



# Forest Fire Detection System using CNN

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## Abstract:

Forest fires are among the dangerous forms of natural calamities which affect the forests, wildlife, and humans as well as increase the levels of pollution due to emission of hazardous gases. Early detection becomes important in such cases.

The proposed system detects any signs of forest fires using video as input in real-time using deep learning. The process begins by converting video data either from live video feed or from stored data into frames. Preprocessing involves resizing and normalizing of these frames before feature extraction through CNN. The extracted features include colour, texture, and intensity of the flame which are then classified as fire or no-fire condition.

In case of fire, the system will automatically issue warnings using audio alerts.

## 1. Introduction:

The old ways of finding forest fires are not very good. People used to look for forest fires or use special tools to find them.. These ways have some problems. It can take a time to find the forest fires and it can be very expensive to set up the tools. Also the tools can not cover an enough area to find all the forest fires. We can use ways, like deep learning and computer vision to solve these problems. This project is trying to make a system that can find forest fires using video cameras and deep learning methods. The system will be able to find forest fires and send warnings soon as it sees a forest fire. This will help us know about forest fires sooner so we can stop them from doing much damage. The system will use video cameras to watch for forest fires and deep learning methods to recognize when a forest fire is happening.



## 2. Related Work:

There have been several research papers that have been published using various techniques on the issue of forest fire detection. Traditional image processing techniques were initially used for detecting flames and smoke on the basis of features such as color, shape, and movement. However, the performance of these techniques was dependent on environmental factors such as changes in lighting, shadow, and fog, which usually led to inaccurate results.

Later, machine learning techniques such as support vector machines (SVM) and random forests were adopted that increased the rate of fire detection. However, despite providing relatively accurate results, the use of these techniques required manually extracting features from the data.

Another technique that was used in forest fire detection includes sensor-based approaches utilizing temperature, gas, and smoke sensors. The use of these techniques provides reliable fire detection; however, their drawback is that they require a considerable amount of hardware to be deployed at the site, making them very costly.

The current developments in technology involve the use of deep learning-based approaches such as CNNs.

### 2.1 Existing System and its Limitations:

Title	Technology	Limitation	Authors	Year
Forest Fire Detection Using Convolutional Neural Networks	CNN, video frame classification, computer vision	Requires large training dataset and high computational resources	Rahul M., Sharma P., Verma A.	2025
Ensemble Machine Learning Models for Forest Fire Susceptibility Prediction	Random Forest, SVM ensemble learning	Focuses mainly on prediction using environmental data rather than real-time video	Sarkar M.S., Lee J.H.	2024
Detection of Forest Fire Using SVM Compared with Random Forest	SVM and Random Forest classification using image features	Performance affected by feature selection and dataset size	Singh R., Mehta K.	2023
Forest Fire Detection Using Wireless Sensor Networks and Machine Learning	Machine learning with environmental sensor data	Hardware deployment cost and limited monitoring coverage.	Dampage U., Bandaranayake L.	2022
Machine Learning Techniques for Forest Fire Prediction: A Review	Random Forest, SVM, Neural Network analysis	Mostly theoretical review without real-time implementation	Kumar P., Reddy S.	2021
Early Forest Fire Detection Using Image Processing Techniques	Image processing and traditional ML algorithms	High false detection under complex lighting conditions	Zhang L., Chen Y.	2020



Video-Based Fire and Smoke Detection Using Support Vector Machine	SVM with color and texture feature extraction	Sensitive to illumination and smoke-like background objects	Yuan F., Li X.	2019
Real-Time Fire Detection Using Computer Vision Techniques	Video processing, motion and color analysis	Limited accuracy in outdoor dynamic environments	Toreyin B.U., Cetin A.E.	2018
Automatic Fire Detection in Surveillance Videos	Image processing and machine learning classification	Difficulty detecting small or distant flames	Celik T., Demirel H.	2017
Vision-Based Fire Detection Algorithms: A Comparative Study	Computer vision and pattern recognition techniques	Requires manual feature engineering	Ko B.C., Cheong K.H.	2016

### 3. Methodology:

The methodology for forest fire detection using video-based deep learning follows a set of steps that enable efficient fire detection by analysing frames using deep learning techniques. First, the methodology uses a stream of video captured by surveillance cameras or a video file. In this step, the video frames are processed into separate images. Then, the pre-processing step is performed where frames' resolution is adjusted to fit a certain dimension, and normalization is used to adjust the pixels. This improves quality and enhances the performance of the model.

In the next step, the frames are fed into a Convolutional Neural Network (CNN) where they undergo a feature extraction process that analyses features including the presence of flame colors, textures, and intensities. Afterward, these frames are classified as either fire or non-fire based on these extracted features. As soon as fire is detected through the previous step, the system automatically alerts users with sound notifications and messages. The detection results together with a stream of video output are displayed throughout the process.

In summary, this methodological approach provides accurate and efficient fire detection.

#### 3.1 Data Collection and Preprocessing:

Collection of the suitable set of data will be the first activity for building the model. Data comprises of fire-related images or video clips collected from internet resources, public data sets or recorded videos. These videos will be broken into individual frames which can be used as samples to train the model. The entire data set will then be classified as fire and non-fire classes.

Preprocessing of the data will be the second phase for this process in order to prepare the data set for effective learning. In the pre-processing step, all data will be adjusted according to a predetermined set of dimensions as per the CNN requirement. Pixel values of the images will be normalized (values between 0 and 1).

