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FIRE DETECTION AND DECISION-MAKING SYSTEM

Abstract. Emergencies, such as a fire, cause harm to a person and his property. Reducing the number of losses is a priority aspect for countries and citizens. The main purpose of this research is to develop a fire warning and detection system, which includes a hardware part for collecting data from sensors and a software part for monitoring the environment. The hardware based on the Internet of Things (IoT) technology consists of a NodeMCU V3 microcontroller and flame, humidity, temperature, pressure, and gas sensors. Readings from sensors, as well as notification of a fire threat can be received from anywhere in the world thanks to a monitoring system and a microcontroller. A key feature of the decision-making system in case of fire is the ability to notify and send SMS to social networks. If deviations from the specified range are detected, a voice warning will sound, the received message will include geolocation of the accident site. The collected database from sensors is used for machine learning methods to reduce the likelihood of false calls and alerts. With the correct implementation of the decision-making system, it will be possible to protect a person from death.

Key words: IoT, NodeMCU, decision-making, alert, fire detection, GPS, machine learning.

1 Introduction

The Internet of Things (IoT) is a combination of objects such as buildings, vehicles, devices in which circuits, electronic elements, sensors, radio-elements, programs for communication and information transmission are integrated. The Internet of Things enables remote maintenance and management of these objects [1]. Sensors, like human sensory organs, can continuously transmit data for subsequent processing by software. The Internet of Things, in turn, makes it possible to access this data from anywhere in the world. There are a huge number of sensors that can adequately replace human vision and sense organs [2]. If a fire alarm is triggered without confirming the presence of a fire, this situation is a false alarm. False alarms give a side effect to the work of fire protection agencies. Time is a critical factor during fire detection. Often, not timely response to an event makes the fire alarm system vulnerable. Sensors make the response system susceptible to false alarms, but it should be borne in mind that they detect a fire at an early stage [3]. Many fire alarms are based on the detection of smoke of a certain category, but not all objects emit smoke of this category during a fire. It is necessary to take into account the properties and types of particles in the air. It is much more efficient to use multiple sensors to increase accuracy and reduce the number of false positives [4].

In the article [5], the authors developed a project of a home fire alarm system based on an Arduino board and sensors. The Arduino board interacts with the GSM module, since the module works through wireless communication, the user can find out the current situation at home in real time. Sending information is carried out by sending SMS. The Arduino microcontroller collects data from sensors, and also performs all decisions, including sending notifications. The GSM module is responsible for the communication part of the circuit.

There are a large number of monitoring systems with image capture. The research paper [6] proposes an integrated system using Raspberry Pi and Arduino Uno. If there is smoke, the system will display an image of the room in which the camera is located. After the event is detected, the system will require user confirmation to alert the fire department via short messages. The advantage of the system can be called a reduction in the number of false alarms, at the same time, the system consumes a little memory and energy.

2 Materials and Methods

The development of this project is divided into two parts, such as hardware and software. Electronic circuits for connecting elements were created in the hardware and a prototype of the project was built. In the software part, block diagrams are implemented and based on this, programs for the web interface and reading data from sensors are written.

2.1 Hardware.

The hardware consists of several sensors for receiving information and a GPS module for detecting geolocation. Figure 1 shows the electronic circuit of the components. All electronic elements are interconnected by means of the NodeMCU V3 microcontroller.

