

# Enhancing the Efficiency of Solar Panel using Artificial Intelligence

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**Abstract:** Solar is now the cheapest form of electricity in the world, but the efficiency of the actual power plants is being analyzed one at a time, and mostly not tractable, especially for a fast-growing industry. Hence, we have considered parameters where we can make improvements to make solar power even more efficient. So, this is where AI comes into picture to analyse and leverage to improve the performance and reliability of PV modules, PV plants, and the prediction of solar energy output; and what is causing the dip in efficiency.

**Keywords:** solar, energy, iot, artificial intelligence, panel, electrical, voltage, time, humidity, temperature

## 1. Introduction

As we all are aware of the fact that, the future of our planet is in threat because of climate change and global warming, it is becoming increasingly vital to find sustainable ways to fulfill our energy requirements. Using solar panel to utilize the sun's energy is one of the most efficient ways of moving towards renewable and non-polluting energy in generating electricity.

Solar panel do not have moving parts, so they are one of the most cost-effective and low-maintenance ways of generating. Despite all their benefits, the efficiency of solar panels can be affected if dust and dirt accumulate. If we need maximum efficiency in power generation, solar panels should be cleaned timely. However, manually cleaning solar panels is hazardous and time-consuming.

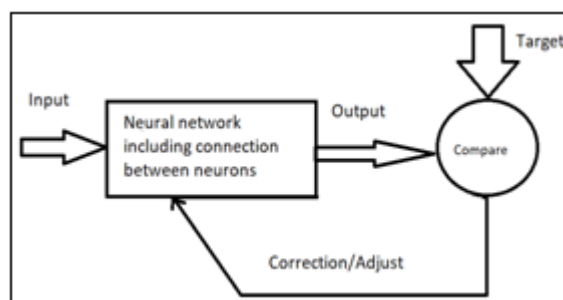
## 2. Abstract

Solar is now the cheapest form of electricity in the world, but the efficiency of the actual power plants is being analyzed one at a time, and mostly not tractable, especially for a fast-growing industry. Hence, we have considered parameters where we can make improvements to make solar power even more efficient. So, this is where AI comes into picture to analyse and leverage to improve the performance and reliability of PV modules, PV plants, and the prediction of solar energy output; and what is causing the dip in efficiency.

### 2.1 AI Techniques

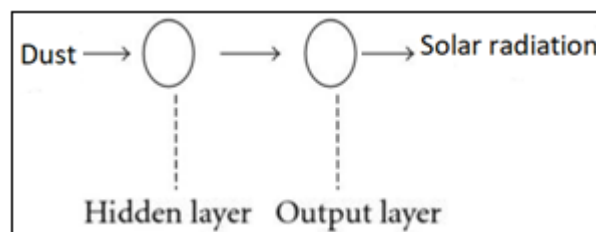
#### 2.1.1 Neural Network

Involving machine learning and acting on data sets without human programming or intervention is the concept of Artificial Intelligence. AI can be put as machine learning, deep learning and neural networks. For tracking we will be using neural networks in the project.



**Figure 1:** Basic Principle of Artificial Neural Network

Neural networks are used for process control because they can build predictive models of the process from multidimensional data routinely collected from sensors. The network usually consists of an input layer, few hidden layers and an output layer. The following diagram shows consideration of one neuron to enhance the solar power.



**Figure 2:** One neuron of the Neural network

The efficiency of solar panel gets affected by the factors like dust particles, wind, humidity, sunshine hours etc. Neural network takes these factors into consideration and help us calculate the efficiency of solar panel.

#### 2.1.2 Information processing in a Neural Network Unit

Neural network is nothing but acts like a neural system of human. Like the neurons in our brain get the pattern and predict things, artificial neural network also does the same with regular image sensory input to the system. The information that is processed in a neural network unit has the weights which gets summed up and activated for each neuron.

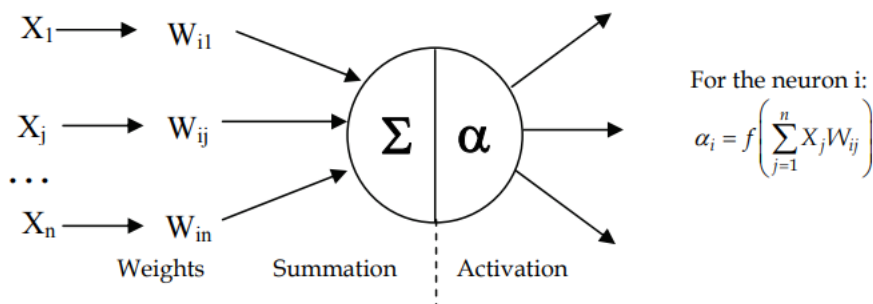


Figure 3: Information processing in Neural Network Unit

### 3. Prototype Model

We have considered the factors tilt angle, temperature, dust, humidity/rainfall in building the prototype. Dust and temperature are the major among these neurons. Using AI we can predict the temperature and rainfall/humidity but sudden shadow and dust drops the efficiency of solar panel to a greater extent. We determine the results using the ANN simulation set and the calculations.

