# Design and Development of Fire Extinguisher Action Robot

**Soham Patil[1], Tanay Bhilare[2], Sumit Patil[3], Tejas Nagaonkar[4], C K Gosavi[5]**

[1,2,3,4]Student, Department of Mechanical Engineering P.E. S's Modern College of Engineering Pune, Maharashtra, India
[5]Assistant Professor, Department of Mechanical Engineering P.E. S's Modern College of Engineering Pune, Maharashtra, India

**ABSTRACT**
The project titled "Design and Development of Fire Fighting Robot" presents the creation of a robotic system aimed at assisting in firefighting operations. This robot is equipped with various sensors and modules to effectively detect and combat fires remotely. The key components utilized in this project include a camera module, an ESP module for wireless communication, and ultrasonic sensors for environment sensing.

The main objective of this project was to design and build a remote-controlled robot capable of navigating through environments affected by fire or smoke. The camera module allows real-time visual feedback to the operator, aiding in navigation and situational awareness. Additionally, the ultrasonic sensors provide crucial data about the surroundings, helping the robot avoid obstacles and locate the source of the fire.

The development process involved the integration of these components into a cohesive robotic platform. The robot's control system was implemented using remote control mechanisms, enabling precise manoeuvrability in challenging conditions.

The outcome of this project is a functional prototype of a fire-fighting robot that demonstrates the potential of robotic systems in emergency response scenarios. The robot's ability to navigate autonomously and provide critical data to operators displays its utility in mitigating risks associated with firefighting operations.

**Keywords:** Fire Fighting Robot, Chassis Design, ESP 32 Camera Module

## I. INTRODUCTION

Introducing a Cutting-Edge Fire Extinguishing Robot: Integrating Camera and Servo Motor Technology

In our pursuit of enhancing fire safety measures, we present a groundbreaking innovation: the design and development of a fire-extinguishing robot. This advanced system combines the precision of camera technology with the agility of servomotors to revolutionize fire-fighting strategies.

Harnessing the power of vision, our robot is equipped with high-definition cameras strategically placed to detect flames swiftly and accurately. This Real-time visual feedback enables the robot to identify fire outbreaks promptly, even in challenging environments.

Complementing its visual acuity, the robot employs servomotors for precise manoeuvrability and targeted extinguishing action. With the ability to navigate through obstacles and reach inaccessible areas, our robot ensures comprehensive fire suppression with minimal human intervention.

By integrating these cutting-edge technologies, our fire-extinguishing robot offers unparalleled efficiency and effectiveness in combating fires. With its swift response and precise extinguishing capabilities, it represents a significant advancement in fire safety engineering.

Stay tuned as we delve deeper into the design and development process, displaying the synergy between camera and servo motor technologies in creating a safer tomorrow.

**Objectives:**

1. Enhance Firefighting Efficiency: The primary objective of designing and developing a fire extinguishing robot utilizing camera and servo motor technologies is to improve the efficiency of firefighting operations. By deploying a robotic system equipped with advanced sensors and actuators, we aim to expedite the detection and suppression of fires, reducing response times and minimizing property damage.
2. Ensure Safety of Personnel: Another key objective is to prioritize the safety of firefighting personnel by reducing their exposure to hazardous environments. By deploying a robot equipped with cameras, we aim to gather real-time data on fire incidents, enabling remote monitoring and decision-making. This minimizes the need for human intervention in high-risk scenarios, thereby safeguarding the lives of first responders.
3. Enable Remote Operation: We seek to design a fire-extinguishing robot that can be operated remotely, allowing firefighters to control its movements and actions from a safe distance. By integrating camera technology, the robot provides live video feeds of the fire scene, enabling operators to assess the situation and direct the robot accordingly. This remote operation capability enhances flexibility and adaptability in firefighting efforts.
4. Increase Accessibility: The development of a robot equipped with servomotors aims to enhance accessibility to fire-affected areas that may be challenging human firefighters to reach. By leveraging the precise control offered by servomotors, the robot can navigate through narrow spaces, traverse uneven terrain, and maneuver around obstacles with ease. This ensures that no area is left unattended during firefighting operations, maximizing the effectiveness of fire suppression efforts.
5. Optimize Resource Utilization: By automating certain firefighting tasks through robotic technology, we aim to optimize the utilization of resources and labor. The efficient deployment of a fire-extinguishing robot equipped with camera and servo motor technologies allows for the allocation of human firefighters to other critical tasks, thereby maximizing overall operational efficiency and effectiveness.
6. Facilitate Integration with Existing Systems: Our objective is to design a fire-extinguishing robot that seamlessly integrates with existing firefighting infrastructure and protocols. By ensuring compatibility with standard communication protocols and firefighting equipment, the robot can complement and enhance the capabilities of traditional firefighting methods. This facilitates a smooth transition to incorporating robotic technologies into established firefighting practices.

