FIRE PREDICTION ANALYSIS BASED ON HYBRID MACHINE LEARNING ALGORITHMS

Abstract:

Fire accident is most tragedy incident in human life. Particularly environmental hazards such as forest fire leads loss of wildlife, economy, wealth, human lives and pollution. Fire prediction risk everything in its vicinity. Preliminary detection of such fires can help to control the blowout and protect nearby locations from loss. Our research purposes of predicting the occurrence of fire incidents using ensemble machine learning models. The best performance is gotten by the ensemble machine learning model for this work. Comparative study of individual model and ensemble model. If you check all models Decision tree predicts 75.4%, Random Forest tree predicts 83.2%, Support Vector machine predicts 71.8%, and K nearest neighbour predicts 82.1%. Ensemble models with two combinations of decision tree and random forest tree predicts accuracy is 80.8%. Support vector machine and KNN predicts the accuracy rate is 73.4%. Compare to ensemble learning model, individual model predicts more accuracy.

Keywords: Fire Prediction Analysis, Hybrid Machine Learning Models, accuracy

I. INTRODUCTION

The forest fires are most important environmental and social issues causing huge damage, wildlife loss and human lives loss [1]. Forest fires are the most unhelpful and overwhelming natural disasters. Forest fire prediction is good lesson for take precautions of forest fire in future. Number of fire detection system available for every strategy. The affected locations estimated with the support of satellite images [2].

Figure 1: Sample fire

The forest fires most frequently occurring disasters in current time. One important reason of fire occurrence in forest is global warming due to temperature of the earth. Some other reasons like human negligence, lightning and thunderstorms [3]. Due to forest fire can lead deforestation, which negative impact on human society. It is reported that every year lakhs of hectors destroyed. Forest fires combine with weather conditions, dryness of flame items and terrain [4]. Machine learning techniques mostly used for predict the forest fires. Few forest authorities use human observers as detectors and reporters of forest fires. Fire accident is most tragedy incident in human life [5]. Particularly environmental hazards such as forest fire leads loss of wildlife, economy, wealth, human lives and pollution. Fire prediction risk everything in its vicinity. Preliminary detection of such fires can help to control the blowout and protect nearby locations from loss [6].

The following paper continue with proposed system and architecture in section two. Section three discuss with result and analysis and comparative study. Final section conclude the paper

II. PROPOSED SYSTEM AND ARCHITECTURE

2.1 Proposed System

This research purposes at predicting the incidence of fires using ensemble machine learning models. If you check all models Decision tree predicts, Random Forest tree predicts, Support Vector machine predicts, and K nearest neighbour. Ensemble models with two combinations of decision tree and random forest tree and Support vector machine and KNN [7].

2.1.1 Data integration

Data integration is finished to make the data into entire file. Hence, it is required to mix the data into file.

2.1.2 Data cleaning

Data cleaning refers to discovery imperfect, incorrect, imprecise data components. We simply alteration the improper format in weather data to carry the accurate analysis [8].

2.1.3 Data reduction

The data reduction reduces the raw data into a more useful format. But weather data already include the useful data for analysis.

2.1.4 Data transformation

Data transformation for altering the scale of measurement of unique data into other forms so that the analysis can read weather data [9].

2.2 Classification model

Numerous models on forest fire prediction using machine learning have been developed. Machine learning integrate informatics and statistical analysis to progress prediction, hence extensively used to resolve uncertainty issues [10].

2.3. Testing and evaluation

For classification modelling, each experiment was performed using the data set split training and test data. The parameters to test every modeming's output as follows: accuracy Root Mean Square Error and confusion matrix [11].

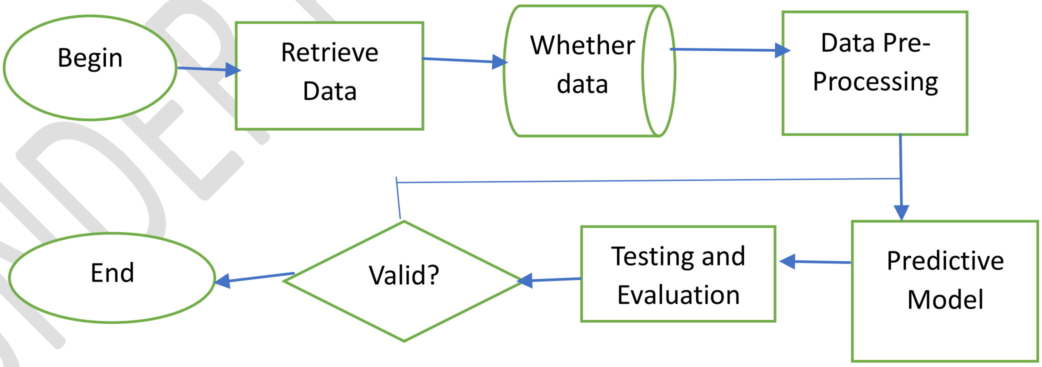


Figure 2: The architecture of Fire prediction using ML models

The figure 2 demonstrations the architecture of projected structure from start to finish of the paper. So many phases from input to output as procedure of machine learning. Fire prediction is most unhelpful and overwhelming natural disasters [12]. The forest fires most frequently occurring disasters in current time. One important reason of fire occurrence in forest is global warming due to temperature of the earth. Some other reasons like human negligence, lightning and thunderstorms. Due to forest fire can lead deforestation, which negative impact on human society [13].

