Section
Секція **III**

INFORMATION TECHNOLOGY IN BIOMEDICINE

ІНФОРМАЦІЙНІ ТЕХНОЛОГІЇ В БІОМЕДИЦИНІ

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ADAPTIVE ALGORITHM FOR ONLINE CORRECTION ARTIFICIAL NEURAL NETWORK IN MPPT CONTROLLERS

Abstract. The characteristics of solar panels depend heavily on weather conditions such as light and temperature. During the day, the temperature and power of the solar generator are constantly changing. These changes result in a shift in the maximum power point and a partial loss of power. In order to obtain the maximum possible power from the solar battery, it is necessary to use the appropriate maximum power point tracking algorithm (MPPT).

Key words: Artificial Neural Network, Induced Degradation (LID), Potential Degradation (PID), Control System, Solar Battery, Maximum Power Point Tracking (MPPT).

The purpose and objectives of the study

The goal of the article is to develop an algorithm on-line correction of the solar cell maximum power point tracking based on artificial network for photovoltaic electric power generation systems with increased efficiency due to intelligent control systems, made using an artificial neural network.

How to create and train an artificial neural network

In recent decades, a new applied field of mathematics, specializing in artificial neural networks, has been developing rapidly. The relevance of research in this direction is confirmed by a lot of different applications of neural networks such as medical diagnostics or electric motor control [1, 2]. ANN has also been widely used in various solar panel studies. In its most general form, ANN simulates tasks or functions by performing calculations through learning. In the course of training, the network searches the training sample in a certain order. Browsing order can be sequential, random, etc. After training, the ANN acquires the ability to generalize and find reasonable exits when input is received data that does not occur during training [2]. The ability to learn is one of the main advantages of neural networks over conventional algorithms [3]. Technically, learning is about finding correlation ratios between neurons. ANN consists of simple processing units, neurons, and directional, weighted connections between these neurons. The connections between neurons are provided by synapses. The input information is multiplied by the corresponding connection strength – weight (synapse weight). The adder then adds signals coming from synaptic connections from the neurons of the previous layer. The last step in the calculation is the activation function through which the weighted amount passes. Further, the result is either passed to the next neuron with new weights, or is the network response. Today, there are many different configurations of neural networks with different operating principles that focus on a variety of tasks. In this work, a multi-layered direct distribution neural network was used, which is widely used to find patterns and classify images. The mathematical model of the neuron is described by the formula:

$$x_k^{(i+1)} = f\left(\sum_{j=1}^{N} w_j^{(k)} \cdot x_j^{(i)}\right) + B^{(k)} \qquad (1)$$

In formula (1) the output of neuron of layer i+1 is calculated as the weighted sum of all its inputs from layer i, to which the activation function normalizing the output signal is applied.

For this task, the artificial neural network has certain requirements: Accuracy and speed of operation, minimizing the number of neurons to facilitate subsequent implementation [4]. The classical method of artificial neural network creation includes several stages:

1. Data collection for training;
2. Production and optimization of data;
3. Selection of the network topology;
4. Selection of activation function;
5. Training and verification.

This technique has been improved and expanded to take into account the features of creating and configuring an artificial neural network to track the maximum power point. The improved synthesis consists of the following points:

1. Evaluation of the influence of external parameters on the solar battery and the system as a whole;
2. Selection of input and output parameters for the artificial neural network. At this stage, it is necessary to determine the place of ANN in the management system. This will determine the choice of the output parameter, the inputs for the ANN will be the parameters that have the strongest influence of the system;
3. Data collection for training. Both basic and supporting parameters;
4. Selection of network topology. Selection of ANN type, activation function, number of neurons in terms of required accuracy and implementation requirements;
5. Experimental modelling taking into account the selected network topology and prepared data for training;
6. Evaluation of the accuracy of the ANN operation, Verification of the operation of the artificial neural network on the test set and adjustment of the number of neurons;
7. Experimental simulation of ANN as part of the control system.

The information provided by the training sample generally determines the performance and efficiency of the ANN. In order to accomplish the task of tracking the solar battery's maximum power point, it is necessary to determine which parameters influence its characteristics, i.e. reflect the object patterns that the model must discover during the training [4]. The choice of parameters for learning artificial neural network and their processing is one of the most difficult and time-consuming steps of solving the problem. The training data set must meet several criteria:

1. The data shall reflect the true behaviour of the object being examined;
2. Data should not be inconsistent.

Location of the neural network in the conversion system

The solar energy conversion system considered in this work is shown in Figure 1. The system consists of an array of solar panels, a three-port DC converter and a control system. The main component of the control system is the unit that operates the converter at the maximum power point. Tracking the maximum power point is a very important task when working with a solar energy converter. Since the function of tracking the maximum power point is performed by an artificial neural network, it will be investigated.

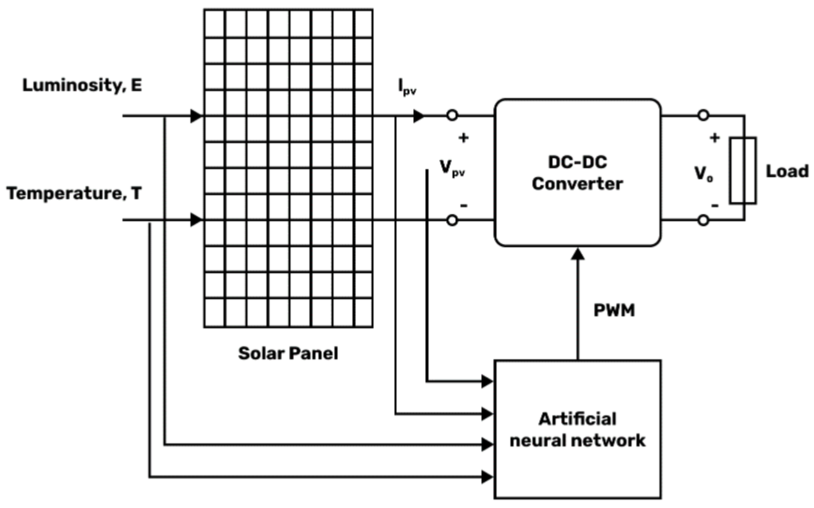

Fig. 1. Photovoltaic system flowchart with control algorithm neural network

The neural network comprises an input layer, one hidden layer and one output. The network input data are: Temperature, voltage and current of the solar module. The output neuron signal is equal to the voltage at which the maximum power of the solar module is achieved.

