QUT SEF VRES 2020 Showcase

Origin-Destination Matrix Estimation using Traffic Counts and Bluetooth Sensors

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Introduction

In highways and major roads, loop detectors count the number of vehicles on a certain section of road, known as link traffic counts. Bluetooth scanners track individual vehicles throughout the scanner network, identifying time and location of vehicle movement, known as sub-path flows. Combined, traffic counts and Bluetooth sub-path flows can be used to estimate the traffic flow between any predefined origin and destination[1].

An **Origin-Destination (OD) matrix** models travel demand between a predetermined number of origins and destinations across a road-based transportation network. The information provided by an OD matrix is invaluable for future network planning and the construction, maintenance and upgrade of road infrastructure.

The aim of this project was to develop a method to estimate the OD matrix using traffic counts and Bluetooth intersection data for a network based on the Brisbane CBD (Figure 2). Specifically, by way of a genetic algorithm[2], a metaheuristic inspired from natural selection and evolution.

Method

To measure the accuracy of an estimated OD matrix, a 'true OD' must be known. This true OD was loaded into the traffic simulation software, AIMSUN, which generated the true link counts (y) and true Bluetooth sub-path flows (t).

A 'prior OD' is an estimation to the true OD and is initially generated from the true OD with some random variation. The goal is then to manipulate this prior OD back into the true OD using only estimated link counts ($\bar{y}$) and estimated Bluetooth sensor data ($\bar{t}$).

This research project was a continuation of work already completed by Dr. Krishna Behara using the optimisation method of gradient descent[3]. The results from gradient descent produced an estimated OD with a 0.83 correlation to the true OD.

A genetic algorithm was implemented in MATLAB, detailed in Figure 1, which aimed to improve the correlation between the estimated and true OD. The objective function used was $Z = \frac{1}{2}(\sum(y-\bar{y})^2)^{1-\rho(t,\bar{t})}$ where ρ is the correlation coefficient between t and $\bar{t}$.

