Forest Fire Susceptibility using Neural Network

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Abstract— ***Forest fires have impacted negatively on ecosystems, cultures, and economies all across the world. Modeling and anticipating the incidence of wild fires are essential to minimize these damages and reducing forest fires because they can help with forest fire prevention strategies. The convolutional neural network (CNN) has emerged as a key state-of-the-art deep learning method in recent years, and its application has enriched a wide range of fields. As a result, we proposed a CNN-based spatial prediction model for forest fire susceptibility. The concept is that this model is used to identify a fire or the beginning of a fire in a forest using (aerial) surveillance data. In the event of a fire, the model might be applied in real time to low-framerate surveillance video or picture and provide a warning. The network will be trained on a dataset that includes images in three categories: 'fire,' 'no fire,' and 'smoke'. The majority of the photographs will be of forests or forest-like situations. Photos labelled 'fire' have visible flames, while images labelled 'smoke' have smoke sensing the smoke. Finally, photographs with the title 'no fire' were taken in forests. We will leverage the data augmentation function offered by Keras (Python Deep Learning API) to conduct a series of random transformations on photos before feeding them to the network in order to train a network that generalizes well to new images. Finally, our goal is to create a legible project which handles every aspect of CNN creation and training. Early detection of fire in the forest is very helpful and our biodiversity can be saved.***

Keywords**— Introduction, Literature Survey, Methodology including CNN architecture, Conclusion and References.**

I. Introduction

A forest fire is a phenomenon that can be defined as an accidental fire in a flammable vegetation region. They have the potential to cause plenty of environmental disasters, as well as significant economic and ecological damages. Forest fire surveillance and tracking have become an important method for preventing this, attracting increasing interest throughout the world. Massive forest fires occurred in a number of locations across India's Karnataka state's Bandipur National Park in February 2019. The Indian Space Research Organization's (ISRO) National Remote Sensing Centre conducted an estimate of the total area damaged by the fire. On February 25, 2019, was projected that the burned area had grown to around 10,920 acres in the five days since February 21, 2019. Because regional forest fire susceptibility is typically influenced by a variety of factors and has typical nonlinear and complex properties, developing accurate forest fire prediction models remains a challenge. For predicting forest fire susceptibility, a variety of methodologies have been proposed, ranging from physics-based methodologies to statistical and machine learning (ML) techniques. ML algorithms have demonstrated the capacity to deliver superior results for the geographical forecast of wildfires when compared to standard qualitative and statistical analytic methodologies. Artificial neural networks, random forests (RF), support vector machine (SVM), multilayer perceptron neural network (MLP), kernel logistic regression (KLR), naive Bayes, and gradient descent trees are just a few of the machine learning algorithms that have already been successfully developed and commonly used to create wildfire susceptibility visualizations.

Deep learning (DL) techniques have lately gotten a lot of attention and have had a lot of success. Deep learning techniques are widely used in domains such as object identification and detection, audio recognition, and natural language processing because they aim to uncover numerous representation levels. In recent studies in areas such as disaster damage detection, remotely sensed image classification, and landslide susceptibility mapping, the convolutional neural network (CNN) has been recognized as one of the most effective and commonly used DL algorithms, which has generated major improvements.

The CNN can fully utilize contextual information and identify several layers of representations from input data, making it better suited to the evolution of fire event spatial features. The DL method shows deep characteristics and may differentiate between geographical entities. As a result, examining the use of the CNN algorithm in forest fire susceptibility assessments has some practical value. The likelihood assessment of fire occurrence in a region is characterized as forest fire susceptibility in this article. The major goal of this research is to use contextual-based CNNs with deep architectures to forecast regional forest fire susceptibility spatially. The forest fire susceptibility model is built using a CNN, and the model's hyperparameters were tuned to increase predictive accuracy.

