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Copula Autoregressive Methodology for Simulation of Solar Irradiance and Air Temperature Time Series for Solar Energy Forecasting

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Abstract : The increasing interest in renewable energies strategies application and the path for diminishing the use of carbon related energy sources have encouraged the development of novel strategies for integration of solar energy into the electricity network. A correct inclusion of the fluctuating energy output of a photovoltaic (PV) energy system into an electric grid requires improvements in the forecasting and simulation methodologies for solar energy potential, and the understanding not only of the mean value of the series but the associated underlying stochastic process. We present a methodology for synthetic generation of solar irradiance (shortwave flux) and air temperature bivariate time series based on copula functions to represent the cross-dependence and temporal structure of the data. We explore the advantages of using this nonlinear time series method over traditional approaches that use a transformation of the data to normal distributions as an intermediate step. The use of copulas gives flexibility to represent the serial variability of the real data on the simulation and allows having more control on the desired properties of the data. We use discrete zero mass density distributions to assess the nature of solar irradiance, alongside vector generalized linear models for the bivariate time series time dependent distributions. We found that the copula autoregressive methodology used, including the zero mass characteristics of the solar irradiance time series, generates a significant improvement over state of the art strategies. These results will help to better understand the fluctuating nature of solar energy forecasting, the underlying stochastic process, and quantify the potential of a photovoltaic (PV) energy generating system integration into a country electricity network. Experimental analysis and real data application substantiate the usage and convenience of the proposed methodology to forecast solar irradiance time series and solar energy across northern hemisphere, southern hemisphere, and equatorial zones.

Keywords : copula autoregressive, solar irradiance forecasting, solar energy forecasting, time series generation
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