ABSTRACT

Fast AI-Based Power Flow Analysis for High-Dimensional Electric Networks

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The research paper titled "Fast AI-Based Power Flow Analysis for High-Dimensional Electric Networks" by Ali R. Al-Roomi and Mohamed E. El-Hawary focuses on the application of Artificial Intelligence (AI) techniques to enhance power flow (PF) analysis in large-scale electric networks. PF analysis, a crucial tool in electric power systems engineering, provides a static snapshot of dynamic electric networks under specific conditions. Traditional iterative techniques, such as the Newton-Raphson (NR) algorithm, while accurate, suffer from decreased processing speed as the network size increases. This paper proposes the use of Artificial Neural Networks (ANNs) to address this limitation, aiming to achieve a balance between processing speed and solution accuracy, especially in critical studies like contingency analysis where processing speed is paramount.

The study begins by emphasizing the fundamental role of PF analysis in power system operations, highlighting its importance in ensuring system security, optimal performance, and in planning and designing future expansions. The authors review existing PF solution techniques, noting the trade-offs between processing speed and accuracy. They point out the limitations of the NR method in large-scale applications due to its high computational demands and memory requirements.

To overcome these challenges, the authors propose an AI-based approach using ANNs. The method involves training ANNs with actual PF readings from test systems, such as the standard 9-bus test system and a larger virtual network comprising 100,000 buses. This training enables the ANNs to quickly and accurately solve PF problems, providing real-time solutions that accommodate system uncertainties.

The paper details the procedure for creating the ANN database, including generating diverse settings of loads and generators through a random process, and solving PF problems using classical solvers to create a comprehensive dataset. The neural network configurations are presented, and the training process is described, emphasizing the importance of accurate input and output variables for effective learning.

Numerical experiments validate the proposed method. The first experiment uses the WSCC 9-bus test system, while the second involves a large virtual test system to evaluate processing speed. The results demonstrate that ANNs can significantly reduce computation time without compromising accuracy, making them a viable alternative for real-time PF analysis in large-scale electric networks.

In conclusion, the paper argues that integrating AI techniques like ANNs into PF analysis can transform the way power systems are monitored and managed, offering a fast, accurate, and scalable solution to the challenges posed by high-dimensional electric networks. This advancement holds the potential to enhance the efficiency and reliability of power systems, paving the way for more robust energy management strategies.

References:

A. R. Al-Roomi and M. E. El-Hawary, "Fast AI-Based Power Flow Analysis for High-Dimensional Electric Networks," 2020 IEEE Electric Power and Energy Conference (EPEC), Edmonton, AB, Canada, 2020, pp. 1-6, doi: 10.1109/EPEC48502.2020.9320057. keywords: {Power systems;Mathematical model;Transfer functions;Energy management;Generators;Artificial neural networks;Conferences;power operation;power flow analysis;load flow analysis;Newton-Raphson;artificial neural networks},

M. Hanan, W. Yousaf, X. Ai, E. Asghar, M. Y. Javed and S. Salman, "Multi-operating Modes Based Energy Management Strategy of Virtual Power Plant," 2018 2nd IEEE Conference on Energy Internet and Energy System Integration (EI2), Beijing, China, 2018, pp. 1-6, doi: 10.1109/EI2.2018.8582406. keywords: {Batteries;Energy management;Wind turbines;State of charge;Mathematical model;Energy Management;Microgrid;VPP;Simulink},