Recurrent neural network for forecasting solar energy production

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With increasing energy needs and oncoming climate crisis, the need for renewable energy has skyrocketed. With energy production accounting for over two-thirds of the planet's greenhouse emissions, renewable energy is of utmost importance.

Solar energy is largely considered the most abundant and environmentally friendly renewable energy source. However, its production is intrinsically volatile: as cloud conditions change, the amount of sunlight received—and thus the amount of solar energy produced—fluctuates dramatically, making it difficult to incorporate solar energy into energy grid systems. Forecasting methods would allow prepared redistribution of resources to mitigate solar energy production volatility. In this study, we investigate the use of deep learning methods for forecasting.

Recurrent neural networks (RNNs) are a special type of deep learning model particularly well suited for forecasting due to their time-based structure. We compared different types of RNNs (standard RNN, LSTM, and GRU) and different ways to build the RNN (number of layers and number of neurons—basically). Additionally, we experimented with a seasonal model, which is comprised of four distinct models, each specialized to a season.

We trained our model on historical solar irradiance and cloud coverage data to forecast future solar irradiance. Solar irradiance and cloud coverage are meteorological metrics confirmed to be closely related to solar energy production. Thus, we effectively forecast solar energy production. Training and optimization were done on the SWING computing cluster at Argonne National Laboratory.

Ultimately, both our non-seasonal and seasonal models strongly predicted solar irradiance, with the seasonal model slightly outperforming the non-seasonal model. This confirms the potential for deep learning in forecasting, encouraging wider exploration in this intersection. Further, this shows promising results for facilitating wider incorporation of solar energy into energy grid systems through deep learning forecasting methods.