# A Project Report

*on*

# Forest Fire Prediction using ML

*carried out as part of the **Minor Project IT3270** Submitted*

by

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*in partial fulfilment for the award of the degree of*

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# CERTIFICATE

Date: 21 April 2023

This is to certify that the minor project titled **FOREST FIRE PREDICTION using ML** is a record of the bonafide work done by **NIMISHA BHADSAVALE** (209302369) and **UDAYAN KHETAN** (209302322) submitted in partial fulfilment of the requirements for the award of the Degree of Bachelor of Technology in Information Technology of Manipal University Jaipur, during the academic year 2022-23.

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## Abstract

Forests are complex ecosystems made up of trees, shrubs, and other vegetation that provide a wide range of ecological, social, and economic benefits. Forests play a crucial role in regulating the Earth's climate by absorbing and storing carbon dioxide, a greenhouse gas that contributes to global warming. They also play an important role in water regulation by acting as watersheds, filtering and regulating the flow of water into streams and rivers. However, forests are under a lot of threat due to forest fires which are spreading devastatingly across globe.

Forest fires can have devastating effects on the environment, including destruction of wildlife habitat, loss of biodiversity, and damage to soil and water resources. They can also pose a serious threat to human lives and property. This is why, prediction of forest fires beforehand in necessary. Forest fire prediction is a complex task that involves the use of various data sources and analytical methods. In this study, we will explore various data mining techniques to find out which of them works best in predicting accurate result. Logistic Regression, Decision Tree, K-Nearest Neighbor and Random Forest are the classification techniques we will be using to predict the occurrence of fire. Occurrence of fire is dependent on various features which will lead to the prediction through the above-mentioned classification techniques. The significance of Forest Fire Prediction model is that if the model predicts the fire accurately and the concerned authorities are notified timely, major destruction can be prevented.

# LIST OF FIGURES

# Table of Contents

# 1. Introduction

## *1.1 Introduction*

Forest fires are as old as the trees themselves. They endanger not only the wealth of the forest, but also the entire regime of the fauna and flora, upsetting the biodiversity, ecology, and ecosystem of a region. The woodlands get covered with dried, senescent leaves and twinges during the summer when there has not been any rain in months and they could catch fire with the smallest spark.

*Causes of Forest Fire*

1. Natural causes - Many forest fires are started by natural events like lightning, which ignites trees. But rain puts out such fires without doing much harm. High ambient temperatures and dryness (low humidity) provide ideal conditions for the onset of a fire.
2. Man-made causes - When an ignition source, such as a naked flame, a cigarette or bidi, an electric spark, or any other source of ignition, comes into touch with an ignitable substance, fire results.

*Types of Forest Fire*

1. Surface Fire - A forest fire, which predominantly burns as a surface fire, spreads along the ground as the surface litter (old, dried-out leaves, twigs, and other vegetation) before being consumed by the flames.
2. Underground Fire - Low intensity fires that consume the organic material underneath and the topsoil of the forest floor are categorized as subsurface fires. Most dense forests have a thick organic layer covering the mineral soil on top. Through the consumption of such things, this fire spreads. Muck fires are another name for this kind of fire.
3. Firestorms - The firestorm, which is an intense fire over a sizable region, is the forest fire that is expanding the fastest. The fire spreads as a result of heat rising and air rushing in as it burns. The fire spins erratically like a storm with more air.

## *1.2 Problem Statement*

Forest fires can cause extensive damage to the environment, wildlife, and human lives. Therefore, it is crucial to have an accurate forest fire prediction model that can alert authorities and individuals of potential fire outbreaks, allowing them to take preventive measures to minimize damage. The problem statement for a forest fire prediction model would be to develop a machine learning model that can accurately predict the occurrence of forest fires based on historical weather data, topography, and other relevant factors. The model should be able to forecast the likelihood of a fire outbreak in a particular region and provide early warnings to authorities and communities to take necessary actions to prevent and control the spread of forest fires.