III. RESULTS AND ANALYSIS

3.1 Dataset Description

Upload dataset of 55 attributes in the current browser session.

Table 1: dataset

	Elevation	Aspect	Slope	Horizontal_Distance_To_Hydrology	Vertical_Distance_To_Hydrology	Horizontal_Distance_To_Roadways	Hillshade_9am	Hillshade_Noon	Hillshade_3pm	Horizontal_Distance_To_Fire_Points
0	2596	51	3	258	0	510	221	232	148	6279
1	2590	56	2	212	-6	390	220	235	151	6225
2	2804	139	9	268	65	3180	234	238	135	6121
3	2785	155	18	242	118	3090	238	238	122	6211
4	2595	45	2	153	-1	391	220	234	150	6172

Soil_Type32	Soil_Type33	Soil_Type34	Soil_Type35	Soil_Type36	Soil_Type37	Soil_Type38	Soil_Type39	Soil_Type40	Cover_Type
0	0	0	0	0	0	0	0	0	5
0	0	0	0	0	0	0	0	0	5
0	0	0	0	0	0	0	0	0	2
0	0	0	0	0	0	0	0	0	2
0	0	0	0	0	0	0	0	0	5

3.2 Data Preprocessing

Check missing values and fill that values using dissimilar methods otherwise ignore that values. Remove abnormal value also.

Table 2: Dataset after pre processing

	Elevation	Aspect	Slope	Horizontal_Distance_To_Hydrology	Vertical_Distance_To_Hydrology	Horizontal_Distance_To_Roadways	Hillshade_9am	Hillshade_Noon	Hillshade_3pm	Horizontal_Distance_To_Fire_Points
count	2000.000000	2000.000000	2000.000000	2000.000000	2000.000000	2000.000000	2000.00000	2000.000000	2000.000000	2000.000000
mean	2894.813000	133.926000	13.902000	222.661500	38.874000	2743.085500	219.25700	217.723000	128.357500	2470.935000
std	233.116052	105.504944	8.484185	172.381674	49.748443	1929.001563	22.37459	23.644509	43.823555	1518.617143
min	2000.000000	0.000000	0.000000	0.000000	-134.000000	67.000000	100.00000	99.000000	0.000000	60.000000
25%	2744.000000	57.000000	7.000000	90.000000	5.000000	849.000000	209.00000	208.000000	107.000000	1489.000000
50%	2907.000000	90.000000	12.000000	190.000000	23.000000	2758.000000	224.00000	223.000000	134.000000	2140.000000
75%	3052.500000	198.500000	18.000000	319.000000	60.000000	4542.750000	234.00000	234.000000	156.000000	2919.500000
max	3404.000000	359.000000	49.000000	997.000000	554.000000	6890.000000	254.00000	254.000000	246.000000	6853.000000

8 rows × 55 columns

Soil_Type32	Soil_Type33	Soil_Type34	Soil_Type35	Soil_Type36	Soil_Type37	Soil_Type38	Soil_Type39	Soil_Type40	Cover_Type
2000.000000	2000.000000	2000.0	2000.0	2000.0	2000.0	2000.000000	2000.00000	2000.000000	2000.000000
0.005500	0.018000	0.0	0.0	0.0	0.0	0.017500	0.01250	0.003500	2.843500
0.073976	0.132984	0.0	0.0	0.0	0.0	0.131158	0.11113	0.059072	1.803783
0.000000	0.000000	0.0	0.0	0.0	0.0	0.000000	0.00000	0.000000	1.000000
0.000000	0.000000	0.0	0.0	0.0	0.0	0.000000	0.00000	0.000000	2.000000
0.000000	0.000000	0.0	0.0	0.0	0.0	0.000000	0.00000	0.000000	2.000000
0.000000	0.000000	0.0	0.0	0.0	0.0	0.000000	0.00000	0.000000	5.000000
1.000000	1.000000	0.0	0.0	0.0	0.0	1.000000	1.00000	1.000000	7.000000

After pre-processing complete list out the variables with count.

Table 3: Variable count

```
2      827
5      518
1      488
7       86
3       43
6       36
4        2
Name: Cover_Type, dtype: int64
```