### 4. Neuron Selection

The factors we have considered for our experiment are given as input neuron to the Neural network. We are considering the factors Temperature, Wind, Tilt angle, Humidity.

#### a) Tilt angle:

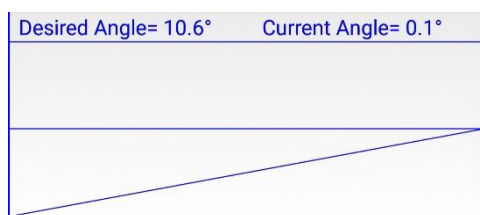


Figure 4: Current and Desired angle suggestion from AI

We have set the angle of the panel at 0.1 degrees, on capturing the neuron, here the AI suggests us the desired angle for an efficient solar outcome as 10.6 degrees. Hence, the panel should be then tilted to the required angle. We can verify these factors from the calculations below.

#### Other neurons

Unlike tilt angle of the panel, we have other factors which we cannot alter for our convenience. We can consider few of them also for our calculation of efficiency, as they play a major role in providing a huge difference in output when monitored keen.

- b) **Day:** As environmental values such as temperature, Humidity etc differs each day, we are considering day also as a neuron to demonstrate ANN injection.
- c) **Temperature:** As we live in tropical area where dew does not affect as much as northern countries, temperature is added advantage to us.
- d) **Humidity:** This works as a driving source for solar panel output when radiation is high or low.

With respect to the calculations below we can enhance the efficiency of the solar panel by considering the neurons we have selected. The more the neurons we select and calculate, the more accurate our results would be.

### 5. Experimental Results

The neurons given are linear in the hidden layer of the neural network, so the output is about to be the dot product of the weights and the input. To put things in perspective, we will use an activation function like sigmoid, signum, etc., which is applied to the dot product.

The neurons are linear, so no activation function has been applied and is directly propagated to the next layer, the output layer. We have considered humidity, temperature, day, month as the input neurons to train the network to receive our desired output.

Hence, finally, the output layer is bipolar. So, we get the activation function (probably sigmoid) is applied to it.

#### Error calculation

We have randomly divided the DATA into 70% training, 15% validation and 15% testing parts, and received RMSE values for both validation and training sets. By these sets, fitness of the model is calculated. The data obtained from the cloud results are plotted in graph, then fed to simulation for results.

