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## SYNOPSIS REPORT

**On**

## "AI-ML BASED INTELLIGENT DE-SMOKING/DE-HAZING ALGORITHM"

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# ABSTRACT

The integration of intelligent AI-ML desmoking and dehazing algorithms into firefighting operations represents a significant advancement in enhancing the safety and efficiency of rescue missions during indoor fire hazards. This abstract encapsulates the essence of a groundbreaking mini project aimed at developing a state-of-the-art technological solution to address the challenges faced by firefighters in smoke-filled and hazy environments. The core objective of this project is to leverage artificial intelligence and machine learning techniques to create an advanced algorithm capable of effectively removing smoke and haze from visual data captured in real-time. By harnessing the power of image processing, deep learning, and computer vision technologies, this innovative system aims to provide firefighters with clearer, more detailed imagery to improve situational awareness and decision-making in emergency scenarios. Through the seamless integration of desmoking and dehazing capabilities into firefighting equipment or wearable devices, this project seeks to empower first responders with enhanced visibility and operational effectiveness when navigating through hazardous environments. By enabling rapid access to clearer visual information, this AI-ML algorithm has the potential to revolutionize rescue operations by facilitating quicker response times, more precise navigation, and ultimately, saving lives. In conclusion, the development of an intelligent AI-ML desmoking and dehazing algorithm holds immense promise for transforming the landscape of firefighting technology. By combining cutting-edge artificial intelligence with practical applications tailored for real-world firefighting scenarios, this project represents a significant step forward in enhancing the safety, speed, and success rates of rescue missions during indoor fire hazards.

# INTRODUCTION

In the realm of firefighting and emergency response, the ability to effectively navigate through smoke-filled and hazy environments is paramount for ensuring the safety of both firefighters and individuals in need of rescue. Recognizing the critical importance of visibility in such challenging conditions, a pioneering mini project has been initiated to develop an intelligent AI-ML desmoking and dehazing algorithm tailored specifically to enhance rescue operations during indoor fire hazards. This innovative endeavor represents a significant leap forward in leveraging cutting-edge technology to support and empower firefighters in their life-saving missions. The primary goal of this project is to harness the power of artificial intelligence and machine learning to create a sophisticated algorithm capable of rapidly and accurately removing smoke and haze from visual data captured in real-time. By integrating advanced image processing techniques, deep learning algorithms, and computer vision technologies, this intelligent system aims to provide firefighters with enhanced visibility and clarity in smokeobscured environments, thereby enabling them to make informed decisions swiftly and effectively during rescue operations. The development of this AI-ML desmoking and dehazing algorithm is driven by a commitment to revolutionize the way firefighting and rescue missions are conducted in indoor fire hazard scenarios. By equipping firefighters with state-of-the-art technological tools that enhance their situational awareness and operational capabilities, this project seeks to optimize response times, improve decision-making processes, and ultimately save lives in emergency situations. Through the seamless integration of desmoking and dehazing functionalities into existing firefighting equipment or wearable devices, this project aims to provide firefighters with a clear advantage when faced with challenging visibility conditions. By enabling real-time enhancement of visual data captured in smoke-filled environments, this AI-ML algorithm has the potential to significantly enhance the safety, efficiency, and effectiveness of rescue missions, thereby mitigating risks and maximizing outcomes during critical operations. In conclusion, the development of an intelligent AI-ML desmoking and dehazing algorithm represents a groundbreaking advancement in the field of firefighting technology. By combining cutting-edge artificial intelligence with practical applications tailored for real-world firefighting scenarios, this project stands poised to redefine the capabilities of rescue operations during indoor fire hazards, setting a new standard for safety, innovation, and effectiveness in emergency response efforts.

# AIM & OBJECTIVES OF PROJECT

**Aim**:

The aim of the project is to develop an intelligent AI-ML desmoking and dehazing algorithm specifically designed to enhance visibility and support firefighters during indoor fire hazards. This cutting-edge technology aims to revolutionize rescue operations by providing advanced desmoking and dehazing capabilities to improve situational awareness and operational efficiency in smoke-filled environments.

