Revisiting the Empirical Fundamental Relationship

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Introduction

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• This work takes a new approach to empirically establishing a fundamental relationship in heavily congested traffic
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Conventional Empirical Fundamental Relations

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Conventional Empirical Fundamental Relations
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Measured $q$ versus $occ$ from one day at one dual loop detector

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- The scatter is commonly attributed to combining non-stationary traffic states in a given sample
Conventional Empirical Fundamental Relations

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- Each $T = 5$ min data point is more likely to combine different non-stationary traffic states, yet the scatter is diminished compared to $T = 30$ sec
Conventional Empirical Fundamental Relations

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- Each $T = 5$ min data point is more likely to combine different non-stationary traffic states, yet the scatter is diminished compared to $T = 30$ sec

- Thus, the noise cannot strictly be due to averaging across non-stationary traffic states
Hypothetical Fundamental Relationship

- Homogeneous fleet of passenger vehicles with \( L = 20 \) ft under stationary conditions and very long sampling periods
Hypothetical Fundamental Relationship

q versus v

v drops by 33% → q drops by 10%

q versus occ
Hypothetical Fundamental Relationship

- The lowest 10 mph covers most of the q-occ plane
  - Yet this speed range exhibits the largest detector errors
Hypothetical Fundamental Relationship

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- Extending the relationship to homogeneous fleets with longer L
  - Many more errors arise due to varying L
Empirical Measurements

- Instead of measuring conventional q, occ and v, this work takes the following the single vehicle passage (svp) measures:

\[ q_{svp} = \frac{1}{h} \]

\[ occ_{svp} = \frac{on\_time}{h} \times 100\% \]

\[ v_{svp} = \frac{detector\_spacing}{traversal\_time} \]

\[ L_{svp} = v_{svp} \times on\_time \]
Data Aggregation

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  - All aggregated data shown today from the new method include at least 100 vehicles in the given bin
  - The result is a homogeneous set of vehicles and speeds in each bin before aggregation
  - Furthermore, suspected detector errors are excluded
  - Most importantly, the new approach eliminates the need to seek out stationary traffic conditions in congested traffic
Empirical Measurements

\[ T = 30 \text{ sec} \]

- Using same day and detector as before, svp point cloud is far noisier than \( T=30 \text{ sec} \) samples
Empirical Measurements

Sorting into length bins...
(3 shown)
Empirical Measurements

Picking the most common length bin and sorting into speed bins... (3 shown)
Empirical Measurements

Picking the most common length bin and sorting into speed bins... (3 shown)

Finding the median q and occ for each speed bin...
Empirical Measurements

Connecting the median $q$ and $occ$ across the speed bins for this length bin.
Empirical Measurements

18–22 ft, one day

Comparing svp against
$T = 30$ sec
Empirical Measurements

18–22 ft, one day

18–22 ft, 18 days individually

Repeating svp over 18 days individually
Empirical Measurements

Combining all 18 days before aggregating

18–22 ft, 18 days individually

18–22 ft, 18 days combined
Empirical Measurements

Repeating across all 4 lanes individually
Empirical Measurements

Combining the days and lanes together, now have enough observations so that the less common lengths have over 100 samples in most speed bins.
Empirical Measurements

- Only use length-speed bins with at least 100 veh observations
- Upper bound $v = 17$ mph from the maximum sustained $q$ at this location
- Lower bound is 5 mph
  - Dual loop detectors assume acceleration can be ignored
  - Can measure $v \leq 5$ mph for a vehicle that stops over the detector
• Only use length-speed bins with at least 100 veh observations
• Upper bound $v = 17$ mph from the maximum sustained $q$ at this location
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• Although $v$ range is 5-17 mph, it covers 25% of observable $occ$
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- Relaxing some of the constraints
- For passenger veh 1-17 mph covers 50% of the observable \( occ \)
Empirical Measurements

All of the speed bins exhibit trends consistent with the hypothetical example.
Discussion and Conclusions

- Historically there have been at least three sources of noise in measuring empirical FR:
  - Errors due to aggregating vehicles together,
  - Errors due to the detector settings, and
  - Variability due to site specific traffic behavior
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- By revealing site specific behavior, this work will help us understand the factors determining driver behavior and traffic flow
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- The 18 days of detector data are available here: http://www.ece.osu.edu/~coifman/documents
  or email me for the current location
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