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Deep-learning-based pipeline for module power prediction from electroluminescense measurements

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Abstract

Automated inspection plays an important role in monitoring large-scale photovoltaic power plants. Commonly, electroluminescense measurements are used to identify various types of defects on solar modules, but have not been used to determine the power of a module. However, knowledge of the power at maximum power point is important as well, since drops in the power of a single module can affect the performance of an entire string. By now, this is commonly determined by measurements that require to discontact or even dismount the module, rendering a regular inspection of individual modules infeasible. In this work, we bridge the gap between electroluminescense measurements and the power determination of a module. We compile a large dataset of 719 electroluminescense measurements of modules at various stages of degradation, especially cell cracks and fractures, and the corresponding power at maximum power point. Here, we focus on inactive regions and cracks as the predominant type of defect. We set up a baseline regression model to predict the power from electroluminescense measurements with a mean absolute error (MAE) of $9.0 \pm 8.4 W_P$ ($4.0 \pm 3.7\%$). Then, we show that deep learning can be used to train a model that performs significantly better ($7.3 \pm 6.5 W_P$ or $3.2 \pm 2.7\%$) and propose a variant of class activation maps to obtain the per cell power loss, as predicted by the model. With this work, we aim to open a new research topic. Therefore, we publicly release the dataset, the code, and trained models to empower other researchers to compare against our results. Finally, we present a thorough evaluation of certain boundary conditions like the dataset size and an automated preprocessing pipeline for on-site measurements showing multiple modules at once.

KEYWORDS

automated inspection, cell power, deep learning, module power

Mathis Hoffmann and Claudia Buerhop-Lutz contributed equally to this study.