Combined AI and Data solutions for DATA COLLECTION

Challenge 1.2

2D/3D image analysis for large Energy Infrastructure predictive maintenance

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Challenge and Context: Timely scheduling maintenance or decommissioning of large energy infrastructures is challenging. Incorrect End-of-Life (EoL) predictions can lead to unexpected failures, unwanted downtime, and high costs. Grid operators aim to avoid these risks, but often maintenance and decommissioning occur too early, causing high waste and unnecessary costs. AI-supported 2D/3D vision analysis technologies can better predict the maintenance needs and EoL of energy infrastructures. A consortium partner seeks solutions to collect information for predictive maintenance of power lines and to improve decommissioning planning.

Use Case and Expected Solution: Red, Green, and Blue (RGB), thermographic, and multispectral/hyperspectral vision can be used for early identification of weaknesses and failures in energy assets and nearby structures. Different types of failures, such as defects, poor contact, insulation deterioration, or magnetic circuit faults, often manifest as temperature rises. Infrared thermography (IRT) is particularly suitable for fault diagnosis, while RGB is used to quantify surface integrity and detect external discontinuities. Studies have shown the effectiveness of photogrammetric inspection, presented as 3D profiles reconstructed from UAV-captured images. Multispectral/hyperspectral images provide more information than RGB alone, identifying issues like material degradation and biofouling. Currently, the partner LEITAT has technology bricks available for fusing these images with installed sensor data and historical O&M data at TRL 4.

Specifications for Use Case: the consortium partners will guide and mentor SMEs to develop a combined AI and data-based predictive model using image analysis. A dedicated combination of photonic and sensor technologies will be used to determine the asset's health conditions. These partners will assist SMEs in selecting the appropriate cameras and collecting the necessary 2D and 3D image data for AI-supported vision-based diagnosis. They will also support the AI-supported analysis of images, looking for early indicators of malfunctioning assets, corrosion, biofilm, etc. The analysis information, combined with data from installed sensors, O&M activities, and historical images, will be used to develop an AI-supported predictive model. In addition, one of the partners will support SMEs during the development, evaluation, and validation of the model. Based on the collected data, a set of assets will be identified for model validation, with at least one asset monitored during O&M actions to decide on continuity or decommissioning.

The TRL 7 image analysis solution will enable predictive planning for the maintenance and decommissioning of part of partner infrastructures leading to better predictions of asset useful life and resulting in environmental and cost benefits. Once demonstrated, the technology can be further developed and deployed for other infrastructures beyond the project's lifetime. For use cases outside the consortium, the results will lead to the development of predictive maintenance and decommissioning planning support tools, based on AI-supported 2D/3D image analysis and data fusion, demonstrated at TRL 7 for large energy infrastructure.

Furthermore, the key use case will involve **vegetation monitoring in transmission line corridors** using multispectral and hyperspectral imagery. The system will enable **automated recognition of vegetation types,** which will be essential for predicting growth rates and planning timely interventions. Additionally, the same imagery will allow for **assessment of vegetation's health,** helping to identify diseased or stressed plants that may pose a higher risk to infrastructure. This dual capability will support more accurate and proactive maintenance strategies, reduce the likelihood of service interruptions, and optimize resource allocation for vegetation management.

The selected third party is expected to contribute with the following:

1. **Vegetation Recognition in Transmission Line Corridors**: Utilizing multispectral/hyperspectral cameras, it shall be made possible to recognize vegetation types from imagery. This is important because different types of vegetation grow at different rates, making it easier to predict when intervention will be necessary.

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2. **Assessing Vegetation Health**: With multispectral/hyperspectral cameras, it shall be made possible to assess the health of vegetation from imagery. This is crucial because healthy vegetation poses significantly less risk to infrastructure compared to diseased or damaged specimens.
3. **Assessing Infrastructure Condition**: Using multispectral/hyperspectral imagery, it shall be made possible to determine the condition of infrastructure. Discussions indicate that it is possible to detect the amount of biofilm and dirt on insulation, identify corrosion, detect overheating, and more.
4. **Other Use Cases**: Additional applications may also be considered.

Key Performance Indicators:

- Prediction accuracy of AI models in identifying maintenance needs and failure risks, Reduction in false positives and false negatives in anomaly detection, Improvement in defect detection and classification compared to traditional methods, reduction in manual intervention required for maintenance planning, improvement in decision-making speed for decommissioning strategies (% accuracy of predictive maintenance model).
- Reduction in infrastructure failures resulting from environmental hazards, compliance with safety regulations and decommissioning best practices, decrease in CO_2 emissions by reducing unnecessary maintenance trips (% reduction in maintenance-related CO_2 emissions)
- Number of prevented accidents due to early hazard or failure detections in comparison to “classical” detections., number of workers trained in AI, data fusion, and predictive maintenance tools.

To be noted, the list of KPIs provided in this section is not exhaustive but rather indicative. Additional KPIs will be studied and can be integrated to ensure quality outcomes.

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