Real-time injury assessment in non-standard seating configurations in highly automated vehicles

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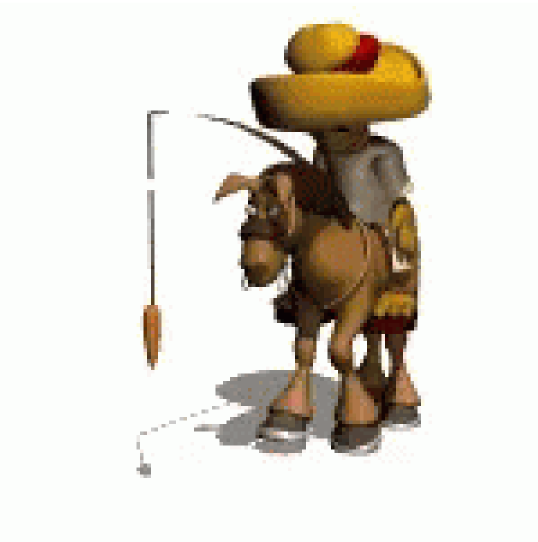
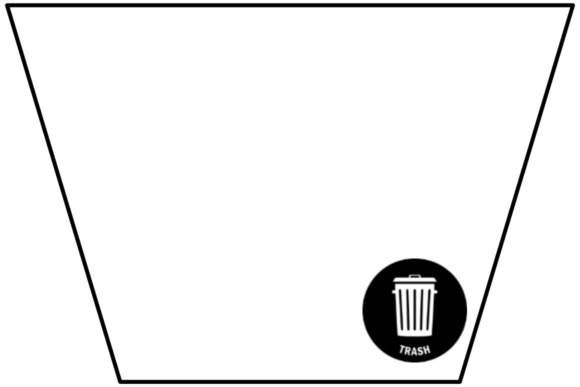
Overview

- *Background*
- *Digital twin model*
- *Analysis method*
- *Artificial Intelligence*
- *Application*

Hands-off mode has been our dream

Can I drive one day
in fully hands-off
mode?

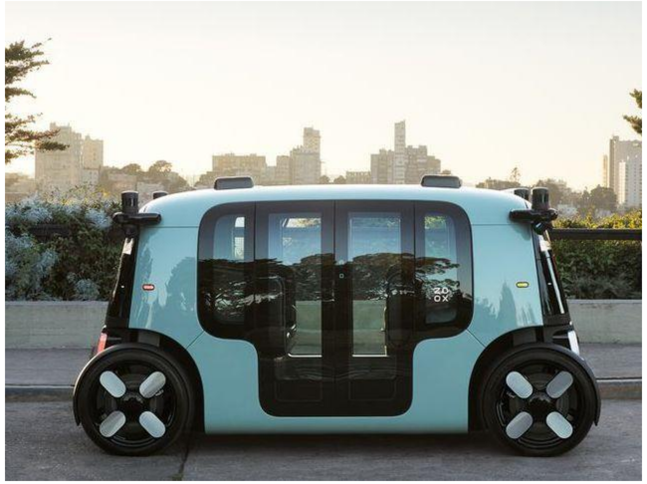




Companies are interested to invest in autonomous cars

BOSCH concept shuttle

New designs are introduced for highly automated vehicles (HAVs) in which occupants will be just passengers in non-standard seating configurations.

