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Fire Fighting Robot with Human Detection and Audio Recognition

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ABSTRACT
This paper presents innovative approaches to firefighting robots, addressing critical challenges in fire safety. CeaseFire, equipped with water and CO2 sprays, ensures real-time operations prioritizing human safety, offering user-friendly handling and extended control range. The DaNI(sbRIO)-powered robot excels in rapid fire detection and extinguishing, providing a reliable solution for hazardous situations. In parallel, the YOLOv4-tiny implemented on a limited hardware robot enhances accuracy in victim rescue during firefighting missions. The Arduino UNO-based mini fire-fighting robot autonomously detects and extinguishes fires, minimizing risks to firefighters and incorporating user intervention through an Android app. Additionally, a modular robot employs computer vision, temperature, and UV-TRON sensors for enhanced fire detection, pathfinding, and extinguishing, promising a significant advancement in autonomous firefighting technology. AFDER, an Autonomous Fire Detecting and Extinguishing Robot, integrates robotics, computer vision, and firefighting tech, autonomously navigating with lidar-based mapping and obstacle avoidance. With precise fire detection and targeted extinguishing capabilities, AFDER reduces human intervention, proving adaptable to diverse environments. Collectively, these advancements showcase the potential to revolutionize firefighting, safeguard lives, and address the complex challenges posed by fire emergencies.

Keywords: CeaseFire, DaNI(sbRIO), YOLOv4-tiny

1. INTRODUCTION

This compilation introduces several cutting-edge firefighting robots designed to revolutionize fire emergency responses. CeaseFire, a user-friendly robot, enhances real-time firefighting with water and carbon dioxide sprays, live video feeds, and swift deployment, emphasizing human safety. The DaNI(sbRIO)-based robot focuses on high-risk scenarios, featuring flame sensors and obstacle avoidance algorithms, addressing challenges posed by flammable materials and inaccessible areas. The Indonesian Search and Rescue Robot Contest's focus on firefighting and rescue missions prompts the proposal of an Arduino UNO-based mini firefighting robot. This system autonomously detects and extinguishes fires, reducing reliance on human intervention and enhancing overall efficiency with an Android App for manual control and alerts. Another approach presents a modular fire-fighting robot employing computer vision for enhanced fire detection and pathfinding. Integrating temperature, UV-TRON sensors, and depth mapping, this robot autonomously navigates toward fires, offering a promising advancement in autonomous

firefighting technology. The AFDER robot integrates robotics, computer vision, and firefighting technologies, utilizing a multi-sensor system for precise fire detection. Advanced machine learning and lidar-based mapping enable swift analysis and navigation, minimizing collateral damage. AFDER's adaptability to various environments marks a significant advancement in fire safety technology, reducing human intervention and safeguarding lives. In summary, these innovative robots showcase advancements in firefighting technology, ranging from user-friendly designs to sophisticated multi-sensor systems, all aiming to mitigate the impact of fire accidents and enhance overall fire emergency responses.

2. LITERATURE REVIEW

Mukul Diwanji, Saurabh Hisvankar and Chhaya Khandelwal[1], This paper introduces AFDER, an Autonomous Fire Detecting and Extinguishing Robot. Combining robotics, computer vision, and firefighting tech, AFDER uses infrared sensors, smoke detectors, and thermal cameras for precise fire detection. Advanced machine learning swiftly analyzes data, distinguishing normal changes from potential fires. AFDER autonomously navigates with lidar-based mapping and obstacle avoidance, efficiently reaching fire sources. Its targeted extinguishing system minimizes collateral damage. With high accuracy in fire detection and efficient suppression capabilities, AFDER reduces human intervention, safeguarding lives. Adaptable to various environments, it's a valuable asset in fire emergency responses, marking a significant advancement in fire safety technology.

Shiva Mittal, Maneesh Kumar Rana, Mayank Bhardwaj, Meenakshi Mataray, Shubham Mittal[2], This paper introduces CeaseFire, a firefighting robot designed to enhance real-time firefighting operations, prioritizing human safety. Equipped with water and carbon dioxide sprays, the robot can extinguish fires, employ mist sprays for self-protection, and provide live video feed from fire sites. The design emphasizes user-friendly handling, swift on-site deployment, and extended remote control range. Firefighters can deploy the robot to assess hazardous areas, analyse conditions through temperature, air-quality, and visual inspections, and effectively extinguish fires with onboard extinguishers. Its rapid and effective response in testing scenarios underscores its reliability for practical use in firefighting situations.

P. Subramanyam Raju, Challapalli Sindhu, Chavala Ajay and Bollaram Srikanth[3], This paper proposes a solution to the high death toll from fire accidents by designing a firefighting robot using DaNI(sbRIO) and interfacing with Robotics LabVIEW. The robot, a Hard Real-Time Embedded System, employs a flame sensor for quick fire detection within a 100cm range, incorporating obstacle avoidance algorithms. In situations where firefighters may not reach, this autonomous robot aims to mitigate the impact of flammable materials, electrical equipment mishaps, and human negligence. With a focus on preserving lives, this technological intervention holds promise in enhancing firefighting capabilities and addressing critical challenges posed by fire accidents.

