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Fire Fighting Robot Using Internet of Things (IoT) for Various Temperature Levels

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Abstract:- The project combines software engineering, electronics, and robotics to create a firefighting robot that can check water levels in real time. The robot must be able to combat fires and adapt to different environments. Chassis, mobility systems, water storage, pumps, and firefighting devices are among the components. For extended use, an efficient power system is built. For the robot to navigate a variety of terrains, mobility is essential. For autonomous operation, a variety of sensors are included, such as infrared and ultrasonic ones. Calibrated water level sensors that send data to a microcontroller enable the integration of real-time water level data. Real-time data transmission, firefighting techniques, navigation, and obstacle avoidance all depend on programming. Remote control and real- time monitoring are made possible by communication systems that utilize Wi-Fi. The project culminates in extensive testing and deployment in accordance with the highest safety standards.

Keywords*:* IoT based Fire Fighting Robot, Arduino, IR sensor, Ultrasonic sensor, Motor driver module, Batteries.

1. Introduction

In order to handle the growing number of fire situations, the development of fire-fighting robots is necessary. With their advanced navigation systems, firefighting tools, and real-time monitoring features, these autonomous or remotely operated vehicles have the potential to save lives and reduce property damage. The goal of this project is to build a firefighting robot that can put out flames and monitor its water level in real time, both of which will maintain the robot’s efficacy throughout extended use. Combining robotics, electronics, and computer programming is necessary to create a firefighting robot. It also calls for technical expertise, safety, adaptation to various terrains, and the capacity to work in dangerous environments. The project starts with a comprehensive examination of the robot’s specifications, encompassing dimensions maneuverability, firefighting skills, and compatibility for many environmental situations. Rechargeable batteries are frequently at the core of dependable power systems, which are built to supply the energy needed for continuous operation. A strong suspension system, wheels, are means of motion and are essential for the robot. Firefighting tools, like water spray nozzles, are carefully chosen depending on the goals of the project and the kinds of fires that might occur. Installing water level sensors that are calibrated to communicate exact data allows for real-time water level monitoring, which is a basic function. In order to enable remote control or autonomous operation, programming entails creating algorithms for data transmission, navigation, obstacle avoidance, and firefighting tactics. Real-time monitoring and remote control are made possible via communication technologies involving Wi-Fi connections. In conclusion, developing a robot that fights fires and has access to real-time water level information.

2. Firefighting Robot

Nowadays, in order to improve efficiency and safety in fire fighting situations, more and more firefighting robots are being utilized. They are employed in remote fire suppression, building inspections, training and simulations, public safety education, monitoring and surveying fire- prone areas, fighting wildfires with aerial drones and ground vehicles, putting out fires in dangerous environments, and conducting search and rescue operations in smoke-filled areas.

3. Literature Review

3.1. An Arduino Uno Controlled Fire Fighting Robot [1] for Fires in Enclosed Spaces

The development of a low-cost firefighting robot consists of software, electronic interface circuits, and hardware. It features four motors that run on batteries and is capable of safely detecting and putting out fires. The robot has a water tank, pump, fire flame sensor, water spraying nozzle, and an Arduino Uno chip for control. This represents a first step toward creating a full-fledged firefighting robot that can rescue victims, even though there is still space for development. The primary duty of the robot is to locate and put out fires more securely and accurately while avoiding endangering firefighters.

3.2. IoT Based Fire Fighting Robot [2]

Technological developments in the field of mechanics have resulted in fewer human disruptions and the deployment of robots for diverse purposes. Fire events have increased in frequency recently, endangering both human life and property. An IoT-based firefighting robot is employed to safeguard people, property, and the surrounding area. Depending on the type of fire, this device can activate its carbon-dioxide or water pump and detects flames. It can also communicate with people who are trapped. Authorities can take the necessary precautions to lessen damage when sensors offer information on the type of fire and carbon monoxide levels.

3.3. Autonomous Fire Detecting and Extinguishing Robot [3]

This essay examines the potential of automation in the vital but risky subject of firefighting. Robots are designed to find fires before they get out of hand. It could be used in concert with firefighters to reduce the likelihood of injury to victims. This paper presents the Fire Fighting Robot. A robot is built up of three parts: hardware, programming, and electronics.

