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Using Machine Learning for Analysis a Database Outdoor Monitoring of Photovoltaic System

Hichem Hafdaoui[1*], El Amin Kouadri Boudjelthia[1], Salim Bouchakour[1], Nasreddine Belhaouas[1]

[1]Centre de Développement des Energies Renouvelables, CDER
16340, Algiers, Algeria

*Corresponding Author

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Abstract: In this paper, a new method for analyzing a database of outdoor monitoring of photovoltaic system using machine learning has been proposed, a Photovoltaic (PV) module (150 w) located in Algiers has been monitored for 80 days and the obtained results have been analyzed. The researchers face many difficulties one of the most significant ones is in terms of collecting and analyzing the obtained results, especially for long period of time of monitoring. In this paper we propose a new method to analyze the results by machine learning using Support Vector Machine (SVM) Classifier. In such away, we regroup a data variable to multiclass for according and analysis using SVM. Which have presented thoroughly all the classification steps. Using method of artificial intelligence (machine learning), recorded data, and the power output for a given photovoltaic module (PV) technology, types, and small or large stations under any seasons it makes analysis and processing easy. The measurements of this works were investigated based on the recorded data by acquisition (Keysight 34972A). The system takes measurements data from sensors in a database ready for analysis. The data was taken from the measurement system from 05h00 to 21h00 with irradiation of 50 W/m^2, which is a starting point, however in 0 to 50 W/m^2 the system cannot detect any photovoltaic effect. Results predict that the performance ratio (PR) from a Poly-crystalline PV module was around 85.28 % for a different season's exposure and 727 point analyses at irradiation of 850-950 W/m^2 at the same time 14h00-15h00. The temperature of a photovoltaic PV module is as well calculated and compared with different irradiation and time.

Keywords: Monitoring, performance ratio, data analysis, machine learning, SVM

1. Introduction

Here in Algiers, which is located on the Mediterranean coast, sunset is different from winter to summer (approximately 16 hours from sunrise to sunset) as to winter (9 hours).

Solar energy is sustainable energy as it is renewable, meaning that it is energy that does not run out. It is a natural energy source and can be used to generate other forms of energy. Solar panels do not cause any noise when they convert sunlight into usable electrical energy Solar power plants and solar panels in Homes do not emit any emissions and do not cause any harmful impact on the environment.

Most of the sources of clean and renewable energies are produced from solar radiation, wind, water and biomass. All of these sources have techniques for exploiting or storing them. It is worth noting that only a small part of the available solar energy has been used in our lifetime. Electrical energy is generated from solar energy by heat engines or photovoltaic converters. Solar energy is considered the mother energy on planet Earth, as it emits all the energies above it. This energy can be converted directly or indirectly into heat, cold, electricity and motive power. And solar energy varies according to its movement and distance from the Earth. Solar energy reaches homes through solar panels. The

*Corresponding author: h.hafdaoui@cder.dz

intensity and intensity of the sun’s rays vary on the map of the Earth according to the seasons of the year over the two hemispheres, its distance from the Earth, its tendencies, and its position over geographical locations throughout the day or during the year [1].

Preventive maintenance in system photovoltaic is the periodic maintenance and is not related to the presence of malfunctions, as maintenance dates are scheduled at certain intervals that comply with recommendations with the recommendations of manufacturers equipment such as photovoltaic inverters, PV modules, control systems and others.

The statistics worldwide for the capacity of PV has increased from almost zero GW in 1990 to 505 GW in 2018 [2-3] and a 102.4 GW growth in PV installation has been observed globally in 2018 alone [2,4]. Be alerted in the event of a malfunction, supervise your photovoltaic installation: it is essential to monitor solar production. Monitoring now offers many possibilities, from simple production measurement to home automation. Some manufacturers even offer support in addition to the monitoring tool: customer service, technical interventions, and additional tools to help solar professionals [5].

