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Wind Power Prediction Using Attention-PowerWiNet

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Abstract

Wind power forecasting is challenged by environmental variability. This project proposes Attention-PowerWiNet, a hybrid model combining PowerNet, WiNet, and attention mechanisms to capture spatial-temporal features. Experiments on two real-world datasets show it achieves the best performance (MAE 0.035, RMSE 2.314, R^2 0.906). SHAP analysis highlights wind speed and cloud cover as key factors. A user-friendly GUI was also developed to support data uploading, prediction, and interpretation, enhancing both accuracy and transparency.

Datasets

Dataset 1 contains 35,040 rows of wind farm operational data from 2017, while Dataset 2 records 14,554 rows of environmental factors from 2018 to 2020.

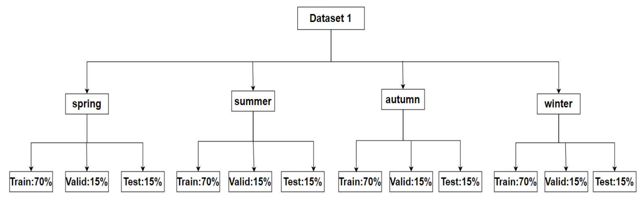

Figure 1. Dataset1 split

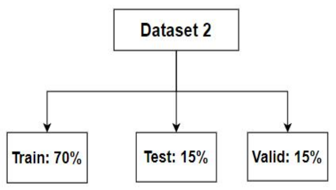

Figure 2. Dataset2 split

Data preprocessing contains: 1. Data Normalization. 2. Time Series Windowing

Proposed model

Attention-PowerWiNet

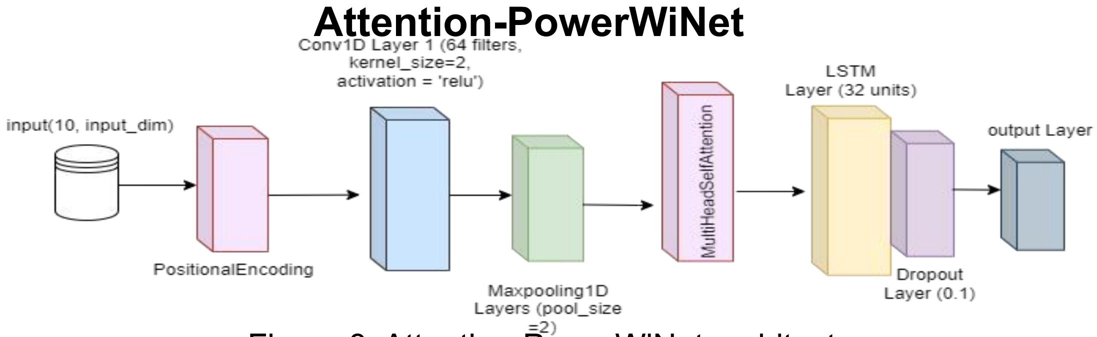

Figure 3. Attention-PowerWiNet architecture

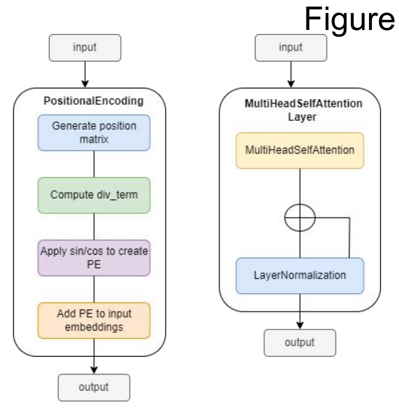

Figure 4. Attention architecture

Figure 3 shows the architecture of Attention-PowerWiNet, which combines a convolution layer, attention, and an LSTM layer. The Attention-PowerWiNet is used to better capture features and time dependencies for wind power forecasting, the architecture of attention in this model shown in Figure 4.