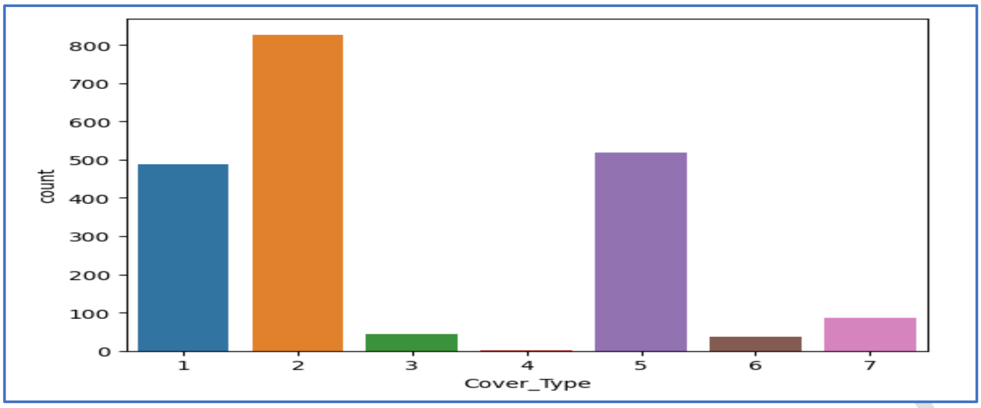


Figure 3: Chart for Variable count

3.3 Visualization

Based on given dataset after pre-processing of data, it can be shows in different graphs with multiple time slots with fire points.

