Polar coordinates for I-V single-diode modeling

SMALL tweak, BIG impact

A new **robust** methodology for the **identification of parameters** on the electrical response of photovoltaic systems **through** the application of **polar coordinates**

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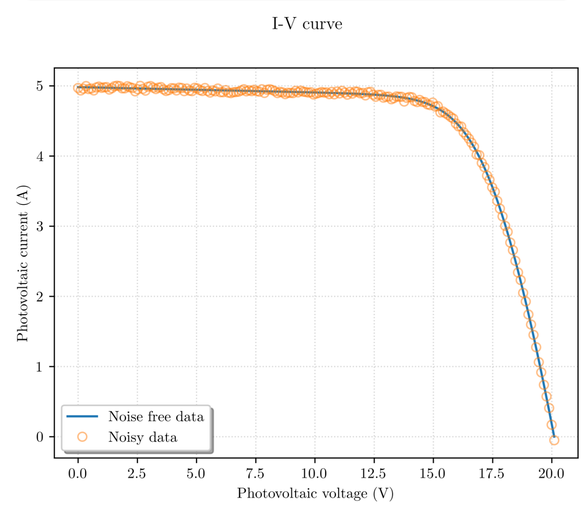
Why are we doing this?

We found several methods to identify the optimal single-diode model (SDM) from current-voltage (I-V) pairs, each with different mathematical structures and responses. In this study, we evaluated **five unidimensional optimization functions** on real and synthetic data. Our results show that the **polar RMSD method is straightforward and fast** to implement while keeping the accuracy of the orthogonal distance regression (ODR).

(*) In the table, the subscript "m" indicates measured data and "k" indicates estimated data.

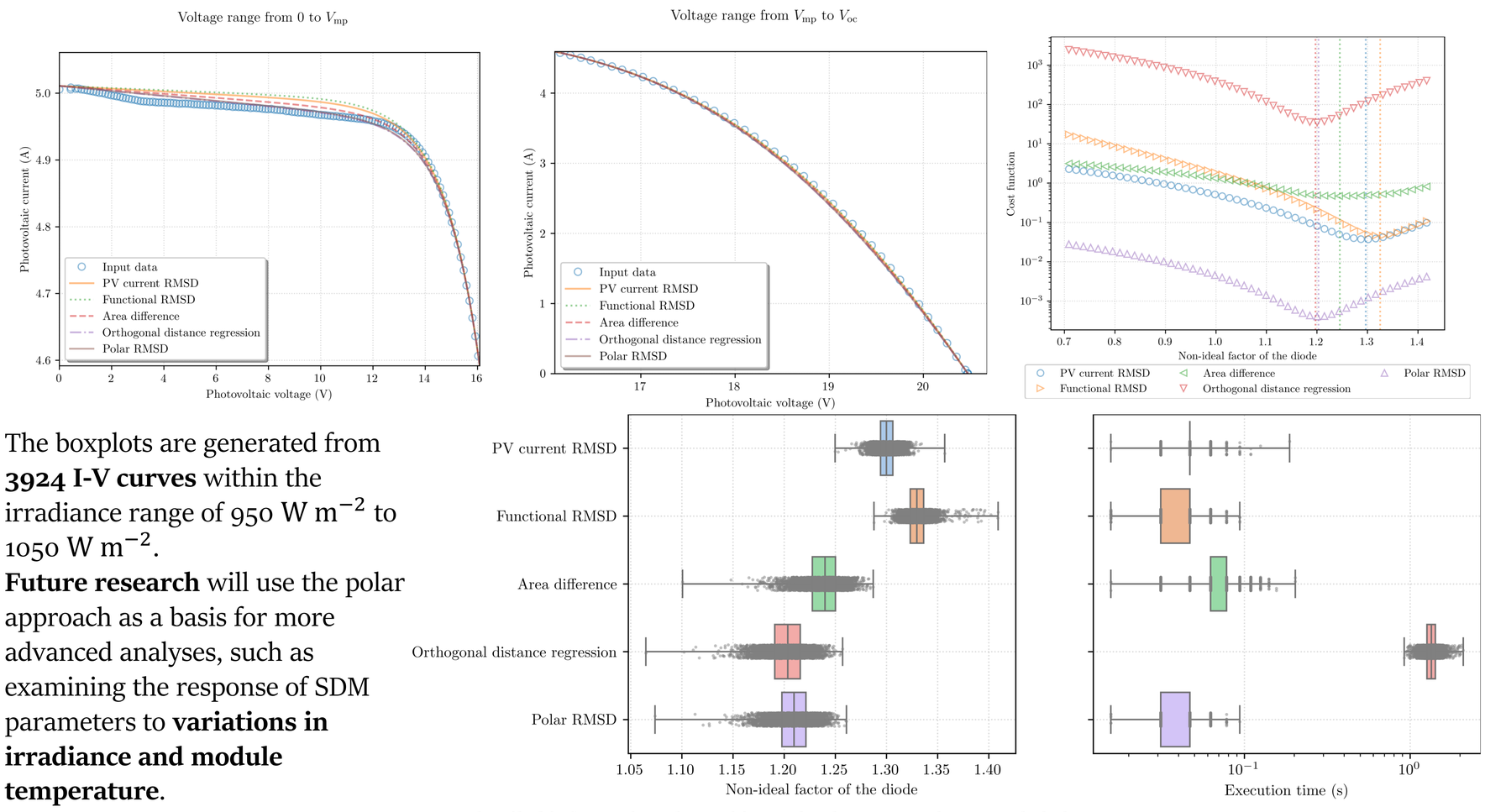
Function nature	Cost function
PV current RMSD	$\sum_{j=1}^{n} (I_{\mathrm{m},j} - I_{\mathrm{k},j})^2$
Functional RMSD	$\sum_{j=1}^{n} \left(I_{\mathrm{o}} \exp\left(q \frac{V_{\mathrm{m},j} + R_{\mathrm{s}} I_{\mathrm{m},j}}{N_{\mathrm{s}} n k_{\mathrm{B}} T_{\mathrm{mod}}} \right) + G_{\mathrm{sh}} V_{\mathrm{m},j} + (G_{\mathrm{sh}} R_{\mathrm{s}} + 1)\, I_{\mathrm{m},j} - (I_{\mathrm{ph}} + I_{\mathrm{o}}) \right)^2$
Area difference	$\Delta I = \lvert I_{\mathrm{m}} - I_{\mathrm{k}} \rvert$ $\sum_{j=1}^{n-1} \lvert V_{\mathrm{m},j+1} - V_{\mathrm{m},j} \rvert \, (\Delta I_j + \Delta I_{j+1})$
ODR	$\sum_{j=1}^{n} \left(\frac{V_{\mathrm{m},j} - V_{\mathrm{k},j}}{\sigma_v} \right)^2 + \left(\frac{I_{\mathrm{m},j} - I_{\mathrm{k},j}}{\sigma_i} \right)^2$
Polar RMSD	$\sum_{j=1}^{n} (\varphi_{\mathrm{m},j} - \varphi_{\mathrm{k},j})^2$

