International Journal of Energy Optimization and Engineering
Volume 11 • Issue 2

Prediction of Photovoltaic Panels Output Performance Using Artificial Neural Network

Abdelouadoud Loukriz, LMSE Laboratory, Biskra University, Algeria*
https://orcid.org/0000-0001-6558-5933

Djamel Saigaa, M'sila University, Algeria

Abdelhammid Kherbachi, Renewable Energy Development Center, Algeria

Mustapha Koriker, M'sila University, Algeria

Ahmed Bendib, Blida 1 University, Algeria

Mahmoud Drif, M'sila University, Algeria

ABSTRACT

To ensure the safe and stable operation of solar photovoltaic system-based power systems, it is essential to predict the PV module output performance under varying operating conditions. In this paper, the interest is to develop an accurate model of a PV module in order to predict its electrical characteristics. For this purpose, an artificial neural network (ANN) based on the backpropagation algorithm is proposed for the performance prediction of a photovoltaic module. In this modeling approach, the temperature and illumination are taken as inputs and the current of the mathematical model as output for the learning of the ANN-PV-Panel. Simulation results showing the performance of the ANN model in obtaining the electrical properties of the chosen PV panel, including I–V curves and P–V curves, in comparison with the mathematical model performance are presented and discussed. The given results show that the error of the maximum power is very small while the current error is about 10-8, which means that the obtained model is able to predict accurately the outputs of the PV panel.

KEYWORDS

Artificial Neural Network (ANN), Backpropagation Algorithm, Learning, Modeling, PV

INTRODUCTION

Today, energy is at the heart of the economy for all countries as well as the basis for all human activity. Over the years, energy resources have diversified in order to meet ever-increasing needs. The developed countries have moved from wood to coal, to hydrocarbons, to hydroelectricity, and finally to nuclear power. However, the use of fossil fuels is responsible for acid rain and global warming (IEA, 2019). On the other hand, the exploitation of nuclear energy presents risks of serious accidents, in addition to those induced by the management of the resulting waste, which can be radioactively dangerous for

DOI: 10.4018/IJEOE.309417
*Corresponding Author

several thousand years (Compaan, 2006),(Panchenko, 2021). Numerous countries have committed themselves under the Kyoto protocol to minimize their greenhouse gas emissions by 8% (Luther, 2005). Renewable energy such as wind, solar, hydropower and biomass have an important role to play in achieving this goal. More particularly, the solar energy resource starts to have a significant contribution to global energy production due to the low cost of maintenance and recurring operation of the photovoltaic systems (Luther, 2005) (Antonanzas et al., 2016).

In the photovoltaic field, the manufacturers provide notations for PV modules under various metrological conditions. However, these conditions are not always evident, which rarely occur in outdoor conditions, as they are mostly performed under laboratory conditions using solar simulators (Naeijian et al., 2021). To this end, the accurate and efficient modeling of solar photovoltaic modules represents one of the most important and difficult problems in the field of photovoltaic systems. These problems are mainly caused by the non-linear characteristics of solar cells, and by the lack of availability of all their parameters (Cortés et al., 2020). Several mathematical models have been developed to characterize the PV module under different working conditions; the widely used being the diode-based model. The most well-known models in the literature are single diode and double diode. The model of the single diode is the simplest model that introduces 5 unknown parameters (Chegaar et al., 2001)(Cardenas et al., 2017)(Villalva et al., 2009), while the double diode model takes into account more features than the double diode model with 7 unknown parameters (Chan & Phang, 1987)(Mathew et al., 2018)(Ishaque et al., 2011). However, the main problem that should be dealt with is the estimation of the unknown parameters of the PV panel model.

To estimate the parameters of a PV panel, various methods have been suggested in the literature. In general, there are two categories of methods: deterministic as well as heuristic methods. In deterministic terms, the methods are classified into analytical and iterative approaches (Waly et al., 2019). The analytical techniques use information from the PV datasheet to estimate the parameters. Among the analytical methods, reduced space search (RSS) (Cardenas et al., 2017), Lambert-W based methods (Peñaranda Chenche et al., 2018), and OSMP based methods (Tong & Pora, 2016). The above-outlined approaches are complex and time-consuming because they solve the non-linear equations to determine the unknown parameters of the PV cell model. The second approach of deterministic methods is that of iterative ones, where the parameters are derived via trial and error and/or iteration. Among them, the Newton-Raphson method (Easwa Rakhanthan et al., 1986) (Ayang et al., 2019), Gauss-Seidel method (Chatterjee et al., 2011), and the Least-Squares (LS) technique (El Achouby et al., 2018). However, the application of iterative methods requires the system equations to be convex, continuous, and differentiable, which restricts the application of these methods. Furthermore, the selection of appropriate initial values in iterative methods is an important issue, in which a wrong choice can lead to getting stuck in local optima (Qais et al., 2020). To overcome the above-mentioned drawbacks of deterministic methods, scientists have oriented themselves towards heuristic methods; the unknown parameters of the PV model being determined by solving an optimization problem. The problem of parameter estimation in heuristic methods is treated as a black-box problem, in this case, it is not necessary to apply certain restrictions to the system equations, in contrast to deterministic methods (Naeijian et al., 2021). According to the literature, a variety of heuristic methods have been successfully applied to extract the PV parameters, among them; Particle Swarm Optimization (PSO) (Ye et al., 2009), Simulated Annealing (SA) (El-Naggar et al., 2012), Artificial Bee Colony Algorithm (ABC) (Oliva et al., 2014), Genetic Algorithm (GA) (Ismail et al., 2013), Salp Swarming Algorithm (SSA) (Abbassi et al., 2019), Enriched HHO (EHHO) (Chen et al., 2020), and Springy whale optimization algorithm (SWOA) (Pourmousa et al., 2021).

Despite heuristic methods showing better accuracy and performance than deterministic methods, some heuristic methods require a significantly high number of iterations to converge, where different results are found by repeating the function.

The Artificial Intelligence (AI) has been used for solving complicated problems in several application areas, including pattern recognition, identification, classification, speech, vision,

Related Content