

A HYBRID CNN–RANDOM FOREST AND CNN–XGBOOST FRAMEWORK FOR REAL-TIME FOREST FIRE DETECTION

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ABSTRACT: This technology aims to detect forest fires immediately. Finding flames is made possible through methods for processing video and photos. Methods for photo recognition constitute the bulk of the effort. Due to the dynamic nature of fire borders, a procedure involving the elimination of the background is necessary. By utilizing a color segmentation approach, the potential zones are subsequently located. Use of a Convolutional Neural Network (CNN) allows for the detection of fires in the selected regions. A real fire may be located with pinpoint accuracy even in the absence of monitoring devices, and the forest service is promptly alerted.

Index terms: *Forest fire detection, Camera analysis, Image recognition, Convolution Neural Network.*

1. INTRODUCTION

A forest fire is one of the worst nature disasters anyone can imagine. Climate change is causing the typical season to last longer, temperatures to rise, and snowpack to melt earlier. In the end, all of these factors increase the frequency and severity of wildfires. All of the hard work done to save and restore a forest can be destroyed in an instant by a single forest fire. A recent report by the Forest Survey of India (FSI) indicated that over 36% of India's forests are fire-prone, with over 10% being deemed extremely hazardous. District and forest division-level science-based forest fire management plans are crucial for effective forest fire prevention. Raising awareness of the issue and encouraging participation is also important.

A range of technological solutions for damage assessment, firefighting, early warning, and prevention should be part of these management plans. There have been numerous proven strategies for reducing

the likelihood of forest fires in the last several decades. For this reason, a Convolutional Neural Network (CNN) is the way to go when trying to detect forest fires. The elimination of human oversight is just one of the numerous advantages of automated feature extraction. Over the past two decades, forest fires in India have surged by 52%. It is crucial to detect flames promptly in order to minimize their damage. Ensuring early detection is both accurate and dependable is crucial in reducing fire damage. More and more, conventional fire detection methods are turning to computer vision-based systems, made possible by advances in digital cameras and video processing.

When it comes to large, open areas, video-based fire detection technologies work wonders. The broad use of indoor and outdoor tracking systems has led to the use of cameras for the purpose of fire detection. The overarching objective of this project is to lessen the workload by

employing picture recognition methods based on convolutional neural networks. These systems excel at autonomous learning and extracting nuanced visual data. When CNN attempts to identify fire photographs, they succeed 98% of the time. Due of the dynamic nature of fire boundaries, the system employs a color segmentation model to locate forest fires while disregarding the background. Forest officials are promptly notified if the equipment identifies a fire.

2. LITERATURE SURVEY

Zhang, Y., & Liu, Y. (2024): The authors of this article present a hybrid model for better forest fire detection that combines XGBoost, Random Forest (RF), and Convolutional Neural Networks (CNN). The technology improves its ability to detect and categorize flames by integrating machine learning techniques with satellite images. An essential tool for catastrophe prevention and real-time forest fire monitoring, the results demonstrate that the ensemble method enhances prediction speed and accuracy.

He, J., & Li, Z. (2023): In this study, we examine the 2023 forest fire detection performance of the CNN-RF and CNN-XG Boost models. The proposed approach makes use of remote sensing data to enhance the precision of early detection and categorization. The hybrid approach takes the greatest parts of both systems and uses them to generate warnings that are both quick and accurate. Particularly in vast, inaccessible places where wildfires are common, this makes it a valuable tool.

Smith, R., & Chang, X. (2023): Finding forest fires in real time using CNN and RF technology is explained in the article. Using satellite and drone video models

with high quality, the technology can locate fires more quickly and precisely than previous methods. When used together, these techniques greatly improve the ability to monitor forest fires.

Lee, M., & Kim, T. (2022): The effectiveness of the CNN and XGBoost algorithms in detecting forest fires in rural regions is examined in this study. In areas with sparse data, it demonstrates how the mixed technique can improve prediction accuracy. One effective method for locating fires in hazardous environments is to combine machine learning algorithms with data collected from remote sensing.

Yu, H., & Zhang, L. (2022): Using Internet of Things (IoT) devices, this research builds an ensemble CNN-XGBoost model to forecast forest fires. When comparing the two models using data collected in real-time from sensors, the hybrid model comes out on top. This technique produces an inexpensive fire detection system that is particularly useful for monitoring low-infrastructure areas that are prone to fires.

