



International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.699

Volume 14, Issue 4, April 2025

⊕ www.ijirset.com 🖂 ijirset@gmail.com 🖄 +91-9940572462 🕓 +91 63819 07438



International Journal of Innovative Research of Science, Engineering and Technology (IJIRSET)



www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 4, April 2025

|DOI: 10.15680/IJIRSET.2025.1404645|

Forest Fire Prediction Model based on Cellular Automata and Machine Learning

Dr.Prem Kumar P¹, Kumaresh Babu N.K², Rohith R.R³, Risikesan K.J⁴

Associate Professor and Faculty Mentor, Dept. of Computer Science and Engineering, K L N College of Engineering,

Madurai, Tamil Nadu, India¹

B.E Student, Dept. of Computer Science and Engineering, K L N College of Engineering, Madurai,

Tamil Nadu, India^{2,3,4}

ABSTRACT: Forest fires are increasingly frequent and destructive, driven by climate change and environmental factors. To address this, we present Wildfire Shield, a web-based application designed for real-time forest fire risk prediction, visualization, and public safety awareness. The platform integrates an interactive fire risk map, a dynamic fire risk calculator, and an AI-powered assistant for fire safety guidance. Leveraging real-time environmental data, the system offers accurate fire risk assessments and promotes proactive wildfire management. Built using modern web technologies, Wildfire Shield is designed to serve forest management authorities, emergency responders, and the public alike.

KEYWORDS: Forest fire prediction, wildfire monitoring, fire risk map, environmental data, AI chatbot, Leaflet.

I. INTRODUCTION

Forest fires pose a significant global threat to biodiversity, ecosystems, human settlements, and air quality. With climate change amplifying the frequency, severity, and unpredictability of wildfires, real-time prediction and responsive monitoring systems have become essential in mitigating their devastating impacts. Traditional fire monitoring methods often rely on satellite data and delayed manual reporting, which may not provide timely insights for preventive action or immediate response. To address these challenges, Wildfire Shield is introduced as a comprehensive, intelligent, and user-friendly web application that enables real-time forest fire risk analysis and public safety support. This platform is designed not only for forest officials and emergency responders but also for the public, making critical fire-related data more accessible and actionable. The application is structured around three key modules: an interactive fire risk map powered by OpenStreetMap and Leaflet, a real-time fire risk calculator that evaluates environmental conditions, and an AI-powered safety assistant leveraging ChatGPT. Together, these features provide users with dynamic situational awareness, personalized fire risk evaluations, and reliable guidance on preventive and emergency measures.

II. LITERATURE SURVEY

Forest fire prediction has been approached using various intelligent techniques to enhance early warning systems and disaster preparedness. A hybrid prediction model based on Cellular Automata (CA) and machine learning was introduced by Sun et al. [1]. The model integrates the Wang Zhengfei CA framework with data-driven learning, enabling dynamic rule adjustment based on influential environmental variables such as vegetation density, slope, wind direction, humidity, and historical fire data. This method significantly improves the realism of fire spread simulation, and the comparative results indicate better accuracy and efficiency over conventional CA and standalone machine learning models.

Ahmad et al. [2] proposed a Decision Tree-based machine learning approach that utilizes meteorological and satellitederived data to predict fire-prone regions. The model incorporates critical environmental features like temperature, wind speed, humidity, and vegetation type. Optimization of the Decision Tree using Grid Search Cross-Validation significantly improved its predictive performance. The model was evaluated using metrics such as accuracy, precision,



International Journal of Innovative Research of Science, Engineering and Technology (IJIRSET)



www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 4, April 2025

|DOI: 10.15680/IJIRSET.2025.1404645|

recall, and F1-score, and demonstrated superior interpretability and usability in practical fire management contexts compared to other models.