Two DC motors provide the robot's drive mechanism, while a castor wheel serves as its steering system. A 12-volt DC water pump with spray and suction capabilities. Servo motor (SG90) with axial motion for water spraying. From very cold to very warm Numerous sensors are also interfaced with the Arduino Uno Board. The programming language Arduino IDE was utilized for the movements and the inputs of the sensors.

4. Components and Explanations

4.1. Arduino

Arduino, the company, is renowned for its creation of open-source software and hardware projects, along with the production of microcontrollers integrated into single boards, as well as comprehensive Arduino microcontroller kits aimed at facilitating the development of digital devices. These Arduino boards are designed to accommodate an array of CPU and controller types, offering versatility to users [4,5]. Within these boards, you'll find a combination of digital and analog in- put/output (I/O) pins, which can be seamlessly connected to various extension boards commonly referred to as "shields," as well as breadboards, ideal for prototyping, and other circuitry. The loading of programs onto these boards is made possible through serial interfaces tailored for communication, with select options supporting USB (Universal Serial Bus) connections.

4.2. ESP 8266 Node MCU

The ESP8266 Wi-Fi module is included in the commonly used microcontroller node MCU ESP8266, which enables It to connect to Wi-Fi networks and carry out a number of functions. Its fundamental functions include controlling Hardware elements, interacting with sensors, and establishing Wi-Fi communication via running code created in the Lua Programming language or the Arduino IDE. In order to Accomplish a variety of functions, including reading sensor data, operating actuators, establishing an internet connection, and sending and receiving data, users can write custom code. It can also host web pages, function as a web server, and communicate with other Internet of Things devices [7]. It is a useful tool for a variety of IoT and automation projects due to its adaptability.

4.3. Motor Driver Module

The L298D is an integrated circuit that functions as a dual H-bridge motor driver and is an essential part of robotics and motor control applications [6]. Its main function is to interface low voltage control signals usually from a micro- controller with the higher voltage and current requirements of the motors, making it easier to drive two DC motors or a single stepper motor. The L298D is equipped with two H- bridges that allow it to independently control motor direction (forward, backward, or stop) and motor speed using pulse- width modulation (PWM) signals. In order to avoid overcurrent situations, certain versions further have current sensing capabilities that enable real-time motor current monitoring. All things considered, the L298D makes motor control duties easier, which makes it a crucial part of many robotic and automation projects.

4.4. Ultrasonic Sensor

An ultrasonic sensor is a tool that measures the separation between two objects using sound waves. By generating a sound wave at a particular frequency and allowing the wave to bounce back, it will determine the distance. The ultrasonic sensor will have the capability of being able to recognize certain objects because it will be able to identify the difference Ein water level because it will be able to detect the reflected sound wave, which may indicate the difference in water level. The humidity and temperature of the surroundings in which the ultrasonic sensor is utilized can also have an impact on its accuracy, although this is a problem that is sometimes ignored.

4.5. Flame IR Sensor

A Flame Detector, also known as a Flame IR Sensor, is a device that uses the distinct infrared light released during combustion to detect the presence of flames. It is utilized in many different applications, including as military vehicles, aircraft, and industrial fire detection systems, to deliver timely notifications for safety and fire prevention. Flame infrared sensors minimize false alarms, work in a variety of environments, and provide a high degree of sensitivity. Their effectiveness depends on routine maintenance and compliance with safety requirements.

4.6. Motor

DC motor run by batteries (BO). Electrical Energy is converted to mechanical energy by the direct current motor. Why does a robot’s motor control circuit use a DC gear motor. A DC MOTOR concept known as gear reduction uses gears to increase torque while lowering vehicle speed. A DC motor can be constructed with a variety of gear arrangements. A motor’s speed is expressed in terms of smooth rotations per minute, or RPM. Revolutions Per Minute is referred to as RPM. The setup assembly helps reduce motor speed and increase torque. Any robot that is built on a microcontroller can use this kind of DC motor.