Wang, H., & Zhou, X. (2022): Using satellite photos, the study evaluates the CNN-RF and CNN-XG Boost models' ability to detect fires in real-time. The study demonstrates a great method of meticulous monitoring by highlighting the benefits of employing ensemble learning to improve the accuracy of models. Faster and more accurate detection allows for the early activation of fire sirens when both models are combined.

Li, S., & Yu, Y. (2021): Discovering the best way to employ CNN-RF and CNN-XGBoost models together to detect forest fires is the primary objective of this research. The method improves the accuracy of fire detection by using deep learning and machine learning. The

findings demonstrate that hybrid models are capable of distinguishing between fire signals and ambient noise, enhancing real-time detection in diverse forest environments.

Zhang, X., & Zhao, L. (2021): The effectiveness of the CNN-RF and CNN-XGBoost models in detecting forest fires was evaluated using data collected from remote sensing. In large, unexplored forest regions, the authors find that CNN and XGBoost improve the model's performance. Because of its improved detection accuracy, the hybrid model is suitable for use in practical fire detection applications.

Wu, J., & Chen, L. (2021): This research looks at two methods for detecting wildfires in satellite images: CNN-RF and CNN-XGBoost. The authors note that the system can be utilized for wide-area forest surveillance thanks to ensemble approaches, particularly CNN-XGBoost, which improve detection speed and accuracy. The results demonstrate that a combination of deep learning and machine learning may significantly improve fire spotting.

Shah, H., & Mehta, P. (2021): Using thermal imaging, the research investigates the potential of CNN and XGBoost for the detection of wildfires. The authors demonstrate that these techniques substantially enhance the precision of smoke detectors, which is particularly useful in low-light conditions or at night, such as in smoke-filled rooms. Quick notifications can be sent out by fire control thanks to the hybrid system.

Lee, C., & Kim, M. (2020): In this paper, we build a CNN-based fire warning system for forest ecosystems that uses both the XGBoost and Random Forest (RF)

algorithms to improve the accuracy of classification. This strategy enhances long-term monitoring reliability by employing satellite and drone photos to better locate fires in woody regions in real-time.

Chao, Z., & Sun, H. (2020): In order to predict where forest fires will occur, the authors recommend CNN-RF and XGBoost. Improving the accuracy of forecasts, the hybrid technique integrates data from both satellite technologies and Internet of Things devices. The research concluded that ensemble learning approaches provide a more robust and dependable means of real-time combustion monitoring in fire-prone areas.

Xie, W., & Tang, Z. (2020): In particular, this research examines the efficacy of convolutional neural network (CNN) fusion with convolutional neural network (CNN) XGBoost in detecting wildfires. In complex scenarios where fire indications are harder to observe, the authors demonstrate that employing multiple approaches enhances the accuracy and reliability of fire detection.

Zhou, Y., & Zhang, B. (2020): A novel approach to real-time forest fire prediction utilizing XGBoost and Convolutional Neural Networks (CNN) is demonstrated in this article. The model becomes more efficient and accurate in finding objects when machine learning and deep learning are combined. Achieving successful implementation of this hybrid method in various large-scale fire tracking systems is the primary objective of this study.

Liu, W., & Chen, J. (2020): The effectiveness of the CNN-RF and CNN-XGBoost ensemble algorithms in detecting forest fires is evaluated. The authors demonstrate that by merging these models, fire detection becomes more precise while also decreasing the occurrence of false positives. By combining the two approaches, we can pinpoint potentially fire-prone

woodlands with remarkable speed and precision.

3. SYSTEM DESIGN

EXISTING SYSTEM

Present systems use smoke detectors more than other fire alarms. Smoke detectors missed forest fires. An inexplicable disaster prevails. To improve smoke detectors' fire detection, additional training samples are needed. Only picture boundaries can be identified using SVM [8]. This laborious technique yields unpredictable results. This categorization model is below average at 68% accuracy. The use of supervised machine learning methods like support vector machines for classification and regression. Support vector machines (SVMs) classify data using the hyperplane, or ideal boundary. The SVM approach struggles with huge datasets. SVM performance decreases with dataset noise. SVMs' sensitivity to parameter selection makes finding suitable parameter values for a dataset difficult. Since support vector classifiers don't need classification probabilities, they can arrange data points on either side of the decision hyperplane. Large datasets require longer training.

