Fire Detection System Using Machine Learning Algorithms

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Abstract-- There are lots of disasters happening in recent times in the world. One of the major disasters which have drawn the most attention is the large area fires, especially forest areas. Forest fires can occur naturally and also sometimes by humans. Forest Fires just does not harm the plants and trees of the forest, but also the animals living in the forest. It also affects the nearbyplaces where humans live since smoke, carbon dioxide and carbon mono-oxide concentration increase in the atmosphere which can lead to several health problems such as respiratory problems. We can detect the fire by deploying various wireless sensor nodes in the forest areas by which they sense the fire and can inform us, sothat we can control the damage to be done by forest fire.

We can increase the efficiency of detection using machine learning techniques on the data collected by various wireless sensor nodes. In this report we will compare some of the machine learning techniques used by researchers with wireless sensor nodes in predicting forest fire.

Keywords: *Forest Fire; WSN; Correlation Coefficient; Sensor Nodes.*

I. INTRODUCTION

In earlier times fires were detected with the help of watching towers or using satellite images. Paper [9] discussed these approaches. Satellites collect imagesand send it to the monitoring authority which will decide by seeing images that it is a fire or not. But this approach was very slow as the fire may have spread in the large areas and caused so much damagebefore the rescue team came. In the watching tower method, there was a man always standing on the tower who would monitor the area and inform if there was fire. This method was also slow because before the man got to know about the fire it may have spread in the inner parts of forest, also it always

requires a man who must be present there. Since, we know that some areas, especially forest areas are large so it is practically impossible to put a man in every part of forest from where they can monitor theforest area. So, both these approaches of watching towers and satellite images failed to detect fire as early as possible to reduce the damage done by fire Problems in fire detection: There were mainly two problems in fire detection as discussed:

Threshold is set, if the value is greater than threshold then it is a fire, else not. So, this problem was removed by using machine learning techniques by many researchers.

Traditional systems usedcables to connect alarm with the detectors. Cable was mainly of copper. But copper wire may be costly or it can suffer from fault in the mid-way. So,this problem was removed using wireless sensor networks.

So, with the advancement in technology researchers find an efficient method to detect forest fire with the help of Wireless Sensor Network. Fire can be detected by deploying sensor nodes in the forest areas by which they inform about the fire. [12] Deploying sensor nodes in the forest area means placing sensors in every part of the forest and mostlyin the prone areas where risk of 9 catching fire is more. With the use of wireless sensor networks, nowit is easy to detect the fire in large areas as soon as possible.

II. LITERATURE SURVEY

CNN has been proposed for the detecting the fire occurrence in different systems [1]. The projected model uses advanced countenance transform and order calculations through deep education and the convolutional affecting animate nerve organs arrangements (CNN) which will boost the dwellings smoke alarm performance and eradicate annoyance alarm sketches.

The CNN based network has been proposed in paper [2], proposes use of transfer learning that is based on deep CNN approach to detect fire. It includes the use of MobileNet and pre-trained deep CNN architecture namely VGG, for development of fire detection system. These deep CNN models are trained on imbalanced datasets to impersonate optimal situations. The aftereffects of deep CNNs models show that these models augmentation accuracy completely and it is visualized that deep CNNs models are beat unoriginal Convolutional Neural Networks model. The veracity of MobileNet is mainly equivalent to VGGNet, nevertheless, MobileNet is more limited in amount and smart than VGG.

Deep Convolutional Neural Network was employed for discovery of mechanical fire structure created to label jungle fires, rather, in their inception. [3] The foundation pipeline processes pictures of the woodland environment and can identify the appearance of fume or blazes. Moreover, the foundation can form an evaluation of the district under start because allure intensity maybe determined. During the time gone composition of a fire picture, one Deep Convolutional Neural Network was employed to separate, from the pictures, the descriptors that are before used to a Logistic Regression classifier.

An Efficient Deep Learning Algorithm for Fire and Smoke Detection with novel deep convolutional interconnected system in paper [4]. It treasure to realize high-veracity fire and the fume representation discovery.

