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Submission date: 19-Nov-2022 08:34AM (UTC-0500)
Submission ID: 1958341115
File name: scopus_Agus.doc (355.5K)
Word count: 2761
Character count: 14095

IMPLEMENTATION OF FUZZY LOGIC FOR FIRE DETECTION SYSTEMS IN BUILDINGS BASED ON IOT (INTERNET OF THINGS)

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Abstract

Fire disaster is a condition or condition where a building in one place is engulfed in fire. This results in loss of assets/property and loss of life in places such as factories, buildings, markets, housing, gas stations and even forests. Based on world data on occupational safety and health accidents, the death toll of the worst victims due to factory fires occurs in almost every country in the world, ranking below natural disasters such as earthquakes/tsunami. As for the cause of the fire, there are several factors, such as: short circuit in electrical installations, exploding gas stoves, cigarette butts, and others. In general, a fire is known if the fire has started to grow or the smoke has started to blacken or has billowed out of the building. Security systems in buildings (buildings or housing) are needed because the danger of fire does not know the time, so early prevention can reduce the emergence of fires, and greater losses. Therefore, an IoT-based fire detection system is needed so that notification of an indication of a fire can be known more quickly even though the homeowner is not at home. In designing this system, 3 sensors are used, namely temperature sensors, gas sensors, and fire sensors. Each of these sensors will monitor the conditions in the surrounding environment and later the conclusion of the fire level will be carried out by fuzzy logic. If there is an indication of a fire, the system will turn on the buzzer. In addition, the condition of all sensors can be monitored via web. The test results show that this system can properly monitor the surrounding conditions and draw conclusions about the fire level by fuzzy logic in accordance with real time conditions. The distance required for the system to detect fires is close because the sensor used is still a prototype.
Keyword : Fire, Fuzzy Logic, IoT (Internet of Things), Arduino.

INTRODUCTION

In this country there are many buildings and housing that are located very close to one another. As a result, fires often occur due to electrical short circuits. This fire disaster is very detrimental to humans, in particular it can cause its own trauma for those who experience it. There are so many causes and impacts of every fire disaster that occurs to cause casualties.

A fire disaster is a condition or condition in which a building is engulfed in flames. This resulted in loss of assets/assets and loss of life in places such as factories, buildings, markets, housing, gas stations and even forests. Based on world data on occupational safety and health (K3) accidents, the most serious deaths due to factory fires occur in almost every country in the world with a ranking below natural disasters such as earthquakes/tsunami disasters.

There are several factors that cause fires, such as electrical installation short circuits, gas stove explosions, cigarette butts, and others. In general, a fire is known when the fire has started to grow or the smoke has started to turn black or has been billowing out of the building. A security system in buildings (buildings or housing) is needed because the fire hazard does not know the time, so that early prevention can reduce the occurrence of fires, and greater losses.

We have often heard news about residential fires everywhere and this is not something new for us, but the public seems indifferent and less alert in responding to fire incidents, especially now that there are so many people working in offices and often leaving houses, but fire hazards can occur in empty houses abandoned by their inhabitants, usually fires that occur in homes are caused by electric currents or gas cylinder explosions, homeowners usually don't know their house has been hit by a fire. Due to the lack of information about fires because the homeowners were not at home, even though the material losses that occurred as a result of fire incidents were enormous, reaching hundreds of billions, not to mention the loss of life. So we need a system that can provide information about the appearance of early symptoms of a fire, especially now that the development of information technology is very advanced.

LITERATURE REVIEW

Definition of Fire

According to the National Fire Protection Association, fire is an oxidation event where 3 elements meet, namely materials, oxygen and heat which can cause material loss or even human death. Every fire can cause various kinds of losses such as damage to production equipment, production materials, and loss of working time during the production process.

Definition of Detection

Detection is a process to examine or examine something using certain methods and techniques. Detection can be used for various problems, for example in a disease detection system, where the system identifies problems related to disease which are commonly called symptoms.

The purpose of detection is to solve a problem in various ways depending on the method used to produce a solution.

Definition of the Internet of Things

According to Hardyanto (2017) IoT (Internet of Thing) can be defined as the ability of various devices that can be connected to each other and exchange data through the internet network. IoT is a technology that allows control, communication, collaboration with various hardware devices, data via the internet network. So that it can be said that the Internet of Things (IoT) is when we connect something (things) that are not operated by humans, to the internet.

But IoT is not only related to controlling devices remotely, but also how to share data, virtualize all real things in the form of the internet, and so on. The internet becomes a link between machines automatically. In addition, there is also a user who serves as a regulator and supervisor of the working of the tool directly. The benefit of using IoT technology is that work done by humans becomes faster, easier and more efficient.