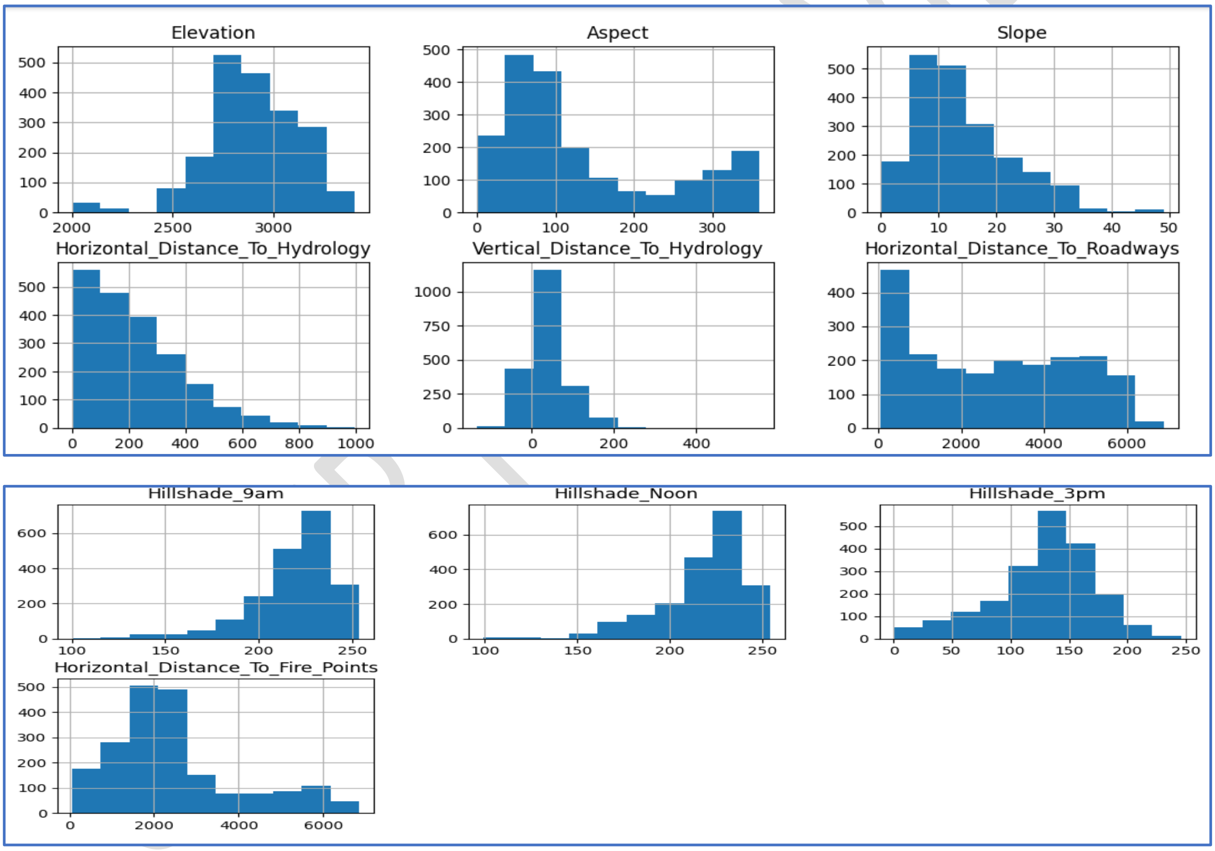
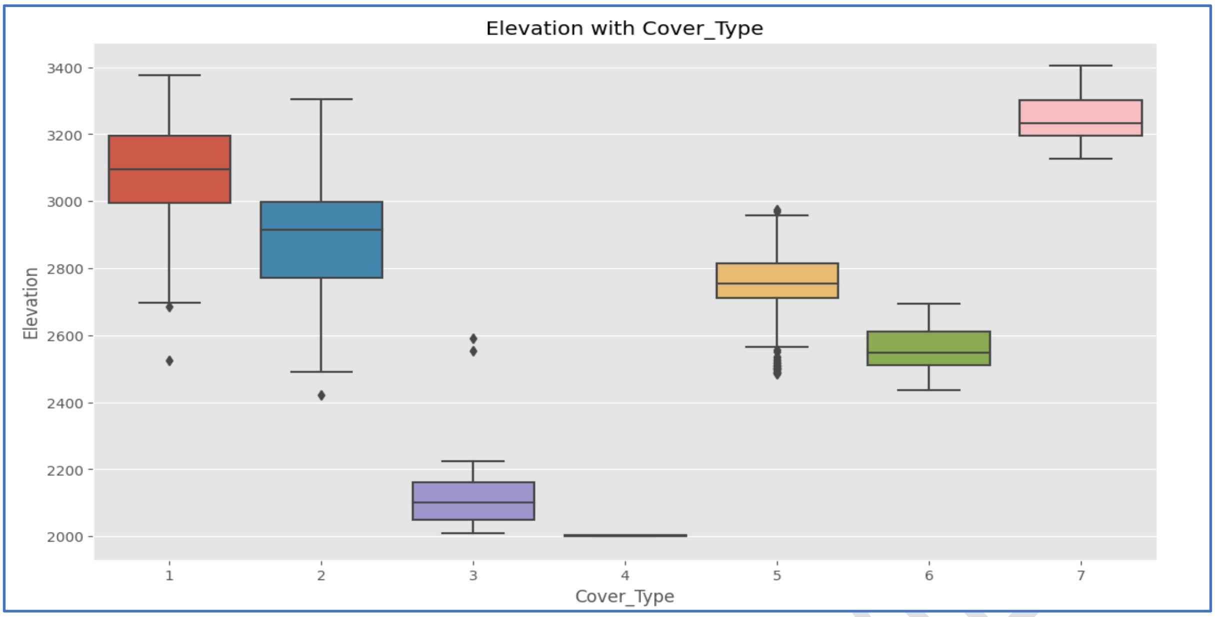
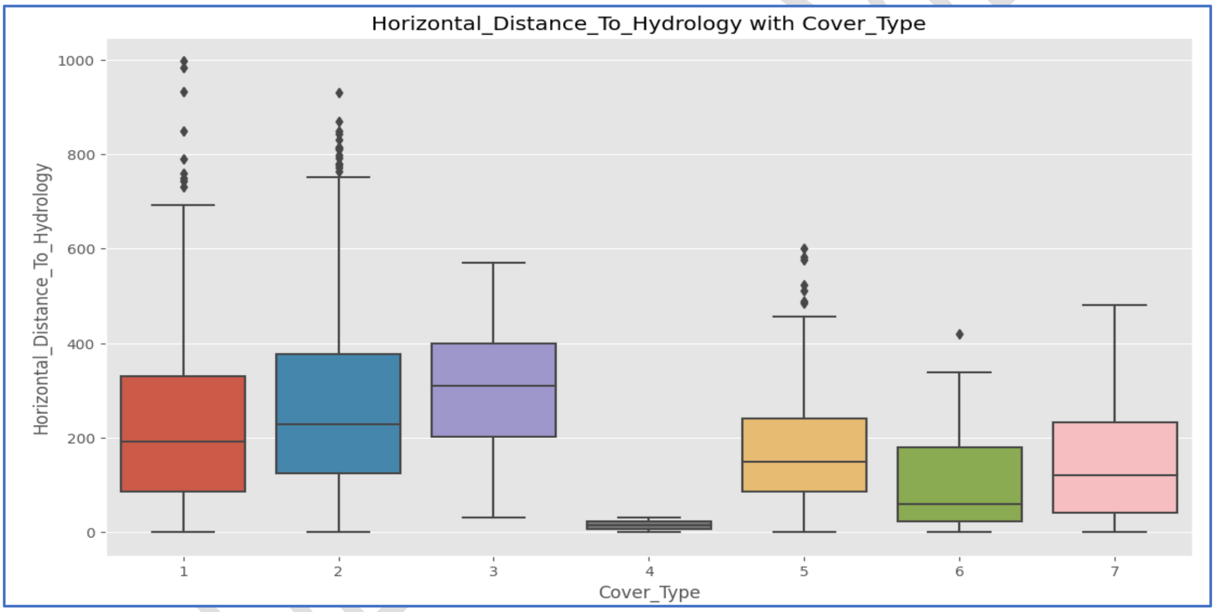
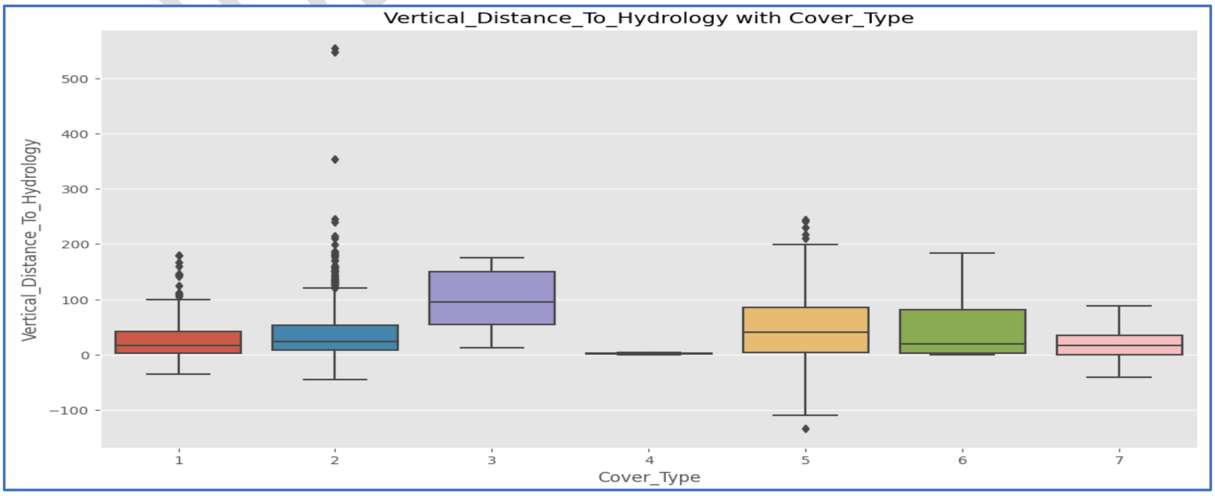


