International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Search and Rescue Optimization Technique for Estimation Parameters in Photovoltaic Models

A. Y. Hassan[*1] and M. Said*[*2]*

[*1]Deparment of power electronic and energy conversion, Electronics Research Institute, Giza, Egypt
[*2]Electrical Engineering Department, Faculty of Engineering, Fayoum University, Fayoum

A B S T R A C T

For predicting the PV parameters of solar cell models, the search and rescue optimisation approach (SAR) is used. The identification of the parameters in solar cell models is the most important problem in the design and simulation of photovoltaic systems (PV). The root mean square error (RMSE) between the estimated data and the observed data is the objective function used to solve the optimisation issue of parameter extraction for the double diode model, three diode model, and single diode model. To evaluate the effectiveness of the SAR algorithm, real data from R.T.C. France solar cells are used.

Keywords: Solar cell, Estimation, Search and rescue optimization.

I. INTRODUCTION

An alternate energy source is solar energy. Solar energy is the second most popular renewable energy source. It is one of the most promising energy sources after wind and has expanded to include a variety of uses, including solar water heating, solar home heating, solar distillation, solar pumping, solar furnaces, and solar cooking, as well as the production of solar electric power for street heating, lighting, cars, farms, tourist attractions, and irrigation [1]. So, of all renewable energy sources, solar or photovoltaic (PV) is the most significant due to its wide range of applications. It doesn't affect the environment, lacks transportation, is safe, and has an abundance of energy. Solar energy has the potential to transform society and usher in an era of energy efficiency [2]. Three PV models, including the Single Diode Model (SD) [3], Double Diode Model (DD) [4], Modified Double Diode Model (MDD), and Triple Diode Model (TD) [5], have been created as a result. The most generally used models are the single-diode and double-diode models, which differ in the accuracy or complexity of their comparable circuits. In order to increase the PV system's efficiency, it is essential to identify and estimate the model parameters, as the accuracy of the system typically depends on these parameters [6, 7]. Five unknown parameters must be found for the SD and MSD model, and seven unknown parameters must be resolved for the DD and MDD model [8, 9].

II. Problem Formulation

modelling of three photovoltaic models

The three PV models such as solar cell single diode model (SCSDM), solar cell double diode model (SCDDM) and solar cell three diode model (SCTDM) are described in the following figures.

