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Research Paper

FIRE FIGHTING ROBOT USING NIGHT VISION CAMERA

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Abstract:

Fire fighter robot is a machine developed by humans to guard human live, because the accidents happening during the fire extinguishing process is uncountable. This robot main function is to detect fire and move towards the fire automatically to extinguish it from a safe distance using water. This robot's movement and behavior will be fully controlled by a programmable raspberry pi. This robot which will be in a form of vehicle will move right, left, front and back to detect and extinguish the fire. This fire fighter robot will also have a thermal camera and an infrared camera mounted over it. The purpose of thermal camera is to detect fire and the temperature and the infrared camera is to provide night vision imaging which will do live recording of the entire process of extinguishing. This live recording can be viewed in PC reference which comes along with a log in system as well.

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I.INTRODUCTION

Fire accidents are one of the most unpredictable and hazardous disasters that can occur in residential, industrial, and commercial environments. They result in the loss of human lives, destruction of property, environmental pollution, and economic setbacks. Traditional firefighting methods often involve human firefighters who put themselves at risk in life-threatening conditions such as dense smoke, toxic gases, high temperatures, and structural collapses. To minimize these risks, the deployment of robotic firefighting systems has become an essential area of research in modern robotics and disaster management. A fire-fighting robot is an intelligent machine designed to detect, approach, and suppress fire autonomously or semi-autonomously. Equipped with advanced sensors, actuators,

and navigation modules, such robots reduce the need for direct human involvement in dangerous environments. Among the latest innovations in this field is the integration of night vision cameras and infrared (thermal) imaging systems, which allow robots to detect fire sources in low-light or smoke-filled conditions where ordinary cameras and human vision fail. The role of night vision is particularly critical in firefighting because fires often occur in areas with disrupted power supplies, leading to poor visibility. Traditional flame sensors and smoke detectors may not provide accurate information under such conditions. However, night vision cameras combined with image processing and deep learning algorithms can detect the exact source and intensity of fire with higher precision.

Furthermore, advancements in Artificial Intelligence (AI), Deep Learning, and Internet of Things (IoT) have enabled fire-fighting robots to function not just as suppression devices but also as early detection, monitoring, and rescue systems. AI-powered image recognition helps distinguish actual fire from false alarms (e.g., reflections or bright lights), while IoT connectivity allows real-time monitoring and alerts to emergency services.

II.LITERATURE SURVEY

1.Design and Development of an Autonomous Fire Fighting Robot

Abstract: This study focuses on the development of an autonomous fire-fighting robot that uses flame sensors, temperature sensors, and water-spraying mechanisms to detect and extinguish fires. The robot is designed with obstacle-avoidance capabilities to navigate in indoor environments such as offices, labs, and homes. The system operates on predefined algorithms and can detect fire from short distances. However, the study identifies limitations in low-visibility conditions, such as smoke-filled rooms, where flame sensors cannot provide accurate detection. The work emphasizes the need for advanced vision-based systems, particularly thermal and night vision cameras, to enhance reliability.

2. IoT-Enabled Fire Detection and Suppression Robot

Abstract: This paper introduces a sensor-based robotic firefighting system integrated with IoT technology. The robot employs gas sensors, flame detectors, and temperature sensors to monitor the environment and detect fire outbreaks. Data is transmitted to a cloud server, where it can be accessed remotely through a mobile application. This allows real-time monitoring and control of the extinguishing mechanisms. The study

shows significant improvements in detection and response times compared to traditional alarms. However, the robot struggles in environments with poor lighting or dense smoke, as the absence of vision-based systems reduces its situational awareness. The paper concludes that incorporating night vision and AI-based image processing would drastically enhance the system's effectiveness**.**

3. Thermal Imaging-Based Fire Detection Robot

Abstract: This research explores the integration of thermal cameras in robotic fire detection. Unlike conventional flame sensors, thermal imaging detects heat signatures, allowing the robot to locate fire hotspots even in dark or smoke-obstructed environments. The system is tested in industrial applications such as factories and warehouses, where fires often spread rapidly due to flammable materials. The robot successfully identifies hidden fire sources that human firefighters may overlook. The study highlights the importance of thermal and night vision cameras in enhancing firefighting robots, but it also points out challenges related to high cost and processing requirements.

4. Vision-Based Autonomous Fire-Fighting Robot with Night Vision Capabilities

Abstract: This work proposes a vision-based fire-fighting robot equipped with night vision cameras and image processing algorithms. The robot uses infrared and low-light imaging to detect fire sources with high precision, even in environments with zero visibility. It integrates ultrasonic sensors for navigation and obstacle avoidance. The night vision system ensures that the robot can differentiate between fire and other bright objects, reducing false alarms. The results demonstrate that the robot achieves a much higher accuracy rate than traditional flame sensor-based models. Additionally, the study discusses the use of deep learning for fire classification, improving the reliability of detection under different environmental conditions.

