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# Short-Term Solar Forecasting by Deep Long-Short Term Memory Recurrent Network Program Considering Time Sequence Data

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**Abstract:** Solar photovoltaic power generation is an intermittent renewable energy source. It is highly dependent on solar irradiance, cloud cover variability, temperature, atmospheric aerosol levels, and other atmosphere parameters. Accurate forecasting of solar power is crucial to short-term generation scheduling and on-line secure economic operation. This paper proposes a short-term hourly solar forecasting technique using deep long-short term memory recurrent network (DLSTM-RNN) program considering time sequence data.

Deep learning techniques are considered as one type of machine learning that can be used for load forecasting, solar forecasting and wind forecasting. The DLSTM-RNN has more advantages than shallow neural network in terms of model architecture and the training process. The network is constructed from combining long-short term memory cell wither current network .The long-short term memory, a kind of feed forward neural network with memory cell unit, is interconnected with an input layer and a hidden layer. With forget gate of the Long-short term memory, it can reduce time consuming and better process bad data during the training process .The recurrent network is a class of feed forward neural network, dividing the input feature into the time sequence. The architecture of recurrent network is designed with the interconnection of two hidden layers to better incorporate time sequence data than the shallow feed forward neural network. The training process of recurrent network is considered to be reinforcement training categories, combining supervised learning and unsupervised learning. The unsupervised learning here is LSTM, used to pre-train the input data feeding to a hidden layer for reducing training time and avoiding vanishing gradient. By eliminating some redundant input, the model is considered to be supervised learning because we assign the target labeled data for testing comparison. The back propagation process to the time of RNN is updating weights between interconnected two hidden layers to minimize the loss function )error between network output and desire output (suitable to process the time sequence than the shallow feed forward neural network. Therefore, combining LSTM with RNN is a deep learning model with complex interconnection of multi hidden layers. The input data used include solar radiation from previous 7 intervals (time sequence data), day of the year, time of the day, temperature, and humidity.

The simulation of hourly solar irradiation forecasting uses the solar irradiation, relevant meteorological and time series data as input which collected from previous 1 year (8760 hourly interval data) to forecast the sample data which is 7 days (91 hourly interval with removing night timehour) of the target current year. From back test simulation, the simulation results from DLSTM-RNN render a better performance than shallow neuron network in terms of root mean square error(RMSE), mean bias error(MBE), mean absolute percentage error (MAPE), mean absolute error (MAE) and correlation coefficient (COR). Comparing with Deep Belief network (DBN) and Auto Encoder Long-short term memory (AUTO-LSTM), our simulation results have lower RMSE, MAE and COR with slightly higher MBE than DBN and AUTO-LSTM. The proposed DLSTM-RNN program is potentially viable for solar forecasting of utilities due to the higher accuracy.

**Biography: Professor Weerakorn Ongsakul, PhD, CFA** obtained B.Eng. (Electrical Eng.) in 1988 from Chulalongkorn University, Thailand; M.S. and Ph.D. (Electrical Eng.) from Texas A&M University, USA in 1991 and 1994, respectively. He is currently a Full Professor of Energy. He served as a Dean of School of Environment, Resources and Development, Asian Institute of Technology from September 2009 to June 2013. His research encompasses the areas of Intelligent System Applications to Energy, Power System Operation & Control, Power System Restructuring and Deregulation, Smart Grid, and Energy Risk & Financial Risk Management. He has conducted projects sponsored by Sida, EC-ASEAN Energy Facility/ACE and EU-Thailand Economic Co-operation Small Project Facility, and projects sponsored by Energy Conservation and Promotion Fund and Electricity Generating Authority of Thailand (EGAT), Provincial Electricity Authority (PEA) with a combined funding of US$3.0 million. Based on his research work, he has published more than **81 international refereed journal articles and 135 conference proceedings papers.** He has **supervised 27 PhD and more than 100 MSc students.** Adviser IEEE Thailand Section, Since 2009. He served as an Energy Specialist, Energy Standing Committee, Senate of Thailand during 2008-2011, a consultant of Asian Development Bank Institute (ADBI) in 2011-2012. He is currently serving as Executive Director of Bangchak Initiative and Innovation Center@AIT (BIIC@AIT), Secretary General of the Greater Mekong Sub region Academic and Research Network (GMSARN), Editor-in-Chief of GMSARN International Journal (Indexed by SCOPUS). He co-authored one book entitled Artificial Intelligence in Power System Optimization, published by CRC Press/Taylor & Francis in March 2013, and subsequently translated to Chinese by China Machine Press, CRC Press/Taylor & Francis in February 2016. He also received a number of national awards and recognitions which include amongst others, the Most Noble Order of the Crown of Thailand (Fifth Class) in 2008, the Most Exalted Order of the White Elephant (Fifth Class) in 2010, and the Royal Decoration on Companion (Seventh Class) of the Most Admirable Order of the Direkgunakorn bestowed by H.M. the King of Thailand in 2011. In addition, he has been a CFA Charter holder since Sept 2017.