4.7. Chassis

Simple chassis for building your own robot cars with Arduino, Raspberry-Pi (Not Included), and other platforms. Acrylic platform that has been routed and pre-drilled for installing the gear motor supplied are tire assemblies, a charger, a switch, and a holder for four "AA" cell batteries (batteries not supplied)

4.8. Batteries

A battery serves as a device housing one or more electrochemical cells with external connections, enabling it to provide power to a wide range of electrical devices such as flashlights, cell phones, and electric cars [11]. In the context of electricity production, the positive terminal of a battery is termed the cathode, while the negative end is referred to as the anode. Electrons that flow from the negative terminal to the positive terminal through an external electric circuit originate at the negative terminal, creating an essential electrical current. When a battery is linked to an external electric load, it triggers a redox (reduction-oxidation) reaction. This transformative process converts high-energy reactants into lower-energy products, with the resulting free-energy difference being channeled into the external circuit as electrical energy. It's worth noting that the term "battery" originally denoted a device comprised of multiple cells, but it has since evolved to encompass devices consisting of a single cell.

4.9. Switch Button and Connecting Wires

A switch is an electrical component that, by cutting current or rerouting it from one conductor to another, has the ability to "build" or "break" an electrical circuit. A switch's action either completely removes or fully restores the conducting path in a circuit. It can be activated manually by something moving, like a door, by a keyboard button or light switch, or by a temperature, pressure, or flow sensor. Several sets of connections that can function alternately, sequentially, or concurrently make up a switch. High-power circuit switches need to operate fast in order to avoid damaging arcing. They may also be equipped with particular features that help them stop a big current from flowing through them right away.

Connecting wires are essentially wires equipped with connector pins on both ends, allowing for the establishment of connections between two points without the necessity of soldering. Jumper wires find extensive application in conjunction with breadboards and various prototyping tools, facilitating swift modifications to circuits when required

This process is straightforward and remarkably uncomplicated, making it one of the simplest methods for creating electrical connections. In fact, it can hardly get any more.

5. Operation of IoT Based Fire Fighting Robot

Upon activation, the robot’s flame sensors initially fail to detect any flames, causing the water pump to remain inactive. Subsequently, when the central flame sensor registers a fire, the robot moves forward with both motors engaged, covering specific distance before coming to a halt. At this point, the water pump springs to life, dispersing water evenly over the flames until the are extinguished. Once the fire is quelled, the robot ceases its forward movement, and the water pump is deactivated.

In instances where the left flame sensor detects a fire, the robot shifts its course to the left, traversing a predetermined distance. During this mancuver, the right-side motor is intermittently powered on and off as necessary [8]. After reaching the specified distance, the water pump is activated in tandem with water being distributed evenly over the flames until they are subdued. Similar to previous scenarios, once the flames are extinguished, the robot halts its movement, deactivates the servo motor, and turns off the water pump. Continuing its firefighting mission, the robot advances leftward, utilizing the left motor in slow motion for a specific duration while deactivating the right motor. It stops once the right flame sensor detects the presence of fire at a predefined distance. In response, the water pump initiates, dousing the flames uniformly until they are no longer threat. Following the successful suppression of the fire, the robot resumes forward movement while deactivating the servo motor and water pump. In addition to its firefighting capabilities, the robot incorporates real time water level monitoring sensors that gauge the water level within its tank [9]. These Sensors convert water level data into electrical signals, which are subsequently processed by the robot’s microprocessor. The robot’s microcontroller collects and analyzes this sensor data to provide ongoing measurements of the water level for enhanced functionality, the robot is equipped with a Wi-Fi module, allowing it to connect to a Wi-Fi network. The data regarding water levels is transmitted to a designated server or cloud-based system for real-time monitoring. Users can conveniently access this real-time data through a web application or specialized software via the robot’s monitoring interface. When the water level reaches a critical point, the system can trigger an alert to notify users that the robot’s water reservoir requires replenishment.

