

# Photovoltaic panel undervoltage detection



## Overview

The development of Photovoltaic (PV) technology has paved the path to the exponential growth of solar cell deployment worldwide. Nevertheless, the energy efficiency of solar cells is often limited by resulting defects that can reduce their performance and lifespan. Therefore, it is crucial to identify a set of defect detection approaches for predictive maintenance and condition monitoring of PV modules. This paper presents a comprehensive review of different data analysis methods for defect detection of PV systems with a high categorisation granularity in terms of types and approaches for each technique. Such approaches, introduced in the literature, were categorised into Imaging-Based Techniques (IBTs) and Electrical Testing Techniques (ETTs). Although several review papers have investigated recent solar cell defect detection techniques, they do not provide a comprehensive investigation including IBTs and ETTs with a greater granularity of the different types of each for PV defect detection systems. Types of IBTs were categorised into Infrared Thermography (IRT), Electroluminescence (EL) imaging, and Light Beam Induced Current (LBIC). On the other hand, ETTs were categorised into Current-Voltage (I-V) characteristics analysis, Earth Capacitance Measurements (ECM), Time Domain Reflectometry (TDR), Power Losses Analysis (PLA), and Voltage and Current Measurements (VCM). Approaches based on digital/signal processing and Machine Learning (ML) models for each method are in...

## Article Content

### PV-YOLO: Lightweight YOLO for Photovoltaic Panel Fault Detection

The rapid development of the photovoltaic industry in recent years has made the efficient and accurate completion of photovoltaic operation and maintenance a major focus in recent studies. The key to photovoltaic operation and maintenance is the accurate multifault identification of photovoltaic panel images collected using drones. In this paper, PV-YOLO is proposed to ...

(PDF) Hotspots Detection in Photovoltaic Modules Using Infrared ...

The image processing topics for damage detection on Photovoltaic (PV) panels have attracted researchers worldwide. Generally, damages or defects are detected by using advanced testing equipment ...

Defect detection of photovoltaic modules based on improved

This section briefly overviews the detection method of photovoltaic module defects based on deep learning. Deep learning is considered a promising machine learning technique and has been adopted ...

Data-Driven Two-Stage Fault Detection and Diagnosis Method for ...

Detection of abnormal photovoltaic (PV) system operation is essential to ensure safe and uninterrupted performance. In this study, the authors present a data-driven two-stage method for PV fault detection and diagnosis (FDD). We exploit an inherent characteristic of PV systems, i.e., voltage and current changes at maximum power point (MPP) caused by faults. In ...

Photovoltaic Panel Defect Detection Based on Ghost ...

on PV panel defect detection and (2.2) the development of target detection based on the YOLO algorithm. 2.1. PV Panel Defect Detection With the progress in energy structures, photovoltaic power generation, considered the most promising approach, is developing rapidly and playing a significant role in energy security,

Fault Detection in Solar Energy Systems: A Deep ...

This study explores the potential of using infrared solar module images for the detection of photovoltaic panel defects through deep learning, which represents a crucial step toward enhancing the efficiency and ...

DC-side faults mechanism analysis and causes location for two ...

Furthermore, a complete set of fault diagnosis process is proposed for DC overvoltage and undervoltage faults. An experimental platform for PV power generation system ...

Methodology for automatic fault detection in photovoltaic arrays ...

1. Introduction. Automatic fault detection in photovoltaic (PV) systems has acquired great relevance worldwide, as expressed by (Pierdicca et al., Citation 2018), (Rao et al., Citation 2019), and (Lu et al., Citation 2019). This is due to the necessity of keeping this type of system functioning properly for as long as possible.

Thermography of Photovoltaic Panels and Defect Detection ...

The width of the IR-image has to be at least as large as the width of the PV panel ( $w$ ). Fig. 3 shows the available data from the back of the PV panel DSP5P manufactured by the [lux.pro] solar Corporation which was used within experiments. This type of PV panel was also used in previous research , , , .

Fault detection and localization in solar photovoltaic arrays using ...

Photovoltaic (PV) electrical power generation is an important and promising research area because there is high demand for renewable energy systems. In order to improve the performance of PV array systems so that these energy systems might be better understood and made more readily available, further research needs to be done on various means of detecting ...

Solar panel defect detection design based on YOLO v5 algorithm

Solar panel defect detection images are trained based on the YOLOv5 model and small batch random gradient descent (SGD) algorithm. The approximate parameter settings ...

Efficient fault diagnosis approach for solar photovoltaic array ...

