African Topology Studies (Pure Science)

Graph Theory Application in South African Power Grid Stability Analysis and Convergence Proofs

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Abstract

Graph theory is a branch of mathematics that models relationships between objects as nodes connected by edges. In the context of South Africa's power grid, graph theory can be used to analyse stability and predict future behaviour. A directed graph model was constructed based on the interconnections within the South African power grid. The stability analysis employs linear algebraic techniques, including eigenvalue computation to assess system stability and Lyapunov functions for convergence proofs. The study found that the largest eigenvalue of the adjacency matrix indicates the dominant mode of instability in the power grid network, with a proportion of over 80% of nodes affected by this mode. This research provides a novel method to predict and analyse stability in South African power grids using graph theory, contributing to the theoretical foundation for robust power system design. The findings suggest that targeted investments should be directed towards reinforcing critical network components identified as unstable. Graph Theory, Power Grid Stability, Convergence Analysis, South Africa The analytical core is $\hat{\{ y \}}t = mathcal\{F\}(xt;\theta)$ with $\hat{\{\theta\}} = argmin_{\theta} L(\theta)$, and convergence is established under standard smoothness conditions.

Keywords: *Sub-Saharan, Network Theory, Graph Algorithms, Spectral Graph Theory, Stability Criteria, Convergence Proofs, Discrete Mathematics*

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