Model Explainability (SHAP)

To enhance model transparency and build trust, uses methods like SHAP

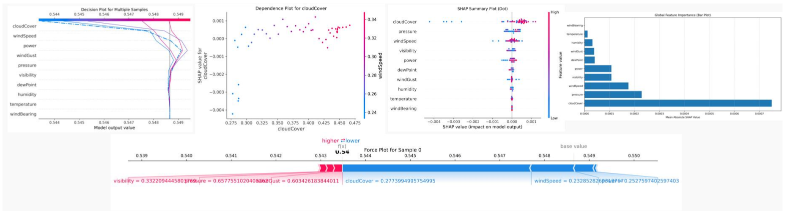

Figure 5. SHAP Plots

Result Analysis

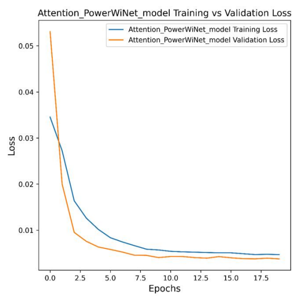

Figure 6. Loss curve

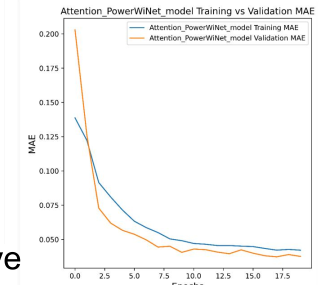

Figure 7. MAE curve

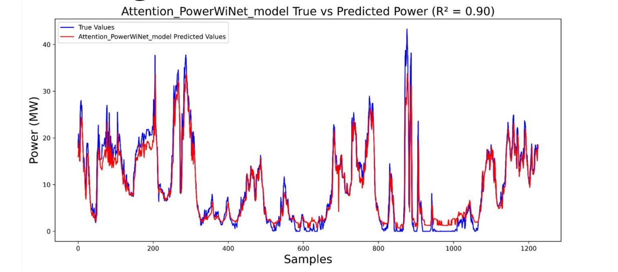

Figure 8. Predicted value - actual value

Figures 6 and 7 show the loss and MAE curves of the summer dataset, and Figure 8 shows the comparison curve between the actual values and the true values.

Conclusion

- Proposed Attention-PowerWiNet to enhance wind power prediction.
- Achieved the best on summer and winter datasets.
- Applied SHAP for interpretability, confirming the rationality of key input features.
- Developed a visual web interface for real-time prediction and result explanation.

Model Deployment

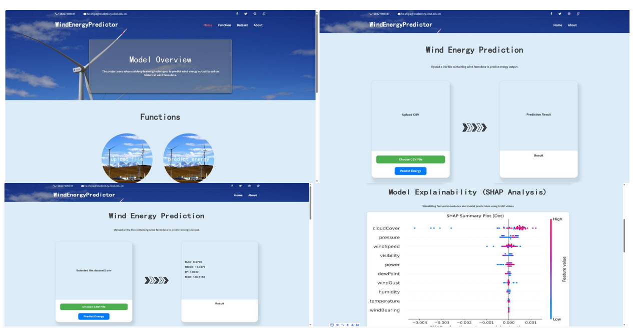

Figure 9. SHAP Plots

This project develops a web-based wind power forecasting platform, supporting CSV data upload, generation prediction via Attention-PowerWiNet, and SHAP-based interpretability alongside prediction results.

References

[1] X. Zheng and X. Li, 'Wind Electricity Power Prediction Based on CNN - LSTM Network Model', in 2023 IEEE International Conference on Sensors, Electronics and Computer Engineering (ICSECE), Aug. 2023, pp. 231–236. doi: 10.1109/ICSECE58870.2023.10263409.

[2] H. Zhang, L. Zhao, and Z. Du, 'Wind power prediction based on CNN-LSTM', in 2021 IEEE 5th Conference on Energy Internet and Energy System Integration (EI2), Oct. 2021, pp. 3097–3102. doi: 10.1109/EI252483.2021.9713238.