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# Forest Fire Detection Using Deep Learning and Image Recognition

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**Abstract -** *Fire is a catastrophic event that swallows the essence of million habitants. It can cause drastic losses of human and animal lives, soil erosion, burnt vegetation, and more. A major percentage of trees, peatlands, moss, grass, lakes, and rivers are depleting. The National Center for Environmental Information reports that 2021 had 5,984 wildfires. Statistics state that wildfires are likely to increase by one-third by 2050. Carbon dioxide emissions are at an all-time high due to forest fires. We could reduce wildfires by planting more trees and making climate change, a global commitment. A reliable fire control system will prove beneficial in fulfilling this mission.*
*HSI (Hue, Saturation, Intensity) model*

***Key Words*: Deep Learning, Image Processing, Fire Detection, Neural Networks, Analysis**

## 1. INTRODUCTION

Fire is an uncontrollable disaster to ecological systems, infrastructures, and human and animal lives. Often fire breakouts happen in schools, colleges, banks, and open areas. With the faster urbanization process, taller buildings appear around us. This change makes the wildfires more frequent and causes damage to human lives and property. A reliable system must be in place to lessen wildfires since fire is a threat to human life and all biological communities. As the damages can be devastating, early fire detection is becoming more and more urgent. A key aspect of fire detection is identifying a fire emergency early to alert the residents and firefighters. The Convolutional Neural Network is an algorithm that classifies images with a high degree of accuracy and with good performance. We aim to improve the accuracy by designing a custom model.

### 1.1 Objective

Deep learning is the most emerging field one could work in to solve real-world problems. Keen on resolving a real-time problem, we began research on forest fires and how to detect them using deep learning. We aim to build a fire detection system by increasing the accuracy rate of the existing system. So it is much more beneficial to work on reducing the devastating impacts of a forest fire.

### 1.2 Related Work

In conventional fire detection systems, we study the features of fire images. Analyze the changes in fire images by comparing them with two different color models. One is RGB (red, green, blue) and another is HSI based on the difference between consecutive frames. After that, we could propose a rule-based approach for fire decisions. A generic rule-based pixel classification using the YCbCr color model is implemented to separate the ones which are more luminant than others.

## 2. EXISTING SYSTEM

Extracted images for the candidate fire area using an HSI model to calculate the flame color. This will help in identifying the fire area. Though, color-based fire detection methods are vulnerable to environmental factors such as lighting and shadow. Adopting the Bayes classifier method to detect fires based on extra features such as the area, surface, and the edges of the fire pixels we find in the frames of every single image to color. Mueller proposed the neural network-based fire detection method using optical flow for the fire area. We combine two different optical flow models in that method. These two combined models, then distinguish between fire and moving objects. Foggia proposed a multi-expert system that combines the analytical results of fire color, shape, and motion characteristics.

Although this is not adequate, the supplementary features to color, including texture, shape, and optical flow, can reduce incorrect detections. These approaches take previous computation results as input in capturing images to explore the features.

Involving visualized information in the temporal, 3D thre form in fire environments eases understanding. We see that image processing is a part of computer vision, extensive use in projects like these. Thus, they count nothing but the short-term behavior although the fire has a long-term dynamic behavior.

The existing system has been implemented in such a way that it takes the help of sensors for predicting whether fire exists or not. It identifies the smoke caused by fire expansion with the help of sensors and alerts everyone by ringing an alarm. This system might identify any trivial smoke like fire, which makes it invalid. Even if the smoke comes from any other source such as candles, the water steams, or burnt cooking.

These sensors will detect this smoke also as fire and rings the alarm. Such false alarms are not beneficial and thus result in wasting a lot of time and money and predicting incorrect conclusions.

We proposed a system that does not detect any false fire and gives more accurate results than sensors, resolving this problem.

## 3. PROPOSED SYSTEM

Real-world data is generally complex and consists of missing, inconsistent values. Those datasets in unusable format are complex to use within machine learning models. So, to remove these noises and make the data readable, we first performed data pre-processing.

Data pre-processing is mandatory for cleaning the data and making it suitable for a deep learning model that helps increase the accuracy and efficiency of the model. In the proposed system, as there are images, we need to pre-process them to remove any inconsistencies in the data.