Figure 4: Data visualization @ multiple time slots with different fire points

The following figures 3 shows the detailed visualization of given dataset with corresponding figure 4.


Elevation with Cover_Type
Elevation
Cover_Type
3400
3200
3000
2800
2600
2400
2200
2000
1
2
3
4
5
6
7


Horizontal_Distance_To_Hydrology with Cover_Type
Horizontal_Distance_To_Hydrology
Cover_Type
1000
800
600
400
200
0
1
2
3
4
5
6
7


Vertical_Distance_To_Hydrology with Cover_Type
Vertical_Distance_To_Hydrology
Cover_Type
500
400
300
200
100
0
−100
1
2
3
4
5
6
7

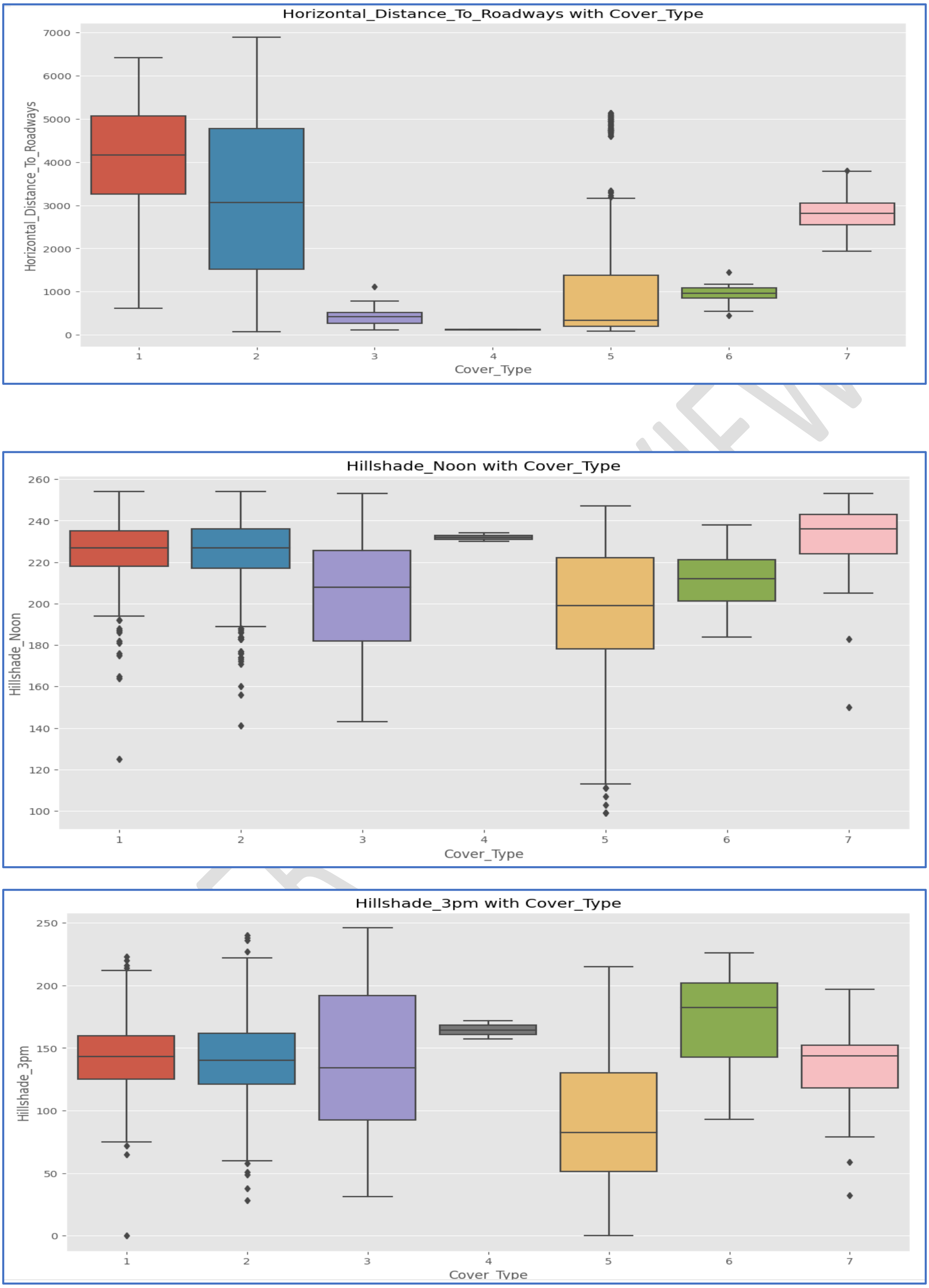


Figure 5: Detaileddata visualization

Heatmaps are used in numerous forms of analytics but are most normally used to demonstration of models.