The "monitoring of photovoltaic installations offers the possibility of following the production performance and the quality of operation of the photovoltaic panels as well as the inverters. It thus makes it possible to detect any operating anomalies that may occur. Indeed, a monitoring system helps to analyze the production data of photovoltaic solar systems and compare them in the form of tables or instantaneous figures or daily, monthly or annual summaries. These data are accessible on site or remotely (from a smart phone, pc or tablet). Installation of photovoltaic systems from data storage and database processing to analysis and display

One of the most important difficulties faced by researchers is collecting and analyzing the data of monitoring for a long period, so In this paper, we propose a method to analyze the results of the solar panel of 150 W during 80 days of outdoor monitoring by Support Vector Machine (SVM) classifier using Heatmap; in the general sense are a visual representation of data, in which different data values are depicted by color to facilitate the process of visualizing and quickly understanding complex data, where we applied in this paper the technique of analyzing the results of monitoring of solar panels by a heatmap [6-9].

2. Support Vector Machine

Support vector machines are a set of supervised learning techniques for solving discrimination and regression problems. SVMs are a generalization of linear classifiers.

Large-margin separators were developed in the 1990s from the theoretical considerations of Vladimir Vapnik on the development of a statistical theory of learning: The Vapnik-Chervonenkis theory. They were quickly adopted for their ability to work with high-dimensional data, the low number of hyperparameters, their theoretical guarantees, and their good results in practice.

SVMs have been applied to many fields (bioinformatics, information retrieval, computer vision, finance, etc.). According to the data, the performance of support vector machines is of the same order, or even superior, to that of a neural network or a mixture model. [10].

The basic principle of SVM consists in reducing the problem of discrimination to that, linear, of the search for an optimal hyperplane. the idea achieves this objective; a define the hyperplane as the solution of a constrained optimization problem whose objective function is only expressed using scalar products between vectors and in which the number of “active” constraints or support vectors controls the complexity of the model. Fig 1 shows the architecture of SVM Classifier. Theory of the SVM classifier is well explained in Refs. [6-8]

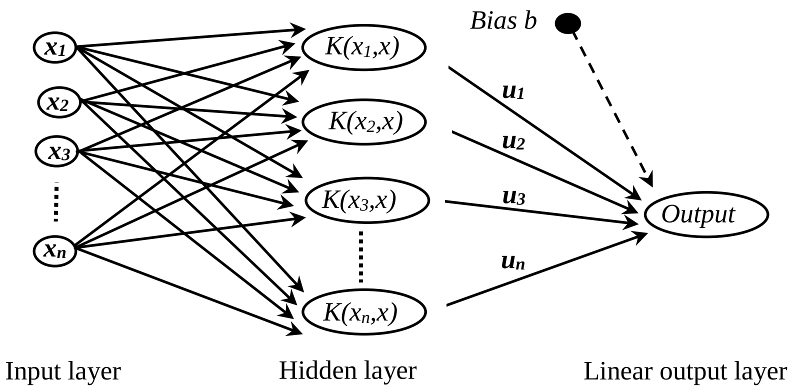

Fig 1 - SVM classifier architecture [9-11]

3. Method of measurement and data processing

The Data Acquisition System consists of a set of data of different units and measurements under different conditions, which is called a database, through which we prepare an analysis system by converting it into structured data that is suitable for fast queries. [12].

Table 1 shows the localization of PV modules installed in out laboratory - CDER, Ben Aknoun City, Algeria

Table 1 – Localization of PV modules

Latitude	Longitude	Altitude
36°44’44,94’’N	3°00’46,80 E	236 Meters

The system collects measurements from different sensors (eg Isc, Voc, Pmax, Imp, Vmp, Tpv Tamb, G, WD, WS, date and time, FF). Using data acquisition (Keysight 34972A), the measurement system starts at 05:00 until 21:00. Where we used the following devices for measurement:

- Pyrometer LSI COD-DPA154.
- Data Acquisition keysight technology 34972A.
- Electronic Charge keysight technology N3300A.
- Sensor - PT100 TC DIRECT

The measurement system diagram of our laboratory shows in Fig 2, the interesting stage in our research work is possessing and analysis

