Predictive Analysis Of Solar Panel Performance with Cloud Services

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Abstract: With the increasing population, the natural resources are becoming extinct. People started to search for alternative resource that can generate electricity and solar panels are one among them. Solar panels convert the sun's energy to electricity. The performance of panels is to be tested before they are launched .Replacing a panel to test involves a lot of money and time. This project helps the user to predict the efficiency of the Solar panel and choose a best efficient panel to their climatic conditions. Here we consider three conditions Temperature, Irradiance and Wind Speed.

Keywords- Solar Panel, Temperature, Irradiance, Artificial Neural Network (ANN), Amazon SimpleDB

I. INTRODUCTION

Solar panels are devices that use sunlight to power machinery that can transform the heat from the sun into required forms. Solar panels contain silicon. There are different types of silicon chips available in the market. Each silicon chip generates electricity based upon its efficiency. For example, a pure silicon chip with purity of 99.9% can generate more electricity compared to an old silicon chip which is only 78% pure.

Efficiency (and thus output) of a chip is also controlled by the natural factors like:

- Wind Speed
- Wind direction
- Irradiance
- Ambient temperature

The main aim of the project is to estimate the efficiency of a silicon chip in various climatic conditions and to develop a mathematical predictive model for its output. This model is expected to provide an opportunity to estimate a behavior of a silicon chip before installing the same in an array.

The study undertaken under this project involves:

- Long term study of the performance of solar grade silicon cells / modules under the high irradiance / temperature conditions in Hyderabad, India.
- Comparing the performance of solar grade silicon cells / modules and arrays with that of semiconductor grade multi crystalline silicon cells / modules and arrays of similar capacity and under identical conditions are irradiance, temperature, wind speed etc. Degradation mechanisms are also studied.
- Using appropriate modeling, simulation and intelligent techniques to predict performance of the solar grade silicon cells / modules / arrays.

We use an Artificial Neural Network (ANN) model to predict the data. The data of the solar panel is stored in a database, Amazon Simple DB. An introduction to ANN is discussed in part II, Role of cloud computing in part III Algorithm to predict the data in part IV. Results in Part V

II. AN APPLICATION OF PREDICTION

An **artificial neural network [2]**, often referred to just as a **neural network**, is a mathematical model inspired by biological neural networks. A neural network consists of an interconnected group of artificial neurons, and it processes information using a connectionist approach to computation. In most cases a neural network is an adaptive system that changes its structure during a learning phase. Neural networks are used to model complex relationships between inputs and outputs or to find patterns in data.

The inspiration for neural networks came from examination of central nervous systems. In an artificial neural network, simple artificial nodes, called "neurons", "neurodes", "processing elements" or "units", are connected together to form a network which mimics a biological neural network.

There is no single formal definition of what an artificial neural network is. Generally, it involves a network of simple processing elements that exhibit complex global behavior determined by the connections between the processing elements and element parameters. Artificial neural networks are used with algorithms designed to alter the strength of the connections in the network to produce a desired signal flow. Neural network models in artificial intelligence are usually referred to as artificial neural networks (ANNs); these are essentially simple mathematical models defining a function $f : X \rightarrow Y$ or a distribution over X or both X and Y, but sometimes models are also intimately associated with a particular learning algorithm or learning rule. A common use of the phrase ANN model really means the definition of a *class* of such functions (where members of the class are obtained by varying parameters, connection weights, or specifics of the architecture such as the number of neurons or their connectivity).

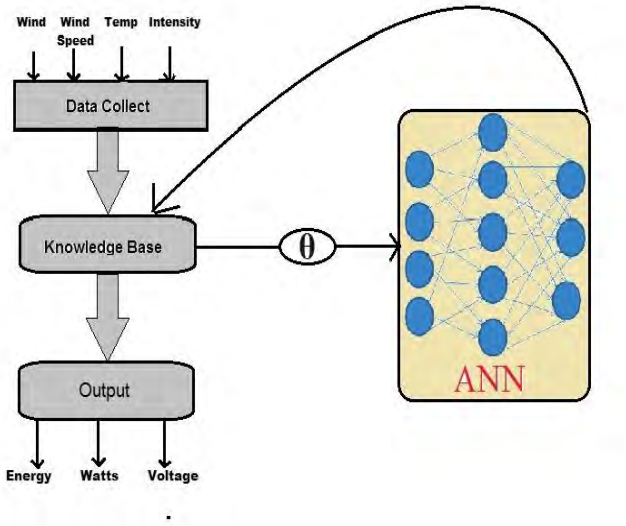

Fig: 1: process flow

In the present project, parameters such as Wind Speed / direction, Irradiance, and Temperature at a particular place or an area act as inputs to the neural network. These inputs are then matched with the middle layer or hidden layer. If the inputs match the data already stored in the network, it outputs the values of Energy (E) - Voltage (V) and Watts (W) which are calculated by the formulations.