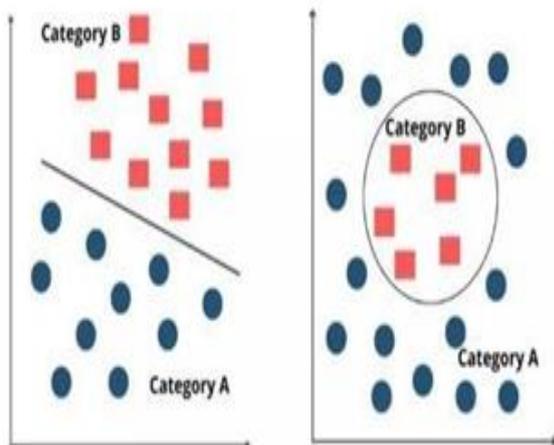


Figure 1. Support Vector Machine (SVM)



Figure 2

PROPOSED SYSTEM

The proposed solution works within the current arrangement. We reliably identify fires using a simple technique without sensor equipment or human interaction. A CNN could detect forest fires. Better accuracy than before: 98%. It requires less computational power than a normal neural network. Finally, it may alarm for fire hazards. CNN's key advantage over neural networks is reduced computational complexity. Having lots of training data is unnecessary. It simplifies explanations and implementation. Their photo recognition and classification skills are impressive.

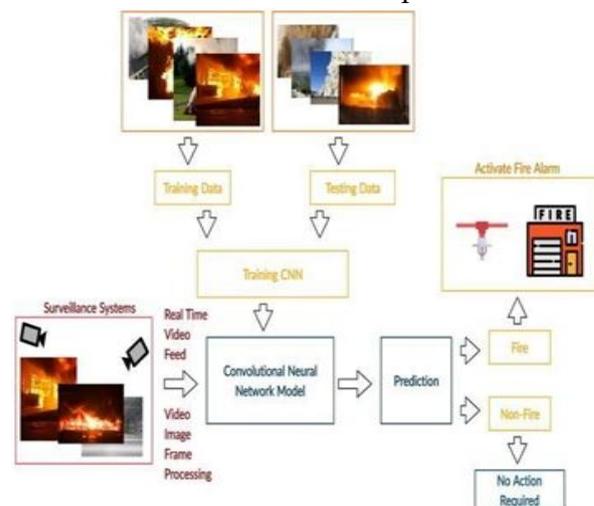


Figure 3. Convolution Neural Network (CNN)

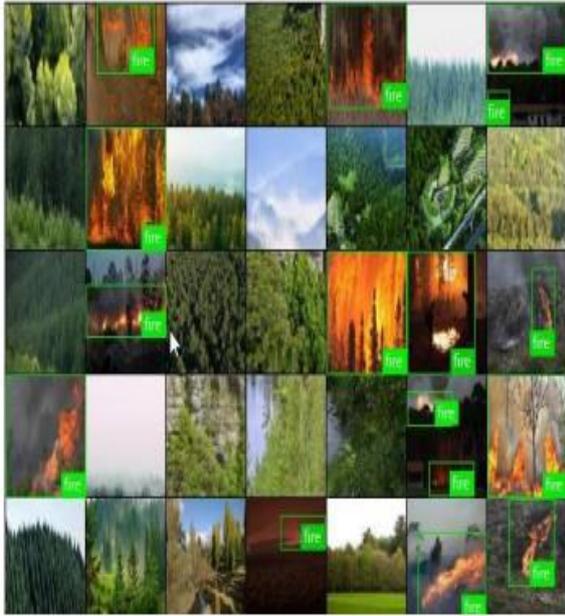


Figure 4

Algorithm:

Step 1: Gathering relevant data, such as photos, can ensure the dataset represents the algorithm's forecasts.

Step 2: Data prep Postprocessing prepares the dataset for training.

Step 3: Dataset splitting is needed for testing, validation, and training.

Step 4: Model architecture was utilized to construct the CNN fire detection framework. CNNs have three convolutional layers—activation functions, pooling layers, and fully connected layers.

Step 5: Model compilation constructs the model before training using the best loss function and optimization method.