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6. Block diagram and connections

The Fig. 1 shows the connection of the fire fighting robot explaining the inputs and outputs and also the basic representation of the fire fighting robot. A block diagram is an illustration of a system that uses lines to show the information or signal flow between various components and blocks to represent the system's various parts or phases. A standard block diagram might be useful in Illuminating the many subsystems and functions of a fire fighting robot. The sensor block is a representation of all the Sensors that are installed on the firefighting robot, including cameras, gas sensors, infrared sensors, and thermal imaging cameras. The communication module block consists of the following components: data link, actuators, control system, response system for emergencies integrating, security systems, mechanical structure, motors, power source, user interface, and environmental feedback [10]. The control system block consists of the mechanical structure, emergency response system integration, onboard computer, autonomous software, motors, power supply, control interface, and microcontroller/processor. The integration of the gateway enables con- tact with various emergency response networks and agencies, while the user interface enables human operators to manage and monitor the robot. Safety sensors keep an eye on robot status and ambient conditions for any potential hazards, while emergency stop mechanisms allow for quick shutdown in the event of failures or unforeseen circumstances. Sensors for environmental feedback, the mobility system, and the chassis make up the mechanical framework. Building an efficient firefighting robot requires an understanding of the relationships and interactions among these building parts. The robot can perform tasks with a high degree of autonomy, assess fire conditions, and navigate through dangerous settings thanks to the integration of modern sensors, communications systems, and control algorithms.

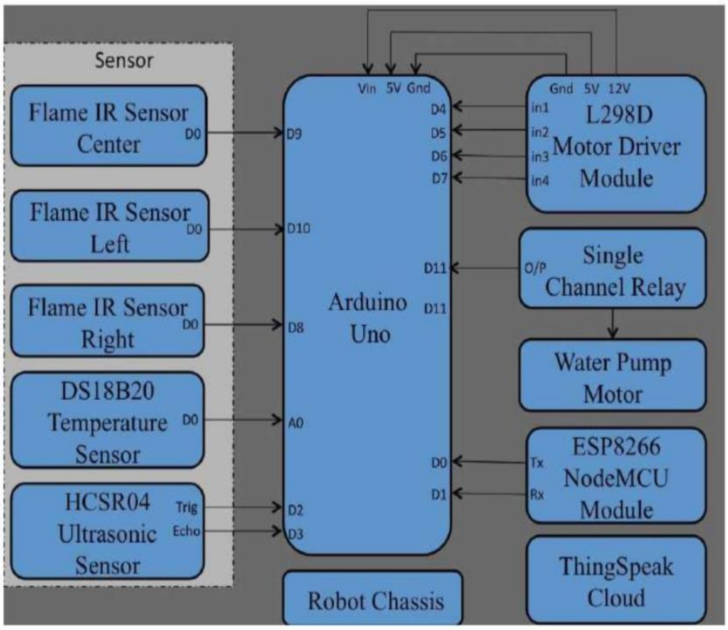

Fig 1. Block Diagram of Fire Fighting Robot

7. Results and Discussions

Wi-Fi enabled firefighting robots make real-time data gathering and transmission possible as shown in Fig. 2, thereby increasing their efficiency on the scene. Firefighters may make educated judgments based on real-time data streams as shown in Fig. 3 by using these robots' Wi-Fi connectivity to transmit vital information to a central command or control center, including temperature, gas levels, video feeds, and sensor data. In dynamic fire conditions, this real-time data collecting and transmission can greatly enhance situational awareness, firefighting coordination, and robot and human responder safety.

In order to manage the growing number of fire situations, the development of fire-fighting robots is essential. These driverless cars could prevent fatalities and lessen property damage [12,13]. The goal of this project is to develop a firefighting robot that can extinguish flames and continuously check its water level while remaining effective for lengthy periods of time. It is vital to combine robotics, electronics, and computer programming; this calls for technical know-how, safety, terrain adaption, and the capacity to operate in hazardous conditions. The project starts with a thorough analysis of the robot's parameters, including its size, mobility, capacity to combat fires, and suitability for a range of climatic conditions. Rechargeable batteries are frequently utilized for robust power supplies, and the robot needs wheels and a robust suspension system. Foam dispensers and water spray nozzles are examples of firefighting tools that are carefully chosen based on the objectives of the project and the types of potential fires. Firefighting robots with Wi-Fi capabilities can collect and transmit data in real time, which boosts their effectiveness on the scene. In dynamic fire circumstances, this data can improve situational awareness, firefighting coordination, and robot and human responder safety.

