

FIRE FIGHTING ROBOT USING MASTER-SLAVE ARCHITECTURE

Reshmaa Saundra G (Department of Computer Science and Engineering, Karunya Institute of Technology and Sciences)(reshmaas900@gmail.com)

Belfin R.V.(Department of Computer Science and Engineering, Karunya Institute of Technology and Sciences) (researchbelfin@gmail.com)

Immanuel Alex Pandian S (Department of Electronics and Communication Engineering, Karunya Institute of Technology and Sciences)(immans@karunya.edu)

ABSTRACT

The usage of robots in a situation of emergency has increased, thus lowering the intervention of human beings. In a lot of emergency situations, robot assistance has provided safe and remote access. One such situation would be a fire accident where a firefighting robot could be deployed. The concept of swarm robotics, which is highly valuable in the field of robotics, is highly beneficial here. Swarm robotics is the coordination of multiple robots as a system that consists of a large number of physical robots. Usually a firefighting Robot uses water or any chemical to extinguish the fire. A firefighting robot which detects fire and moves to the location to put off the fire using a fan without damaging the area around the fire. IR sensors are used to detect the fire, and if the fire is noticed, then the robot moves to the location of the fire using DC motors and then fire is put off using a fan. Another robot with the same model is used to work to put off the fire. This Robot could be used indoors and in places where water cannot be used. A swarm of firefighting robots could be used in buildings, warehouses, luxurious hotels and showrooms. These places consist of perishable or valuable items which could be damaged by water or chemicals. So a fire-fighting robot which uses a fan could be used to put off fire.

KEYWORDS

Fire Fighting robot, Swarm robotics, Arduino UNO, IR sensor, DC motors, Motor Driver.

INTRODUCTION

Robotics industry has contributed a lot of innovative ways to protect humans or properties in emergency situations. One of the most common scenarios could be fire accidents. In this case, a Fire Fighting Robot could be used in the scenario. Fire Fighting involves 3 processes - fire detection, fire allocation and fire extinguishing which contributes wholly to the suppression of fire. The top priority of a firefighting robot must be to prevent loss of lives and protect properties before it is damaged. Some of the other priorities include prevention of further fire spreading, extinguishing fire autonomously and decreasing the time taken to extinguish a fire without the help of a firefighter.

In many cases, a fire-fighting robot is controlled by mobile phones or an operator. But in this project, the Robot is wholly autonomous. As it is dangerous for humans to take measures to extinguish fires over all the affected areas, a Fire Fighting Robot could take over. Loss of lives could be prevented and less time is required. Another advantage would be the use of technology, instead of human beings. This would reduce the time and would be able to offer a better performance efficiently. Hence this concept would benefit the process. In case of operation, the most effective process of operation would be using the autonomous robots. While in most cases, the robots are either operated by mobile or a user which makes the Robot manually operated or semi-autonomous and doesn't make the Robot completely autonomous [13],[25]. There are also remote controlled firefighting robots which use only human intervention through any device and are not autonomous [14]. Some robots are also controlled using android applications which are customized for the usage of the robots and are semi-autonomous and not completely autonomous [26]. Some examples of an android controlled robot would be a Fire Fighting Robot, used for fire detection and water sprinkling which is operated by an android device [16]. Many android apps and features which support sensors are used to control the firefighting robots though there are comparatively fewer robots which are autonomous [19]. Certain embedded systems also have an android robot control for the easy controlling of the firefighting robots [20],[24]. Despite this, some robots also have water leaking issues from the tank which could decrease the performance efficiency of the Robot. Most firefighting robots require human intervention as it may not be of much accurate or timely in putting off fire. Some Fire Fighting Robots are created using concepts of IOT which consists of SMS and GPRS packs [28],[30]. Some robots are created with intelligence could be used in applications of fire emergency situations with the concepts of dynamics and motion [17],[22].

Sufficient space is provided between the three IR sensors and is placed in the appropriate angles for immediate fire detection. The formation of the swarm robots also plays a major role in the process. Collective and cooperative behavior in swarm robotics is a vital essence for the working of the extinguishing process [15]. A remote Fire Fighting Robot is operated away from the fire scene which is completely autonomous [27],[29].

