

Fire Extinguisher Robot Using Ultrasonic Camera and Wi-Fi Network Controlled with Android Smartphone

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Abstract. Fire disasters can occur anytime and result in high losses. It is often that fire fighters cannot access the source of fire due to the damage of building and very high temperature, or even due to the presence of explosive materials. With such constraints and high risk in the handling of the fire, a technological breakthrough that can help fighting the fire is necessary. Our paper proposed the use of robots to extinguish the fire that can be controlled from a specified distance in order to reduce the risk. A fire extinguisher robot was assembled with the intention to extinguish the fire by using a water pump as actuators. The robot movement was controlled using Android smartphones via Wi-fi networks utilizing Wi-fi module contained in the robot. User commands were sent to the microcontroller on the robot and then translated into robotic movement. We used ATmega8 as main microcontroller in the robot. The robot was equipped with cameras and ultrasonic sensors. The camera played role in giving feedback to user and in finding the source of fire. Ultrasonic sensors were used to avoid collisions during movement. Feedback provided by camera on the robot displayed on a screen of smartphone. In lab, testing environment the robot can move following the user command such as turn right, turn left, forward and backward. The ultrasonic sensors worked well that the robot can be stopped at a distance of less than 15 cm. In the fire test, the robot can perform the task properly to extinguish the fire.

1. Introduction

One technology that grows at this moment is the Robotic technology. Robots can help people performing certain jobs, especially in the field that requires a high degree of precision, high-risk, or a job that requires a great power. In general, the robot can be defined as a mechanical device capable of performing human tasks or behave like humans [1, 2].

Fire disaster is a common disaster caused by humans. It can occur at anytime, anywhere, with varies trigger that could lead to fires. Important factors in handling of fire are how precise we define a location of the source and how fast we put out the fire.

One man's work that can be perfectly done by robots is fire extinguisher. This type of work requires quick reaction to avoid fire spreading too wide. When the hazard area spread, fire-fighter jobs will be a tough job and increase the risk. It is often that fire fighters cannot access the source of fire due to the damage of building and very high temperature, or even due to the presence of explosive materials. Considering the human constraints and due to high level of risk in handling of the fire, it



would require a technological development that could help fire fighters in extinguishing the fire e.g. by using robots. Fire extinguisher robot would be very useful to extinguish the fire [3, 4]. The use of fire fighting robot that can be controlled from a distance specified is expected to reduce the risk. With this, fire fighters do not have to enter the building since the building that burnt can be collapsed and there was potential explosion at any time.

In 2013 Suryatini et.al conducted research about a fire extinguisher robot with ultrasonic sensors by using wall follower method. The process to search hotspots was done by detecting the ultraviolet rays emitted by the fire using fire sensors. To extinguish the fire they used a fan driven by a DC motor. A PING ultrasonic range finder sensor was used to guide the robot navigation in avoiding obstacles [5]. Aji et.al proposed quite similar system with ultrasound sensor and ATMELEL 89552[6]. More sophisticated fire extinguisher robot systems were proposed by UC Berkeley by using wireless sensor network and Incident Command [7] and from Trondheim Norway by developing snake Robot [8] and vertical robot [9] which are considered to be too expensive for implementation.

The propose of this study is to developed a fire extinguisher robot that connected to the Smartphone via Wi-fi networks so that it can be controlled at a certain distance.

2. Material and Method

General architecture of whole processes in developing fire extinguisher robots can be seen in Figure 1.