### *1.3 Objectives*

- Early warning: The primary objective of a forest fire prediction model is to provide an early warning of potential fire outbreaks.
- Accuracy: The model is be able to accurately predict the likelihood of a fire outbreak in a particular region. The accuracy of the model will depend on the quality of data used to train the model and the complexity of the model.
- Speed: The model is able to generate predictions quickly to ensure that authorities and communities have enough time to take necessary actions to prevent or contain the spread of fires.
- Cost-effectiveness: The model is designed to be cost-effective and efficient in terms of data processing, storage, and analysis. This will ensure that the model can be easily deployed and used in areas that are prone to forest fires.
- Accessibility: The model is accessible to everyone who needs it. This includes authorities, communities, and individuals who live in areas that are prone to forest fires. The model should be easy to use and understand, even for non-technical users.

### *1.4 Scope of Project*

The scope of such a project can vary depending on factors such as the geographic region, the types of data available, and the objectives of the project.
Some potential areas of focus for a forest fire prediction project could include:

- Prediction models: Developing statistical or machine learning models that use historical data on weather patterns, vegetation, topography, and other relevant factors to predict the likelihood and severity of forest fires in a given area.
- Early warning systems: Building systems that can detect potential forest fires early on and alert authorities and residents in the affected area.
- Risk assessment: Assessing the risk of forest fires in a particular area based on factors such as the prevalence of dry and flammable vegetation, the topography, and the local climate.
- Wildfire management: Developing strategies and tools for managing wildfires, such as fire suppression tactics or controlled burns.
- Environmental impact assessment: Analyzing the potential environmental impact of forest fires, such as air pollution or damage to ecosystems, and developing mitigation strategies.

Overall, the scope of a forest fire prediction project can be quite broad, encompassing a range of data analysis and modeling techniques as well as practical applications for managing and mitigating the effects of forest fires.

## 2 Background Detail

[1] Sakr, G. E., Elhajj, I. H., Mitri, G., & Wejinya, U. C. (2010, July). Artificial intelligence for forest fire prediction. In 2010 IEEE/ASME international conference on advanced intelligent mechatronics (pp. 1311-1316). IEEE. An approach to the study of forest fire prediction methods based on artificial intelligence has been suggested. Forest fire risk forecast algorithm is built on help vector machines. Lebanon data were used for the application of the algorithm and has proven the ability to correctly estimate the risk of fire.

[2] Kansal, A., Singh, Y., Kumar, N., & Mohindru, V. (2015, December). Detection of forest fires using machine learning technique: A perspective. In 2015 third international conference on image information processing (ICIIP) (pp. 241-245). IEEE. In this paper, comparison of various machine learning techniques such as SVM, regression, decision trees, neural networks etc. has been done for prediction of forest fires. The proposed approach in this paper presents how regression works best for detection of forest fires with high accuracy by dividing the dataset. Fast detection of forest fires is done in this paper by taking less time as compared to other machine learning techniques.

[3] Yu, L., Wang, N., & Meng, X. (2005, September). Real-time forest fire detection with wireless sensor networks. In Proceedings. 2005 International Conference on Wireless Communications, Networking and Mobile Computing, 2005. (Vol. 2, pp. 1214-1217). Ieee. In this paper, they propose a wireless sensor network paradigm for real-time forest fire detection. The wireless sensor network can detect and forecast forest fire more promptly than the traditional satellite-based detection approach. This paper mainly describes the data collecting and processing in wireless sensor networks for real-time forest fire detection. A neural network method is applied to in-network data processing. We evaluate the performance of our approach by simulations.

[4] Cortez, P., & Morais, A. D. J. R. (2007). A data mining approach to predict forest fires using meteorological data. In this work, they explore a Data Mining (DM) approach to predict the burned area of forest fires. Five different DM techniques, e.g., Support Vector Machines (SVM) and Random Forests, and four distinct feature selection setups were tested on recent real-world data collected from the northeast region of Portugal. The best configuration uses a SVM and four meteorological and it is capable of predicting the burned area of small fires, which are more frequent.