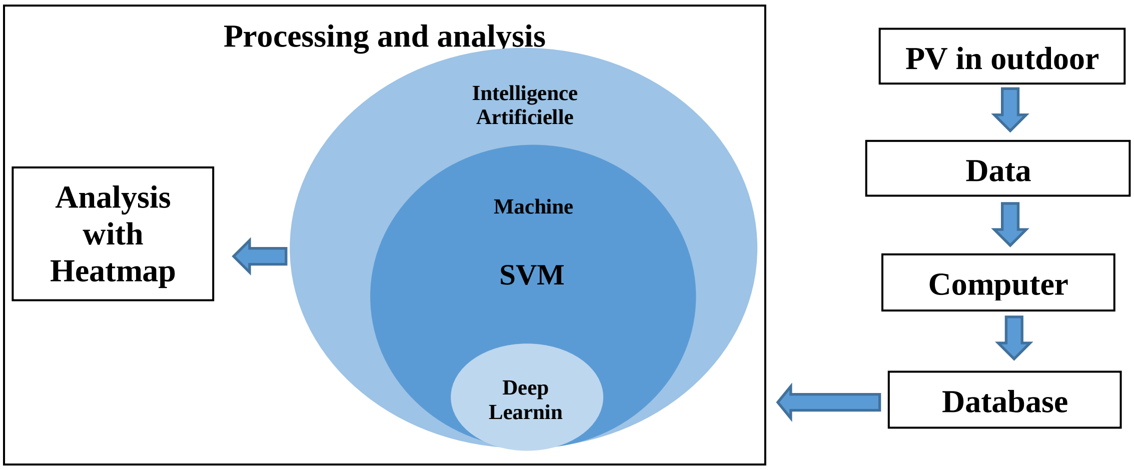

Fig 2 - Diagram of system measurement

We apply Machine learning using SVM classifier to analyze the data obtained during 80 days of outdoor monitoring, in order to facilitate the study of measurements. We convert the variables data into class, and then grouping them according to the objectives and analytical requirements (Fig 3).

Heatmap it is a gradual color display that helps to read the data easily.

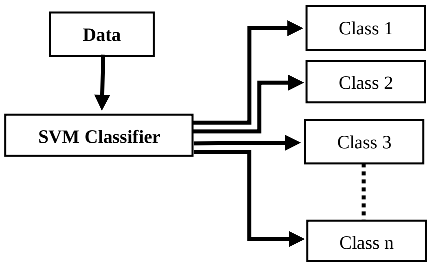

Fig 3 - Single multiclass SVM

4. Results and discussion

The system of data acquisition in Outdoor supplies a wide range of measurement conditions. This data contains parameters that are predicted by different measurement units and saved. Moreover, the parameters measured were imported into a common database for preparing further analysis through which we prepare an analysis system by converting it into structured data that is suitable for fast queries. [11]. In this paper, we discussed the importance of machine learning monitoring data to analyze using heatmap, Fig 4 shows the number of data points which represent measurements in each class. The maximum point analyze in this duration is 727 measurement points at 850 > G > 950 W/m^2, between (14h00 15h00) (See Table 2). In Fig 5 the Pmax at this point was 85.28% as the maximal power point, and at same point the PV module reached the temperature of 50.77°C in same condition and time (see Fig 6). We notice that the PR is between 80% and 90%, so it can be said that 20% of the energy loses it in 80 days. In order to classify the data and to can eliminate the not acceptable point in any irradiation the heat map based on machine learning was facilitate our study and measurement for choosing the logical point.

To select another point, we do it analyze each point to can select and make difference. Any data can investigate with the same procedure and analysis method.

The PR of a PV module is determined as follows: [13]

$$PR = \sum_{i}^{n} \frac{P_i}{P_{max\,STC}} \times \sum_{i}^{n} \frac{G_i}{G_{STC}} \qquad (1)$$

P_i is the measured power of the PV module in W.

$P_{max\ STC}$ output power of the PV module under standard test conditions.

G_i is the measured irradiance in W/m^2,

G_{STC} the irradiance at standard test conditions.

