Pedestrian behavior and safety at roundabouts: a comparative study between real and microsimulation outcomes

Chiara Gruden[1] , Irena Ištoka Otković[2] , Matjaž Šraml[1] *

[1] *Faculty of Civil Engineering, Transportation Engineering and Architecture, University of Maribor, Smetanova ulica 17 – 2000 Maribor (SI),* *chiara.gruden1@um.si*

[2] *Faculty of Civil Engineering and Architecture Osijek, Josip Juraj Strossmayer University of Osijek, Vladimira Preloga 3 – 31000 Osijek (HR), iirena@gfos.hr*

Table of contents
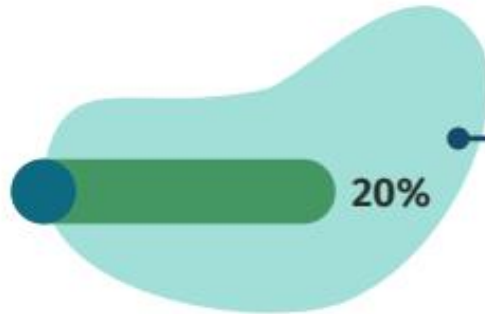
Urban areas

37 % of road fatalities happen in urban areas
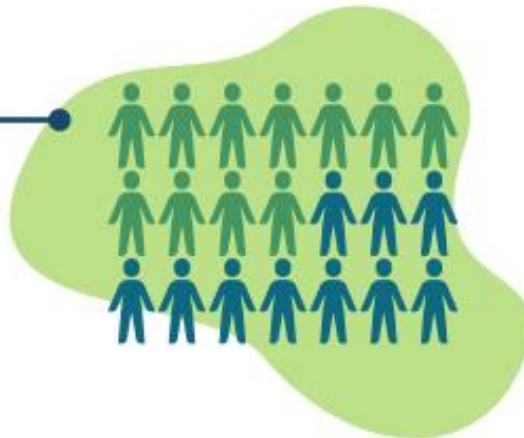
35%
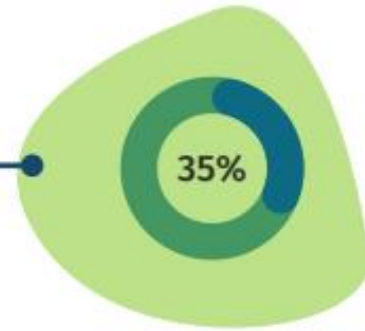
Intersections

1 in 5 fatal accidents occur at an intersection.

20%

Pedestrians

Percentage of pedestrians killed at intersections steadily increased from 19.5 % in 2006 to 23 % in 2015.

Introduction

SOLUTION: ROUNDABOUTS

BUT WHAT ABOUT PEDESTRIANS?

AIM:

to understand behavioral and safety characteristics of pedestrians crossing at roundabouts.
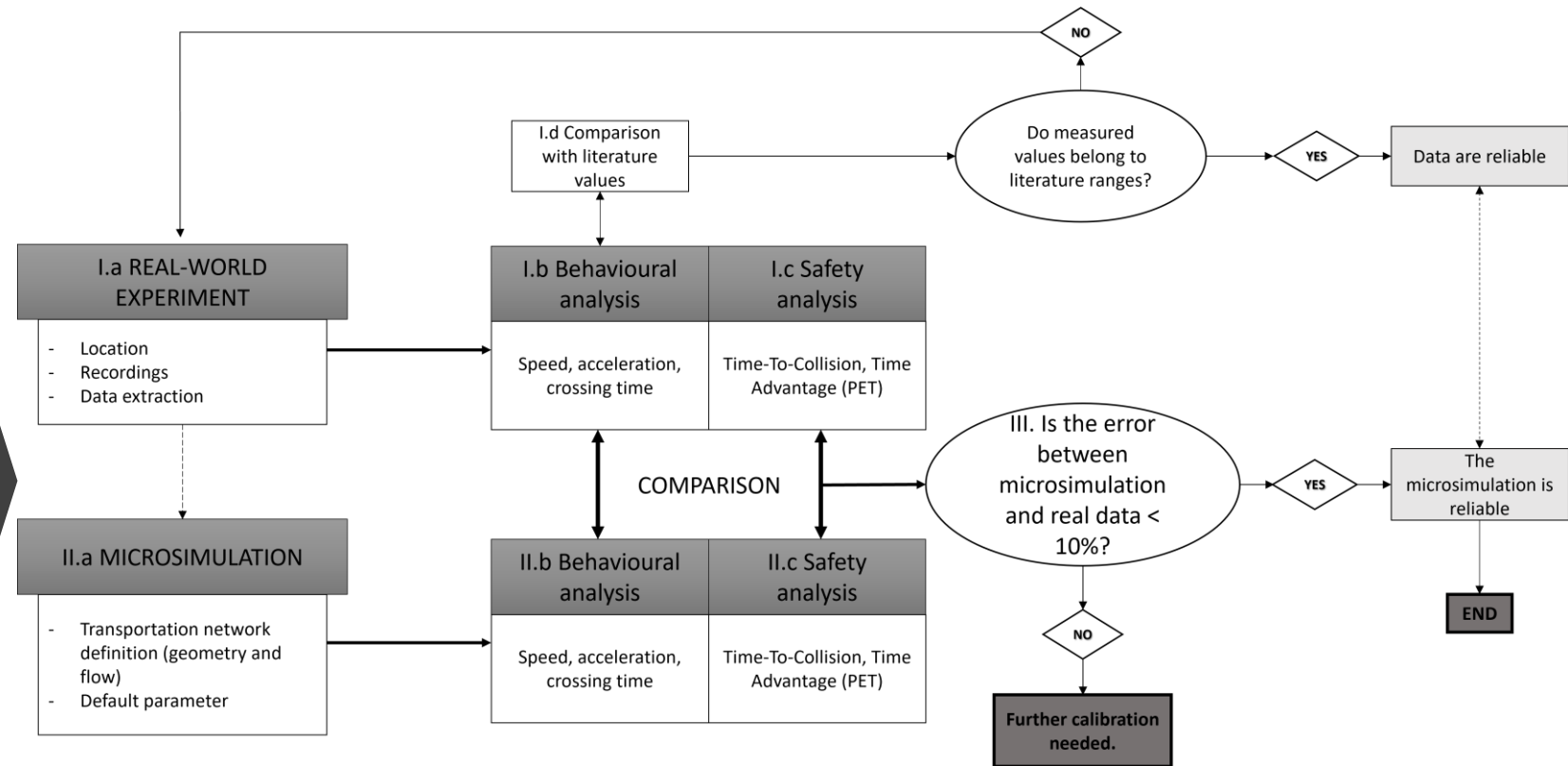
Location and network

Entity type	Link/area	Volume (users/hour)
Vehicles	Link 1	325
	Link 2	325
	Link 3	650
	Link 4	165
	Link 5	165
Pedestrians	Area 1	46
	Area 2	20
	Area 3	43
	Area 4	20
	Area 5	3

Behavioral analysis – video footages

GENDER	MALE 48 %; FEMALE 52 %
AGE	12-25 yrs – 7 %; 25- 60 yrs – 77 %; 60+ yrs – 16 %
BEHAVIOR	JAYWALKING – 20 % (majority male); INTERACTION – 75 %

	Mean	Standard Deviation	Median
Crossing speed (m/s)	1.55	0.027	1.49
Crossing acceleration (m/s^2)	-0.007	0.246	0.0073
Crossing time (s)	8.27	1.544	8.00

