An Approach To Sparse, Fine-Grained OD Estimation

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Abstract

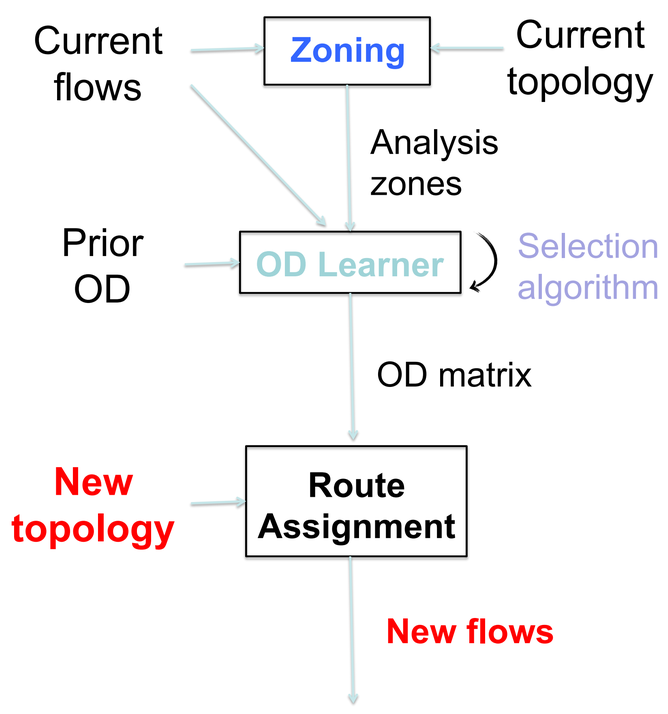
We present an approach to automatically identify fine-grained traffic analysis zones, estimate a sparse OD matrix for this fine-grained zoning, and evaluate the performance of competing OD estimates.

Motivation: Urban OD Estimation

Our work is borne out of forecasting flow under closure to certain high volume links in an urban environment. This requires the accurate modelling of the OD matrix at a sufficiently fine level of granularity.

However, we face some challenges:

- How do we identify suitably detailed zones?
- How do we reliably estimate OD matrices at a fine granularity?
- How do we choose between competing OD matrices?



Fine-Grained Zoning

Goal: Ensure a minimal number of intra-zonal trips, so as to account for flow on high-volume links.

Strategy: Use as zonal centroids those sites that frequently rely on high-volume links for travel to other sites.

Details: Define:

$P(e)$ = Set of OD pairs relying on link e for travel (with high probability)
$C(i, j)$ = Count of high-volume links that the pair of sites (i, j) relies on for travel.

- Perform equilibrium assignment on a per-site zoning, with uniform OD matrix.
- Compute $P(e)$ for every link.
- Compute $C(i, j)$ for every pair (i, j) of sites.
- Select site pairs in decreasing order of $C(i, j)$, until sufficient high-volume links are accounted for.

An Approach To Sparse, Fine-Grained OD Estimation

Sparse OD Estimation

Goal: With a fine-grained zoning, we have to estimate a large # of OD flows reliably.

Strategy*:* Intuitively, most OD pairs will not be involved in any trips over a fixed period (e.g. AM peak). We thus regularise OD estimates to be sparse, by employing L1 regularisation. The more popular L2 (squared) regularisation typically produces dense solutions.

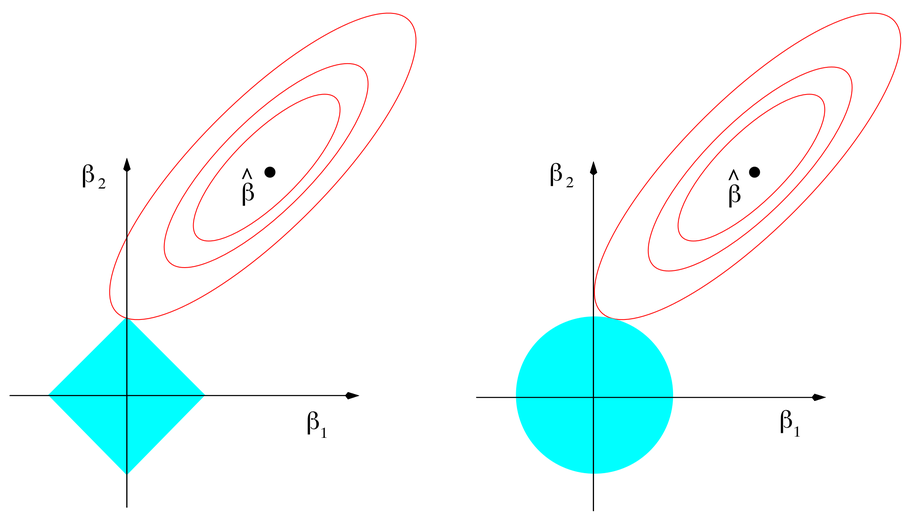
Details: With L1 regularisation, we need to solve

$$\min_{\mathbf{x} \succeq \mathbf{0}} (\mathbf{A}\mathbf{x} - \mathbf{y})^T \mathbf{W}^{-1} (\mathbf{A}\mathbf{x} - \mathbf{y}) + \Omega(\mathbf{X})$$

$$\Omega(\mathbf{X}) = \mathbf{1}^T \mathrm{vec}(\mathbf{X})$$

Standard GLS objective — Regulariser

so that the regulariser is simply linear. This objective can be minimised by optimisers suitable for box-constraints, such as L-BFGS-B.

