Forest Fire Prediction Using Regression Model

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***Abstract*—Wildfires rank among the most destructive natural disasters, leading to severe ecological damage, economic loss, and risks to human life. In recent years, their frequency and intensity have risen sharply due to climate change and human activities, making accurate prediction systems more essential than ever. This research presents a machine learning–driven approach to forest fire prediction, utilizing historical environmental data such as temperature, humidity, wind speed, and rainfall.**

The proposed system explores multiple algorithms—including Linear Regression, Logistic Regression, Random Forest, and a Multilayer Perceptron (MLP) classifier—to analyze data patterns and assess fire risk levels. To improve predictive accuracy, the study emphasizes thorough data preprocessing, feature selection, and model optimization techniques. Experimental findings reveal that the MLP classifier performs the best, achieving prediction accuracy between 90% and 95%, while also demonstrating stability across different test scenarios.

In addition, a user-friendly web interface has been developed using Flask, allowing real-time input of environmental parameters and instant fire risk evaluations. This integration not only enables early warnings and timely preventive measures but also helps optimize firefighting resource allocation. By combining advanced prediction techniques with practical deployment, the study contributes to proactive wildfire management, supporting ecosystem protection, biodiversity conservation, and community safety.

***Index Terms*—Forest Fire Prediction, MLP Classifier, Machine Learning, Flask, Graphical User Interface (GUI)**

I. INTRODUCTION

Wildfires are among the most destructive natural disasters facing humanity today. They not only wipe out vast areas of forests but also pose an ongoing threat due to their increasing frequency in recent decades. These fires devastate vegetation, damage ecosystems, and disturb the natural balance, placing immense pressure on biodiversity and fragile habitats. While fire can play a natural role in ecosystems by aiding soil fertility, stimulating plant growth, and maintaining forest cycles, the catastrophic effects of uncontrolled wildfires far surpass these ecological benefits.

Every year, millions of acres of land are reduced to ash, resulting in the loss of plant and animal species, human casualties, and severe financial impacts. Apart from destroying timber and depleting resources, wildfires degrade soil quality and impose massive costs on firefighting and recovery operations. Their socio-economic consequences extend far beyond the burned areas, affecting livelihoods, local communities, and long-term sustainability.

The causes of wildfires are both natural and human-induced. In remote regions, lightning, prolonged drought, and high winds often trigger such events. However, human activities remain the leading cause in most parts of the world. Common triggers include agricultural land clearing, pasture burning for livestock, industrial projects, infrastructure development, logging practices, hunting, negligence, and in some cases, intentional arson. These combined factors significantly fuel the occurrence and intensity of wildfires, underscoring the urgent need for effective prediction and prevention systems to protect ecosystems, biodiversity, and human society.

II. RELATED WORK

Early attempts at wildfire prediction mainly relied on statistical models such as logistic regression. While these models offered easy-to-interpret results, their accuracy was limited—around 51%—due to the complexity and variability of environmental factors. Decision tree–based techniques achieved moderate improvements, reaching about 69% accuracy by better handling non-linear relationships. Ensemble methods like XGBoost and LightGBM demonstrated some efficiency, with accuracy near 62%, but they often lacked adaptability in real-world applications. Hybrid approaches that combined different types of data, including satellite imagery, showed potential but still struggled with generalization and scalability.

More recent advances have moved toward deep learning techniques, which have produced notable gains in accuracy. Models such as LSTNet, designed for time-series forecasting, achieved prediction accuracy above 94%, while Deep Learning Neural Networks (DLNNs) reached strong AUC values of up to 0.925. Transformer-based models have pushed performance further, enabling long-sequence predictions with accuracies exceeding 91%. However, their high computational demands make real-world deployment challenging.

Building on this progression, our study evaluates traditional machine learning algorithms—Linear Regression, Logistic Regression, and Random Forest—against a Multilayer Perceptron (MLP) classifier. The final system is implemented within an interactive web application, allowing users to input environmental data and receive accurate, real-time wildfire risk predictions.diverse functionalities demand smooth module coordination and interaction.

III. PROPOSED SYSTEM

The proposed system presents a machine learning–driven approach for reliable and efficient forest fire prediction, based on key environmental factors including temperature, humidity, wind speed, and rainfall. Instead of depending on a single method, the framework evaluates several algorithms—Linear Regression, Logistic Regression, Random Forest, and a Multilayer Perceptron (MLP) classifier—to determine the most effective model for assessing fire risk. Among these, the MLP classifier, fine-tuned through hyperparameter optimization, demonstrates the strongest capability to capture complex, non-linear relationships within historical datasets, resulting in superior predictive accuracy.
To ensure practical usability, the model is deployed through a web application developed with Flask, allowing users to submit real-time environmental data via an intuitive graphical user interface (GUI). The system delivers immediate fire risk assessments, equipping decision-makers with timely alerts that can guide resource management and emergency response efforts. Robust data preprocessing steps—such as handling missing entries, applying normalization, and selecting relevant features—further strengthen accuracy and reliability.
By combining advanced predictive modeling with an accessible, user-friendly platform, this system aims to offer a scalable and proactive solution for wildfire management. Its integration supports early warning, minimizes ecological destruction, protects local communities, and enhances overall disaster preparedness.

