
Iterative Scaling in Network Tomography

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Outline

1. General Research Interests
2. Current Research on Network Tomography
 - The Gaussian Model (Cao et al, 2000)
 - Iterative Scaling: a Geometric View
 - Regularized Projection via Gravity Model
 - Sprint PoP Network Data

General Research Interests

- Statistical Inference, Machine Learning
- Minimum Description Length Principle (MDL) and applications
- Networks Tomography (Traffic Matrix Estimation and Topology Discovery)
- Cloud Detection over Ice/Snow based on Satellite Images
- Data Analysis in Neuroscience.

Research history in network tomography

- 98-00: MTS, Bell Labs (Cao et al paper on Gaussian model)
- 00-Present: back to Berkeley and working with Gang Liang and Taft's group at Sprint labs.
 - With Liang: Pseudo-likelihood approach to network tomography (Liang and Yu, 2003, IEEE Sig. Proc). Analysis of Iterative Scaling (current research).
 - With Taft's group: analysis of Sprint PoP Network Data.

Problem Statement

X : traffic matrix, important in traffic engineering;

A : routing matrix (known);

Y : observed traffic link load statistics with $Y = AX$.

Note: it is an ill-posed linear inverse problem because the dimension of X is ususally much higher than that of Y .

Goal: recover X from Y .

Iterative Scaling Procedure

Given (a) a set of marginal linear constraints L
(b) a starting distribution q

Iterative scaling: a simple procedure to find the distribution which minimizes the KL-divergence among those satisfying all marginal constraints, i.e.,

$$(1) \quad \hat{p} = \arg \min_{p \in L} D(p||q)$$

Special case: it maximizes entropy if starting from a uniform distribution.

Gravity Model

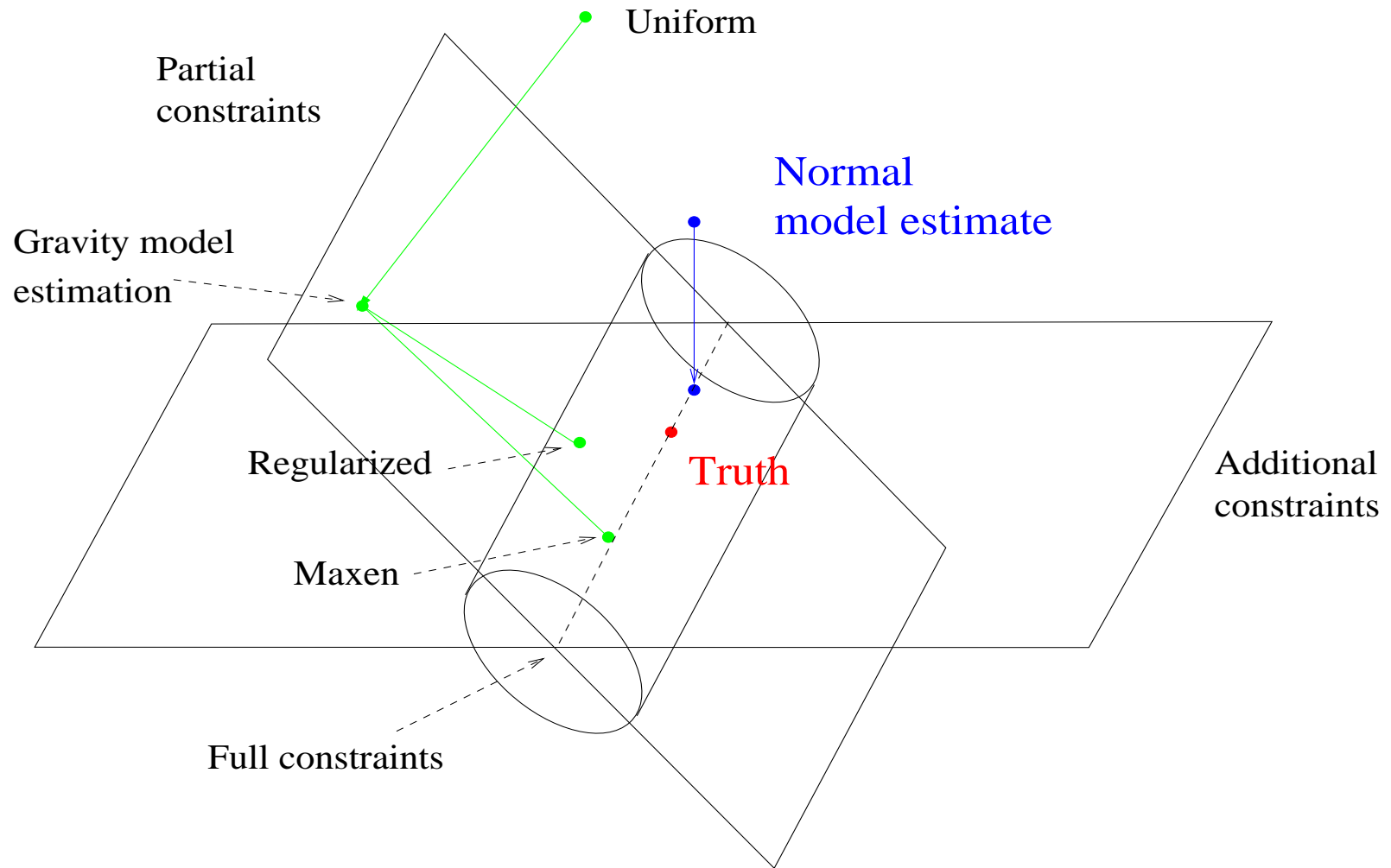
Gravity Model: let $N(s)$ be total traffic entering s and $N(d)$ total traffic leaving d . It says

