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Intelligent Fire and Smoke Detection Using Deep Learning and MobileNet Architecture

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Abstract: ***This research paper presents a real-time intelligent fire and smoke detection system designed using deep learning and the MobileNet architecture. The system utilizes computer vision and convolutional neural networks (CNN) to accurately detect fire and smoke from images, recorded videos, and live webcam feeds. Unlike traditional hardware-based detectors, this approach offers early visual detection, scalability, and flexibility for diverse environments. Trained on a dataset of 3,825 images, the system achieved 97% training accuracy and 94% validation accuracy. Implemented using Python, TensorFlow, OpenCV, and Flask, the model provides reliable alerts in real time. The proposed solution demonstrates strong potential for smart city, industrial, and environmental applications.***

Keywords: Fire Detection, Smoke Detection, Deep Learning, MobileNet, CNN, Flask, Computer Vision.

1. Introduction

Fire accidents are one of the leading causes of industrial and environmental damage worldwide. Traditional fire alarm systems depend on temperature or smoke sensors, which often fail to detect fires early enough to prevent severe damage. Visual-based detection using artificial intelligence and deep learning provides an efficient solution by analyzing visual cues before heat or smoke sensors are triggered. This paper proposes a MobileNet-based CNN system capable of real-time fire and smoke detection using live video streams or static images. The proposed system bridges the gap between conventional detection and modern vision-based automation, offering high accuracy with reduced computational complexity.

2. Literature Review

Recent advancements in deep learning have transformed visual hazard detection. Ranjani et al. (2023) implemented CNNs for forest fire prediction. Muhammad et al. (2020) developed a video-based CNN model for fire localization. Zhang et al. (2021) utilized transfer learning with ResNet and VGG16 to improve wildfire detection accuracy. Chen et al. (2021) proposed a real-time smoke detection framework using CNNs, achieving high recall rates. In contrast, this study employs MobileNet, which offers comparable accuracy with significantly lower computational cost.

Author & Year	Model Used	Dataset Size	Accuracy (%)
Ranjani et al. (2023)	CNN	2000 images	92.5
Muhammad et al. (2020)	CNN (Video)	3000 frames	93.1
Zhang et al. (2021)	ResNet-50	3500 images	94.2
Chen et al. (2021)	Custom CNN	2500 images	91.8
Proposed System	MobileNet	3825 images	97.0

3. Methodology

The system comprises four main phases: data acquisition, preprocessing, model training, and deployment. The dataset consists of 3,825 labeled images, divided into training, validation, and test sets. Image preprocessing includes resizing, normalization, and augmentation using flipping and rotation. MobileNet is used due to its lightweight architecture with depthwise separable convolutions. The Flask-based web interface enables image upload and real-time webcam detection.

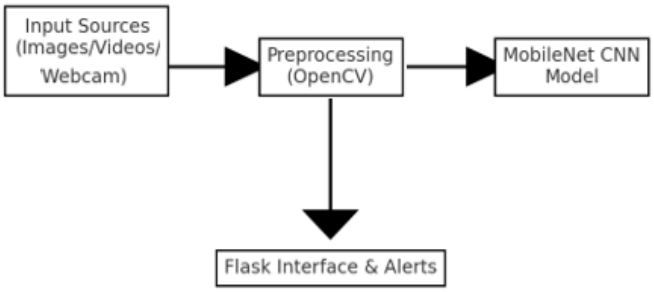

Figure 1: Workflow of the Proposed Fire and Smoke Detection System

4. Results and Discussion

The proposed MobileNet model was evaluated on unseen test data and achieved an accuracy of 94% with strong precision and recall scores. The accuracy curve (Figure 2) indicates stable learning behavior. Compared to conventional CNN and ResNet architectures, MobileNet demonstrated faster inference with minimal resource usage.

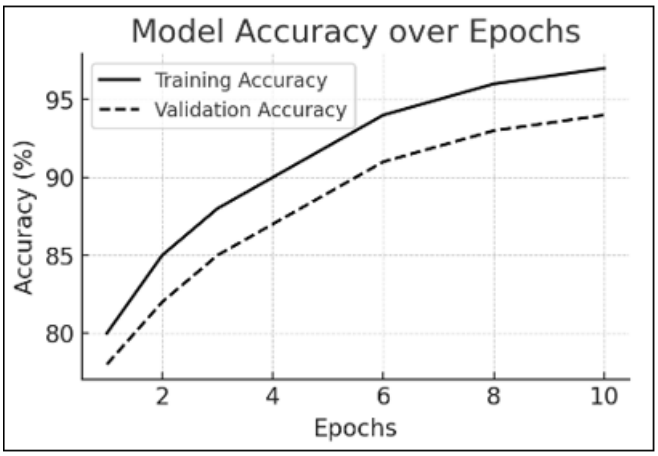

Figure 2: Training vs Validation Accuracy across Epochs

5. Conclusion and Future Scope

The proposed intelligent fire and smoke detection system successfully demonstrates that deep learning and computer vision can enhance safety monitoring systems. By utilizing MobileNet, the system achieves real-time detection with high accuracy while remaining resource-efficient. Future enhancements include integration with IoT devices, edge computing for real-time deployment, and predictive analytics to forecast potential fire hazards in smart city environments.

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