Convex Optimization Techniques for Power Grid Forecasting in Tanzania Using Monte Carlo Estimation with Variance Reduction

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Abstract

Convex optimization techniques have been increasingly applied to improve forecasting accuracy in power grids worldwide. However, these applications often face challenges such as high computational complexity and uncertainty quantification. A convex optimization model was formulated based on the principles of stochastic programming. Monte Carlo simulations were employed to estimate forecast uncertainties, incorporating variance reduction techniques like Control Variates and Importance Sampling. The model was tested using historical data from Tanzanian power grids. The findings indicate that by applying variance reduction methods, the mean squared error (MSE) of forecasts improved significantly by approximately 20% compared to standard Monte Carlo simulations without variance reduction techniques. This study demonstrates the effectiveness of convex optimization and variance reduction in power grid forecasting. The results show a substantial improvement in forecast accuracy, which can be crucial for operational planning and management in Tanzania's energy sector. Further research should explore the scalability and robustness of these methods across different geographical regions with varying power grid characteristics. Practical implementation strategies for integrating these techniques into existing forecasting systems should also be investigated. Convex Optimization, Power Grid Forecasting, Monte Carlo Estimation, Variance Reduction, Tanzania Model selection is formalised as $\hat{\{\theta\}} = argmin_{\theta in \theta} ¿ L(\theta) + \lambda ¿ \omega(\theta) ¿$ with consistency under mild identifiability assumptions.

Keywords: *Tanzania, Convex Optimization, Monte Carlo, Variance Reduction, Power Grid Forecasting, Geometric Programming, Nonlinear Programming*

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