$$(2) \quad \hat{N}(s, d) = N(s) * N(d) / N$$

where N is the total traffic in the network.

- It is equivalent to the source-destination independent model in Zhang et al. (2003).
- It is a special case of maximum entropy estimation when only in/out marginal constraints are considered.

A Pictorial Illustration



Example: Sprint European PoP Network

Configuration: 13 PoPs, and 18 internal links.

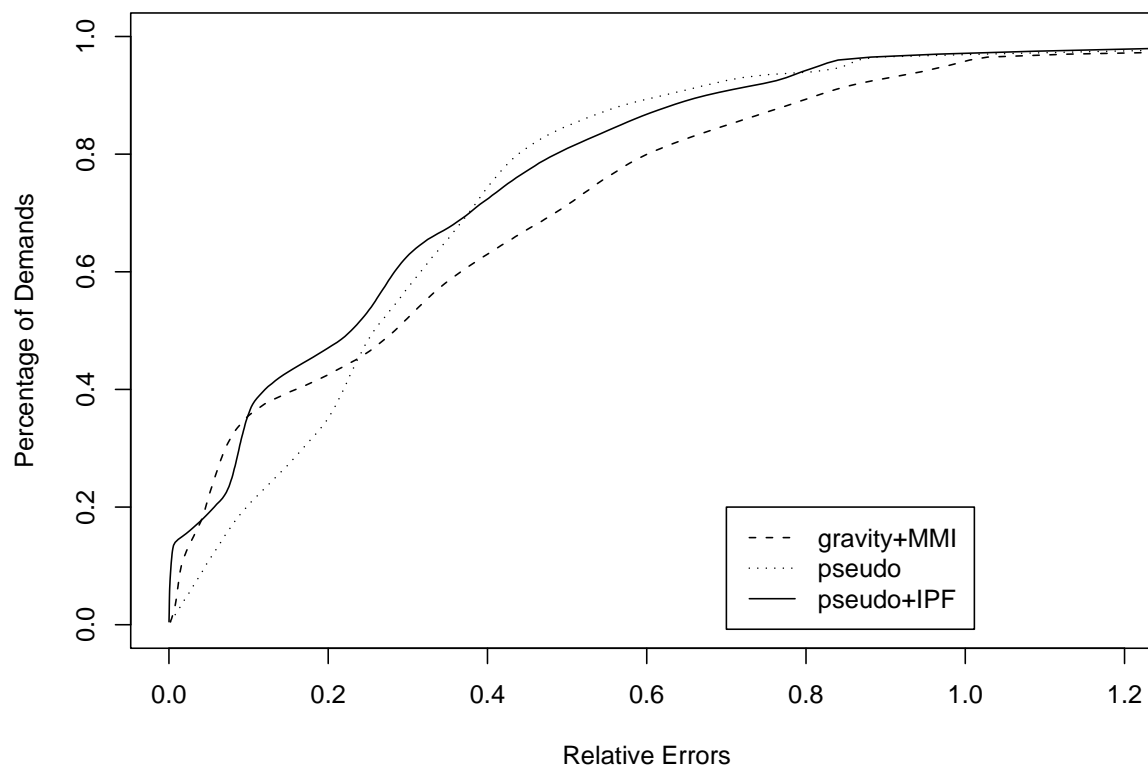