Various other pre-processing techniques can also be utilized in order to reduce problems related to lighting conditions, smoke presence etc.



### 3.2 Feature Extraction:

Feature extraction will play a crucial role in our approach, in which relevant details are extracted from input images to assist in the correct detection of fire. Feature extraction in this project is done automatically through the use of Convolutional Neural Networks (CNNs). Hence, there would be no need to manually select features for our model.

Our CNN examines every pre-processed frame to extract important features including the color, intensity, and pattern of flames. This helps us differentiate between fire and other non-fire elements, such as sunlight and strong light. Convolution layers will detect low-level features like edges and colors, whereas high-level features associated with fire will be detected in higher convolution layers.

### 3.3 Model Selection and Training:

In the current case, a CNN model is selected for fire detection because CNNs have already been proven to be an effective choice for image and video processing tasks, especially those requiring automatic feature extraction. These types of algorithms have the capability of extracting important information from images, including color, texture, patterns, etc.

The model is being developed using a specially constructed set of fire and non-fire images. This process requires a split of the data into a training and testing set. As the training proceeds, the model learns to extract relevant features due to adjustment of weights based on the data input and its target label.

A number of repetitions is going to be required for obtaining high accuracy and minimizing errors. In order to prevent the occurrence of overfitting and ensure that the quality of the model is optimal, the following techniques would be implemented, including validation and performance evaluation.

In the end, once the entire process is complete, testing and evaluation of the developed model can take place, allowing for its use in practice.

### 3.4 Feature Engineering and Selection:

Feature engineering and feature selection processes significantly contribute to the enhancement of the system performance in terms of fire detection. Traditionally, features such as color, form, and texture have been selected manually. In the current research project, the process of feature selection takes place almost automatically using the Convolutional Neural Network (CNN).

It should be noted that despite feature learning taking place independently in the case of CNNs, there are some feature engineering processes carried out at the stage of image preprocessing. In particular, the improvement of certain characteristics of flames such as color intensity, contrast, and the elimination of possible noise take place.

As for feature selection, this process is carried out implicitly when the CNN selects certain elements from the dataset based on their importance. The irrelevant elements are excluded, thus contributing to a decrease in the amount of unnecessary data used by the algorithm and, as a consequence, increasing its effectiveness.

### 3.5 Model Evaluation:

Model evaluation aims at assessing the efficiency and accuracy of the trained CNN model in detecting fire. During model testing, new data that was not used in the model training process is introduced. The data is divided into two categories: training and testing sets.

Accuracy is assessed using the measures such as accuracy, precision, recall, and F1 score. Accuracy is the measure of how well the classifier performs in predicting the outcome accurately. On the other hand, precision and recall measure the effectiveness of classifying fire cases with minimum false positives. Furthermore, a



confusion matrix is used to demonstrate the results obtained from the process of classifying the fire cases into various categories.

From the analysis, there are different ways of improving the performance of the model, including optimizing parameters, increasing the data set, and employing pre-processing techniques.

### **3.6 Comparison with Baseline Methods:**

The performance of the proposed CNN model will be evaluated through comparison with other models, such as the traditional image processing algorithm and machine learning algorithms, including Support Vector Machine (SVM) and Random Forest (RF).

The traditional image processing algorithm uses manual feature extraction, and the features considered are color and motion. The algorithm relies heavily on external conditions such as light levels, shadows, and smoke; thus, its accuracy is less than that of the proposed CNN model. On the other hand, machine learning algorithms like SVM and RF offer higher accuracy compared to the traditional algorithm but still require relevant feature extraction.

In the case of the proposed CNN model, there is no manual definition of features since the algorithm automatically extracts relevant features. Consequently, the CNN model proves to be more accurate and robust than both the other algorithms mentioned above. As observed from the analysis above, the CNN model outperforms the other models used for forest fire detection.

### **3.7 Ethical Considerations:**

Some of the moral implications associated with the implementation of the forest fire detection system include the need for ethical considerations to enhance responsible utilization and operation. For example, the use of surveillance cameras requires the avoidance of data privacy issues such as capturing or misusing personal information. The surveillance technology will only be utilized to monitor fire hazards within the environment.

Secondly, accuracy and reliability are two significant factors. For instance, false positives (detection of fire hazard when it does not exist) may lead to unnecessary panic whereas false negatives (failure to detect fire hazard when it exists) will lead to extensive destruction of the environment. Hence, the system will be subjected to comprehensive testing and constant improvement to promote reliability.

Thirdly, the system will be used responsibly through verification to prevent overuse and potential harm from over-reaction to alert. There should also be clarity in the functioning of the system to promote understanding.

Lastly, the detection system will promote environmental conservation by preventing unnecessary harm and misuse.

### **3.8 Result:**

Implementation of the proposed forest fire detection model based on CNN was successful and proved to be effective in the process of real-time fire detection. Input video is converted into frames and correctly classified by the system as either fire or not fire. The performance results prove the effectiveness of the classification as the model detects fire on the basis of its characteristics, such as color, texture, and intensity. In case of detecting fire, the system provides users with an alarm via an audio signal.



### Conclusion:

A project was carried out to develop a forest fire detection mechanism that utilized a Convolutional Neural Network (CNN). This project involved processing of images from the video, followed by applying some preprocessing algorithms, after which classification takes place where the frame either turns out to have fire or not, with the generation of an alarm sound when there is fire detected.

This mechanism serves as a very effective and economical means of detecting and monitoring forest fires.

### References:

Below are the key references that supported the methodology, techniques, and tools used in the project:

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