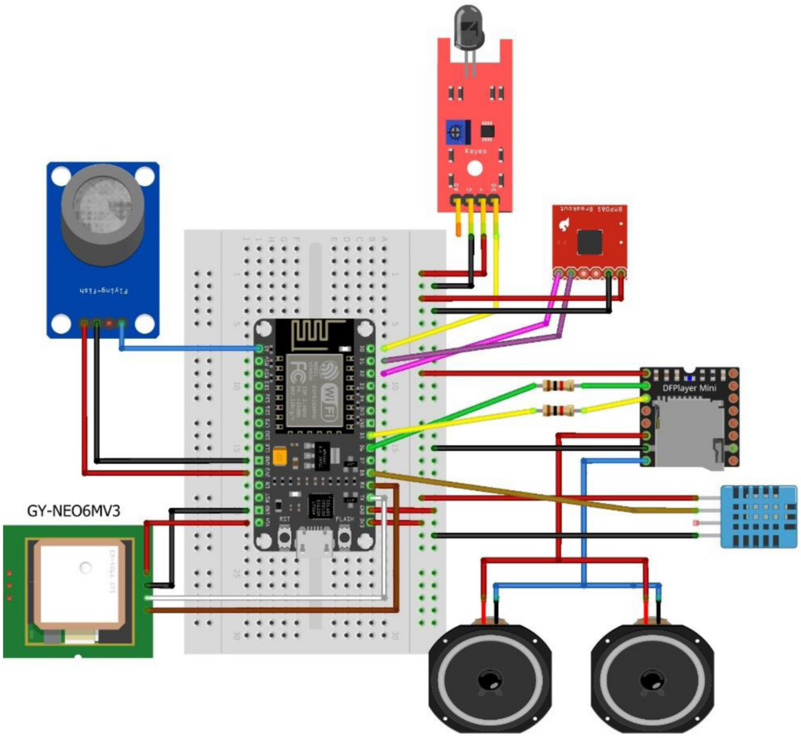

Figure 1 – Wiring diagram of electronic components

To implement this project, components such as NodeMCU, GPS Module, MQ-2, DHT 11, Flame sensor, BMP180 were used. Below is a description of these radio elements.

NodeMCU is an ESP8266-based microcontroller for creating various Internet of Things objects. With this module, devices can locally send or receive information using wireless Wi-Fi communication [7].

The GPS module is an electronic circuit that connects to the NodeMCU board to receive information about location, speed, time and date. The NMEA protocol is used to transmit geolocation information via a serial port [8].

MQ-2 is a gas and smoke sensor. This sensor detects gases such as propane, methane, butane, alcohol and hydrogen in the medium. There is a potentiometer on the case, which allows you to adjust the sensitivity of the sensor at your discretion. The voltage at the sensor output is directly proportional to the gas value, that is, it varies depending on the gas level. The sensor has two outputs, such as digital and analog [9].

DHT 11 – temperature and humidity sensor. The indicators of this sensor are the most important during the detection of a fire. This sensor outputs a digital signal directly proportional to the values of humidity and temperature [10].

Flame sensor – generates a threshold value, which is adjusted using a potentiometer. This sensor mainly detects waves in the range of 760 nm – 1100 nm, which corresponds to fire. The sensor receiver is coated with black epoxy resin, as it is sensitive to infrared radiation.

BMP180 is a pressure and temperature sensor. This sensor is also used to determine the height.

Table 1 shows the outputs of the microcontroller to which the elements are connected. Since the NodeMCU microcontroller has only one analog output, it was decided to use digital sensors. The only analog sensor used in the project is the gas sensor.

Table 1 – Pins for connecting elements

NodeMcu	elements
D0	Flame sensor(D0)
D1	BMP(SCL)
D2	BMP(SDA)
D5	DFPlayer(TX)
D6	DFPlayer(RX)
D8	DHT11(D0)
Rx	GPS(TX)
Tx	GPS(RX)
A0	MQ2(A0)

2.2 Software development

The software part of the project is based on the logic shown in Figure 2. At the first stage, the decision-making system is connected to the power supply. The following steps follow:

– Pins of electronic components are assigned to the pins of the microcontroller, which are shown in Table 1.

– Data collection. During data collection, information about temperature, humidity, pressure, the presence of flame and gas in the atmosphere enters the database every three seconds. The data is stored in a MySQL database. In Figure 3, you can see the structure of the database. The first column is the numbering, the second column is the temperature value, the third is humidity, the fourth is pressure, the fifth is gas, the sixth is the presence of flame, the seventh is the time of reading data from sensors.