The Polar SDM



Test on NREL dataset

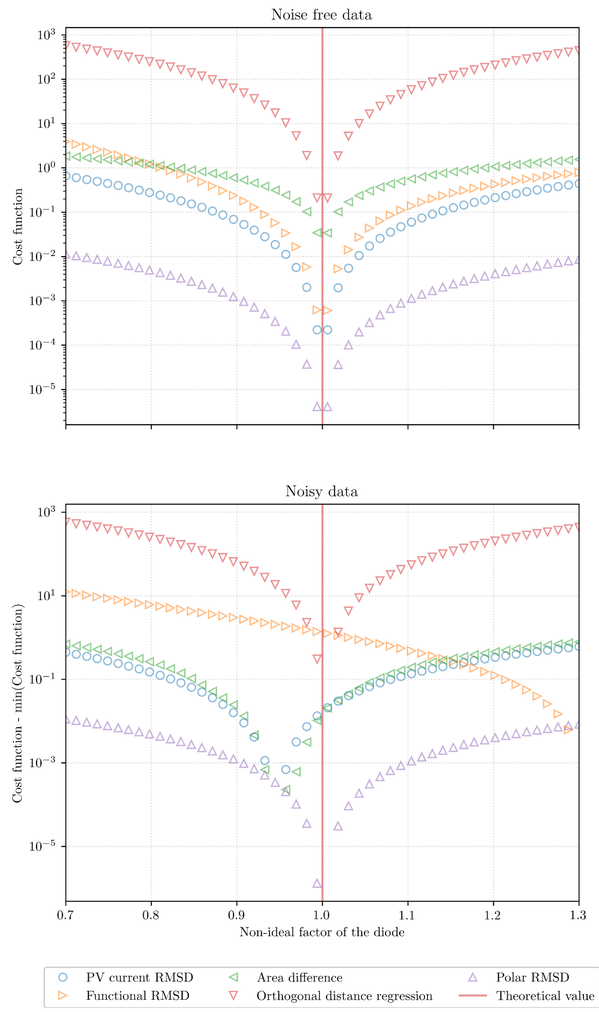
Randomly selected I-V curve. Irradiance = 1005 W m^{-2}; Module temperature = 45 °C.



The boxplots are generated from **3924 I-V curves** within the irradiance range of 950 W m^{-2} to 1050 W m^{-2}.

Future research will use the polar approach as a basis for more advanced analyses, such as examining the response of SDM parameters to **variations in irradiance and module temperature**.

Test on synthetic data



For more detailed information about this work, please scan the QR code below.

Acknowledgments and affiliations

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