[5] Castelli, M., Vanneschi, L., & Popovič, A. (2015). Predicting burned areas of forest fires: an artificial intelligence approach. Fire ecology, 11(1), 106-118. The purpose of this study was to develop an intelligent system based on genetic programming for the prediction of burned areas, using only data related to the forest under analysis and meteorological data. They used geometric semantic genetic programming based on recently defined geometric semantic genetic operators for genetic programming. results obtained with geometric semantic genetic programming were significantly better than those produced by standard genetic programming and other state of the art machine learning methods on both training and out-of-sample data. This study suggests that deeper investigation of genetic programming in the field of forest fires prediction may be productive.

[6] Madhurima De, Linika Labdhi, Bindu Garg (2020, April). Predicting Forest Fires With Different Data Mining Techniques. Bharati Vidyapeeth (Deemed to be University) College of Engineering, Pune, Maharashtra, India. ISSN: 2455-2631, IJSDR. In this work, we will be exploring various Data Mining (DM) approaches to predict the burnt area of forest fires. Five different DM techniques, e.g., Support Vector Machines (SVM) and Random Forests, and four distinct feature selection setups (using spatial, temporal, FWI components and weather attributes), were tested on recent real-world data.

[7] Preeti, T., Kanakaraddi, S., Beelagi, A., Malagi, S., & Sudi, A. (2021, June). Forest Fire Prediction Using Machine Learning Techniques. In 2021 International Conference on Intelligent Technologies (CONIT) (pp. 1-6). IEEE. This paper discusses about a comparative study of different models for predicting forest fire such as Decision Tree, Random Forest, Support Vector Machine, Artificial Neural networks (ANN) algorithms. The study of calculation of RandomizedSearchCV coefficient using Hyperparameter tuning gives best results of Mean absolute error (MAE) 0.03, Mean squared error (MSE) 0.004, Root mean squared error (RMSR) 0.07

[8] Elshewey, A. M., & Elsonbaty, A. A. (2020). Forest Fires Detection Using Machine Learning Techniques. Journal of Xi'an University of Architecture & Technology, 12(IX). This research proposes three machine learning approaches, linear regression, ridge regression, and lasso regression algorithm with data set size 517 entries and 13 features for each row. This paper uses two versions, all features are included in the first, and 70% of the features were included in the second. The paper uses a training set which is 70% of the data set, and the test set is 30% of the data set. The accuracy of the linear regression algorithm gives more accuracy than ridge regression and lasso regression algorithms.

[9] Gaikwad, A., Bhuta, N., Jadhav, T., Jangale, P., & Shinde, S. (2022, August). A Review On Forest Fire Prediction Techniques. In 2022 6th International Conference On Computing, Communication, Control And Automation (ICCUBEA (pp. 1-5). IEEE. Techniques studied in this paper are-Deep Learning, Machine Learning, and Artificial Intelligence, and Image Processing. Under these techniques, various algorithms like Genetic Algorithm, Fuzzy Logic, Decision Tree, Multilayer Perceptron (MLP), Artificial Neural Networks (ANN), Random Forest (RF), Spatial Wavelet Analysis for Colour Variations were studied. When compared to alternative techniques, the Artificial Intelligence approach produces better outcomes. The average accuracy obtained was higher than 90%.

[10] Manalu, D. R., Zarlis, M., Mawengkang, H., & Sitompul, O. S. (2020, December). Forest fire prediction in northern sumatera using support vector machine based on the fire weather index. In CS & IT Conference Proceedings (Vol. 10, No. 19). CS & IT Conference Proceedings. The aim of this study to predict the burned area and identify the forest fire in Aek Godang areas, North Sumatera. The result of this study indicated that Fire fighting and prevention activity may be one reason for the observed lack of correlation. The fact that this dataset exists indicates that there is already some effort going into fire prevention.