LITERATURE SURVEY

A firefighting Robot is used with various other facilities to detect and suppress a fire in many cases. An autonomous fire-fighting robot which is able to traverse through a maze with concepts of maze navigation. The firefighting Robot must detect the fire lit in different locations in the maze while avoiding obstacles through the maze. This Robot is designed with the rules proposed by Malaysian Fire Fighting Robot competition(MUROC)[1]. A Fire Fighting robot, controlled by mobile which is used to detect a fire and extinguish it using a water pump. The Fire Fighting Robot has an extinguisher attached to it. A water pump attached to a water container is used to extinguish the fire. A mobile is used to control the Fire Fighting Robot [2]. A Fire Fighting Robot is used to detect the fire and extinguish the fire immediately. The Fire Fighting Robot uses GUI(Graphical User Interface) and Bluetooth to connect the mobile to the robot for communication purposes. The Fire Fighting Robot uses the water sprinkling system to put off fire [3]. An autonomous Fire Fighting Robot detects fire and moves towards the location of the fire and uses an extinguishing fan to put off the fire. The Robot moves towards the fire, stops at a certain distance and detects the fire. Then after extinguishing the fire, the Robot moves back to its original position [4]. An unmanned Fire Fighting Robot detects fire and moves towards the fire and extinguishes the fire using a fan. This Fire Fighting Robot using Arduino and sensors detects the fire for further process [5].A Fire Fighting Robot detects the fire and moves to the location of the fire. It uses the water tank to put off the fire. The temperature of the fire is monitored with the Fire Fighting Robot [11].

A Fire Fighting Robot is designed to extinguish the fire with the usage of water. The movement of the Robot is fully controlled by a raspberry pi. A thermal camera and an infrared camera is mounted to the fire-fighting Robot. The thermal camera is used to sense heat while capturing footage of the fire scene. The infrared camera is used for capturing the fire scene at night [6]. An autonomous Fire Fighting Robot with vision camera and gas sensors. This Fire Fighting Robot uses a camera to detect the fire with the flame detector. The Fire Fighting Robot uses a water sprinkler to put off the fire [7]. An Autonomous Fire Extinguishing Robot using sound waves is created to extinguish fire using sound waves. The direction of the sound waves plays a major role in the fire extinguishing process [8].

A Fire Fighting Robot has a Wi-Fi enabled camera to the body of the robot which makes it easy to be control the robot from a remote place [9].A remote control emergency handling robot is developed, which is also a firefighting Robot. The firefighting Robot is controlled by a remote with a human from an area far away from the fire scene. This Robot is used for emergency situations to prevent loss of life and property damage [10]. In large case scenarios, a robot takes control over the process of fire extinguishing, where the safety measures are carried out remotely. A relatively new area considers a swarm of robots performing the fire extinguishing process. The swarm robots work with the firefighters to extinguish the fire. The emergency situation is assisted by the swarm robots and the firefighters are helped by the robots to navigate and extinguish the fires. The Robot is based on the principle of swarm intelligence which had been studied with the growing interest over the years [15].

PROBLEM STATEMENT

When a fire occurs in a building that contains perishable items, valuable things, and documents, water cannot be used for extinguishing the fire. So in places similar to this, a fire-fighting robot with a fan is really helpful. This Robot could also be used in a warehouse, luxurious hotels, and jewelry shops. Water or any other chemical substance may cause harm to the objects or things inside these structures. In order to avoid damage to the objects or things inside the buildings, warehouses, and luxurious places, this Robot could be used. One Robot couldn't just put off the fire immediately, so a swarm of robots could help in solving the situation without further spread. Having these robots on the premises would help during times of emergencies as it may prevent the spreading of fire as soon as the fire starts. Any manual intervention would take longer to reach the place or simply put off the fire. Hence this methodology would be implemented.

MASTER AND SLAVE APPROACH

The fire-fighting Robot consists of IR sensors, DC motors, Motor drivers, extinguishing fans and Arduino UNO. The Robot has two chassis, which is made up of wood. The two chassis are connected and mounted to each

other with screws using a screwdriver. The upper chassis consists of the breadboard, Arduino UNO and Motor driver. The lower chassis consists of 3 IR sensors in the right, left and center to the front. The wheels are attached to the DC motors at the bottom of the lower chassis. Each end of the DC motors is connected to the breadboard through a connecting wire. From the breadboard, the point at which the wire is present is connected to the Motor driver using another wire. Then the Arduino UNO is connected to the breadboard using male and female pin connectors. The Arduino UNO is connected to the extinguishing fan, which is mounted on the upper chassis.

