Simulation of Pedestrian-Vehicle Interactions at Roundabouts

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Outline

• Sponsor: National Eye Institute / NIH through Western Michigan University

• Introduction and problem statement

• Observational studies
  ➤ Data collection
  ➤ Data extraction
  ➤ Sample results

• Simulation studies
  ➤ Why simulation
  ➤ Sample results

• On-going activities
Introduction

• **Purpose:** Analyze mutual impact of pedestrians and vehicles @ roundabouts w.r.t. traffic operations and potential safety

• **Why?**
  - Poorly documented in the literature
  - Assumed right-of-way priorities unconfirmed with empirical observations (e.g., HCM TWSC, AWSC; Roundabout informational guide).
  - Blind pedestrians’ access (US Access Board)
  - Assess possible treatments to improve operations and safety
  - Traffic simulation models rarely consider ped-veh. interactions in the analysis of urban streets
Entry capacity reduction effect of pedestrians

- Assumes pedestrians always have priority
- Based on German data (Brilon et al) in KREISEL
- Other models: HCM, aaSIDRA, RODEL, NCHRP 3-65

Source: FHWA Roundabout Informational Guide
Methodology

• **Observational studies of crossing behavior**
  - Document interactions
  - Provide input for model calibration and validation

• **Simulation studies**
  - Incorporate interaction models in simulation
  - Allow for system-wide evaluation
  - Extend the observational studies beyond the range of empirical data (volumes, geometries, etc.)
  - Low-risk platform for assessing treatments prior to field implementation

Data Collection

• **Method:** Videotaping

• **Sites:** Two-single lane roundabouts
  - Pullen-Stinson, NC State University campus
  - NC 751, Durham, NC

• **Purpose:**
  - Gather basic veh-veh & ped-veh interaction data
  - Calibrate basic model (no peds)
  - Validate basic model
The Pullen-Stinson Roundabout

- Approach speed = 35 mph
- Circulating speed = 18 mph
- Inscribed diameter = 88 ft
- Central Island diameter = 52 ft
- Entry Width = 14 ft
- Peak Hour Volume ~ 1400 veh, 160 peds.

Credit: www.skysiteaerial.com
Data Extraction

- Customized Video-Image Processing (VIP) software code (ITRE-mv)
- Coded in C language

**Process**
- Development of X-Y grid system of field of view
- Identification of fixed, reference points
- Convert digital video into image frames (20 frames /sec)
- Detects all objects in the field of view at specified detector locations
  - Vehicles
  - Pedestrians
- Tracks all object movements in the field of view

**Ratio of Processing: Real Time = 6:1 (vs. 24:1 using manual data extraction)**
ITRE-mv run sample
ITRE-mv Outputs and Use
(i=for model input; v= for validation)

- **Vehicle Related**
  - Origin and destination (O&D) counts by vehicle type (i)
  - Vehicle speed profile by O&D (v)
  - Entry and exit headway distributions (i,v)
  - Yield line accepted and rejected gaps and lags (i)
  - Delays at yield line, and approach queues (v)
ITRE-mv Outputs and Use
(i=for model input; v= for validation)

- **Pedestrian Related**
  - Pedestrian waiting time at curb and splitter island (v)
  - Pedestrian crossing time by direction (i)
  - Fraction of drivers yielding to pedestrians (i)
  - Time lag between pedestrian crossing and vehicle arrival at crosswalk
  - Pedestrian accepted & rejected vehicle gaps and lags (i)
  - Position of yielding vehicle from crosswalk location (i)
Comparing 15 min O&D Counts
Noon Peak- Manual vs. ITRE-mv

