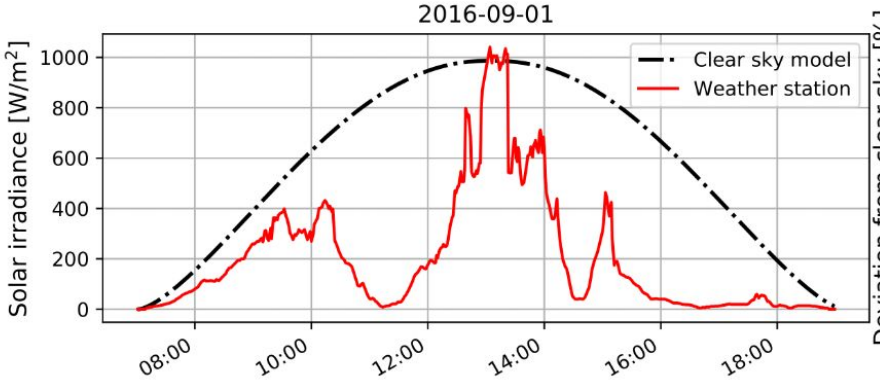
Predicting Solar Irradiance in Singapore

T. A. Fathima, Vasudevan Nedumpozhimana, Yee Hui Lee, Stefan Winkler, Soumyabrata Dev

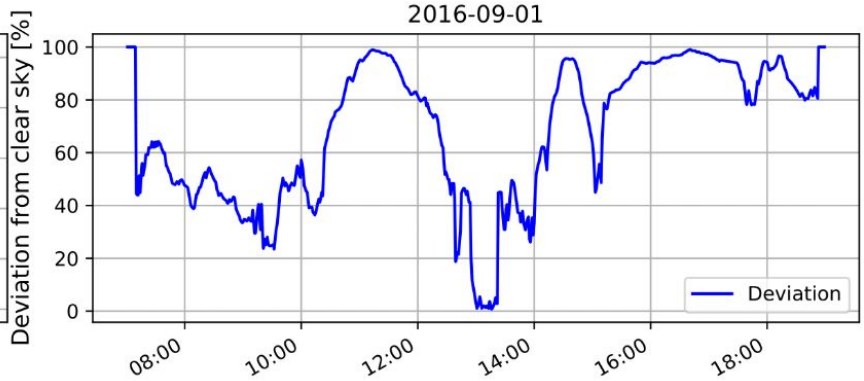
The ADAPT Centre is funded under the SFI Research Centres Programme (Grant 13/RC/2106) and is co-funded under the European Regional Development Fund.

Atmospheric Sensing using images

The accurate estimation and prediction of solar energy generation is a challenging task, because of the rapid fluctuations in received solar irradiance.



(a) Measured solar irradiance along with clear-sky model.



(b) Percentage deviation of solar irradiance from clear sky data.

Triple Exponential Smoothing

- Triple Exponential Smoothing (TES) explicitly adds support for trend and seasonality to the univariate time series.
- Widely used technique for forecasting univariate time series data.
- The forecast will be the weighted average of the past observations in which the weight will decay exponentially as the observations gets older[1].

$$F_{t+m} = (S_t + mb_t)I_{t-L+m} \quad \text{Forecast}$$

[1] R. J. Hyndman and G. Athanasopoulos, Forecasting: Principles and Practice, OTexts, Australia, 2nd edition, 2018.

Experimental Procedure

- Our weather measurements are recorded at the rooftop of the university building at Nanyang Technological University Singapore, located at 1.3°N, 103.68°E.

