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Design Of Automatic Fire Detection and Extinguishing Devices Using Arduino

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Abstract: A robot is a series of hardware and software in the form of a driving program. Robots are not only used in industry; in developed countries, robots are widely used to help with household chores. Many jobs that require a lot of energy are high-risk or dangerous, one of which is detecting and extinguishing fires. Fires can be avoided if the fire can be extinguished before it spreads. When the fire has spread, extinguishing it will be difficult and high-risk. Fires can cause huge losses of both property and lives that cannot be saved. The problem can be reduced if the source of the fire can be quickly found and extinguished. In this research, a fire extinguisher robot will be designed with an Arduino Mega 2560 and an infrared flame detector to detect the presence of fire. This robot is accompanied by an HC-SR04 ultrasonic sensor so that the robot can walk automatically without hitting obstacles because this robot aims to walk down hallways such as areas in the house or in any area that has a hallway for the robot's path. This research aims to implement Arduino for the control of the ultrasonic sensor and the movement of the fire extinguisher robot. The use of an Arduino micro-controller on the fire extinguisher robot is expected to make the robot move steadily and avoid obstacles in the hallway.

Keywords: Robotics, Fire Detection, Fire Extinguisher, Arduino, Sensor

INTRODUCTION

A robot is a mechanical device that can perform physical tasks, either using human supervision and control or using predefined programs in the form of artificial intelligence (Putri, 2019). Nowadays, robots are nothing new. Robots are widely used in a variety of sectors or fields, including manufacturing, health, education, aviation (transportation), and even NASA researchers use robots to send to outer space destinations such as Mars and the Moon.Pathfinder, Curiosity, and Perseverance are some examples of the many robots sent by NASA into space. A robot is a series of pieces of hardware equipped with software in the form of a driving program. Robots are not only used in industry; some in developed countries are already widely used to help with household chores. Therefore, robotics is one of the technologies of interest in the world of research. In Indonesia, many robots are being developed that are able to complete missions in dangerous terrain, such as bomb disposal robots.

There are many jobs that require a lot of energy or are high-risk or dangerous. One of the human jobs that can be done by robots is firefighting. Fire is one of the many disasters that can cause damage. Some of the causes of fire include exploding gas cylinders, electrical short circuits, and others (Saputra et al., 2016). This requires a very fast and careful reaction because fires can be avoided if the fire can be extinguished before it spreads. Because when the fire has spread, the firefighting work will be difficult and high-risk. The problem of fire spread can be reduced if the source of the fire can be found and the signs of fire are extinguished in a timely manner. There have been many cases of fires that are widely heard about and occur around us and outside, where there are huge losses and many lives that cannot be saved.

In this study, researchers want to design a fire extinguisher robot using an Arduino Mega 2560, an infrared flame detector to detect the presence of fire so that it can find out where the fire point is located, and an HC-SR04 ultrasonic sensor for installation on the robot so that it can walk automatically without bumping into obstacles because this robot aims to walk down hallways such as areas in the house or in any area that has a hallway for the robot's path. This research aims to implement Arduino for the control of the ultrasonic sensor and the movement of the fire extinguisher robot. The use of the Arduino micro-controller on the fire extinguisher robot is expected to be able to make the robot move steadily and avoid obstacles in the hallway. In this study, the avoider design will use an Arduino Mega 2560. This fire avoider only detects fires and extinguishes them with a DC motor-powered water spraying system.

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LITERATURE REVIEW

Robots

The word "robot" comes from the Czech "robota," which means worker. A robot is an electronic device that is programmed to automatically perform tasks normally performed by humans (Yusep Mulyana, 2022). Robots are very useful to help alleviate human work and can even replace humans in doing a job that requires high accuracy and high risk, or even work that requires a lot of energy, that is run by a series of predefined programs or artificial intelligence (Paryanta et al., 2018). A robot is a mechanical device capable of carrying out physical tasks, either under the control of human supervision or run by a series of predefined programs (Dodu et al., 2019). Robotics today is no longer limited to being part of science fiction but has become a reality that is widely found in real life (Abrar & Armin, 2020). From the above expression, it can be concluded that the robot has the ability to help humans work because it can move and talk and is able to move automatically without having to be operated.

