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

Gennady Waizman

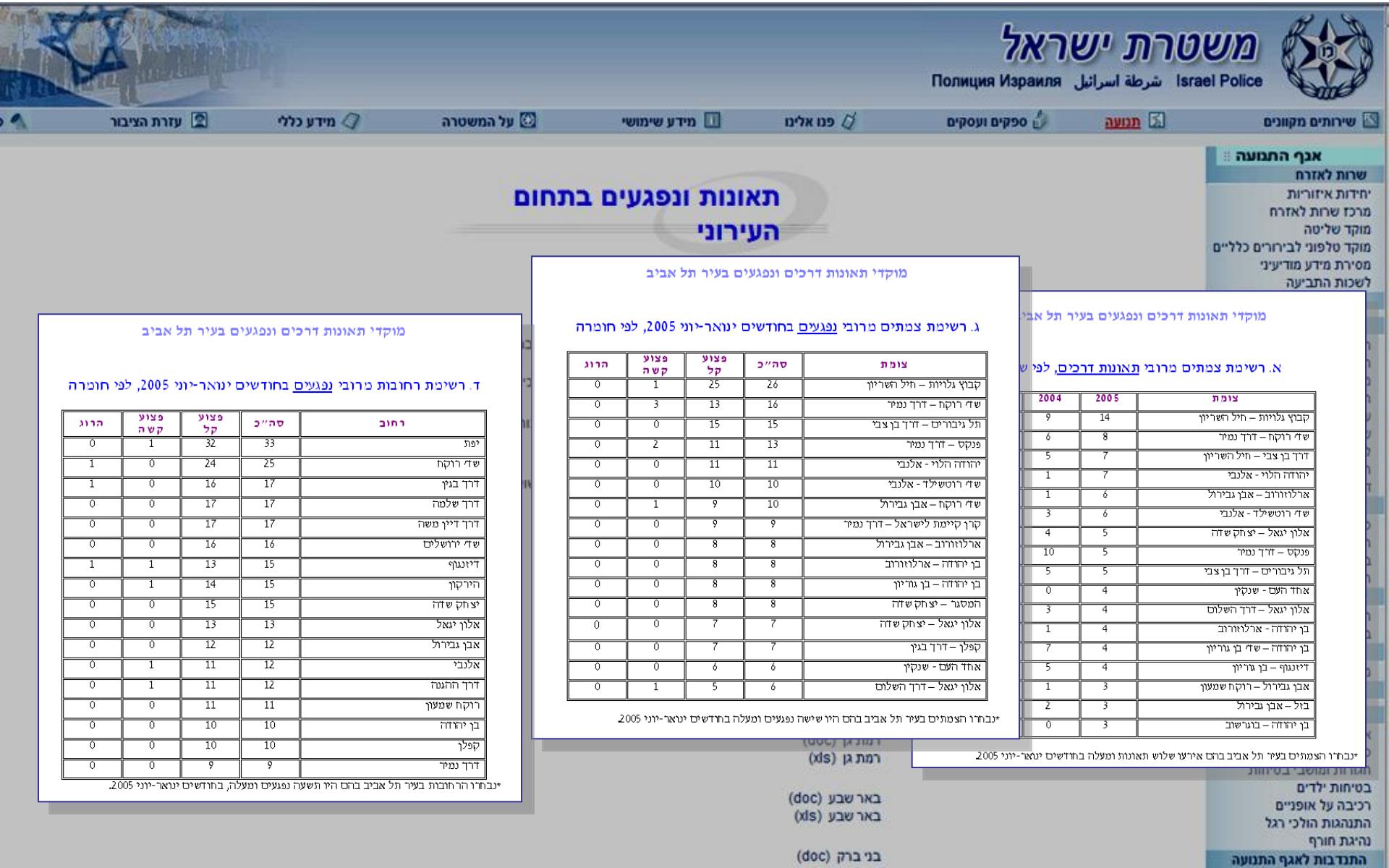
Eilon Blank

Itzhak Benenson

Geosimulation and Spatial Analysis Laboratory

Department of Geography and Human Environment, TAU

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

$$E(\mathrm{Accs}_i) = \mathrm{yrs}_i e^{\beta_0} (\mathrm{ADP}_i)^{\beta_1} (\mathrm{ADT}_i)^{\beta_2} e^{\beta_2 L_{2i}} e^{\beta_2 L_{4i}} \quad (4)$$

- **Police lack of expertise required to classify the injuries**
- **Lack of information from the accident scene for deriving the reasons underlying the accident**
- **Underreporting**

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

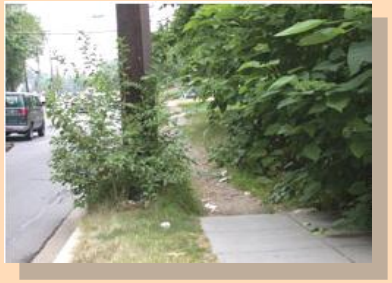
Parameter estimates for these basic models are shown in table 2.

Table 2. Parameter estimates for basic marked and unmarked crosswalk models.

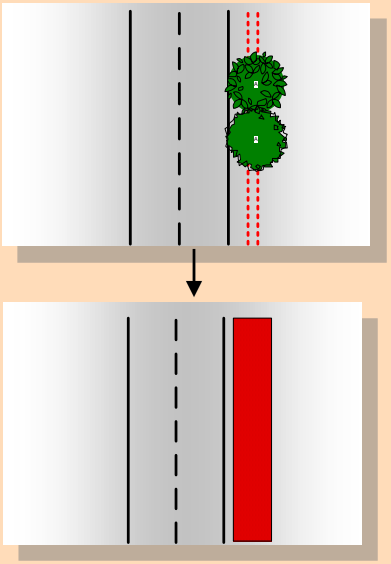
Parameter	Marked Crosswalks			Unmarked Crosswalks		
	Estimate	S.E.*	*p*-Value	Estimate	S.E.*	*p*-Value
Constant (β_0)	-14.55	1.95	< .0001	-10.25	2.72	.0002
ADP (β_1)	.381	.065	< .0001	.602	.134	< .0001
ADT (β_2)	1.006	.184	< .0001	.304	.258	.2388
L_2 (β_3)	-.599	.328	.0678	-.066	.592	.9115
L_4 (β_4)	.075	.247	.7608	-.208	.553	.7076