# 3 System Design and Methodology

## *3.1 System Design*

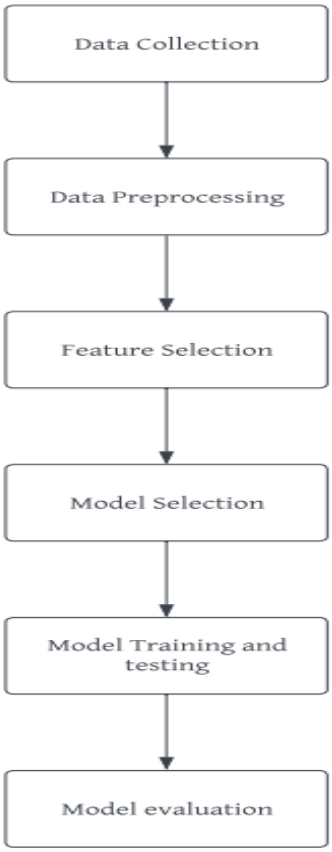


Fig 3.1.1: System Architecture

## *3.2 Development Environment*

*Hardware requirements*

- RAM-Min 4GB
- Processor: -I 3

*Software requirements*

- *Python compiler*
- *Vscode*

## *3.3 Methodology*

### *3.3.1 Data collection*

The first step is to gather relevant data that can be used to train the model. This can include historical data on past forest fires, weather patterns, topography, vegetation, and other factors that may influence the likelihood of a fire.
The forest fire dataset is a multivariate dataset which is a data set consisting of two or more than two variables is referred to as multivariate dataset. It has 13 attributes having 517 instances. The attributes are explained as follows:

1. Date: (DD/MM/YYYY) Day, month ('June' to 'September'), year (2012)
Weather data observations
2. Temp: temperature noon (temperature max) in Celsius degrees: 22 to 42
3. RH: Relative Humidity in %: 21 to 90
4. Ws: Wind speed in km/h: 6 to 29
5. Rain: total day in mm: 0 to 16.8
FWI Components
6. Fine Fuel Moisture Code (FFMC) index from the FWI system: 28.6 to 92.5
7. Duff Moisture Code (DMC) index from the FWI system: 1.1 to 65.9
8. Drought Code (DC) index from the FWI system: 7 to 220.4
9. Initial Spread Index (ISI) index from the FWI system: 0 to 18.5
10. Buildup Index (BUI) index from the FWI system: 1.1 to 68
11. Fire Weather Index (FWI) Index: 0 to 31.1
12. Classes: two classes, namely fire or not fire

### *3.3.2 Data preprocessing*

Once the data is collected, it may need to be preprocessed to ensure that it is in a suitable format for analysis. This can involve cleaning the data, normalizing it, and converting it into a format that can be easily fed into the machine learning model. Data augmentation is also done which duplicates examples from the minority class in the training dataset prior to fitting a model. This can balance the class distribution but does not provide any additional information to the model

### *3.3.3 Feature engineering*

After preprocessing, the data may need to be transformed into features that can be used to train the model. This involves selecting the most relevant variables and creating new features based on domain knowledge and statistical analysis.

We have performed feature selection using random forest. We have pruned ‘Ws’ feature and kept ‘FFMC’, ‘FWI’, ‘DMC’, ‘ISI’, ‘BUI’, ‘Rain’, ‘DC’, ‘Temp’, ‘RH’.

### *3.3.4 Model selection*

Next, a suitable machine learning algorithm needs to be selected to build the model. We have used 4 machine learning algorithms. Decision Tree, KNN, Logistic regression and Random Forest.

- Logistic Regression

  A statistical technique for forecasting binary classes is logistic regression. The desired variable or outcome is binary in nature. It can be applied, for instance, to issues with cancer detection. It determines the likelihood that an event will occur. It uses binomial regression in its design. It can forecast the target variable because of the relationship between the dependent and independent variables. The logistic regression makes use of the sigmoid function to calculate their likelihood and map them to some discrete values. It falls between [0, 1] in terms of value. Consequently, it is possible to say that 'z' indicates the likelihood of happening.

- Decision Trees

  Each internal node of a decision tree represents a test on a feature (such as whether a coin will land on its head or tail), each leaf node represents a class label (decision made after computing all features), and branches represent conjunctions of features that result in those class labels. Classification rules are represented by the routes from root to leaf. An algorithmic method for dividing a data collection into segments based on several criteria is used to build decision trees. It is among the most popular and useful techniques for supervised learning. A non-parametric supervised learning technique called decision trees is utilized for both classification and regression tasks.