Rather than promoting traditional rectified straight parts or functions, they exploit flexible piecewise uninterrupted units in the secret coatings of the institution. They still founded a new narrow dataset of fire and smoke figures to train and judge our model. To resolve the overfitting issue caused success by way of training the arrangement on a limited dataset, they bother the pile of approachable preparing pictures appropriating normal facts that increases blueprints and fruitful adversarial networks. Test results show that the projected approach achieves extreme veracity and a extreme location rate, while an intensely depressed pace of counterfeit alerts.

Utilizing Convolutional Neural Networks (CNN) algorithms in detection of fire [5]. They intend a novel whole for recognizing fire. Location of fire maybe intensely worrisome applying existent approaches for smoke sensors popularized in the buildings. They are slow and cost careless by way of their raw design and innovation. This paper basically dissects the opportunity of Artificial awareness for acknowledgment and shipping alarms accompanying video from CCTV movie. This project resorts to a self-massed dataset holding broadcast frames with fire. The news is therefore preprocessed and applied for one CNN to assemble a machine learning model. The test set of the dataset is likely as recommendation for authorizing the judgment and inquiries are eminent. The undertaking center about construction cost-adept and deeply exact machines that can be exploited in nearly some exercise instance of the fire discovery.

Mechanical fire discovery is significant for early finding and fast airless fire [6]. There are plentiful examinations investigating high-quality sensor mixes and correct approaches for early fire recognition. In the past examinations, fire finding has either happened thought-out as utilization of a particular field or the basic worry for that methods have existed definitely projected (e.g., fire acknowledgment handling detached detecting processes). These various methods arise differing foundations of chemists directing fire, like operating system engineering, terrain and ground understanding, and fire security. In this report, they survey past examinations in accordance with three outlooks: (1). fire acknowledgment procedures for neighborhoods, (2). fire finding forms for timberlands, and (3). obligations of sensor organizations to early fire discovery.

Inspection search out address the plan issues in WSNs is presented. [7] As maybe visualized inside this paper, incalculable undertakings have existed influenced earlier; a few design issues in detached sensor networks have happened helped to handle differing AI methods. Using AI-based forethoughts in WSNs needs to analyze differing imperatives, e.g., insignificant wellsprings of the organization request that really needs unconnected events expected understood just as added working and non-working aspects.

III. PROPOSED APPROACH

A. Acquisition of Dataset

Dataset or informational index is taken from UCIMachine Learning repository; description of dataset is described as: Dataset contains image and video data; Image data contains train and test data in each having 3 class i.e., default, smoke, fire. in image format; Test_default has 84 images; test_fire has 57 images, test_smoke has 30 images; Test_video contains 3 videos; Train_video contains 12 videos consisting of fire with smoke, only fire, only smoke, no fire videos.

B. Data Preprocessing

Data preprocessing is the following phase of building a quality AI model. Here, the data gets cleaned and handled or basically makes the information fit for use. Data preprocessing comprises of eliminating the commotions and other undesirable objects from the edge.

C. Data Analysis

The data is then observed and analyzed in order to extract the features which is most the responsible for fire in a particular area.

D. Training and Testing

The dataset is then passed through various machine learning models where it trained using training data and then testing is performed using raw input data.

E. Model Performance Metrics

The below table is represented as a two-category confusion matrix containing four parameters.

Table 1. Performance Metrics Calculation Table

		True class p	True class n
Hypothesized class	Y	True Positives	False Positives
	N	False Negatives	True Negatives
Column totals:		P	N

True Positive (TP): The prediction is positive, and the actual is a positive example.

False Positive (FP): The prediction is a positive example, and the actual is a negative example.

True Negative (TN): The forecast is negative and the actual is negative.

False Negative (FN): The prediction is a positive example, and the actual is a negative example.

