Deep Learning for Weather Prediction

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Abstract

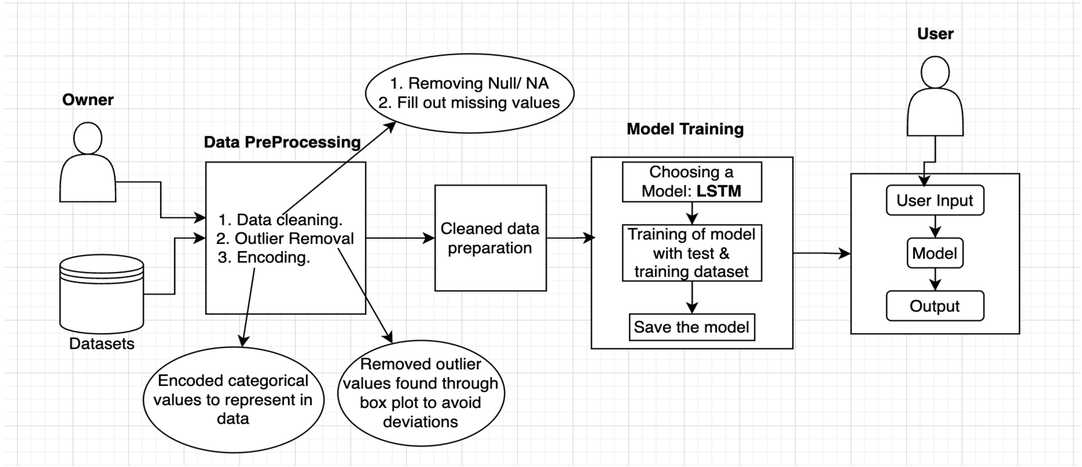
Weather forecasting plays a crucial role in agriculture, disaster preparedness, transportation, and day-to-day planning. This project focuses on creating a reliable weather prediction system using a Long Short-Term Memory (LSTM) neural network — a type of deep learning model suited for time series data. Multiple datasets, including climate observations, provincial data, and station-specific details, are merged and preprocessed for this task. The project entails comprehensive data cleaning, visualization, and modeling workflows to ensure accuracy and robustness. The LSTM model is trained to learn temporal patterns and forecast weather metrics, demonstrating strong potential for real-world forecasting applications

LSTM

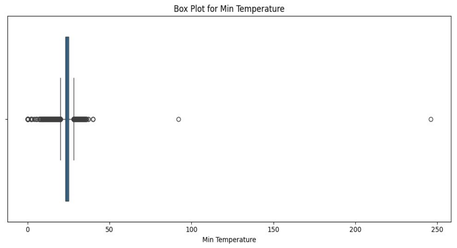
- LSTM is a type of RNN designed to remember information over long sequences.
- It uses a memory cell to retain important data across time steps.
- The forget gate controls which information to discard.
- The input gate regulates which new information to store.
- The output gate determines what information is passed forward.
- It solves the vanishing gradient problem common in traditional RNNs.
- LSTM is highly effective for time series and sequential data.
- It can be stacked to build deeper learning models.
- LSTM supports bidirectional processing for richer context understanding.
- It's widely used in weather forecasting, NLP, and financial predictions.

Results/Implementation

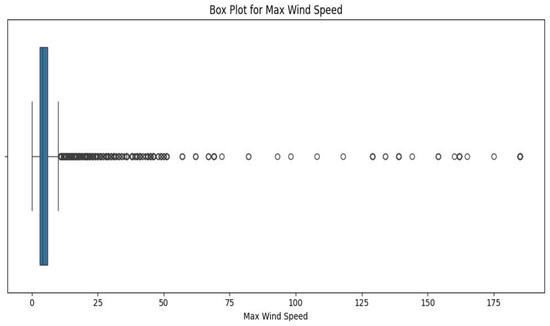
Proposed Methodology

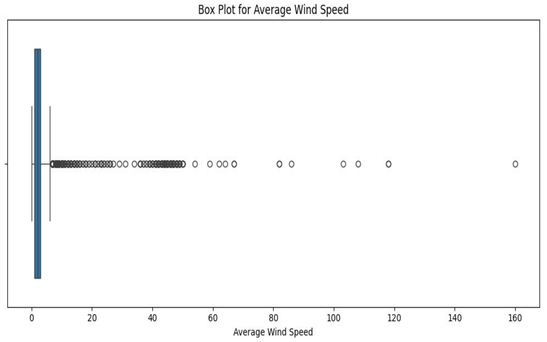


Implementation Plots



Layer (type)	Output Shape	Param #
lstm (LSTM)	(None, 7, 64)	23,552
lstm_1 (LSTM)	(None, 32)	12,416
dense (Dense)	(None, 16)	528
dense_1 (Dense)	(None, 18)	306





Prediction Demonstration

```
Enter Province ID: 7

Available Regions:
ID: 123 - Name: Kota Bengkulu
ID: 121 - Name: Kab. Kepahiang

Enter Region ID: 123

Available Stations:
ID: 96253 - Name: Stasiun Meteorologi
ID: 96255 - Name: Stasiun Klimatologi

Enter Station ID: 96255
Enter date (DD-MM-YYYY): 03-09-2020
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 549ms/step

📅 **Prediction Date:** 2020-09-03

Min Temperature: 24.96
Max Temperature: 32.30
Average Temperature: 28.30
Average Humidity: 80.25
Rainfall: 2.50
Sunshine Duration: 8.93
Max Wind Speed: 7.37
Wind Direction at Max Speed: 153.23
Average Wind Speed: 3.59
Most Wind Direction: S
```

Technical Details

Hardware Requirements:

Processor	:	Any
Ram	:	4 GB
Hard Disk	:	250 GB

Software Requirements:

OS	:	Windows family
Technology	:	Python 3.11
Libraries	:	NumPy, Pandas
IDE	:	Google Collaboratory

Future Work

- Incorporate satellite and radar data into the dataset.
- Add new features like air quality, humidity, and wind metrics.
- Use ConvLSTM for enhanced spatiotemporal modeling.
- Integrate GIS data for better spatial resolution.
- Deploy a real-time web-based weather forecasting app.
- Connect live weather APIs for continuous updates.
- Evaluate model performance across seasons and regions.

Bibliography

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