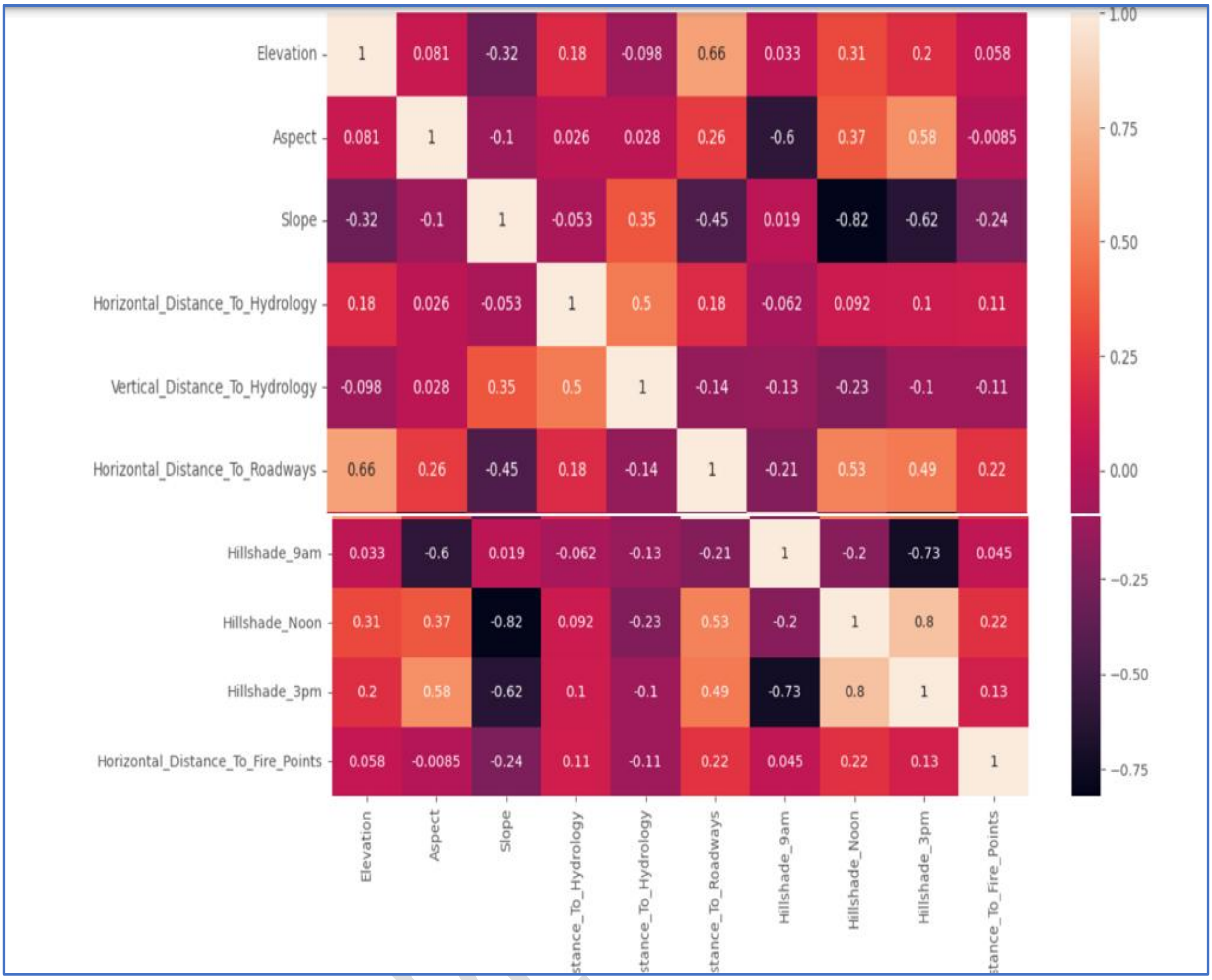


Figure 6: Heatmap for correlation of dataset

3.4 Feature Selection

In feature selection, initially separate the features and target. After that reduce the feature using dimensionality reduction algorithms and then shape the novel features. Finally split the data into test and train.

3.5 Ensemble Modelling

In past most of the research did the individual model of the data. Now we propose ensemble model that means combination of two or more models. Predict the results using these hybrid models. The following description for different models.

3.5.1 Decision Tree

```
[ ]  from sklearn.tree import DecisionTreeClassifier
     dt = DecisionTreeClassifier()

     dt.fit(X_train, y_train)

     y_pred = dt.predict(X_test)
     print("Accuracy -- ", dt.score(X_test, y_test)*100)

     Accuracy --  75.4
```

Decision tree predicts the accuracy rate is 75.4 percentage.