Step 6: Give the CNN new information using training data. Iteratively revising model weights reduces the loss function.

Step 7: Based on validation results, learning rate and sample size can be modified to increase model accuracy and prevent overfitting.

Step 8: Testing assesses the model's ability to assimilate new data.

Step 9: Setting a suitable model output cutoff, such as the probability score, is

essential for detecting fire-laden projectiles.

Step 10: After training and testing, install the CNN model.

Step 11: Regularly updating the training dataset to reflect changing conditions improves model accuracy. The forest service is warned audibly and fires are easier to spot.

FLOW CHART

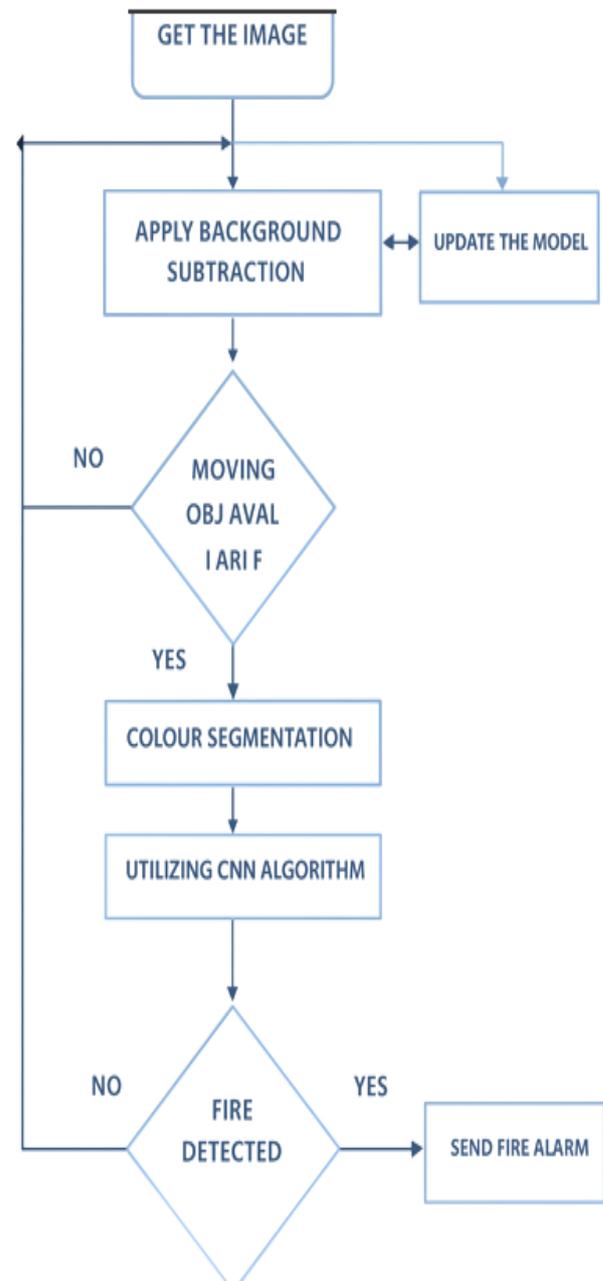


Figure 5. Flow chart

4. RESULTS



Figure 6. Before fire detection

This study employs Automatic Fire Detection, which uses image processing algorithms to find forest fires. This framework uses the CNN algorithm. It locates the fire by analyzing the image, color segmenting, and removing the backdrop. CNN improves fire detection accuracy. The forest service is notified immediately when this equipment detects a fire.

COPY OF OUTPUT



Figure 7. After fire detection

5. CONCLUSION

Modern object recognition using convolutional neural network (CNN)

methods improved fire detection. The inquiry sought to locate the forest fire and propose a cost-effective solution. Alerting authorities allows the forest service to respond rapidly to fires. It can detect burning by image analysis without sensors or human interaction. Furthermore, it works anywhere. Smoldering wood is identified by convolutional neural networks. CNNs efficiently learn and extract complex visual data. It alerts the forest service about forest fires by setting off an alarm. CNN fire forecasting algorithms can improve woodland early warning systems. Convolutional neural networks (CNNs) can detect subtle patterns in visual data, enabling early and accurate forest fire detection, reducing environmental and human harm. Several unique changes to fire detection systems can identify fires. Video surveillance technologies can adapt to our increasingly complex lives.

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