Figure 1: Relative Errors of Different methods. The average error of psuedo+IPF is .297, and gravity+MMI is .37 after removing small traffi c which accounts for 20% of total traffi c counts.

Boxplot of Relative Errors

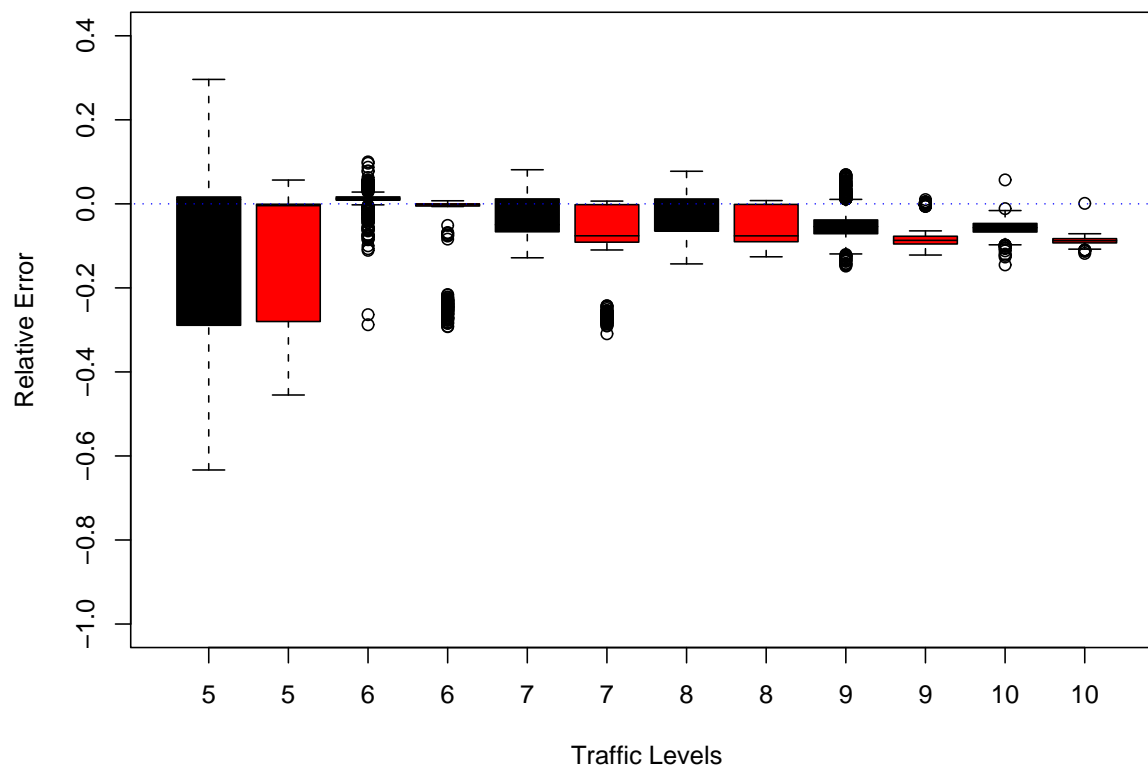


Figure 2: Boxplot of Relative Errors: all traffic is aggregated into 10 bins according to their true OD counts. Plots are based on data points inside each bin. Red: pseudo+IPF; black: gravity+MMI.