Definition of Fuzzy Logic

Fuzzy is linguistically defined as fuzzy or vague which means a value can be true or false simultaneously. In fuzzy, it is known that the degree of membership has a range of values from 0 (zero) to 1 (one). Fuzzy logic is a logic that has a value of fuzzyness or ambiguity between right or wrong. In fuzzy logic theory a value can be true or false simultaneously. But how much truth and error depends on the weight of membership it has.

Fuzzy logic has a degree of membership in the range 0 to 1 and fuzzy logic shows how far a value is true and how far a value is wrong. Fuzzy logic is an appropriate way to map an input space into an output space and has a continuous value. Fuzzy expressed in degrees of membership and degrees of truth. Therefore something can be said to be partly right and partly wrong at the same time.

METHOD

System Analysis

Analysis is a detailed study or research by conducting an experiment which results in conclusions from the decomposition of a complete system into its component parts with the intention of identifying and evaluating all problems that arise, obstacles that occur as well as opportunities and needs so that solutions can be created to overcome problems that arise. can build the system to be made.

Problem Analysis

A fire disaster is a condition or condition in which a building is engulfed in flames. This resulted in loss of assets/assets and loss of life in places such as factories, buildings, markets, housing, gas stations and even forests. Based on world data on occupational safety and health (K3) accidents, the most serious deaths due to factory fires occur in almost every country in the world with a ranking below natural disasters such as earthquakes/tsunami disasters.

RESULTS AND IMPLEMENTATION

Result

General Fire Detection System Design

This section contains the general design of automatic fire detectors and the following is a block diagram regarding the hardware for automatic fire detectors that are being designed

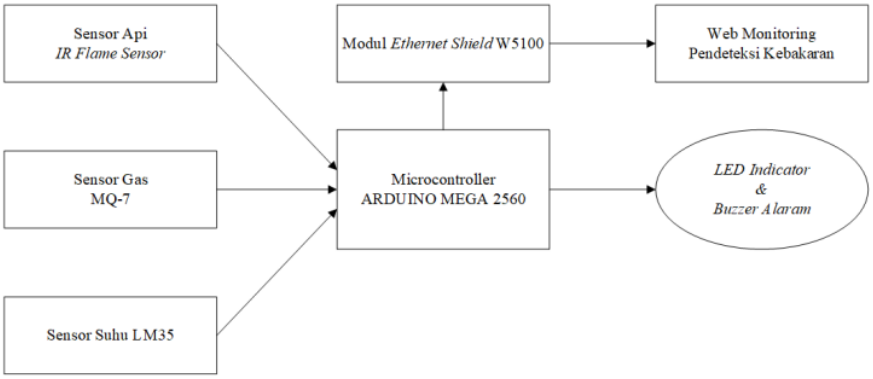

fig.1 General Fire Detection System Design

Figure 1 shows that this fire detection system uses several components to create a fire detection system in this study and the description of each hardware component is as follows:

1. Fire Sensor
   The fire sensor used is a fire sensor that uses infrared to detect a fire. The output from this fire sensor is in the form of an analog value ranging from 0 to 1024 and this analog value will be the input for the fire detection system.
2. MQ-7 Gas Sensor
   This MQ-7 sensor is a type of gas sensor that is commonly used in making a system. The MQ-7 gas sensor can measure the concentration of various types of gases in a room, but in this study the MQ-7 gas sensor will focus more on CO gas only. The output from the MQ-7 gas sensor is the gas concentration value in a room and the output value from this sensor will be input to the fire detection system.
3. LM35 Temperature Sensor
   This LM35 temperature sensor is one type of room temperature sensor that is commonly used. The output of this LM35 sensor is in the form of a real-time temperature value in a room and the output value of this sensor will be input for the fire detection system.
4. Arduino Mega 2560 microcontroller
   Arduino Mega contains all the programs which include the sensor program and the fuzzy logic program itself. The program written into the Arduino Mega microcontroller is useful for making the fire detection system operate as desired.
5. Buzzers
   The buzzer in this study is used as an output where the buzzer will make a sound if a fire is detected in the place being observed.
6. LEDs
   The LED in this study is used as an output where an LED with a certain color will light up according to the status issued by this fire detection system.
7. Ethernet Shield Module
   The Ethernet Shield module is a module used to connect Arduino to the internet using a cable (Wired).
8. Web Monitoring

Data from Arduino will be sent to the web server so that data in the form of temperature, gas and fire values can be monitored anywhere.