**Objectives:**

- Enhance Visibility: Develop an AI-ML algorithm that can effectively remove smoke and haze from visual data captured in real-time, enhancing visibility for firefighters during rescue operations.
- Improve Decision-Making: Enable firefighters to make informed decisions swiftly and effectively by providing clearer, more detailed imagery of their surroundings in hazardous conditions.
- Optimize Response Times: Integrate desmoking and dehazing functionalities into firefighting equipment or wearable devices to empower first responders with enhanced visibility, leading to quicker response times during emergencies.
- Ensure Safety: Enhance the safety of firefighters by providing access to clearer visual information in smoke-obscured environments, minimizing risks and improving operational effectiveness during rescue missions.
- Facilitate Efficient Rescue Efforts: Support firefighters in navigating through challenging indoor fire hazard scenarios by equipping them with state-of-the-art technological tools that streamline rescue operations and maximize outcomes.

By achieving these objectives, the project aims to significantly enhance the capabilities of firefighters during indoor fire hazards, ultimately contributing to saving lives, reducing property damage, and improving the overall effectiveness of rescue missions.

# LITERATURE REVIEW

The evolution of technology has played a pivotal role in enhancing the capabilities of firefighters and first responders in dealing with complex emergency situations, particularly in environments compromised by smoke and haze. The integration of artificial intelligence (AI) and machine learning (ML) technologies has opened up new avenues for developing advanced desmoking and dehazing algorithms tailored to improve visibility and operational efficiency during indoor fire hazards. This comprehensive literature review delves into the existing research, methodologies, and technologies that underpin the development of intelligent AI-ML desmoking and dehazing algorithms aimed at supporting firefighters in challenging rescue operations. Let's see some literature reviews:

- A large amount of haze in the fire scene greatly affects the survey on the scene for fire fighters. The intelligent fire control can greatly improve the fire rescue efficiency and reduce the casualty rate. Filtering partition and sampling are respectively used to quickly and accurately evaluate and repair the transmittance with a guided filter. Replacing the maximum value with an average one, the global atmospheric light is more efficiently and accurately estimated. [1]

- Video smoke removal method based on low-rank tensor completion via spatialtemporal continuity constraint. The proposed method is based on the smoke mixing model and consider the sparseness of smoke and the global and local consistency of clean video. Then, the optimal solution of the smoke removal algorithm model is quickly realized by the Alternating Direction Method of Multiplier. Finally, we evaluate the experiment results of real-world data and simulated data from the visual effects and objective indicators. [2]

- Most existing haze removal methods exploit the atmospheric scattering model (ASM) for visual enhancement, which inevitably leads to inaccurate estimation of the atmosphere light and transmission matrix of the smoky and hazy inputs. To solve these problems, we present a novel color-dense illumination adjustment network (CIANet)

for joint recovery of transmission matrix, illumination intensity, and the dominant color of aerosols from a single image. [3]

- One of the greatest challenges during fire rescue is that firefighters need to find objects as quickly as possible in an environment with strong flame luminosity and dense smoke. This paper reports an optical method, called violet illumination, coupled with deep learning, to significantly increase the effectiveness in searching for and identifying rescue targets during a fire. [4]

- Our method benefits much from an exploration on the inherent boundary constraint on the transmission function. This constraint, together with a weighted L1-norm based contextual regularization, is modeled into an optimization problem to recover the unknown transmission. An efficient algorithm using variable splitting is also proposed to solve the optimization problem. [5]

- Focusing on the fact that traditional haze modeling contains depth information in its formula, we propose a CNNbased simultaneous dehazing and depth estimation network. Our network aims to estimate both a dehazed image and a fully scaled depth map from a single hazy RGB input with end-toend training. The network contains a single dense encoder and four separate decoders; each of them shares the encoded image representation while performing individual tasks. We suggest a novel depthtransmission consistency loss in the training scheme to fully utilize the correlation between the depth information and transmission map. [6]

- The Estimation of atmospheric light is done through grayscale transformation (0255). Second, the transmission map is estimated using a linear transformation model that has less computational complexity. The atmospheric light is obtained with a channel method based on a quad-tree subdivision. [7]