Arduino

Arduino is a relatively easy and fast microcontroller system for making electronics and robotics applications (Afira et al., 2022). Arduino is an open-source electronic system that can be used freely and can be used with both hardware and software. Arduino can create programs through the Atmega328 chip (Wardiansyah, 2022). In another sense, Arduino is a tool to control electronic items (Husin, 2022). According to Hidayanti, the Arduino Uno is a microcontroller device that can operate a device with the help of programming codes. This microcontroller is open source and designed to facilitate the assembly of a device or piece of hardware (M. Andrea Riswanto, 2022). Arduino Uno has 14 digital input/output legs, of which 6 digital legs can be used as PWM (Pulse Width Modulation) signals (Prasetyo et al., 2018). Therefore, to underline the discussion about Arduino, namely the use of a very large number of users so as to provide program code that will be made among hardware and modules that support a large number, Certainly, this can make it easier for everyone to recognize the name Arduino. Arduino Uno is an Italian hardware output in the form of a minimal system using the Atmega 328 microcontroller.

IR Flame Detector

The use of sensors has been widely studied in previous research, whether it is fire, speed, light, heat, or other sensors. Most of them are combined with microcontrollers such as Arduino, the ATMega328, the MPU 6050, and other sensors (Priswanto & Haryono, 2022). According to (Sokibi & Nugraha, 2020), the fire sensor is a sensor that has a function as a flame detector, where the fire has a wavelength of 760 nm–1100 nm. This sensor has a reading angle of 60 degrees and operates at a temperature of 25–85 degrees Celsius. The way this sensor works is by detecting flames using an optical method. This sensor employs an infrared sensor as a transducer.which is where this transducer is used to absorb light at a certain wavelength.

Ultrasonic Sensors

Ultrasonic sensors are sensor modules that function to detect obstacles using sound sensors that will be converted into electrical quantities or vice versa. This sensor works based on the reflection of sound waves. Because the origin of the sensor will emit sound waves towards the target in the area around the sensor, Then the reflection of the sound waves is received by the sensor and will be interpreted to determine how far away the intended object is (Amin et al., 2020). This HC-SR04 sensor has the ability to measure distances between 2 and 400 cm with a 15-degree measurement reflection. Basically, what is read by an ultrasonic sensor is the travel time of alternating waves from the transmitter to the receiver (Setyawan et al., 2020).

METHOD

Research Design

The research design is as follows:

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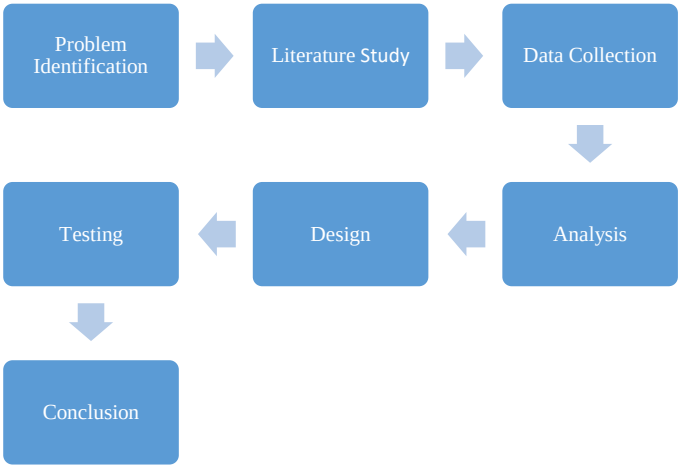

Fig.1. Research Design

Tool Design

In the creation and testing of tools, computer hardware plays an important role in the performance of a computer system. It is critical to be prepared to support the system from the tool's hardware when designing this tool. There are several types of design in the tool, namely:

1. Robot design, Designing tools for a robot can be in the form of a construction design for a robot that describes how researchers can design an interface that will be made.
2. Electrical Design, In making up and testing tools using electronic components to run such as ultrasonic sensors, fire sensors, servo motors, and DC motors, you give commands to the Arduino Mega 2560, which has been connected in a box.

