Forest Fire Detection using Machine Learning-A Review

[1]Minit Arora ,[2]Sanjay Sharma ,[3]Bhumika Gupta
[1]Research Scholar, School of CA & IT, SGRR University, Dehradun, Uttarakhand, India
[2]Professor, School of CA & IT, SGRR University, Dehradun, Uttarakhand, India
[3]Associate Professor, G.B.P.I.E.T., Pauri, India
[1]minitarora@gmail.com,[2]sanjaypokhriyal@yahoo.com,[3]mail2bhumikagupta@gmail.com

Abstract
Forest fire causes adverse impacts on the environment. It causes damage to climate, natural resources, ecology and human prosperity. It is important to detect forest fire before it spreads to a large area. But unfortunately most of the time fire is detected after it has spread to a wide area . Forest fire detection and prediction can reduce the impact of forest fires. Various machine learning algorithms are in use to detect forest fire. In this paper we have reviewed some of the techniques that may be used to detect forest fire.

Keywords: Convolution Neural Networks, SVM, Logistic Regression

1. Introduction

Forest fire damages millions of hectares of land every year. It burns vast areas of land and produces carbon dioxide and carbon monoxide. Early fire detection can save damage to life and property as well as economy .Traditional optical electronic systems for fire detection have many drawbacks. It requires fault free hardware which also requires regular maintenance, It may also raise false alarms.

Machine learning can be used to detect forest fire. Some of supervised learning algorithms used to Detect Forest fire include Regression , SVM (Support Vector Machine), Decision Tree, Random Forest and so on.

1.1 Regression

Regression is one of the basic Machine Learning techniques. It can solve problems using the following ways

a) Predicting a variable using another variable, time series is an example

b) Relationship between dependent and independent variable y=f(x).

c) How independent variable contributes to variation

Regression studies the relationship between a dependent variable or attribute i.e level of fire which depends on attribute like humidity, rain, wind speed etc.

Regression is used for burnt area prediction for forest fire detection . Burnt area is calculated using fuzzy logic [1,2] . It predicts burnt area in a fuzzy vector of low medium and high. Mean Absolute Error (MAE) and Root Mean Square Error (RMSE) is calculated

Mohammad et al proposes multiple linear regression for fire prediction Factors like wind, humidity , rain and temperature are considered. Methods like least square, guassseidel and guass Jordan have been used for calculating different regression coefficients. Comparative analysis has been done [4]

1.2 Decision tree

The decision tree builds a regression model with a tree structure. The data set is split into smaller subsets . Decision tree is rendered downwards from the root node dividing the knowledge into homogeneous value subsets.

1.3 SVM

SVM is used as a regression technique that maintains options of algorithmic rules. SVR makes use of constant principles as SVM for classifications with small variations. In SVM we maximise the distance or the margin between hyper plane and data points. image loss helps in maximizing margin .[5]

1.4 Random Forest

It uses ensemble learning for regression and classification. It is a meta estimator. It includes the outcome of many predictions. The tree run in parallel. The number of choices is proportionate to the total.

1.5 CNN

Convolutional Neural Network is a deep learning technique that helps to detect forest fire taking input as images followed by a series of convolution and max pooling layers for feature extraction and reducing the dimensionality and classifying the images as fire or non fire.

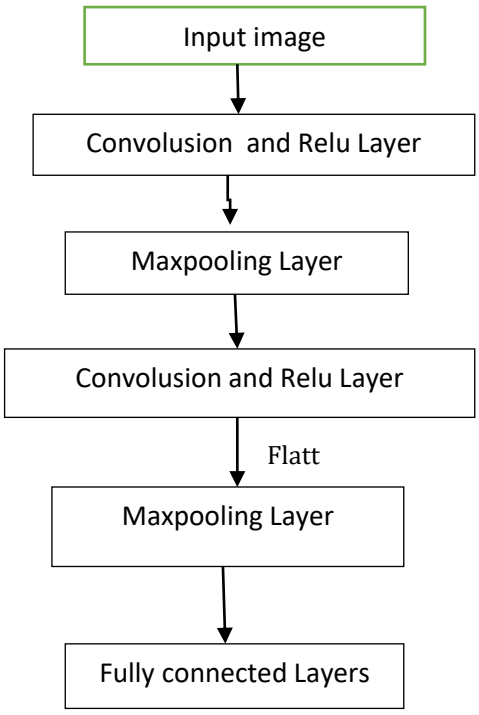

Fig1: CNN

2 Literature Review

Preeti T et al [6] in their paper Forest Fire Prediction using machine learning techniques has done a comparative study of different models for forest fire detection such as Random Forest, ANN, Decision tree and SVM. They used Data collected for prediction .Temperature, wind speed and humidity is analysed for forest fire predicction. Random forest, decision tree and SVR are used as regression techniques. Python is used as a platform .A comparative study is done between these models, Random Forest , Decision Tree and SVR. Mean Absolute Error, Accuracy is calculated for random forest, decision tree and SVR. [3]

Mean Square Error determines the proximity of a regression curve to a set of points .It does this by determining the distance of points to regression curve . This distance is considered as errors. They are then squared to get rid of negative signs. It is called mean square errors because it finds the common collection of error.