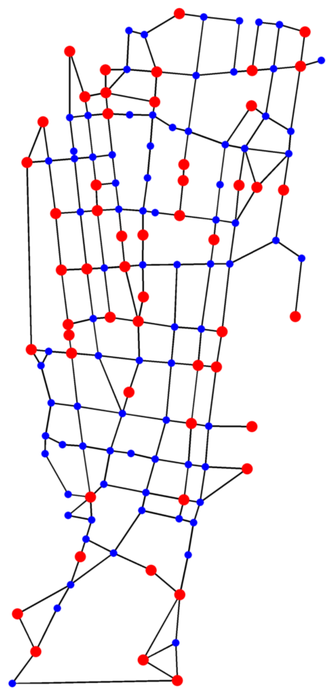


Experiments

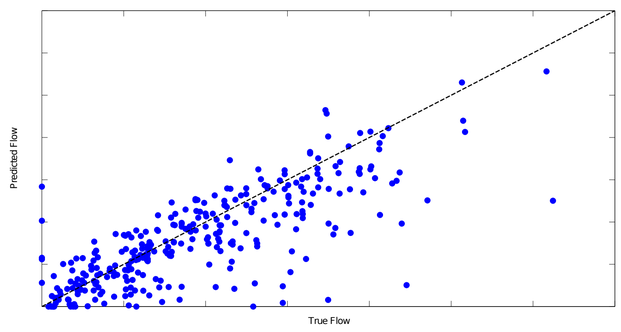
We apply our techniques to a real-world urban network with 136 sites and 331 links. The automated zoning scheme discovers ~40 sites that ensure good coverage of high volume links.

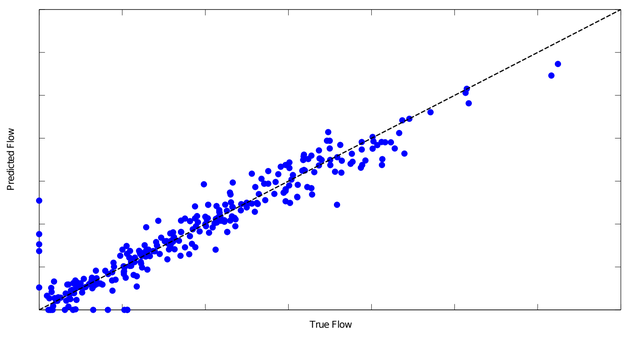
With the fine-grained zoning, we are able to get a much better fit to the observed link flows as compared to a manually created zoning of the network. We diagnose the quality of OD estimates by looking at held-out flow prediction, as is popular in statistics and machine learning.

The use of L1 regularisation is seen to induce sparse OD estimates. These estimates are much more interpretable than those produced by standard L2 regularisation.

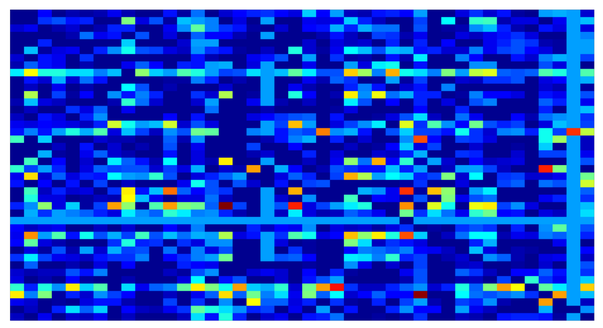


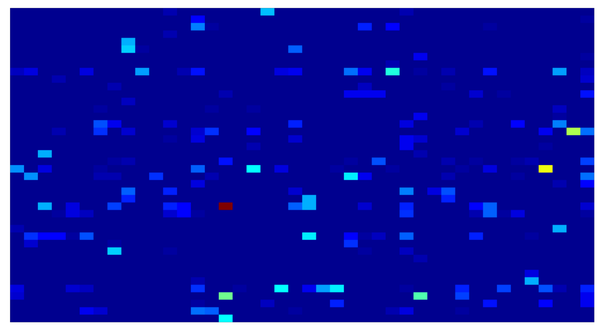
Results of fine-grained zoning On urban network.





Comparison of predicted flows, coarse and fine zoning.





Comparison of OD estimates, L2 and L1 regularisation.

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