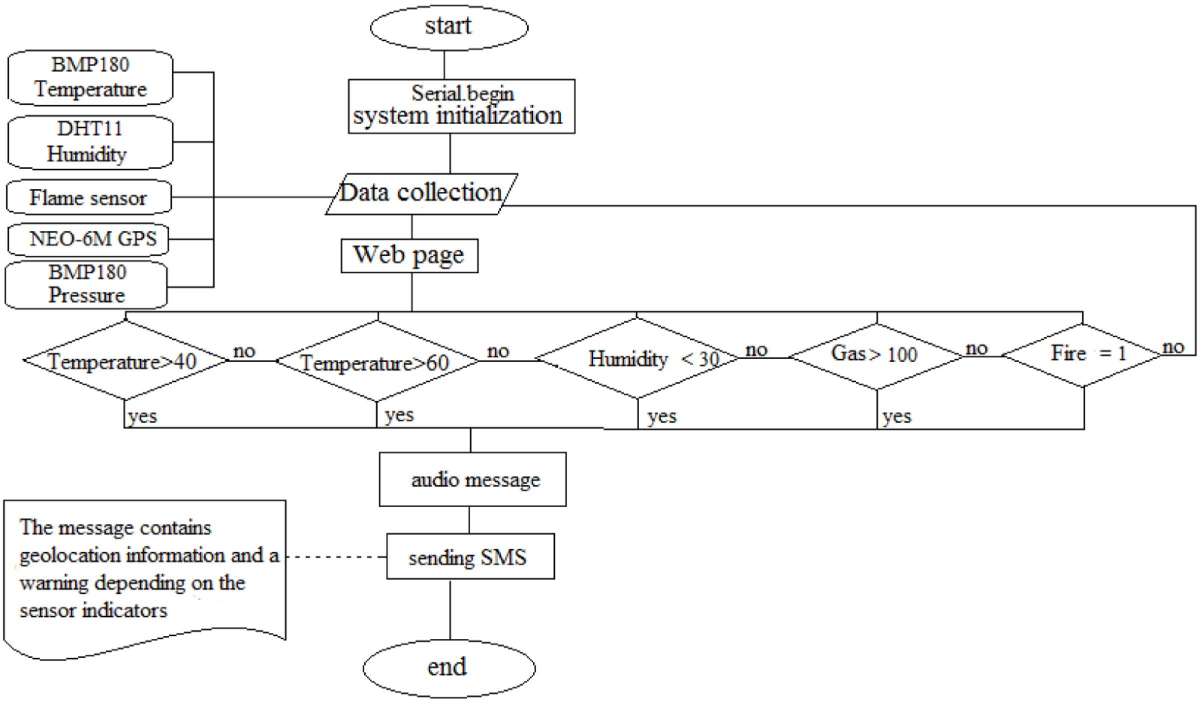

Figure 2 – The flowchart of the C programming in NodeMCU

– Comparison of the received data with a certain value. The ranges of measures were taken from emergency statistics. Whenever there is a fire, there is an increase in temperature and an inversely proportional decrease in humidity. If the value exceeds the threshold measure, the system will notify you via voice and SMS alerts. Just like the DHT11 and BMP180 sensors, the flame sensor generates a value that determines the presence of a flame. The gas sensor reads the data in real time, which in turn is compared with the threshold value.

id	value1	value2	value3	value4	value5	reading_time
1	26.10	818.18	918.74	51	1	2022-12-13 12:33:13
2	26.10	818.09	918.70	57	1	2022-12-13 12:33:16
3	26.10	817.64	918.75	61	1	2022-12-13 12:33:20
4	26.20	818.36	918.71	69	1	2022-12-13 12:33:23

Figure 3 – Database structure

3 Results

As a result of the work done, a web page has been implemented for monitoring data received from sensors. The system is assembled and fully functional. Test situations were carried out, during the experiment the warning system reacted clearly to the specified fire conditions.

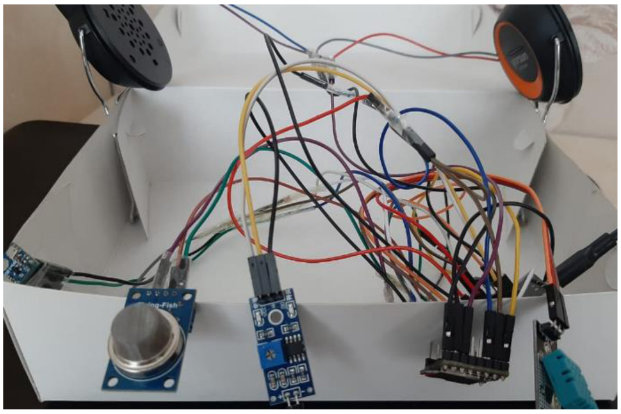

Figure 4 – Model of the notification and decision-making system

When testing the model, warnings were received in the form of a message. The message structure looks like this: The amount of gas in the medium exceeded the threshold value. There is a risk of fire. Check out the web environment!: http://zvezdajq.beget.tech/esp-chart.php Yandex: http://maps.yandex.ru/?ll=77.16582,43.29907&pt=77.165428,43.299434&L=map & z=18 Google: https://www.google.ru/maps/place/43.299434, 77.165428?hl=ru.