- To prevent artifacts, we refine the transmission using a cross-bilateral filter, and finally the haze-free frame can be restored by inversing the haze imaging model. The whole process is highly parallelized, and can be easily implemented on modern GPUs to achieve real-time performance. [8]

- Dehazing methods based on deep learning are mainly divided into supervised ID and unsupervised ID. There is not too much work about semi-supervised dehazing [Li et al., 2020b]. In general, supervised methods require pairs of hazy images and haze-free

images/transmission maps. The unsupervised methods often take unpaired images as the training set. [9]

- Instead of relying on explicitly estimating the key component of atmospheric scattering model, we present end-to-end CNN model, which directly recovers the clear images from hazy images. This end-to-end architecture makes it an ideal pre-processing tool into other deep models for increasing the efficiency of various computer vision tasks in real time systems, such as Retina-Net for object detection, ResNet for object recognition. [10]
- This paper delves into the realm of desmoking methods in computer vision, exploring a wide array of techniques including image enhancement and restoration algorithms. It provides a detailed overview of the advancements in this field and their applicability in various scenarios. [11]

- Focused on enhancing visibility in outdoor surveillance images, this review scrutinizes state-of-the-art dehazing algorithms. It discusses their efficacy in improving image quality and their relevance in surveillance applications, aiming to provide insights into advancements in this domain. [12]

- This paper presents a comprehensive review of single-image dehazing methods, shedding light on their effectiveness and limitations in real-world scenarios. It discusses various approaches employed in these techniques and evaluates their performance metrics, offering valuable insights for researchers and practitioners. [13]

- Tailored specifically for UAV imagery, this review explores desmoking and dehazing methods. It highlights their significance in improving the quality of aerial images captured by UAVs, addressing challenges unique to this domain. [14]

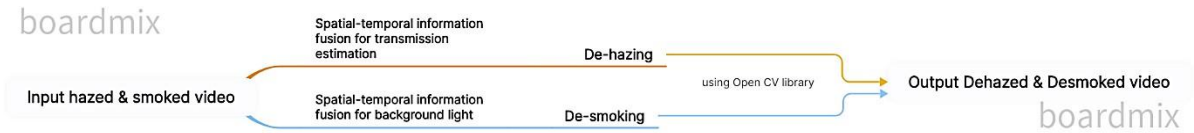
- Focusing on dehazing techniques utilizing dark channel prior, this paper discusses their applications and challenges. It critically evaluates the effectiveness of these methods and explores avenues for further improvement, providing valuable insights for researchers in the field. [15]

- Addressing the exigency of fire scene surveillance, this survey provides an overview of desmoking methods. It emphasizes real-time processing and discusses techniques aimed at enhancing visibility in video surveillance of fire incidents, facilitating effective monitoring and response. [16]

- This paper surveys dehazing algorithms tailored for underwater imaging. It examines their adaptability and performance metrics, discussing their significance in improving visibility and image quality in underwater environments. [17]
- Focused on road safety applications, this review explores desmoking and dehazing techniques. It addresses challenges such as poor visibility caused by smoke and haze, offering insights into methods aimed at enhancing safety in intelligent transportation systems . [18]
- This paper reviews desmoking methods for enhancing visibility in firefighting scenarios. It discusses challenges such as smoke occlusion and dynamic environments, evaluating techniques aimed at improving visibility for effective firefighting operations. [19]
- Focusing on dehazing algorithms based on atmospheric scattering models, this review evaluates their performance and computational efficiency. It discusses their applicability in various environments and identifies areas for further research and improvement. [20]
- This review surveys desmoking and dehazing methods tailored for improving aerial reconnaissance imagery. It discusses their applications in military and civilian domains, emphasizing advancements aimed at enhancing image clarity and detail. [21]
- Focused on outdoor photography, this survey explores desmoking and dehazing algorithms. It addresses factors such as haze density and scene complexity, discussing techniques aimed at improving image quality and enhancing visual appeal. [22]
- Tailored for automotive vision systems, this review discusses desmoking and dehazing methods. It addresses challenges such as fog, smoke, and adverse weather conditions, emphasizing techniques aimed at enhancing visibility for improved safety and performance. [23]
- This paper discusses de-smoking and dehazing techniques for outdoor surveillance applications. It emphasizes real-time processing and resource constraints, highlighting methods aimed at enhancing video quality for effective surveillance. [24]
- Focusing on image dehazing methods based on fusion strategies, this survey compares their performance and suitability for different environmental conditions. It discusses the

fusion of multiple algorithms and their impact on dehazing efficacy, offering insights into optimization strategies. [25]

