

Envision of Solar Photovoltaic Module Parameters using AI Techniques

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Abstract - The necessity of power demand is raising in the present-day world and hence the entire world is turning towards alternating energy resources due to the fact that the conventional energy resources are going to be extinct in future. Nowadays huge research is going on in every corner of the world to find out the best possible ways in order to meet the power demand at the end and the researchers strongly believe that Solar energy is one of the best renewable energy resources. There are various parameters to be taken into consideration while using solar PV modules in the real time applications. The AI techniques nowadays playing an important role in solving many complex problems. In this paper, Artificial neural network is used in order to predict the solar PV module parameters. The Simulation was performed using NNTOOL in MATLAB/SIMULINK software.

Index Terms - Artificial neural networks, Solar pv module.

INTRODUCTION

Artificial neural networks play an important role in present day research as ANNs provide an extensive solution to different complex problems related to various sectors. The main advantage of ANNs is that they can adapt to any change in the environment i.e., they exhibit the characteristics of Adaptability. For example, there is no need to provide the exact temperature at the beginning as ANNs can adapt to any change in the temperature. Another most important characteristic of ANNs is that they can learn with examples to give accuracy i.e., if we provide more inputs or learn by more examples, then the accuracy of the Neural network will be more. Apart from these, there are many advantages in using ANNs for accomplishing many tasks in the research fields. The characteristics of the ANNs will be discussed in the later sections of this paper.

ANNs comes under the field of Artificial Intelligence. AI is the branch of study which deals with making the machine (computer) to perform some works or tasks

which a human brain can do better. The main aim of the AI is to make the computers to mimic the behavior of the human brain. An actual AI system always used to perform three different tasks i.e., 1. It should store the knowledge 2. It should apply the knowledge to solve problems and 3. It should acquire the new knowledge from the past experience.

LITERATURE SURVEY

The models of artificial neural networks and various algorithms were explained [1].The different characteristics of Artificial neural network has been proposed [2]. In [3],various algorithms were proposed and explained. The historical developments of ANNs were given in [4]. In [5], the characteristics of the ANNs were proposed besides various algorithms. In [6], [7],[8],[9], the concepts of ANNs with various models and learning rules were discussed. The applications of ANNs were discussed in [10], [11]. The Biological Neuron model and the characteristics of ANNs were discussed in [12]. The basic model of ANN is discussed in [13]. A detailed analysis of ANNs was presented [14]. The detailed modeling of solar pv module was discussed in [15] ,[16].

Modeling of a Solar PV cell:[15][16]

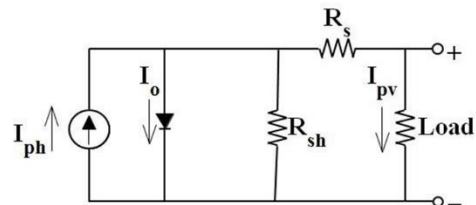


Fig 1: Equivalent circuit of a solar pv cell

The output current of the PV module is

$$I_{pv} = N_p * I_{ph} - N_p * I_o [\exp\{(q * V_{pv} + I_{pv} * R_s) / N_s * A * K * T\} - 1]$$

Artificial Neural Networks:

The Three main parts of our human brain are Cerebrum, Cerebellum and Medulla Oblongata. These three parts play an important role in performing essential functions like Protection, Audio and Visionary operations, Breathing etc. In actual practice, our human brain is an interconnection of many neurons (Ten billion in number) and we consider each neuron to be a cell. The cell uses biochemical reactions in order to receive, transmit and process the information. [1]

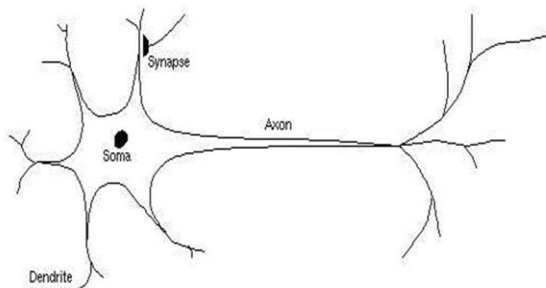


Fig 2: Biological Neuron

The above figure denotes a biological neuron. It mainly consists of Five main parts such as Dendrites, Soma, Axon, Axon hillock and Synapse. Dendrites are tree like structure in which these acts as input to the Soma. Soma I considered to be a unit in which processing of input can be done. Axon is a tube-like structure at where we can access the output. Synapse or Synaptic gaps or Neuro transmitters will transfer the output of the previous neuron to the dendrites of the next neurons.