II. Literature Survey

[1] Early fire detection using convolutional neural networks during surveillance for effective disaster management: CCTV cameras can now do several forms of processing, such as object and motion recognition and tracking, thanks to recent advancements. With these processing skills, it is feasible to identify fire at an early stage during monitoring, which can aid disaster management systems by preventing massive ecological and economic losses and saving a large number of human lives. In this study they offer an early fire detection framework for CCTV surveillance cameras that uses fine-tuned convolutional neural networks and can detect fire in a variety of indoor and outdoor scenarios. We suggested an early fire detection approach based on fine-tuned CNNs during CCTV monitoring with this objective in mind. We demonstrated that by including deep characteristics into our framework, fire may be detected at an earlier stage with greater accuracy in a variety of indoor and outdoor contexts while reducing false fire alarms. We presented a prioritizing technique that may adaptively adjust the priority of camera nodes based on the value of the information it receives, which is another desirable component of disaster management. A dynamic channel selection technique employing cognitive radio networks ensures the dependability of crucial frames and prompt reaction to the disaster management system. Through experiments on videos containing fire-like moving objects and real fire in indoor and outdoor environments, we confirmed that our framework can detect fire at an early stage with good accuracy and minimal false fire alarms, as well as ensure an autonomous response and reliable transmission of representative contents under surveillance, which can greatly facilitate disaster management systems.

[2] Forest fire image recognition based on convolutional neural network: This research proposes a forest fire picture identification approach based on convolutional neural networks for autonomously detecting fire. Fire recognition algorithms may be divided into two categories. The first uses classic image processing techniques, while the second uses convolutional neural networks. Because of blindness and unpredictability in the feature selection step, the former is prone to false detection, which latter applies an unprocessed convolutional neural network immediately, resulting in inaccurate properties learnt by the network and a lower recognition rate. In order to address these issues, traditional image processing approaches are merged with convolutional neural networks, and an adaptive pooling strategy is devised. This algorithm can partition the fire flame region and learn the features ahead of time. Simultaneously, blindness is avoided in the classic feature extraction method, as is the learning of incorrect features in the convolutional neural network. Experiments reveal that the adaptive pooling convolutional neural network technique performs better and has a greater recognition rate.

[3] Survey on different fire and smoke detection techniques using image processing: Physical sensors are utilized to detect fire in traditional fire detection systems. Sensors measure the chemical characteristics of airborne particles, which are then employed by traditional fire detection systems to sound an alert. However, the alarm is not activated until particles reach the sensors, resulting in a sluggish fire detection. As a result, they can't be used in open regions or huge enclosed places. For the protection of the inhabitants, a quick and effective fire detection mechanism is critical. For the safety and protection of people and the environment, many smoke and fire detection systems have been developed. To avoid harmful situations caused by fire, it is critical to build an adequate detection system. The suggested two-step technique completely utilizes color and pixel change information in the detection of fire. The performance of the suggested fire detection system may be further enhanced by considering smoke at early stages of fire. The fire detection approach based on fire color modelling and motion detection utilizing CIE L*a*b* color space to identify fire pixels increases the performance. This method employs the background subtraction method. Data fusion is used to build a new pre-alarm using an approach based on color characteristics and dynamics analysis. This module's primary job is to reject false alerts triggered by other fire-like moving objects. Color information and a feature extraction module are used to differentiate fire and smoke pixels. As a result, this research provides a comparison of various models for smoke and fire detection utilizing image processing. This document discusses several fire and smoke detection systems, as well as their benefits and drawbacks. Because smoke is an excellent predictor of fire, it is included. A system that can detect fire by analyzing real-time video footage would function in an open environment and would not require a large budget.

III. METHODOLOGY

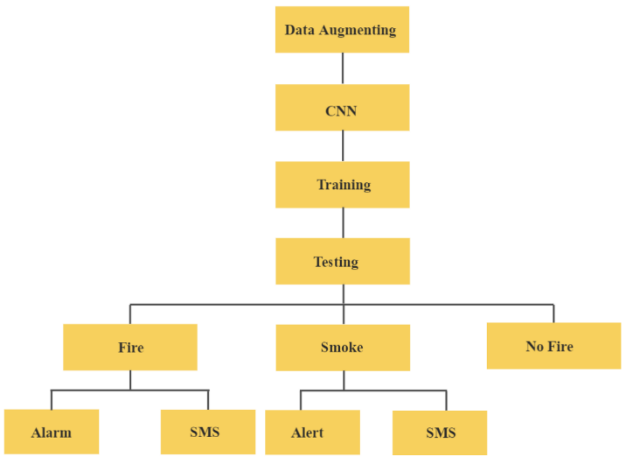

Fig. 1 Work flow of the model

A. *Data Augmenting*

Data augmentation is a strategy that enables practitioners to significantly increase the diversity of data available for training models, without actually collecting new data. Data augmentation techniques such as cropping, padding, and horizontal flipping are commonly used to train large neural networks.

