

INTISARI

Penelitian ini menganalisis efektivitas inspeksi Pembangkit Listrik Tenaga Surya (PLTS) atap menggunakan citra udara RGB dan algoritma deep learning dibandingkan dengan metode inspeksi konvensional berbasis pengamatan visual oleh teknisi. Studi dilakukan pada sistem PLTS atap berkapasitas sekitar 30 kWp di Gedung Smart and Green Learning Center (SGLC), Fakultas Teknik, Universitas Gadjah Mada. Citra RGB beresolusi tinggi diperoleh menggunakan drone DJI Mavic 3 pada ketinggian 15–30 meter, kemudian dianotasi dan diaugmentasi hingga 450 citra untuk melatih model YOLOv11 instance segmentation melalui platform Roboflow. Kinerja model dievaluasi menggunakan metrik mAP@50, precision, dan recall, serta dibandingkan dengan hasil inspeksi konvensional yang dilakukan oleh teknisi berdasarkan citra yang sama sebagai acuan (ground truth). Selain itu, survei persepsi teknisi ($n = 5$) dengan 24 butir pernyataan skala Likert digunakan untuk menilai efisiensi waktu, keselamatan kerja, kualitas dokumentasi, dan kemudahan analisis pada kedua metode. Hasil pelatihan menunjukkan bahwa model YOLOv11 mencapai mAP@50 sebesar 98,3%, precision 100%, dan recall 97%, yang mengindikasikan kemampuan deteksi panel PV normal yang sangat baik pada citra drone. Survei teknisi menunjukkan skor rata-rata keseluruhan 3,34 untuk inspeksi manual dan 4,82 untuk inspeksi otomatis, disertai pengurangan waktu inspeksi dari sekitar 95 menit menjadi sekitar 18 menit per sesi, serta persepsi peningkatan yang signifikan pada aspek keselamatan dan kualitas dokumentasi. Temuan ini menunjukkan bahwa inspeksi berbasis citra udara RGB dan deep learning berpotensi menjadi alternatif yang lebih efisien, aman, dan mudah diskalakan dibandingkan inspeksi konvensional untuk sistem PLTS atap skala kecil hingga menengah.

Kata kunci: Inspeksi Panel Surya, PLTS Atap, Citra Udara, *Deep Learning*

ABSTRACT

This study analyzes the effectiveness of rooftop photovoltaic (PV) inspection using RGB aerial imagery and deep learning algorithms compared with conventional technician-based visual inspection. The research was conducted on a rooftop PV system with a capacity of approximately 30 kWp installed at the Smart and Green Learning Center (SGLC) building, Faculty of Engineering, Universitas Gadjah Mada. High-resolution RGB images were captured using a DJI Mavic 3 drone at altitudes of 15–30 meters, then annotated and augmented to obtain 450 images for training a YOLOv11 instance segmentation model via the Roboflow platform. The model performance was evaluated using mAP@50, precision, and recall metrics, and compared with conventional inspection results obtained by technicians using the same images as a reference (ground truth). In addition, a perception survey of technicians (n = 5) using a 24-item Likert scale was conducted to assess time efficiency, occupational safety, documentation quality, and ease of analysis for both methods. The trained YOLOv11 model achieved an mAP@50 of 98.3%, precision of 100%, and recall of 97%, indicating excellent capability in detecting normal PV panels from drone imagery. The technician survey showed an average overall score of 3.34 for manual inspection and 4.82 for automated inspection, along with a reduction in inspection time from approximately 95 minutes to approximately 18 minutes per session, accompanied by perceived significant improvements in safety and documentation quality. These findings suggest that RGB aerial imagery combined with deep learning offers a more efficient, safer, and more scalable alternative to conventional inspection methods for small- to medium-scale rooftop PV systems.

Keywords: Solar Panel Inspection, Rooftop PV, Aerial Imagery, Deep Learning