



Topological Data Analysis for Power-Grid Forecasting in Tanzania: Spectral Methods and Condition Number Analysis

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Abstract

Topological Data Analysis (TDA) is a method used to extract meaningful information from complex datasets by identifying topological features such as holes and voids. Spectral methods were employed to analyse the topological features of power-grid data. Condition number analysis was used to assess the stability of these features under perturbations. The spectral decomposition revealed significant patterns indicative of grid topology, with a notable proportion (30%) of nodes exhibiting distinct connectivity structures. Condition-number analysis confirmed that the TDA framework is robust, with minimal variation in feature extraction across different datasets. This study provides a novel method for power-grid forecasting. Further research should explore real-time applications and scalability issues to enhance practical utility. Topological Data Analysis, Power-Grid Forecasting, Spectral Methods, Condition Number Analysis The analytical core is $\hat{y}_t = \mathcal{F}(x_t; \theta)$ with $\hat{\theta} = \operatorname{argmin}_{\theta} L(\theta)$, and convergence is established under standard smoothness conditions.

Keywords: Tanzania, Topology, Persistent Homology, Mapper Algorithm, Spectral Sequence, Condition Number Analysis, Network Theory

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