And the calculation formulas are used as follows:

Accuracy = (TP + TN) / (TP + TN + FP +FN)

Precision = TP / (TP + FP)

Recall = TP / (TP + FN)

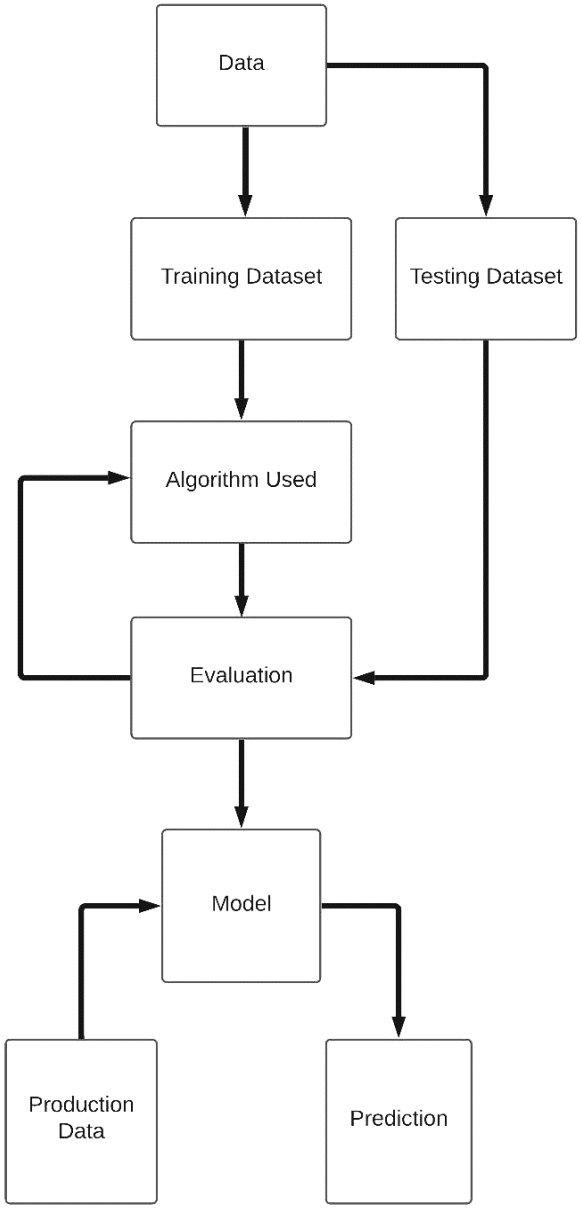

Fig.1. Project Workflow Diagram

Above fig.1 is the workflow diagram of project that performs various tasks such as - to gather the data, to pre-process data, to identify the model best fitted for our data, to train the data and evaluate it.

IV. EXPERIMENT AND RESULTS

For this purpose, **"Forest-fires.csv"** dataset from UCI machine learning repository was taken and machine learning algorithms were applied to find accuracy of detection. The dataset **"Forest-fires.csv"** contains 517 instances and 13 attributes.

Table 2. Correlation Coefficient Analysis

Attributes	Correlation Coefficient
Day	-0.042970
RH	-0.035587
Rain	0.025550
ISI	0.035663
Wind	0.055702
Y	0.056892
X	0.062491
DMC	0.062672
FFMC	0.073823
Temperature	0.076047
DC	0.096724
Month	0.130329
Output	1.000000

Thus, we can see from the table that attribute month has the highest correlation coefficient value. [13] Hence it is most responsible for fire in a particular area. We used various algorithms for our purpose such as KNN, Decision Tree, SVM, etc.

For example, let us take **KNN Algorithm**

1. Importing K Nearest Neighbor

```
from sklearn.neighbors import KNeighborsClassifier
k_nearest_neighbor_model = KNeighborsClassifier(n_neighbors=1)
k_nearest_neighbor_model.fit(X_train,y_train)
pred = k_nearest_neighbor_model.predict(X_test)
```

2. Error Rate VS K-value:

```
error_rate = []
for i in range(1,100):
    k_nearest_neighbor_model = KNeighborsClassifier(n_neighbors=i)
    k_nearest_neighbor_model.fit(X_train,y_train)
    pred_i = k_nearest_neighbor_model.predict(X_test)
    error_rate.append(np.mean(pred_i != y_test))


plt.figure(figsize=(10,6))
plt.plot(range(1,100),error_rate,color='blue', linestyle='dashed',
        marker='o', markerfacecolor='red', markersize=10)
plt.title('Error Rate vs. K Value')
plt.xlabel('K')
plt.ylabel('Error Rate')
```

The following graph shows the variation of error rate with K Value.

