Short-Long-Term Weather and Load Forecasts for Energy Systems Control

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Scarcity of Long-and-Short-term Mixed Forecasting Models

- Machine learning technology has been widely used not only for weather forecasts which are essential for optimal predictive control of energy systems, but also for predicting the energy consumption at the load side to help achieve a balance between the supply and the demand.
- Conventional machine/deep-learning-based weather forecasts are either short-term or long-term so that they cannot be directly used for coordinated multi-time-scale control of multiple systems with different response times.
- In a centralized machine learning model training process, the conventional method is to collect all the data from users and perform training on servers together. This traditional method is risky, and it can raise serious data privacy issues.
- In our project, a novel scheme for short/long-term stochastic weather forecasts will be developed to use LSTM for temporal coordinated control of multiple energy systems.
- A decentralized machine learning technique will also be applied, which does not require explicitly transmitting users' data to the data center for training, to predict the load energy consumption in the short/long term.
- We hope to build a house with more dynamic building responses (e.g., room conditions) at hours-days-timescale with our weather forecasting and load forecasting model.

Reference and Acknowledgements

References:

[1] Voyant, Cyril, et al. "Machine learning methods for solar radiation forecasting: A review."Renewable Energy 105 (2017): 569-582.
[2] Ferrari, Stefano, et al. "Illuminance prediction through extreme learning machines." 2012 IEEE Workshop on Environmental Energy and Structural Monitoring Systems (EESMS). IEEE,2012.
[3] Reikard, Gordon. "Predicting solar radiation at high resolutions: A comparison of time series forecasts." Solar Energy 83.3 (2009): 342-349.
[4] Wang, Zhe, Tianzhen Hong, and Mary Ann Piette. "Building thermal load prediction through shallow machine learning and deep learning." Applied Energy 263 (2020): 114683.10.
[5] Bonawitz, Keith, et al. "Practical secure aggregation for federated learning on user-held data." arXiv preprint :1611.04482 (2016).
[6] Taïk, Afaf, and Soumaya Cherkaoui. "Electrical load forecasting using edge computing and federated learning." ICC 2020-2020 IEEE International Conference on Communications (ICC).IEEE, 2020.

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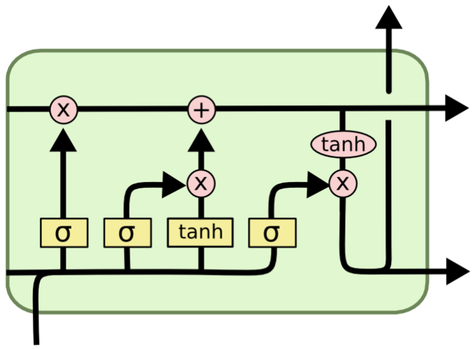
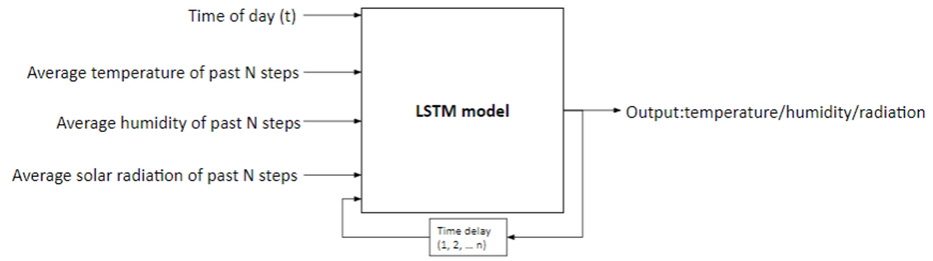
Implementations

LSTM

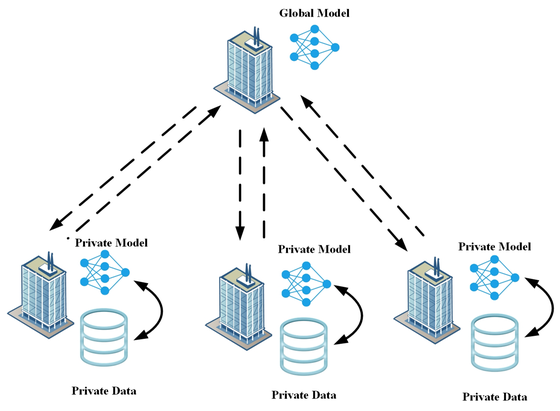


Why did we use LSTM:

- Based on our paper review, it was widely used for diffterent parameters for weather and load forecasting and achieved very good results.
- It addressed the vanishing gradient problem that makes network training difficult for a long sequence of words or integers.



Federated Learning



Why did we use federated learning:

- Security: Instead of transmitting data, only transmit weights and biases to centralized model
- Scalability: Training processes are performed in distributed fashion. Centralized model's parameters are the averages of the collected model parameters.
- Diversity: It collects data from different clients, so the model can learn more patterns and can provide higher prediction accuracy.

Flower: A Friendly Federated Learning Framework

The federated learning framework used in the project: Flower.

It adopts microservice architecture, and the communication between each client and the centralized server is realized by using gRPC.

Weather Prediction

Dataset: The data is imported from weatherunderground.com, which records the temperature, relative humidity and solar radiation every 5 mins in the year 2021. The weather monitor station is #KNYITHAC52, which locates in Ithaca, NY, 14850.

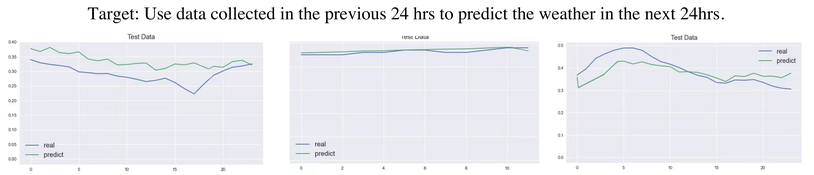
Short-term prediction

Target: Use data collected in the previous 30 mins to predict the weather in the next 5 mins.

Target: Use data collected in the previous 30 mins to predict the weather in the next 60 mins.

Long-term prediction

Target: Use data collected in the previous 24 hrs to predict the weather in the next 24hrs.



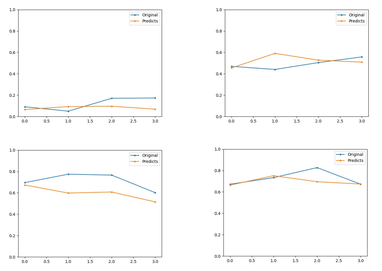
Temperature | Humidity | Solar Radiation

Power Load Prediction

Dataset: Grafana, which records the power usage, chilled water, and steam pressure of each building utility on Cornell campus. Data sampled every 15 mins.
The building selected for training and inference are Upson Hall, Carpenter Hall, and Sage Hall.

Short-term prediction

Target: Use data collected in the previous hour to predict the power load in the next hour.
Model Hyperparameters: 1 layer of LSTM with 256 hidden units connected with a linear layer with dimension of 4.



Long-term prediction

Target: Use data collected in the previous day to predict the power load in the next day.
Model Hyperparameters: 1 layer of LSTM with 128 hidden units connected with a linear layer with dimension of 96.