If the inputs do not match with the data which is stored in the network, then a different formulation is used:

New input=old input+Θ (desired-output)*input

Where **Θ** is learning rate. The database stores the new output and it is automatically fetched for use in further estimations.

III. ROLE OF CLOUD COMPUTING

Cloud computing is the use of computing resources that are delivered as a service over a network The name comes from the use of a cloud-shaped symbol as an abstraction for the a complex infrastructure. cloud computing applies remote services to a user's data, software and computation.

We specifically use the concept of cloud computing in this project because of the following reasons:

- The Amazon Web Services **Amazon EC2** is enabled for deployment of this application for high performance computing.
- The solar panels are generating a huge amount of data during the training, testing and production phases, hence an expandable and sink capable database is needed, which can be deployed by **Amazon SimpleDB**

- We need specific machine learning tools for classification and regression training, where a tool called **Caret: Classification and Regression Training**, which works best on **Amazon EC2**.
- The architecture of the application is also required to be centralized with a minimum replication of data.

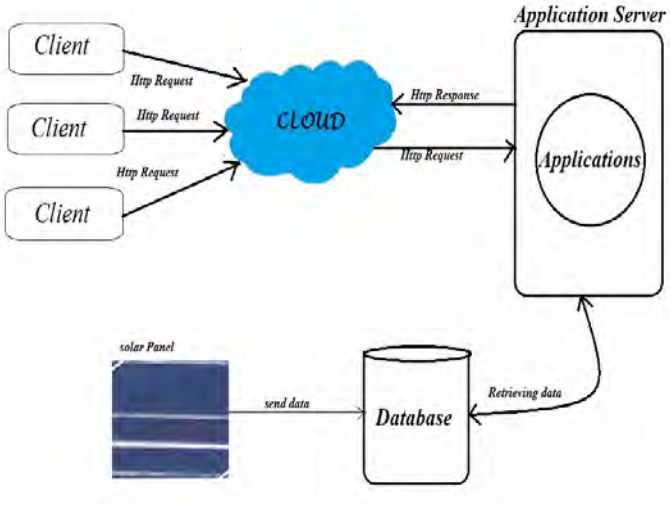

Fig: 2: System Architecture

The system architecture depicts a client-server model. The clients are the users of the system. The client sends a Http Request to the Application Server and the server processes the request and send's a response to the client. The data recorded from the solar panel is fed to the database.

IV. COMPUTATIONAL MODAL

The following formulations are used to compute

1. Current:

$$isc_{comp} = \left(isc * \left(temp \div 1000\right) + isc * \left(temp \div 1000\right) * d * \left(irr - 25\right)\right)$$

Where isc-current at short circuit; comp-new computed value; temp-temperature; irr-irradiance d=(0.04f/100).

2. Voltage:

$$voc_{comp} = \left(voc - \left(voc * c *\right)\left(irr - 25\right)\right)$$

Where voc-voltage at open circuit; comp-new computed value; irr-irradiance; c=(-0.36f/100)

3. Power

$$p_{comp} = (isc_{comp} * voc_{comp})$$

Where p-power; comp-new computed value; isc-current at short circuit; voc-voltage at open circuit.

4. Energy

$$Energy_{comp} = (p_{comp} \div 60) \div 1000$$

Where p-power; comp-new computed value;

5. Current of the module

$$imp_{comp} = \left(imp + \left(imp * isc * \left(irr - 25\right)\right)\right)$$

Where imp-current of the module; isc-current at short circuit; comp-new computed value; irr-irradiance.

6. Maximum Power of the module

$$p\max_{comp} = \left(p\max - \left(p\max * e * \left(irr - 25\right)\right)\right)$$

Where pmax-maximum power; comp-new computed value; irr-irradiance. e=(0.43f/100)

7. Voltage of the module

$$vmp_{comp} = \left(p\max_{comp} \div imp_{comp} \right)$$

Where vmp-voltage of the module; comp-new computed value; pmax-maximum power; imp-current of the module.

8. **Formula for Prediction:**

$$a_i = \sum_{i=0}^{n} u_i w_i \pm \theta$$

Where "θ" represents threshold in artificial neuron, "w_i" represents weights. "u_i" represents input values.

9. **Formula for Weight Modification:**

Where "θ (t+1)" represents the next threshold in an artificial neuron "θ (t)" represents the present

$$\theta(t+1) = \theta(t) \pm \frac{\Delta\theta}{\Delta t}$$

threshold in an artificial neuron

V. RESULTS

The above formulations were used on the test-bed solar panel laid out for the project and actual readings (inputs / outputs) were fed into the database for the last 1 year to create an initial data table. This data was used to create a real-time predictive model that resides on the cloud. The model was used to calculate predictive output values using artificial inputs. The test output thus obtained was compared with actual outputs to validate the model. An accuracy of above 98% was obtained using this predictive model.