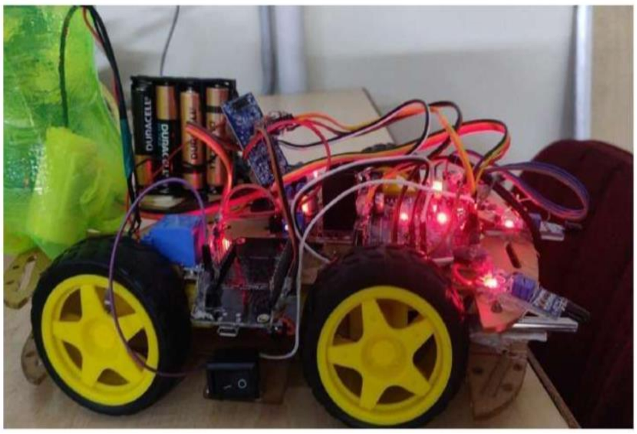

Fig 2. Hardware setup of Fire Fighting Robot

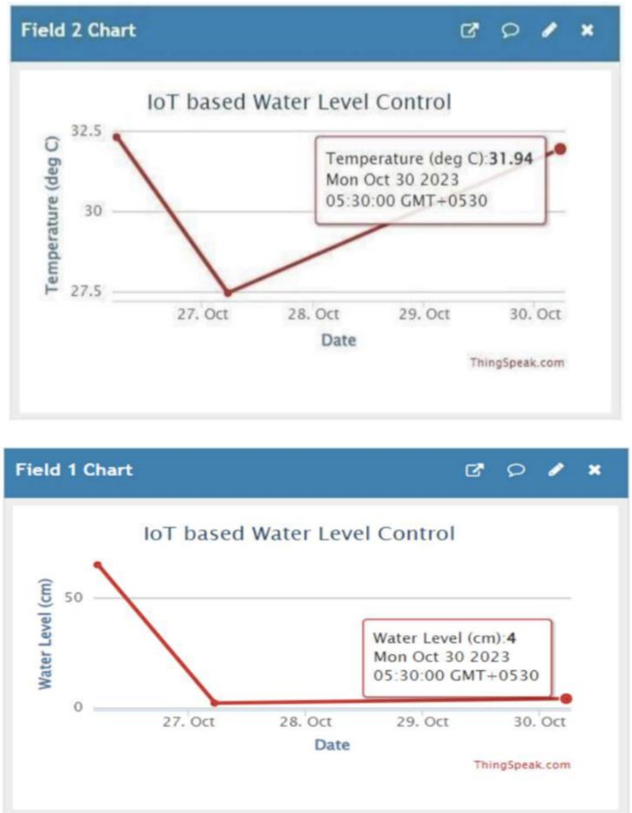

Fig. 3 Think speak cloud page output of water level control

Robots that fight fires are a ground-breaking development in emergency response systems, with a host of benefits that can greatly improve the efficacy, safety, and efficiency of combating fires. These robots can work in dangerous areas, reducing the possibility of human fatalities by evaluating the circumstances and communicating vital information to human responders. Because they may be controlled remotely, users can experience a more immersive awareness of their surroundings while being secure. Fires must be contained and extinguished quickly to prevent them from becoming out of control. The firefighting robots can be quickly deployed and get to the incident site more quickly than traditional methods because of their improved mobility features. Successful firefighting operations are aided by continuous operation, which keeps personnel on the scene all the time. Robots are able to determine potential threats, find hidden hotspots, and evaluate the level of danger of the fire thanks to the latest sensor technology and information collection. More intelligent decision-making results in more successful firefighting strategies because of this real-time knowledge. Robots can navigate complicated and dynamic settings on their own thanks to autonomous navigation, which makes use of artificial intelligence and sophisticated algorithms. This is especially useful in scenarios where human operator contact may be difficult or impossible. A further advantage of using firefighting robots is resource optimization. Robots can result in a more effective use of resources by minimizing the requirement for a large human being to be at the incident site. Robots with many functions can handle a variety of tasks during rescue operations. Robots that battle fires also have the benefit of being economical. Over time, significant cost savings can be achieved by maintaining continuous operations, minimizing property damage, and using fewer human resources. Many firefighting robots are modular, which increases their operating life and cost-effectiveness by enabling updates and modifications. Emergency response tactics can be positively impacted by the public's view and embrace of firefighting robots. Firefighting robots will probably get much more advanced as technology develops, which will increase their usefulness and influence.