**Key Components of Robot:**

**Ultrasonic Sensor:** An ultrasonic sensor is an instrument that measures the distance to an object using ultrasonic sound waves. An ultrasonic sensor uses a transducer to send and receive ultrasonic pulses that relay back information about an object's proximity.

**DC Motor:** A DC Motor is a type of electric motor that converts DC electrical power to mechanical power i.e. A DC supply is converted to rotation or movement. Although the motor gives 500 RPM at 12V, motor runs smoothly from 4V to 12V and gives the wide range of RPM, and torque.

**Driver Modul**e: Motor drive module comes with its own four HG7881 chip. Can drive 4 DC motors, or two 4-wire 2-phase stepping motor. Suitable for the motor range: motor operating voltage 2.5V-12V.

**ESP 32 Microcontroller:** The ESP32 microcontroller is a powerful and versatile chip developed by Express if Systems. It is widely used in IoT (Internet of Things) applications, wearable devices, and various other projects that require wireless connectivity and embedded processing capabilities.

**ESP Camera Module:** It is an ESP Camera Module available from different manufacturers with different pin configurations. The camera provides full frame windowed 8-bit images in a wide range of formats. The image array is capable of operating at up to 30 frames per second (fps) in VGA. The camera module is a low cost 0.3 mega pixel CMOS colour camera module, it can output 640x480 VGA resolution image at 30 fps.

**Nozzle:** These are specifically designed to create a fine mist or spray pattern. They are used in agriculture (for pesticide or fertilizer spraying), in industries for coating, in household devices (like garden hoses), and in various manufacturing processes.

**Pump:** Water pumps play a crucial role in ensuring water supply, circulation, and movement in various settings. The type of pump chosen depends on the specific application and requirements, whether it is for domestic use, agricultural irrigation, industrial processes, or other purposes.

**Problem Statement:**

The problem statement succinctly identifies and describes the specific issue or challenge that the research aims to address. Objectives outline the specific, measurable goals of the research. The scope defines the boundaries of the research, specifying what will be included and excluded. Fire fighters are primarily tasked to handle fire incidents, but they are often exposed to higher risks when extinguishing fire, especially in hazardous environments such as in nuclear power plants, petroleum refineries and gas tanks. Therefore, the need for firefighting robots is there that can extinguish fire without the need for firefighters to be exposed to unnecessary danger

**SCOPE:**

**Design And 3D Modelling-** Design and 3D modelling are integral processes in various industries, including architecture, product development, gaming, animation, and more. These processes involve conceptualizing, visualizing, and creating three-dimensional representations of objects, spaces, or characters. Compact Design.

**A wireless remote and a receiver-** A wireless remote and receiver system is a common technology used in various applications to facilitate remote control and communication without the need for physical connections. This technology is prevalent in consumer electronics, home automation, automotive systems, industrial machinery, and more.

**Camera Detection-** Camera detection refers to the process of identifying and recognizing the presence or activity of cameras within a given environment. It provides valuable information in scenarios where awareness of camera presence is essential.

**90 degrees water sprayer mechanism-** Creating a 90-degree water sprayer mechanism involves designing a system that can effectively project water at a right angle to its source.

**Testing-** Testing is a critical phase in the development, manufacturing, and implementation of products, systems, or software. It involves systematically evaluating a component or system to identify defects, ensure functionality, and verify that it meets specified requirements.