In [3], the authors developed a forest fire prediction system using Logistic Regression and Support Vector Machine (SVM) models trained on environmental parameters such as temperature, humidity, oxygen levels, and vegetation types. SVM slightly outperformed Logistic Regression, particularly in precision and F1-score. The study highlights that lower humidity and higher temperatures play a vital role in increasing fire risks. The evaluation of the models shows that machine learning approaches can deliver timely and accurate fire risk assessments, making them highly valuable in preventive forestry strategies.

Rakshit et al. [4] carried out a comparative analysis of multiple machine learning algorithms, including SVM, K-Nearest Neighbors (KNN), and Decision Tree, for forest fire prediction. Dimensionality reduction techniques were used to address high-dimensional datasets and improve model performance. Among the models tested, SVM demonstrated the highest accuracy, especially when combined with dimensionality reduction. The results emphasize the need for careful algorithm selection and data preprocessing to build robust and efficient fire prediction models for real-world applications.

III. METHODOLOGY

The proposed system, WildFireShield, utilizes a multi-component architecture that integrates environmental data analysis, geospatial visualization, and AI-powered assistance for effective forest fire risk prediction and monitoring. The methodology involves the following modules: The Interactive Fire Risk Map is developed using OpenStreetMap and Leaflet, which visualizes global fire risk data with a color-coded scheme—red for high risk, yellow for medium risk, and green for low risk. The map allows country-wise selection and displays environmental parameters such as temperature, humidity, and wind speed through dynamic popups. The Fire Risk Calculator is based on a weighted algorithm that considers environmental factors including temperature ($0-50^{\circ}C$), wind speed (0-100 km/h), humidity ($0-100^{\circ}$), and vegetation type (forest, grassland, shrubland, mixed). Each parameter contributes differently to the fire probability score. The algorithm computes the risk level in real time and classifies it as low, medium, or high.

The AI-Powered Fire Safety Assistant is integrated using the OpenAI GPT API. It acts as a chatbot providing real-time contextual information regarding fire safety, emergency response, evacuation strategies, and environmental conditions. It enhances user engagement and delivers intelligent recommendations based on user queries. The application is developed using React with TypeScript for frontend logic, Tailwind CSS for responsive UI design, and Lucide React icons for a clean interface. Real-time environmental data is processed and rendered on the platform to offer instant updates to the users.

IV. EXPERIMENTAL RESULTS

Figures illustrate the functional outcomes of each major module in the Wildfire Shield application. Fig. 1 shows the Interactive Fire Risk Map, where countries are color-coded based on fire risk levels. Users can select a country and view live environmental data through map popups.





International Journal of Innovative Research of Science, Engineering and Technology (IJIRSET)



www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 4, April 2025

|DOI: 10.15680/IJIRSET.2025.1404645|

Fig. 2 demonstrates the working of the Fire Risk Calculator. (a) represents the input interface where the user enters parameters such as temperature, wind speed, humidity, and vegetation type. (b) shows the calculated fire risk probability and the corresponding risk category.



Fig. 3 displays the AI-Powered Fire Safety Assistant in action. (a) shows user interaction with the chatbot where safety queries are input. (b) shows the assistant providing fire prevention tips and evacuation guidelines in real time, based on current environmental context.



IJIRSET©2025



International Journal of Innovative Research of Science, Engineering and Technology (IJIRSET)



www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 4, April 2025

|DOI: 10.15680/IJIRSET.2025.1404645|

The experimental validation confirms that the system effectively identifies fire risk zones, accurately calculates fire probability based on user-defined parameters, and provides real-time, intelligent assistance. This integrated methodology supports proactive wildfire management for authorities and individuals alike.

V. CONCLUSION

We have developed an intelligent web-based forest fire risk prediction and monitoring system named Wildfire Shield. Our application successfully integrates real-time environmental data visualization, an interactive fire risk calculator, and an AI-powered fire safety assistant. We have tested the platform with diverse environmental scenarios and user queries, and it accurately predicts fire risk levels and provides relevant safety recommendations. The interactive map and risk calculator work effectively across various countries and vegetation types, while the AI assistant offers realtime guidance on fire prevention and emergency response. Our system demonstrates the potential of combining geospatial visualization, environmental modelling, and AI to aid in proactive wildfire management.

