

NETWORK-BASED SPATIAL MODELING FOR TRAFFIC VOLUME PREDICTION

I.K.S.H. Wijayawansa^{*}, S.G.J. Senarathne and M.B. Dehideniya

Department of Statistics and Computer Science, University of Peradeniya, Peradeniya, Sri Lanka.

**shehanharindu@gmail.com*

Accurately predicting traffic volume is critical for effective urban planning, congestion reduction, and infrastructure development. While numerous statistical and machine learning approaches have been applied to this task, many overlook temporal patterns and the influence of predictors, while failing to capture the unique spatial structure of urban road networks. Spatial models based on Euclidean distances address spatial dependence to some extent; but they do not reflect the actual movement constraints of road networks, where connectivity and road layout govern traffic flow. This study introduces a novel approach for predicting traffic volume by integrating road network-based distances into a spatial regression framework. Traffic count data from 237 locations in Glasgow (15,384 observations, 2000 – 2023) were used. Predictors included temporal features (weekday, peak/off-peak, quarter, and week number) and road characteristics (*e.g.*, road type). A regression-kriging model was developed, combining fixed-effect predictors with spatial effects derived from a Gaussian Process based on road distances. An empirical variogram was computed from Generalised Linear Model residuals and fitted with an exponential model to estimate spatial parameters (nugget, partial sill, and range). These parameters were then used to construct a spatial covariance matrix and simulate spatial effects from the posterior distribution. Incorporating these effects into a Bayesian spatial regression significantly improved performance, achieving a pseudo- R^2 of 0.849 and RMSE of 0.494, compared with 0.478 and 0.915 in the non-spatial model. Compared to Euclidean-based models ($R^2 = 0.839$, RMSE = 0.517), the road distance-based model more effectively captured true spatial dependencies in traffic patterns. This statistically grounded and interpretable approach offers practical value for transportation planning and urban analytics.

Keywords: Bayesian spatial regression, Generalised linear model, Kriging, Posterior distribution, Spatial model