3.5.2 Random Forest

```
[ ]  #Random Forest
     from sklearn.ensemble import RandomForestClassifier
     rf = RandomForestClassifier(n_estimators=100)

     #fit
     rf.fit(X_train, y_train)

     #prediction
     y_pred = rf.predict(X_test)

     #score
     print("Accuracy -- ", rf.score(X_test, y_test)*100)

     Accuracy --  83.2
```

Random forest tree predicts the accuracy rate is 83.2 percentage.

3.5.3 Decision tree and Random Forest tree

We propose ensemble learning with the combination of decision tree and Random Forest tree. This model predicts the accuracy rate is 80.8 Percentage. This ensemble model performance is better than decision tree and low performance compare to random forest tree. Ensemble model is not good compare to random forest tree performance. Because Random Forest tree give more performance 83.2%. In this comparison Individual model is best than ensemble model.

```
from sklearn.ensemble import VotingClassifier

ensemble_model1 = VotingClassifier(estimators=[('decision_tree', dt), ('random_forest', rf)], voting='hard')

#fit
ensemble_model1.fit(X_train, y_train)

#prediction
y_pred = ensemble_model1.predict(X_test)

#score
print("Accuracy -- ", ensemble_model1.score(X_test, y_test)*100)

#confusion
cm = confusion_matrix(y_pred, y_test)
plt.figure(figsize=(10, 8))
sb.set(font_scale=1.2)
sb.heatmap(cm, annot=True, fmt='g')
plt.show()

Accuracy --  80.80000000000001
```

In predictive analytics, a table of confusion is a table with two rows and two columns that reports the number of true positives, false negatives, false positives, and true negatives.

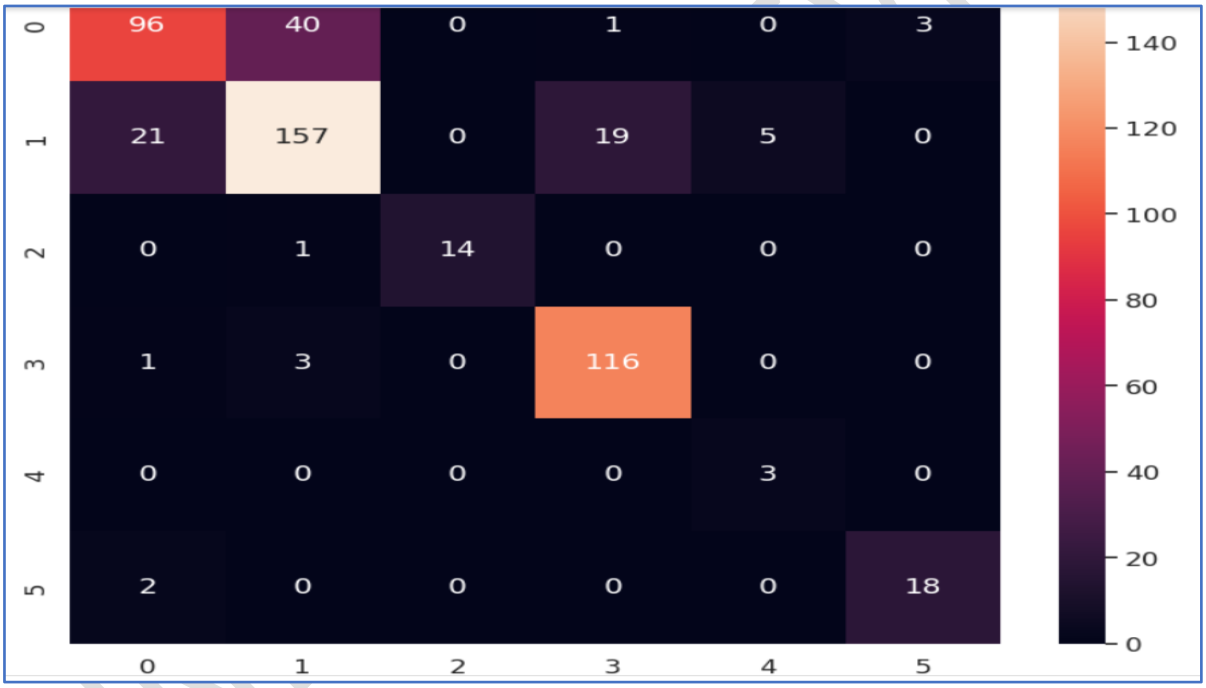


Figure 7: confusion matrix for ensemble learning (DT+RF)

5.6Ensemble model

5.6.1 Support Vector Machine

The support vector machine predicts the accuracy rate is 71.8%.

```
from sklearn.svm import SVC

svm_classifier = SVC(kernel='linear', C=1.0, random_state=42)

#fit
svm_classifier.fit(X_train, y_train)

#prediction
y_pred = svm_classifier.predict(X_test)

#score
print("Accuracy -- ", svm_classifier.score(X_test, y_test)*100)

Accuracy --  71.8
```