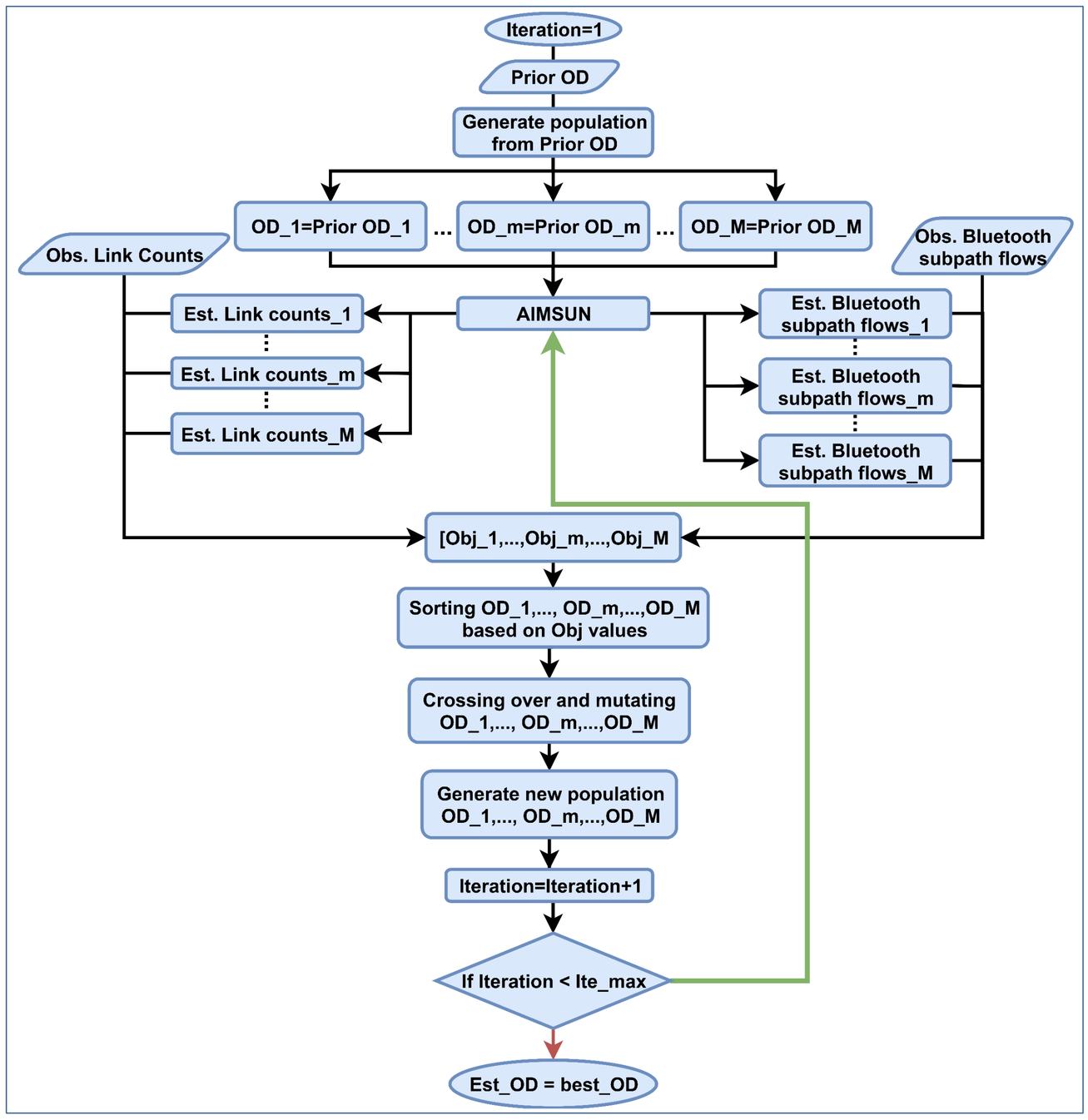

Figure 1. Genetic Algorithm Flow Chart

Results

Using the parameters specified in Figure 3, the genetic algorithm was unable to produce a better estimation to the true OD than gradient descent. As shown in Figure 3, when the value of the objective function decreased, so did the correlation between the estimated and true OD (peaking at approximately 0.8). However, this resulted in a smaller root mean square error (RMSE) for the estimated and true link flows, even though the RMSE of the estimated OD increased.

This means that the algorithm was able to accurately estimate link flows but could not distribute them between the OD pairs, indicating the objective function over emphasised the use of link flows at the expense of the Bluetooth detector data. This resulted in an OD that did not represent the structure of the true OD accurately.