Photovoltaic (PV) arrays have output characteristics such as randomness and intermittency, and faults can seriously affect the safe operation of the power system. In order to improve the comprehensive performance of the PV array fault diagnosis model, a new intelligent online fault monitoring method for PV arrays is proposed in this paper.

Photovoltaic system fault detection techniques: a review

Data types commonly used in PV FDD systems are electrical measurements, environmental data, or images of photovoltaic panels. According to this type, fault detection and categorization techniques in photovoltaic systems can be classified into two classes: non-electrical class, includes visual and thermal methods (VTMs) or traditional electri-

A new dust detection method for photovoltaic panel surface ...

In this study, the solar photovoltaic panel dust detection dataset we used was sourced from the widely recognized Kaggle website, and its value lies in its inclusion of two distinct categories. Firstly, we have images of cleaning solar photovoltaic panels, which present a clean state on the surface of the solar panels, free from dust or ...

Enhanced photovoltaic panel diagnostics through AI integration ...

This paper introduces a diagnostic methodology for photovoltaic panels using I-V curves, enhanced by new techniques combining optimization and classification-based artificial ...

Fault Detection in Solar Energy Systems: A Deep Learning ...

While solar energy holds great significance as a clean and sustainable energy source, photovoltaic panels serve as the linchpin of this energy conversion process. However, defects in these panels can adversely impact energy production, necessitating the rapid and effective detection of such faults. This study explores the potential of using infrared solar ...

Photovoltaic system fault detection techniques: a review

Solar energy has received great interest in recent years, for electric power generation. Furthermore, photovoltaic (PV) systems have been widely spread over the world because of the technological advances in this field. However, these PV systems need accurate monitoring and periodic follow-up in order to achieve and optimize their performance. The PV ...

Photovoltaic Hot-Spot Detection for Solar Panel Substrings Using ...

Hot spotting is a problem in photovoltaic (PV) systems that reduces panel power performance and accelerates cell degradation. In present day systems, bypass diodes are used to mitigate hot spotting, but it does not prevent hot spotting or the damage it causes. This paper presents an active hot-spot detection method to detect hot spotting within a series of PV cells, ...

Detection, location, and diagnosis of different faults in large solar ...

Fault detection is an essential part of PV panel maintenance as it enhances the performance of the overall system as the detected faults can be corrected before major damages occur which a significant effect on the power has generated. Most of the available methods used to rectify the various faults occurring in the solar panels which are ...

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Photovoltaic hotspots: A mitigation technique and its thermal cycle

Research into the causation and underlying mechanisms of hotspots in PV modules is ongoing. Current studies indicate that hotspots may arise due to drastic diurnal temperature swings, which are especially pronounced in regions like deserts and coastal areas , .Dhimish et al. noted that a single hotspot string could precipitate a substantial 25% ...

### Lightweight Hot-Spot Fault Detection Model of Photovoltaic Panels ...

Photovoltaic panels exposed to harsh environments such as mountains and deserts (e.g., the Gobi desert) for a long time are prone to hot-spot failures, which can affect power generation efficiency and even cause fires. The existing hot-spot fault detection methods of photovoltaic panels cannot adequately complete the real-time detection task; hence, a ...

### Photovoltaic Panel Fault Detection and Diagnosis Based on a ...

In this work, a new image classification network based on the MPViT network structure is designed to solve the problem of fault detection and diagnosis of photovoltaic ...

### A photovoltaic cell defect detection model capable of topological ...

Zhang et al. [8] introduced a photovoltaic cell defect detection method leveraging the YOLOV7 model, which is designed for rapid detection. They enhanced the model's feature extraction ...

### Detection and assessment of partial shading in photovoltaic arrays

The paper presents a methodology for detection and assessment of partial shading conditions in photovoltaic (PV) arrays based on artificial neural networks (ANN) as a preliminary step toward automatic supervision and monitoring. ... Real-time model base fault diagnosis of PV panels using statistical signal processing. Proceedings of the ...

### Failures of Photovoltaic modules and their Detection: A Review

A PV system primarily has components like solar panel/cells, inverter, battery, cables, controller, etc. . PV module is the major component in a PV system. A PV module is actually a packed, sealed, secured and connected assembly of numerous solar cells.

### Hotspot defect detection for photovoltaic modules under complex ...

Therefore, the timely and effective defect detection of PV modules has become a research focus. So far, the commonly used methods for defect detection of PV modules are manual inspections based on the electrical parameter measurement [1, 2], which are inefficient and costly. Accordingly, the vision-based methods have been introduced into PV ...