III.EXISTING SYSTEM

In the existing system, most fire-fighting robots rely primarily on basic flame sensors, temperature sensors, and gas detectors to identify fire outbreaks. These robots are often equipped with simple water pumps or extinguishing modules to suppress the fire once detected. While they can be useful in small indoor environments such as homes, offices, or laboratories, their effectiveness is limited under challenging conditions. For instance, in environments filled with dense

smoke, toxic gases, or complete darkness, flame sensors fail to detect the source accurately. Similarly, infrared sensors and smoke detectors may produce false positives due to reflections, sunlight, or heat from non-fire sources. Moreover, many existing systems lack autonomous navigation and intelligent decision-making capabilities, often requiring manual control to guide the robot toward the fire. These limitations make conventional fire-fighting robots less reliable in complex real-world disaster situations such as large-scale industrial fires, forest fires, or underground accidents where visibility is very low.

IV.PROPOSED SYSTEM

The proposed system introduces a fire-fighting robot enhanced with night vision cameras and AI-based image processing to overcome the drawbacks of conventional models. By integrating night vision and thermal imaging cameras, the robot can effectively detect fire sources in low-light or smoke-filled environments where ordinary sensors fail. Advanced computer vision algorithms analyze the video feed in real time to identify fire patterns and assess their intensity, ensuring higher accuracy in detection and reducing false alarms. The system also incorporates autonomous navigation with obstacle avoidance using ultrasonic sensors, allowing the robot to safely reach the fire source without manual intervention. Furthermore, AI-powered decision-making enables the robot to determine the most suitable extinguishing method—such as water spray, chemical agents, or CO_2 suppression—based on the fire type. In addition, IoT connectivity allows real-time monitoring and communication with emergency services, ensuring quick response and coordination. Thus, the proposed system provides a safer, smarter, and more efficient solution for fire detection and suppression, capable of functioning effectively in environments where human firefighters or traditional robots would struggle.

V.SYSTEM ARCHITECTURE

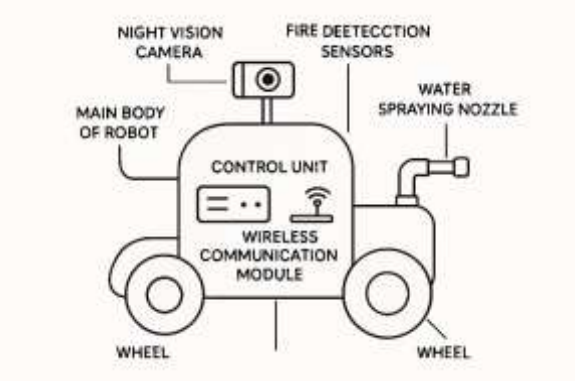

Fig 5.1 System Architecture

The image depicts a straightforward architecture for a fire-fighting robot equipped with a night vision camera. At the center is the robot chassis, which houses the main components such as the

microcontroller (like NodeMCU or 8051), motor drivers, and DC motors that enable movement. Mounted on top of the robot is a night vision camera, allowing it to capture images and video in low-light or smoky environments, critical for locating fire sources and navigating safely. The robot also includes a water tank and a sprayer or pump mechanism, controlled by the onboard electronics, for extinguishing fires remotely. Additional components, such as RF modules or wireless transmitters, enable remote control and communication, while an LCD display may be used to provide real-time feedback to operators. This configuration illustrates how the integration of night vision technology enhances the robot's capability to operate effectively in challenging visibility conditions and makes fire-fighting operations safer and more efficient by minimizing human exposure to hazards.

VI.IMPLEMENTATION

Fig 6.1 Login Page

Fig 6.2 Control Interface

Fig 6.3 Fire Fighter Robot Rotates 360 to Detect Fire

Fig 6.4 fire fighter robot has been successfully extinguished the fire

VII.CONCLUSION

All through this examination; structure and assembling process are clarified, elements of

the robot are talked about. The fabricated robot is a model of the arranged progressed firefighting robot. The financial plan of this task is constrained and propelled fabricating machines, sensors and equipment can't be utilized, so the robot is delivered utilizing the least expensive segments that can be found in the market effortlessly. Regardless of the inconveniences, fire recognition robot breezed through the capacity's tests effectively. The versatile combination calculation technique is for tire identification of firefighting robot. This venture is accepted to be assembled effectively utilizing the above instruments and programming dialect referenced as the abovementioned. Like some other projects, there are upgrades which could be made into this Fire Fighter Robot with Night Vision Camera later on

VIII.FUTURE SCOPE

The future scope of a firefighting robot using a night vision camera is highly promising, as it can be further enhanced with advanced technologies to improve efficiency, safety, and adaptability in real-world scenarios. In the coming years, these robots can be integrated with artificial intelligence and machine learning algorithms to detect fire sources more accurately and differentiate between smoke, heat, and human presence, enabling better decision-making in critical situations. The use of thermal imaging sensors along with night vision can improve visibility in complete darkness and dense smoke, making operations more effective. Future designs may also focus on autonomous navigation with GPS, LiDAR, and IoT connectivity, allowing real-time monitoring, remote control, and coordination with fire departments. Additionally, the robot can be equipped with drones for aerial surveillance and mapping of fire zones, expanding its coverage. With the advancement of lightweight materials, longer battery life, and water/foam carrying capacity, these robots can become more practical for large-scale use. Beyond firefighting, such systems can also be adapted for search and rescue operations, hazardous industrial inspections, and disaster management, making them a versatile solution for public safety in the future.

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