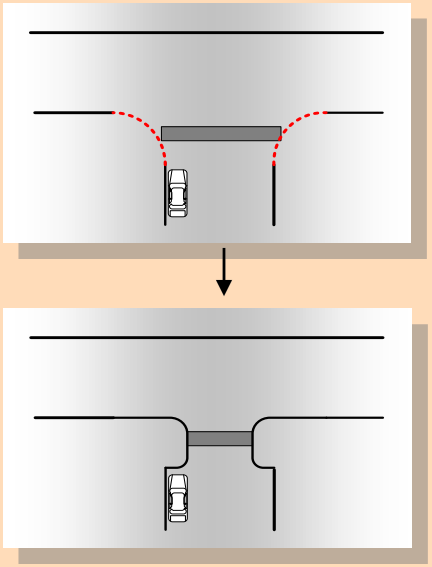
*S.E. = Standard Error

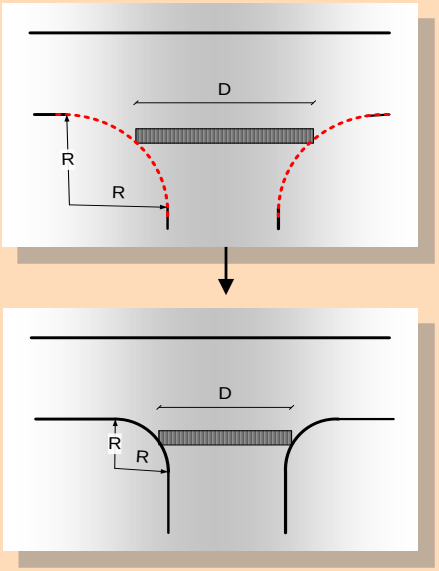
Research objectives



To estimate accident risk on the road intersections



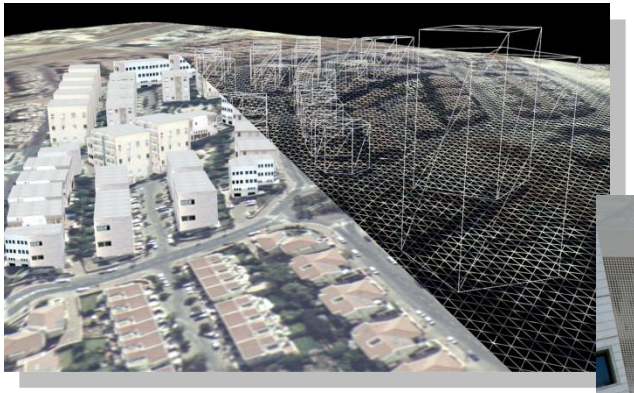




To detect the factors (architectural, environmental) that increase the risk

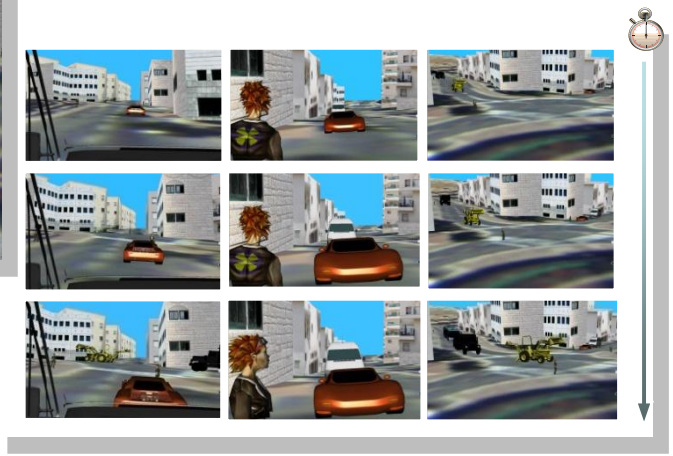
SAFEPAD Simulator

Explicit 3D Reconstruction



Agent-Based Simulation

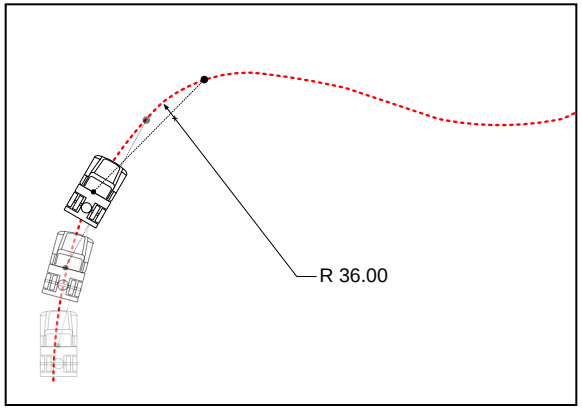
Multiple Viewpoints



http://www.youtube.com/watch?v=ia3W8oiTVYw&feature=related

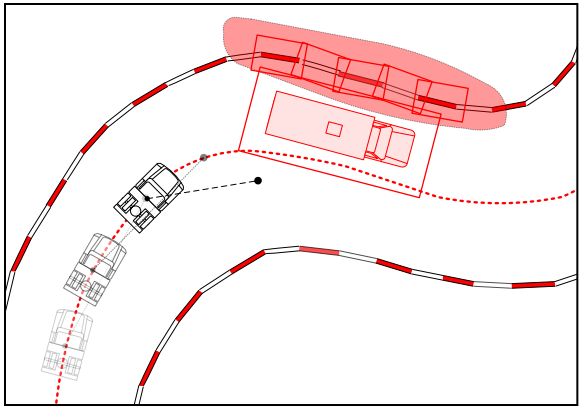
Agents Behavior Model

Driver Agent Tactical Motion Planning

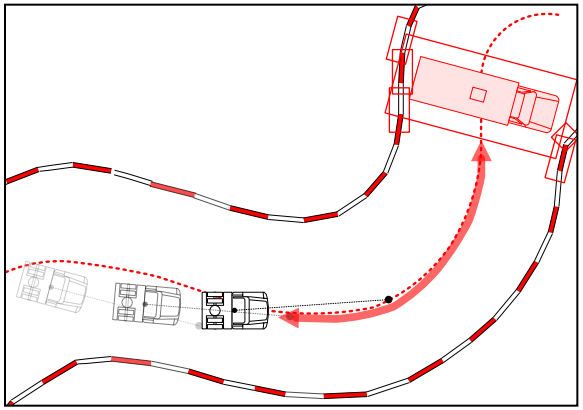


Drivers follow human laws of motion (e.g. comfortable lateral acceleration)

Pedestrians behave according to the similar laws

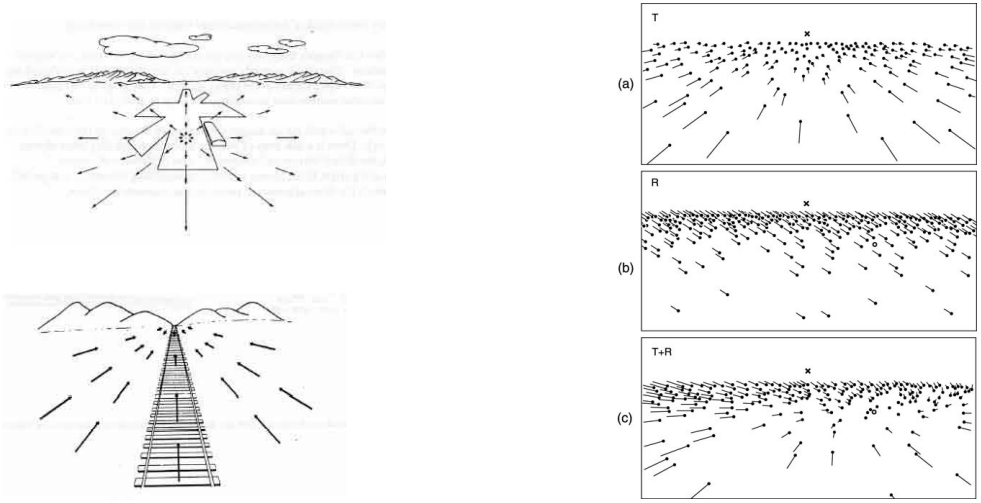


Bypass road blocks

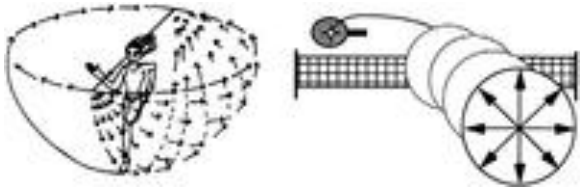


React to the road jams

SAFEPED Agents
“Perception-in-Action”



