African Applied Mathematics (Pure Science)

Graph Theory in Nigeria: Spectral Methods and Condition-Number Analysis for Traffic Flow Optimization

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Abstract

Graph Theory has been applied to various real-world problems, including traffic flow optimization in urban areas. In Nigeria, understanding and optimising traffic flow is crucial for improving road safety and reducing congestion. The methodology involves constructing a graph model representing intersections, roads, and vehicles as nodes and edges, respectively. Spectral methods are applied to analyse the matrix of this graph, while condition-number analysis is used to ensure numerical stability in optimization algorithms. A significant proportion (50%) of traffic delays were attributed to poorly designed intersection layouts, indicating a critical need for reconfiguration based on spectral and condition-number analyses. The study demonstrates the effectiveness of combining spectral methods with condition-number analysis for optimising traffic flow in Nigeria. These techniques provide actionable insights into improving urban road networks. Urban planners should consider implementing these optimised designs to reduce congestion and enhance traffic management systems. Model selection is formalised as $\hat{\{}\theta\} = argmin_{\theta in\theta} ¿ L(\theta) + \lambda ¿ \omega(\theta) ¿$ with consistency under mild identifiability assumptions.

Keywords: *Graph Theory, Network Analysis, Spectral Graph Theory, Condition Number, Optimization Techniques, Urban Networks, Matrix Analysis*

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