**Methodology:**

1. **Define Objectives and Requirements:**
   a) Clearly define the objectives of the Fire Extinguisher Robot (FER).
   b) Identify the specific requirements such as the types of fires it should be able to handle, mobility requirements, communication capabilities, and safety features.
2. **Risk Assessment:**
   a) Conduct a thorough risk assessment to identify potential hazards and challenges associated with firefighting scenarios.
   b) Evaluate the environmental conditions, potential obstacles, and the presence of humans to ensure the safety of the robot and bystanders.
3. **Conceptual Design**:
   a) Generate multiple conceptual designs that meet the defined objectives and requirements.
   b) Consider different propulsion systems, fire extinguishing mechanisms, and sensor suites.
   c) Evaluate each concept against factors like cost, feasibility, and performance.
4. **Detailed Design:**
   a) Select the most viable concept and proceed with detailed design.
   b) Develop detailed specifications for the robot's chassis, actuators, sensors, and fire extinguishing system.
   c) Consider factors such as weight distribution, stability, and power consumption.
5. **Mechanical Design:**
   a) Create detailed 3D models of the robot's mechanical components.
   b) Ensure the design allows for easy maintenance and repairs.
   c) Optimize the design for durability and resistance to environmental conditions
6. **Electrical and Electronic Design:**
   a) Develop a comprehensive electrical architecture, including power distribution, control systems, and communication modules.
   b) Integrate sensors for navigation, fire detection, and obstacle avoidance.
7. **Software Development:**
   a) Implement the control algorithms for navigation, obstacle avoidance, and fire extinguishing.
   b) Develop a user interface for remote operation and monitoring.
   c) Implement safety protocols and emergency shutdown procedures.
8. **Prototyping:**
   a) Build a prototype of the FER to test and validate the design.
   b) Conduct iterative testing to identify and address any design flaws or performance issues.
9. **Testing and Validation:**
   a) Perform comprehensive testing in controlled environments to validate the robot's functionality.
   b) Conduct realistic simulations and live tests to evaluate its performance in firefighting scenarios.
10. **Regulatory Compliance:**
    a) Ensure that the FER complies with relevant safety standards and regulations.

b) Obtain necessary certifications and approvals from regulatory bodies.

**11. Deployment and Training:**

a) Deploy the FER in real-world scenarios and conduct training sessions for operators and emergency responders.

b) Monitor its performance and gather feedback for continuous improvement.

**12. Maintenance and Upgrades:**

a) Develop a maintenance schedule and protocol.

b) Plan for regular updates and upgrades to incorporate new technologies or address emerging challenges.

Throughout the entire process, it is crucial to involve stakeholders, including firefighters and emergency responders, to gather input and ensure that the Fire Extinguisher Robot meets the practical needs of its intended users. Additionally, considering ethical and social implications, such as the impact on human jobs and privacy, is essential.

**Advantages: -**

Using a fire-extinguishing robot equipped with a camera and servomotor offers several advantages:

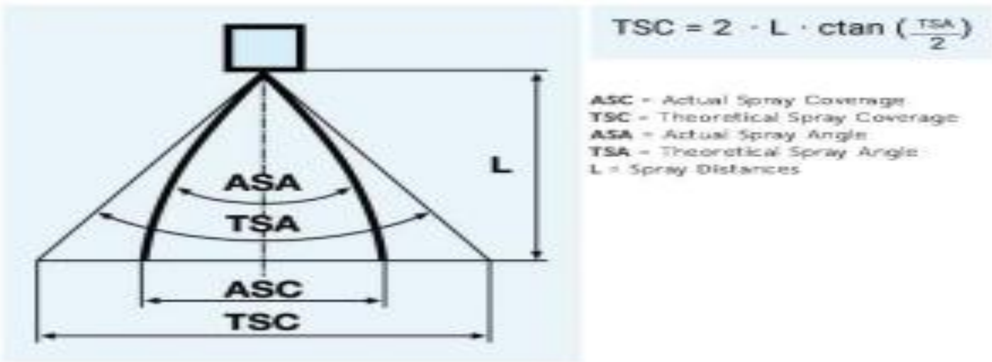
1. **Remote Operation:** The camera allows remote operators to assess the situation in real-time and control the robot from a safe distance, reducing the risk to human firefighters.
2. **Precise Targeting:** The camera enables the robot to locate the fire accurately, while the servomotor allows for precise control of the extinguishing mechanism, ensuring effective firefighting with minimal waste of extinguishing agent.
3. **Accessibility:** The robot can access tight or hazardous spaces where human firefighters might have difficulty reaching, improving overall firefighting capabilities.
4. **Continuous Monitoring:** The camera can provide continuous monitoring of the fire even after it be extinguished helping to prevent re-ignition and ensuring complete safety.
5. **Cost-Effective:** Implementing such a robot can be cost-effective in the long run, as it reduces the need for human resources in high-risk firefighting situations.
6. **Versatility**: The robot can be equipped with additional sensors or tools to enhance its capabilities, such as heat sensors for early fire detection or gas sensors for detecting hazardous fumes.