Gibson’s Optical Flow-field

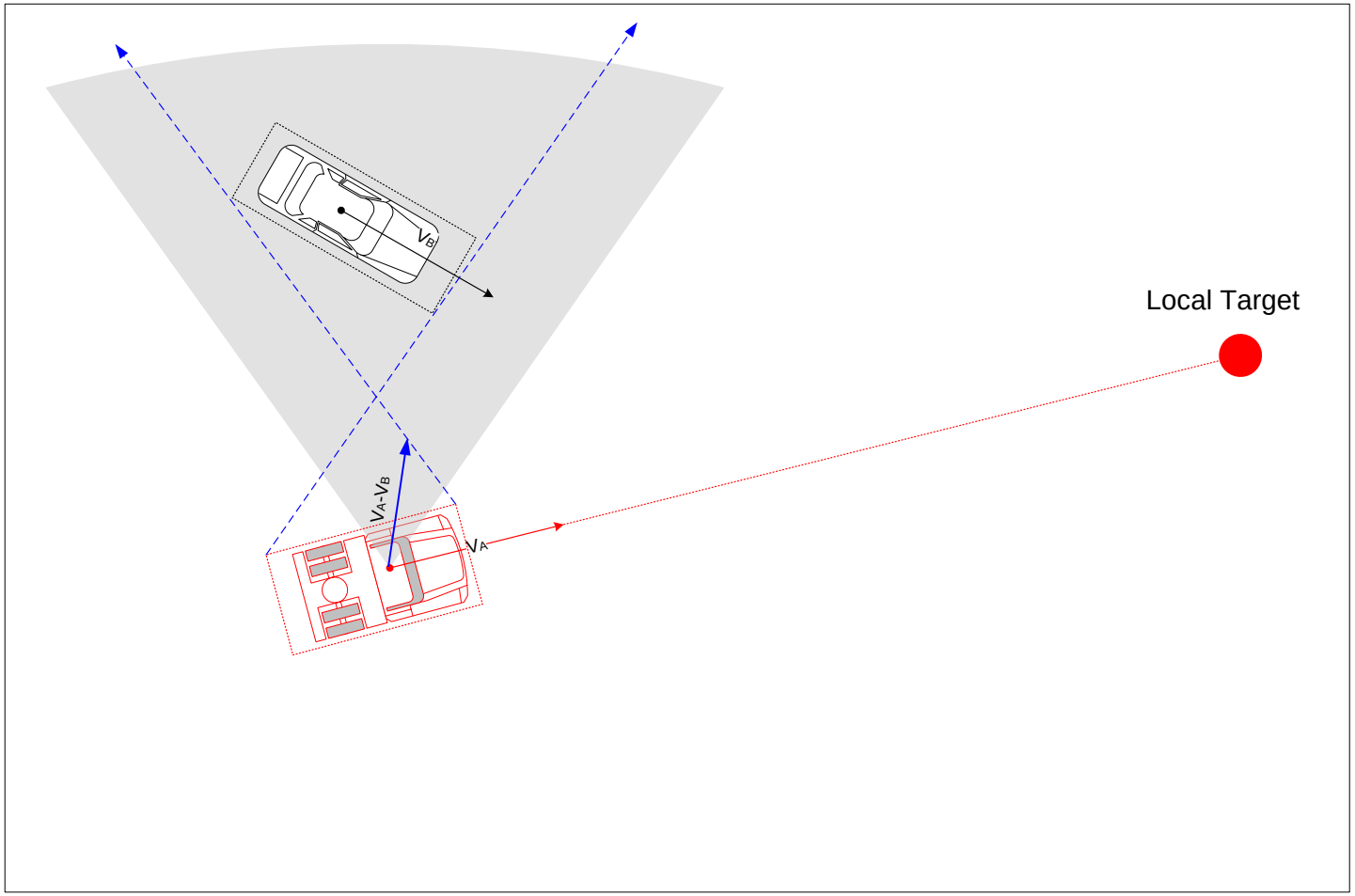


Gibson’s General Tau Theory

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

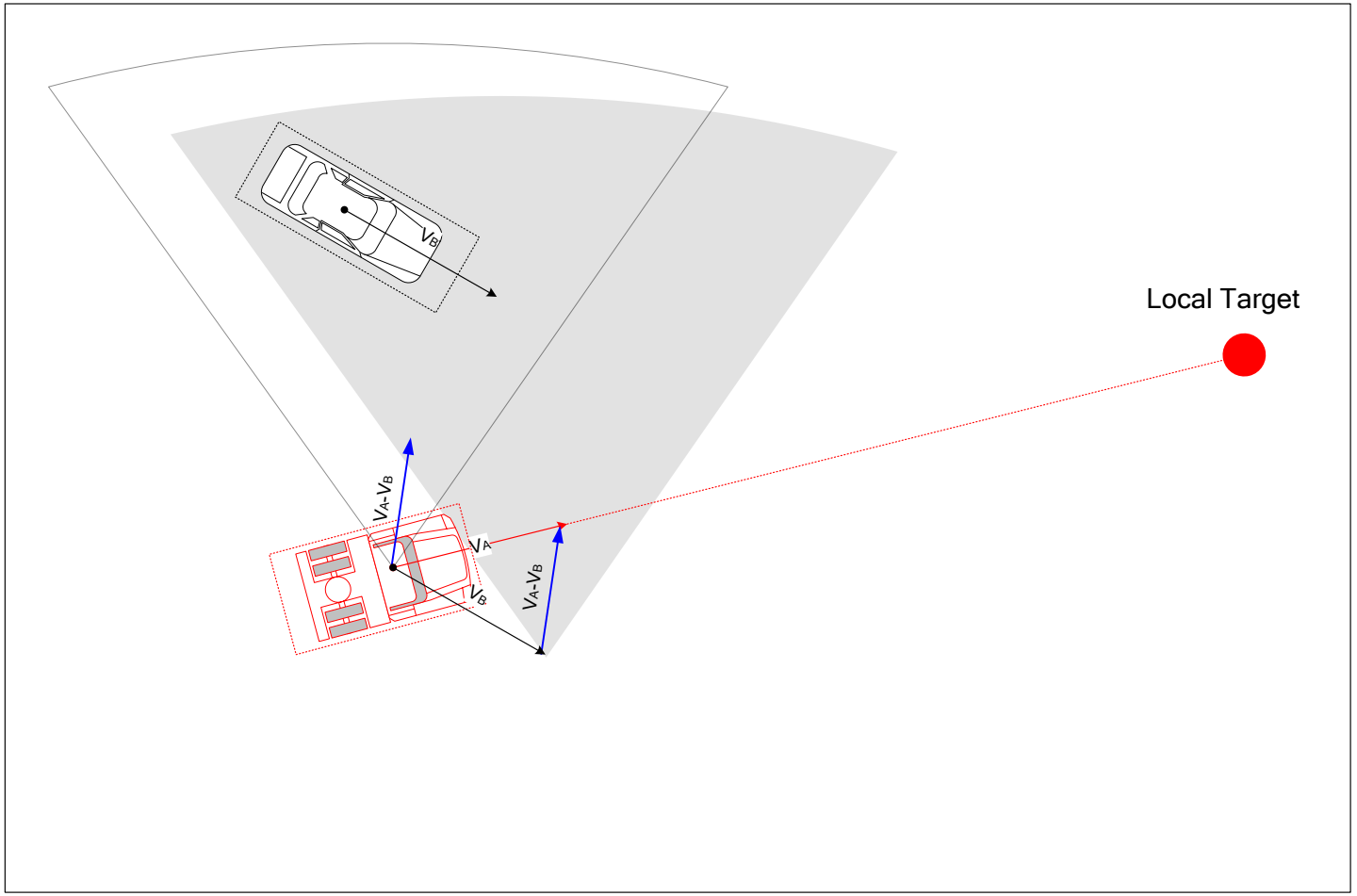
http://www.youtube.com/watch?v=BO2rW1alVv8

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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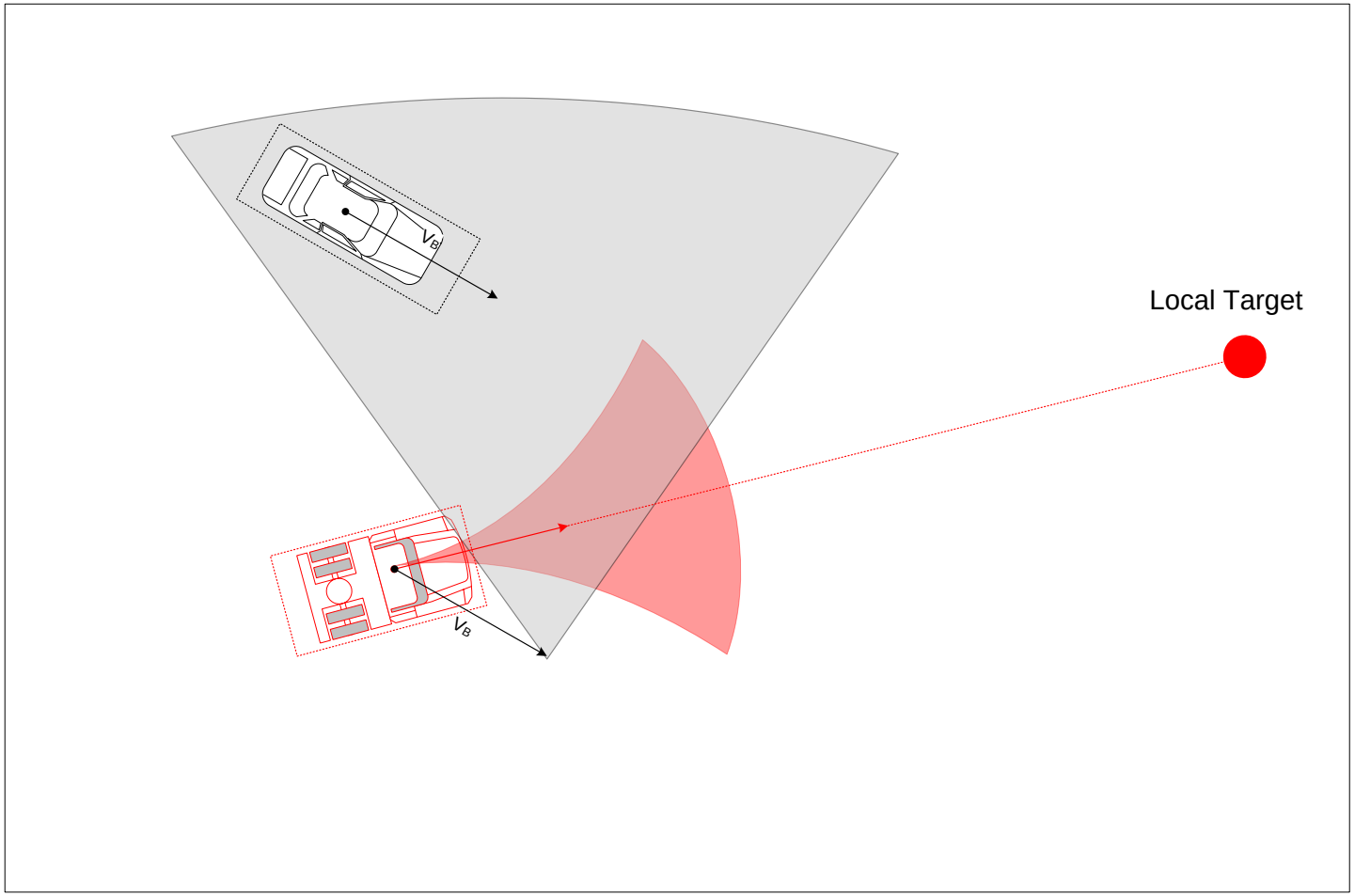