B. CNN Architecture

The convolutional neural network (CNN) is one of the most well-known deep learning (DL) algorithms, with good results in feature learning for image categorization and identification. It's a feed-forward neural network whose parameters are learned using the backpropagation technique and the traditional stochastic gradient descent algorithm.

The CNN is made up of numerous layers, including convolutional, pooling, and fully linked layers. The many types of processing layers have varied functions. The feature maps are produced by the convolutional layers, which conduct linear convolution operations between the input tensor and a collection of filters.

A nonlinear activation function is usually used after each feature map. The most widely employed activation function is the rectified linear unit (ReLU), which conducts a nonlinear modification of the feature map created by the convolution layer and adds nonlinearity into the system. The convolution technique is used to extract distinct characteristics from the input layer and accomplish weight sharing. Each stage's input and output are feature maps, which are collections of arrays. If the input is a 2-dimensional image x, for example, the input is first decomposed into a sequential array x= {x1, x2,..., xN}.

To minimize the size of the feature maps, the pooling layers execute a subsampling process. The pooling layer may be separated into max-pooling and average-pooling layers based on the maximum and average functions. High-level abstraction features are provided by the fully connected layers, which are flat feedforward neural network layers. They are frequently utilized at the conclusion of the network design to construct the final nonlinear feature combinations needed by the network to make predictions. The activation function for the final fully linked layer must be chosen carefully based on the tasks at hand. The posterior probability for each grid cell may be computed using the SoftMax or sigmoid function.

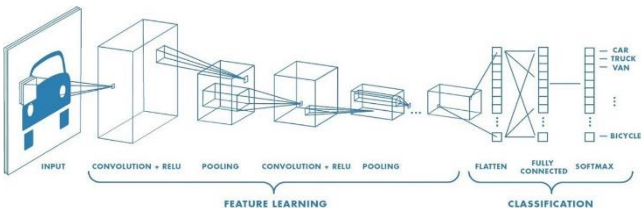

Fig. 2 Architecture of proposed CNN

As illustrated in Fig. 2, it contained five convolution layers, five pooling layers, and five fully linked layers. Color photos with a size of 256 x 256 x 3 are fed into the model as input. To produce 16 feature maps, the first convolution layer applies 16 kernels of size 3 x 3 with a stride of 2 to the input picture. The first pooling layer chooses the highest activations from these feature maps in tiny regions of 3 x 3 pixels with a stride of 2 pixels. As a result, the feature maps size is decreased by a factor of two. The second convolution layer is made up of 32 kernels of size 3 x 3, followed by a max pooling layer that is comparable to the first. It is followed by a stack of three convolution layers, each with 64, 128, and 256 kernels with uniform kernel sizes of 3 x 3. All the pooling layer works in a similar way to the first two. Finally, there are five fully linked layers with 512 neurons apiece (corresponding to the number of classes). And finally output layer consist of 3 neurons to output the result. The SoftMax classifier uses the output of the final layer to determine probabilities for the two classes.

C. Training and Testing

Model is trained with approximately around 16000 – 17000 images including of three categories of “Fire”, “No Fire” and “Smoke”. To get the better and clear view of the data we have used around 10 attributes to clean the data like; rescale=1.0/255, horizontal flip=True, vertical flip=True, zoom range=0.2, shear range=0.2, featurewise center=True, featurewise std normalization=True, rotation range=40, width shift range=0.2, height shift range=0.2, and data is also is divided into 70 to 30 percent training and testing ratio. The model is trained for 5 epochs or iterations and got the accuracy of 96 percent. We have taken n number of images to test the result and got around 99 percent accurate result. Fig. 3 shows some of the images which has been successfully predicted the result.

Fig. 3 Images of Successfully predicted result.

IV. CONCLUSION AND FUTURE ENHANCEMENT

In this model we have successfully implemented the CNN (Convolutional Neural Network) model which suspect the various fire flames in the images and smoke in the provided the images. We implemented the CNN with five – five layers of convolution and polling respectively. The image data collected from google search engine and performed data augmenting on the image dataset. We have also implemented alarm and SMS notification whenever model detects the fire or smoke in the image. Alarm is done with the help of “pygame” python module and SMS features using “twilio” python module. The accuracy of the predicted result is almost 100 percent based on the trained data. Number of false alarms is less and accuracy of the trained dataset is 96 percent. As a part of future enhancement this can be implemented in IOT based project to capture the live picture of forest using drone or some other means and detect the fire and smoke in the very early stage, and notify to the fire authority.

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