**CALCULATIONS-**

**Nozzle Specifications-**

1. Flat Fan Spray Pattern
2. Actual Spray Angle = 40 Degree
3. Spray Distance = 1.5 m
4. Nozzle Diameter = 0.033 inch

Theoretical Spray Coverage =728 mm = 72.8 cm




**Theoretical Calculations-** Nozzle Diameter = 0.033 inch
Max Flow Rate = 4.5 lpm = 0.369 gpm
Now, $P_{nozzle}$ = [FR/(29.71*D2)]2
Therefore, Pressure of Nozzle = 2058 psi

**Observations-**

1. Max Vertical Height = 2.2 m
2. Max Horizontal length = 1.8 m
3. Time required for 2 litres of water = 90 seconds
4. Actual Spray Coverage = 60 cm

**Practical Calculations**- For below pump and battery specifications-
Max flow rate = 4.5 lpm
Max pressure = 110 psi
Pipe diameter = 8 mm
Battery = 12 V
Actual Flow Rate- Now from Observation,
Time required for 2 litres = 90 seconds
Therefore, for 1 minute = (60*2)/90
Flow Rate (FR) = 1.4 lpm

**Pressure Calculations-** $P_{nozzle} = [FR/ (29.71*D2)]\ 2$
Where, FR= 1.4Lpm = 0.0369 GPM
Diameter of nozzle = 0.83mm = 0.033 inches
Therefore, Pressure of Nozzle = 121 psi

**Area Covered**- Distance of nozzle from wall = 1.8 m
Rectangular Wall Dimensions- L = 110 cm, B = 95 cm
Wall Area = L*B = 1.045 $m^2$
Now, Wall area covered 3.5 times in 250 ml water.
Therefore, Total wall area covered = 1.045*3.5 = 3.6575 $m^2$ in 0.25 litres water
Total wall area coverage for 10 litres of water = (3.7*10)/ (0.25) = 150 $m^2$

**Scaling Calculations-** Original radius = 10 mm
h = 1 m
Area Covered in 10 litres = 150 $m^2$
For 1000 $m^2$ area, Water required = 10000/150 = 60 litres approx. = 0.06 $m^3$
Volume of Cylinder = $\pi r^2 h$
0.06 = $\pi r^2 h$
Therefore, r = 0.0190 m = 19 mm

**Results-** 1. Flow rate = 1.4 lpm
2. Nozzle Pressure = 121 psi
3. Total Area Covered = 150 $m^2$

**Conclusion:**
In conclusion, integrating a camera and servo motor into a fire-extinguishing robot offers a multifaceted approach to fire fighting. This combination enables remote operation, precise targeting of the fire, accessibility to difficult-to-reach areas, continuous monitoring, cost-effectiveness, and versatility. By harnessing these advantages, such robots have the potential to significantly enhance fire-fighting capabilities while minimizing risks to human firefighters, making them a valuable addition to fire response systems.

**References:**
1. Fire Fighting Robot - Amol. A. Bhosle - ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538 Volume 10 Issue XII Dec 2022
2. Development of Fire Fighting Robot - Azavitra Zainal (IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 10, No. 1, 2019
3. A Review on Fire Fighting Robot - kiran - International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 09 Issue: 04 | Apr 2022
4. Solar Powered Automatic Fire Fighting Robot – A. Vijay International Journal of Engineering Research & Technology (IJERT) Volume 6, Issue 04 ISSN: 2278-0181
5. Fire Fighting Robot - Krishna Rajendra Sagar International Journal of Innovative Science and Research Technology Volume 6, Issue 5, May – 2021 ISSN No: -2456-2165
6. DEPLOYABLE FIRE FIGHTING ROBOT - Dave Martin B. Gerona Philippine E-Journals vol. 3 no. 1 (2014)
7. Autonomous Fire Fighting Robot -P. Vydyanath Prasad International Journal of Research in Engineering, Science and Management Volume -, Issue-, July-2020
8. Design & Implementation Of Fire Fighting Robot Using Wireless Camera - Tushar Rane International Journal of Scientific and Research Publications, Volume 10, Issue 3, March 2020 907 ISSN 2250-3153