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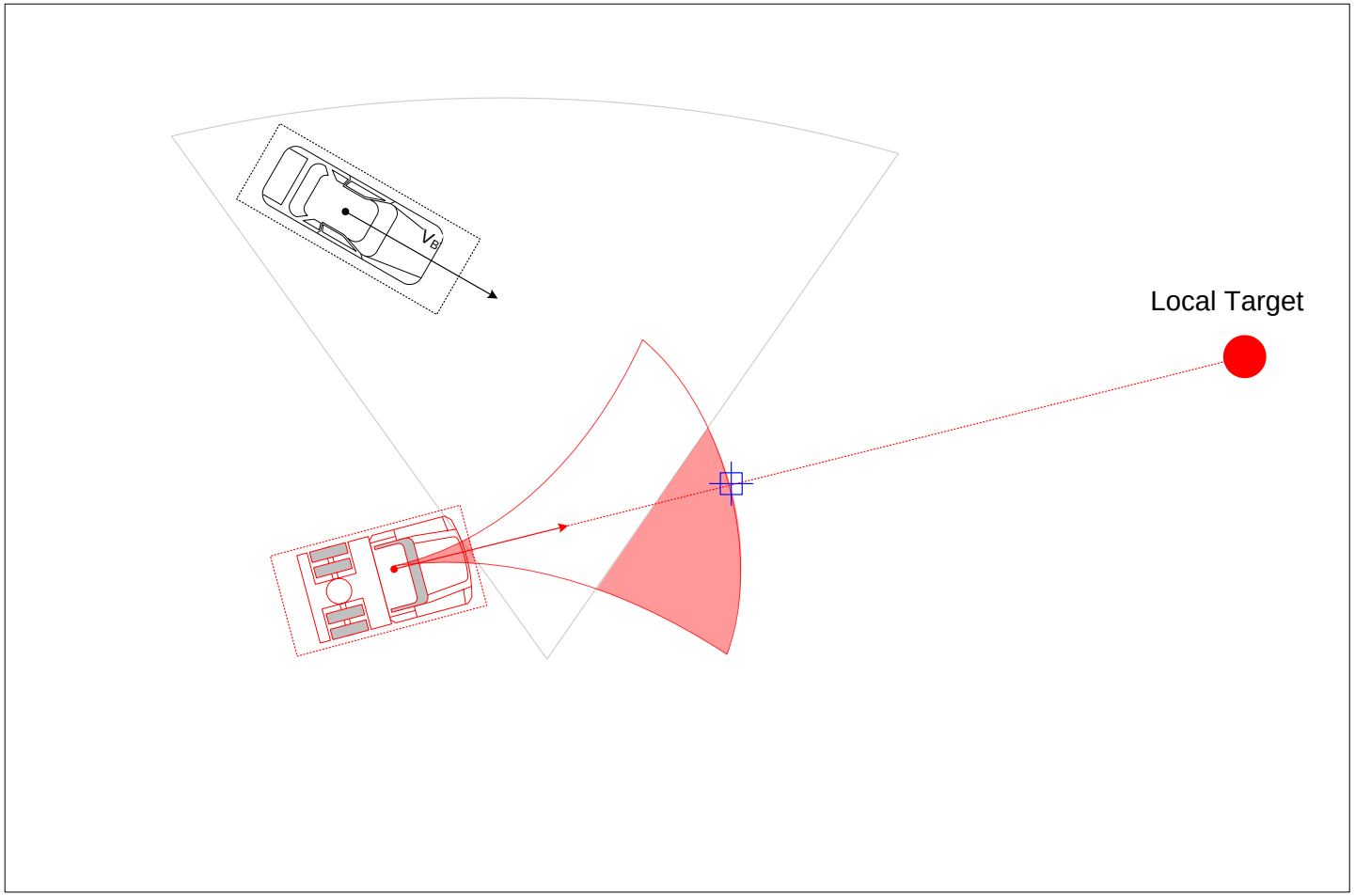
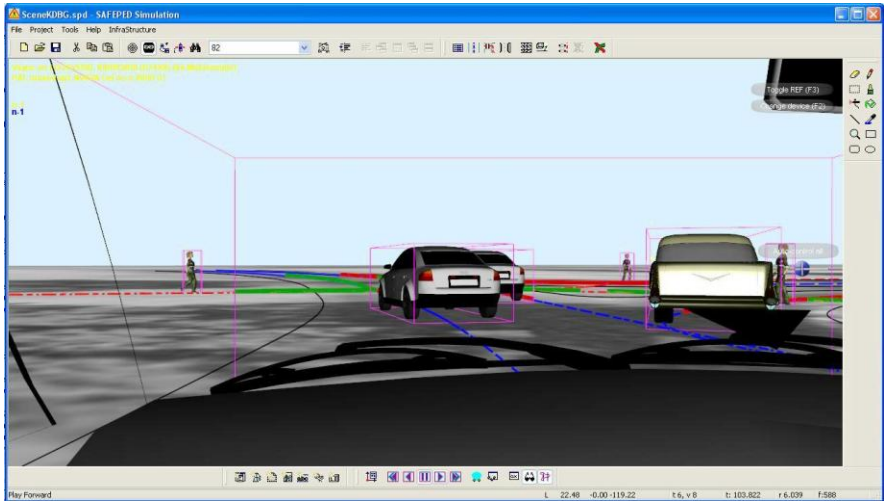
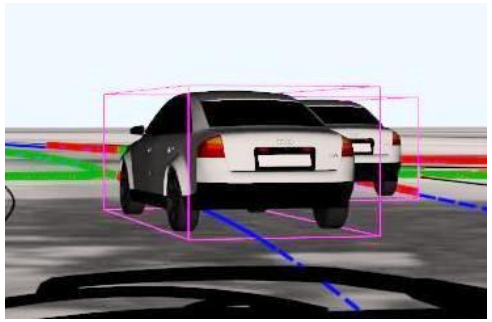
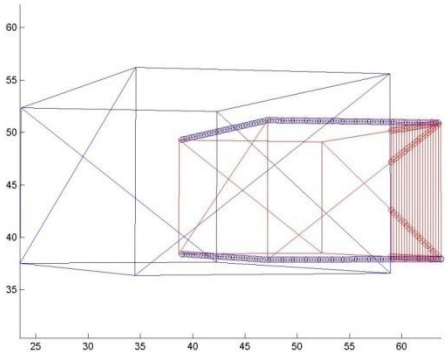


Modeling 3D visibility



Drivers View





Projecting Bounding Boxes to Driver's Eyes

http://www.youtube.com/watch?v=6KFcfFRElt8&feature=related

Basic laws of driver’s and pedestrian’s behavior is estimated in the field

(Video Motion Detection)

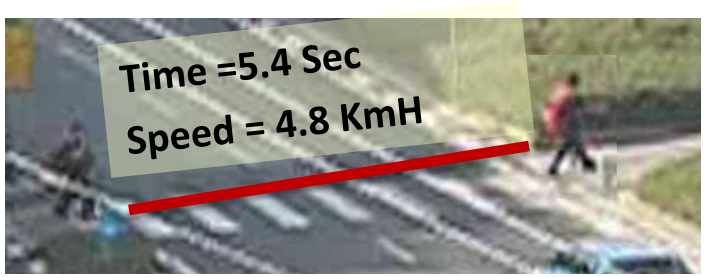
Our approach is based on the Video Motion Detection

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

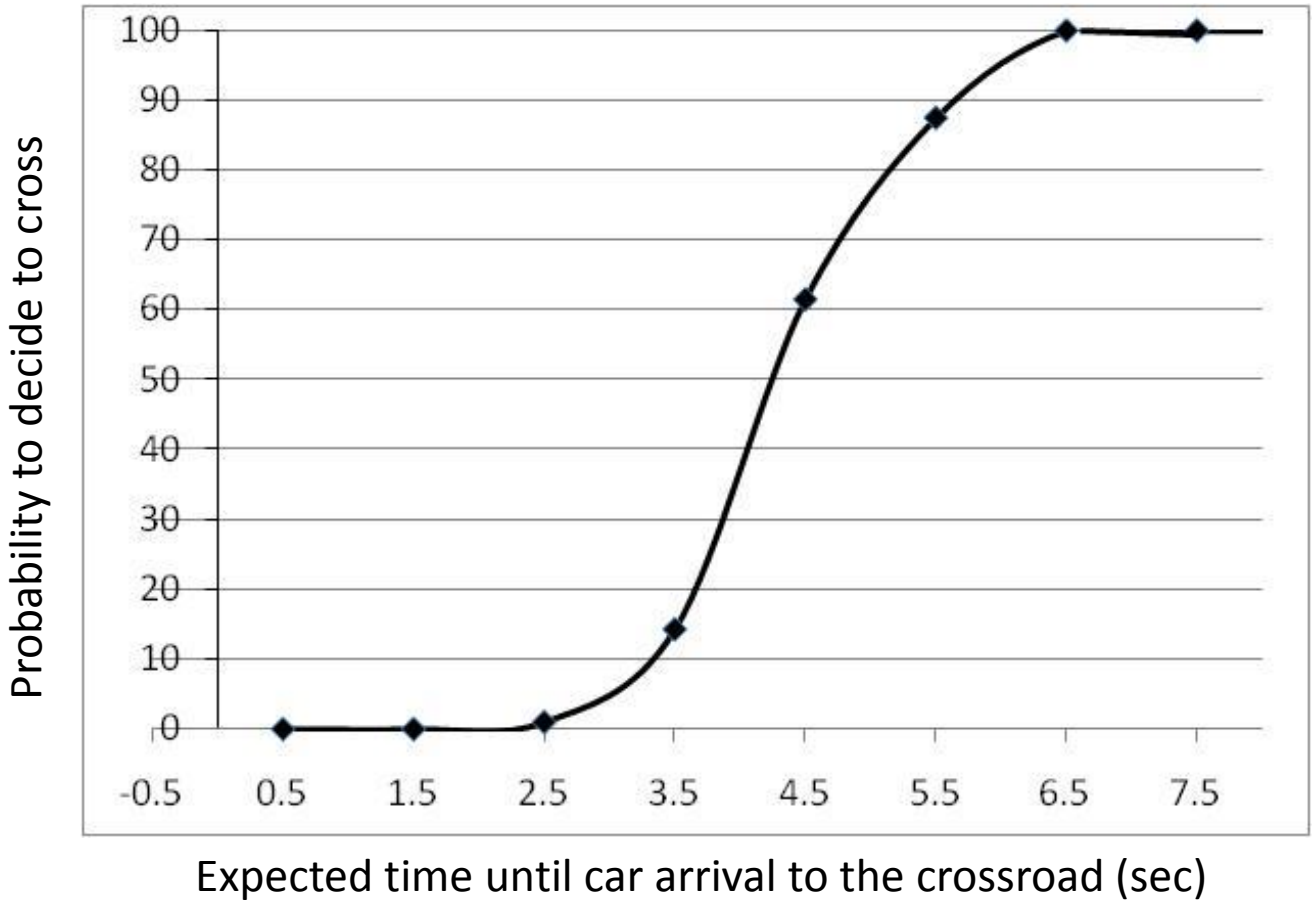
- **Solution** – using two video cameras with different zoom