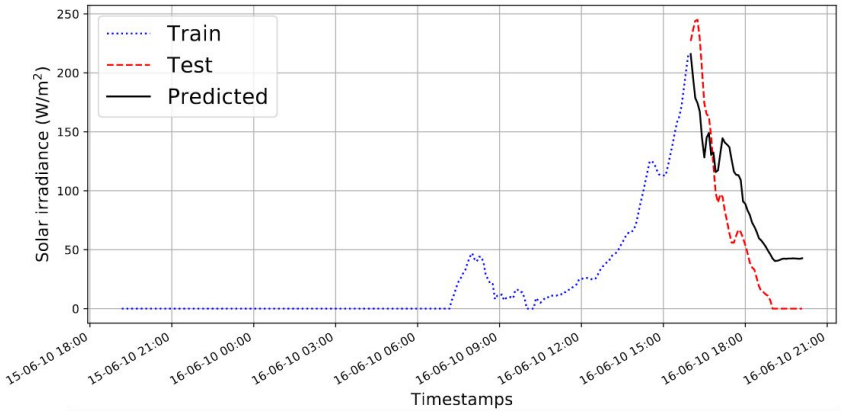
- We use Davis Instruments 7440 Weather Vantage Pro I with a tipping rain gauge to record temperature, humidity, wind-speed, solar irradiance, dew point temperature and rainfall rate. All these measurements are recorded with a resolution of 5 minutes.

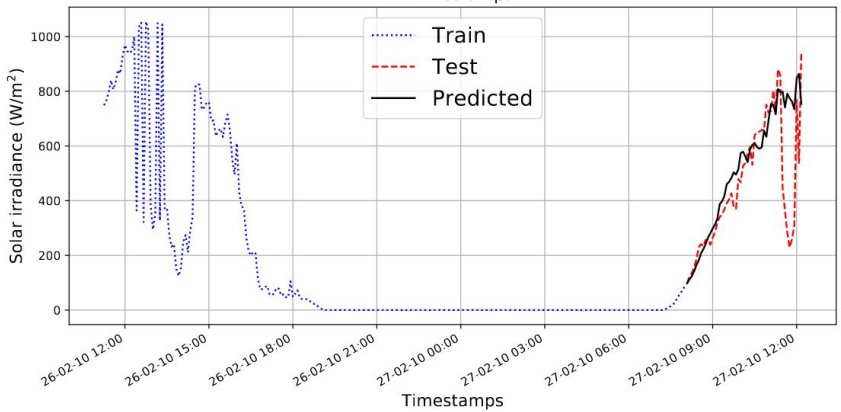
- We use a training set of 2000 observations to train the TES model.

- We perform a subjective evaluation of the proposed method for both short and long lead times.

Qualitative Evaluation

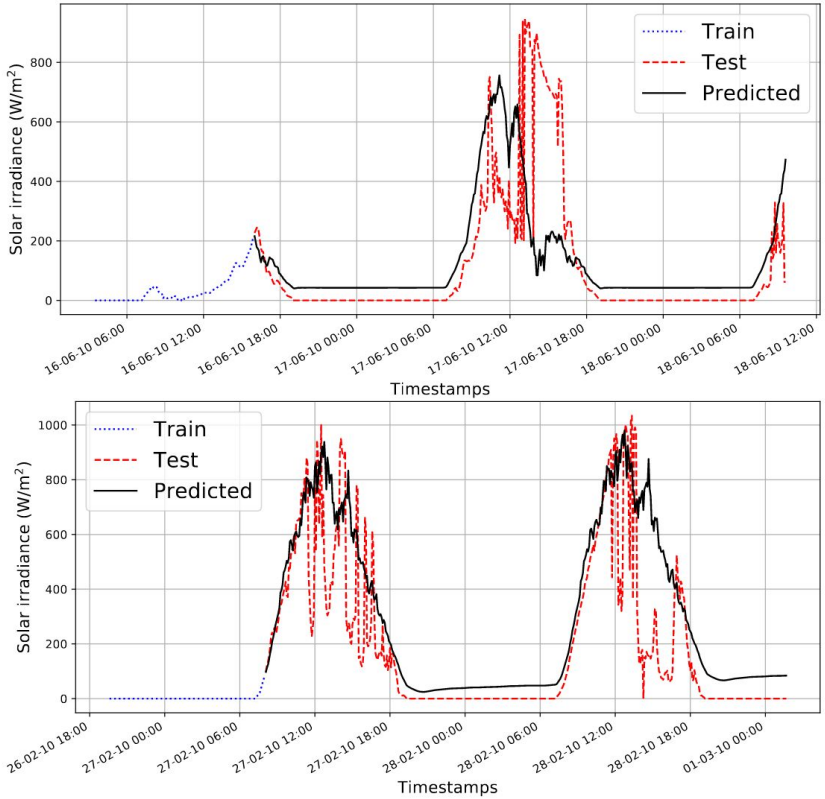
We use TES for forecasting solar irradiance in Singapore for shorter lead time.





