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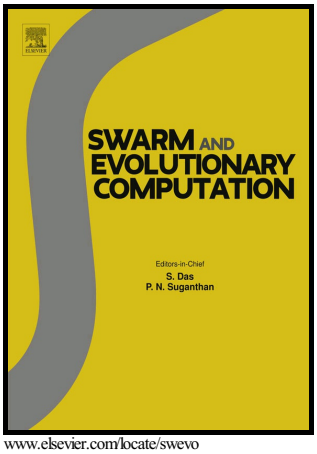

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Time Series Analysis and Short-Term Forecasting of Solar Irradiation, a New Hybrid Approach

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Abstract: In this paper, nonlinear time series analysis and short-term prediction of solar irradiation were considered, simultaneously. The proposed methodology is to employ time series analysis methods as well as swarm and evolutionary algorithms in conjunction with well-known regression, fuzzy and neural network model structures to develop a simple but efficient and applicable model for solar irradiation forecasting. The employed experimental data was the hourly solar irradiation of Qazvin city in Iran for five years. At first, the solar irradiation data was normalized using the daily clear sky irradiation data which is an annually periodic time series. Then, the properties of normalized solar irradiation were characterized via time series analysis methods such as recurrence plots, autocorrelation and mutual information analysis. Based on these analyses, each year was divided into two seasons, the sunny and cloudy seasons which are noticeably different in dynamics. Next, a hybrid but simple model was developed to predict the solar irradiation in different seasons. For the sunny season, an optimized multivariate regression model was proposed; and for the cloudy season a bi-level model consisting of an optimized regression model and ANFIS was developed. The model parameters were tuned optimally by various evolutionary algorithms being GA, PSO, ABC, COA, and flower pollination algorithm (FPA). A Fourier-type model was also developed for modeling of the clear sky data. The results showed the out-performance of FPA method in tuning of the model parameters and convergence time. Besides, the performance of the proposed bi-level model was evaluated in comparison with some other model structures such as artificial neural networks, ANFIS networks, LSE-regression models, LS-support vector machines model, etc. The results showed that the proposed method performs considerably better than the other methods in forecasting the solar irradiation time series in both sunny and cloudy seasons.

Keywords: Clear sky irradiation; Flower Pollination Algorithm (FPA); Recurrence plot; ANFIS; Multivariate regression model; Solar irradiation correlation analysis.

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1. Introduction

Solar cell is an energy source that is able to convert solar energy directly into electrical energy. Till 2030, 30% of the total energy will be supplied by renewable energy sources. That is, from this value, the share of solar cells will be about 10% of total energy [1] and up to 30% of the energy resources of the European countries [2].

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