Analysis of Fusion-based Photovoltaic Fault Diagnosis Methods

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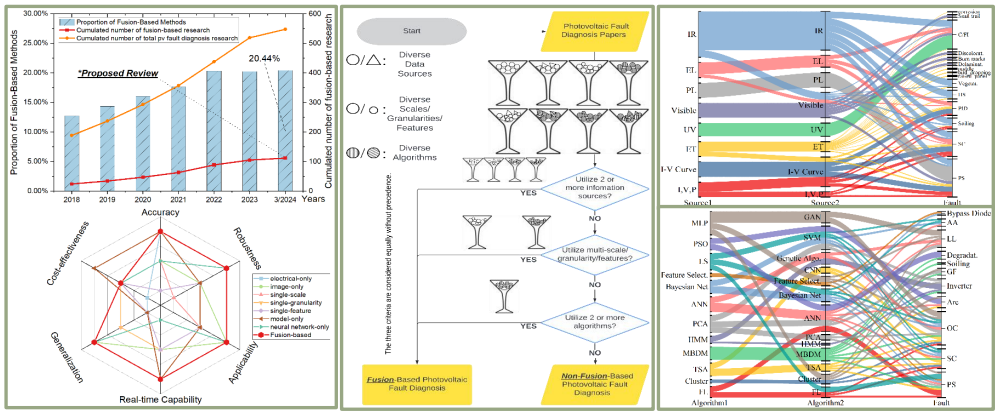
As solar PV becomes central to the global clean energy transition, the importance of photovoltaic (PV) fault diagnosis in socio-economic production has grown. According to the IEA, solar PV is a key contributor to international energy and climate goals, with deployments increasing significantly over the past decade [1]. PV fault diagnosis can utilize multiple data sources and algorithms, and fusion-based approaches are gaining traction in this field, as shown in Figure 1(a). This paper proposes a unified framework for fusion strategies that systematically addresses the classification of PV faults by integrating data sources, algorithms, and fusion strategies, filling a gap in the analysis of fusion methods for PV fault classification.

Fusion strategies are categorized into multi-X fusion, explicit fusion (EFS), and implicit fusion (IFS). Multi-X fusion involves processes like multi-scale and multi-feature applied solely to data sources. EFS merges algorithm outputs without additional data manipulation. IFS is more complex, involving both data and algorithm modifications, with information propagated through model parameters instead of direct result merging. Examples include multi-scale fusion [2], voting classifiers [3], and transfer learning [4].

This study statistically analyzes various fusion combinations, examining their effectiveness in diagnosing specific PV faults. Figure 1(c) illustrates how different fusion strategies are applied across faults, aiding both researchers and practitioners in selecting appropriate methods. This work supports the future development of advanced fusion-based PV fault diagnosis methods and validates the proposed framework.



(a) (b) (c)

FIGURE 1. Comparison of fusion strategies for photovoltaic fault diagnosis. (a) Growing research focus on fusion-based methods. (b) Classification of multi-X fusion strategy, EFS, and IFS. (c) Data and algorithm combinations to specific PV faults, offering guidance for selecting optimal fusion approaches.

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