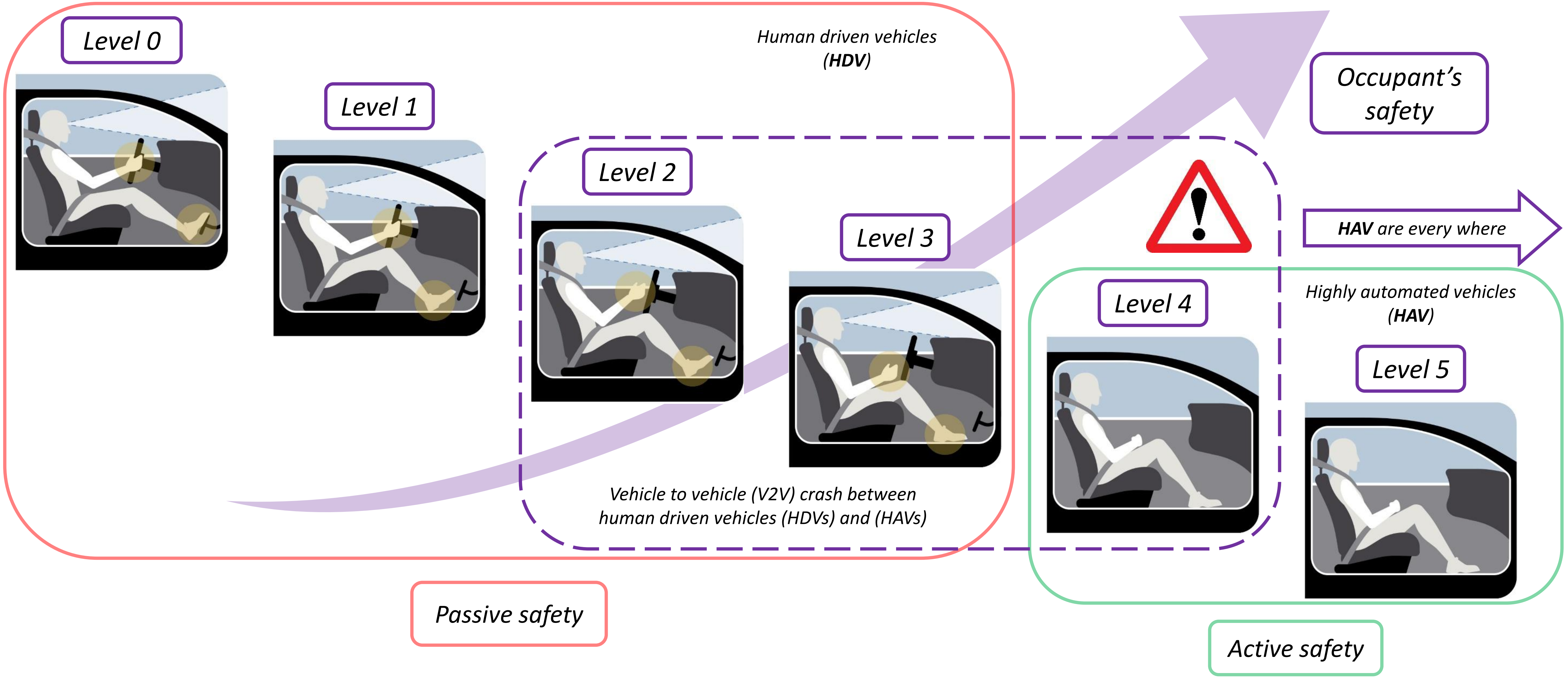


ZOOX concept shuttle

ZF concept shuttle

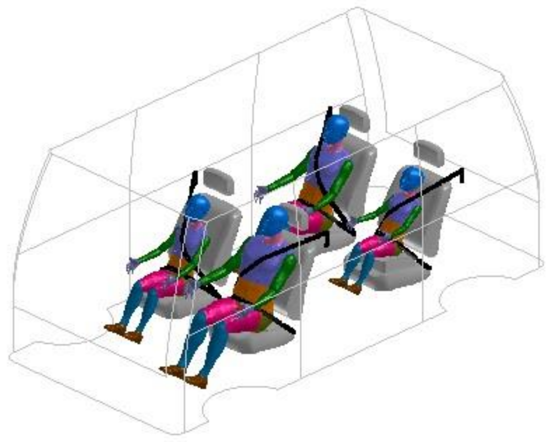
TOYOTA concept shuttle

From HDV to HAV



How many crash test did we need?

Right now the only available seating configuration for a family in a vehicle is
Standard
(Face-forwarded passengers)



If occupants can change their seats there exists
24 possibilities

If all passengers can freely,

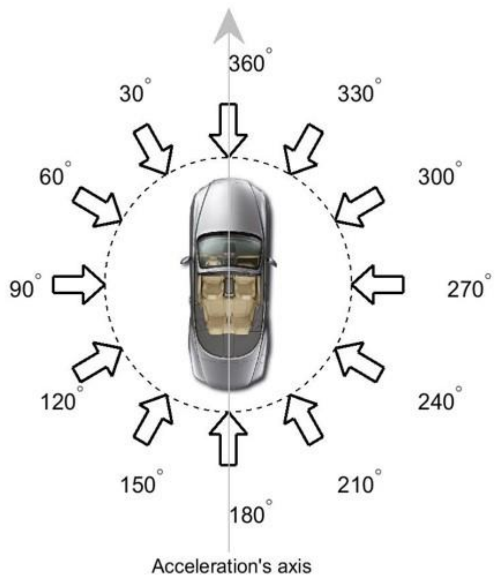
- *rotate seats*
- *recline seats' back*
- *changing their seats*

It means

7 962 600

seating configurations possibilities.

A crash can happen from any direction



The crash occurrence possibilities reaches to

95 551 200

These are named,
Non-Standard

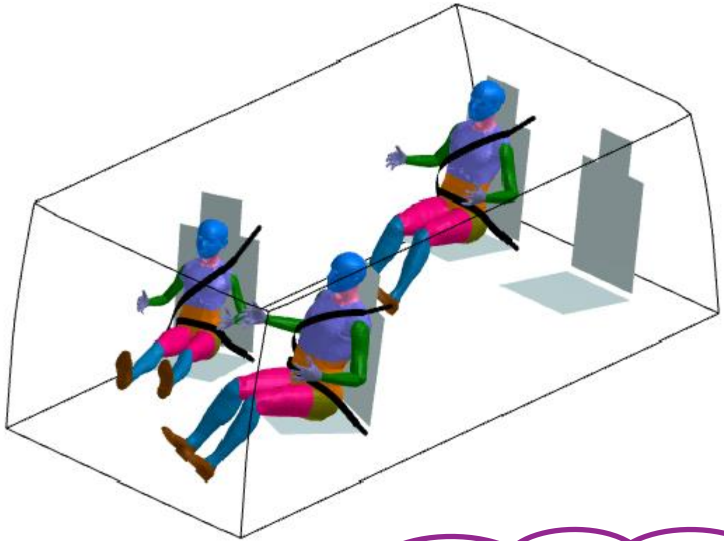
How to evaluate new seating configurations safety?

Are non-standard seating configuration safe enough for occupants in Highly Automated Vehicle?

In first look it is needed to run crash tests with ***382 204 800*** *models*

post-mortem human subjects ***(PMHS)***	*Dummies*	*Digital twin model*
There were 67.1 million deaths in 2022 (ref)	*The latest crash test dummies run closer to $1,000,000* (ref)	*It is low-cost and saves time more than other methods*

Digital twin model



A quite similar digital twin model was made.

Virthuman model

Anthropometric database

5117 Men 5333 Women

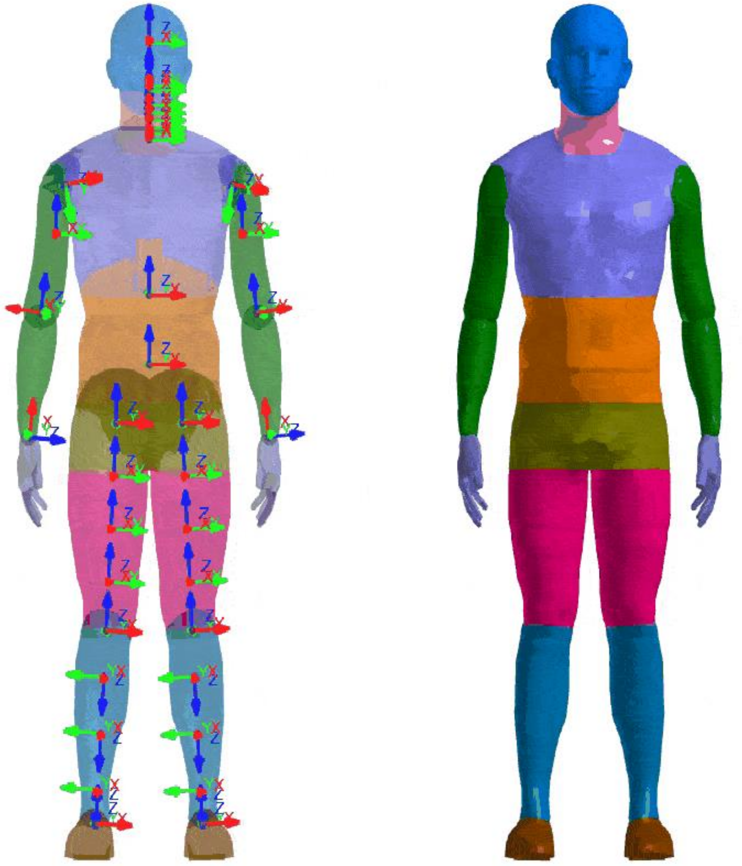
Age 6-65 year old

Czech and Slovak population in 1985

get it right®

UNIVERSITY
OF WEST
BOHEMIA

[*MECAS ESI s.r.o.*]

