

The Role of Algorithms in Relay Protection



Overview

Artificial intelligence algorithms enhancing relay protection and. In this research project, Artificial Intelligence (AI) algorithms applied to the relay.

Key Takeaways

Modern relay protection algorithms use multidimensional analysis and machine learning to detect faults and manage electrical network parameters efficiently. Overview of Relay Protection Algorithms

Relay protection algorithms are designed to detect abnormal or emergency conditions in electrical networks, such as short circuits, overloads, or phase imbalances. These algorithms operate based on triggering rules derived from model experiments and real-time measurements of network parameters like current, voltage, resistance, and phase angles. Modern algorithms are multidimensional, meaning they can simultaneously analyze multiple features to improve fault detection accuracy.

Classical and Machine Learning Approaches

Traditional relay protection relies on deterministic rules and threshold-based logic. However, with the advent of digital substations and intelligent electronic devices (IEDs), more sophisticated algorithms have been developed:

- k-Nearest Neighbors (k-NN): Classifies network states by comparing current measurements with historical data to detect anomalies.

- Logistic Regression: Predicts the probability of a fault based on input features, allowing probabilistic decision-making .
- Support Vector Machines (SVM): Separates normal and fault conditions in a multidimensional feature space for precise fault recognition . These machine learning methods allow relay protection systems to learn from historical and simulated data, improving sensitivity and reducing false trips.

Specialized Trainable Triggering Elements

Modern RPA systems incorporate trainable triggering elements that can adapt to changing network conditions. These elements enhance traditional relays by:

- Increasing fault recognition sensitivity
- Handling complex network topologies
- Supporting simultaneous monitoring of multiple parameters Such elements are particularly useful in digital substations, where computational power allows real-time processing of large datasets.

Implementation in Intelligent Electronic Devices

The algorithms are implemented in IEDs, which are capable of:

- Real-time monitoring of electrical parameters
- Executing multidimensional fault detection algorithms
- Communicating with other devices for coordinated protection and automation This integration ensures faster, more reliable fault detection and contributes to the overall stability of the power system .

Key Advantages

- Enhanced accuracy: Multidimensional analysis reduces false positives.
- Adaptive learning: Machine learning algorithms improve over time with more data.
- Scalability: Algorithms can handle complex networks with multiple nodes and parameters.
- Integration with smart grids: Supports automation and intelligent decision-making in modern power systems. In summary, relay protection algorithms have evolved from simple threshold-based logic to advanced multidimensional and machine learning-based systems, enabling faster, more accurate, and adaptive fault detection in modern electrical networks.

Article Content

A review on protective relays" developments and trends

Since the advent of the first commercial digital relay that was introduced in 1980 and more recently, the Ethernet-based

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