- Random Forest
  Like its name suggests, a random forest is made up of numerous independent decision trees that work together as an ensemble. The class with the most votes become the prediction of our model from each individual tree in the random forest. Because they address the over-fitting problem with decision trees, random forests have an advantage over them.

- K-Nearest Neighbor
  A straightforward yet effective machine learning approach called K-Nearest Neighbors (KNN) is used to solve classification and regression issues. Since it is a non-parametric approach, the distribution of the input data is not presumptively assumed.
  The primary goal of KNN is to locate the K data points that are closest to a given query point using a distance metric, such as Manhattan distance or Euclidean distance. The algorithm predicts the class or value of the query point based on the most prevalent class among its K neighbors (for classification) or the average of the values of its K neighbors (for regression) after identifying the query point's K nearest neighbors.

### *3.3.5 Model Training*

The machine learning algorithms need to be trained on the preprocessed data to create a predictive model. This involves splitting the data into training and testing sets and using the training data to fit the model.

### *3.3.6 Model Evaluation*

After training, the model needs to be evaluated to determine its accuracy and performance. This can involve using various metrics such as precision, recall, F1 score, and area under the curve (AUC). The model with the highest accuracy is the one which predicts the occurrence of fire correctly.

### *3.3.7 Deployment*

Once the model has been trained and evaluated, it can be deployed in a production environment where it can be used to predict the likelihood of forest fires in real-time. This can involve integrating the model into a web application or a mobile app that can be accessed by stakeholders such as forest rangers, firefighters, and local authorities.

### *3.3.8 Monitoring and maintenance*

After deployment, the model needs to be monitored and maintained to ensure that it continues to perform well over time. This can involve tracking its accuracy, retraining it periodically, and updating it with new data as it becomes available.

Overall, designing a forest fire prediction model requires a combination of domain knowledge, statistical analysis, and machine learning expertise. The process involves several steps, from data collection and preprocessing to model selection, training, evaluation, deployment, and maintenance.

# 4 Implementation and Result

## *4.1 Modules of Project*

The libraries of python which are used are: -

- **NumPy** can be used to perform variety of mathematical operations on arrays
- **Pandas** provides fast, flexible, and expressive data structures designed to make working with "relational" or "labeled" data both easy and intuitive.
- The **sklearn.metrics** module implements functions assessing prediction error for specific purposes.
- The **sklearn.ensemble** module includes two averaging algorithms based on randomized decision trees
- The **sklearn.preprocessing** package provides several common utility functions and transformer classes to change raw feature vectors into a representation that is more suitable for the downstream estimators.
- **sklearn.model_selection** splits arrays or matrices into random train and test subsets.
- **linear_model** is a class of the sklearn module if contain different functions for performing machine learning with linear models.
- **sklearn.neighbors** provides functionality for unsupervised and supervised neighbors-based learning methods.
- **Imblearn.over_sampling** This object is an implementation of SMOTE

## *4.2 Implementation Detail*

After the dataset is finalized, data preprocessing has to be done to put the data into right shape and quality for training. We performed Data augmentation which duplicates examples from the minority class in the training dataset prior to fitting a model. This can balance the class distribution but does not provide any additional information to the model. Now, Feature selection is done to remove useless attributes which may weigh down the accuracy. This graph best describes the useless features: -

