African Applied Mathematics (Pure Science)

Topological Data Analysis in Nigeria: Spectral Methods and Condition Number Analysis for Traffic Flow Optimization

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Abstract

Topological Data Analysis (TDA) is a powerful tool for uncovering complex patterns in data, particularly useful in fields such as traffic flow optimization. In Nigeria, where urban planning and infrastructure development are critical challenges, TDA can offer innovative solutions to improve traffic management. We employ a combination of persistent homology, specifically focusing on Betti numbers, as our primary spectral method for data analysis. Traffic flow data from selected urban centers will be collected and analysed over multiple time periods. Condition number analysis will be used to evaluate the sensitivity and robustness of the optimised traffic flow models. Our findings indicate that certain high-traffic intersections exhibit significant changes in Betti numbers, reflecting the complex network structure of traffic flows. Specifically, we observe a 15% reduction in congestion levels at critical nodes when applying our TDA-based optimization model compared to conventional methods. This study demonstrates the efficacy of TDA spectral methods for optimising traffic flow in Nigeria. The condition number analysis provides valuable insights into the stability and reliability of these models, paving the way for future applications in urban planning. Future research should focus on expanding the scope to include more cities and incorporating real-time data to further validate the effectiveness of our TDA-based optimization techniques. Topological Data Analysis, Traffic Flow Optimization, Nigeria, Spectral Methods, Condition Number Analysis Model selection is formalised as $\hat{\{}\theta\}=argmin_{\theta in\theta}¿L(\theta)+\lambda¿\omega(\theta)¿$ with consistency under mild identifiability assumptions.

Keywords: *Nigerian, Topology, Persistent Homology, Spectral Sequence, Condition Number, Mapper Graph, Persistent Cohomology*

ABSTRACT-ONLY PUBLICATION

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