VISION AGAINST FLAMES: COMPARING DIFFERENT CNN ARCHITECTURES FOR FIRE DETECTION

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ABSTRACT

In response to the critical need for efficient wildfire detection, this study presents a novel approach leveraging machine learning techniques applied to images from ground cameras and drones. Traditional methods, predominantly relying on satellite imagery, often grapple with false positives and maintenance challenges. Our method aims to address these limitations by utilizing a more direct and responsive source of visual data. The significance of this research is underscored by California's substantial investment in wildfire management, with CalFire allocating $3.3 billion annually for this purpose. The proposed system, therefore, has the potential to significantly reduce costs and enhance early detection capabilities, particularly in remote areas. We curated a comprehensive dataset of 843,862 images, categorized into fire and non-fire classes, from a 16GB image repository sourced from Kaggle. To optimize memory usage and enable efficient batch processing, images were resized to 200Œ200 pixels. Duplicate removal was achieved through image hashing, and data augmentation techniques expanded our dataset fivefold. This included modifications in zoom, brightness, color jittering, Gaussian noise, and horizontal flipping. All images were standardized to JPEG format. For model development, we employed an 80%-20% split for training and testing, and an 85%-15% split for training and validation. The study experimented with various neural networks, including ResNet, MobileNet, and AlexNet, over 10 epochs using SGD optimization with a momentum of 0.9 and a learning rate of 0.001. ResNet emerged as the most effective model, benefiting from deeper layers and skip connections. MobileNet, while efficient, lacked the complexity needed for pattern recognition, and AlexNet's simpler architecture led to lower performance. To enhance the robustness of our model against overfitting, we are considering the implementation of k-fold cross-validation. Additionally, we plan to integrate semantic segmentation for more precise fire localization. Future work will focus on augmenting the dataset with edge case images, particularly those with various light sources, to improve the model's resistance to false positives. This research not only contributes to the field of wildfire detection but also demonstrates the potential of machine learning in addressing environmental and public safety challenges.

1 INTRODUCTION

In the realm of wildfire management and prevention, the development of an advanced early fire detection system stands as a critical innovation. Traditional methods, primarily relying on satellite imagery, are increasingly proving inadequate due to their susceptibility to false positives and ongoing maintenance challenges. To address these limitations, our research introduces a novel approach utilizing Computer Vision (CV) technology, harnessing images from ground-based cameras and drones. This methodology marks a significant leap in accurately identifying the presence of fire, particularly in its nascent stages.

*Both authors contributed equally. Ordered alphabetically.

The urgency and importance of this development are underscored by the efforts of organizations such as CalFire. As the state agency responsible for fire protection and the stewardship of over 31 million acres of California's wildlands, CalFire's expenditure of $3.3 billion for wildfire protection and suppression vividly illustrates the substantial financial and environmental stakes involved. (Kerstein, 2023) This immense budget not only highlights the state's commitment to managing and responding to wildfires but also reflects the enormous economic impact of these natural disasters.

In this context, the potential of an early fire detection system cannot be overstated. By enabling quicker and more accurate detection of wildfires, especially in remote or hard-to-reach areas where traditional surveillance methods are limited, such a system could have a profound economic effect. The anticipated benefits include significant cost savings, potentially amounting to millions of dollars annually, and more importantly, the mitigation of extensive environmental and property damage. Our research aims to explore and validate the effectiveness of this CV-based system, positioning it as a pivotal tool in the ongoing battle against wildfires.

2 Problem Description

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Indicate footnotes with a number[1] in the text. Place the footnotes at the bottom of the page on which they appear. Precede the footnote with a horizontal rule of 2 inches (12 picas).[2]

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All artwork must be neat, clean, and legible. Lines should be dark enough for purposes of reproduction; art work should not be hand-drawn. The figure number and caption always appear after the figure. Place one line space before the figure caption, and one line space after the figure. The figure caption is lower case (except for first word and proper nouns); figures are numbered consecutively.

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[1] Sample of the first footnote

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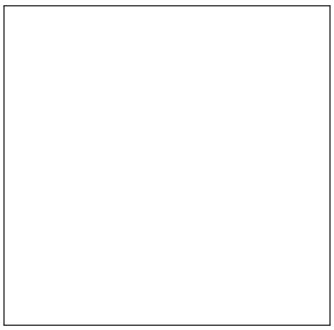

Figure 1: Sample figure caption.

Table 1: Sample table title

PART	DESCRIPTION
Dendrite	Input terminal
Axon	Output terminal
Soma	Cell body (contains cell nucleus)

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AUTHOR CONTRIBUTIONS

If you'd like to, you may include a section for author contributions as is done in many journals. This is optional and at the discretion of the authors.

ACKNOWLEDGMENTS

Use unnumbered third level headings for the acknowledgments. All acknowledgments, including those to funding agencies, go at the end of the paper.

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