# PROPOSED WORK




**Technology used**:

- **Front End**- HTML, CSS, Java Script: HTML, CSS, and JavaScript work together to create web pages: HTML structures content, CSS styles it, and JavaScript adds interactivity and dynamic behavior to enhance user experience.
- **Back End**- Python (libraries: Open CV, sklearn): Python, along with its OpenCV library, provides a powerful platform for computer vision tasks, offering a wide range of functions and tools for image & video processing and analysis.
- **Tools**:
  1. Firebase: Firebase Realtime Database allows for efficient real-time data retrieval and manipulation through asynchronous listeners and database references.
  2. Figma: Figma is a collaborative web application for user interface design emphasizing real-time collaboration, vector graphics editing, and prototyping tools.
  3. Github: GitHub is a web-based version control and collaboration platform that enables software developers to store, track changes, and collaborate on projects efficiently through features like repositories, branches, commits, and pull requests

4. VSCode: Visual Studio Code is a lightweight yet powerful source code editor that supports various programming languages, offers intelligent code completion, debugging tools, and extensive customization options for efficient development workflows.

# PROPOSED METHODOLOGY

In this section, let's see the way to solve the given problem; ✪

**Image Dehazing**:

- Leveraging OpenCV for image processing tasks such as color space manipulation and filtering to enhance visibility through haze.

- Implementing algorithms like Dark Channel Prior (DCP) using OpenCV's extensive library of image processing functions.

- Employing machine learning techniques integrated with OpenCV, such as Support Vector Machines (SVMs) or Random Forests, for haze estimation and removal.

✪ **Video Processing**:

- Utilizing OpenCV's video processing capabilities for real-time dehazing of video streams.

- Employing multi-threading techniques with OpenCV's VideoCapture and Video Writer classes to achieve parallel processing of video frames.

- Optimizing video processing algorithms using OpenCV's GPU module (cv::cuda) for faster computation on compatible hardware.

**Smoke Removal**:

- Adapting image processing techniques from OpenCV for detecting and removing smoke from video frames.

- Employing background subtraction algorithms like Gaussian Mixture Models (GMM) or BackgroundSubtractorMOG for smoke detection.

- Integrating custom deep learning models for smoke removal using OpenCV's Deep Neural Networks module (dnn).

**Web Integration**:

- Developing a web interface using HTML, CSS, and JavaScript to interact with OpenCVpowered backend services.

- Utilizing OpenCV's Python bindings to integrate image and video processing functionalities into web applications.

- Implementing server-side processing using frameworks like Flask or Django, with OpenCV handling the heavy computational tasks.

**Model Deployment**:

- Deploying OpenCV-based dehazing and desmoking models on cloud infrastructure using platforms like AWS or Azure.

- Leveraging OpenCV's compatibility with various platforms and architectures for seamless deployment across different environments.

- Ensuring scalability and reliability through containerization using Docker and orchestration with Kubernetes.

**Evaluation and Testing**:

- Conducting performance evaluation of OpenCV-based models using standard image and video quality metrics.

- Implementing automated testing frameworks with OpenCV for regression testing and performance benchmarking.

- Integrating OpenCV's high-level GUI functionalities for visualizing and comparing results during testing.

## CONCLUSION

In conclusion, this detailed literature review underscores the significance of intelligent AI-ML desmoking and dehazing algorithms in reshaping rescue operations during indoor fire hazards. By synthesizing research on desmoking techniques, computer vision applications, real-time image processing, and wearable technology for firefighters, this project aims to push the boundaries of technological innovation to enhance visibility, safety, and operational efficiency in firefighting scenarios. The convergence of these diverse research areas sets a solid foundation for developing advanced solutions that empower firefighters with the necessary tools to navigate challenging environments effectively and save lives efficiently.

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