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



Crashes and Near-Crash

Crashes are few,

Near Crashes are many

Experimental study of drivers' behavior:

Crash and near-crash kinematic signatures are identical!

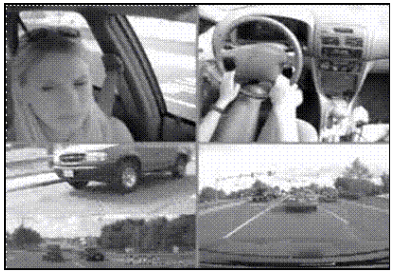
U.S. Department of Transportation
National Highway Traffic Safety Administration

www.nhtsa.dot.gov
nhtsa
people saving people

DOT HS 810 593

April 2006

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

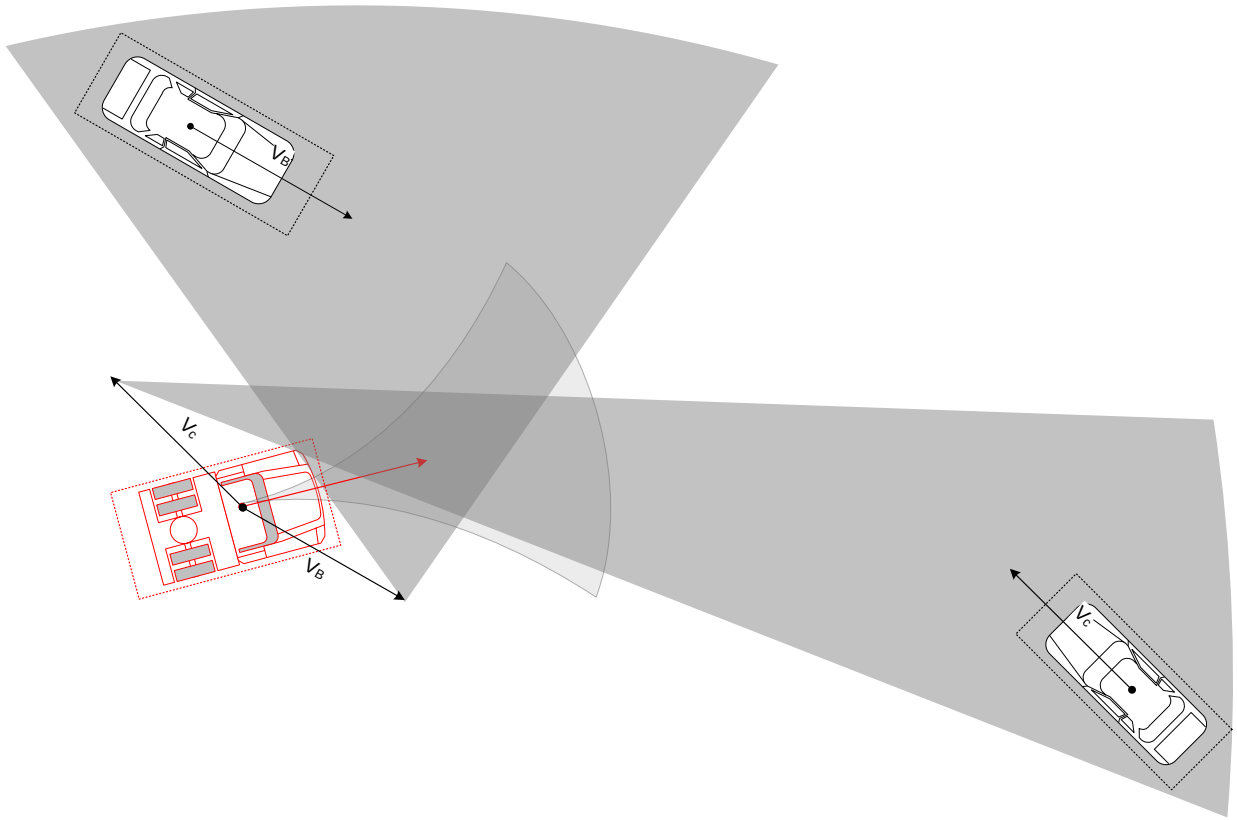


Five cameras monitored driver's face, driver's and passenger's sides of the vehicle, forward and rear views

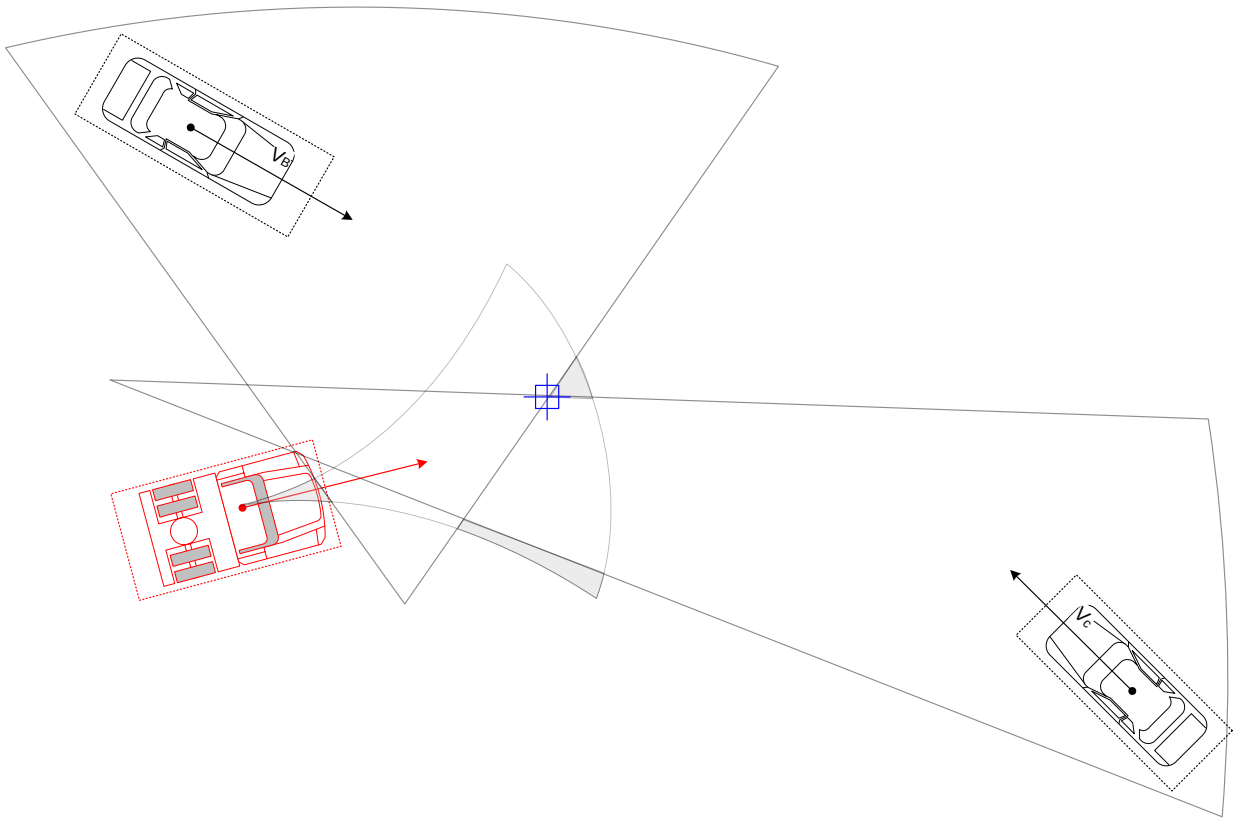
Doppler radar antennas recognized surrounding vehicles

