Wildfire Predictive Sentinel: A Neural Network Approach to Forest Fire Detection

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Abstract:

Wildfires pose a significant threat to ecosystems, property, and human life, and their early detection is crucial for effective management and mitigation. The Wildfire Predictive Sentinel project aims to harness the capabilities of neural networks to predict the likelihood of wildfire occurrences based on environmental data. By leveraging historical data and real-time environmental variables, such as temperature, humidity, and wind speed, our model will identify patterns and potential high-risk areas. The unique advantage of this approach lies in its simplicity and effectiveness, utilizing a straightforward neural network architecture that provides accurate predictions without unnecessary complexity. The project will involve data collection, preprocessing, model development, and validation. The end goal is to create a reliable tool that can be used by authorities for early warning and preventive measures.

Introduction:

Wildfires have become more frequent and devastating due to climate change and various anthropogenic factors. Traditional methods of prediction and detection often rely on human observation and reporting, which can lead to delays in response time. The Wildfire Predictive Sentinel project is conceived to address this gap by applying machine learning to environmental data for real-time wildfire risk assessment. By integrating a neural network model, this project seeks to provide a continuous, automated monitoring system that can alert relevant bodies before a potential wildfire becomes uncontrollable. The focus on a simple yet potent neural network design ensures the model remains accessible and maintainable, while also being capable of scaling up with additional data sources in the future.

Literature Review:

The development of our wildfire prediction model is inspired by some key studies and resources:

" THE LARGE-SCALE WILDFIRE SPREAD PREDICTION USING A MULTI-KERNEL CONVOLUTIONAL NEURAL NETWORK " (Marjani, Mesagari, 2023) demonstrates the effectiveness of CNNs in modeling complex spatial patterns in environmental data.

"A Machine Learning Approach to Wildfire Risk Prediction" (Shmuel & Heifetz 2022) shows how different machine learning models can be applied to the problem of wildfire prediction.

TensorFlow tutorials on neural networks provided foundational knowledge for the architecture of our model.

These references have shaped our understanding of the challenges and potential solutions in wildfire prediction, guiding our approach to model selection and training.

Technical Plan:

Our technical plan includes the following key components:

- **Data Collection:** Gather historical wildfire data and real-time environmental data from various sources.
- **Data Preprocessing:** Clean and preprocess the data to ensure it is suitable for input into the neural network. This will involve normalizing the data and handling missing values.
- **Model Selection and Development:** Implement a feedforward neural network using TensorFlow, starting with a simple architecture that can be iteratively improved.
- **Training and Validation:** Train the model on historical data, using cross-validation set to monitor for overfitting and to fine-tune hyperparameters.
- **Evaluation:** Assess the model's performance using metrics such as accuracy, precision, and recall.

Completed Results:

We have imported the necessary libraries, loaded and preprocessed a dataset of wildfires, and constructed a neural network using TensorFlow and Keras. The network has been trained and cross-validated which show the following results:

- Achieved a test accuracy of approximately 75%.
- Has the precision of 78%
- Has the Recall of 83%

We experimented in using more complex neural network architectures such as CNN's and RNN's but these weren't optimal for our dataset. We found that our feedforward neural network was the most effective for predicting wildfire occurrences.

During our attempts at using real-time data, we had challenges with integrating a weather API. With the limited free queries and our inexperience in working with API's we found

Link to results:

https://colab.research.google.com/drive/1FIp3u263hJKHy3-2I3TP0vKHCWF4g5kp?usp=sharing

Future Work:

In the future, we plan to revisit the integration of real-time data once we have gained more experience in handling API's effectively. Learning from our initial challenges with the weather API, we aim to develop strategies to manage query limits and data integration more efficiently.

Furthermore, We plan to investigate hybrid models that might combine the strengths of different neural network architectures. While the simpler feedforward architecture has proven effective, a hybrid approach might allow us to capture more complex patterns and interactions in the data, potentially leading to improved predictive performance.

Finally, there is room for a GUI that could allow users to add local metrics to see if their area is at risk of a wildfire as well as what authorities can do to reduce the risk.

References:

Marjani, Mesagari, (2023). THE LARGE-SCALE WILDFIRE SPREAD PREDICTION USING A MULTI-KERNEL CONVOLUTIONAL NEURAL NETWORK. Remote Sensing and Spatial Information Sciences.

Shmuel, E, Heifetz (2022). "A Machine Learning Approach to Wildfire Risk Prediction. Fire , Volume 6, Issue 8

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