Project Proposal: An Intelligent Decision Support System for Wildfire Risk Assessment

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1 Introduction and Motivation

Wildfires represent a significant and growing threat to ecosystems, infrastructure, and human lives. The ability to predict and identify high-risk conditions is extremely valuable for effective prevention and resource allocation. This project proposes the development of an Intelligent Decision Support System (IDSS) designed to provide early warnings for wildfire risk based on meteorological data. The system will function as an automatic risk-assessment tool, triggering alarms when it detects atmospheric and environmental conditions that have historically correlated with the outbreak of wildfires. Our goal is to create a robust, reliable, and user-friendly tool that can be used by fire departments, government agencies, and land managers to enhance their decision-making capabilities.

2 Core Methodology

The foundation of our IDSS will be a hybrid approach that integrates data-driven machine learning models with knowledge-based components derived from expert domain knowledge.

2.1 Data-Driven Component

We will utilize the extensive US Wildfire Dataset, which contains 126,800 labeled samples (50,720 positive ignition events; 76,080 negative samples) from 2014 to 2025, each of them expanded into a 75-day sequence, yielding >9.5 million sequence-rows [1]. This historical data will be used to train and validate a machine learning component (e.g., Neural Network) to identify complex, non-linear relationships between various meteorological parameters (temperature, humidity, wind speed, precipitation, etc.) and wildfire occurrences. The primary output of this component will be a probabilistic risk score for a given set of conditions.

2.2 Knowledge-Based Component

To complement the machine learning model, we will incorporate a knowledge-based system. This component will employ expert knowledge from the fields of physics and meteorological sciences. It will consist of a set of rules and physical constraints based on established principles of fire behavior, such as the physics of fuel moisture content and wind-driven fire spread. This will serve two purposes: firstly, to act as a validation layer for the predictions of the data-driven model, and secondly, to handle edge cases or novel conditions that may not be well-represented in the historical dataset, thereby increasing the system's overall robustness.

3 System Features and Deployment

To ensure the practical utility of the IDSS, we will implement two key features:

- **Risk Visualization Tool:** A user-facing dashboard will be developed featuring an interactive map of the United States. When the system triggers a high-risk alert, the specific geographical area will be highlighted on the map, providing an intuitive and immediate visual representation of the threat. Users will be able to click on the alert to view the specific meteorological data that triggered it.

- **Live Data Ingestion:** To enable a real-world, live deployment, we plan to implement a data ingestion pipeline. This pipeline will connect to an existing third-party API to fetch live meteorological data from external providers (e.g., national weather services). Time permitting, this feature will enable real-time risk analysis and ensure that the alerts are based on the most current environmental conditions available.

4 Conclusion

By combining the pattern-recognition strengths of machine learning with the rigor of established scientific knowledge, this project aims to build a powerful and accurate Intelligent Decision Support System for wildfire prediction. The inclusion of a map-based visualization tool and a real-time data ingestion pipeline will ensure the system is not only a powerful analytical tool but also a practical asset for real-world decision-making in wildfire management.

References

[1] Firecast Team. Us wildfire dataset. https://www.kaggle.com/datasets/firecastrl/us-wildfire-dataset, 2021.