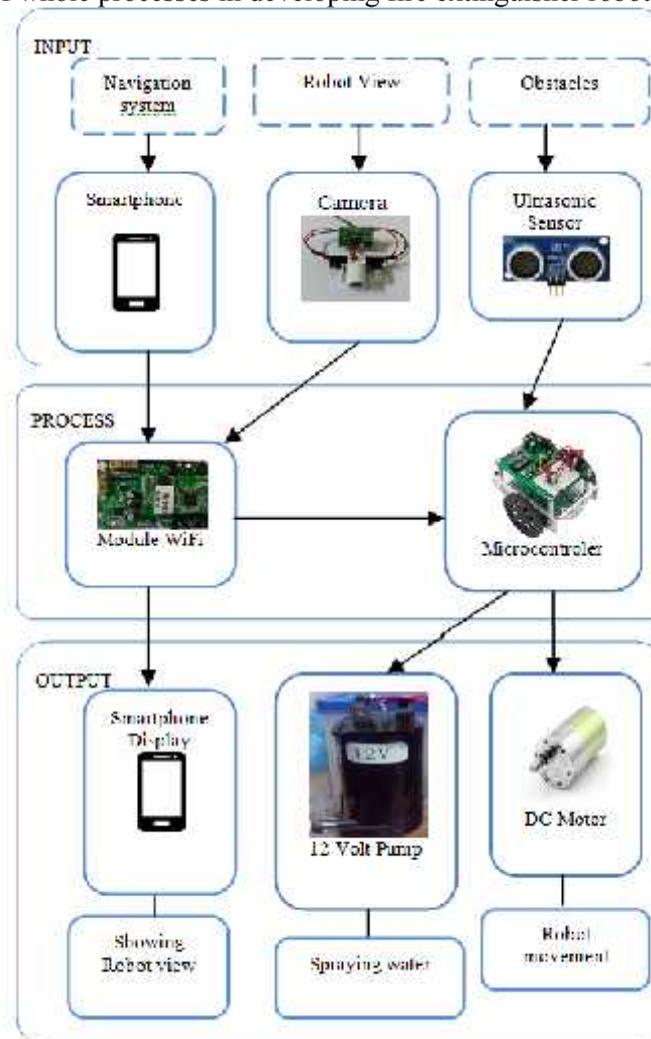


Figure 1. General Architecture for Fire Extinguisher Robot

Input received for the robot came from the smartphone, camera, and ultrasonic sensors, which will help in controlling the fire-fighting robot. On the smartphones a dedicated software application were built contained buttons in the form of commands to control the movement of the robot: moving forward, backward, turn right, turn left, and activate the pump to spray the water. These commands were delivered from smartphone to the robot, especially to the microcontroller via Wi-fi network. The camera mounted on the robot captured the view in front of the robot and then displayed on smartphones to help users control the robot. Ultrasonic sensors installed on the robot served in detecting obstacles surrounding the robot. Sensor shot the ultrasonic waves and received it back to determine the distance of obstacles in front of it. When the robot perform the backward movement, the ultrasonic sensor turns on automatically and detect the obstacle behind the robot

The commands sent by smartphones delivered through Wi-fi network and received by the Wi-fi module on the robot. The command signals then forwarded to the microcontroller to be converted into movement of the robot. The microcontroller converted the commands from the smartphone into DC current which serves to drive the DC motor and water pump on the robot. Image received from the camera on the robot was directly sent to smartphone display using a Wi-fi module through a Wi-fi network that connected between the robot and smartphone. Input received on ultrasonic sensors located on the robot was sent to the microcontroller to be processed as indicator when the robot moved. If the distance with the obstacle was less than 15 cm, then the robot automatically stopped.

The main process of fire extinguisher robot were a smartphone that can display images in front of the robot captured by the camera on the robot, the robot movement based on the control of an application on a smartphone, and the water pump that can be switched on or off via a smartphone.

3. Result

System Performance testing was performed to check whether the fire extinguisher robot run well or not. Some aspects in input process, process and output were analyzed, for example, pressing a key on the button on the smartphone can be detected as an input by the microcontroller and the device functioned properly to assist in the movement of the robot. The performance test included robot actuator test, robot movement test, water pump test, ultrasonic sensor test, camera test, and robot control distance test. The overall results of testing process can be seen in Table 1.

Table 1. Results of Overall Testing

No	Testing subject	Result
1	Forward movement	Succeed
2	Backward movement	Succeed
3	Turn Left	Succeed
4	Turn Right	Succeed
5	Sensor Ultrasonic	Succeed
6	Camera	Succeed
7	Water Pump	Succeed

Robot actuator test concerned about the performance of motor drive with Module program in the application. This test was done to see if the movement of the robot in accordance with commands from user. Result of robot actuator test can be seen in Figure 2.

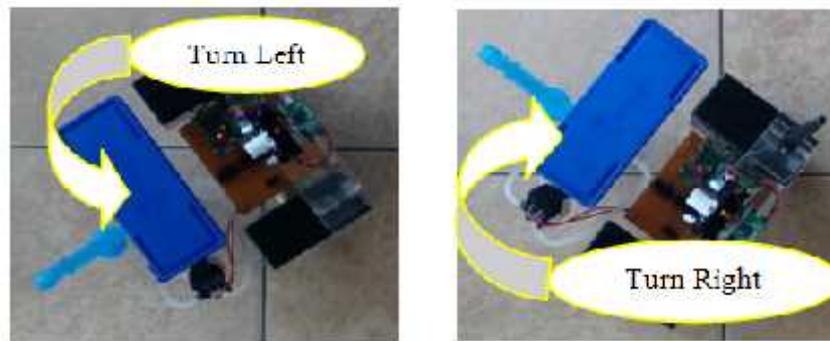


Figure 2. Robot actuator test (a) turn left (b) turn right

Water pump test checked the capability of the robot to extinguish the fire. We can see in Figure 3 water pump on the robot was able to extinguish the fire on lit candles. In this case the pump had been able to function well to extinguish the flame.