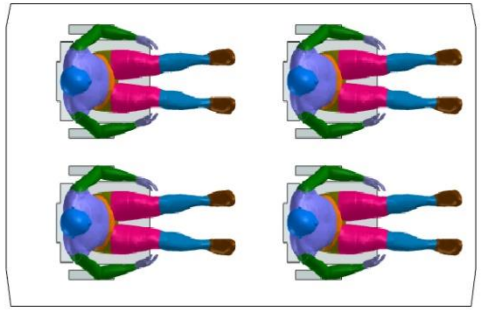


[*Hyncik, L., Cechova, H., Kovar, L., and Blaha, P., "On Scaling Virtual Human Models," SAE Technical Paper 2013-01-0074, 2013*]

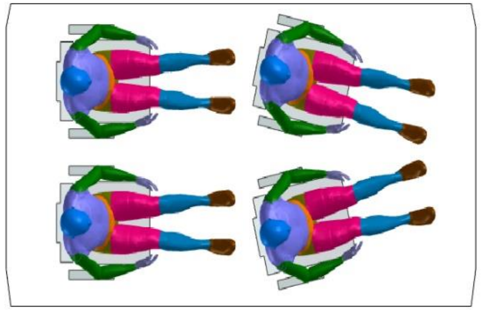
[Vychytil, J., Manas, J., Cechova, H., Spirk, S. et al., "Scalable Multi-Purpose Virtual Human Model for Future Safety Assessment," SAE Technical Paper 2014-01-0534, 2014]

Selected interiors

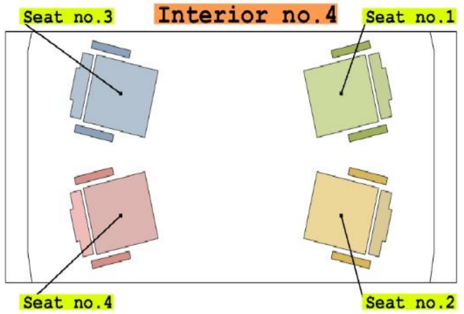
Standard
(0)



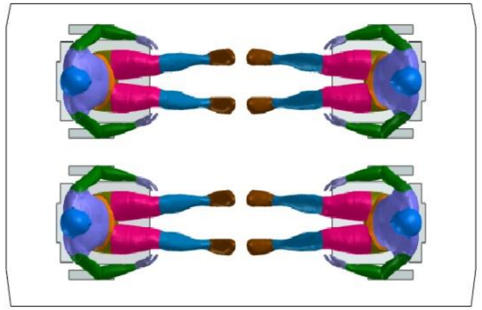
Conversation
(1)



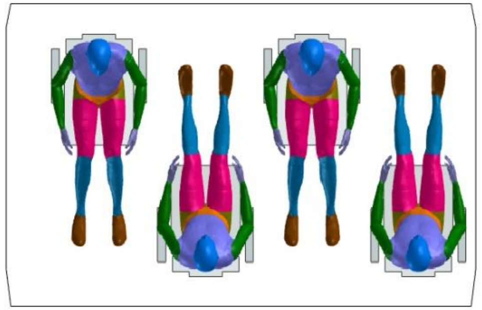
Seat position
number



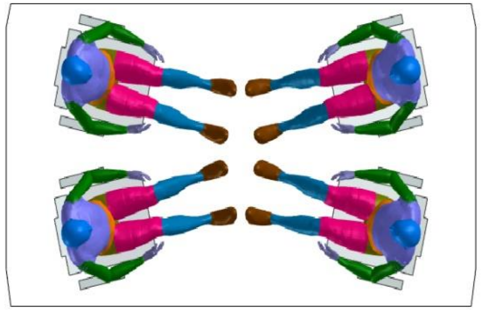
Face-to-face
(2)



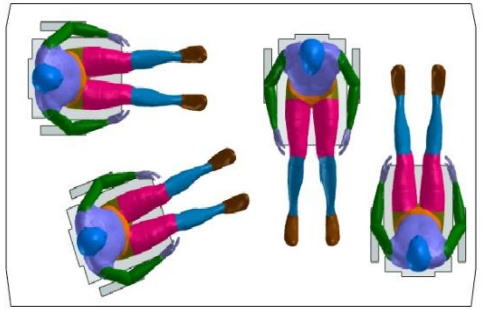
Along-side
(3)