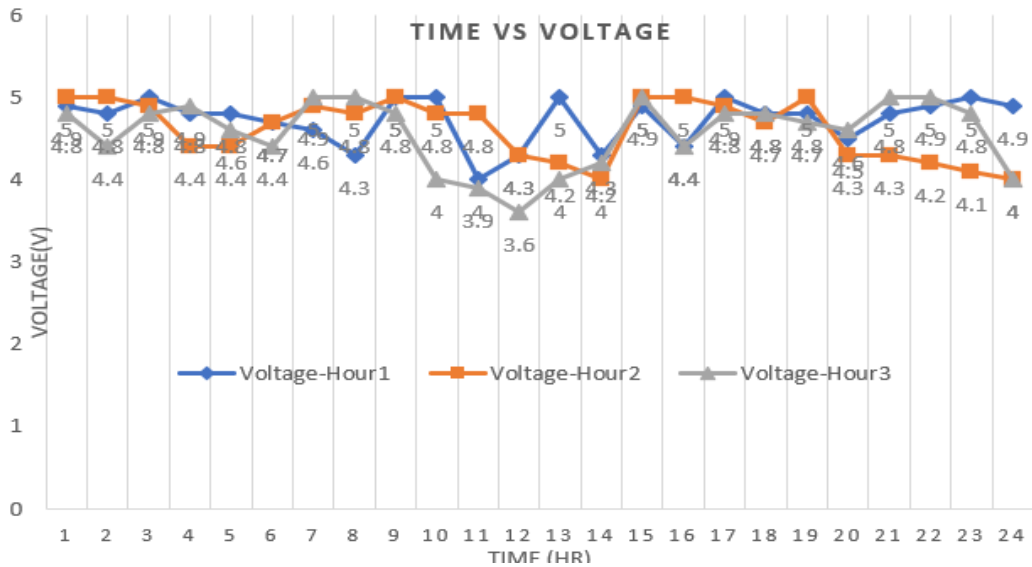


Figure 5: Hourly Forecast for Voltage in different colors for 3 hours

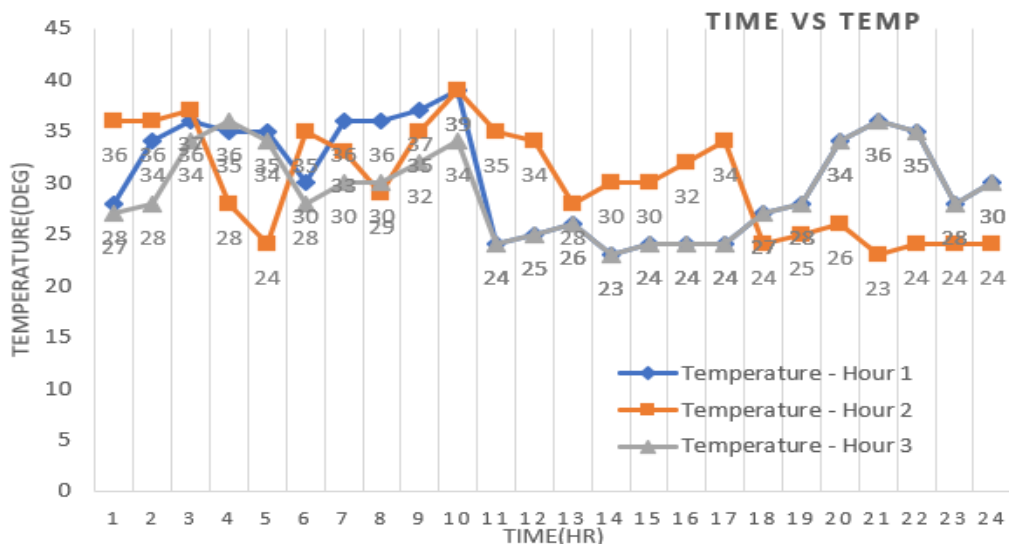


Figure 5: Hourly Forecast for Temperature in different colors for 3 hours

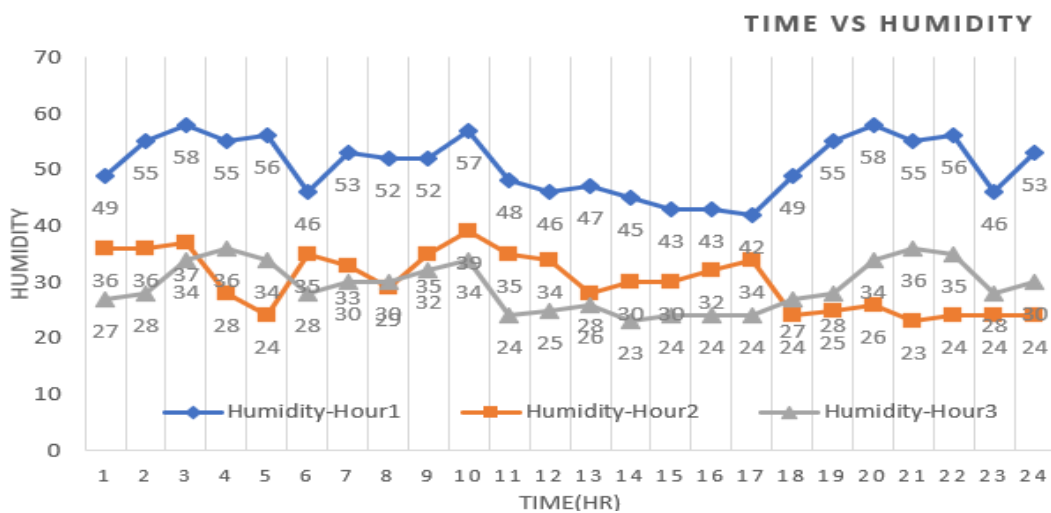
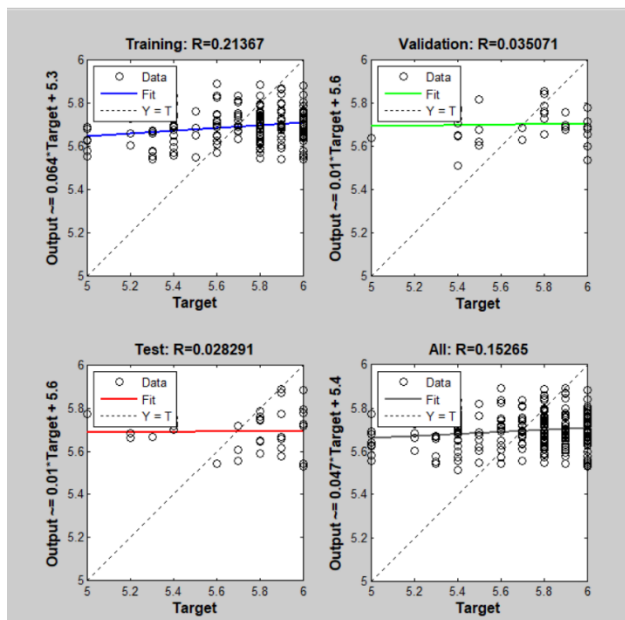


