Journal scientific and applied research, vol. 28, 2025
International Journal

ISSN 1314-6289 (Print)
ISSN 2815-4622 (Online)

Original Contribution

USE OF DRONES FOR SOLAR PANEL INSPECTION IN SOLAR PARKS

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ABSTRACT: *The use of drones to inspect solar panels in solar parks has become one of the most effective, efficient, and safe approaches for maintaining and optimizing large-scale photovoltaic (PV) installations.*

KEY WORDS: *Drones, Photogrammetry, Solar parks, Photovoltaic panels, Monitoring, RGB, Mission planning, Security, Sniffer, Traffic.*

1. Introduction

More and more countries all around the globe are trying to reach their respective carbon neutral remark, renewable energy resources are gradually phasing out fossil fuels. One of the most prominent renewable energy sources is solar energy. With the rapid expansion of solar energy capacity worldwide, maintaining the performance and reliability of solar parks has become increasingly important. Traditional manual inspections of photovoltaic (PV) panels are time-consuming, labor-intensive, and limited in scope. The adoption of unmanned aerial vehicles (UAVs), commonly known as drones, has revolutionized the inspection process by offering fast, accurate, and non-invasive monitoring solutions.

2. Drone Technology

Modern inspection drones are equipped with high-resolution cameras, thermal sensors, and GPS-based navigation systems. These components enable the collection of precise visual and thermal data for assessing the operational health of PV panels.

Key technologies used in drone-based inspections include:

• RGB Cameras (Red–Green–Blue) capture images using a sensor that records visible light across three color channels.

Each pixel stores intensity values for red, green, and blue wavelengths, typically ranging from 400–700 nm.

The combination of these channels produces high-resolution color images of solar panels, allowing visual identification of surface defects.

• Thermal (Infrared) Cameras detect infrared radiation (heat energy) emitted by objects rather than visible light.

Every solar panel emits infrared radiation proportional to its temperature.

When a panel or a cell experiences an electrical fault (e.g., cell crack, shading, or connection failure), localized heating occurs — visible as a hotspot in the thermal image.

These temperature anomalies indicate performance degradation or safety risks (e.g., short circuits or fire hazards).

• Multispectral Sensors – capture reflected light across several narrow wavelength bands beyond the standard RGB range.

Unlike RGB cameras (which record only three visible bands), multispectral sensors detect visible and near-infrared (VNIR) or short-wave infrared (SWIR) wavelengths.

This extended spectral sensitivity allows engineers to assess surface reflectance, soiling, vegetation impact, and even material degradation of solar panels.

The key principle is that each material (glass, metal, vegetation, dust, etc.) reflects light differently at various wavelengths — enabling spectral analysis and condition monitoring.

• LiDAR and RTK GPS – Provide accurate mapping and georeferencing for asset management.

• AI and ML Algorithms – Automate fault detection, image classification, and report generation.

3. Inspection Workflow

A typical drone inspection workflow involves several automated stages that minimize human intervention while maximizing efficiency and accuracy:

1. Mission Planning – Flight paths are designed using mission-planning software such as DroneDeploy, Mission Planner, Litchi or DJ Pilot, ensuring full coverage of the solar park.

2. Data Collection – Drones capture high-resolution RGB and thermal imagery under optimal sunlight conditions, typically around noon (see fig. 1).

3. Data Processing – Collected images are stitched into orthomosaic maps, and AI algorithms identify anomalies such as hotspots, cracks, or shading.

4. Analysis & Reporting – Results are integrated with asset management systems (e.g., SCADA) to generate precise maintenance recommendations.

5. Maintenance Action – Ground teams repair or replace defective panels based on GPS-tagged inspection results.

Fig. 1. Solar panel cell hotspot detection

4. Technological Advantages

Drone-based inspection systems offer several advantages over manual or ground-based techniques:

- High inspection speed and coverage of large-scale solar parks.
- High-resolution imaging for early fault detection and performance optimization.
- Enhanced safety by reducing the need for on-ground manual checks.
- Consistent and repeatable data for long-term performance tracking.
- Integration with AI-driven analytics platforms for predictive maintenance.

5. Challenges and Considerations

While drone inspection offers numerous benefits, several challenges remain:

- Regulatory restrictions on drone flights, particularly beyond visual line of sight (BVLOS).
- Environmental factors such as wind and cloud cover affecting thermal accuracy.
- Requirement for trained pilots and certified operators.
- Large data management and storage requirements for high-resolution imagery.

6. Future Trends

Emerging trends in drone-based solar inspection include autonomous drone-in-a-box systems for regular scheduled surveys, enhanced AI algorithms for real-time fault prioritization, and integration with digital twins for continuous monitoring. These innovations are expected to further reduce operational costs and improve the reliability of solar power systems.

7. Conclusion

The integration of drone technology into solar park maintenance has transformed traditional inspection methods. With advancements in sensor technology, AI-based data analytics, and autonomous operations, drones are becoming an indispensable tool for engineers seeking efficient and data-driven management of renewable energy assets.

Acknowledgments

This scientific article under project number RD-08-117/06.02.2025 „Application of a specialized geographic information system for solving problems in the field of cadastre“ is funded.

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