Optimizing Computer Vision and Neural Network Combinations for Electroluminescence-Based Solar Cell Degradation Analysis

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Abstract: The recent rise of powerful neural network models and computer vision tools have allowed us to extract significant features from visual datasets and train accurate predictors based on them. These advanced tools are widely utilized in the industry, especially in assembly lines where defectious products are quickly recovered from the production process. In this work, solar cell's electroluminescence (EL) characteristic is employed to visualize its degradation in thermal cycling conditions. Such degradation is visualized in the forms of rectangular dark areas or finger shadows through the EL technique and it has been shown that the degradation increases with the number of thermal cycling cycles. In this work, it is first attempted to use computer vision tools and neural networks to train a model that can accurately estimate the number of cycles any solar cell has gone through. In order to counteract the lack of image samples and also imbalance between the samples, we utilize data augmentation techniques based on computer vision tools. Secondly, unlike the popular LLMs which focus on accuracy and computational speed, the application of ML & CV within the prognostics and reliability field requires somewhat different objectives. Since utmost priority is in filtering out defective products on the assembly line, once a certain threshold of high accuracy is acquired, more significance is given to the recall rate and detection speed of a model. Multiple different image pre-processing / augmentation methods as well as deep neural networks are combined to find the best combination that can return high accuracy, recall rate, and detection speed.