Near Crash Dynamics

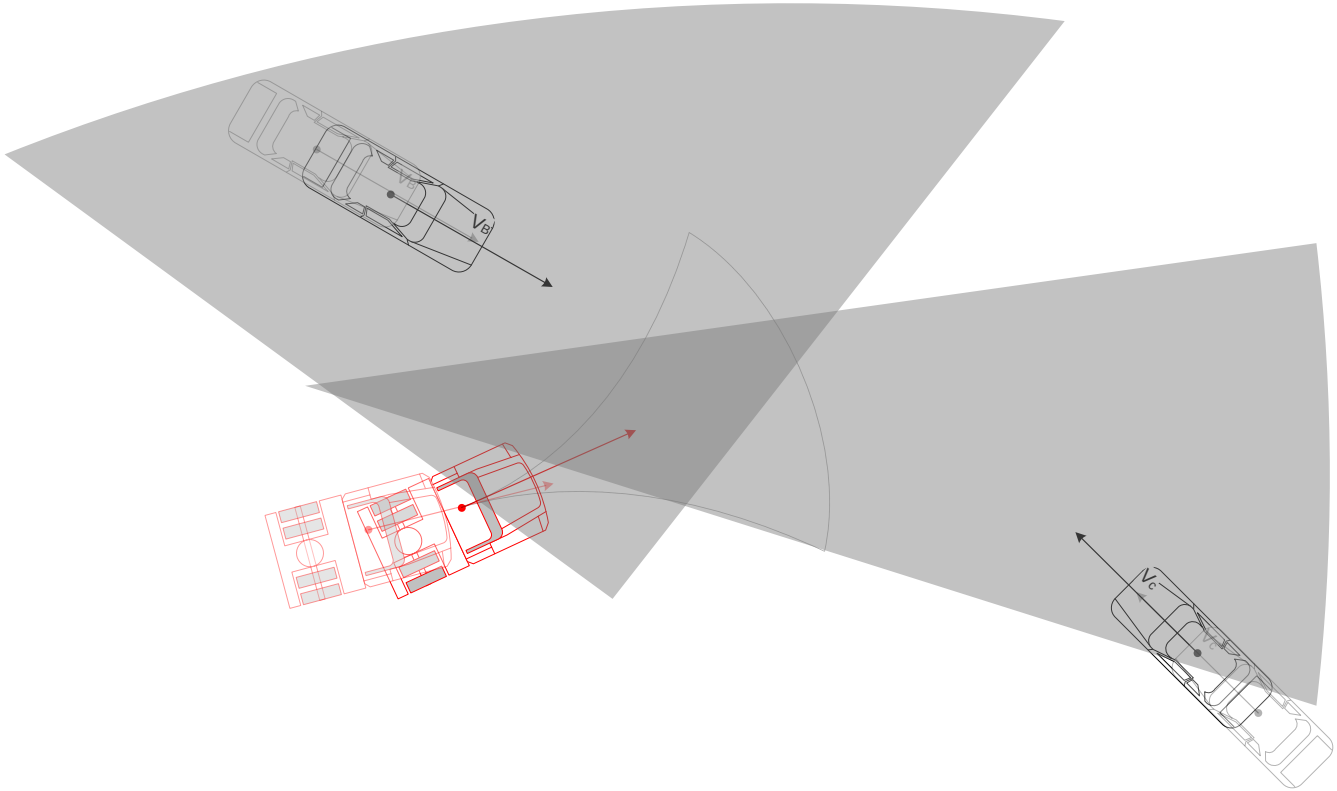
A moment before Near-Crash: Red car has few options not leading to Collision



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)



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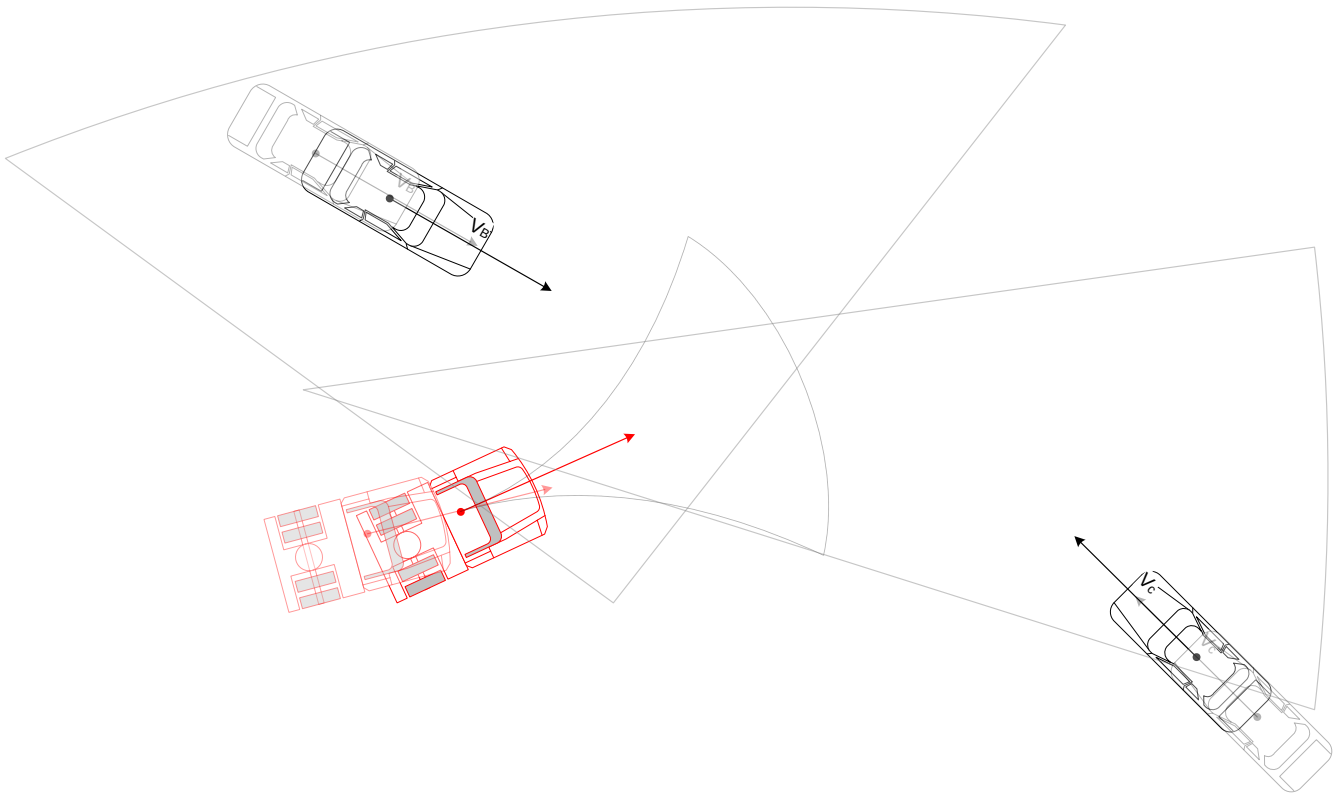
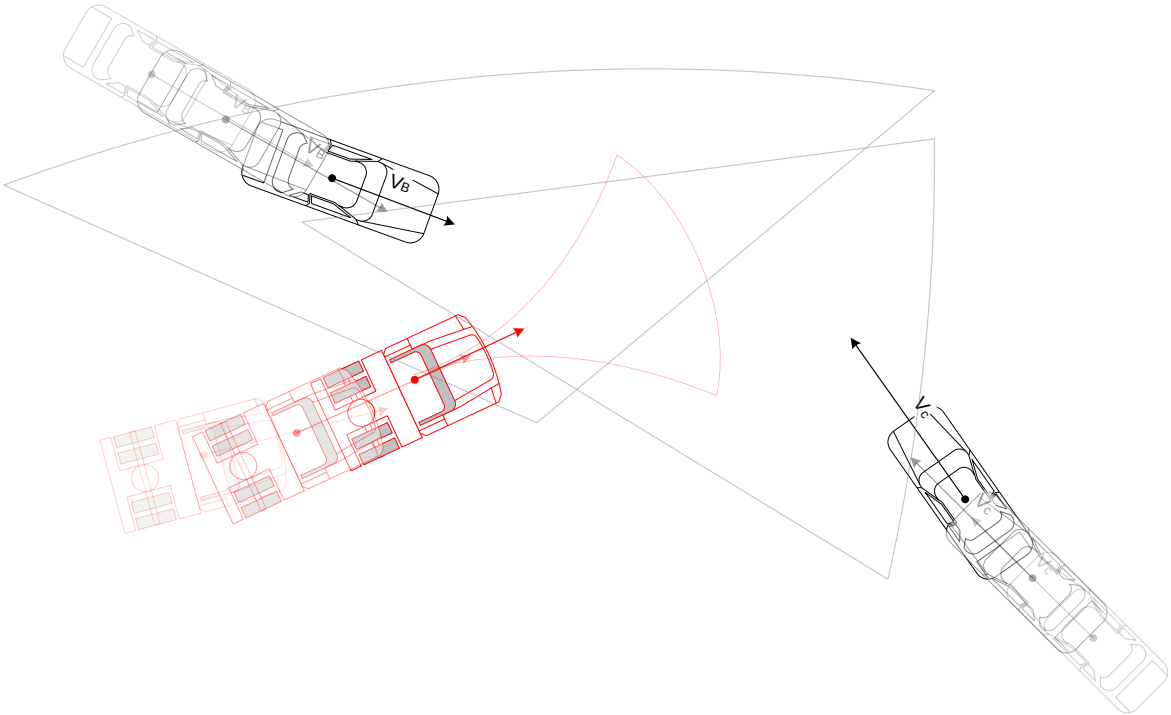
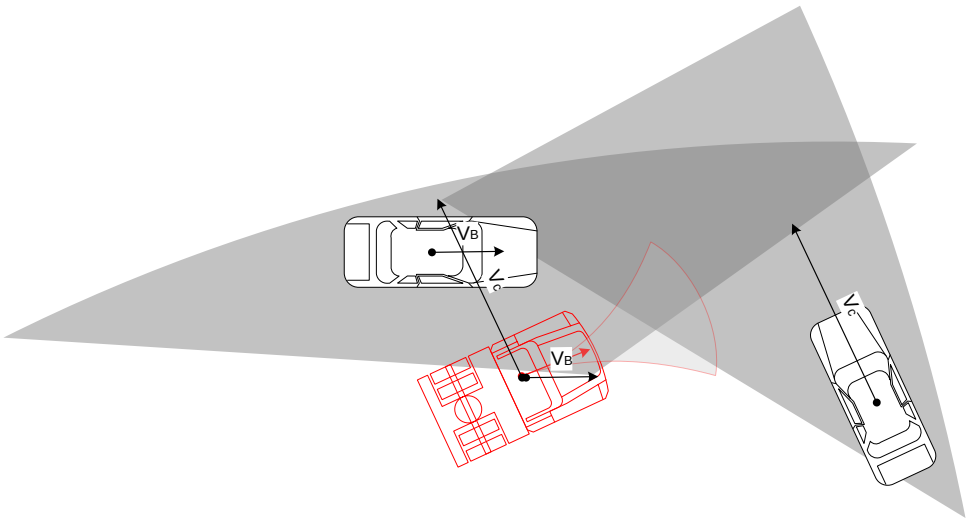