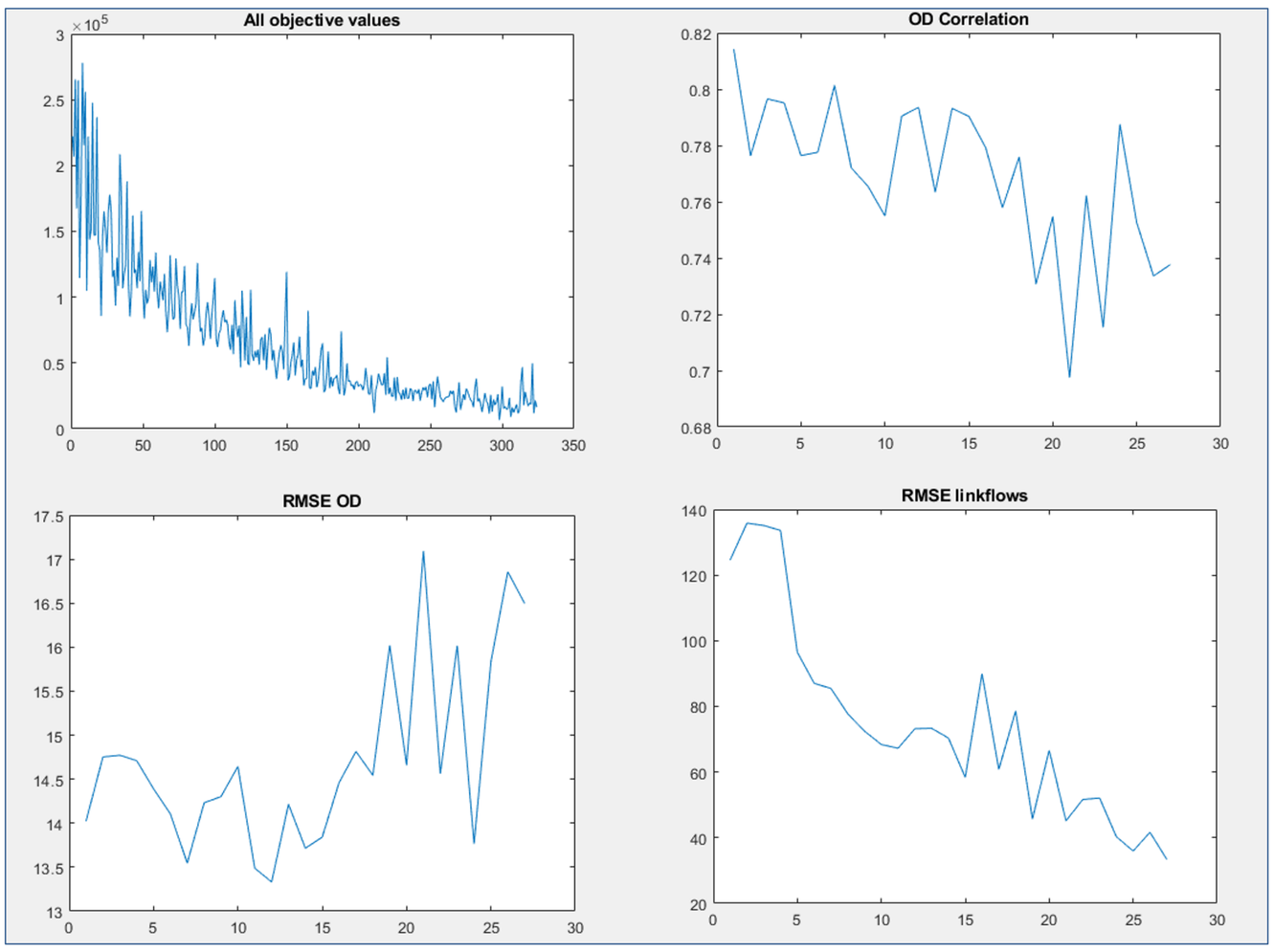

Figure 3. Results and statistical measures from the genetic algorithm. Parameters: 325 iterations, population size of 10, 30% mutation ratio, 20% variance in initial population from prior OD

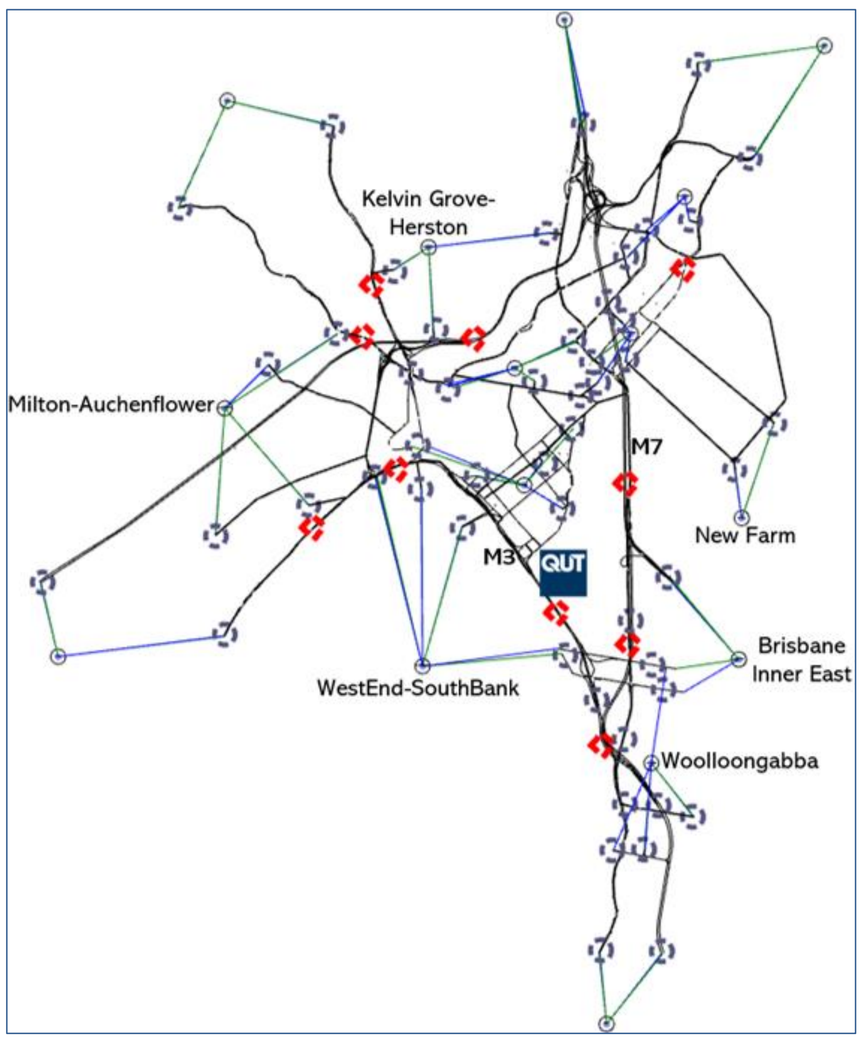

Figure 2. Network model based on Brisbane CBD. Red markers represent loop detectors and blue represent Bluetooth scanners

Conclusion

The genetic algorithm was able to moderately predict the true OD from link flows and Bluetooth data, but was highly dependent on the prior OD. It was computationally expensive and utilised several parameters which in themselves had the potential to be optimised (such as population size, mutation ratio, etc.).

Future work on this project would involve manipulating the objective function so that more emphasis is placed on the correlation of the Bluetooth flows, while maintaining the same accuracy in the link counts.

Contact

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References

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