<table>
<thead>
<tr>
<th></th>
<th>South</th>
<th>North</th>
<th>East</th>
<th>West</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>From</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South</td>
<td>1(1)</td>
<td>113(113)</td>
<td>6(6)</td>
<td>25(25)</td>
<td>145(145)</td>
</tr>
<tr>
<td>North</td>
<td>133(132)</td>
<td>2(4)</td>
<td>4(3)</td>
<td>29(20)</td>
<td>168(159)</td>
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<tr>
<td>East</td>
<td>0(0)</td>
<td>0(1)</td>
<td>0(0)</td>
<td>0(0)</td>
<td>0(1)</td>
</tr>
<tr>
<td>West</td>
<td>23(24)</td>
<td>13(13)</td>
<td>0(0)</td>
<td>0(0)</td>
<td>36(37)</td>
</tr>
<tr>
<td>Total</td>
<td>157(157)</td>
<td>128(131)</td>
<td>10(9)</td>
<td>54(45)</td>
<td>342(349)</td>
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</tbody>
</table>

- **ITRE-mv (Manual)**
- Max absolute error = 9veh
- Mean overall error ~ 2%
Average Speed Profile (ft/sec) by O&D

Speed Profile

TH 112
LT 25

25mph
18 mph
Pedestrian Travel Time Distribution

Crossing Distance: 54ft
min Travel Time: 12sec

Travel Time Includes:
• Waiting time @ curb and splitter island
• Actual crossing time
Drivers Yielding to Pedestrians
Sample- 15 min observations

<table>
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<tr>
<th>Driver Location</th>
<th>Yield**</th>
<th>No Yield</th>
<th>Total</th>
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<tbody>
<tr>
<td>Entry Leg</td>
<td>7 (35%)</td>
<td>13 (65%)</td>
<td>20</td>
</tr>
<tr>
<td>Exit Leg</td>
<td>5 (21%)</td>
<td>19 (79%)</td>
<td>24</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>32</td>
<td>44</td>
</tr>
</tbody>
</table>

**Statistically significant at the 95% CL
Time lag between crossing initiation and vehicle on crosswalk

![Graph showing cumulative distribution of time lag between crossing initiation and vehicle on crosswalk. The x-axis represents lag size in seconds, ranging from 0 to 22, while the y-axis represents the cumulative distribution from 0% to 100%. Two lines are depicted: one for 'Yield' and another for 'No Yield'.]
Sighted and Blind Ped. Crossings

**Sighted:**
- Natural gap acceptance (visual)
- Yield detection (visual)
- Traffic signal

**Blind:**
- Natural gap acceptance (auditory)
- Yield detection (assisted only)
- Traffic signal (APS)
Assisted Yield Detection
Micro-simulation model

- VISSIM model (PTV)
- Models pedestrian and vehicle movements
- Priority / interaction rules must be defined by the user, otherwise
- Requires extensive calibration & validation
- Simulates various traffic crossing scenarios,
  (1) natural gap acceptance,
  (2) signal control and
  (3) natural gap acceptance with automated yield and gap detection for blind pedestrians
- Generates text and visual output for model verification and results presentations
VISSIM-Natural Gap Crossing

Color Codes
Veh: Black (YIELD) ; Other (NO YIELD)
Ped: Black Top (Blind) ; Blue Top (Sighted)
VISSIM- Signalized Crossing

Clip showing sighted and blind pedestrian crossings at remote APS signal location
VISSIM - Automated Yield and Natural Gap Detection

Color Codes
Veh: Black (YIELD) ; Other (NO YIELD)
Ped: Black Top (Blind) ; Blue Top (Sighted)
Summary & Conclusions

- VIP procedure developed to capture ped. veh interactions at roundabouts
- VIP estimate O&D flows at acceptable accuracy
- Initial results show that 35% of drivers yield to pedestrians at entry vs. 21% at exit leg
- Initial results show close to 28% of pedestrians crossing in gaps < nominal crossing time when drivers do not yield
- Micro-simulation is a useful tool to integrate ped. veh. Interactions into the traffic system, and to assess the utility of treatments for blind pedestrians
An Invitation to Participate
In NCHRP 3-78

Crossing Solutions at Roundabouts for Pedestrians with Vision Disabilities

• As a contributor of treatment concepts

• As a vendor who makes available system components

• As a state, city, or town willing to host treatments and their evaluation.
For Those Interested in Participating

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