Integrating Drone-Based Visual Inspection and AI-Powered Object Detection for Remote Powerline Monitoring

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INTRODUCTION & AIM

In recent years, the use of Unmanned Aerial Vehicles (UAVs) combined with computer vision has significantly advanced the field of infrastructure monitoring. Numerous studies have demonstrated the effectiveness of UAV-based inspections for identifying faults in electrical powerlines, offering faster and safer alternatives to manual surveys. However, the integration of such models into **operational, daily-use utility systems** remains limited in many practical deployments.

To address this, Başarsoft has developed a fully integrated inspection platform called *Powerline AI*. Unlike experimental or stand-alone models, Powerline AI is embedded into a **web-based GIS platform** that allows field teams or drones to upload images of powerline components directly into the system. Using an AI-powered object detection module, the system not only identifies core inventory objects (such as poles, insulators, and crossarms), but also assesses their structural and operational integrity. This includes detecting potential issues such as damaged equipment, missing safety components like guardrails, or foreign objects such as bird nests—all of which are critical for preventive maintenance and asset safety.

METHOD

Powerline AI system is a web-based application platform built on customized artificial intelligence algorithms, specifically designed to analyze UAV-captured imagery for power grid infrastructure monitoring. The platform incorporates multiple model types, each optimized for a specific analytical task:
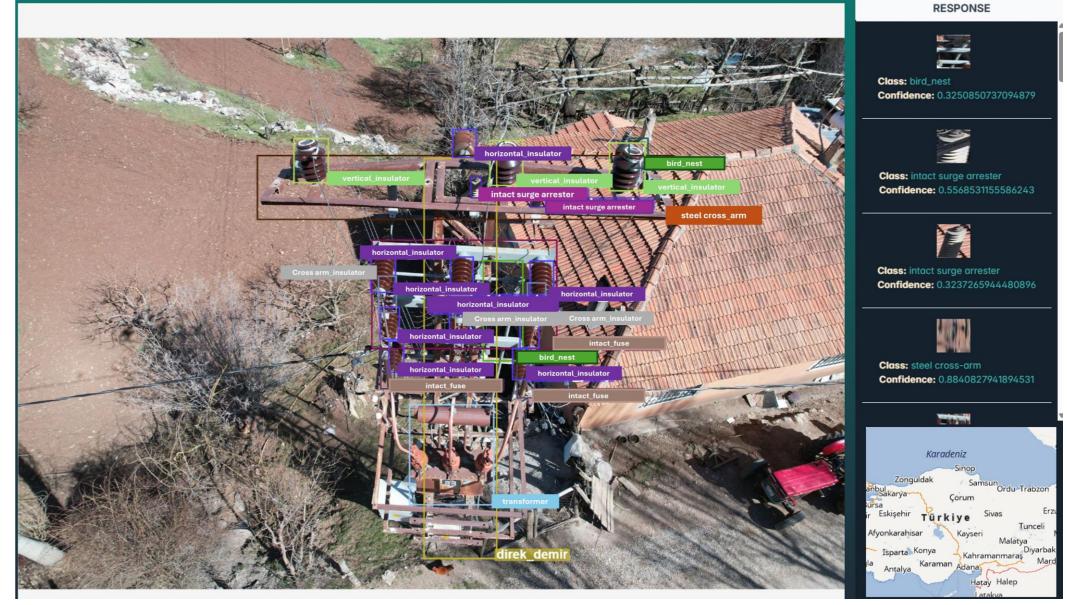
○ **Object Detection:** A YOLOv8L (You Only Look Once, version 8 Large) model is used to detect over 14 different infrastructure components and potential risk factors with high precision. These include transformers, insulators (horizontal, vertical, cross-type), crossarms, disconnectors, bird nests, and surge arresters.

○ **Semantic Segmentation:** An Attention U-Net architecture is employed to segment and highlight physical damage on critical components, particularly insulators. This allows for pixel-level identification of cracks, surface wear, or missing parts within the detected objects.

○ **Classification:** An EfficientNet-B5 model is used to classify the operational status of detected components. It can automatically identify high-risk failure indicators such as rust, oil leakage, or deformation on transformers and related equipment.

RESULTS & DISCUSSION

The Powerline AI system was evaluated using UAV-acquired imagery over medium-voltage distribution assets in geographically challenging areas. The findings are summarized as follows:

Component Detection Performance:

The AI model successfully identified key network components such as insulators (horizontal, vertical, cross-type), transformers, steel crossarms, surge arresters, and high-voltage fuses. Confidence scores for correctly classified objects typically exceeded 0.80, indicating robust detection performance under varying visual conditions.

CONCLUSION

The deployment of Powerline AI demonstrates the feasibility of integrating UAV-based visual data collection with advanced deep learning models for automated powerline inspection. To further enhance the operational value of Powerline AI, several development directions are planned:

• **Integration with Grid Information Systems**
The anomaly and condition data generated by the AI models will be linked directly to network inventory records within the existing GIS-based electricity distribution management systems.

• **Lifecycle-Based Asset Monitoring:**
Historical inspection data will be stored and analyzed to support condition-based maintenance planning, degradation tracking, and investment prioritization.

• **Multi-Source Data Fusion:**
Additional data layers such as thermal imagery, LiDAR point clouds, and SCADA/OMS system outputs will be incorporated to improve fault type recognition, spatial localization, and predictive maintenance capabilities.

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