The Arduino IDE is used for programming the arduino UNO. A program is written for the detection of fire, movement of Robots, and extinguishing the fire. If the fire is detected, the Robot starts to move towards the fire else, the Robot 'doesn't move. The movement of the Robot changes according to the direction of the fire. The IR sensors measure the direction of the fire, and the DC motors adjust the position of the wheel to reach the fire scene. The IR sensors detect the presence of the light using a transducer, which converts the light energy to mechanical energy. Therefore it powers the DC motors in coordination with the motor drivers. The DC motors function with Fleming's left hand rule as its main principle.

Therefore a swarm of robots could be created with this model for the efficient handling of the situation. The Master-Slave approach is noted for its efficiency in resolving issues. A master robot is accompanied by a group of slave robots that make the process easier and faster than the normal time required for resolving the issue. This methodology could be time-efficient and perform better than many other approaches. In this case, a master robot and a slave robot are created. The master robot has IR sensors, DC motors, and motor drivers with an Arduino UNO board. The same components are present in the slave robot. Both of the robots are connected using the concept of swarm robotics, and they both coordinate well to put off the fire. They are linked using the program in Arduino IDE with the concepts of advanced swarm robotics.

The master and slave robots are linked to each other for extinguishing the fire. Likewise a swarm of robots could be created for the extinguishing process. The most common algorithm includes the movements of the Robot controlled by an android app or remote control. The Robot functions according to the input of the user. But in the master and slave approach, the robots autonomously work with each other to put off the fire. This also consumes less time as the robots themselves function with the sensor. Another commonly used algorithm is simply the detection of fire and extinguishing it with a single firefighting robot. But in this case, the master-slave approach plays a big role in putting off the fire immediately. In some cases, a stationary firefighting system is installed, which could not reach all the places in the fire scenes with simple sensing and extinguishing process. In this case, the movement of the robots is programmed to reach the fire scene immediately after the detection of the fire.

BLOCK DIAGRAM

The following are the block diagrams of the Fire Fighting Robot of both the master and slave robots. Figure 1 shows the assembled components of a Fire Fighting Robot. Figure 2 shows the block diagram of the Fire Fighting Robot.