REFERENCES

- [1] X. Sun et al., "A Forest Fire Prediction Model Based on Cellular Automata and Machine Learning," in IEEE Access, vol. 12, pp. 55389–55403, 2024.
- [2] F. Ahmad, Z. Waseem, M. Ahmad, and M. Z. Ansari, "Forest Fire Prediction Using Machine Learning Techniques," in 2023 International Conference on Recent Advances in Electrical, Electronics & Digital Healthcare Technologies (REEDCON), New Delhi, India, 2023, pp. 705–708.
- [3] S. Pawar, K. Pandit, R. Prabhu, R. Samaga, and Geethalaxmi, "A Machine Learning Approach to Forest Fire Prediction Through Environment Parameters," in 2022 International Conference on Artificial Intelligence and Data Engineering (AIDE), Karkala, India, 2022, pp. 1–7.
- [4] P. Rakshit et al., "Prediction of Forest Fire Using Machine Learning Algorithms: The Search for the Better Algorithm," in 2021 6th International Conference on Innovative Technology in Intelligent System and Industrial Applications (CITISIA), Sydney, Australia, 2021, pp. 1–6.
- [5] C. Kopitsa, I. G. Tsoulos, V. Charilogis, and A. Stavrakoudis, "Predicting the Duration of Forest Fires Using Machine Learning Methods," in Future Internet, vol. 16, no. 11, p. 396, 2024.
- [6] C. Mambile, S. F. Kaijage, and J. Leo, "Application of Deep Learning in Forest Fire Prediction: A Systematic Review," in IEEE Access, vol. 12, pp. 190554–190581, 2024.
- [7] S. Shen, S. Seneviratne, X. Wanyan, and M. Kirley, "FireRisk: A Remote Sensing Dataset for Fire Risk Assessment with Benchmarks Using Supervised and Self-supervised Learning," in arXiv preprint arXiv:2303.07035, 2023.
- [8] D. Dulal, J. J. Charney, M. Gallagher, C. Navasca, and N. Skowronski, "Exploring and Analyzing Wildland Fire Data Via Machine Learning Techniques," in arXiv preprint arXiv:2311.05128, 2023.
- [9] H. Xiao, "Estimating Fire Duration Using Regression Methods," in arXiv preprint arXiv:2308.08936, 2023.
- [10] S. Cheng, Y. Guo, and R. Arcucci, "A Generative Model for Surrogates of Spatial-Temporal Wildfire Nowcasting," in arXiv preprint arXiv:2308.02810, 2023.
- [11] V. E. Sathishkumar, J. Cho, M. Subramanian, and O. S. Naren, "Forest Fire and Smoke Detection Using Deep Learning-Based Learning Without Forgetting," in Fire Ecology, vol. 19, pp. 1–17, 2023.
- [12] C. Mambile, S. F. Kaijage, and J. Leo, "Application of Deep Learning in Forest Fire Prediction: A Systematic Review," in IEEE Access, vol. 12, pp. 190554–190581, 2024.
- [13] S. Pawar, K. Pandit, R. Prabhu, R. Samaga, and Geethalaxmi, "A Machine Learning Approach to Forest Fire Prediction Through Environment Parameters," in 2022 International Conference on Artificial Intelligence and Data Engineering (AIDE), Karkala, India, 2022, pp. 1–7.
- [14] P. Rakshit et al., "Prediction of Forest Fire Using Machine Learning Algorithms: The Search for the Better Algorithm," in 2021 6th International Conference on Innovative Technology in Intelligent System and Industrial Applications (CITISIA), Sydney, Australia, 2021, pp. 1–6.
- [15] C. Kopitsa, I. G. Tsoulos, V. Charilogis, and A. Stavrakoudis, "Predicting the Duration of Forest Fires Using Machine Learning Methods," in Future Internet, vol. 16, no. 11, p. 396, 2024.









INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY





www.ijirset.com