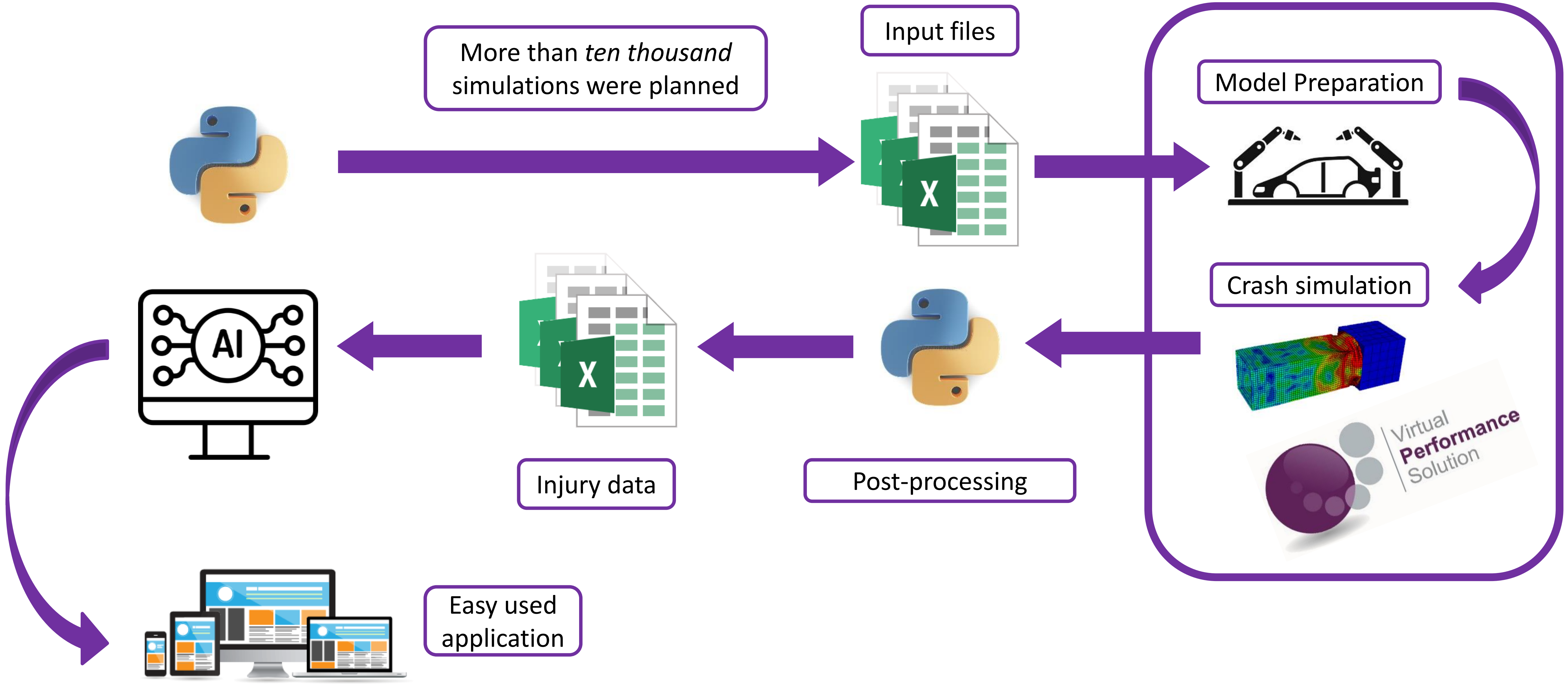
Living-room
(4)



Arbitrary
(5)

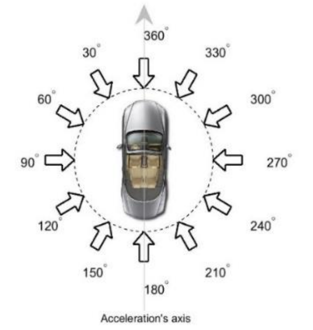


We made an application to predict occupant injury

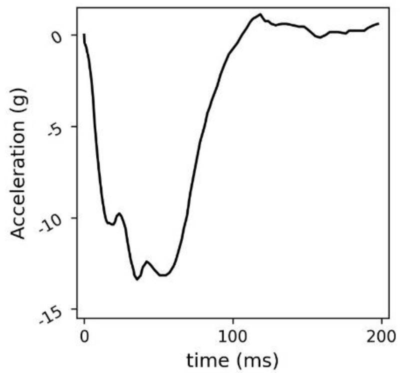


Input file structure

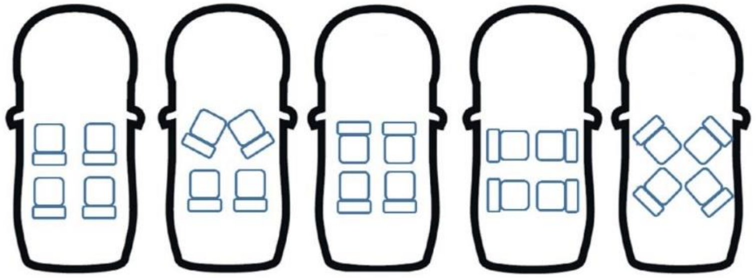
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Input for N runs is a text file with N rows, each row contains the order of 19 integers (3 for vehicle and 4 x 4 for passengers) described below																		
2	Vehicle		Interior	Passenger 1				Passenger 2				Passenger 3				Passenger 4			
3	Vehicle orientation Integer in [0, 359]	Acceleration level Integer in [10, 90]	Seating configuration Integer in [0, 5]	Gender Integer 0 (M) or 1 (F)	Age Integer in [6, 75]	Height Integer [cm]	Mass Integer [kg]	Gender Integer 0 (M) or 1 (F)	Age Integer in [6, 75]	Height Integer [cm]	Mass Integer [kg]	Gender Integer 0 (M) or 1 (F)	Age Integer in [6, 75]	Height Integer [cm]	Mass Integer [kg]	Gender Integer 0 (M) or 1 (F)	Age Integer in [6, 75]	Height Integer [cm]	Mass Integer [kg]
4	0	30	0	0	35	176	84	1	10	143	34	0	6	120	23	1	30	165	62
5	0	30	1	0	35	176	84	1	10	143	34	0	6	120	23	1	30	165	62
6	0	30	2	0	35	176	84	1	10	143	34	0	6	120	23	1	30	165	62
7	0	30	3	0	35	176	84	1	10	143	34	0	6	120	23	1	30	165	62
8	0	30	4	0	35	176	84	1	10	143	34	0	6	120	23	1	30	165	62
9	0	30	5	0	35	176	84	1	10	143	34	0	6	120	23	1	30	165	62
10																			