Software design, which includes the process of data from several devices assembled to the Arduino Nano board, is needed in this process. In this case, we need the software contained on Arduino, namely the Arduino IDE. The Arduino IDE is software for programming on Arduino, which is programmed by a programming language whose library comes from the C/C++ language called "Wiring," which facilitates the process of input and output data on Arduino. The following is a flowchart of the tool that will be assembled:

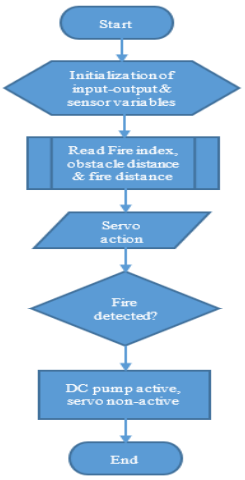

Fig.2. Flowchart

How the system works is by initializing the input and sensor, then the sensor reads the fire index, obstacle distance, and fire distance, then proceeds to the servo. If a fire is detected, then the DC pump is active and the servo will be inactive. Otherwise, it will return to the obstacle sensor and read the fire index.

RESULT

Hardware Design

The results of the hardware design, which includes an Arduino Mega 2560, are used to support the work system of this robot. In the input, ultrasonic sensors and fire sensors are selected as inputs. to avoid obstacles

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using an ultrasonic sensor and to detect fire using a fire sensor. This hardware design consists of mechanical and electrical components.

Mechanical Design

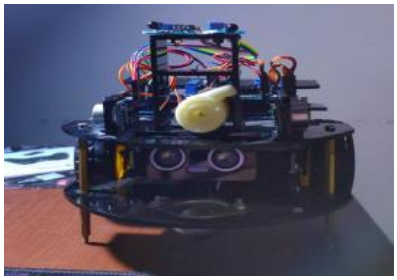

Fig.3. Front View

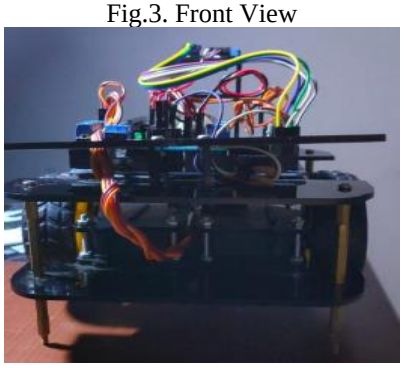

Fig.4. Back View

Electrical Design

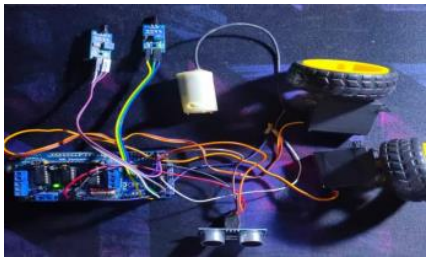

Fig.5. Electrical Circuit

a. Arduino Mega Design with HC-SR04 Ultrasonic Sensor

Fig.6. Arduino with Ultrasonic Sensor

Table 1. Servo Pin Addressing

Ultrasonic Sensor PINs	Arduino Mega 2560 PIN
D22	Echo (Left)
D23	Trig (Left)
D24	Echo (Front)
D25	Trig (Front)
D26	Echo (Right)
D27	Trig (Right)
Vcc	Vcc
Gnd	Gnd (Ground)

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b. Arduino Design with KY-06 Flame Sensor

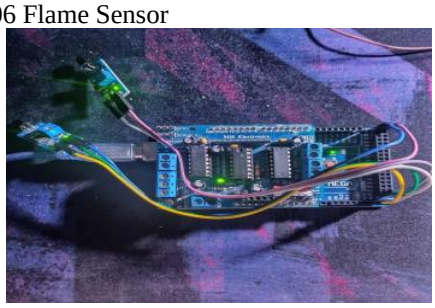

Fig.7. Arduino with Sensor API

Table 2. Flame Sensor Pin Addressing

Arduino Mega Pins	Fire Sensor Pins (Left/Right)
Right	A0(Left)
Gnd	GND(Ground)
Vcc	Vcc
A15	A0(Right)

c. L293D Motor Driver Design with 360° Brushless Servo Motor

Fig. 8. Arduino with Servo Motor

Table 3. Servo Motor Pin Addressing

Pin Motor Driver	Fire Sensor Pins (Left/Right)
Ser_1(Servo 1) Gnd	Gnd (Brown Jumper)
Ser_1(Servo 1) Vcc	Vcc (Red Jumper)
Ser_1(Servo 1) Signal (D9)	Signal (Oranye Jumper)
Servo_2 Gnd	Gnd (Brown Jumper)
Servo_2 Vcc	Vcc (Red Jumper)
Servo_2 Signal (D10)	Signal (Oranye Jumper)

