

AI-Powered Smart Grid Fault Identification

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ABSTRACT

Fault detection and system dependability have been transformed by the incorporation of Artificial Intelligence into smart grids. In complicated power systems, conventional fault detection techniques are slower and less precise. Real-time monitoring, early problem prediction and automatic fault categorization are made possible by AI-based methods like machine learning and deep learning. The design, operation, algorithms, and benefits of AI-based smart grid defect detection systems are covered in this study, with an emphasis on how they might improve grid efficiency and stability.

KEY WORDS

Artificial Intelligence, Machine Learning, Design, Operation, Algorithms.

INTRODUCTION

A smart grid is a sophisticated electrical network that enhances power systems' sustainability, dependability, and efficiency through automation and digital communication. Faults such as:

- Short circuits
- Line-to-ground faults
- Equipment failures

AI helps in:

- Fast fault detection
- Fault classification
- Predictive maintenance

System Architecture Components

1. Sensors & Smart Meters
2. Data Acquisition System
3. Communication Network (IoT-based)
4. Control Center (Cloud/Edge Computing)
5. AI Model (ML/DL algorithms)

Working Principle

1. Sensors gather information on voltage, current, and frequency.
2. Data sent via IoT to the control center.
3. An AI model examines data in real time.
4. The fault is identified and categorized.
5. The system initiates automatic isolation or a warning.

AI TECHNIQUES USED

1. Machine Learning

- Linear Regression: Forecasts continuous numerical data, such as sales and prices.
- For binary classification problems, such as spam detection, logistic regression is utilized.
- Decision Trees: A highly interpretable tree-structured model for regression and classification.
- Random Forest: An ensemble technique that reduces over fitting and increases accuracy by combining many decision trees.
- The best hyperplane for classifying data in high-dimensional spaces is found using Support Vector Machines (SVM).
- K-Nearest Neighbors (KNN): Uses similarity to adjacent neighbors to classify data.

2. Deep Learning (DL) Algorithms

- Deep learning is a subset of ML based on artificial neural networks with multiple layers.
- Multi-layer Perceptron (MLP) for typical data processing are part of artificial neural networks (ANN).
- CNNs, or convolutional neural networks, are specialised for visual applications such as image identification.
- For sequential data, such time series or natural language, recurrent neural networks (RNNs) were created.
- One kind of RNN that can learn long-term dependencies is called a Long Short-Term Memory Network (LSTM).
- By putting two neural networks against one another, Generative Adversarial Networks (GANs) are used to create new material.
- Autoencoders: Applied to unsupervised learning tasks such as dimensionality reduction and data denoising.

3. Data Processing

- Feature extraction
- Signal processing (FFT, Wavelet Transform)

Types of Faults Detected

- Single Line-to-Ground Fault
- Line-to-Line Fault
- Double Line-to-Ground Fault
- Three-Phase Fault

❖ Advantages

- High accuracy (up to 95–99%)
- Real-time detection

- Self-learning capability Reduced downtime Predictive maintenance

❖ Applications

- Smart grids
- Power transmission systems
- Industrial electrical networks
- Renewable energy systems (solar, wind)

❖ Limitations

- Requires large data sets
- High computational cost
- Data security concerns

❖ Future Prospect

- completely self-sufficient smart grids
- Self-healing technology powered by AI
- Block chain integration
- Energy management in smart cities

CONCLUSION

The efficiency and dependability of contemporary power systems are greatly increased by AI-based smart grid problem detection. AI enhances energy management and lowers power outages by providing real-time monitoring, predictive analysis, and automated reaction. AI will be essential to the creation of intelligent and self-healing power grids as long as it continues to improve.

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