Orientation



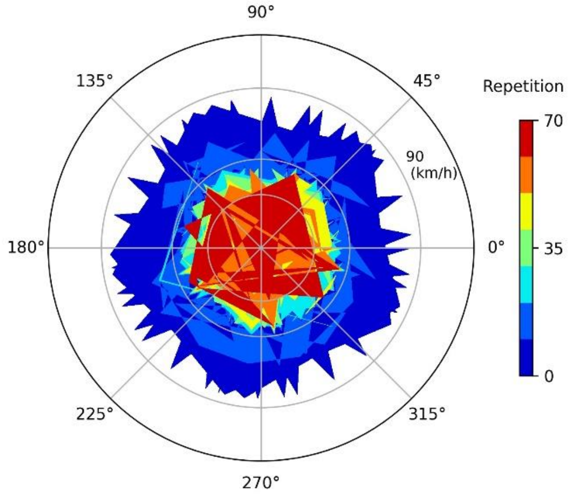
Acceleration



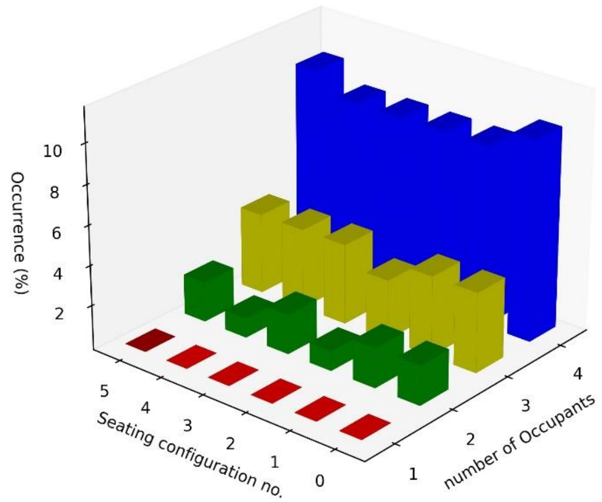
Interior

body models

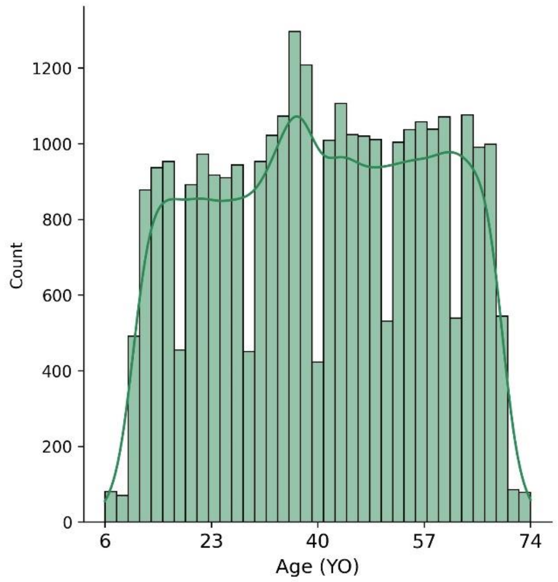
Input data Distribution



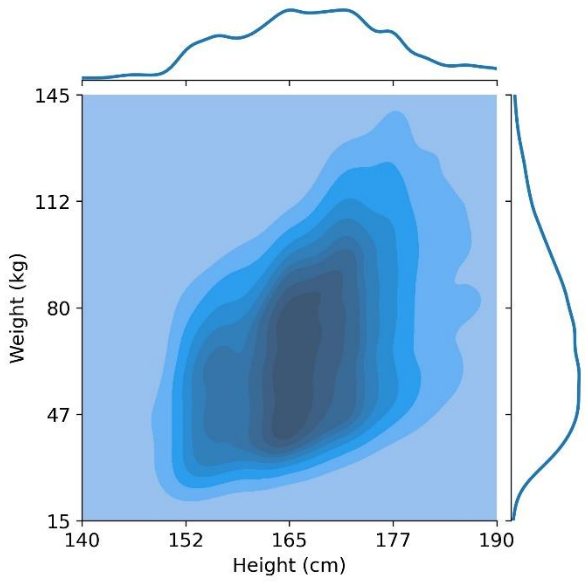
Speed & Orientation



Seating Configuration

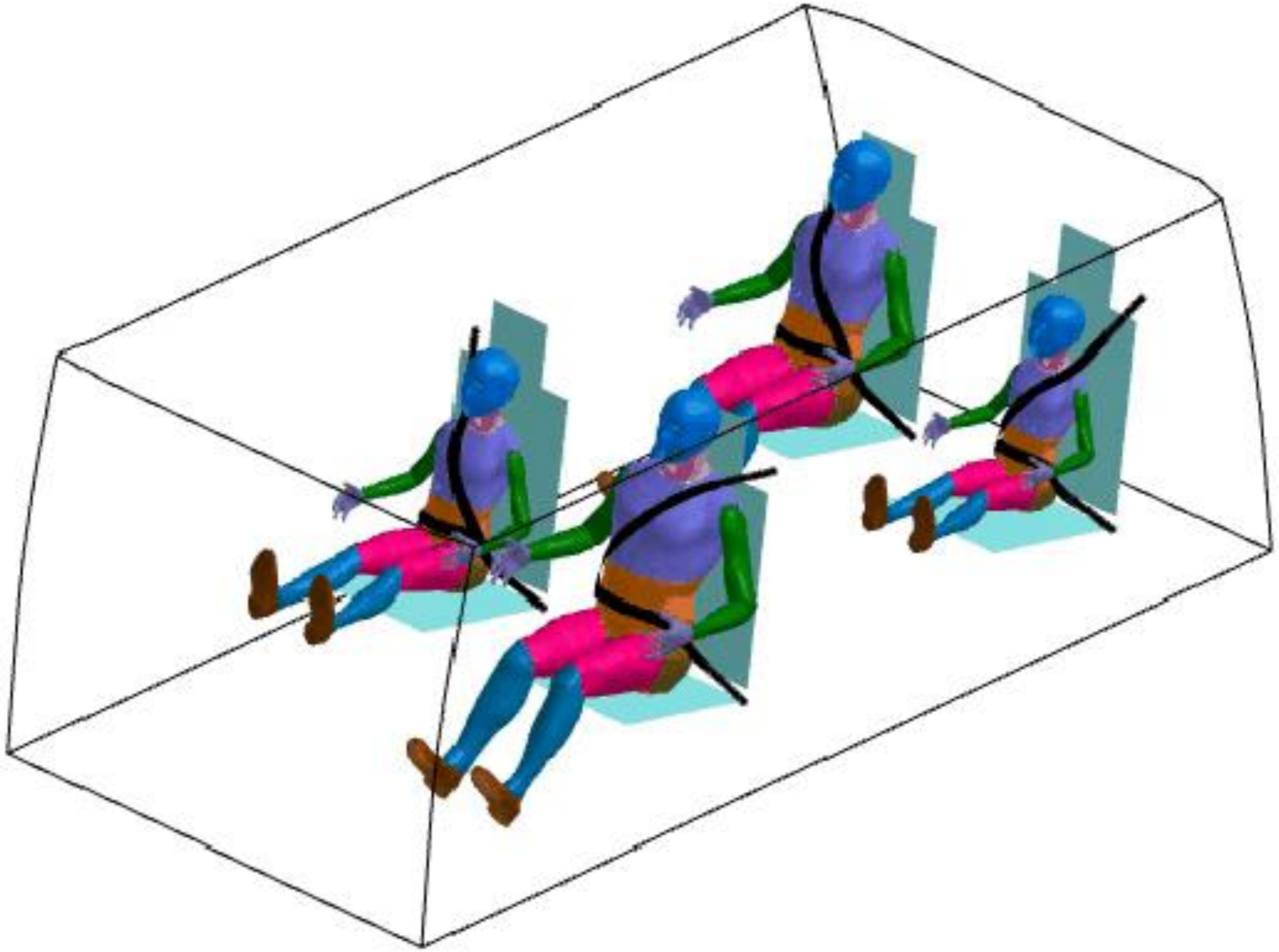


Age

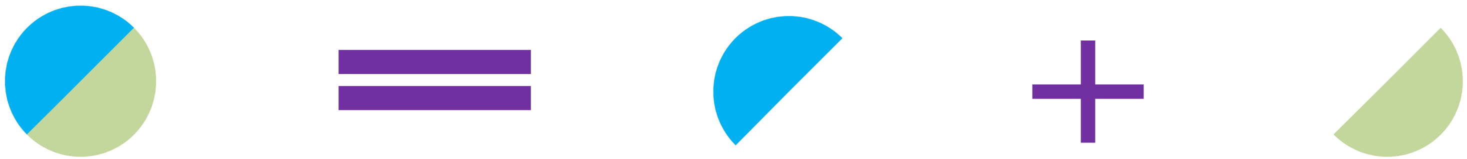


Weight & Height

Frontal crash 30 km/h



Injury data structure



