Comparative Analysis of AI and Signal Processing Techniques for Power System Condition Monitoring

1. Introduction

Power system condition monitoring is an important process to ensure stability and efficiency of electricity networks. The paper employs a hybrid approach with Artificial Intelligence models and signal processing technique to identify faults and fault classification more effectively. Artificial Neural Network (ANN), Radial Basis Neural Network (RBNN), and Adaptive Neuro-Fuzzy Inference System (ANFIS) are employed as Artificial Intelligence models in this research work. Wavelet Transform as a signal processing technique facilitates easy extraction of interest features from raw signals of power systems.

2. Methodology

2.1 Data Preprocessing

- The data includes electrical parameters: **Ia, Ib, Ic (currents) and Va, Vb, Vc (voltages).**
- Target attribute is **G**, which signifies fault conditions.
- Data is split into **training (80%)** and **test (20%)** sets.

2.2 Wavelet Transform for Feature Extraction

- **db4 wavelet** with **3-level decomposition** is utilized.
- **Mean and standard deviation** of each wavelet coefficient are utilized as extracted features.
- These features form the input to AI models.

2.3 AI Models Implemented

(a) Artificial Neural Network (ANN)

- **Model**: Multi-Layer Perceptron (MLP) with two hidden layers.
- **Training**: Backpropagation with **ReLU activation** and **Adam optimizer**.
- **Evaluation Metric**: Accuracy.

(b) Support Vector Machine(SVM)

- Support vector machines (SVMs) are a set of supervised learning methods used for classification, regression and outliers detection.

(c) Adaptive Neuro-Fuzzy Inference System (ANFIS)

- Hybrid of **fuzzy logic and neural networks**.
- Performs **rule extraction from data** and learns it with a learning algorithm.\

(d) Radial Basis Neural Network (RBNN)

- Uses an **RBF kernel** for feature classification.
- Requires **Gaussian function** for activation of hidden layer.

3. Results and Discussion

The table below summarizes the accuracy of each model:

Model Performance:

Model	Precision	Recall	F1-score	Accuracy	AUC-ROC Score
ANN	0.98(Class0), 0.78(Class1)	0.79(Class 0), 0.98 (Class 1)	0.87 (for both classes)	**86.01%**	**0.88**
SVM	0.89(Class 0), 0.84(Class1)	0.88 (Class 0), 0.85 (Class 1)	0.88 (Class 0), 0.85 (Class 1)	**87%**	**0.87**
ANFIS	0.85 (Class0), 0.70(Class1)	0.72 (Class 0), 0.83 (Class 1)	0.78 (Class 0), 0.76 (Class 1)	**77%**	**0.78**
RBNN	0.88 (Class0), 0.83(Class1)	0.87 (Class 0), 0.85 (Class 1)	0.87 (Class 0), 0.84 (Class 1)	**86%**	**0.86**

Best Performing Model:

Based on accuracy, F1-score, and AUC-ROC score, the Artificial Neural Network (ANN) is the best-performing model, achieving an **accuracy of 86.01%** and an AUC-ROC score of 0.88. Although SVM also performed well **with an accuracy of 87%**, ANN had a slightly better AUC-ROC score, indicating better overall classification ability

4. Conclusion

In summary, ANN was better than SVM , ANFIS and RBNN for classification accuracy. While SVM was equally accurate to ANN, ANN had a higher AUC-ROC score. ANFIS had the worst accuracy and AUC-ROC score and thus was the lowest-performing model for this test. Future enhancements could be hyperparameter tuning and additional feature engineering to optimize model performance.