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Artificial intelligence solution for managing a photovoltaic energy production unit

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Abstract

The aim of the paper is to investigate the possibility of using artificial intelligence in photovoltaic energy production forecasting. The presented approach is conceived as a module of energy management and production planning of a photovoltaic power plant located in central part of Romania. The main goal of the research is to develop a solution that provides the electricity production based on historical and current available solar radiation data in real-time. Different data input cases and configurations of feedforward neural network are tested and used as a basis for discussions and conclusions.

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Keywords: electricity production forecasting; photovoltaic energy production management; artificial neural networks; optimal power planning.

1. Introduction

A constant increase of renewable energy sources usage for energy production correlated with national and international energy policies could be noticed in the recent years. Along with benefits also theirs usage implies a issues diversification to be solved on different levels. The presence of renewable energy sources may lead to changes in energy flows, line voltage, currents in normal or short-circuit regimes may affect the power quality in the distribution network and may cause changes in power system protection setup and stability. Consequently, it can be observed that the integration of renewable energy sources into the actual power system configuration represents a

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complex technical challenges requiring a set of specific analyzes such as: energy quality, power system protection, operational command of networks, control of load curve coverage, power system management, etc. Taking into account the case of solar photovoltaic sources integrated in the utility grid, an increased attention should be paid to analyzing solar variance availability, given its high short-term variability even up to 80% in the case of a passing cloud [1].

The paper investigates the possibility to estimate the generated power in case of significant impact solar photovoltaic units integrated in the grid, mainly useful for minimizing its impact on the utility grid and improving the grid overall operational control.

The main challenge on achieving the proposed goal is related to the complexity of the involved models by the difficulty in finding appropriate forecasting solution with adequate precision. Modern solutions based on artificial intelligence techniques can represent a suitable exploring way to model the complex dependency from the data used in estimation process.

The problem of estimating the power generated is well documented in literature as numerous resources regarding solar photovoltaic energy forecast can be found. There are also multiple approaches that can lead to the prediction of the generated power: considering as a starting point the solar radiation availability (hourly, daily, weekly, monthly solar radiation) or directly the electricity output from the photovoltaic systems [2,3,4,5,6,7,8].

As in a preview research [9] was stated, the energy production from photovoltaic sources estimation need analysis regarding:

- globally patterns differences in terms of solar energy availability as a result of geographical and climate conditions;
- lately climate changes, which leads to reconsideration of some used models and patterns;
- the large scale production systems for electricity from solar energy usage and thus the increased impact of these systems on existing energy systems;
- correlation of solar energy availability with climatic factors, pollution and energy consumption.

In the following sections the authors intend to evaluate the electricity production forecast from a photovoltaic energy production unit placed in Mures County.

2. Artificial Intelligence in Photovoltaic Electricity Production

Artificial intelligence is claimed to be an appropriate solution for many technical problem where is hard to develop an accurate model associated to the studied system. In the estimation problems neural networks proved good results. Results obtained from preview researches [9,10] indicate the possibility of adopting feedforward neural networks for modeling renewable energy resources, in this case being tested for a particular case of photovoltaic electricity production.

2.1. Feedforward Artificial Neural Network as an Estimator

Feedforward artificial neural networks (FANN) can already be considered a classic configuration of neural network widely used in researches to prove the effectiveness in classification, pattern recognition and data forecasting.

Considering the forecasting processes, FANN can deal with the nonlinearities and some degree of uncertainty found in models or in the used data series. This ability is given by its architecture consisting from a collection of elementary processing units represented by neurons, organized in three interconnected types of layers: input, hidden and output layer.

A real model is encoded by a set of weights that represent the learnt model and are found as weighted connection in the internal structure given by neurons placed on different layers of the neural network.

A feature that characterizes the FANN is the propagation of the data processing flow from the input through each layer until it reaches the output of the neural network.

In order to provide the expected results, a proper architecture of the FANN must be designed and the structure parameters have to be appropriately set in the learning process phase based on sample input and given/known output data.