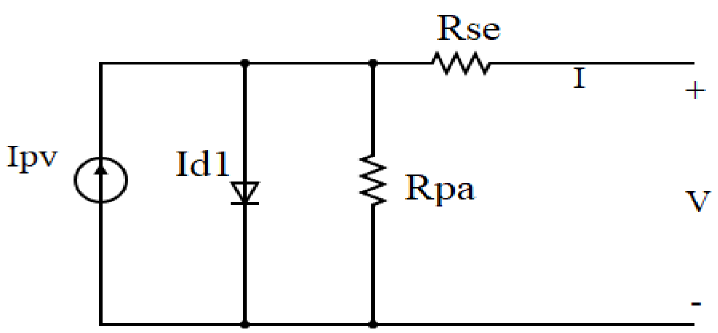

Figure1. circuit of SCSDM

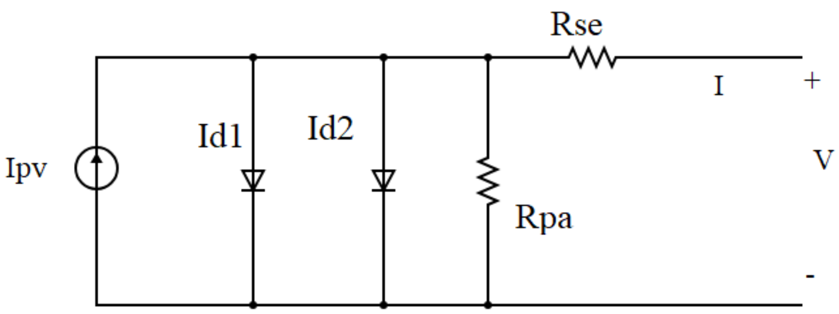

Figure2. circuit of SCDDM

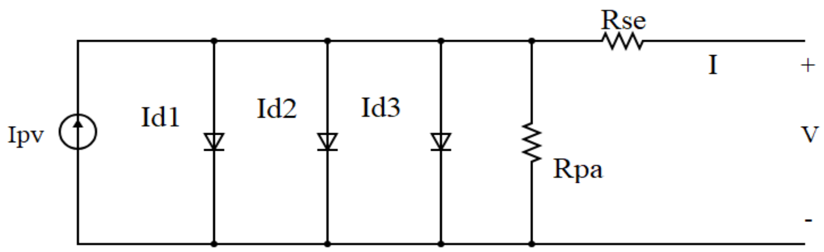

Figure3. circuit of SCTDM

III. Analysis of objective function

The main items in optimization algorithms are the objective function and the boundaries of variables. Table 1 illustrate the theses limits of decision variables. Minimizing the root mean square error (RMSE) is the main objective function. The formula that analyses RMSE is calculated as follow:

$$J(V.I.X) = I - I_{exp} \quad (1)$$

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(J(V.I.X)\right)^2} \quad (2)$$

Where I_{exp} , is the measured current, N is the number of data reading and X is the extracted variables.

The SCSDM estimated variables are $X = \{(R_{se}.\ I_{o1}.\ h_1.\ R_{pa}\ and\ I_{pv})\}$. The SCDDM estimated variables are $X = \{(R_{se}.\ I_{o1}.h_1\ .\ R_{pa}\ .I_{pv}\ .\ I_{o2}\ and\ h_2)\}$. The SCTDM estimated variables are $X = \{(R_{se}.\ I_{o1}.\ h_1.\ R_{pa}\ .I_{pv}\ .\ I_{o2}\ .h_2\ .I_{o3}\ and\ h_3)\}$.

Table1 the limits of variables

Parameters	Lower bound	Upper bound
I_{pv}	0	1
$I_{o1}\ .I_{o2}\ and\ I_{o3}\quad(\mu A)$	0	1
R_{se}	0	0.5
R_{pa}	0	100
$h_1\ .h_2\ and\ h_3$	1	2

IV. Search and Rescue Optimization

Shabani, Amir, et al. [10] have suggested a novel metaheuristic algorithm called Search and rescue optimisation algorithm (SAR) for solving optimisation problems. When using SAR, the human position is used to determine how well the solution fits the relevance of the clue that was discovered. A stronger answer denotes a stronger hint, and vice versa.

V. Analysis of Results

SCSDM Outcomes

Table 2 shows the estimated variables with the best RMSE for SCSDM. Based on this table, the SAR algorithm, with a value of 0.000986022, achieves the best RMSE. The statistical analysis is discussed in table 3.

Table2: the variable estimated for SCSDM at the best RMSE

Algorithm	I_{pv} (A)	I_{o1} (A)	h_1	R_{se} (Ω)	R_{pa} (Ω)	RMSE
SAR	0.76077553	3.23E-07	1.481183598	0.036377092	53.71852406	**0.000986022**

Table3: Statistical analysis for SCSDM

algorithm	Min	mean	max	SD
SAR	**0.000986022**	**0.000986022**	**0.000986022**	**6.56E-13**

SCDDM Outcomes

Table 4 shows the estimated variables with the best RMSE for SCSDM. Based on this table, the SAR algorithm, with a value of 0.000982884, achieves the best RMSE. The statistical analysis is discussed in table 5.

Table4: the variable estimated for SCDDM at the best RMSE

Algorithm	I_{pv} (A)	I_{o1} (A)	h_1	R_{se} (Ω)	R_{pa} (Ω)	I_{o1} (A)	h_1	RMSE
SAR	0.760771922	2.92E-07	1.472372304	0.036493001	54.65022939	5.10E-07	2.223028127	**0.000982884**

Table5: Statistical analysis for SCDDM

algorithm	Min	mean	Max	SD
SAR	0.000982884	0.001063966	0.001458195	0.000110176

SCTDM Outcomes

Table 6 shows the estimated variables with the best RMSE for SCSDM. Based on this table, the SAR algorithm, with a value of 0.000982884, achieves the best RMSE. The statistical analysis is discussed in table 7.

