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Hybrid MobileNet-BiLSTM Model with Multi-Head Attention Mechanism for Solar Radiation Prediction

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Abstract

The importance of solar energy is increasing with the demand for sustainable energy. Solar radiation prediction is the key to improve the performance of power generation system. This project proposes a hybrid MobileNet-BiLSTM model that combines multi-head attention mechanism to predict solar radiation. The model uses MobileNet to extract image features, BiLSTM to process time series, multi-head attention to improve the prediction accuracy, MAE 0.2355, MSE 0.1159, RMSE 0.3405. The integration of XAI technology improves the transparency and reliability of the model, and provides a new scheme for solar energy utilization.

Dataset

Figure 1 Composition of Data

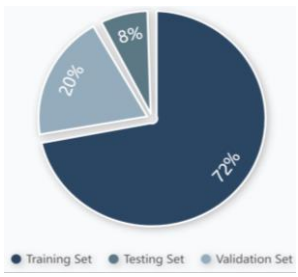

Figure 2 Split of Data

The dataset consists of sky images and temporal features, where images are used to extract spatial features and temporal features are used to capture temporal variations. The dataset was first divided into 80% of the training set and 20% of the validation set, and then further divided into 10% of the training set as the test set.

Ensemble models

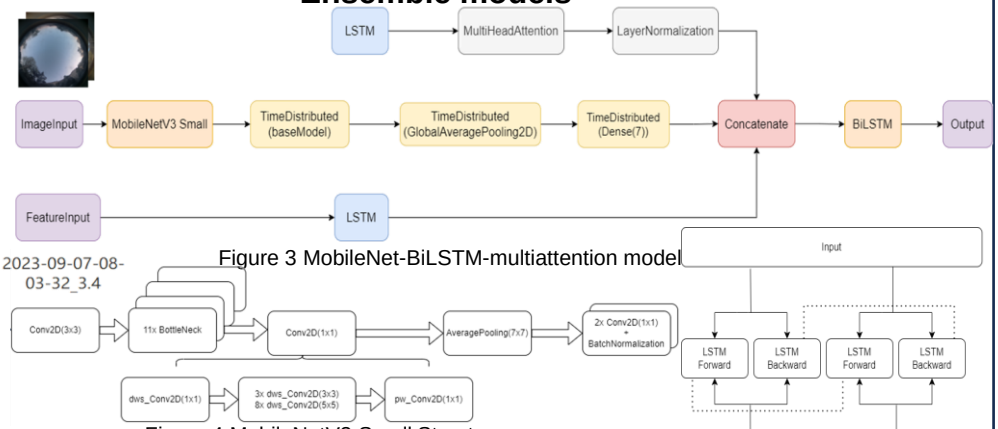

Figure 3 MobileNet-BiLSTM-multiattention model

Figure 4 MobileNetV3 Small Structure

Figure 5 BiLSTM Structure

Figure 3 shows the hybrid architecture of the Mobilenet-BiLSTM-multi-head attention mechanism, which aims to jointly process the spatio-temporal features of solar radiation prediction. The figure highlights three key information flows: (1) image feature extraction via MobileNet's convolutional blocks, (2) temporal pattern encoding via BiLSTM, and (3) cross-modal feature fusion using attention weights.
Figure 4 and Figure 5 displays the internal structure of single models.

Model evaluation

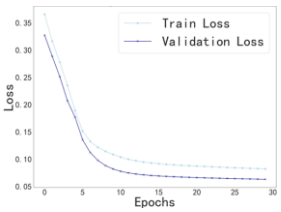

Figure 4 Loss Result

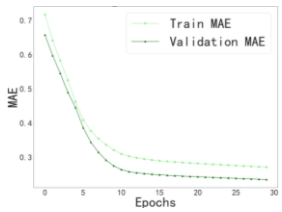

Figure 5 MAE Result

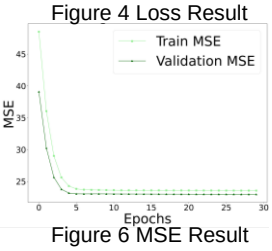

Figure 6 MSE Result

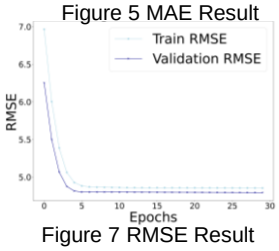

Figure 7 RMSE Result

As shown in the figure, these four error metrics are slightly reduced and remain in a low range compared to the training results without multi-head attention mechanism. The results show that the prediction error of the proposed model is controlled in a very small range, and it has a strong prediction ability.

Model Explanation

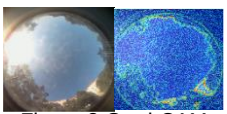

Figure 8 Grad-CAM Explanation

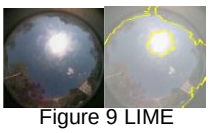

Figure 9 LIME Explanation

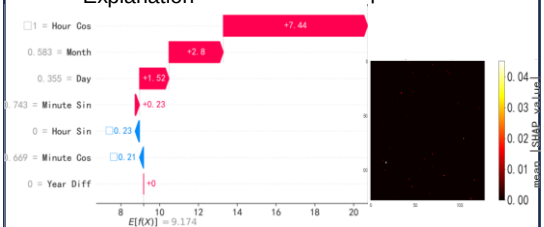

Figure 10 SHAP Explanations

The figure shows how model interpretation techniques enhance model interpretability and ensure that predictions are consistent with physical laws. These techniques not only improve the transparency of the model, but also enhance the user's trust in the model results, thus promoting the reliability and effectiveness of the model in practical applications.

Deployment

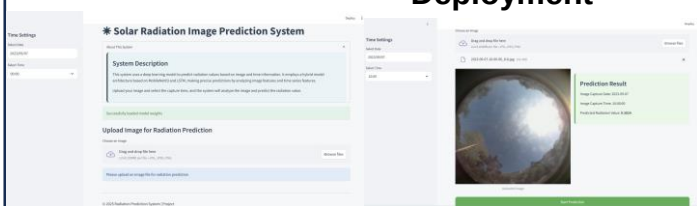

Figure 11 Interface for Prediction

Figure 12 Prediction Result

The project is deployed in the browser, once running, the web page automatically loads the trained model, and the user can upload the sky image and select the corresponding time to predict the solar radiation value.

Future work

Future work will be devoted to improving the generalization ability of the model, considering more influencing factors such as atmospheric quality and geographical location, and reducing the model energy consumption for stable operation on low-power devices in remote solar power stations.