Figure 6: Hourly Forecast for Humidity in different colors for 3 hours



The data sets considered to build ANN model (Validation, Training, Testing)

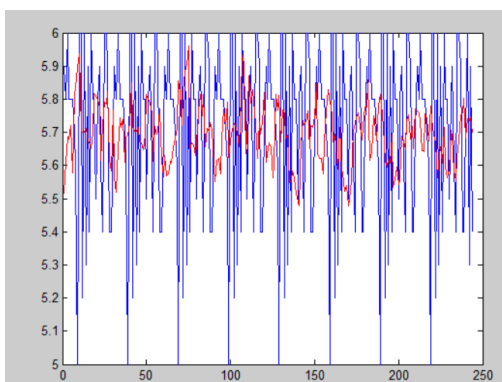


Figure 7: Model Fitness during Training/Validation Phase (Red – model output, blue – actual value)

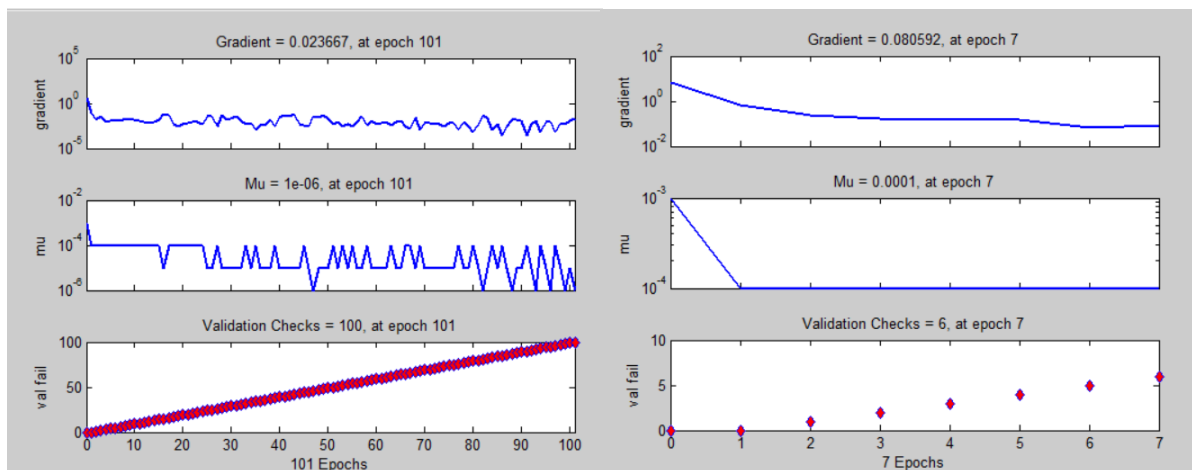


Figure 8: Validation checks of back propagation algorithm

We received error at 101, hence here we give the weight as back propagation to input to receive the desired value. We keep back propagating the error obtained from our results until the errors are reduced or until our desired values are obtained. The above plot is where the error has reduced to epoch 7, so we consider the trained and validated results comparing both the plots.

## 6. Literature Review

- Murshiduzzaman, J.A. Kadir, Z.N. Ismarrubie, et al., Development of IoT Based Dust Density and Solar Panel Efficiency Monitoring System, (2021), study investigates the accumulation of dust and efficiency of solar panel by developing an IoT based dust sensing system. IoT is much user-friendly, but when we consider

the fact Cybersecurity that is where Neural Network is helpful.

- Nurul F. Zainuddin et.al “Design and Development of Smart Self-Cleaning Solar Panel System” IEEE International Conference on Automatic Control and Intelligent Systems, 29 June 2019. In this study, a flexible cleaning gadget is developed, which ventures to every part of the whole length of the solar panel Solar power. But, the fine particles collected, dust and water from the air above the solar panel will prevent sunlight from reaching the surface of the solar cell. This is a notable issue since the light block materials present as external impedance that lower the solar based photovoltaic execution. The technique can also to monitor the power generated from the solar cells and instructions for cleaning solar cell photovoltaic surfaces can be activated when required by using Internet of Things (IOT) mobile applications. The result of the module demonstrates that the external resistance could bring down the performance of the solar panel up to 22%.
- Gabriel Moura Dantas, Odilon Linhares Carvalho Mende, and et al., Dust detection in solar panel using image processing techniques, (2020), uses methodology of an algorithm interprets image through attempts to find relationships between the input images.
- Ahmet Afsin Kulaksiz and Ali Unluturk, Image Processing-based Assessment of Dust Accumulation on Photovoltaic Modules (2019), was designed to evaluate the performance degradation of PV module with the help of image processing techniques, and the degree of PV module pollution was predicted which had 18% of efficiency results.

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