ECP 2024 Conference

The 3rd International Electronic Conference on Processes

29–31 May 2024 | Online

Extraction the optimal parameters of single-diode photovoltaic cell using earthworm optimization algorithm

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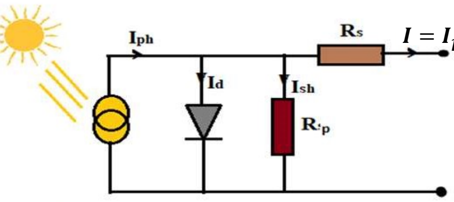
INTRODUCTION & AIM

Solar cells are critical in the transition to a low-carbon society in a world where the climate emergency necessitates long-term energy solutions. At the center of this technology are diode solar cells, which provide a vital channel for turning sunlight into power. The main objective is to extract parameters from the simplified diode solar cell circuit model, enabling accurate estimation of current-voltage and power-voltage characteristics. The study introduces a novel method for assessing and deriving the electrical properties of simple diode model solar cells through the utilization of the Earthworm Optimization Algorithm (EOA). The analysis primarily relies on the current-voltage curve to compute a constrained objective function. Furthermore, the outcomes obtained via EOA are contrasted with those derived from other algorithms, namely gray wolf optimizer (GWO) [1], whale optimization algorithm (WOA) [2], sine cosine algorithm (SCA) [3], and the genetic algorithm with convex combination crossover (GA-CCC)[4]. Statistical assessments are employed to verify the accuracy of the derived parameters, demonstrating that the theoretical outcomes closely align with experimental data, showcasing superior precision compared to other algorithms.

METHOD

The simple diode model of a solar cell is a simplification of reality. The equation of this model is generally based on the equation of the current-voltage characteristic (I-V) of an ideal diode of ideality factor **n** in parallel with a resistance R_P and in series with a resistance R_s



$$I = I_{ph} - I_{01}\left(e^{\frac{V+IR_s}{nV_t}} - 1\right) - \frac{V + IR_s}{R_P}$$

Employing the innate foraging abilities of earthworms as inspiration, the algorithm is crafted to capitalize on this insight. This methodology facilitates the precise extraction of solar cell properties. Here is a summary of the algorithm

```
Begin
Initialize earthworms randomly
    Best solution (best_earthworm) = First earthworm
    Best error (best_error) = Infinite
    For each iteration up to num_iterations
        For every earthworm
            Evaluate the error with PV model
            Update best_earthworm and best_error if error is better
            Update position with random disturbance
            Limit the new position within the limits defined by
param_bounds
    Returns the best solution found (best_earthworm)
END
```

FUTURE WORK / REFERENCES

[1]: S. Mirjalili, S. M. Mirjalili, et A. Lewis, « Grey Wolf Optimizer », *Adv. Eng. Softw.*, vol. 69, p. 46-61, mars 2014, doi:

[2]: D. Oliva, M. Abd El Aziz, et A. Ella Hassanien, « Parameter estimation of photovoltaic cells using an improved chaotic whale optimization algorithm », Appl. Energy, vol. 200, p. 141-154, août 2017, doi: 10.1016/j.apenergy.2017.05.029.

[3]: S. Mirjalili, « SCA: A Sine Cosine Algorithm for solving optimization problems », Knowl.-Based Syst., vol. 96, p. 120-133, mars 2016, doi: 10.1016/j.knosys.2015.12.022.

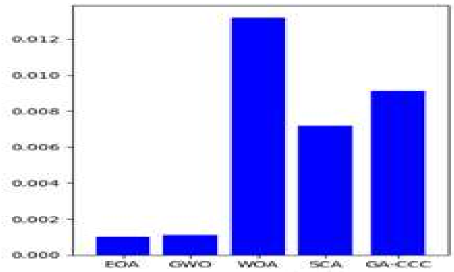
[4]: J. A. Jervase, H. Bourdoucen, et A. Al-Lawati, « Solar cell parameter extraction using genetic algorithms », *Meas. Sci. Technol.*, vol. 12, nº 11, p. 1922-1925, nov. 2001, doi: 10.1088/0957-0233/12/11/322.

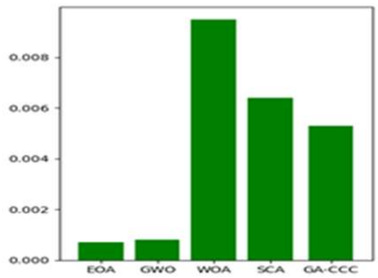
RESULTS & DISCUSSION

The optimal parameters for solar cell parameters.

Parameters	EOA	GWO	WOA	SCA	GA-CCC
I_{ph}(A)	0.76100	0.7606	0.76405	0.7515	0.7607755
I_{01}(A)	3.570E-07	2.2496E−07	2.8588E−07	2.5606E−07	0.32302E-07
n	1.57366	1.4455	1.4702	1.4593	1.481182
Rs(Ω)	0.03592	0.0385	0.0484	0.0372	0.036377
Rp(Ω)	54.9993	54.6069	59.9940	54.2298	53.718520

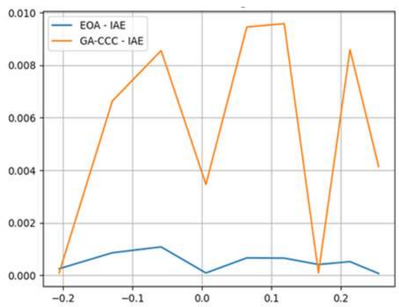
The Root Mean Square Error (RMSE) for the EOA algorithm inspired by the behavior of earthworms, gray wolf optimizer, the genetic algorithm with convex combination crossover, the whale optimization algorithm, and the sine cosine algorithm





The Mean Absolute Error (MAE) for the EOA algorithm inspired by the behavior of earthworms, gray wolf optimizer, the genetic algorithm with convex combination crossover, the whale optimization algorithm, and the sine cosine algorithm

The Absolute Integral Error (IAE) for the EOA algorithm inspired by the behavior of earthworms and the genetic algorithm with convex combination crossover



CONCLUSION

This research presents a novel approach for extracting the intrinsic electrical characteristics of single diode solar cells, involving five unknown parameters, utilizing the Earthworm Optimization Algorithm (EOA). To assess the effectiveness of this method, a comprehensive comparison is undertaken against alternative optimization algorithms including the Gray Wolf Optimizer (GWO), Genetic Algorithm with Convex Combination Crossover (GA-CCC), Whale Optimization Algorithm (WOA), and Sine Cosine Algorithm (SCA). The algorithms are utilized as standards for assessing how well the EOA can accurately extract inherent electrical characteristics. The study incorporates statistical analyses to meticulously assess the accuracy of parameters derived from each method. Comparative analysis indicates that the results obtained via EOA demonstrate significant concordance with experimental data, exceeding the precision of alternative algorithms. This implies that the proposed methodology based on EOA offers a more precise and dependable estimation.