Online artificial neural network training

The experimental part of this article consists in the design, training, adjustment and subsequent adjustment of artificial neural network coefficients. When designing the ANN, the Elliott function was used as the activation function. The neural network was trained on data that included 100 volt-ampere characteristics in the light range from 10 to 1000 W/m^2 and temperatures from -30 to +50 °C. When designing an artificial neural network in real conditions, the light and temperature limits will change according to the climatic conditions of the region in question.

To avoid this problem, the artificial neural network needs to undergo additional learning after degradation. For this purpose, the calendar year was divided into zones where weather conditions, one way or another, repeat. As a rule, photovoltaic stations are installed during the summer period and, in the case of the proposed maximum power point tracking algorithm, there is a primary neural network based on the original VAC simulated or laboratory conditions. As mentioned earlier, the training array should cover all seasons by light and temperature. A properly configured and trained system will work successfully until a certain time elapses and the characteristics of the solar battery will not change, i.e. until it starts to degrade. For this purpose, the control system should store tables with temperature, maximum power and voltage values at the maximum power point (the table has a limited size equal to the number of VACs participating in the initial training).Next, when the system is in set mode, the control unit receives a command to compare the current temperature, maximum power and voltage at the optimum point.If in the zone of a given season there is a line with the closest values of these parameters and the data on the optimum voltage have not been updated for a long time, the system goes into the mode of withdrawal of volt-ampere characteristic, which replaces previous values in the learning array to further form a new learning data array with subsequent online correction of artificial neural network coefficients. Such an experiment was carried out in Matlab software.

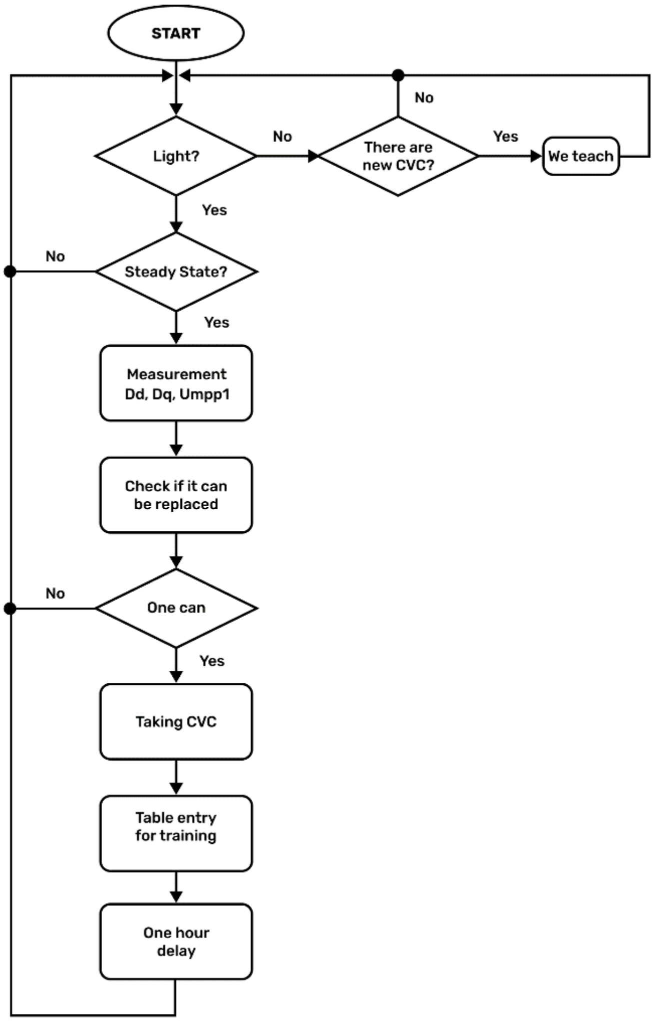

Fig. 2. Online Artificial Neural Network Coefficient Correction Flowchart

Result of research

On the basis of the results shown in the tables, we can conclude that the less old data left during retraining, the better the neural network is trained. Since the mean square error was counted on test data that were not part of the learning set, it can be observed that the regularization factor has no definite value. When designing the control system for the AC converter, a similar method of online correction of ANN coefficients will be used. The algorithm for the online correction of the coefficients of the artificial neural network will work according to the flowchart presented in Figure 2. The algorithm works as follows: To begin, the system must determine whether there is sufficient light, Next, when the system is in set mode, the control unit is commanded to measure d, q and voltage at the maximum power point. If in the zone of a given season there is a line with the closest values of these parameters and the data on the optimum voltage have not been updated for a long time, the system goes into the mode of withdrawal of volt-ampere characteristic, which replaces the previous values in the learning array to further form a new learning data array followed by additional training. For an AC system, the algorithm will differ only in the number of artificial neural networks, respectively, the number of parameters and tables that must be stored in the microprocessor memory.

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