SOURCE REVIEW / INTELLIGENT PV DIAGNOSTICS

Intelligent PV fault detection from sensing to deployment

Decision-oriented synthesis of sensing modalities, multimodal AI, generalization, and field-deployment requirements for PV diagnosis.

DOCUMENT	DATE	PREPARED BY	STATUS
TP-007	OCT 2026	SPECTRA GROUP S.A.S.	TECHNICAL SUMMARY

Technical scope

Wang et al. review intelligent photovoltaic fault detection across I-V and SCADA data, RGB imaging, infrared thermography, electroluminescence, UAV inspection, and multimodal sensing. The review links fault observability and sensing physics with AI methodology, dataset provenance, localization capability, cross-site generalization, and deployment requirements. Its central position is that practical model selection should be driven by fault mechanism, inspection scale, acquisition constraints, and O&M needs rather than headline accuracy alone.

01 Sensing & fusion

Electrical / SCADA. Continuous operational context supports fault detection and performance analysis, but provides limited spatial localization.

RGB / IRT / EL. RGB captures surface-visible defects; IRT localizes abnormal thermal patterns; EL resolves fine internal and electrically inactive regions under controlled acquisition.

Multimodal fusion. Data-, feature-, and decision-level fusion are distinguished, with attention and transformers emerging for adaptive cross-modal integration.

Field evidence. A paired RGB-IRT field framework is cited at 91.7% mAP@0.5, 95% defect-detection accuracy, and 36 FPS; the review cautions that such results are study-specific.

02 Deployment & generalization

Cross-site validation. Random same-plant splits can overstate performance; plant-wise or module-wise splits and independent-site testing are preferred.

Data discipline. Representative synchronized datasets, class balance, acquisition metadata, and explicit real-versus-simulated provenance are required for credible benchmarking.

Operational metrics. Accuracy and mAP should be evaluated with precision, recall, F1, localization reliability, inference latency, compute cost, and robustness under field conditions.

Roadmap. Priorities include self-supervised and foundation models, physics-informed learning, missing-modality robustness, lightweight edge intelligence, and hierarchical SCADA-to-UAV-to-targeted confirmation workflows.

SOURCE Wang, W.; Su, Q.; Hou, L. Frontiers in Earth Science 2026, 14:1949465. Published 22 Sep 2026.
DOI: 10.3389/feart.2026.1949465 | https://www.frontiersin.org/journals/earth-science/articles/10.3389/feart.2026.1949465/full

SOURCE TITLE Intelligent fault detection in photovoltaic systems: sensing modalities, AI methods, generalization and future trends