Assessment of Quality of Signal Timing

Aobo Wang

Graduate Research Assistant
Center for Advanced Transportation Education and Research
University of Nevada, Reno
Reno, NV89557

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Quality vs. Performance

- Positive Correlation
- Different Boundaries
- Uniform vs. Multifarious
- Stable vs. Varying
- Discriminated vs. Indistinguishable
Objective

- A ruler to judge engineers’ work
- A zoom tool to find where the shortages are
- A marker to direct future improvements
Problem Statement

Effectively – operability and accessibility

- All the components can be measured
- Should be valid under limited-data environment
Problem Statement

Unbiasedly – data and approaches

- Data inputs should be independent between each other

- Engineer judgements vs. quantitative measures
Problem Statement

Comprehensively – multi-source and multi-dimension

- The coverage of data
- The ramifications beyond vehicle traffic
What is going to indicate quality of signal timing?

- Safety – base
- Efficiency – optimization goal
- Equity – constraints
  - Environmental concerns
  - Multimodal traffic
Indicators

Delay:

- The most common-used measure in research
- Depends on volume, arrival distribution, capacity
- Can not be measure when it is over-saturated
Indicators

Queue Length:

- Depends on volume, *arrival distribution*, capacity
- Certain boundaries
- Non-time-related – Average? Maximum?
Indicators

**Average Speed / Travel time:**

- Depends on *delay (on road and at intersections)* and other factors
- Certain upper boundary
- Non-space-related – link by link? different O-D?
Indicators

Stops:

• Depend on coordination level

• No boundaries, no certain relationship

• No clear definition – stop once and wait one minute, or stop twice and wait 30 seconds each stop / The shorter stop and the longer stop.
Indicators

### Waiting time:

- Delay for individuals
- No boundaries and hard to find boundaries
- Specific conditions – after the main street is empty
Indicators

Platoon ratio:

- For level of coordination
- Clear boundaries
- No spatial attributes
What kind of data we can use?

**GPS trajectories**

- Travel time/ average speed
- Stops and durations of stops
- Queue lengths

Problem – Non-volume-related
What kind of data we can use?

**Purdue Signal Performance Measure**

- Has been implemented in some cities
- Phase Termination
- Purdue Coordination Diagram

Problem – Isolated intersections
What kind of data we can use?

X: Time

Y: Cycle Time

C

C

C

2C

3C
What kind of data we can use?
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**Aggregated performance measures – INRIX data**

- Based on GPS
- More samples
- Speed and Delay
- Before – After Analysis
What kind of data we can use?
What kind of data we can use?

| Date    | 12 AM | 1 AM  | 2 AM  | 3 AM  | 4 AM  | 5 AM  | 6 AM  | 7 AM  | 8 AM  | 9 AM  | 10 AM | 11 AM | 12 PM | 1 PM  | 2 PM  | 3 PM  | 4 PM  | 5 PM  |
|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 4/01/16 | $0K   | $0K   | $0K   | $0K   | $0.8K | $1.7K | $0K   | $0.7K | $0K   | $0.9K | $5.8K | $3.7K | $0K   | $0.8K | $5.4K | $15.3K|
| 4/02/16 | $0K   | $0K   | $0K   | $0K   | $0K   | $0K   | $9.5K | $20.5K| $2.1K | $1K   | $1.1K | $2K   | $7.2K | $3.4K | $1.7K | $3.8K  |
| 4/03/16 | $0.6K | $0.5K | $0K   | $0K   | $0K   | $0K   | $0K   | $0K   | $0K   | $0K   | $0K   | $0.6K | $1.8K | $2.3K | $0.5K | $0.5K  |
| 4/04/16 | $0K   | $0K   | $0K   | $0K   | $1.3K | $3.5K | $1.6K | $3K   | $1.3K | $0.1K | $0K   | $0.1K | $4.4K | $4.4K | $5K   | $4.4K  |
| 4/05/16 | $0K   | $0K   | $0K   | $0K   | $0.4K | $1K   | $0.1K | $6.3K | $1K   | $0K   | $0K   | $0K   | $1.2K | $2K   | $4.6K | $4.9K  |
| 4/06/16 | $0K   | $0K   | $0K   | $0K   | $0.6K | $1.5K | $0K   | $0K   | $0K   | $0K   | $0K   | $0K   | $2.8K | $5.3K | $1.7K | $3.9K  |
| 4/07/16 | $0K   | $0K   | $0K   | $0K   | $0.5K | $1.4K | $0K   | $0K   | $0K   | $0K   | $0.3K | $1.4K | $3K   | $4.1K | $1.3K | $1.7K  |
| 4/08/16 | $0K   | $0K   | $0K   | $0K   | $0.7K | $2.7K | $0.4K | $1.5K | $0K   | $0.7K | $0.7K | $3K   | $4.1K | $2.7K | $20.4K| $34.1K| $5K   |
| 4/09/16 | $0K   | $0K   | $0K   | $0K   | $0.1K | $3K   | $1K   | $0.2K | $0K   | $0K   | $0K   | $2.1K | $16.3K| $12.2K| $7.7K | $2.3K  |
| 4/10/16 | $0.1K | $0K   | $0K   | $0K   | $0K   | $0K   | $0K   | $0K   | $0K   | $0K   | $0.1K | $0.3K | $0.5K | $0K   | $0.3K | $0.3K  |
| 4/11/16 | $0K   | $0K   | $0K   | $0K   | $1.3K | $3.6K | $0K   | $0K   | $0K   | $0K   | $0K   | $0K   | $0K   | $0K   | $0.5K | $0.4K  |
Some Methodologies

- **Structural Equation Modelling**
  - It is used to assess **unobservable** constructs
  - confirmatory factor analysis, path analysis, partial least squares path modeling, and latent growth modeling
  - latent constructs - Preference, comprehensive thinking
Some Methodologies

- **Fuzzy Scaling**
  - Normalize engineer judgements
  - Determine the weight and constraints

For the-lower-the-better indicators

$$
\mu_{jk}^i = \frac{[x_{j(max)}^i + x_{j(min)}^i - x_{jk}^i]}{[x_{j(max)}^i + x_{j(min)}^i]}
$$

For the-higher-the-better indicators

$$
\mu_{jk}^i = \frac{x_{jk}^i}{[x_{j(max)}^i + x_{j(min)}^i]}
$$
3 groups for trips generation data

2 groups for parking data
Questions and Suggestions

Aobo Wang
UNR CATER
Email:
aobowang@nevada.unr.edu