Proxy-Informed Diffusion for Corrosion Fault Synthesis in Photovoltaic Electroluminescence Imaging

Wei-Qing LU,[1] Demba Diallo,[1] Claude Delpha,[1,2] and Anne Migan-Dubois[1]

[1] *Univ. Paris-Saclay, CentraleSupelec, CNRS, GeePs*
[2] *Univ. Paris-Saclay, CentraleSupelec, CNRS, L2S*

This short study investigates whether proxy-informed diffusion models [1] can support electroluminescence (EL) image augmentation for busbar corrosion analysis in photovoltaic (PV) modules. A public available dataset from was considered [2]. We define severity using two structural proxies:

$$s_{area} = \frac{A_{inactive}}{A_{cell}}, \tag{1}$$

$$s_{conn} = \frac{A_{max}}{A_{cell}}, \tag{2}$$

where $A_{inactive}$ is the inactive area, A_{cell} is the total cell area, and A_{max} is the largest connected dark region. These priors were injected into the diffusion process via side-tuning.

Preliminary evaluation shows that synthetic images exhibit moderate distributional fidelity compared to real corrosion cases (FID = 23.5), while train-healthy separation was substantially higher (FID = 81.9). Classifiers trained with augmented corrosion images achieved a 6.2% improvement in detecting early-stage busbar corrosion relative to baseline.

Although limited in dataset scale and lacking I–V curve validation, these findings demonstrate the feasibility of leveraging physics-informed synthesis to mitigate data scarcity in corrosion-focused PV diagnostics. The approach is positioned as a proof-of-concept rather than a mature deployment.

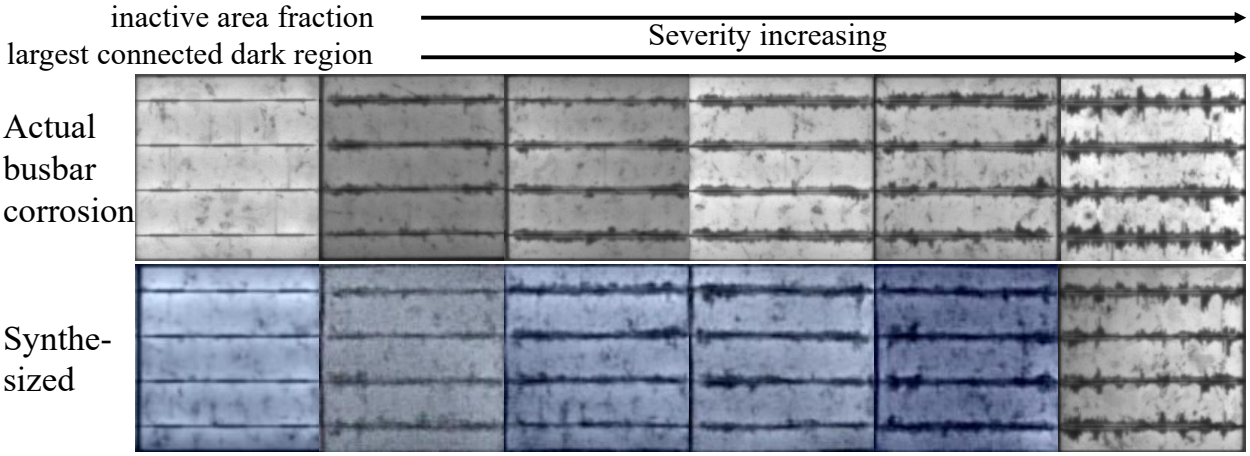

FIGURE 1. Comparison of real and proxy-informed diffusion synthesized busbar corrosion data.

REFERENCES

1. R. Rombach, A. Blattmann, D. Lorenz, P. Esser, and B. Ommer, "High-resolution image synthesis with latent diffusion models," in *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR)* (2022) pp. 10684–10695.
2. A. M. Karimi, J. S. Fada, M. A. Hossain, S. Yang, T. J. Peshek, J. L. Braid, and R. H. French, "Automated pipeline for photovoltaic module electroluminescence image processing and degradation feature classification," IEEE Journal of Photovoltaics **9**, 1324–1335 (2019).