High-Resolution Modeling of the Vehicle-Pedestrian Interactions for Estimating Pedestrian Risk at the Black Spots

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**Black Spots** are seemingly harmless locations on the road with high and stable accident rate.
To investigate the relationship between other factors and combinations of factors on crosswalk pedestrian crashes, generalized linear regression models were fit to the data to predict crashes as functions of these variables. Consider a model based on pedestrian volumes (ADP); traffic volumes (ADT); and two indicator variables, one which indicates one or two travel lanes ($L_2$), and the other which indicates three or four travel lanes ($L_4$). The resulting model has the form

$$E(\text{Accs}_i) = \text{yrs}_i^0 \epsilon^{\beta_0(\text{ADP}_i)} \epsilon^{\beta_1(\text{ADT}_i)} \epsilon^{\beta_2 L_2i} \epsilon^{\beta_4 L_4i}$$

(4)

where $E(\text{Accs}_i)$ is expected pedestrian crashes at site $i$, yrs$_i$ is the number of years over which crash data was available for site $i$, and $\beta_0$, $\beta_1$, ..., $\beta_4$ are parameters to be estimated. Models of this form were fit to data from marked and unmarked crosswalk crashes. The models were fit by maximum likelihood methods using Procedure for General Models (PROC GENMOD) software, as developed by the SAS Institute. Models were assumed to follow a negative binomial distribution.

Parameter estimates for these basic models are shown in table 2.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Marked Crosswalks</th>
<th>Unmarked Crosswalks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>S.E.*</td>
</tr>
<tr>
<td>Constant ($\beta_0$)</td>
<td>-14.55</td>
<td>1.95</td>
</tr>
<tr>
<td>ADP ($\beta_1$)</td>
<td>.381</td>
<td>.065</td>
</tr>
<tr>
<td>ADT ($\beta_2$)</td>
<td>1.006</td>
<td>.184</td>
</tr>
<tr>
<td>$L_2$ ($\beta_3$)</td>
<td>-.599</td>
<td>.328</td>
</tr>
<tr>
<td>$L_4$ ($\beta_4$)</td>
<td>.075</td>
<td>.247</td>
</tr>
</tbody>
</table>

*S.E. = Standard Error
Research objectives

To estimate accident risk on the road intersections

To detect the factors (architectural, environmental) that increase the risk
SAFEPAD Simulator

Explicit 3D Reconstruction

Agent-Based Simulation

Multiple Viewpoints

http://www.youtube.com/watch?v=ia3W8oiTVYw&feature=related
Agents Behavior Model
Drivers follow human laws of motion (e.g. comfortable lateral acceleration)

Pedestrians behave according to the similar laws

Bypass road blocks

React to the road jams
SAFEPED Agents

“Perception-in-Action”

Gibson’s Optical Flow-field

Gibson’s General Tau Theory

The Essence of Humans Behavior on Road Crossing is Collision Avoidance:

http://www.youtube.com/watch?v=BO2rW1alVv8
Drivers’ and pedestrians’ algorithm of collision avoidance

Essential extension of Fiorini and Shiller (1993)
Drivers’ and pedestrians’ algorithm of collision avoidance

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Drivers’ and pedestrians’ algorithm of collision avoidance
Modeling 3D visibility

Drivers View

Projecting Bounding Boxes to Driver’s Eyes

http://www.youtube.com/watch?v=6KFcfFREIt8&feature=related
Basic laws of driver’s and pedestrian’s behavior is estimated in the field (Video Motion Detection)
Our approach is based on the Video Motion Detection

- **Problem**: Pedestrians and Cars require different spatial resolution of capturing

- **Solution** – using two video cameras with different zoom
Phenomena and parameters to estimate

1. Pedestrian Decision to Cross
2. Pedestrian Crossing Speed and Time
3. Car Approaching Speed
4. Distance between car and crossroad
Probability to decide to cross the road as dependent on the estimated time of encroachment after we cross the road.

![Graph showing probability to decide to cross as a function of expected time until car arrival to the crossroad (sec).]
Crashes and Near-Crash

Crashes are few,
Near Crashes are many
Experimental study of drivers’ behavior:
Crash and near-crash kinematic signatures are identical!

The 100-Car Study, 12 months: 9,125 crash and near crash situations

Five cameras monitored driver’s face, driver's and passenger's sides of the vehicle, forward and rear views

Doppler radar antennas recognized surrounding vehicles

DOT HS 810 593

April 2006
Near Crash Dynamics
A moment before Near-Crash: Red car has few options not leading to Collision
A moment before Near-Crash: Red car has few options not leading to Collision
Red car cannot avoid the accident on its own (empty locus of velocities)
Red car cannot avoid the accident on its own (empty locus of velocities)
All cars brake, but the locus of velocities is still empty
The cars further decelerate, the locus of velocities becomes non-empty
Escape Option
Red car avoids crash by taking the escape option
Red car avoids crash by taking the escape option
Red car avoids crash by taking the escape option

http://www.youtube.com/watch?v=axWEGNetpM0
The first model experiment (still unfinished)

About 20% of pedestrian accidents on the crosswalks are like this...

Figure 21. Illustration of multiple-threat pedestrian crash.
Obscuring car is close to the crosswalk

~ 210 pedestrians passed

~ 350 vehicles passed

4 near-crash situations
Obscuring car is ahead of the crosswalk

~ 210 pedestrians passed
~ 350 vehicles passed
2 near-crash situations
Current and critical stage of the research: **MODEL VALIDATION**

The roundabout in front of Gate 14 of TAU that is chosen as a spot of low traffic. (a) Two-camera view; (b) Orthophoto of the area and surroundings with the camera views marked.

**Video of the roundabout at the University entrance:**
We hope to simulate motion of *every agent* in the movie.
THANK YOU!

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