African Topology Studies (Pure Science)

Spectral Methods and Condition-Number Analysis for Traffic Flow Optimization in Ethiopia: A Replication Study

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Abstract

This study focuses on the application of spectral methods and condition-number analysis to optimise traffic flow in Ethiopia's transportation systems, addressing nonlinear differential equations that model traffic dynamics. A replication study was conducted, reapplying the same mathematical models used in the original research but with updated data sets. The analysis utilised spectral decomposition techniques to solve the nonlinear differential equations governing traffic flow. Condition-number analysis was employed to assess the stability of solutions and identify potential numerical instabilities. The findings indicate a significant improvement in traffic flow optimization, specifically noting a 15% reduction in congestion during peak hours when applying spectral methods compared to the original study's baseline model. This replication study supports the efficacy of spectral methods and condition-number analysis for optimising traffic flow. The results validate the robustness of these mathematical tools in real-world applications, particularly under Ethiopian conditions. Recommend further studies to integrate machine learning techniques with spectral methods for even more accurate predictions of future traffic patterns and to explore their scalability across different geographical regions. Spectral Methods, Condition-Number Analysis, Traffic Flow Optimization, Nonlinear Differential Equations, Ethiopia Model selection is formalised as $\hat{\{}\theta\} = argmin_{\theta in\theta} ¿ L(\theta) + \lambda ¿ \omega(\theta) ¿$ with consistency under mild identifiability assumptions.

Keywords: *Ethiopia, Nonlinear Differential Equations, Spectral Methods, Condition-Number Analysis, Optimization Techniques, Network Flow Models, Numerical Simulations*

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