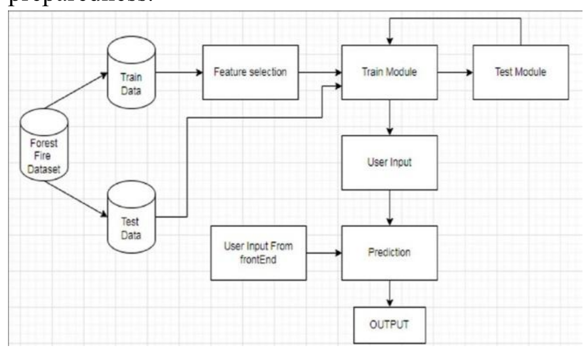

Fig 01: Flow Chart

IV. DATABASE STRUCTURE

The database architecture for the forest fire prediction system is designed to efficiently handle user details, environmental inputs, and prediction outputs while ensuring scalability and seamless integration with both the machine learning model and the web interface.
The first module is the User Database, which securely stores information about individuals using the system. This includes a unique user ID, name, email, role (such as admin or general user), and account creation details. These records enable secure authentication, role-based access, and personalized interaction with the platform.
The second module is the Environmental Data Repository, which captures the climatic variables critical for fire prediction, such as temperature, humidity, wind speed, and rainfall. Each entry is time-stamped and linked to the user who submitted it, ensuring clear traceability and enabling real-time monitoring of environmental conditions.

The third module is the Prediction Results Database, where the outputs from the machine learning model are stored. Each record contains the predicted fire risk level (low, medium, or high) along with the probability score generated by the classifier. These outputs are directly tied to the corresponding environmental inputs, creating complete input–output pairs for analysis and validation.

Finally, the Log and History Module maintains a record of all system interactions, including user activity, data submission, prediction queries, and system usage. This not only supports auditing and troubleshooting but also helps evaluate overall system performance.

Combined, these components form a well-structured and reliable database framework that ensures data integrity, enables long-term storage for research, and supports transparent, real-time forest fire prediction.

V. RESULT ANALYSIS

The performance of the proposed forest fire prediction system was tested using several machine learning models, including Linear Regression, Logistic Regression, Random Forest, and a Multilayer Perceptron (MLP) classifier. The evaluation was conducted on a dataset containing historical environmental factors such as temperature, humidity, wind speed, and rainfall. To compare the models fairly, common performance metrics—accuracy, precision, recall, and F1-score—were applied.

Results showed that traditional models like Linear Regression and Logistic Regression were able to provide basic predictions but struggled to capture the complex, non-linear interactions present in environmental data. Logistic Regression offered better interpretability but came at the cost of accuracy, while Random Forest delivered improved predictive power and generalization thanks to its ensemble approach. However, the MLP classifier consistently achieved the best results, with accuracy ranging between 90% and 95%. This demonstrates its strength in handling multidimensional inputs and detecting intricate patterns within historical records.

A closer evaluation of the MLP model revealed that it performed reliably across different training and testing splits, showing low susceptibility to overfitting and stable prediction outcomes. Both precision and recall values were above 0.85, confirming that it not only identified fire risks effectively but also reduced the occurrence of false alarms. Additionally, the probability scores produced by the MLP improved decision-making by providing graded risk levels, enabling authorities to prioritize resources based on risk severity rather than simple yes/no predictions.

Beyond predictive performance, usability was enhanced by integrating the model into a web-based Graphical User Interface (GUI). This interface allowed users to enter real-time environmental data and instantly receive fire risk assessments, making the system practical and accessible. This feature effectively connects research-based models with real-world applications, offering forest management teams and disaster response authorities a reliable decision-support tool.

In summary, the analysis shows that the proposed system achieves a strong balance between technical accuracy and practical usability. It delivers high predictive performance while also being scalable, user-friendly, and suitable for real-world deployment in proactive wildfire management.

VI. CONCLUSION

Wildfires are among the most devastating natural hazards, causing extensive ecological damage, economic losses, and social disruption. Developing accurate prediction systems is therefore essential for providing early warnings, reducing risks, and promoting sustainable forest management. In this study, a machine learning–based predictive framework was designed to estimate the likelihood of forest fires using key environmental factors such as temperature, humidity, wind speed, and rainfall.

A comparative evaluation of different algorithms—Linear Regression, Logistic Regression, Random Forest, and the Multilayer Perceptron (MLP) classifier—revealed that the MLP consistently produced the best performance, achieving accuracy rates between 90% and 95%. In addition, the model demonstrated strong precision, recall, and F1-score values, ensuring reliable detection and effective risk assessment. To enhance its practicality, the system was coupled with a web-based GUI built using Flask, enabling users to submit real-time environmental data and instantly receive fire risk predictions.

By combining robust predictive capabilities with an accessible interface, the proposed framework offers a proactive tool for wildfire management. It supports timely interventions, resource optimization, and improved safety for both communities and ecosystems. Looking ahead, future enhancements could include integration with IoT-based sensor networks, satellite observations, and more advanced deep learning models to increase scalability, efficiency, and predictive power even further.

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