d. Arduino Design with DC Pump

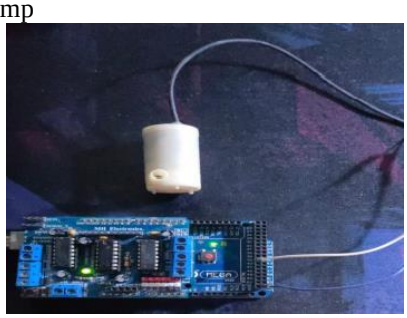

Fig. 9. Arduino with DC Water Pump

Table 4. DC Pump Sensor Pin Addressing

Arduino Mega Pins	DC Pump Pin
D40	Vcc
Gnd	Gnd

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Software Design

The results of the software design on this system use Arduino IDE software to run the program in the hardware design of the device circuit. This program gives commands to ultrasonic sensors to detect obstacles and to fire sensors to detect fire.

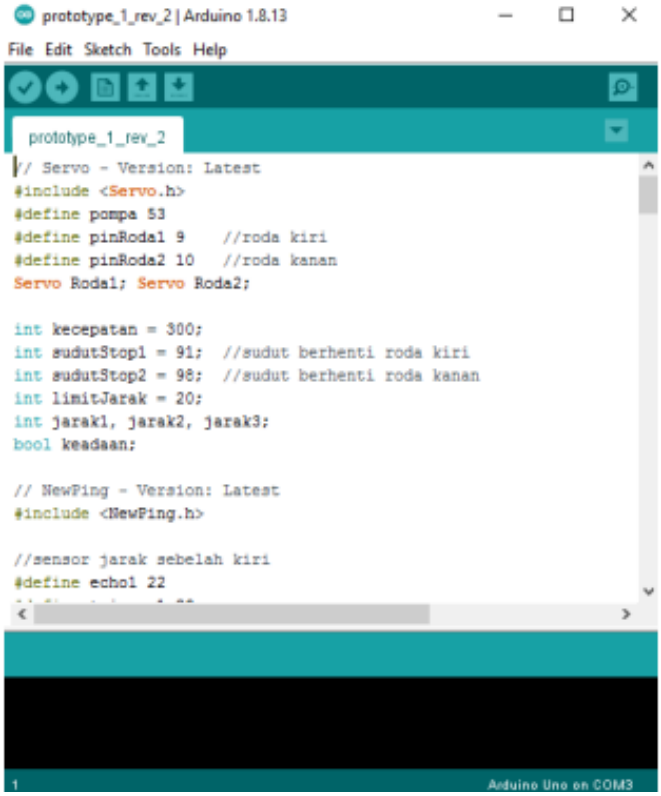

Fig. 10. Arduino IDE program

Testing

After completing all stages in system design, hardware, and software, the next step is the testing stage in the circuit to find out and ensure that the tools that have been designed and programmed work as expected by the researcher.

The first stage of testing is to determine the robot's ability to run automatically.

a. The robot walks forward

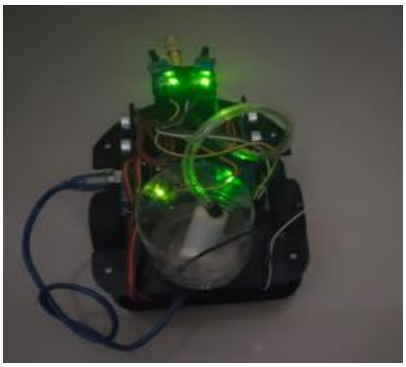

Fig. 11. The robot walks forward

The robot's first test is to move forward using a servo motor as a wheel drive powered by a 5 volt battery.

b. Ultrasonic sensor testing when there is an obstacle in front of the robot

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Fig. 12. Turning due to wall obstruction

In the second test, the robot runs and the ultrasonic sensor reads an obstacle. If the ultrasonic sensor reads an obstacle in front, the robot will avoid it. The ultrasonic sensor has been programmed to avoid the wall at a predetermined distance.

c. The fire sensor detects the presence of fire.