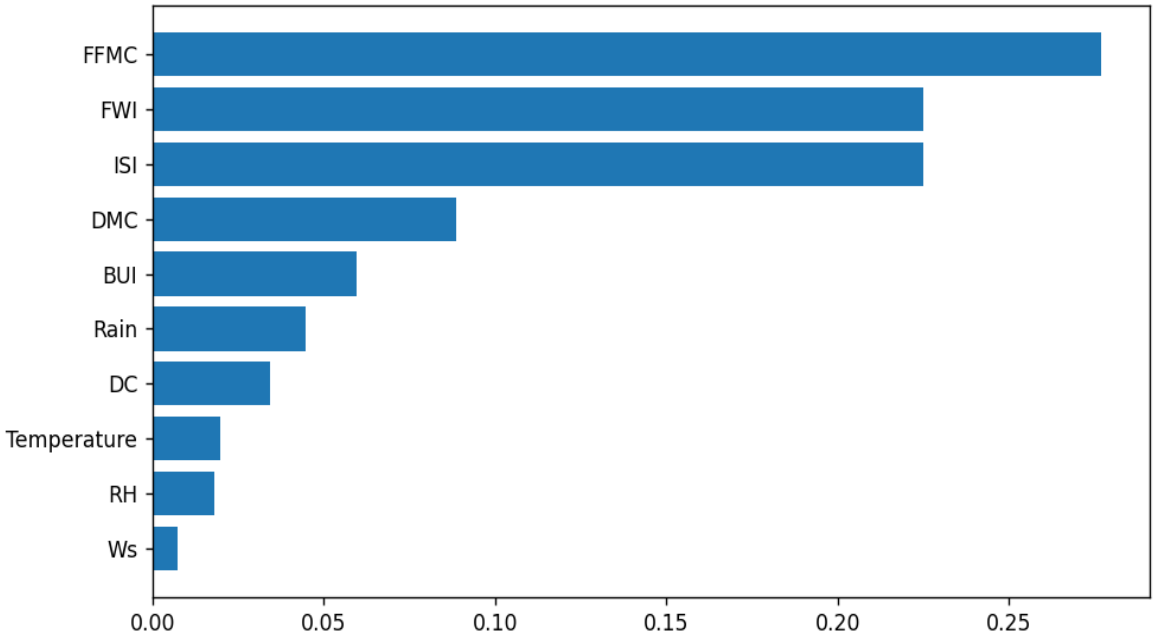

Fig 4.2.1: Feature Selection

Here we can see the 'Ws', Wind speed feature does not matter much, hence removed. Now we selected 4 Classification models and we calculate the accuracy of each of the models by training them on this dataset. After training we find the resultant accuracies of each model as: -
Decision Tree- 96.72%
Logistic Regression- 90.16%
Random Forest- 98.36%
K-Nearest Neighbors- 91.80% (when k=7), 85.24% (when k=4)

### *4.3 Results and Discussion*

After implementation of all the models we find out that Random Forest holds the highest accuracy of 98.36%.

*4.4 Timeline/Gantt chart*

| **S. no.** | **Activity** | 9 Jan'23 | 23 Jan'23 | 13 Feb'23 | 6 Mar'23 | 27 Mar'23 | 17 Apr'23 | 1 May'23 |
|---|---|---|---|---|---|---|---|---|
| 1 | Detailed literature review specific to problem | | | | | | | |
| 2 | Implementation of proposed solution | | | | | | | |
| 3 | Publication related to the proposed solution/techniques methods | | | | | | | |
| 4 | Thesis writing | | | | | | | |

# 5 Conclusion and Future Plan

The flora and fauna frequently experience forest fires. Numerous hectares of forest are lost every year all around the world. The loss of valuable human lives had further negative effects on the ecosystem. Forest fires are a severe environmental risk that endangers the preservation of the forests while harming the economy, the environment, and people. Rapid fire detection and response are effective ways to lessen fire damage. In order to improve early fire prediction and detection systems, which support the development of fireside response techniques, numerous studies are carried out. It denotes the provision of early warning detection. Early warning detection is expanded by reliable result prediction backed by established parameters.

After completing our research, we developed a system that uses weather information from the user, such as temperature, oxygen content, and humidity, to forecast the proportions of fires that may occur. The plan correctly foresees whether the fire will start or not.

This project can be improved by being enlarged in order to improve the models' capabilities and the results. For the application's UI, we might have built some real-time performance. The user may enter the local and zip code according to the UI model's procedure. We'll use the zip code to obtain latitude and longitude using any available APIs, then use the coordinates as inputs to retrieve meteorological data for a specific day, including the maximum and minimum temperatures, humidity levels, wind speeds, and more.

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