Estimating the Traffic Flow Impact of Pedestrians With Limited Data

Daniel Tischler, Elizabeth Sall, Lisa Zorn & Jennifer Ziebarth

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Making the Case

I have problems.

I’m trying to model San Francisco traffic conditions, but

Pedestrians affect vehicle capacity
My dynamic traffic assignment model is needy
Data is scarce
Network capacity

Road capacity is a key input in traffic assignment. We assign capacities to roads by facility classification schemes.
Network capacity

In our DTA model, signal timing becomes the primary determinant of capacity.
Pedestrians interact with vehicles

Lots of pedestrians crossing the street prevent cars from turning
Pedestrian volumes vary

Our meso-level, dynamic assignment model does not simulate pedestrians. It does not know that right turns at “A” are more restricted than at “B”
Methodologies

- Analytical methods
- Simulation methods
- Local observations
Analytical approaches

HCM (2010) saturation flow rate adjustment factor

\[ s = s_0 \cdot \prod_{i=1}^{n} f_i \]

where \( s_0 \) is the base saturation flow rate,

\( f_i \) is one of \( n \) adjustment factors and

\( s \) is adjusted saturation flow
Analytical approaches

**HCM (2010) saturation flow rate adjustment factor**

\[ f_{Rpb} \] : pedestrian-bicycle adjustment factor for right-turn groups

\[ \text{OCCpedg (Pedestrian occupancy)} = \frac{V_{ped}}{2,000} \text{ if } V_{ped} < 1000 \]

\[ \text{OCCpedg} = 0.4 + \frac{V_{ped}}{10,000} \text{ if } 1000 < V_{ped} < 5000 \]

Next determine conflict zone coccupancy (OCCr)

If all RT time available for peds then \( \text{OCCr} = \text{OCCpedg} \) (otherwise \( \text{OCCpedg} \times (\text{green for peds} / \text{green for RT}) \))

Unoccupied time = Apbt, \( \text{Apbt} = 1 - \text{OCCr} \)

If cars maneuver around peds when turning, \( \text{Apbt} = 1 - 0.6 \times \text{OCCr} \)

\[ f_{Rpb} = \text{Apbt} \]
Pedestrian volume – vehicle flow relationship

- Assumes 2 sec veh-veh headway, 50% green time
- Doesn’t allow for ped volumes > 5,000
Comparing different methods

Rouphail and Eads, 1997
Applying pedestrian friction in the model

Saturation flow rate

Follow-up time

Green time

Critical Gap:
- U-turn: 5.20 s
- Left turn - conflicting through: 3.60 s
- Left turn - conflicting right: 3.60 s
- Turn on red: 4.96 s

Critical Wait:
- All movements: 60.00 s

Follow-up Time / Permitted Capacity:
- U-turn: 4.00 s, 900 vph
- Left turn: 2.50 s, 1440 vph
- Right turn: 2.50 s, 1440 vph
- Through: 1.80 s, 2000 vph
- Turn on red: 4.00 s, 900 vph

Allow turn-on-red by default
Scale of Application

Area Type Method

Neighborhood Type Method

Uniform Parameters Method

Unique Intersection Method

Existing approach

Under consideration

Do nothing approach

Under consideration

55%

74%

87%
Resources

SFMTA pedestrian count program
SFMTA pedestrian model
Project-related pedestrian counts
Pedestrian-vehicle observations
SFMTA pedestrian count program

- 2-hour pedestrian counts at 50 locations (2009/2010)
- Six automatic pedestrian counters (24/7 observations)

Actual pedestrian count binder
Automated pedestrian counters

- Time and day profiles

Union Square

Tenderloin

Castro
Pedestrian count locations
HCM 2010 flow rate adjustment factors
SFMTA pedestrian model

- Used count data and log-linear regression model to estimate pedestrian volumes throughout San Francisco
  \[ \ln Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_j X_{ji} \]

- Combined with auto traffic and collision data to develop pedestrian crossing accident risk factors
Pedestrian volume estimates
Local validation of pedestrian estimation

Ped Model Estimates

Ped Counts
Pedestrian-vehicle interaction observations

SFCTA staff observed downtown intersections of varying pedestrian volumes
Collected information on quantity of pedestrians and relative restriction of vehicle turning movement capacity

The urban environment is complex:
- Groupings of peds, directions of travel
- Bicycles, unique timing plans, variations in geometry, etc.
Observed pedestrian-vehicle interactions

Pedestrian Impedance of Turning Vehicles

Incremental pedestrians have the greatest impact at low pedestrian volumes

Pedestrian Flow in Crosswalk (peds/hr during walk phase)
Observed pedestrian-vehicle interactions

Rouphail and Eads, 1997
Model Tests

Uniform parameters method
Area type method
Neighborhood type method – sat flow rate
Neighborhood type method – green time reduction
Focus on pedestrian count-rich area

SoMa pedestrian count locations

1. 4th / Market
2. 6th / Market
3. 8th / Market
4. 6th / Mission
5. 3rd / Howard
6. 7th / Folsom
Hourly pedestrian counts

- Market St: 3,300
- Mission St: 600
- Howard St: 1,100
- Folsom St: 3,000
- 7th St: 1,100
- 5th St: 10,000
- 3rd St: 1,200
Network parameters
Uniform parameter method

- All Signals
- Sat flow 1,800
- Spacing 2.0s
Network parameters
Area type method

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<th>Sat flow</th>
<th>Spacing</th>
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Network parameters
Neighborhood type method

Adjust saturation flow rates

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<td>Sat Flow 1,530</td>
<td>Spacing 2.4s</td>
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</table>
Network parameters
Neighborhood type method

Reduce green time for turning movements

- 55% less green
- 30% less green
- 15% less green
- 90% less green
Testing pedestrian friction methods

- **Evaluation not yet complete!**
- **Numbers**
  
  At select subarea nodes, turning movement volume validation improves with neighborhood type method
- **Queuing**
  
  Neighborhood method *seems* to produce more realistic queue formation than area method
Conclusions

• Pedestrian-vehicle friction is very important at some locations!

• Numerous options to make assignment models sensitive to pedestrians

• The most realistic approaches are very difficult

• We still have work to do:
  • Run more tests
  • More local validation
  • Develop better neighborhood system
  • Incorporate time of day factors
  • Develop strategy for scenarios that change pedestrian volumes
The End.

Questions?