5.6.2 K Nearest Neighbour

The KNN model predicts the accuracy rate is 82.1%.

```
[ ]  from sklearn.neighbors import KNeighborsClassifier

     # Create a KNN classifier
     knn_classifier = KNeighborsClassifier(n_neighbors=3)

     #fit
     knn_classifier.fit(X_train, y_train)

     #prediction
     y_pred = knn_classifier.predict(X_test)

     #score
     print("Accuracy -- ", knn_classifier.score(X_test, y_test)*100)

     Accuracy --  82.19999999999999
```

6.2 Ensemble Model SVM and KNN

Ensemble model predicts the accuracy rate is 73.4%. This model predicts less accuracy compare to individual model of machine learning. KNN model predicts the 82.1% accuracy, it is better performance compare to ensemble learning (SVM+KNN).

```python
from sklearn.ensemble import VotingClassifier

ensemble_model2 = VotingClassifier(estimators=[('svm', svm_classifier), ('knn', knn_classifier)], voting='hard')

#fit
ensemble_model2.fit(X_train, y_train)

#prediction
y_pred = ensemble_model2.predict(X_test)

#score
print("Accuracy -- ", ensemble_model2.score(X_test, y_test)*100)

#confusion
cm = confusion_matrix(y_pred, y_test)
plt.figure(figsize=(10, 8))
sb.set(font_scale=1.2)
sb.heatmap(cm, annot=True, fmt='g')
plt.show()
```

```
Accuracy --  73.4
```

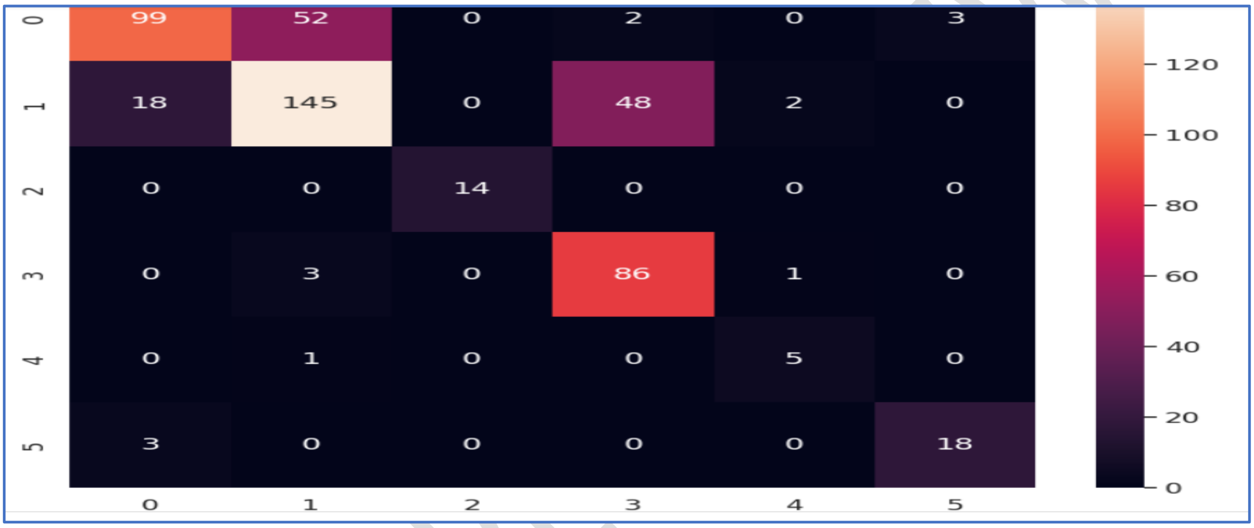


Figure 8: confusion matrix for ensemble learning (SVM+KNN)

5.7 Comparative study

The following table 4 for comparative study of individual model and ensemble model. If you check all models Decision tree predicts 75.4%, Random Forest tree predicts 83.2%, Support Vector machine predicts 71.8%, and K nearest neighbour predicts 82.1%.

Ensemble models with two combinations of decision tree and random forest tree predicts accuracy is 80.8%. Support vector machine and KNN predicts the accuracy rate is 73.4%. Compare to ensemble learning model, individual model predicts more accuracy.

Table 4: Comparative study of models

S. No.	Model Name	Accuracy Rate (%)
1	Decision tree	75.4
2	**Random forest tree**	**83.2**
3	SVM	71.8
4	**KNN**	**82.1**
5	DT+RF	80.8
6	SVM+KNN	73.4

IV. CONCLUSION

Fire accident is most tragedy incident in human life. Particularly environmental hazards such as forest fire leads loss of wildlife, economy, wealth, human lives and pollution. Fire prediction risk everything in its vicinity. Preliminary detection of such fires can help to control the blowout and protect nearby locations from loss. Our research purposes of predicting the occurrence of fire incidents using ensemble machine learning models. The best performance is gotten by the ensemble machine learning model for this work. The following table 4 for comparative study of individual model and ensemble model. If you check all models Decision tree predicts 75.4%, Random Forest tree predicts 83.2%, Support Vector machine predicts 71.8%, and K nearest neighbour predicts 82.1%. Ensemble models with two combinations of decision tree and random forest tree predicts accuracy is 80.8%. Support vector machine and KNN predicts the accuracy rate is 73.4%. Compare to ensemble learning model, individual model predicts more accuracy.

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