Behavioral analysis – video footages

Factors	Speed (m/s)		Acceleration (m/s^2)		Crossing time (s)	
	p-value	h-value	p-value	h-value	p-value	h-value
Gender	0.329	0.95	0.359	0.84	0.618	0.25
Age	0.042	6.34	0.032	6.88	0.008	9.68
Movement in group	0.004	11.13	0.015	8.37	0.139	3.95
Mobile texting	0.281	1.16	0.313	1.02	0.665	0.19
Mobile talk	0.870	0.28	0.319	2.28	0.814	0.41
Person with luggage	0.619	0.25	0.166	1.91	0.790	0.07
Parent with child	0.042	4.14	0.236	1.40	0.758	0.09
Parent with stroller	0.462	0.54	0.692	0.16	0.445	0.58
Jaywalking	0.79	0.07	0.192	1.70	0.883	0.02

	Speed (m/s)		Acceleration (m/s^2)		crossing time (s)	
	mean	st. dev.	mean	st. dev.	mean	st. dev.
Young	1.55	0.303	-0.032	0.185	8.0	1.348
Adult	1.57	0.324	0.006	0.270	8.02	1.319
Elderly	1.42	0.293	-0.047	0.147	9.4	1.979
Male	1.59	0.367	-0.037	0.339	8.363	1.553
Female	1.50	0.277	0.016	0.141	8.136	1.536

Behavioral analysis – video footages

Study	Value [m/s]	Location
Present study	1.55	Roundabout crossing
HCM [20]	1.20	General locations
TEH [22]	1.37	General locations
MUTCD [25]	1.21	General crossing
Bennett [26]	1.24	General crossing
Lam, Cheung [9]	1.44	Signalized crossing
Knoblauch [23]	1.46	Signalized crossing (youngers)
Knoblauch [23]	1.20	Signalized crossing (olders)
Onelcin, Alver [11]	1.31	Signalized crossing
Lam, Cheung [9]	1.26	Unsignalized crossing

Behavioral analysis – microsimulation

	simulated crossing time [s]	simulated speed [m/s]
Mean	12.11	1.01
Standard error	0.56	0.041
Median	11	0.92
Standard deviation	6	0.44
Asymmetry	1.18	0.86
Min	4	0.33
Max	35	2.22

Crossing time	
Male	Female
11.89 s	12.48 s
Speed	
Male	Female
1.04 m/s	0.96 m/s

Safety analysis – video footages

Car-pedestrian encounter

+

90° ANGLE

→

Very high vulnerabiltiy
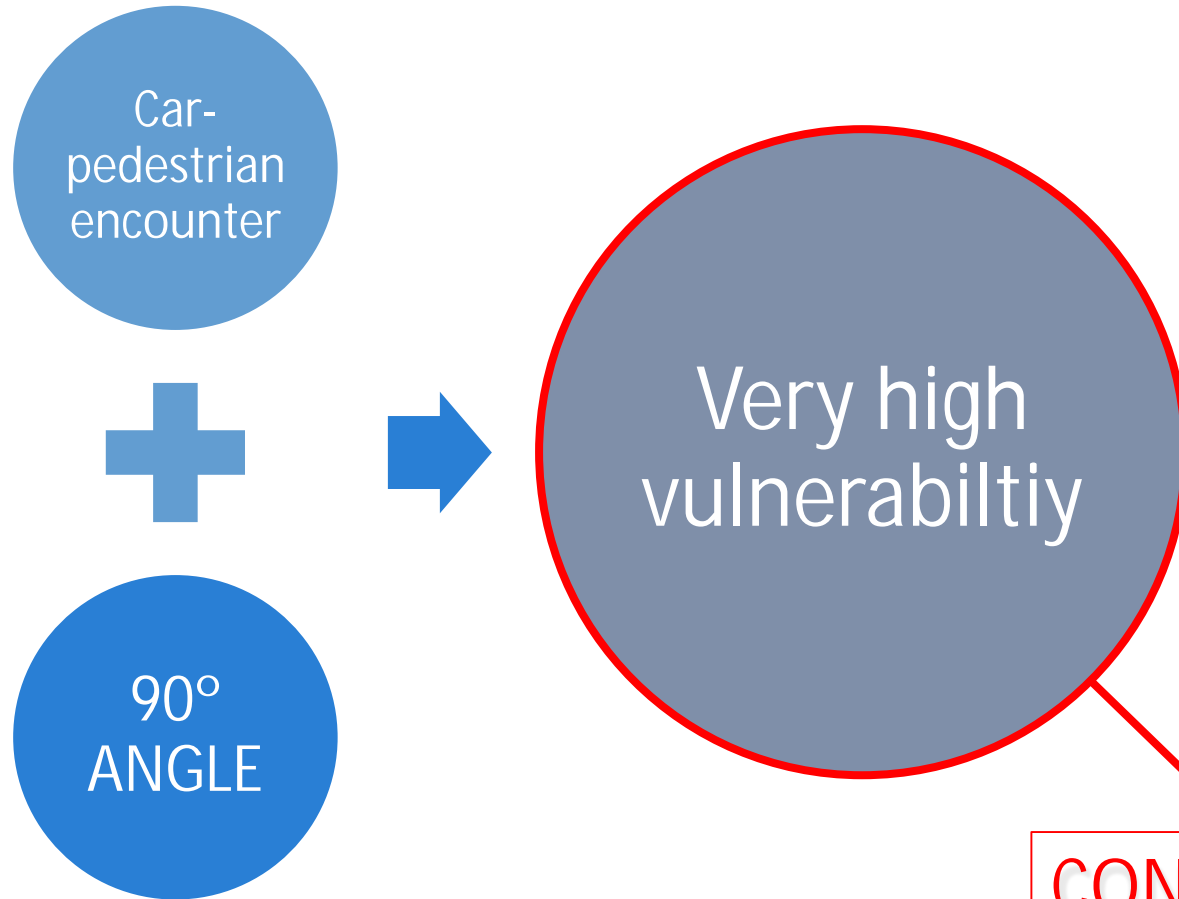
Video footages	
TTC < 1.5 sec	21 %
Tadv < 1.0 sec	44 %
Vrel > 10 m/s	59 %