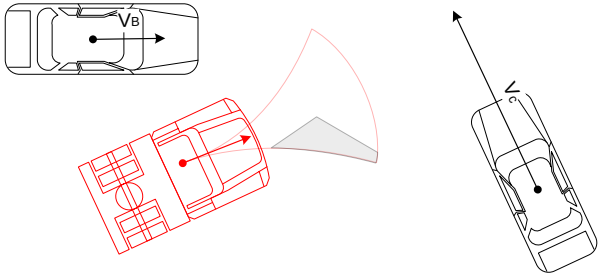
All cars brake, but the locus of velocities is still empty



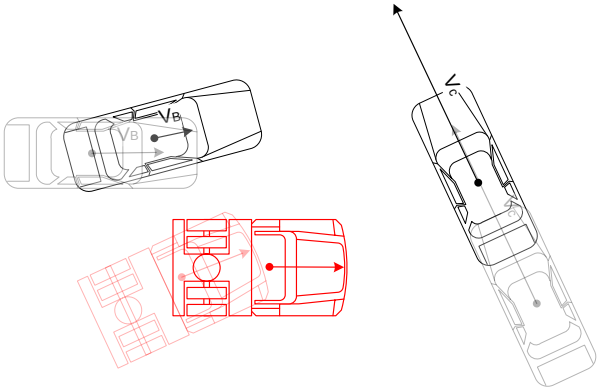
The cars further decelerate, the locus of velocities becomes non-empty



Escape Option



Red car avoids crash by taking the escape option



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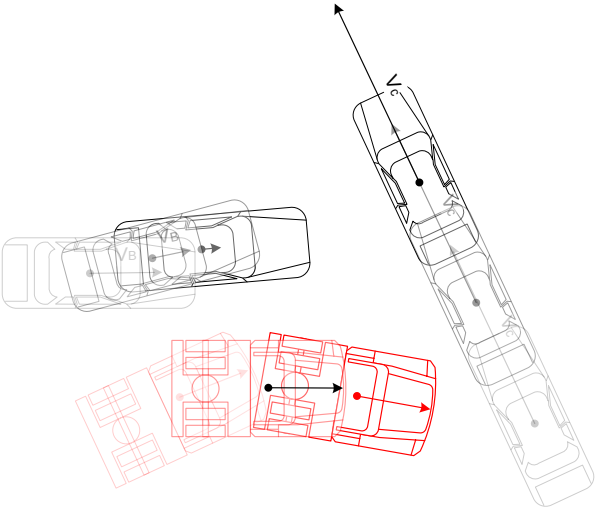

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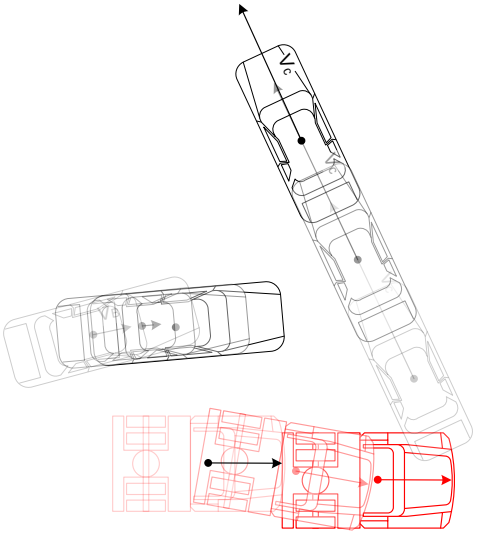


http://www.youtube.com/watch?v=axWEGNetpM0

The first model experiment (still unfinished)

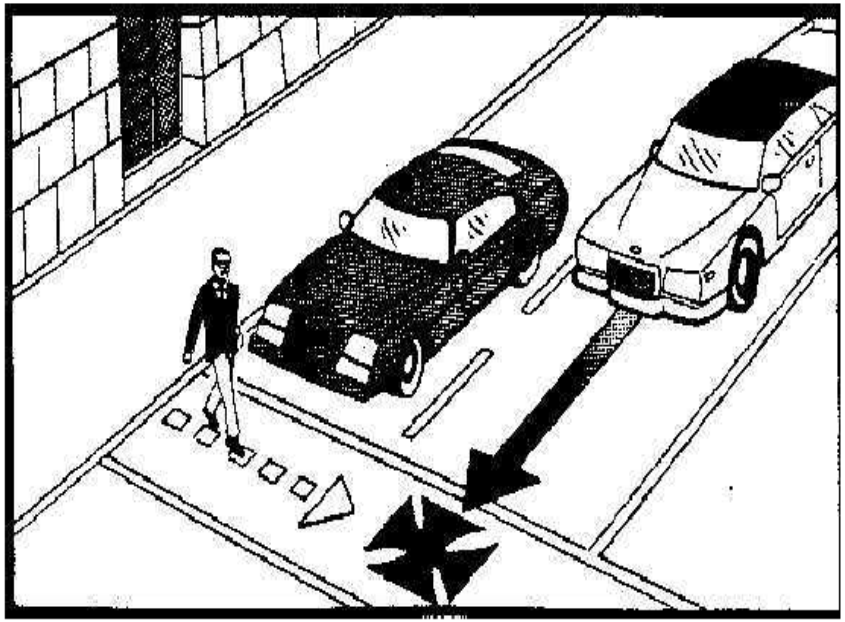
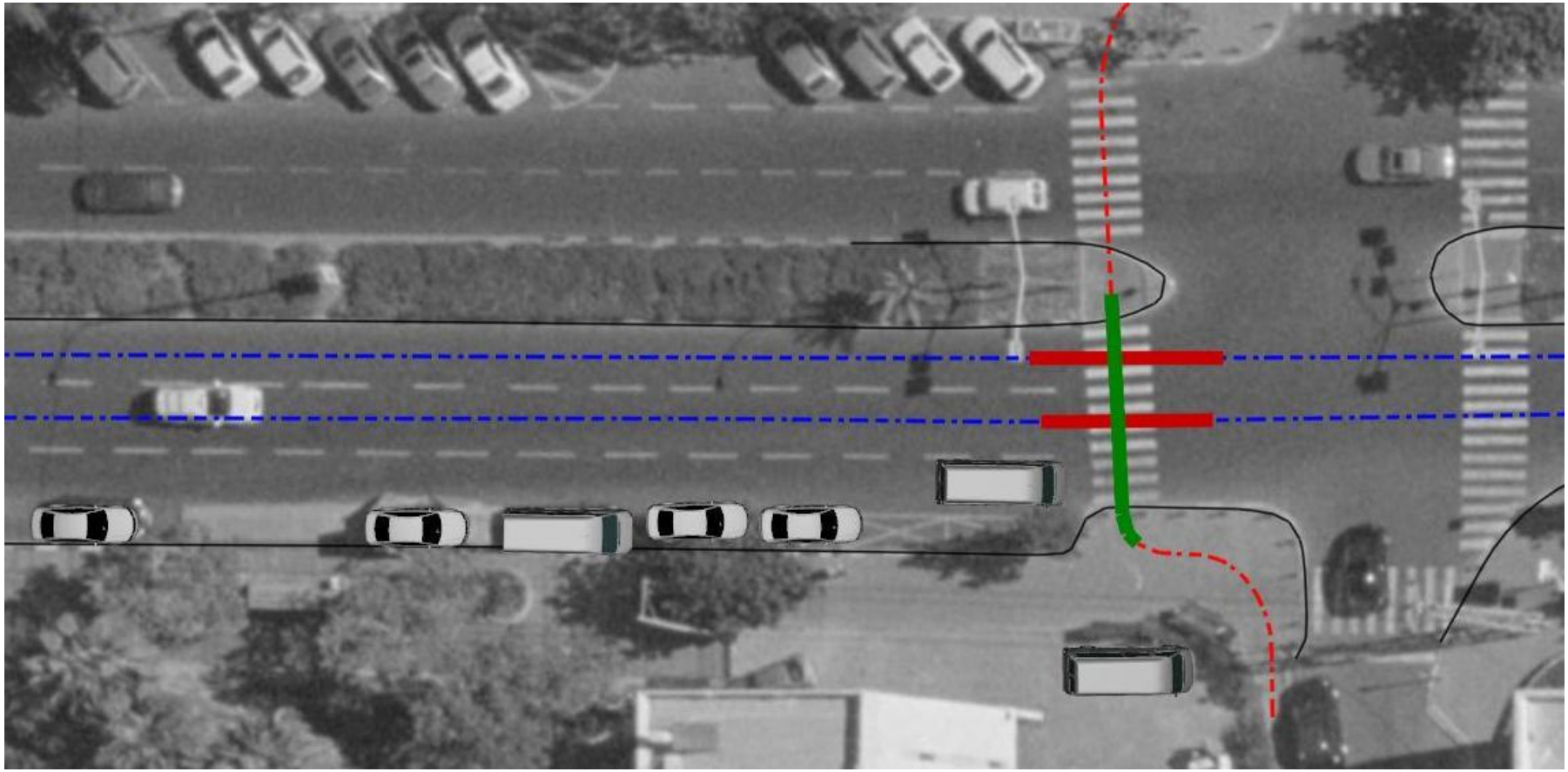