Input Parameters		
temperature	irradiance	Wind speed
27.333	864.174	2.678
27.552	786.549	1.879
27.833	1153.793	4.276
27.58	1118.05	5.874
27.625	1166.908	1.879

Table1: Input Parameters

Output Parameters							
Actual Values				Predicted Values			
dcamps(act)	dcvolts(act)	watts(act)	energy(act)	dc amps	dc volts	watts	energy
7.08	187.754	1329.762	22.1627	6.356	192.8	1225.926	20.4321
5.05	197.235	995.999	16.5999833	4.435	207.324	919.48194	15.324699
9.334	181.494	1694.475	28.24125	8.935	198.554	1774.08	29.568
8.982	180.077	1616.627	26.9437833	7.996	191.234	1529.1071	25.485118
7.459	203.574	1518.514	25.3085667	7.123	210.78	1501.3859	25.023099

Table2: Output Parameters

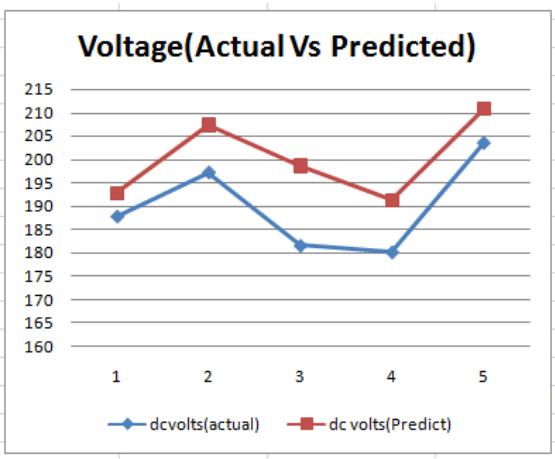

Fig. 3: graph of Voltage (Actual Versus Predicted)

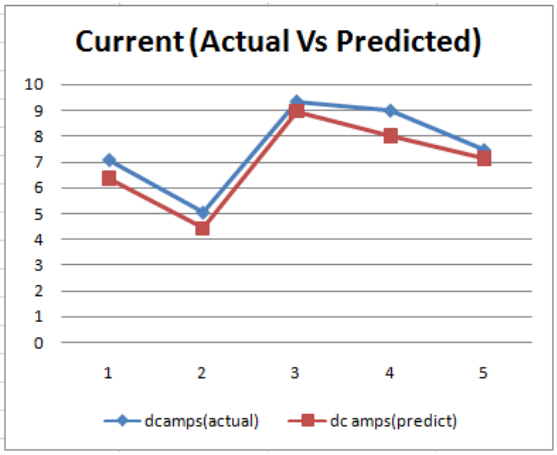

Fig. 4: graph of Current (Actual Versus Predicted)

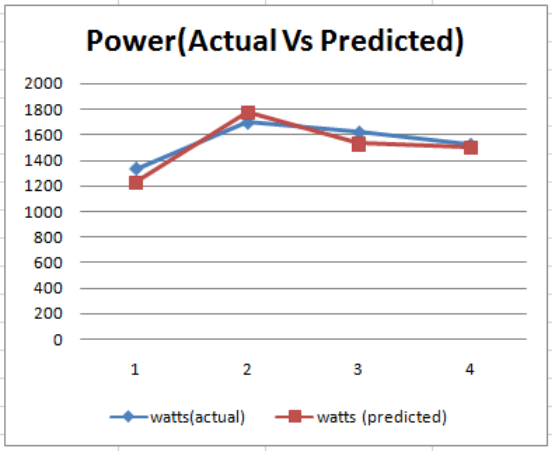

Fig. 5: graph of Power (Actual Versus Predicted)

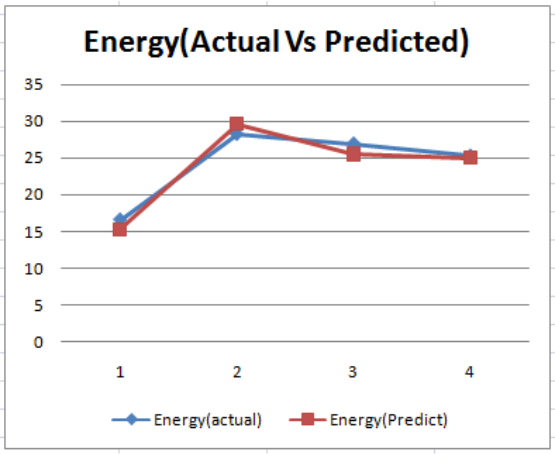

Fig. 6: graph of Energy (Actual Versus Predicted)

VI. CONCLUSION

In this paper, we present a predictive model to test the efficiency of the Solar panel. This system not only predicts data, but also provides functions for further information by data mining and friendly user interface display.

The performance of Solar panel is analyzed on a recorded dataset, which is large in volume and the learning of ANN is well studied. and a comparison of the actual value to the predicted values are shown above. With this the panel may be tested before it is launched.

VII. FUTURE WORK

In this paper, we have demonstrated predictions using Artificial neural networks..the data can be further analyzed to predict the temperature for mere future i.e.,, future weather prediction.

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