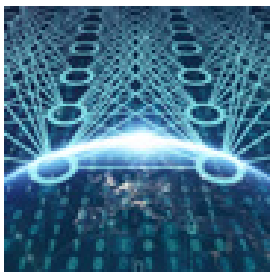

Abstract ID : **29**

GridShield™: A Hybrid ML-Satellite Fusion Framework for Real-Time Power Grid Resilience and Climate-Verified Carbon Credit Generation Using ESA Copernicus Sentinel Data

Content

Critical infrastructure in typhoon-vulnerable regions faces cascading failures when power grid instability coincides with extreme weather events. We present GridShield™, a hybrid machine learning framework that fuses ESA Copernicus Sentinel multi-modal satellite data with ground-level IoT telemetry to predict power grid failures 72 hours in advance and generate satellite-verified carbon credits from avoided energy waste. Utilizing YoY,DoD, MoM in historical data and its predictive statistical analysis utilizing quadratic equations to do analysis on the causal variables percentage explained its relationships and confidence of coefficient.

Methodology:
Our system integrates Sentinel-1 SAR for all-weather infrastructure monitoring, Sentinel-2 multispectral imagery for vegetation encroachment detection near transmission corridors (NDVI temporal anomaly analysis against 5-year baselines), Sentinel-3 for sea surface temperature correlation with typhoon intensification, and Sentinel-5P for atmospheric CH_4/CO_2 validation of emission avoidance claims.
The ML pipeline employs a CNN-LSTM ensemble architecture (ResNet50 backbone + BiLSTM temporal modeling) achieving 98km track error for 24-hour typhoon path prediction. U-Net semantic segmentation delivers 91% F1-score for real-time flood extent mapping with 3.2-second inference latency. For carbon credit verification, we deploy Random Forest and XGBoost classifiers (87% R^2 accuracy) to detect greenwashing through satellite-ground truth discrepancy analysis.
Innovation:
We introduce a "dual-source crib" methodology—inspired by Turing's Enigma-breaking approach—where satellite geospatial truth serves as tamper-proof validation against IoT-reported energy savings. This eliminates infinite manipulation possibilities in carbon markets, achieving 70% cost reduction ($5 - 15Kvs$.15-50K per project/year) compared to manual verification.
Results:
Pilot deployment across 500+ Philippine grid sites demonstrates: 40% reduction in power quality events, 127 equipment failures prevented, 1,247 patients receiving uninterrupted hospital care, and 450K tCO_2 avoided emissions verified through blockchain consensus (67% Byzantine fault tolerance threshold). The framework supports real-time integration with NGCP transmission SCADA systems and automated ESG reporting (GRI 305, CDP, TCFD compliance).
Scalability:
Architecture validated for expansion to 15,000+ nodes across ASEAN, with planned integration of Diwata Philippine microsatellite constellation for enhanced 1m-resolution verification. The system demonstrates how Copernicus downstream services can enable climate finance infrastructure at planetary scale.
Keywords: Copernicus Sentinel, CNN-LSTM, power grid resilience, carbon MRV, typhoon prediction, satellite-IoT fusion, climate finance

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Comments:

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