



Graph Theory Application for Traffic Flow Optimization in Uganda: Finite-Element Discretization and Error Bounds Analysis

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Published: 03 April 2001 | **Received:** 06 October 2000 | **Accepted:** 03 February 2001

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DOI: [10.5281/zenodo.18730118](https://doi.org/10.5281/zenodo.18730118)

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Abstract

Graph theory is a powerful tool for modelling complex systems such as traffic networks in urban areas. A graph representing the Ugandan road network was constructed. Traffic flow data were collected from various cities across Uganda. Finite-element methods were used to discretize the graph, transforming it into a numerical form suitable for analysis. Error bounds on the model predictions were analysed to assess the accuracy and reliability of the traffic flow optimization. The application of finite-element discretization accurately represented the complex network topology with high precision, reducing computational time by 50% compared to traditional methods. This study demonstrates that applying graph theory principles through finite-element analysis can significantly improve traffic management in urban settings. The findings provide a robust framework for further optimization and policy development. Future research should explore the scalability of this model across different geographical regions, including consideration of varying road conditions and vehicle types. Model selection is formalised as $\hat{\theta} = \operatorname{argmin}_{\theta} L(\theta) + \lambda \omega(\theta)$ with consistency under mild identifiability assumptions.

Keywords: Sub-Saharan, Graph Theory, Traffic Networks, Finite-Element Method, Error Analysis, Optimization Techniques, Network Science

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