Injury data = Simulation data + Injury for a body parts

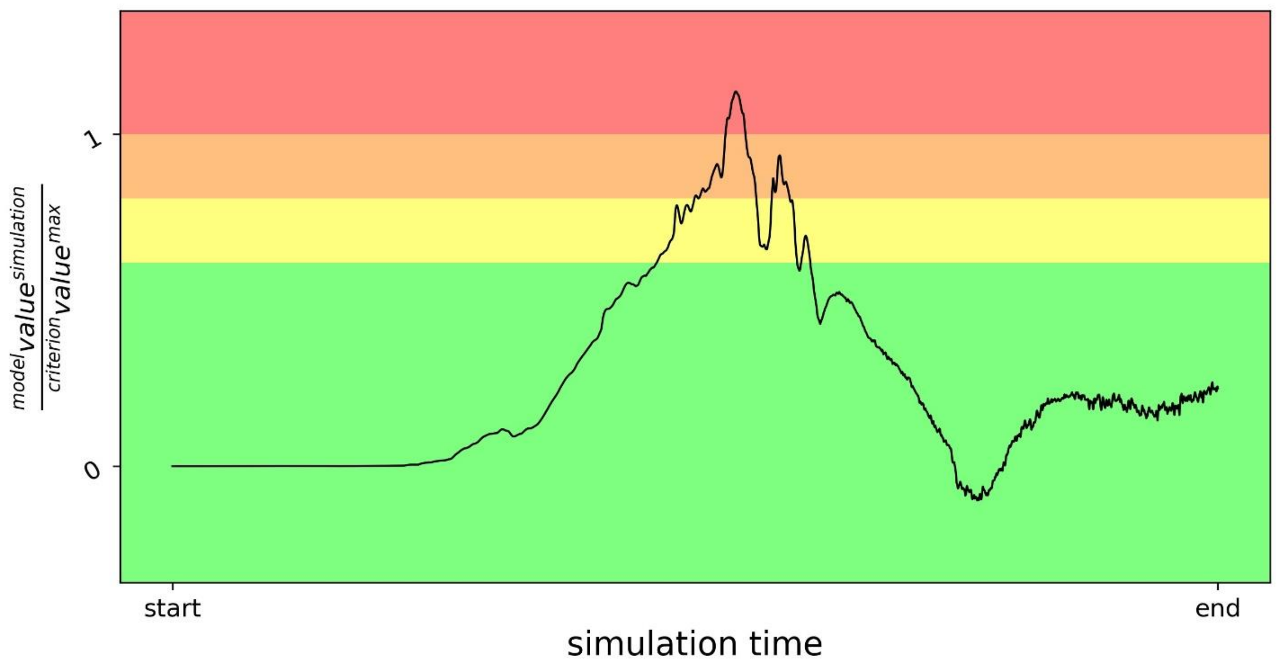
Orientation (0 --> 359)	Acceleration pulse (10 --> 90)	Interior (0 --> 5)	Occupant 1	Occupant 2	Occupant 3	Occupant 4	Body number (1, 2, 3, 4)
			Gender	*Gender*	*Gender*	*Gender*	
			Age	*Age*	*Age*	*Age*	
			Height	*Height*	*Height*	*Height*	
			Weight	*Weight*	*Weight*	*Weight*	

Note: If the seat is not occupied all values are "0" for that seat.