Yudanta Ina Putra, Ali Husein Alasiry, Adytia Darmawan, Hary Oktavianto, Zakha Maisat Eka Darmawan[4], The Indonesian Search and Rescue Robot Contest focuses on firefighting and rescue missions in burning buildings. Teams face challenges in victim rescue, often relying on color-based object detection algorithms using cameras. To enhance accuracy, this paper proposes implementing YOLOv4-tiny on a robot with limited hardware. The model achieves a 98.25% mAP from training with 458 data points. In real-time scenarios, it detects 178 of 195 objects with 79.23% IoU, running at 17.8 FPS. The YOLO model excels in varied light conditions, detecting victims and candles up to 1.5 meters away. Its precision and speed make it suitable for the competition.

Pramod Mathew Jacob, Jeni Moni, Roja Baby Robins, Merlin Elizabeth Varghese, Sherlin Sosa babu, Vismaya K Bose[5], This paper introduces an Arduino UNO-based mini fire-fighting robot to address the prevalent issue of fire accidents. The proposed system autonomously detects and extinguishes fires, reducing the reliance on human intervention and minimizing the risk to firefighters. Additionally, it features manual control through an Android App for user intervention. The accompanying app sends alert messages and alarms to notify users of fire outbreaks, enhancing the overall efficiency and effectiveness of fire prevention and control in emergency situations.

M K Rangan, S M Rakesh, G S P Sandeep, C Sharmila Suttur[6], In this paper, we present a modular fire-fighting robot that employs an innovative approach for enhanced fire detection, pathfinding, and extinguishing. Unlike traditional methods using limited-range sensors, our design incorporates a computer vision-based algorithm for fire detection, utilizing color segmentation and correlation to identify non-static fire properties. To overcome environmental challenges, we integrate temperature and UV-TRON sensors for confirmation, along with depth mapping. The robot autonomously navigates towards the detected fire, addressing the limitations of conventional path-directing mechanisms. Ultimately, a water sprinkler system is deployed for efficient fire extinguishing. This comprehensive solution offers a promising advancement in autonomous fire-fighting technology.

3. PAPER COMPARISON

Robot Name	Technology	Detection Mechanism	Navigation	Extinguishing Method	Special Features
CeaseFire	Water and CO2 sprays	Video feed	Remote Control	Onboard extinguishers	User-friendly, swift deployment
DaNI(sbRIO)	Hard Real-Time Embedded System	Flame Sensor	Autonomous	N/A	Obstacle avoidance, 100cm range
Indonesian Search and Rescue Robot	YOLOv4-tiny on limited hardware	Color-based object detection	Real-time	N/A	98.25% mAP, 79.23% IoU, 17.8 FPS
Arduino UNO-based mini robot	Arduino UNO	Autonomous and Manual Control	Android App	Extinguishing System	User alerts, Android app control
Modular Fire-fighting Robot	Computer vision, temperature, UV-TRON sensors	Color segmentation, correlation	Autonomous	Water sprinkler system	Innovative fire detection, depth mapping
AFDER	Infrared sensors, smoke detectors,	Machine learning	Lidar-based mapping	Targeted extinguishing system	Adaptable to various environment

	thermal cameras				

4. CONCLUSION

In conclusion, the presented papers collectively showcase a diverse array of innovative firefighting robots, each designed to address specific challenges associated with fire emergencies. CeaseFire, an adept firefighting robot prioritizing human safety, stands out for its real-time operations, user-friendly handling, and extended remote control range. Its multi-functional capabilities, including water and carbon dioxide sprays, along with live video feed provision, underscore its reliability in practical firefighting scenarios. The utilization of DaNI(sbRIO) and interfacing with Robotics LabVIEW in the design of a Hard Real-Time Embedded System highlights a solution geared towards minimizing the high death toll from fire accidents. This autonomous robot, equipped with flame sensors and obstacle avoidance algorithms, aims to reach hazardous areas where human intervention may be challenging, effectively mitigating the impact of diverse fire-related incidents. The Indonesian Search and Rescue Robot Contest focuses on enhancing firefighting and rescue missions, introducing a robot employing YOLOv4-tiny for color-based object detection. This model, achieving high accuracy in real-time scenarios, offers a robust solution for victim rescue in burning buildings, showcasing its precision and speed, particularly crucial for competition settings. The introduction of an Arduino UNO-based mini fire-fighting robot presents a promising approach to addressing the prevalent issue of fire accidents. Its autonomous fire detection and extinguishing capabilities, coupled with a user-friendly Android App for manual control and alerts, contribute to an efficient and effective fire prevention and control system, minimizing risks to both lives and property. The modular fire-fighting robot, with its computer vision-based approach, surpasses traditional methods by incorporating temperature, UV-TRON sensors, and depth mapping for enhanced fire detection, pathfinding, and extinguishing. Overcoming environmental challenges, this robot offers a comprehensive solution that marks a significant advancement in autonomous firefighting technology. Finally, AFDER, the Autonomous Fire Detecting and Extinguishing Robot, stands as an innovative integration of robotics, computer vision, and firefighting technologies. Its multi-sensor system, advanced machine learning, and lidar-based mapping ensure precise fire detection, efficient navigation, and targeted extinguishing, reducing the need for extensive human intervention. AFDER's adaptability to various environments makes it a valuable asset in emergency responses, contributing significantly to advancements in fire safety technology.

In essence, these diverse firefighting robots collectively represent a technological frontier in enhancing fire emergency responses, emphasizing safety, efficiency, and adaptability in the face of evolving challenges.

5. REFERENCES

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