7.1. Limitations

Limitations faced by firefighting robots that have been equipped with a Wi-Fi module for real-time water level monitoring include cyber security issues, scalability issues, high prices, restricted autonomy, environmental restrictions, and technological difficulties. These robots intricate technological requirements may give rise to malfunctions, which would diminish their dependability in battling fires. Additionally, be- cause of unusual constructions or harsh conditions, they would not be appropriate for all firefighting scenarios and might need human intervention for difficult duties. Furthermore, there may be cyber security problems associated with the Wi-Fi module, and it can be difficult to integrate these robots into the current infrastructure. One of its drawbacks is that they can't execute certain activities that require human judgment and accuracy, such as handling delicate items, crossing congested and complex environments, and making snap decisions in uncertain circumstances. Furthermore, the present generation of firefighting robots may be limited in regards to battery life and connectivity range, as well as in terms of movement and agility in specific terrains. These restrictions show that in order to overcome these obstacles, more developments in artificial intelligence (AI), mobility, battery technology, and communication technologies are required.

8. Conclusion

The integration of a Wi-Fi module for real-time data collecting in a firefighting robot is a noteworthy technological achievement in disaster management. By giving vital information without putting lives in danger, it can improve safety. Even in circumstances when human assistance could be postponed owing to safety concerns, these robots can deploy quickly. During firefighting operations, the Wi-Fi module facilitates data collecting and analysis, allowing for well-informed judgments. Remote operation makes it possible to access difficult- to-reach places and explore hazardous areas. First responders and firefighters can work together more effectively if these robots are incorporated into the emergency response systems that are already in place. Multiple robots can be deployed simultaneously thanks to scalability. Effective communication, durability, and technical difficulties are among the challenges. By lowering the risks involved in combating fires and facilitating early fire detection and prevention, technology improves public safety. Improved sensors, efficient algorithms, and increased autonomy examples of future development buildings. Together with human firefighters, these robots provide vital assistance in difficult and hazardous circumstances, ultimately saving lives and property.

8.1. Future Scope

With real-time water level monitoring and Wi-Fi connectivity, firefighting robots have a bright future ahead of them. Advanced sensor integration, artificial intelligence (AI), machine learning, multi-robot coordination, hybrid systems, long-range communication, human-robot cooperation, cost-effectiveness, worldwide adoption, data analytics, public safety, education and training, and international standards are all included in this. Improved sensors will let the robot detect and put out fires more successfully, and Al and machine learning will allow it to make judgments on its own. Coordinating many robots will increase coverage and efficiency. Drones and aerial vehicles will be integrated with hybrid systems data collecting and aerial assistance. Long-range communication will guarantee continuous connectivity in situations involving far-off or massive fires. Interfaces and protocols will improve the cooperation between humans and robots. A wider range of firefighting organizations will also have easier access to the technology, particularly in areas where resources for battling flames are scarce or wildfires are a common occurrence. With the ability to monitor water levels in real time and link to Wi-Fi, firefighting robots have a bright future ahead of them. There will be chances for technological breakthroughs, greater human-machine collaboration, and a wider deployment to improve public safety and fire control. Future innovations in firefighting robots will encompass increased ability to move around, longer battery life, better communication methods, and advances in artificial intelligence. In order to provide firefighting robots greater autonomy and decision-making power in intricate and dynamic firefighting circumstances, researchers and engineers are utilizing artificial intelligence to this purpose. Furthermore, attempts are underway to enhance these robot’s agility and dexterity so they can more adeptly traverse unexpected and uneven terrains. In order to increase the amount of time that firefighting robots can remain operational during emergencies, research and development is being done on longer-lasting battery systems. Ultimately, the goal of communication system developments is to improve human operator’s and firefighting robot’s coordination and connectivity, allowing for a smooth incorporation into fire-fighting operations.