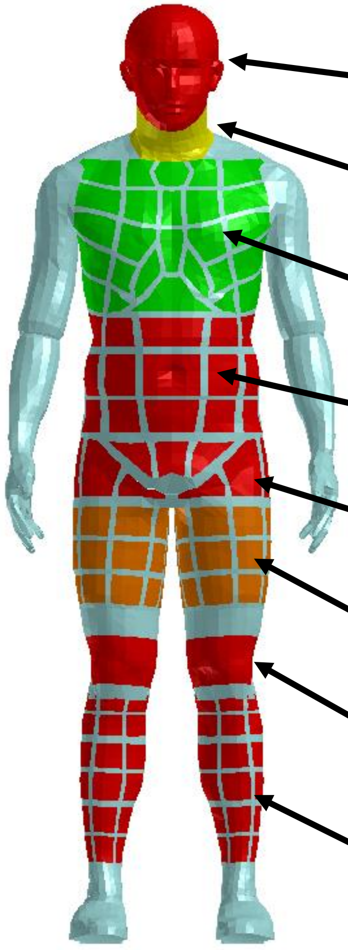
Body injury
Head
Neck
Thorax
Abdomen
Pelvis
Femurs
Knees
Tibiae

Good (3) ★★★
Acceptable (2) ★★☆
Marginal (1) ★☆☆
Poor (0) ☆☆☆

Body part injury number



Poor	0
Marginal	1
Acceptable	2
Good	3

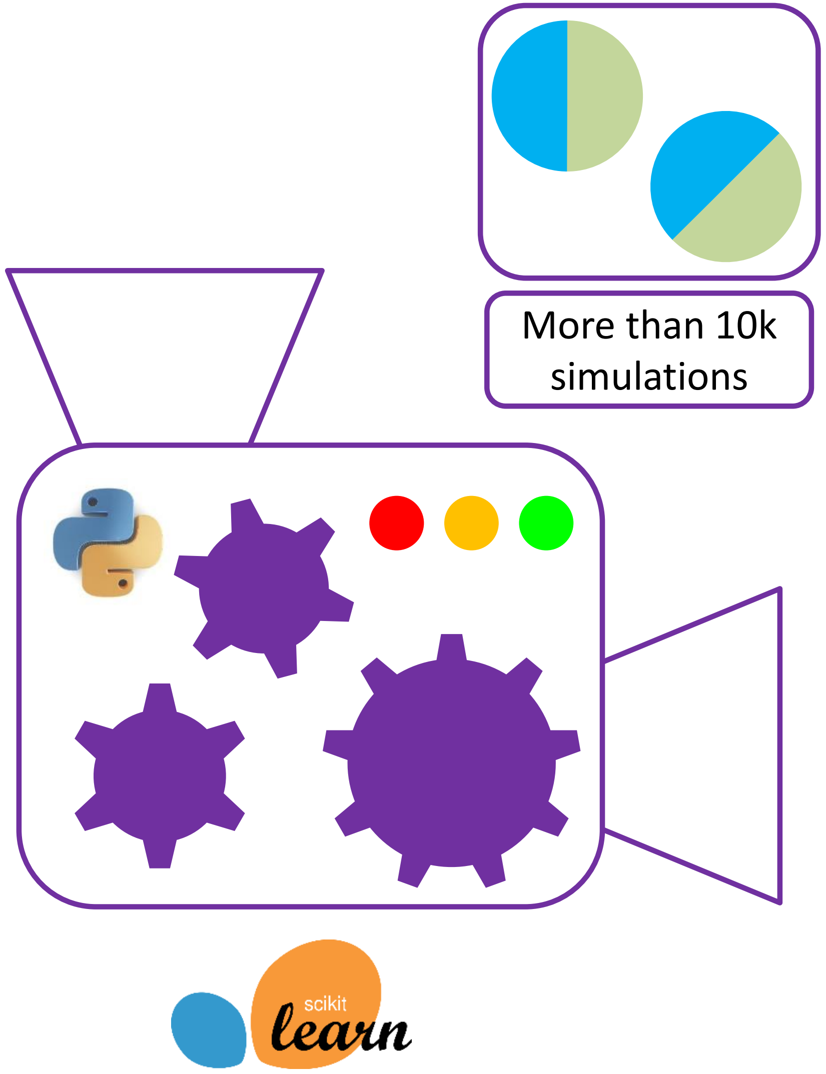


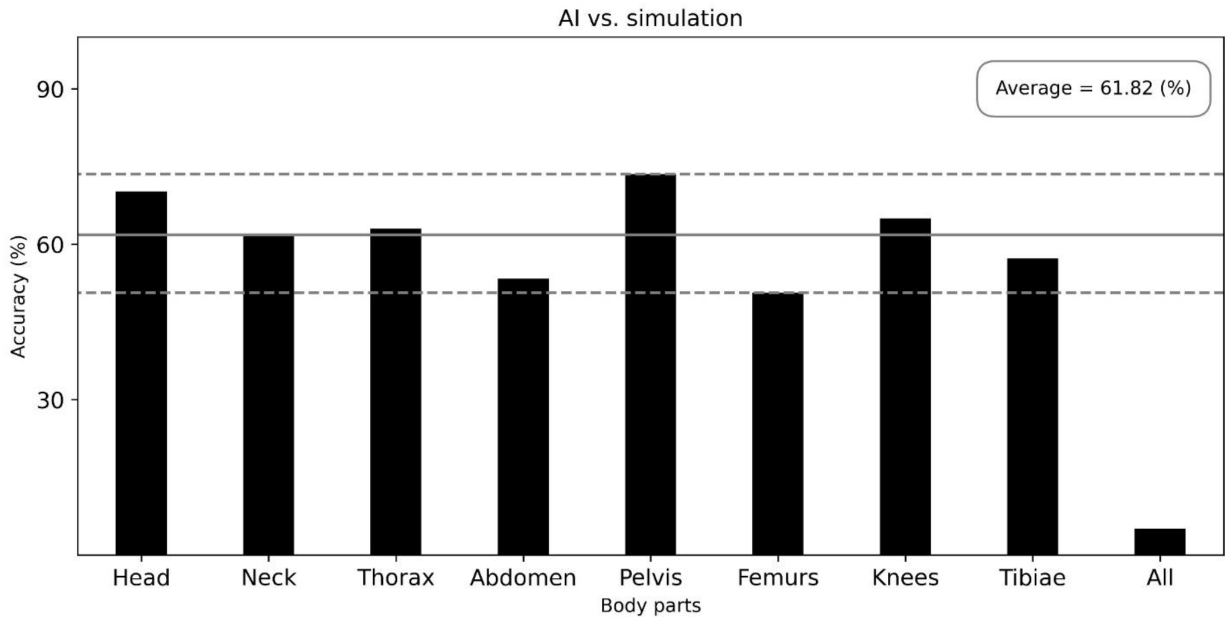
0	Head
2	Neck
3	Thorax
0	Abdomen
0	Pelvis
1	Femurs
0	Knees
0	Tibiae