To reduce the number of false alarms, a machine learning method called Decision tree classifier was used. The model was trained in three classes, such as, first class – there is no fire, second class – the presence of a fire is unlikely, third class – a fire has started. Information from the database was fed to the input of the trained model. As a result, this machine learning method classified the incident with a high probability. In Figure 5, you can see a decision tree based on temperature indicators.

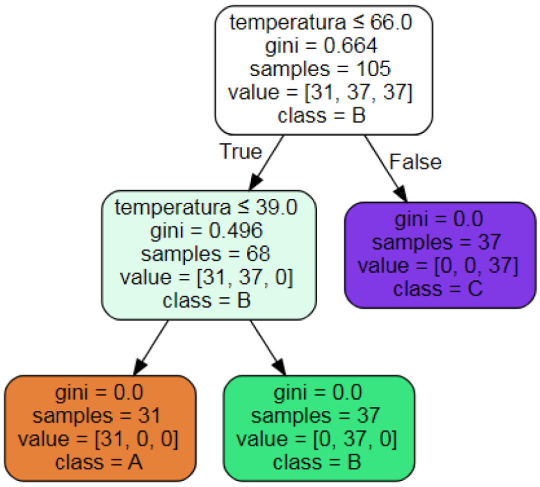

Figure 5 – Decision tree classifier

The web page for monitoring the system displays the indicators obtained from the sensors. As shown in Figure 5, the information is extracted from the database, then displayed on the graph as a diagram.

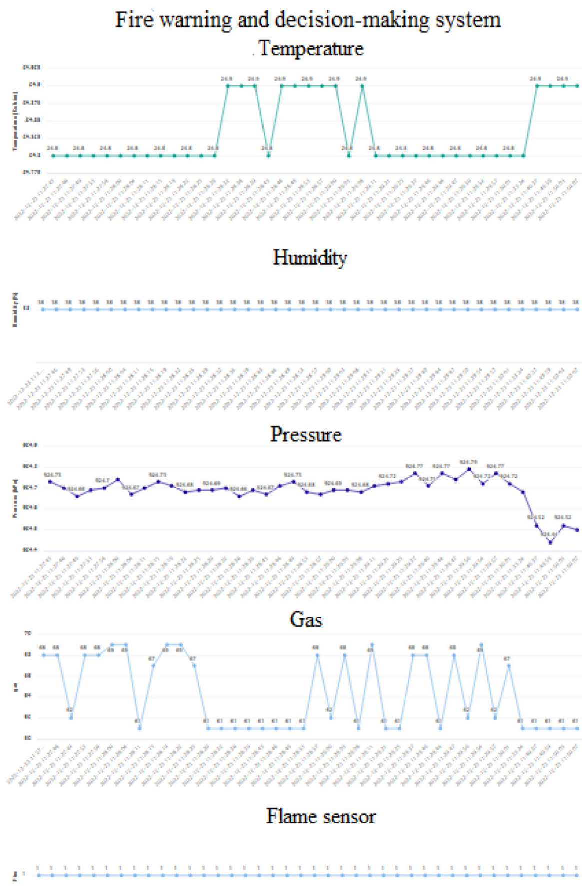

Figure 6 – Web page

4 Conclusion

In that research paper, a decision-making and fire warning system was presented. The project is fully functional and tested. The developed prototype warns the user, first notifying with a voice notification, then sends an SMS notification to the social network. In this project, inexpensive but reliable electronic elements were used, which makes it possible to be re-implemented and accessible to everyone. By introducing Internet of Things technologies into everyday life, it becomes possible to prevent many emergencies.

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