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Urban Traffic Network Control

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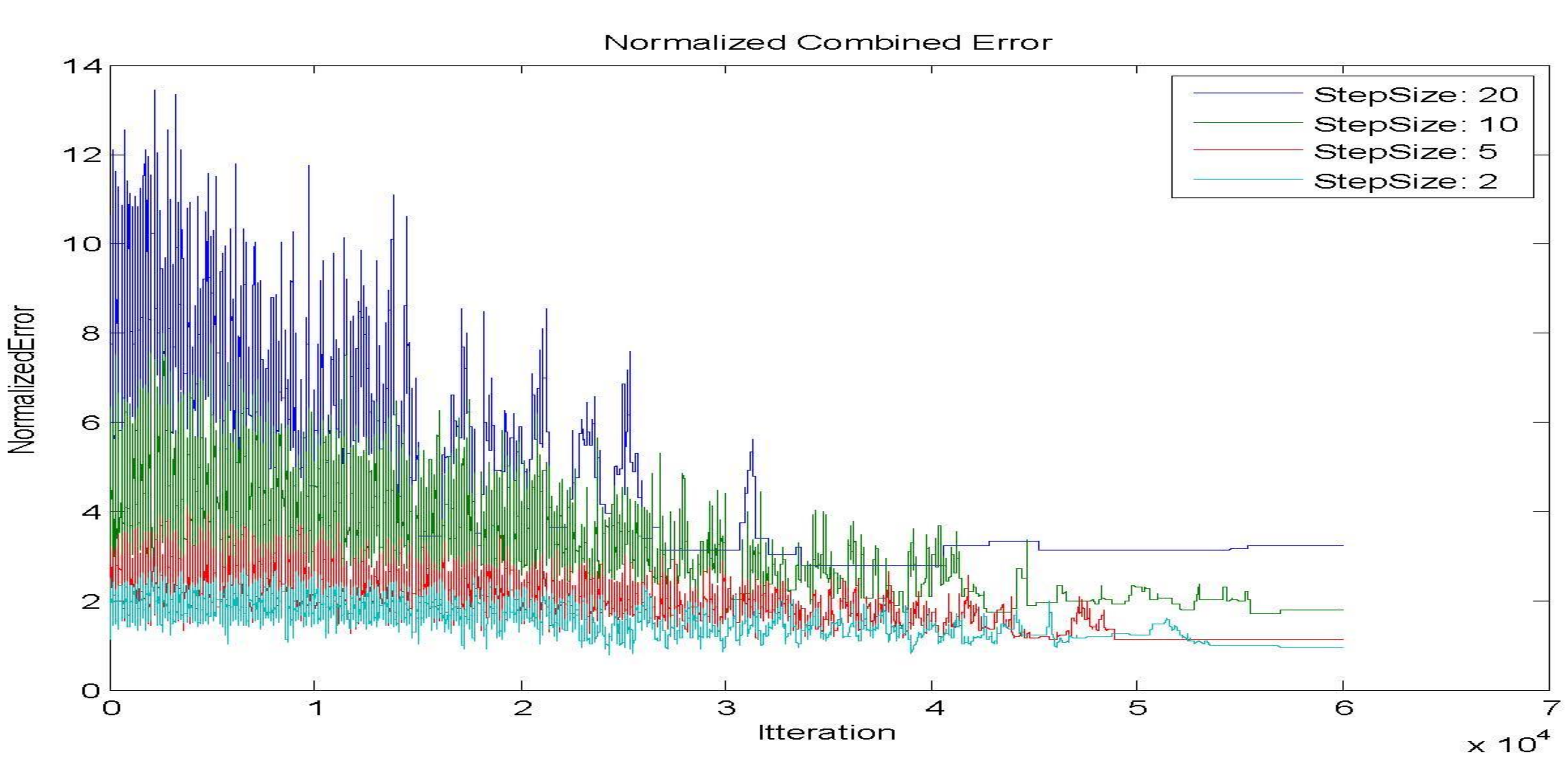
Motivation & Introduction

With the rapid industrialization and urbanization of human society, several complications has been arisen. A vast majority of human population have been centered in less than one percent of available land fields. High concentration led to frequent traffic congestion and critical population level. Many of these arising issues can be addressed by traffic control. The ultimate goal of the project is to set a sustainable smart framework that can learn the traffic, pollution sources, understand underlying frame work, compute the OD matrix and play with the traffic signs and regulations to change the spatial distribution of pollution and congestion.

Origin Destination Matrix Est.