Figure 21. Illustration of multiple-threat pedestrian crash.

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

Obscuring car is close to the crosswalk

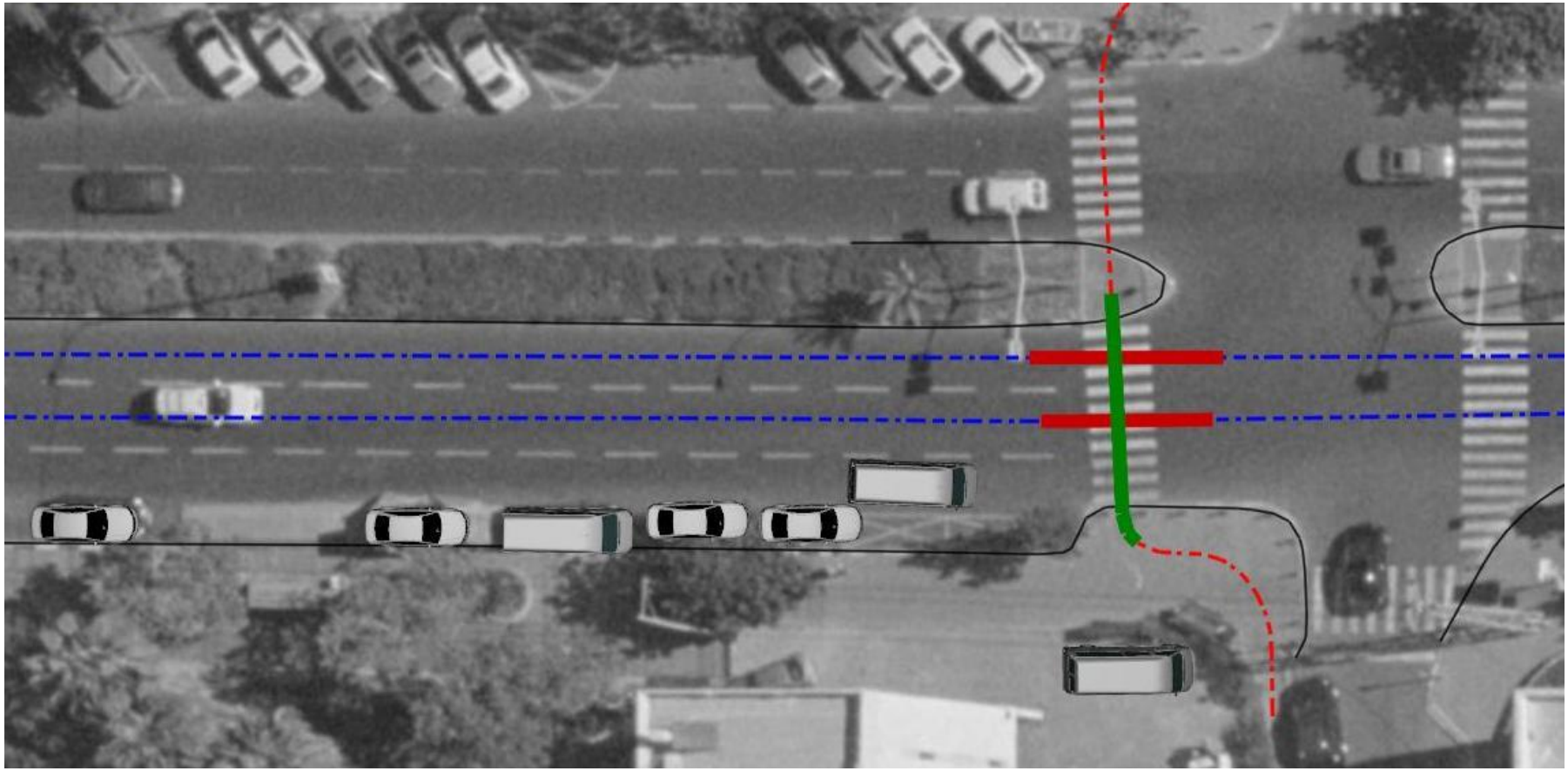


~ 210 pedestrians passed

~ 350 vehicles passed

4 near-crash situations

Obscuring car is ahead of the crosswalk

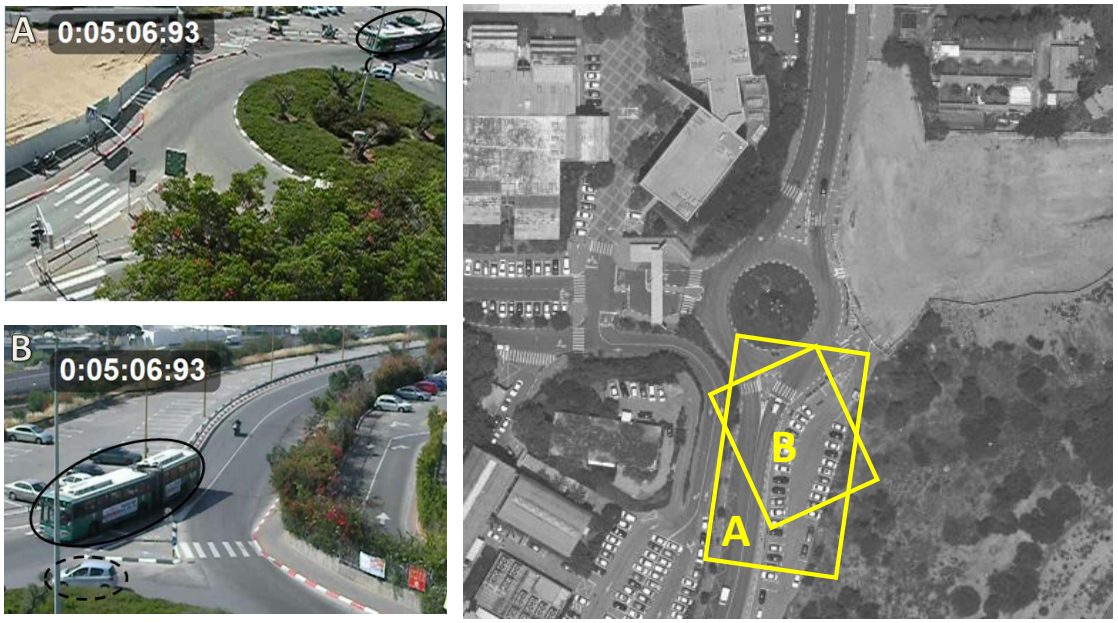


~ 210 pedestrians passed

~ 350 vehicles passed

2 near-crash situations

Current and critical stage of the research: *MODEL VALIDATION*



(a) (b)

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!

gwaizman@gmail.com