Figure 3. Water pump test (a) without and (b) with water spray

Ultrasonic sensors test examined its function to control the movement of robot through obstacles. In this test, an ultrasonic sensor was used only to control the movement of the robot at the time of retreat, since robot had one camera in front of it. Result of ultrasonic sensor test can be seen in Figure 4.

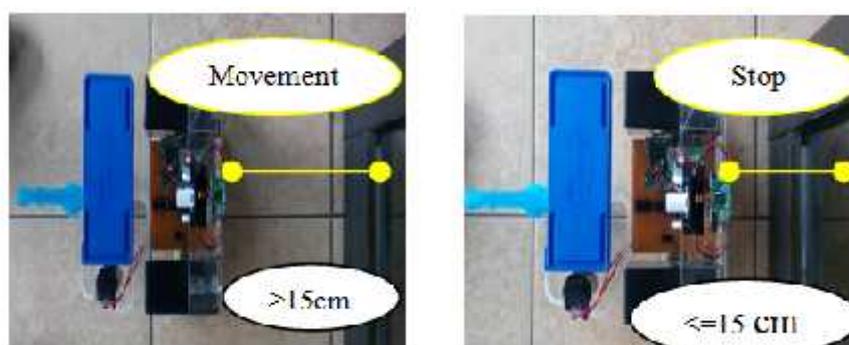


Figure 4. Ultrasonic sensor test, the robot automatically stopped at distance less than 15cm

The camera on the robot served to show the front view of a robot, which can assist user in controlling the movement of the robot. In this test, robot view was be displayed on the smartphones. The test results can be seen in Figure 5.



Figure 5. Camera test displaying view in front of robot

Fire extinguisher robot was controlled from a Smartphone via Wi-Fi networks contained in the robot. The robot can be controlled from a smartphone while it is connected to a Wi-Fi network. The testing was conducted in order to determine the maximum distance we can still control the robot. Testing was done on an open area that there are no obstructions whatsoever. The result is shown in Table 2.

Table 2. Testing distance for controlling robot

No	Distance	Result
1	10 meter	Good controlling
2	20 meter	Good controlling
3	30 meter	Good controlling
4	40 meter	Good controlling
5	50 meter	Not Good controlling
6	60 meter	No control

4. Discussion

Here we implemented a firefighting robot using microcontroller ATmega8 and android-based smartphone. The robot movements were successfully controlled by user via an application on the smartphone, including forward and backward movement, turn right and left, and activated the pump.

By the time the robot moved backward when there was obstacle at a distance of ≤ 15 the robot automatically stopped. The robot moved to extinguish the fire with corresponding control from the user with the aid of a camera on module attached on the robot and displayed on the smartphone. The performance was comparable to the use of wireless sensor network as suggested by Arampatzis in their survey [10].

The development of autonomous robot for fighting fire had also been started in several projects, such as Khoon, et.al [11], Al-Azemi [12], Baba [13] and Prasanna [14]. Prasanna et al for example proposed a monitoring robot to detect a fire by using four pieces of sensors and GSM modem. Robot will continuously monitor the room and in case of fire robot will send a warning message to users and fire fighting office [14]. The fire extinguisher robot was also developed nowadays with implanted artificial intelligence [15, 16]. The successful rate of this kind of fire extinguisher robot is highly dependent on the circumstances and real condition on the field. Low adaptability is main issue that manual control of the fire extinguisher robot is preferable.

Further development is recommended for more controlling on the water pump attached on the robot, for example controlling up and down, making it easier to extinguish the fire. The development\

is also suggested regarding the trajectory of the robot in the form of inclines and should be able to overcome more variance of obstacles.

5. Conclusions

In this study, we developed a fire extinguisher robot that connected to the Smartphone via Wi-Fi networks so that it can be controlled at a certain distance. This robot can be used to help fire fighters extinguish the fire remotely and therefore reducing risk in handling the fire hazard.

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