- **Random Search: (Simulated Annealing)**



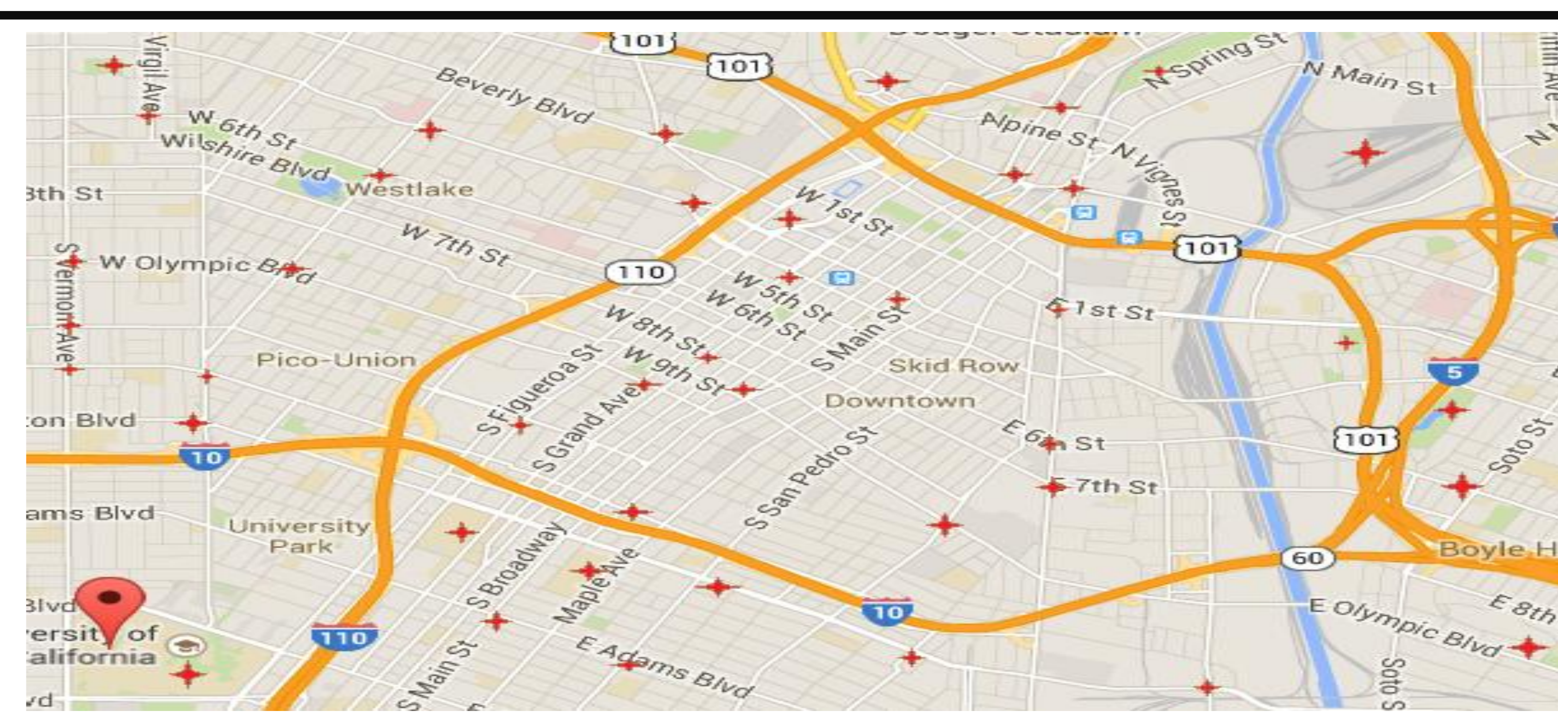
- **Analytical solution:** $Ax = b$**?**

  $x^{v(v-1)\times 1}$: Vector of unknowns (OD pairs),

  $A^{|E|\times v(v-1)}$: Routing Matrix,

  $b^{|E|\times 1}$: Sensed data, $|E| \leq 4v$.