Fuzzy Logic Design

The design of the Fuzzy Logic system itself is divided into several stages, including:

1. Create a Fuzzy set

Creating a Fuzzy set is the first step in which at this stage the number of linguistic variables to be used is determined and the distribution of data on each linguistic variable. This fire detection system uses 3 input variables where the input variables are the output values from the fire, temperature, and gas sensors. Each of these input variables also each has 3 linguistic variables. So for the design of the fuzzy system input on this fire detector are as follows:

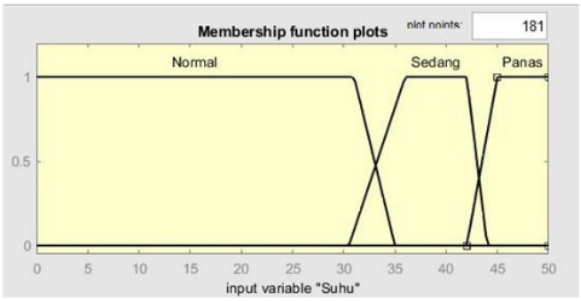

fig 2 Temperature input variable

In Figure 2, 3 linguistic variables are made, which include Normal (0 °C to 35 °C), Moderate (30 °C to 45 °C) and Hot (40 °C onwards). So that in Figure 4.3 if translated it will form the following equation:

$$Normal = \begin{cases} 1, & x \leq 31 \\ \frac{35-x}{4}, & 31 \leq x \leq 35 \\ 0, & x \geq 35 \end{cases}$$

$$Sedang = \begin{cases} 1, & 36 \leq x \leq 42 \\ \frac{44-x}{2}, & 31 \leq x \leq 35 \\ \frac{x-30,5}{5,5}, & 31 \leq x \leq 35 \\ 0, & 30,5 \geq x \; dan \; x \leq 44 \end{cases}$$

$$Panas = \begin{cases} 1, & x \geq 45 \\ \frac{x-42}{3}, & 42 \leq x \leq 45 \\ 0, & x \leq 42 \end{cases}$$

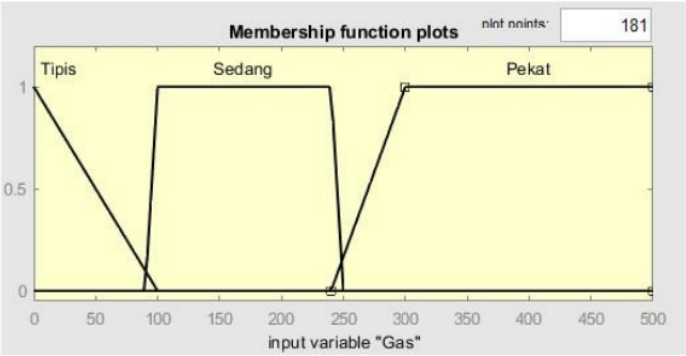

fig. 3 Gas Input Variable

In Figure 3 the gas input variables also have 3 linguistic variables, namely Thin (0 ppm – 100 ppm), Medium (90 ppm – 250ppm) and Thick (240 pmm onwards). So that in Figure 4.4 if translated it will form the following equation:

$$Tipis = \begin{cases} 1, & x \leq 0 \\ \frac{100 - x}{100}, & 0 \leq x \leq 100 \\ 0, & x \geq 100 \end{cases}$$

$$Sedang = \begin{cases} 1, & 100 \leq x \leq 220 \\ \frac{250 - x}{30}, & 220 \leq x \leq 250 \\ \frac{x - 90}{10}, & 90 \leq x \leq 100 \\ 0, & x \geq 250 \; dan \; x \leq 90 \end{cases}$$

$$Pekat = \begin{cases} 1, & x \geq 300 \\ \frac{x - 240}{60}, & 240 \leq x \leq 300 \\ 0, & x \leq 240 \end{cases}$$

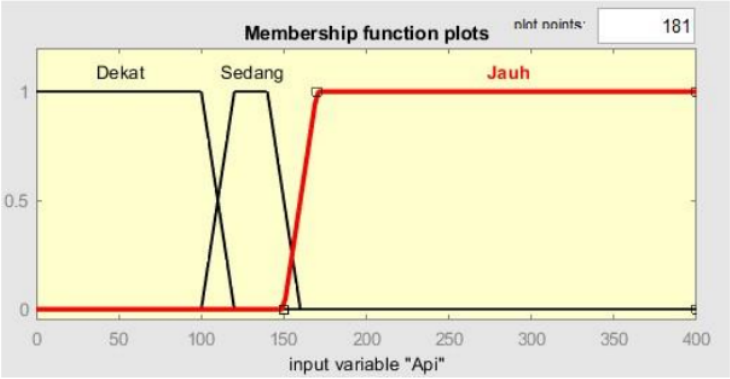

Fig 4 Fire input variable

In Figure 4 the fire input variable also has 3 linguistic variables, namely Near (0-120), Moderate (100-160) and Far (150-1023). So that in Figure 4.5 if translated it will form the following equation:

$$Jauh = \begin{cases} 1, & x \geq 170 \\ \dfrac{x-150}{20}, & 150 \leq x \leq 170 \\ 0, & x \leq 150 \end{cases}$$

$$Sedang = \begin{cases} 1, & 110 \leq x \leq 140 \\ \dfrac{160-x}{20}, & 140 \leq x \leq 160 \\ \dfrac{x-100}{10}, & 100 \leq x \leq 110 \\ 0, & x \geq 160 \; dan \; x \leq 100 \end{cases}$$

$$Dekat = \begin{cases} 1, & x \leq 100 \\ \dfrac{120-x}{20}, & 100 \leq x \leq 120 \\ 0, & x \geq 120 \end{cases}$$

In addition to designing fuzzy input variables, at this stage the output variables are also designed and the design of the output variables in this system is as follows:

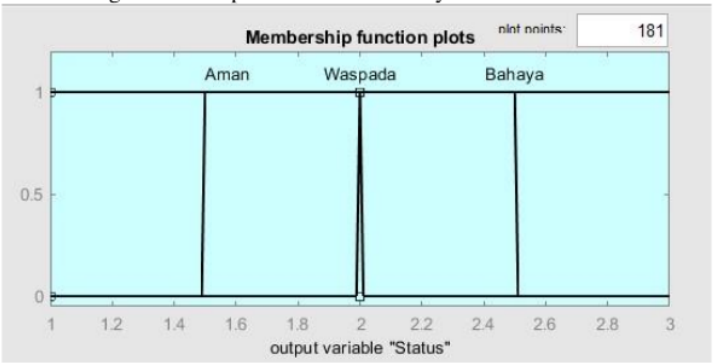

Fig 5 The Status output variable

Variabel *output* Status

In Figure 5 it can be seen that the output variables of the fuzzy system are designed to have 3 linguistic variables and the three variables are Safe (1 – 2), Alert (1.5 – 2.5) and Danger (2 – 3). It is from this output variable that the level of a fire can be predicted by the fire detection system.

SYSTEM IMPLEMENTATION

System implementation is a process of implementing the system that has been designed, where this stage is the stage of putting the system ready for use and also as an effort to realize the system that has been designed.

System Implementation Requirements

Hardware Requirements

The hardware used in making this fire detection system is:

1. computer with specs:
   A. *Processor* : AMD Ryzen 5-3550H 2.1GHz
   B. *Storage* : Harddisk 1 TB + SSD NVMe 256 GB
   C. RAM : 8GB DDR4 2400MHz SDRAM
2. Arduino Mega2560
3. Modul Arduino *Ethernet Shield*
4. Fire cencor
5. cencor LM35
6. cencor Gas MQ7
7. LED
8. Kabel Jumper
9. *Breadboard*
10. Adaptor 9 Volt
11. *Access Point*
12. LAN

Software Requirements

The software used in making this fire detection system is:

1. Operating System : Windows 11 Home Single 64-bit
2. *Code Editor* : Arduino IDE & Visual Studio Code
3. Design Simulator : Fritzing
4. Diagram Design : Microsoft Visio 2016

5. Web Server : Apache
6. Database Server : MariaDB

System Usage Guide

How to Use a Fire Detection System:

1. Give Power to the Arduino by inserting the power cable from Arduino to the mains.
2. After Arduino is connected to electricity, the sensor will automatically turn on and start detection.
3. If the green light is on then it indicates that the status is safe.
4. If the yellow light is on and the buzzer sounds every 1 second then it indicates that the status is alert.
5. If the red light is on and the buzzer sounds then it indicates that the status is dangerous.

CONCLUSION AND RECOMMENDATIONS

Conclusion

After conducting system analysis, design, and testing, it can be concluded that an automatic fire detection system can detect the surrounding conditions correctly and also the use of a fuzzy system in this system can make the fire detection system more informative by having more fire level indicators, namely SAFE, Towards BEWARE , BEWARE, Towards DANGER, and DANGER. The distance required by the system to detect a fire is relatively close, which is around less than 1 meter.

Recomendation

The following are suggestions that the compiler can use for the development stage of this system, including:

1. This system cannot be connected directly to the fire department so that fires can be handled quickly.
2. This system has not yet reached the stage where it can be implemented in daily activities because the sensors used are still limited to prototypes.
3. The first prevention feature can be added, such as pouring water so that the fire does not spread.

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