# Regularization Techniques and Model Selection in Partial Differential Equations for Telecom Network Reliability in Tanzania

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## Abstract

Partial differential equations (PDEs) are fundamental in modelling complex systems such as telecommunications networks. In Tanzania, where telecom infrastructure is expanding rapidly, precise mathematical models are essential for understanding network reliability and managing resources efficiently. Regularization techniques such as L1 and L2 penalties are employed within a PDE framework to address overfitting issues. Cross-validation is used to determine the best hyperparameters that minimise prediction errors on unseen data. A key assumption is that network data exhibits spatial and temporal correlation, which is crucial for accurate modelling. In simulations conducted across different geographical regions in Tanzania, we observed a significant reduction in prediction error when using L2 regularization compared to no regularization, indicating improved model generalization. The cross-validation process identified optimal hyperparameters leading to more stable and reliable predictions. This study provides evidence that PDEs combined with regularization techniques can effectively enhance the reliability of telecom network models in Tanzania, offering a practical tool for network planners and operators. Future research could explore incorporating additional factors such as user behaviour and environmental conditions into the model to further improve its predictive accuracy. Additionally, expanding the dataset from multiple regions would allow for more robust validation of the findings. Partial Differential Equations, Telecom Network Reliability, Regularization, Model Selection, Cross-Validation Under standard regularity and boundary assumptions, the forecast state is modelled by $partial t\, u(t,x) = \kappa \, \partial\{xx\} u(t,x) + f(t,x)$, and stability follows from bounded perturbations.

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