Targeted Area & Data Structure



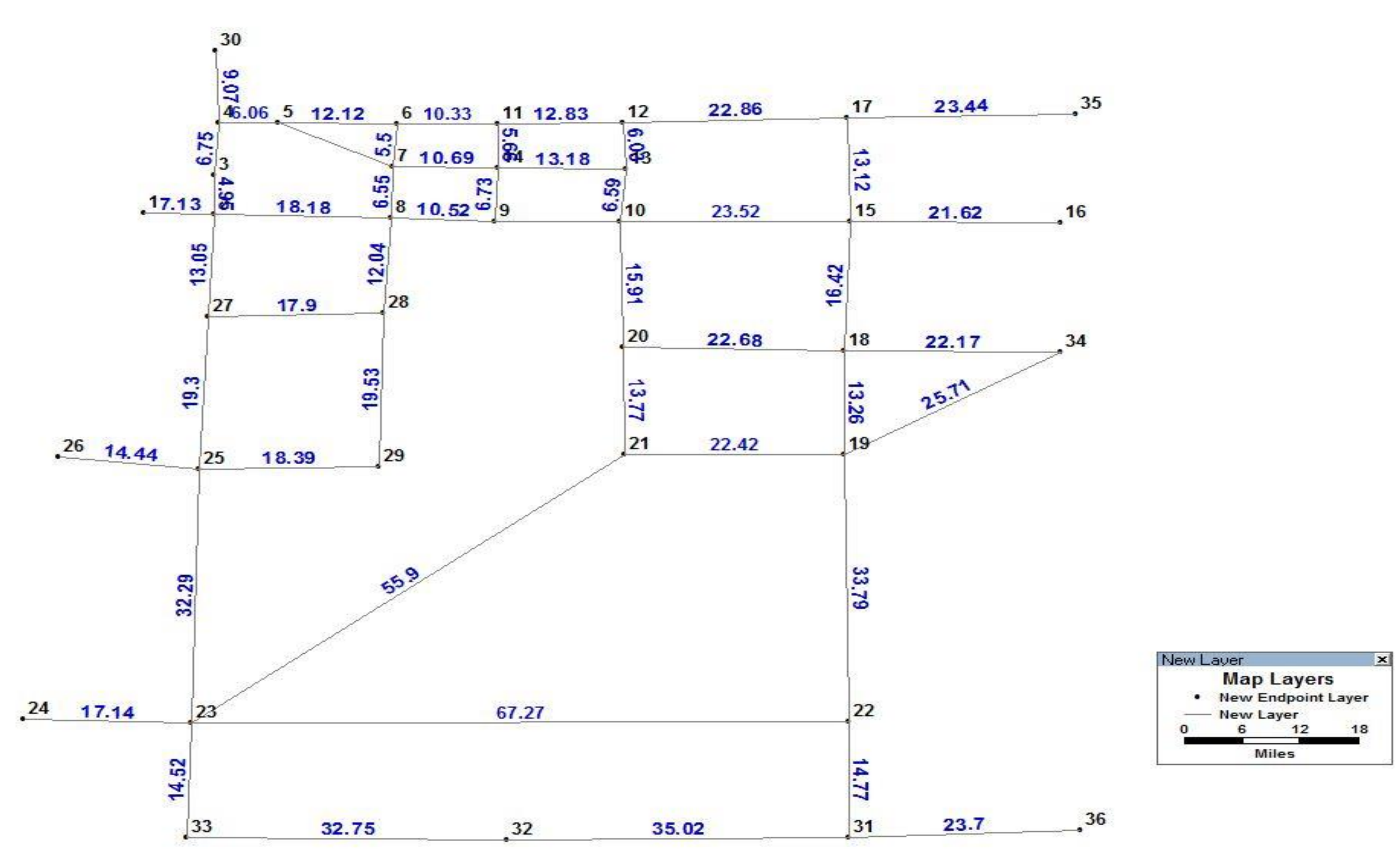
Road Seg. ID	Name	At	Dir	Traffic Volume	Speed	Lat-Lon
10583	Hoover	Pico	N	15.7	30 mph	---
10783	Figueroa	Venice	E	20.6	45 mph	---
11640	Grand	5th	S	12.4	25 mph	---
…	…	…	…	…	…	…

Problem Modelling & Formulation

$$\min_{\vec{d}} \boldsymbol{C}(G, \vec{\boldsymbol{d}}, \vec{\boldsymbol{f}})$$

Subject to: $\boldsymbol{C}(G, \vec{\boldsymbol{d}}, \vec{\boldsymbol{f}}) = \sum_{k,l \in I} \sum_{i,j \in P_{kl}} f_{kl}(w_i + d_{ij})$

$$\vec{\boldsymbol{d}} \geq \vec{\boldsymbol{d}}_{\boldsymbol{min}}$$



4 Approximation Algorithm

- **Theorem:** An assignment of delays as such: $d_{ij}^H = \max(w_i, d_{min})$ in a any road network results in an objective which is not worse than 4 times the optimum objective value.

Proof: $w_{ij} \leq d_{ij}^H \Rightarrow w_{ij} + d_{ij}^H \leq 2d_{ij}^H \leq 2(d_{min} + w_{ij}) \leq 2(d_{ij}^* + w_{ij})$, $C'_{kl} = \sum_{s_{ij} \in P_{kl}^*} f_{kl}(w_i + d_{ij}^H)$, $C_{kl}^H = \sum_{s_{ij} \in P_{kl}^H} f_{kl}(w_i + d_{ij}^H)$

$$\sum_{ij \in P_{kl}^H} d_{ij}^H \leq \sum_{ij \in P_{kl}^*} d_{ij}^H \Rightarrow$$

$$C_{kl}^H / f_{kl} = \sum_{ij \in P_{kl}^H} d_{ij}^H + \sum_{ij \in P_{kl}^H} w_{ij}$$

$$\leq \sum_{ij \in P_{kl}^*} d_{ij}^H + \sum_{ij \in P_{kl}^*} w_{ij} - \sum_{ij \in P_{kl}^*} w_{ij} + \sum_{ij \in P_{kl}^H} w_{ij}$$

$$\leq \sum_{ij \in P_{kl}^*} d_{ij}^H + \sum_{ij \in P_{kl}^*} w_{ij} + \sum_{ij \in P_{kl}^H} w_{ij}$$

$$\leq C'_{kl}/f_{kl} + \sum_{ij \in P_{kl}^*} d_{ij}^H + \sum_{ij \in P_{kl}^*} w_{ij}$$

As a result: $C_{kl}^H \leq 4C_{kl}^*$ ∎

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