Table 2 - Examples for reading heatmaps with each other

	G(W/m²)	Time	Number of data points		PR (%)		Tm(°C)
	250-350	08h00-09h00	475		89,22		32,21
	550-650	16h00-17h00	703		89,62		46,60
Figure 4	>1150	14h00-15h00	1	**Figure 5**	92,4	**Figure 6**	34,1
	950-1050	12h00-13h00	639		84,47		57,81
	550-650	18h00-19h00	0		No Value		No Value

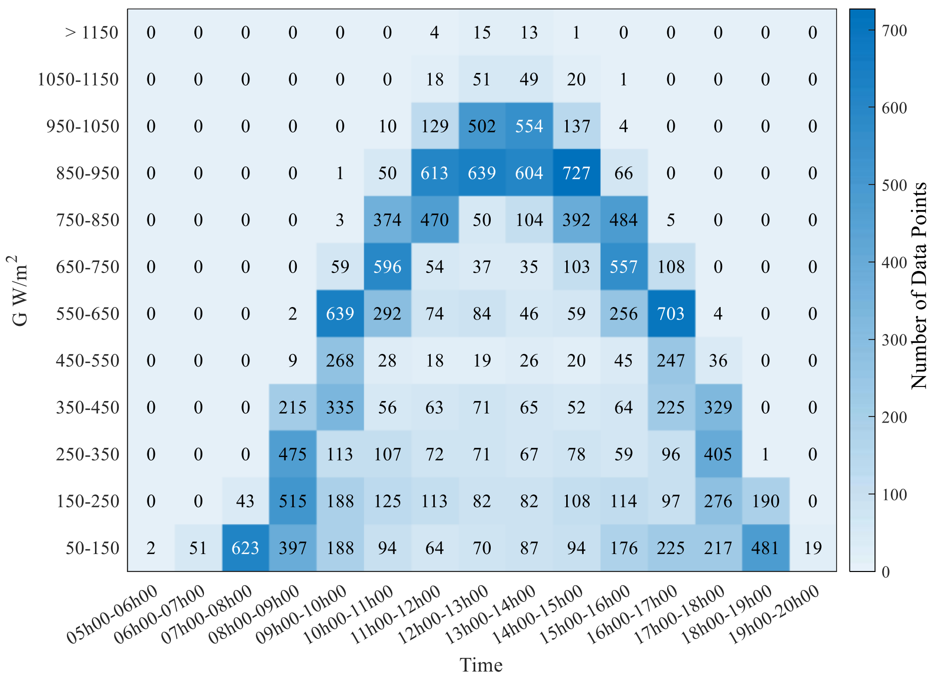

Fig 4 - Number of data points and G (W/m^2) Versus time in 80 days

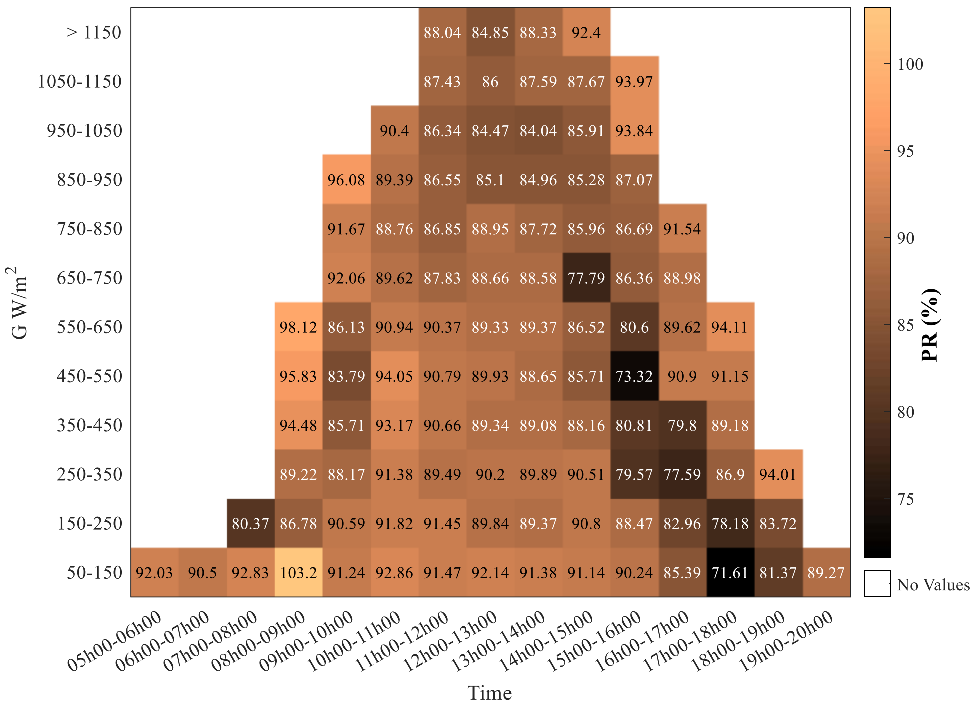

Fig 5 - PR (%) and G (W/m²) versus Time in 80 days

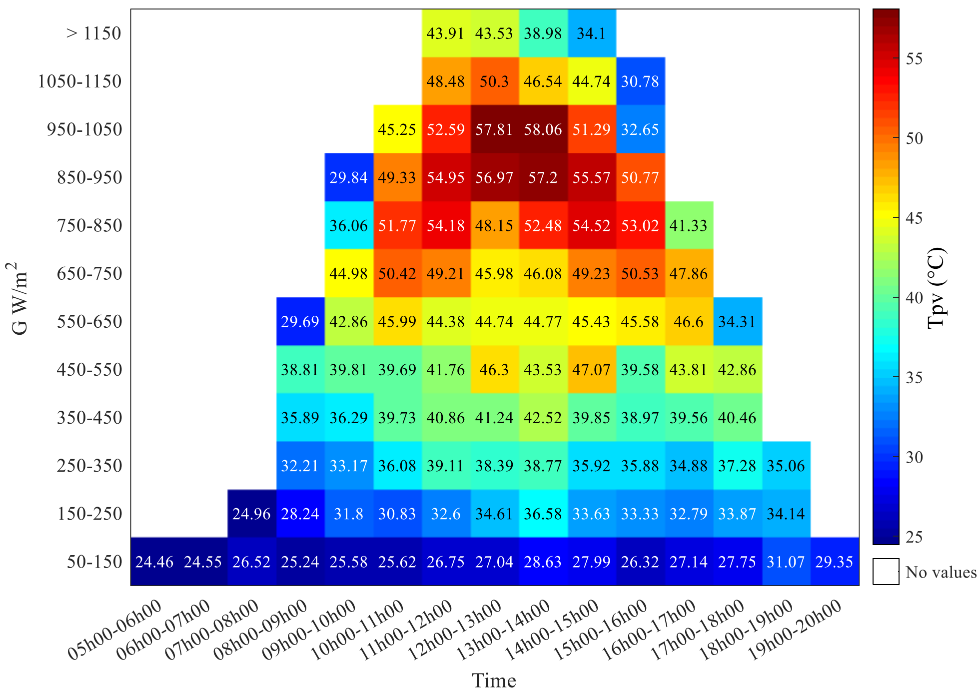

Fig 6 - Tpv (°C) and G (W/m²) versus Time in 80 days

5. Conclusion

Solar PV plant monitoring techniques allow stakeholders to track the production of the solar PV system, evaluate its performance, detect problems, and prepare reports on all of this. It provides complete solutions for single source monitoring of solar power plants from the planning stage and delivery of all components to the operational stage of the remote monitoring technologies.

The application of machine learning by SVM in PV monitoring gave us an easy and straightforward view for analysis interpretation. Furthermore, the application of Artificial intelligence (AI) is to perform tasks that typically require human intelligence. SVM classifier shows the importance of machine learning in the processing of databases for monitoring photovoltaic systems. AI is an interdisciplinary science with multiple approaches, which can facilitate analysis, and aims to answer Turing's question in the affirmative, this method of AI does not require high processing time and its results are very accurate compared to the classical techniques that depend on data and graphics that cannot analyze more accurately. From a perspective, we will focus AI method to analyze and extract all the photoelectric effects to support our research work and discover in detail such as the degradation of PV modules and solar stations over large periods so that we can also give a new breath in analyzing the results in the field of the photovoltaic system. The advantages of this method constitute the dominant trends and the isolation of marginal phenomena. This method can be applied to compare the different photovoltaic systems in terms of the technologies used, by tracking and monitoring all phenomena, in future works we will compare between several different technologies for example in the upcoming works, we will analyze the monitoring database of works [14] and [15] with different technologies using those methods of machine learning and artificial intelligence.

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