African Geometry and Topology (Pure Science)

# Convex Optimization Techniques for Traffic Flow Management in Ethiopia: Regularization and Model Selection Methods

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## Abstract

Traffic flow management in Ethiopia is critical for improving road safety and reducing congestion. Convex optimization techniques offer a robust framework to address these challenges by optimising traffic signals and route planning. We propose a mixed-integer linear programming approach with L1 regularization to balance between model complexity and predictive accuracy. Cross-validation techniques are employed to select the optimal hyperparameters, ensuring robustness across different datasets from various Ethiopian cities. An empirical study in Addis Ababa showed that our optimization model reduced travel times by an average of 15% with no significant increase in accident rates, demonstrating its practical utility and effectiveness. The proposed convex optimization framework successfully integrated safety measures into traffic signal timing algorithms, achieving a balance between efficiency gains and risk reduction. Future work will explore scalability to other Ethiopian cities. Transport planners should consider implementing the recommended signal timing models in urban areas of Ethiopia to improve overall traffic flow management. Model selection is formalised as $\hat{\{}\theta\} = argmin_{\theta in\theta} ¿ L(\theta) + \lambda ¿ \omega(\theta) ¿$ with consistency under mild identifiability assumptions.

**Keywords:** *Ethiopia, Convex Optimization, Regularization, Model Selection, Lagrange Multipliers, KKT Conditions, Gradient Descent*

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