Fig.13. Fire sensor detects fire

The third test of the robot detects a fire in front of the robot. When the robot is in front of the fire, the IR flame detector sensor will work, and the sensor will work according to the distance that has been programmed when there is a fire in front, and the robot will stop.

d. Spraying with a direct current motor

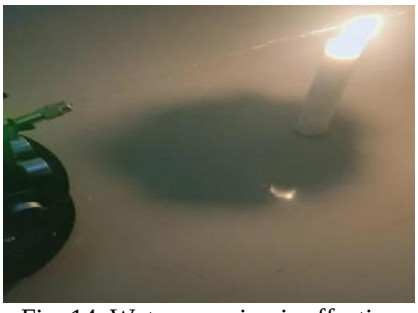

Fig. 14. Water spraying is effective

The fourth water sprayer test is activated when the IR flame detector sensor detects a fire.Then the DC motor that has been programmed into the Arduino will spray water on the object. This object uses a candle as test data. And the fire has been extinguished, as shown in Figure 15.

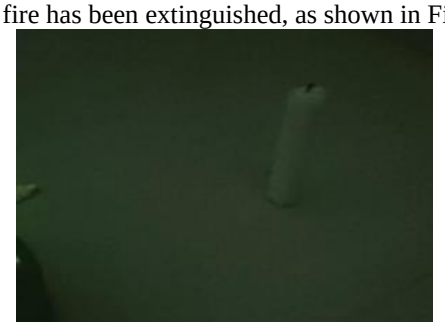

Fig. 15. The fire has been extinguished.

Test Result Data

Fire Extinguisher Robot testing has gone through several stages to obtain samples; the next step is to obtain the test results, as shown in Table 5.

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Table 5. Test Result Data

Distance (y)	Voltage (x)
10	0,16
20	2,16
30	3,46
40	4,36
50	4,56
60	4,86
Straight-line equation	Y = mx +b
m/slope	9,75885152
b/intercept	2,45423018
So	
Distance = 9,758*volt + 2,45	

The calculation for the fire detection distance that has been set for the fire detection sensor is shown in the table above.

DISCUSSIONS

This research produces a prototype robot that can identify and extinguish fires if the source of the fire has been found. This research is a contribution to helping identify and prevent fires and the impacts caused by them. Several stages in this research are the first to identify problems and learn about common fire problems and phenomena. The second is to conduct a literature study to collect data from various sources to be used as reference material. The third is to collect data and related tools that will be used in this research. The fourth stage is to analyze the data that has been collected so that it can be grouped according to the needs of the designed tool. The fifth stage is the tool design stage, where there are two parts to the design, namely hardware design and software design. The sixth stage is the testing stage, where after the tool is made, testing will be carried out to find out whether the tool that has been made functions as expected. The last stage is to conclude the results of the research that has been done. The working mechanism of this robot begins with initializing the input, output, and sensor variables, then proceeds with reading the API index, obstacle distance, and fire distance, after which the servo will be active. If the fire is not detected, the process will return to the input, output, and sensor initialization stages. If the fire is detected, the DC pump will activate and spray water on the fire source that has been found, and then the servo will deactivate. After the robot manufacturing process is complete, the testing process is carried out. From the results of the tests that have been carried out, there are no obstacles where the tools made can run and function according to what has been previously determined. It is hoped that in the future, the tools can be further developed by adding GPS features so that they can find out where the robot is and where it is going. In addition, it is also necessary to add fire sensors in all directions to facilitate spraying in various directions, not just the front direction. This development can provide enough benefits for all parties who need them.

CONCLUSION

After designing the tool and testing it, several conclusions can be drawn, namely: (1) This design uses a fire sensor to detect fire; when the sensor detects a fire, the sensor will work according to what has been programmed into Arduino. The test results prove that the sensor functions properly in detecting fire. (2) The use of ultrasonic sensors functions as an obstacle detection device so that the robot does not hit walls or obstacles that have been installed by the sensor. The existence of this sensor allows the robot to avoid existing obstacles. (3) The use of a DC motor as a water sprayer when the fire sensor detects a fire in front of the fire sensor also works well. The robot can spray water when it finds the source of the fire.

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