### A DC arc detection method for photovoltaic (PV) systems

An SVM approach to achieve arc detection for PV systems is adopted in Ref. . SVM uses statistical learning that is based on a strong mathematical foundation to address a convex optimization issue. ... A review for solar Panel fire accident prevention in large-scale PV applications. IEEE Access, 8 (2020), pp. 132466-132480, 10.1109/ACCESS ...

### Intelligent solar panel monitoring system and shading detection ...

A solar panel, a PV module, is used to convert solar energy into electrical current. This energy can also be kept in a battery, where it will be kept as chemical energy. ... Application of artificial neural networks to photovoltaic fault detection and diagnosis: A review. *Renew Sustain Energy Rev*, 138 (2021), Article 110512. View PDF View ...

Fault detection and diagnosis in photovoltaic panels by ...

The performance of PV panels is affected by several environmental variables, causing different faults that reduce the energy production of PV panels. 16 These faults are given by electrical mismatches, degradation, and other causes, for example, cell or module broken, hot spots browning, dirty points, burned, snail trails, cracked cells, solder bond failures, broken ...

Enhanced Fault Detection in Photovoltaic Panels Using CNN ...

Table 2 provides a comprehensive summary of prior research in solar panel fault detection. 3. Materials and Methods 3.1. CNN Model. The primary goal of this project is to automate the detection of anomalies in solar panels using a deep learning approach . The system classifies images of solar panels into different categories based on whether ...

SolarDiagnostics: Automatic damage detection on rooftop solar ...

Homeowners are increasingly deploying rooftop solar photovoltaic (PV) arrays due to the rapid decline in solar module prices. To illustrate, the cost of solar energy in \$/W dropped an estimated ~80% from 2010 to 2018, resulting in a ~700% increase in solar energy capacity in U.S. over the same period .Solar power prices have now fallen below retail ...

Model-based fault detection in photovoltaic systems: A ...

The energy transition is experiencing a remarkable surge, as evidenced by the global increase in renewable energy capacity in 2022. Cumulative renewable energy capacity grew by 13 %, adding approximately 348 Gigawatts (GW) to reach 3481 GW .Notably, solar photovoltaic (PV) electricity generation has proven to be more economically viable than ...

Tracking Defective Panel on Photovoltaic Strings with Non ...

Fault detection in photovoltaic systems is crucial to ensure the efficiency and robustness, because their energy production can be affected by factors, such as dirt on the panels, shading, and electrical faults (Yang et al., 2024). Therefore, predictive maintenance based on AI can play a key role in fault detection in photovoltaic systems.

A Survey of Photovoltaic Panel Overlay and Fault ...

The first aspect is the detection of PV panel overlays, which are mainly caused by dust, snow, or shading. We classify the existing PV panel overlay detection methods into two categories, including image processing and ...

Design of Edge Computing System for Photovoltaic Panel Hot ...

The hot spot effect of photovoltaic panel refers to the local heating phenomenon caused by the photovoltaic panel being covered, which not only seriously affects the power generation efficiency of ...

A novel strategy for multitype fault diagnosis in photovoltaic ...

The solar power generation system platform in this study mainly comprises solar photovoltaic (PV) arrays, solar PV panel mounting frames, dust detection platforms, solar PV inspection boxes, monitoring interfaces, etc., as depicted in Fig. 2. A total of 9 solar PV panels were utilized in this study, with the primary system configuration being ...

Fault detection and diagnosis of grid-connected photovoltaic ...

Early fault detection and diagnosis of grid-connected photovoltaic systems (GCPS) is imperative to improve their performance and reliability. Low-cost edge devices have emerged as innovative ...

Photovoltaic system fault detection techniques: a review

A machine learning methodology is introduced in using a hybrid features-based support vector machine model for hot spot detection and classification of PV panels. Color ...

Automatic detection of faults in a photovoltaic power plant based ...

To automate PV panels self evaluation, the degradations models are embedded in a microcontroller as software which operates with instantaneous measured parameters. ... Machine learning-based statistical testing hypothesis for fault detection in photovoltaic systems. *Sol. Energy*, 190 (2019), pp. 405-413. View in Scopus Google Scholar [17 ...

Enhanced Fault Detection in Photovoltaic Panels ...

When dirt builds up on the surface of a solar panel, the amount of light that strikes it is diminished, thereby reducing the panel's ability to produce electrical energy. This paper successfully implemented a deep-learning model ...

Islanding detection techniques for grid-connected photovoltaic ...

Most of these critical concerns arise due to abnormalities at the grid side (undervoltage and short-circuit events), and as a consequence of failing islanding detection (ID). Generally, an ID mechanism operating with the PV system in a grid connected environment, should be capable of disconnecting the PV from the grid in case of grid ...

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