Gray Areas in Isolated Intersection Control-Type Selection

A Complementary Decision-Support Tool

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Overview

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About me

• BS in Transportation System Engineering, Ajou University, South Korea

• MS in City Planning, Seoul National University, South Korea

• Worked as a Traffic Engineer/Traffic Signal Operator in Seoul, South Korea

• PhD Candidate in Civil Engineering/MS Candidate in Statistics, University of Tennessee
Motivation

• Previous works for intersection control type comparison

(a) Highway Capacity Manual 2000

(b) Han et al. (2008)
Motivation (Cont’d)

• How to deal with uncertainties in a modeling process?

  • Control Delay (HCM 2010)
    - Signalized Intersections: 
      \[ d = \frac{0.5C(1-g/C)^2}{1-[\min(1,X)g/C]} + 900T \left[ (X - 1) + \sqrt{(X - 1)^2 + \frac{8kIX}{c_{lgT}}} \right] \]
    - Two Way Stop Control (TWSC): 
      \[ d = \frac{3,600}{c_{m.x}} + 900T \left[ \frac{v_x}{c_{m.x}} - 1 + \sqrt{\left( \frac{v_x}{c_{m.x}} - 1 \right)^2 + \left( \frac{3,600}{c_{m.x}} \right) \left( \frac{v_x}{c_{m.x}} \right)} \right] + 5 \]
    - All Was Stop Control (AWSC): 
      \[ d = t_s + 900T \left[ (x - 1) + \sqrt{(x - 1)^2 + \frac{h_dx}{450T}} \right] + 5 \]
    - Roundabout: 
      \[ d = \frac{3,600}{c} + 900T \left[ (x - 1) + \sqrt{(x - 1)^2 + \left( \frac{3,600}{c} \right)x_{vc}} \right] + 5 \times \min[x_{vc},1] \]
Motivation (Cont’d)

• Does a human driver perceive one or two seconds of delay difference at an intersection?

  • “User-perceived service quality ratings do not correspond to the level of service evaluated using the HCM methods”
    - Lee at el. (2007)

  • “… weak linear association between user perceptions (LOS ratings) and capacities (or volume-to-capacity ratios).”
    - Chen at el. (2009)

  • “Trip purpose, socioeconomic-, road-related characteristics, and weather conditions are all significant influential factors … ”
    - Jou at el. (2013)
Scenario design for analysis

• Control delay comparison for the intersection control types:
  • TWSC, AWSC, Signal Control, and Roundabout

• Average control delay models of HCM 2010 (FHWA)

• Total 21,525 scenarios were analyzed in terms of the following factors.
  • 4-legged single-lane intersection
  • Major and minor streets volume of 0-2,000 veh/h in 50 veh/h increments
  • Left-turn volume percentage of 0-20%
Analysis results

- 20% Left Turn Volume
Analysis results

- 20% Left Turn Volume

*a* Upper case letter indicates the level of service for each control type;

*b* Each solid and dotted contour line represents 0-5 second difference in delay between two control types.
Analysis results

- 20% Left Turn Volume
Analysis results

- No signal optimization
Analysis results

- Signal optimization (Cycle length and splits)
Conclusions

- The gray area concept can help engineers and practitioners make an engineering judgement.
- The gray areas can be used for a benefit-costs analysis for converting intersection control type from one to another in the future.
- This conceptual tool can be applied many other decision making situations based on quantitative metrics.