Qualitative Evaluation

We check the efficacy of TES for longer lead time too.



Quantitative Evaluation

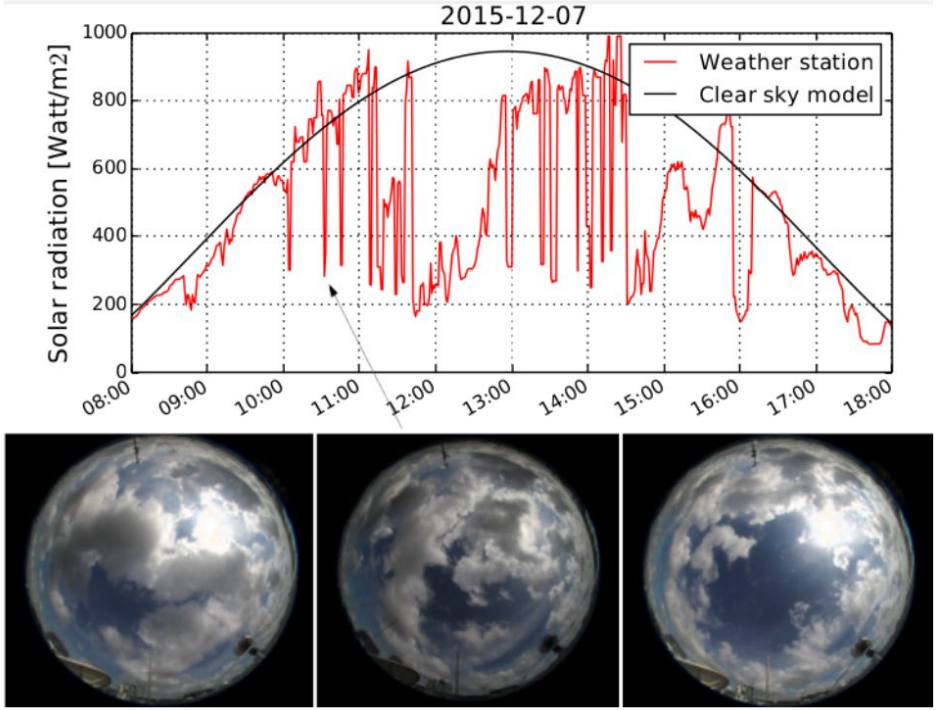
- We benchmark our method with two baseline approaches – persistence model and average model.
- The RMSE values are computed for lead times of 5, 10 and 15 minutes.
- We consider observations from 07:00 am till 06:00 pm.

Table 1: RMSE (W/m^2) for varying lead times of the benchmarking algorithms. The reported values are the average obtained from 10 experiments.

Lead Time	Proposed	Persistence	Average
5 min	29.28	55.30	298.63
10 min	111.71	167.89	200.06
15 min	147.32	188.17	322.96

Can ground-based images assist us?

Clouds are mostly responsible for solar irradiance fluctuations.



10:30 (758 W/m^2) 10:32 (283 W/m^2) 10:34 (714 W/m^2)

Conclusion

- We have proposed a time-series based technique for forecasting solar irradiance in Singapore.
- The RMSE of the proposed method is lower for all lead times as compared to the benchmarking algorithms.
- In the future, we intend to use other meteorological sensors and ground-based cameras to further improve the forecasting accuracy.

Final thoughts

Interested in pursuing a fully-funded PhD program in computer vision + machine learning, with applications to atmospheric study, multimedia or network security, at University College Dublin, Ireland?

Contact me at soumyabrata.dev@adaptcentre.ie for more details.

Engaging Content
Engaging People

Info and Contact

Soumyabrata DEV
https://soumyabrata.dev/

Ireland's European Structural and Investment Funds Programmes 2014-2020
Co-funded by the Irish Government and the European Union
European Union
European Regional Development Fund

The ADAPT Centre is funded under the SFI Research Centres Programme (Grant 13/RC/2106) and is co-funded under the European Regional Development Fund.