CONSISTENT LEVEL OF SEVERITY

Safety analysis - microsimulation

$$V_{rel} = \left| V_{ped} - V_{veh} \right| \quad (1)$$

$$TTC = \frac{D}{\left| V_{ped} - V_{veh} \right|} \quad (2)$$

$$TAdv = \left| \frac{S_{ped}}{V_{ped}} - \frac{S_{veh}}{V_{veh}} \right| \quad (3)$$

Microsimulation	
TTC < 1.5 sec	7.19 %
Tadv < 1.0 sec	0.73 %
Vrel > 10 m/s	0.35 %

Discussion

	Simulation	Real	Difference	%
Crossing time (s)	12,11	8,27	3,84	<mark>46,4</mark>
male	11,89	8,13	3,76	46,2
female	12,48	8,36	4,12	49,3
Speed (m/s)	1,01	1,55	0,54	<mark>34,8</mark>
male	1,04	1,6	0,56	35
female	0,96	1,51	0,55	36,4

Video footages		Microsimulation
TTC < 1.5 sec	21 %	7.19 %
Tadv < 1.0 sec	44 %	0.13 %
Vrel > 10 m/s	59 %	0.35 %

Conclusions

OBJECTIVES:

- To provide an insight in behavioral parameters at a roundabout crossing;

- To understand if they are comparable with other crossing typologies;

- To understand to what extent such a location can be reliably microsimulated;

ROUNDABOUT:
AVG SPEED = 1.55 m/s

SIGNALIZED INTERSECTIONS:
AVG SPEED = 1.44 m/s

UNSIGNALIZED INTERSECTIONS:
AVG SPEED = 1.26 m/s

CROSSING TIME: 8.27 sec

ADULT: 8.02 sec

YOUNGER: 8 sec

ELDERLY: 9.4 sec

- CONSISTENT ERROR ON CROSSING TIME (46 %) AND SPEED (35 %)

- MUCH LOWER VALUES OF SSM THAN FROM VIDEOS

THANK YOU FOR YOUR ATTENTION! ☺

Chiara Gruden

Faculty of Civil Eng., Transportation Eng. and Architecture

University of Maribor (Slovenia)