Conflicts of Interest

There is no conflicts of interest to declare.

References

[1] M. P. Suresh, V. R. Vedha Rhythesh, J. Dinesh, K. Deepak and J. Manikandan, "An Arduino Uno Controlled Fire Fighting Robot for Fires in Enclosed Spaces," 2022 Sixth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I- SMAC), Dharan, Nepal, 2022, pp. 398-402, doi: 10.1109/I-SMAC55078.2022.9987432.

[2] S. L. U. Maheshwari, R. M. Atheeq, U. N. Surendar and S. N. Vaishnav, "IoT based Fire Fighting Robot," 2022 International Conference on Edge Computing and Applications (ICECAA), Tamil Nadu, India, 2022, pp. 664-668, doi: 10.1109/ICECAA55415.2022.9936575.

[3] M. Diwanji, S. Hisvankar and C. Khandelwal, "Autonomous Fire Detecting and Extinguishing Robot," 2019 2nd International Conference on Intelligent Communication and Computational Techniques (ICCT), Jaipur, India, 2019, pp. 327-329, doi: 10.1109/ICCT46177.2019.8969067.

[4] P. B. N., H. K. N., P. B. J. and H. R., "Fire Fighting Robot," 2019 International Conference on Information and Communication Technology Convergence (ICTC), Jeju, Korea (South), 2019, pp. 889-892, doi: 10.1109/ICTC46691.2019.9025012.

[5] A. A. A. Rahman, Z. Janin, R. Sam, M. Masrie, T. S. Gunawan and F. D. A. Rahman, "Firefighting Robot Based On IoT and Ban Levels Technique," 2022 IEEE 8th International Conference on Smart Instrumentation, Measurement and Applications (ICSIMA), Melaka, Malaysia, 2022, pp. 138-142, doi: 10.1109/ICSIMA55652.2022.9929114.

[6] N. A. Bassam, J. Khan and S. A. Hussain, "IoT based Autonomous Fire Suppression System For Vehicles," 2020 International Conference on Emerging Trends in Information Technology and Engineering (ic-ETITE), Vellore, India, 2020, pp. 1-6, doi: 10.1109/ic- ETITE47903.2020.216.

[7] L. Chen, "Design and Manufacture of Indoor Intelligent Fire Fighting Robot," 2020 International Workshop on Electronic Communication and Artificial Intelligence (IWECAI), Shanghai, China, 2020, pp. 201-204, doi: 10.1109/IWECAI50956.2020.00048.

[8] S. V. P. K. Maddukuri, U. K. Renduchintala, A. Visvakumar, C. Pang and S. K. Mittapally, "A low cost sensor based autonomous and semi-autonomous fire-fighting squad robot," 2016 Sixth International Symposium on Embedded Computing and System Design (ISED), Patna, India, 2016, pp. 279-283, doi: 10.1109/ISED.2016.7977097.

[9] W.Z. Wan Hasan, Mohd Hasimi Mohd Sidek, Suhaidi Shafie, Mohammad Hamiruce Marhaban, Fire Fighting Robot, Conference: APSAEM2010.At: Malaysia, July 2010.

[10] Swati Deshmukh, Karishma Matte and Rashmi Pandhare, “Wireless Fire Fighting Robot”, International journal for research in emerging science and technology, vol.-2, pp.373 - 375, March-2015.

[11] K. Vibha, Kishore Bala K, “Half Bridge Converter for EV Battery Charger”, Journal of Propulsion Technology, Pg no. 4646-4656, Vol. 45, No. 2, 2024.

[12] Pramod B.N., Hemalatha K.N., Poornima B.J., Harshita R., Fire Fighting Robot, 2019, IEEE, International Conference on Information and Communication Technology Convergence (ICTC), Jeju, South Korea, Oct 2019

[13] Kristi Kosasih, E. Merry Sartika, M. Jimmy Hasugian, danMuliady, “The Intelligent Fire Fighting Tank Robot”, Electrical Engineering Journal Vol. 1, No. 1, October 2010.