Embedding Cyclical Information in Solar Irradiance Forecasting

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Introduction

- Growing Energy Demand causes air pollution and global warming
- Clean renewable energy is a solution
- Solar energy is a reliable and renewable energy source
- The efficiency of power production is highly dependant on weather conditions
  - Rainy/cloudy days affects the power production
- Forecasting solar irradiance in advance helps in the efficient operation of photovoltaic cells
Objectives

● To develop a solar irradiance forecasting model using historic time series data

● To improve the forecasting accuracy by embedding periodic nature of solar irradiance
Forecasting without Time Stamp Information

- Used 1 year solar irradiance time series data with 1 minute temporal resolution from the weather station located at NTU Singapore.
- Downscaled to 60 mins, 30 mins, and 15 mins temporal resolution
- Previous d time series data is used to predict solar irradiance
  - Varied the values of $d$ from 1 to 9
- *Multi-Layer Perceptron Regression* model is trained for forecasting
Forecasting with Time Stamp Information

- Used the same one year solar irradiance time series data with 1 minute temporal resolution from *NTU Singapore*.
- Downscaled to 60 mins, 30 mins, and 15 mins temporal resolution
- Previous d time series data is used to predict solar irradiance
  - Varied the values of d from 1 to 9
- Used timestamp information along with previous time series data
  - Applied a trigonometric transformation with 24 hr periodicity
- *Multi-Layer Perceptron Regression* model is trained for forecasting
## Results

| d  | Solar60 Without time | Solar60 With time | Solar30 Without time | Solar30 With time | Solar15 Without time | Solar15 With time |
|----|----------------------|-------------------|----------------------|-------------------|----------------------|-------------------|
| 1  | 0.63                 | 0.73              | 0.74                 | 0.77              | 0.8                  | 0.82              |
| 2  | 0.65                 | 0.73              | 0.74                 | 0.78              | 0.81                 | 0.82              |
| 3  | 0.65                 | 0.73              | 0.74                 | 0.78              | 0.81                 | 0.82              |
| 4  | 0.66                 | 0.73              | 0.74                 | 0.78              | 0.81                 | 0.83              |
| 5  | 0.67                 | 0.72              | 0.75                 | 0.78              | 0.8                  | 0.82              |
| 6  | 0.68                 | 0.72              | 0.74                 | 0.77              | 0.81                 | 0.82              |
| 7  | 0.69                 | 0.72              | 0.75                 | 0.77              | 0.8                  | 0.82              |
| 8  | 0.7                  | 0.72              | 0.75                 | 0.77              | 0.8                  | 0.82              |
| 9  | 0.7                  | 0.72              | 0.75                 | 0.78              | 0.8                  | 0.82              |

$R^2$ value with- and without- cyclic time feature for varying number of previous time series data (d) and varying temporal resolution.
Discussions

- The forecasting model using time stamp information outperforms the one without time stamp information.
- We obtain 3% increase in the R2 value for the three data sets with varying temporal resolution.
- The periodic nature of solar irradiance is an important information during forecasting.
- It is observed that higher the resolution of data used in our forecasting model, the better is the model performance.
- We observed considerable improvement in the performance by increasing the embedding dimensions but not beyond 7.
Conclusions

- The importance of embedding temporal information for solar irradiance forecasting is demonstrated.
- We observed that including the temporal feature increases the forecasting accuracy for different historical training periods.

https://github.com/FathimaTA/Forecasting
Thank You