ANNs are said to be Massively, Parallel, Adaptive network consisting of some simple non-linear computing elements called Neurons which are intended to perform some computational tasks similar to a Biological neuron. It can also be defined as, “An Information processing paradigm which is highly inspired by the way of human biological neuronal systems”. [2]

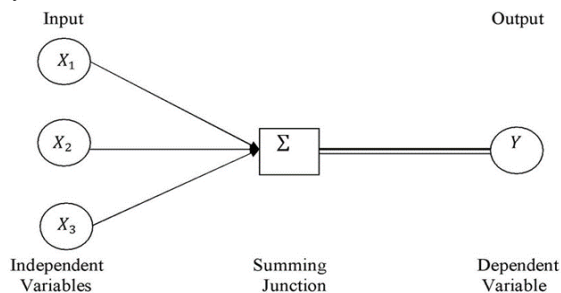


Fig 3: Artificial Neural Network

The above figure represents the basic model of Artificial Neural Network. [3] It consists of an Input layer, weights, Summation or Aggregation Block, Activation function block and an Output layer. In the above network, $x_1, x_2, x_3, \dots, x_n$ represents the input nodes of the input layer and weight are represented by $w_1, w_2, w_3, \dots, w_n$ and the weights are used to store the information. The summation block or aggregation block represented in the block diagram performs the computation i.e., it solves the equation of products of input nodes and weights. The result obtained from the summation block is considered to be Net input and it is then sent to an activation function unit. There are several activation functions and are discussed in the later sections of this paper. Finally, the result which comes from the activation unit will be considered as the output of the network. [13][14]

Historical development of ANNs: [4][5]

The era of ANNs have been started in the year 1943 after commencement of research towards the design of ANN by the scientists Warren Mc-Culloch and Walter Pitts. The network which they proposed allows only binary numbers i.e. 0 and 1. They also proposed that the neuron will be activated only after the net input is greater than the value of Threshold and the concept of Threshold holds much importance in this model. In the year 1949, the scientist Hebb published a book “The organization of behavior” proposed a book that there exists a continuous alteration in the connectivity of the brain and the root cause for this alteration is the organism learns different functional tasks. For the first time in the era of ANNs, Synaptic Modification has been introduced. The main concept behind his theory is that if two neurons are active simultaneously, then the strength of the connection between the two neurons should be increased. In the year 1958, the scientist Rossenblatt introduced Perceptron Network and Iterative weight adjustment process can be used in this type of network. Later in the year 1960, Widrow and Hoff had introduced a network called ADALINE (Adaptive Linear neuron) and this network uses a Learning rule called “Least mean square (LMS) rule “or “Delta rule”. In the year 1982, John Hopfield introduced a network called “Hopfield Network” and these nets are found to be mostly used as Associative nets. Later in the year 1972, Kohonen’s self-organizing maps (KSOM) have been come into existence and these nets have been applied to many

Recognition problems. In 1985 and 1986, Back propagation network was introduced in the neural network and it is considered to be a multi-layered feed forward network which is being trained by means of back propagation. In 1988, the scientist Grossberg had developed a learning rule which seems to be like the rule developed by Kohonen and this learning rule is used in out star learning. Later in the years 1987,1990, Adaptive Resonance Theory (ART) was introduced followed by Radial basis functions (RBF) and support vector machines in the years 1988 and 1990 respectively.