0	2	3	0	0	1	0	0

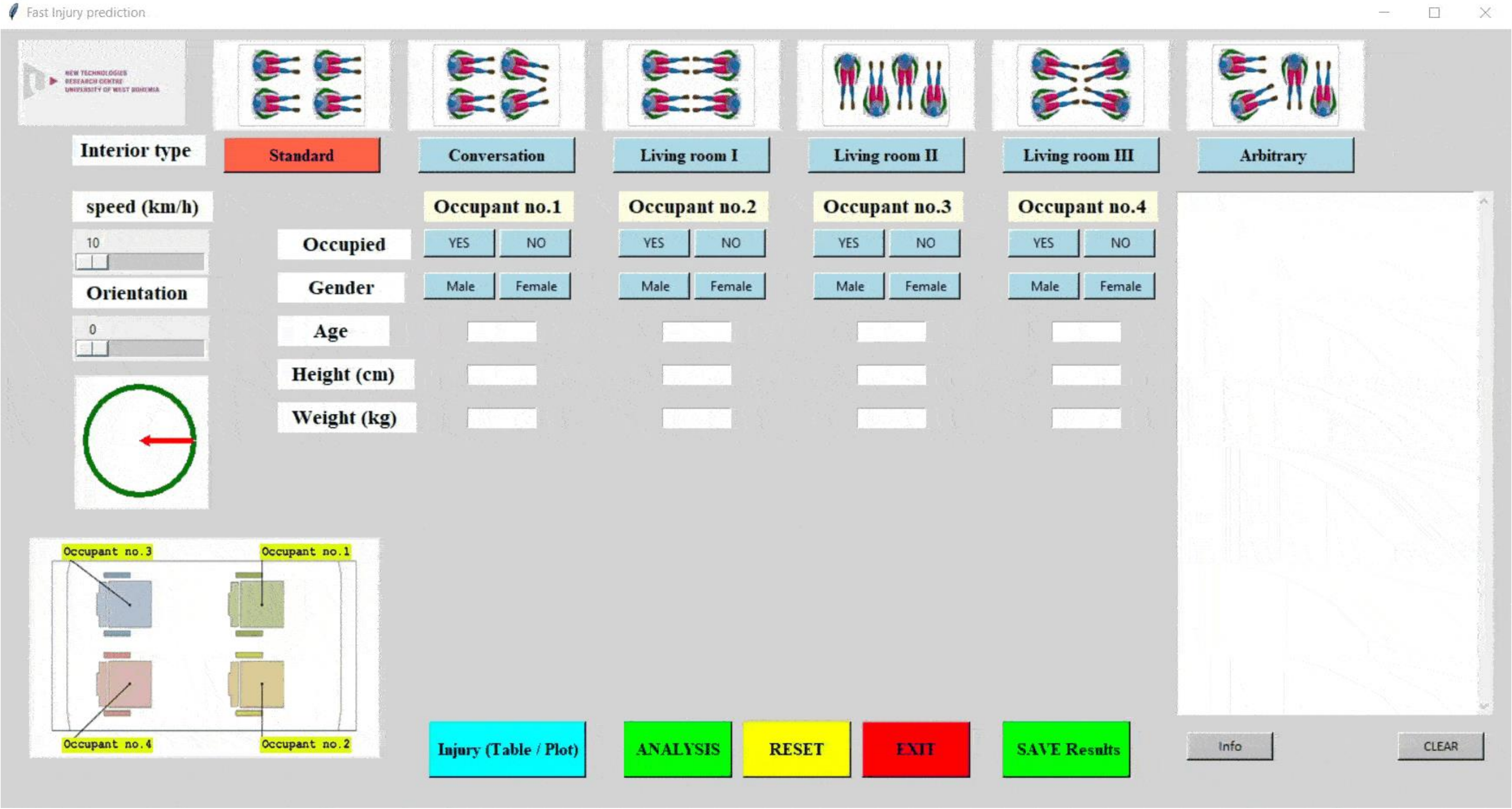
Injury per body part

Artificial Intelligence





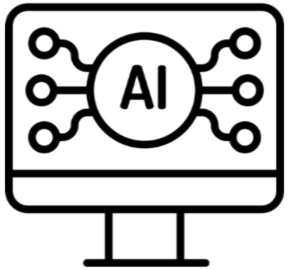
Application for Fast Injury prediction



The application can be used also for …

Call HAV
Taxi / shared car

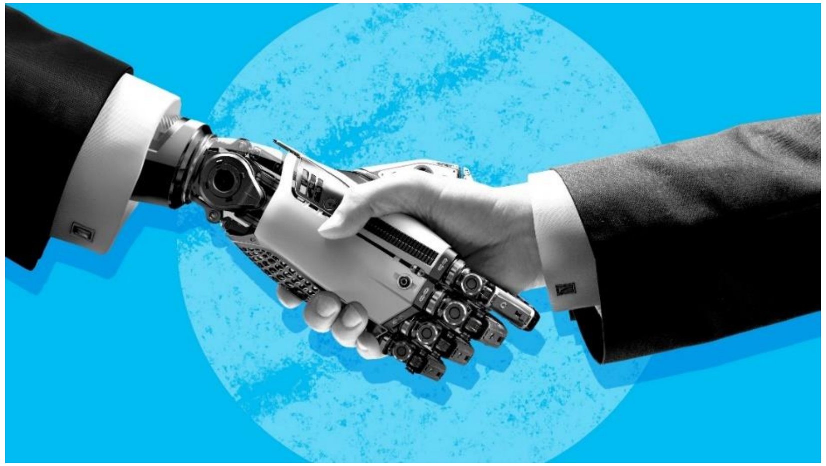
Occupants data
(gender, age, height and weight)
are sent to the server via App.



The AI program
assesses an
occupant’s injury for
different possible
crash scenarios.

- Suggests the safest seat for each occupants.
- Car’s maneuvers are considered regarding to its passengers’ data.

We will use AI for our projects



It was just a beginning of a journey.
You will hear soon from us about other applicable projects with AI regarding to occupants safety.

Thank you!

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Thank you
for your attention!