Table6: the variable estimated for SCTDM at the best RMSE

Algorithm	SAR
I_{pv} (A)	0.760780768
I_{o1} (A)	2.32E-07
h_1	1.45324947
R_{se} (Ω)	0.036712439
R_{pa} (Ω)	55.33937477
I_{o2} (A)	6.91E-07
h_2	1.99787841
I_{o3} (A)	1.07E-10
h_3	1.999989
RMSE	**0.000982529**

Table7: Statistical analysis for SCTDM

algorithm	Min	mean	Max	SD
SAR	**0.000982529**	**0.00106004**	**0.001367482**	**0.000144562**

VI. Conclusion

In this study, the variables of the solar cell models are extracted using the Search and Rescue Optimisation approach (SAR), a modern optimisation approach. For SCTDM, SCDDM, and SCSDM, the relationship between the voltage and the current has a nonlinear mathematical formulation. The solar cell models for these three technologies have, respectively, nine, seven, and five variables. Based on reducing the RMSE of these data and the data generated by all algorithms, R.T.C. France SC measurements. A novel optimisation method called the suggested SAR is used to reduce the objective function of parameter identification in PV models like the SCTDM, SCDDM, and SCSDM. For SCTDM and SCDDM, the best RMSE across all algorithms is 0.000982529, 0.000982884, and 0.000986022.

VII. REFERENCES

[1] B. M. Alshammari, T. Guesmi, New chaotic sunflower optimization algorithm for optimal tuning of power system stabilizers, Journal of Electrical Engineering & Technology 15 (5) (2020) 1985–1997.

[2] J. Jurasz, F. Canales, A. Kies, M. Guezgouz, A. Beluco, A review on the complementarity of renewable energy sources: Concept, metrics, application and future research directions, Solar 363 Energy 195 (2020) 703–724.

[3] X.-K. Gao, C.-A. Yao, X.-C. Gao, Y.-C. Yu, Accuracy comparison between implicit and explicit single-diode models of photovoltaic cells and modules, Acta Physica Sinica 63 (17) (2014) 178401.

[4] M. Hejri, H. Mokhtari, M. R. Azizian, M. Ghandhari, L. Söder, On the parameter extraction of a five-parameter double-diode model of photovoltaic cells and modules, IEEE Journal of Photovoltaics 4 (3) (2014) 915–923.

[5] V. Khanna, B. Das, D. Bisht, P. Singh, et al., A three diode model for industrial solar cells and estimation of solar cell parameters using pso algorithm, Renewable Energy 78 (2015) 105–113.

[6] D. Yousri, D. Allam, T. S. Babu, A. M. AbdelAty, A. G. Radwan, V. K. Ramachandaramurthy, M. Eteiba, Fractional chaos maps with flower pollination algorithm for chaotic systems' parameters identification, NEURAL COMPUTING & APPLICATIONS.

[7] D. Yousri, S. B. Thanikanti, D. Allam, V. K. Ramachandaramurthy, M. Eteiba, Fractional chaotic ensemble particle swarm optimizer for identifying the single, double, and three diode photovoltaic models' parameters, Energy 195 (2020) 116979.

[8] A. Abbassi, R. Abbassi, A. A. Heidari, D. Oliva, H. Chen, A. Habib, M. Jemli, M. Wang, Parameters identification of photovoltaic cell models using enhanced exploratory salp chains-based approach, Energy (2020) 117333.

[9] W. Long, S. Cai, J. Jiao, M. Xu, T. Wu, A new hybrid algorithm based on grey wolf optimizer and cuckoo search for parameter extraction of solar photovoltaic models, Energy Conversion and Management 203 (2020) 112243.

[10] A. Shabani, B. Asgarian, M. Salido, S. A. Gharebaghi, Search and rescue optimization algorithm: A new optimization method for solving constrained engineering optimization problems, Expert Systems with Applications 161 (2020) 113698.