Hurricane Path Prediction using LSTM Networks

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Abstract

As hurricanes become more common and intense, predicting their paths accurately is vital to keeping people safe and minimizing damage. In this study, we developed a machine learning model designed to predict where a hurricane is headed over the next 48 hours. By analyzing past hurricane data---like wind speed, pressure, and location---our model uses Long Short-Term Memory (LSTM) networks to forecast the storm's future path. The results are promising, especially in the early stages of prediction, though there's room for improvement as the hurricane progresses. This work highlights how AI can play a crucial role in improving early warning systems and guiding disaster response efforts.

1. Introduction

Hurricanes, known for their immense power and potential for destruction, are tropical cyclones that form over warm ocean waters. As these storms become more frequent and severe, predicting their paths accurately has never been more important. Our project focuses on developing a machine learning model that can forecast where a hurricane will go over the next 48 hours. By using Long Short-Term Memory (LSTM) networks, we aim to create a model that not only predicts hurricane paths with greater accuracy but also provides valuable

insights for disaster preparedness. The model works by analyzing key factors like wind speed, atmospheric pressure, and the storm's previous movements, helping to deliver more reliable predictions that can save lives and reduce the impact of these powerful storms.

2. Method

Our model predicts a hurricane's future path over 48 hours, using previous latitude and longitude positions, along with wind speed, pressure, direction, and distance at each position.

The model includes 5 layers:

1. An initial LSTM layer

2. A second LSTM layer

3. Three fully connected layers

The output layer predicts the latitude and longitude positions for the next 48 hours.

We used the activation function tanh, which normalizes the outputs between -1 and 1, helping to stabilize the training process.

3. Results

The RNN model demonstrated promising results:

- 77.61% accuracy on the training set

- 65.55% accuracy on the validation set

- Notable decrease in loss over the training period, indicating effective learning of data patterns

The minor divergence between training and validation loss, where training loss is lower, suggests that our model is slightly overfitting. This could be remedied with the addition of a dropout layer.

The model predicted hurricane paths in many instances with varied accuracies across different trajectories, pointing to areas that need refinement. The model shows potential as a valuable tool for predicting hurricane trajectories, complementing existing methods. However, its limitations include inconsistent accuracy, which may be

due to the complexity of hurricane behavior and the quality of the training data.

4. Conclusion

Our AI model has shown significant potential in predicting the paths of hurricanes. However, the accuracy of the predictions can be influenced by the quality of historical data and the comprehensiveness of the input features used in training. Moving forward, we plan to:

1. Integrate attention mechanisms

2. Expand the dataset with more detailed meteorological inputs

3. Validate the model against a broader range of historical storms

These enhancements aim to improve the model's reliability and applicability in real-world scenarios, ultimately contributing to more effective disaster management strategies.

References

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