Variance means how much variation is there between observed value and the expected value's averages, how much they deviate from the mean predicted value. Then they are normalized by converting to value ranging between 0 and 1.

For dimensionality reduction, the technique of Principal Component Analysis is used. Basic Matrix operation from statistics and linear algebra are used. Principal Component Analysis is used to plot a graph of the fire affected and non-affected area

The paper concludes that extreme high temperatures and moderate humidity with high wind speed increase the chance of forest fires,

Aditi Kansal et al [7] compares different machine learning techniques including regression, SVM and decision tree for predicting forest fires and concludes that regression predicts fire with high accuracy. In their paper they show that their proposed model has the highest accuracy as it has the least root mean square error They also show that analysis time of proposed model is less compared asto other approaches. R square value of the proposed approach is larger compared to other approaches. The authors conclude that their approach of using regression along with dividing the datasets into months is the best approach producing a high level of R square and low value of RMSE.

Ahmad M Elsheway [8] in their paper discuss Linear Regression, ridge regression and Lasso Regression and demonstrate that linear regression works best for forest fire prediction as it gives more accuracy. The study is carried out using 70% training data and 30% test data on the Montesinos park in Portugal taking dataset from UCI repository.

Pragati et al [9] proposed a combination of WSN (Wireless Sensor Networks) and Decision Tree to propose a technique for forest fire detection and conclude that Decision Tree is better than SVM as machine Learning for forest fire detection as it gives better accuracy. They present a machine learning approach for fire detection along with Wireless Sensor Networks. They propose a decision tree machine learning

approach. They propose that decision tree performs with a great accuracy and also reduce the possibility of a false alarm. The approach can accurately determine fire in the early stages and differentiate fire from no fire.

Himanshu et al[10] use CNN to detect forest fire. CNN takes images as input and distinguish the features that indicate fire Then an alert is sent to the forest officers so that they can take action. Their model is motivated from Google Net.

Spoorthy M.R et al [11] explore different machine learning methods including SVM, Regression, K nearest neighbour and decision tree They conclude regression is the best technique to detect forest fire. They conclude Extra tree regressor and decision tree give best results with high accuracy and less error .

Vighneshwaran SR et al[12] propose SVM for detecting forest fire which isa a robust and accurate approach. They also compare Support Vector Machines with logistic regression / According to the authors logistic regression has a detection rate of 88% while SVM obtains a detection rate of 94% Therefore SVM is more stable and accurate for classifyi[ng fire and non fire and detecting fire .

Suhas G et al[13] propose use of Deep Learning to detect forest fire. Deep Learning is based on ANN (Artificial Neural Networks) and is emerging concept that can give excellent results. It can overcome the shortfalls of existing systems and give accurate results with early detection of forest fire,. The authors propose use of deep learning for video frames with the use of transfer learning. Features are extracted using ResNet50 and Inception Res_Net V2 Support Vector Machine, Decision Tree, Naïve Bayes and Logistic Regression are the Machine Learning algorithm which are used to detect fire from the video frames. The best result are obtained with ResNet 50 and SVM It also sends alert mail using GUI The authors claim it to be cost effective accurate and more reliable compared to existing hardware based systems

QuinjeZang et al [14] propose a deep learning approach for detecting forest fire. They use deep CNN including full image and fine grain patch classifier. First fire is detected from the full image . Then a patch fire classifier is used to detect the exact location of fire. The accuracy of their model is 97% on training dataset and 90% on testing dataset.

Yanhong Chen et al [15] propose forest fire detection approach based on unmanned aerial vehicle (UAV) image . Fist LBP (Local binary pattern) feature extraction and SVM classifier are used to detect smoke Then image is fed to the CNN network histogram equalization and smooth low pass filtering. Smoke and flame are detected using two CNN model. CNN-17 improves the accuracy and reduces algorithm complexity,. The paper proposes methods that detect both smoke and flame.