Differences between Computer and the Human Brain: [6][7]

Sl.No	Parameter	Computer	Human Brain
1	Processor	Complex and high speed	Simple and low speed
2	Memory	Separate from a processor	Integrated into the Processor
3	Computing	Centralized computing mechanism exists	No centralized computing system
4	Reliability	Highly Vulnerable	Robust
5	Expertise	Numerical and Symbolic manipulations	Perceptual Problems
6	Operation	Well defined or Clearly defined	Poorly defined
7	Environment	Well Constrained	Unconstrained

Table 1: Differences between Computer and Human Brain

In actual practice, the biological neurons are even though seems to be simple but process the information slowly when compared to the computers. The computers can process any information in Nano seconds range. [11] The one of the main advantages of human brain is that is very energy efficient as it consumes less energy per operation per second (normally $10^{-16}J$) compared to that of computer ($10^{-6}J$). The human brain can perform tasks like Pattern recognition, Perceptron, Motor control etc. many times faster than that of computers. The possibility of being attacked or harmed is very high in case of a computer and hence it is highly vulnerable whereas the reliability in case of a human brain is

robust. The computers in general has an expertise in Numerical and symbolic manipulations whereas the human brain has expertise in Perceptual problems.

ANNs in general exhibit the characteristics such as follows.

1. They process information in parallel.
2. They can deal with non-linearity.
3. They exhibit mapping capabilities i.e., they have the tendency to map input and output patterns.
4. They have the ability to learn more by examples.
5. They are fault tolerant.
6. They can adapt to any environment.
7. They have the tendency to provide confident response

Essentials of ANNs:

The models of the ANNs are specified by three basic entities i.e.

1. Processing elements (Neurons)
2. Interconnections and Structures i.e. Network topologies
3. Learning rules

The layer that receives the input in a network is called Input layer and the layer where we are supposed to determine the output is called Output layer whereas any layer in between the input and output layers is called Hidden layer. The ANNs in general possess three different type of architectures. [12] They are Feed forward, Feedback and Recurrent networks. If the output of a certain node is not fed back as an input to a node in the same or preceding layer, the network is said to be Feed forward network. If the output of the network is fed back as the input to the same or preceding layer, then the network is called Feedback network. If the feedback network has closed loops, then it is called ‘Recurrent Network’.[8][9][10]

There are three learning schemes in ANNs. They are Supervised, Unsupervised and Reinforcement learning. In Supervised learning scheme, the learning is happened under the presence of a teacher or supervisor. Here the teacher will give us the information of actual output and desired output. When an error occurs in the network, the error signal will be fed back to the learning mechanism unit until the desired output is obtained. In an Unsupervised learning scheme, the teacher will not be present and hence depend upon the value of the output we obtained, we have to learn our system. Reinforcement

learning is similar to the supervised learning. Here in this scheme, teacher will be present but he won't suggest whether the result obtained is right or wrong. This scheme will provide us Critics.

Prediction of Solar PV module parameters using ANNs:

ANNs are extensively used in prediction applications. In this paper, we have taken a solar pv module with inputs as Irradiation and Temperature and we have predicted the values of voltage, current and Power of a solar pv module at maximum power points. In order to predict the data using ANNs, a précised data sis necessary and hence in this paper, a set of 1000 values of input data were taken and analyzed. The prediction was done using NNTOOL in MATLAB and finally drawn the results.

Results:

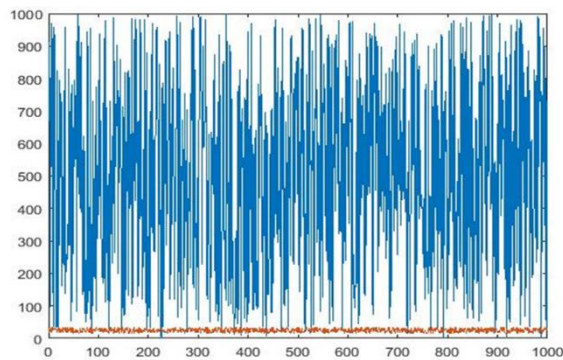


Fig 4: Input values of Irradiance and Temperature

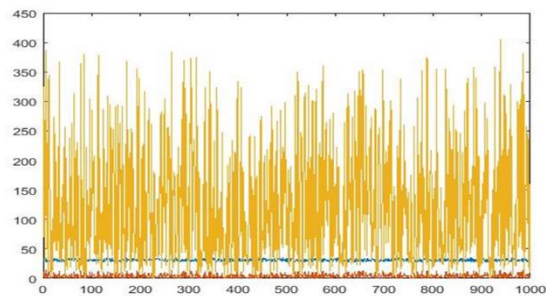


Fig 5: Output values of Vmp, Imp and Pmp

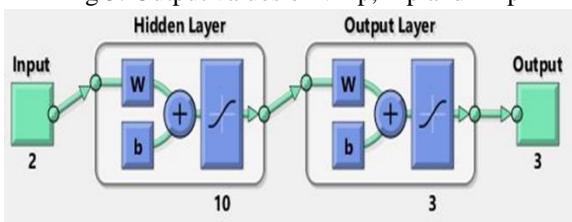


Fig 6: ANN model for Prediction

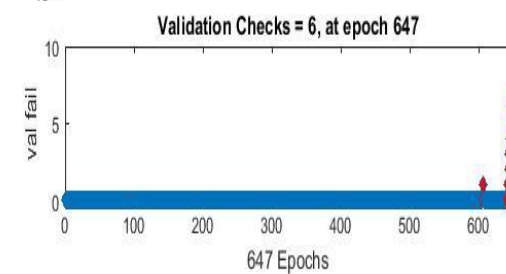
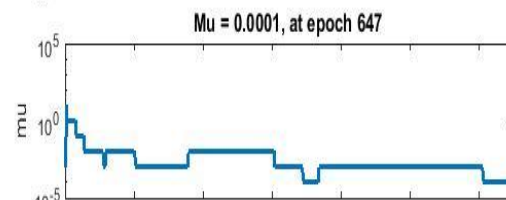
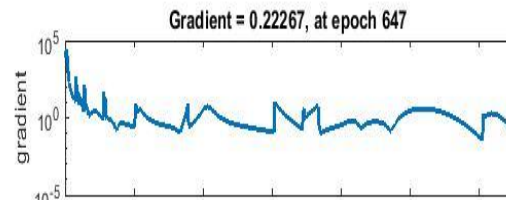
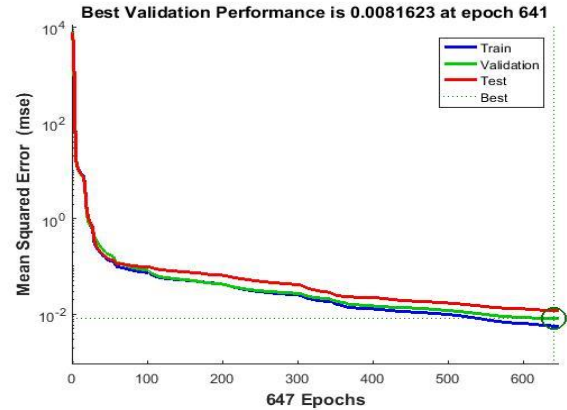


Fig 7: Performance analysis graphs

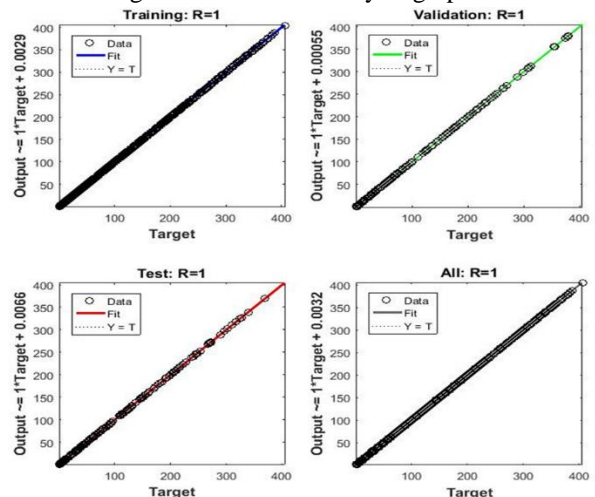


Fig 8: Regression plot of the ANN model

CONCLUSION

In this paper, we have addressed on the prediction of solar pv module parameters at maximum conditions by using Artificial neural networks. Initially we have generated the input values of irradiation and temperature randomly and owing to the fact that neural networks perform well with more number of inputs, we have generated the input values more in number. The output results were added in the paper and here the performance was analyzed by using NNTOOL in MATLAB software.

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