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Correlating defects in electroluminescence images to photovoltaic module power loss using DeepLabV3 for semantic segmentation

May, Siyasanga I
Council for Scientific and Industrial Research (CSIR)
Meiring Naude Drive, Pretoria, 0184
Email: SMay@csir.co.za

This article investigates a multi-class semantic segmentation model for correlating defects in electroluminescence (EL) images and PV module power degradation in fielded modules. The case study uses machine learning and statistical methods to identify a potential root cause for power degradation in 680 PV modules sampled from a multi-MW PV plant in South Africa. The EL image and the electrical performance were measured and recorded for each module at the CSIR PV Module Quality and Reliability Lab. A deep-learning model previously trained for multi-class defect detection in EL images of solar cells was re-trained to include 24 samples of a new ‘brightening’ defect. The updated model was used to classify each pixel on 48,960 solar cells into one of 29 classes. Based on an exponential decay model, the degree of ‘brightening’ defect averaged across all cells in a module correlated to the module fill factor ($r^2 = 0.42$), indicating that 42% of the variability in Fill Factor (FF) measured for this set of modules could be explained by the brightening defect. While the strength of the correlation is moderate, it may provide some insight into the root cause of the degradation in FF. The authors speculate that the brightening defect is a signature of solar cells with non-uniform current distribution resulting from ageing. Updates to the multi-class prediction model were relatively simple and fast, enabling a similar analysis for new defects in PV modules as they emerge.