Gayatri et al [16] propose a method of forest fire detection using deep learning CNN. After detection, alert is sent to the forest team along with location of fire. Google's firease is used for sending alerts to mobile phones or IOT devices. Conmbination of CNN BiLSTM is used along with firebase. . Bidirectional LSTM is used to extract features from image. CNN optimises the classification.

ZhentianJio et al [17] propose an algorithm for forest fire detection that use YOLO v3to Unmanned Aerial Vehicles based images. A UAV based plaform is developed and then a CNN is implemented using YOLOv3. For real time forest fire detection. It has found to have recognition rate of 83%. It has frame rate of 3.2fps. The proposed method is implemented for small scale UAV's The limitation of this approach is that it is not as effective in detecting small scale fire spots. In forests. It works best for large scale forests. Accuracy and speed is at the expected level in the UAV platform and deep learning forest fire detection approach.

B Premamayudu et al [18] propose a CNN based fire detection approach. They analyse AI for detection of fire from CCTV footage. The dataset used contain video frames with fire. Data preprocessing is done followed by use of Convolution Neural Network to detect fire. CNN uses

convolution, activation function and max pooling on different batch size and epoch values to ensure fire detection with a high accuracy. The model achieves 95%accuracy.

M Ranjith Kumar et al [19] propose method of deep learning based on CNN to predict forest fire It improves accuracy of existing systems and shows low false positive.

3 Analysis:

According to most authors, Wireless Sensor networks are inefficient in detecting forest fire as they cause lead to false alarm and are difficult to maintain in the harsh conditions of forest. So machine learning techniques are used along with wireless sensor nodes or on images or videos obtained from UAV for real time forest fire detection.

In the category of machine learning. Supervised Learning has shown better results. Regression and Decision Tree are advocated by most authors. Apart from these deep learning algorithm CNN is used by authors to show accuracy.

4 Evaluation Criterion

Most of the authors have reported image-level evaluation, i.e., fire and non-fire image classification accuracy. Some of them have also reported patch-level detection accuracy, but ground truth are not publicly available. We consider an evaluation criteria for both image-level as well as patch-level classification accuracy.

Criteriato evaluate a fire detector:

ACCURACY =TP+TN/NPOS +NNEG

DETECTION RATE=TP/NPOS

FALSE ALARM RATE =FN/NNEG

where

TP is the number of true positives, i.e. the number of fire patches classified as fire

TN is the number of true negatives, i.e. the number of non-fire patchesclassified as non-fire,

FN is the number of false negatives, i.e., the number of non-fire patches classified as fire. NPOS and NNEG are the number of positives and the number of negatives in the ground truth respectively.

5 Results

Table1: Accuracy Results

Algorithm	Accuracy
Logistic Regression	89.47%
Random Forest	84.21%
KNN	73.68%
SVM	89.47%
Decision Tree	73.68%

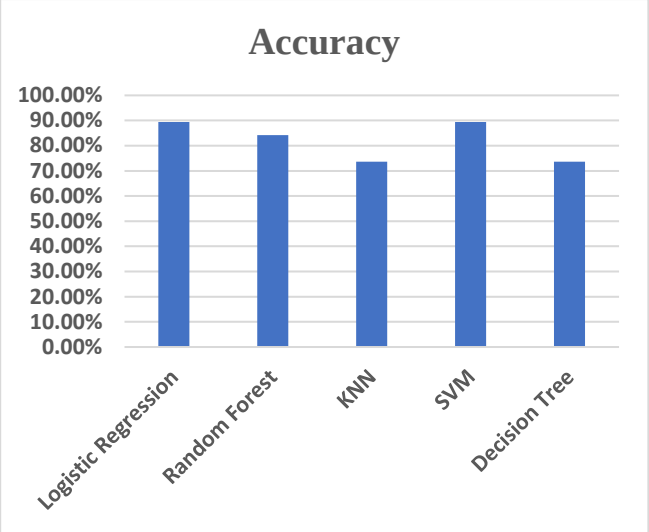

Fig 2: Accuracy Comparison Chart

6 Conclusion

In this paper an analysis of various machine learning techniques has been done after reviewing the literature on forest fire detection. Various techniques have been studied .These techniques include Regression, Decision Tree, Random Forest, SVM and CNN .The methodology in these techniques has been studied. A measurement of the accuracy to evaluate these techniques for forest fire detection has been done. The accuracy of these models has been compared

We strongly advocate machine learning techniques for forest fire detection Logistic regression has been shown to be an efficient machine learning algorithm for forest fire detection.

CNN is also a potential technique for forest fire detection that could show good results and may be considered for further research.

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