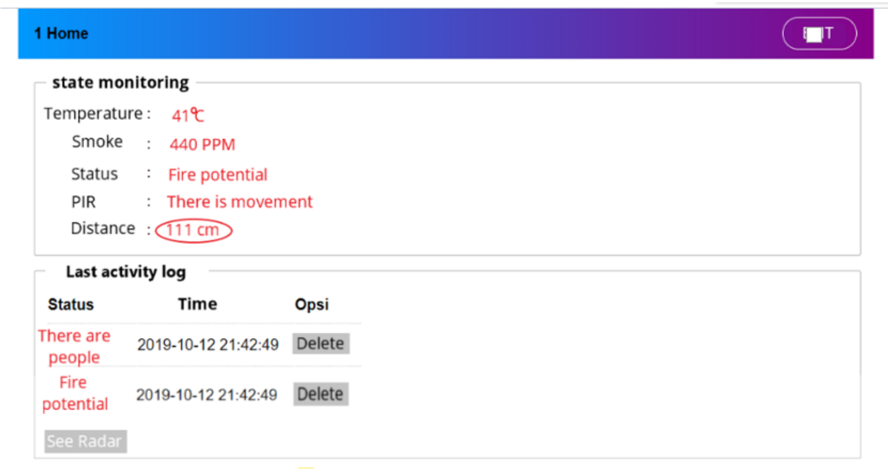

FIGURE 8. Notification of human detection

The test results using the servo radar movement will display the position and angle of the object. The red dot is the position of the distance and angle of an object that is detected or captured by an object, as in Figure 9.

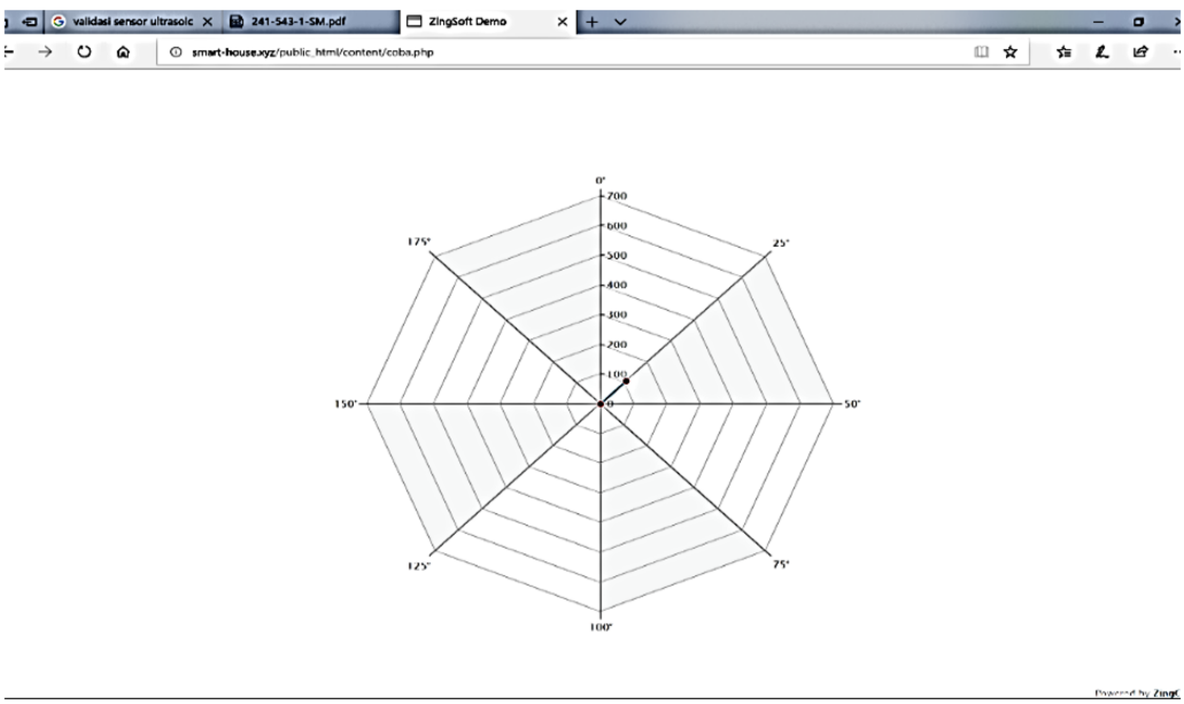

FIGURE 9. Radar detection of object position

To save energy usage, the data transmission and the appearance of notifications on the server only occur if the PIR sensor detects human movement or a temperature sensor and the smoke sensors show a value that exceeds a predetermined threshold.

4. **Conclusions.** The system built is able to integrate temperature sensors, ultrasonic sensors, smoke sensors, PIR sensors, Arduino Uno, Xbee, and Ethernet shield microcontrollers, so that they can be used to detect fires and theft at home as early as possible.

The fire detection system works by displaying the temperature and smoke content (CO) in ppm. If it exceeds the specified limit, there will be a notification on the website that there will be a potential for fire. For home security detection systems, PIR sensors and ultrasonic sensors will detect human movements and the notification will also be displayed on the website. In the future, fire sensors and artificial intelligence systems will be added, so the detection system that is built will be more accurate and avoid false notifications.

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