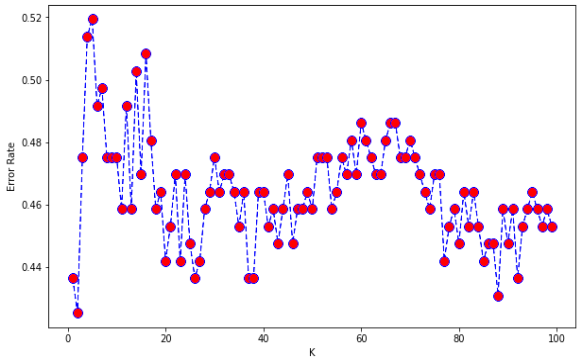

Fig.2. Error rate vs K Value Diagram

3. Training the Machine using Dataset:

This algorithm is then fitted according to the dataset provided.

```
knn = KNeighborsClassifier(n_neighbors=7)
knn.fit(X_train,y_train)
pred = knn.predict(X_test)
print('WITH K=7')
print('\n')
print(confusion_matrix(y_test,pred))
print('\n')
print(classification_report(y_test,pred))
```

Output:

```
WITH K=7


[[42 48]
 [42 49]]


              precision    recall  f1-score   support

         0.0       0.50      0.47      0.48        90
         1.0       0.51      0.54      0.52        91

    accuracy                           0.50       181
   macro avg       0.50      0.50      0.50       181
weighted avg       0.50      0.50      0.50       181
```

4. Finding Accuracy, Precision, Recall:

```
from sklearn import metrics
print("Accuracy:",metrics.accuracy_score(y_test, pred))
print("Precision:",metrics.precision_score(y_test, pred))
print("Recall:",metrics.recall_score(y_test, pred))
```

Output:

Accuracy: 0.5193370165745856
Precision: 0.5181818181818182
Recall: 0.6263736263736264

5. Testing the model with user input:

The fitted model is then tested by providing testing data to it.

```
classes={0:'safe',1:'On Fire'}
x_new=[[1, 4, 9 ,1 ,91.5, 130.1, 807.1, 7.5, 21.3, 35, 2.2, 0]]
y_predict=knn.predict(x_new)
print(classes[y_predict[0]])
```

Output:

On Fire

Following are the accuracies obtained from different machine learning algorithms. Table clearly shows that KNN Algorithm is the most accurate in predicting fire (accuracy 62.82%).

Table 2 Accuracy analysis of algorithm

Machine Learning Algorithm	Accuracy
Decision Tree	52.56%
Naïve Bayes Classifier	48.07%
Logistic Regression	55.80%
Support Vector Machine	61.50%
K nearest neighbor	62.82%

V. CONCLUSION & FUTURE WORK

In this paper, wireless sensor networks are helpful in detecting events. In the case of forest fire detection wireless network sensor nodes remove the difficulty faced in traditional methods like man standing on a tower a & monitoring the environment.

Now with the use of WSN we can put sensor nodes in each and everypart of forest and mostly in the region where the risk is high. All the data collected by sensor nodes have to be aggregated to reach the result so it is done by usingtree based and cluster-based methods. The machine learning techniques add enhancement to the security of wireless sensor networks. With the use of machine learning techniques, the problem of faulty nodes is minimized. With the use of regression algorithm network lifetime is enhanced and with the use of decision tree algorithm network lifetime is enhanced as well as accuracy.

We will be finding a method based on machine learning which will be *Accurate in prediction, Fault Tolerant, Robust* and then finding its space and time complexity and will try to optimize it

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