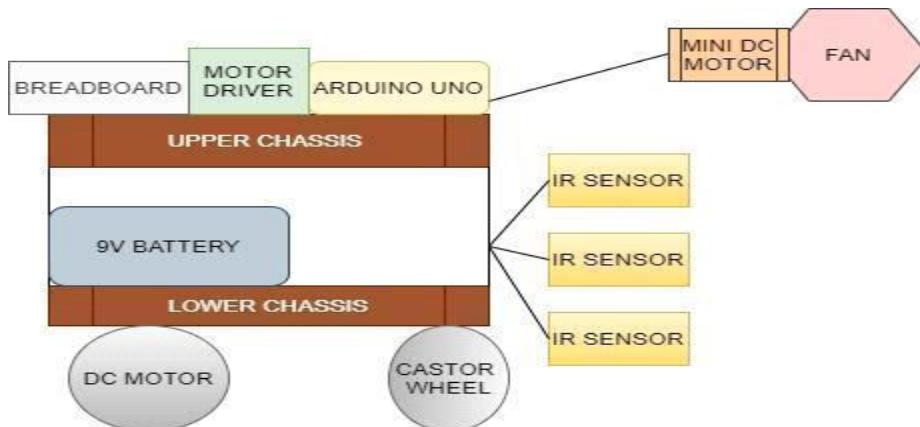


Figure 1: Components of Fire Fighting Robot

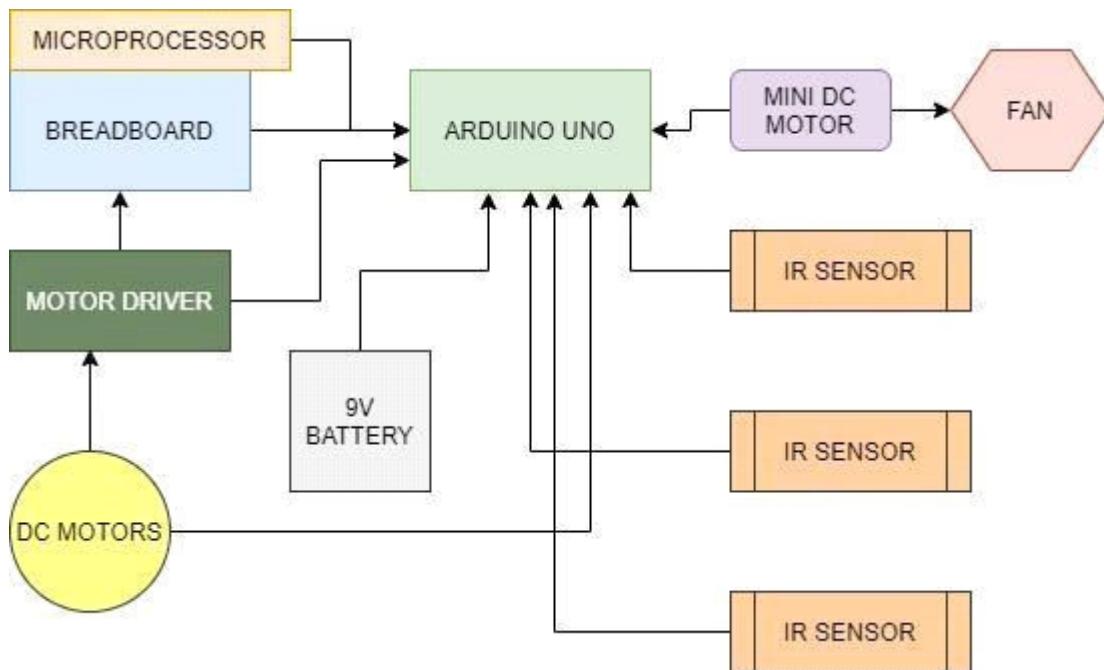
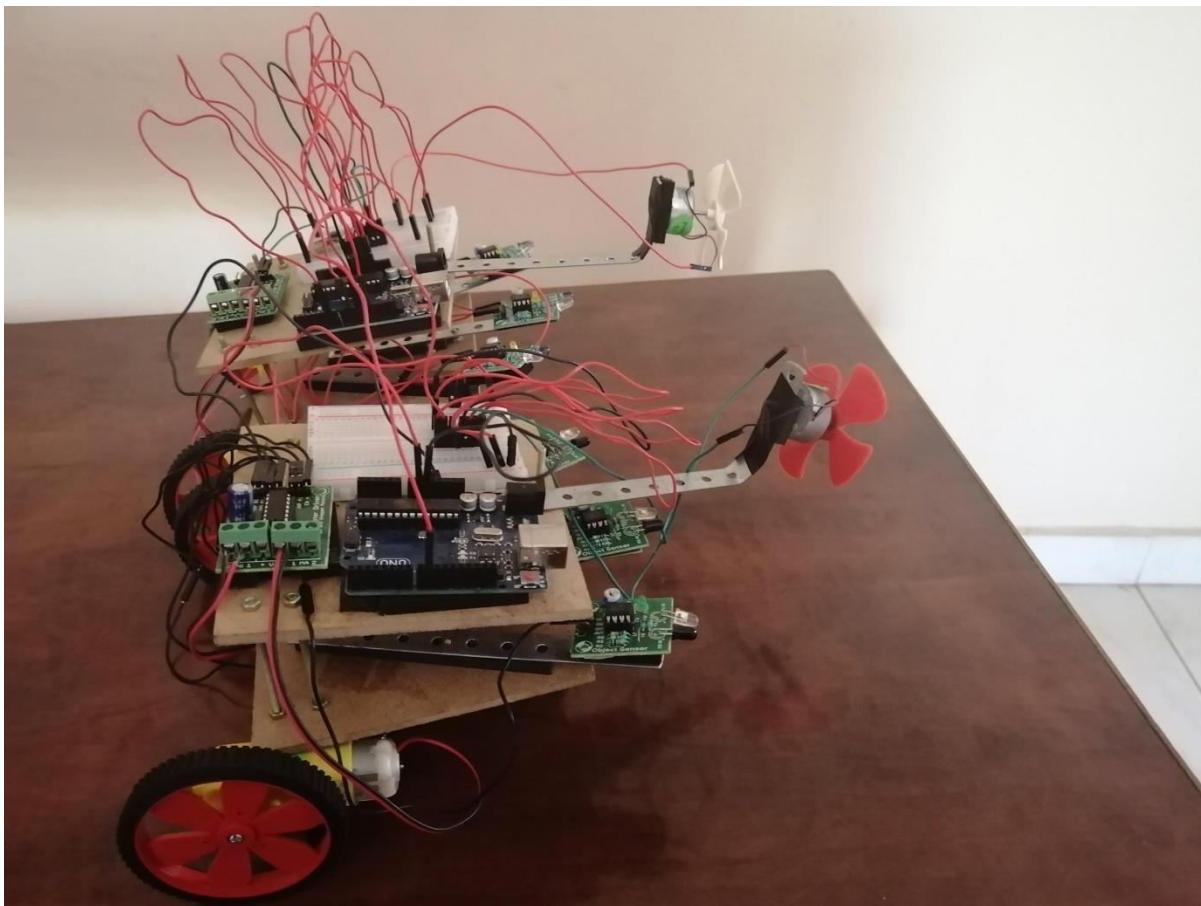