### 3.1 System Architecture

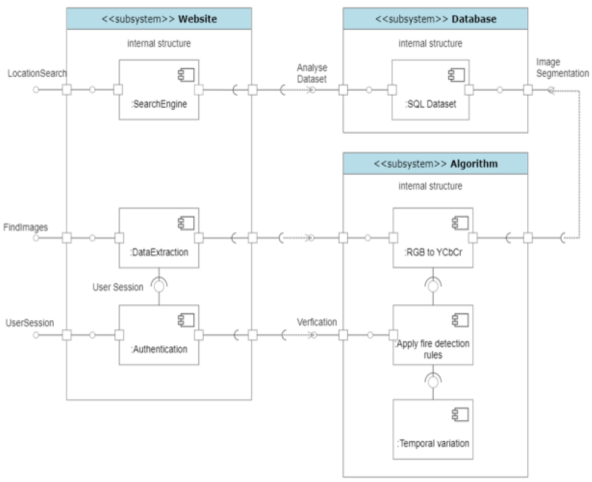


**Fig -1**: Fire detection system

The core component of Neural Networks has layers like the Convolutional layer, Max pooling, Softmax, and Fully connected layer are the core components of Convolutional Neural Networks. Although we have observed the architecture of CNN in the previous implementations, it isn't as accurate as required. So, to increase the accuracy of the proposed system, we have also used the VGG16 model for transfer learning.

### 3.2 Training of Model

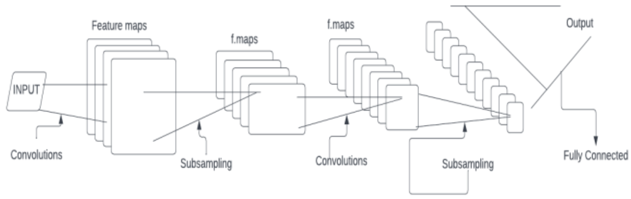


**Fig -2**: Layers of Convolutional Neural Networks

The VGG16 model churns out higher accuracy as compared to other models. Actually, the VGG16 model was for more than 100 classifications but in the proposed system we need only one classification. Hence, we have customized the existing VGG16 model as per the needs of the system.

After capturing images, OpenCV reads every single frame of the image. One frame contains all the pixels of the image. Each frame is of 224x224 size. Every frame has index values, stored in an array to access. The dataset used in this system has * fire images and * non-fire images. We tried to keep separate datasets while training as well as testing the dataset.

## 4. ALGORITHM

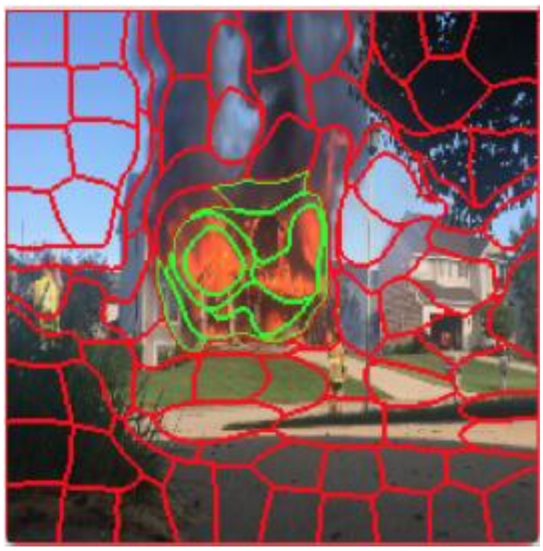

**Fig -3**: Fire image classifier

I. Capture real-time images through the camera. We can also do this using surveillance cameras to cut down on costs. The captured image undergoes processing through various layers of system architecture. For example, data pre-processing, max pooling, fully connected layer, etc.

II. The input layer communicates with the output shape going through the convolutional layer. Generates the kernel of 3x3 every time it does the computation.

III. Feature maps are the output generated in convolutional processing. These feature maps are of varied sizes.

IV. These feature maps become the input to the next process called subsampling.

V. Subsampling or pooling is where the dimensions of feature vectors are reduced. Further, high-level abstraction happens with these feature vectors in a fully connected layer.

VI. The weights on the convolutional layer and fully connected layer are called neurons. They help better represent data while training the model.

VII. At last, an activation function named 'SIGMOID' classifies the image as fire or non-fire. And it activates the respective neuron.

VIII. In case we detect a fire, sending an alert to the fire control system would prevent the consequences. Else, we can continue with the analysis.

## 5. CONCLUSIONS

We have implemented a fire detection system to detect fire by capturing images. The system uses CNN, transfer learning, and image processing techniques. In this system, the VGG16 model is more accurate as compared to other deep learning models. After testing the VGG16 model, we interpreted that the system could produce results at 91% accuracy.

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