Figure 2: Block diagram of Firefighting Robot

RESULTS AND DISCUSSION

The below image is the autonomous firefighting robot that uses IR sensors to detect the fire, moves to the location of the fire using DC motors, and puts off the fire using a fan. A swarm of robots could be built with this, which would help the process of extinguishing the fire. Each Robot would be of the same model but would coordinate with each other while working to put off the fire. This would stop the fire initially after it starts as the action is taken immediately.

The concept of swarm robotics provides an interesting approach to the future of robotics in emergency situations. Human intervention may not even be needed in the near future where robots could actually work in an environment with no human monitoring or supervision. The development of Robotics with various different concepts in order to maintain the efficiency of the performance parameter. There are several different forms of human-robot interactions, allowing a team of robots to take advantage of the skills of each Robot. Research in swarm robotics considers interactions between humans, the environment, and a group of robots performing as a swarm. This work is concerned with the interactive use of autonomous robots in fire emergency settings. The Fire Fighting Robot has the ability to detect the fire, move towards the fire, and suppress the fire. The control circuit of the robot has five sensors, which senses the presence and intensity of fire to take the responsive action accordingly. The Robot is designed to detect the intensity of fire for further process in putting off the fire. The robot is automated and it isn't used by a remote control. Usually, the circuit control of the Robot is built on Arduino UNO. There are three fire sensors interfaced in the circuit control in the forward, left, and right side of the Robot. A motor fan is attached to the Robot which will actually extinguish the fire.

Figure 3: shows the Fire Fighting Robots using master and slave approach.**Figure 3: Master and Slave Fire Fighting Robots**

CONCLUSION

Therefore the Firefighting Robot is completed. The Fire Fighting Robot is implemented entirely and deployed for its completion. Then the robot could be used for the detection of fire and fire suppression. This Firefighting Robot is a prototype model. Apart from the components mounted on the circuit, the main significance is of the Arduino sketch which is with the controller circuit. For the software intelligence which is provided by the arduino sketch, the fire intensity is sensed by the fire sensors. The robot moves in the direction where the fire intensity is more. From the results achieved, a conclusion could be made that the master and the slave robots could manage time efficiently in the firefighting process with almost coordination and cooperation. The usage of the air to extinguish fire instead of water comes with the benefit of not damaging any perishable and luxurious items in the warehouse or luxury hotels. There is also no consumption of water, which could save a lot of water in the process itself. The already available air is used for the process of extinguishing the fire. The coordination and cooperation of the master and the slave robot make the process efficient with time. The actions taken by the robots are immediately after the fire is detected. So the further spreading of the fire could be prevented in the earlier levels. The movements of the robots are coordinated in such a way to extinguish the fire immediately. Furthermore, research and developments are done in this area.

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