

Appendix

Table A1. Summary of the information for cases reconstructed. (ETW: electric two-wheeler; A: A-pillar, B: bonnet, W: windshield, G-ground)

Case ID.	Accident type	Impact velocity: Vehicle/VRU (km/h)	Vehicle information			VRU information			
			Vehicle type	Brand	Year built	Gender	Age	Height (cm)	Head impact area
C1	Pedestrian	36/8.57	Seden	Buick	2015	Male	74	165	B+G
C2	Pedestrian	30/5.04	Seden	BYD	2011	Male	69	168	A+G
C3	Pedestrian	28.6/2.16	MPV	Dongfeng	2008	Female	79	158	G
C4	Pedestrian	28.17/0	Sedan	Volkswegen	2011	Female	73	142	G
C5	Pedestrian	33.12/7.2	SUV	Zhongtai	2017	Female	80	154	G
C6	Pedestrian	40/0	Sedan	Volkswegen	2011	Male	80	166	B+G
C7	ETW	25.18/7.2	Sedan	Dongfeng	2008	Male	80	168	G
C8	ETW	61.1/19.7	MPV	Wuling	2015	Female	68	159	W+G
C9	ETW	72.02/17.02	Sedan	Audi	2014	Male	78	174	W+G
C10	ETW	45.4/19.6	Sedan	Chevrolet	2016	Female	66	160	A+G
C11	Bicycle	51.1/10.8	SUV	Beijing	2014	Male	67	170	B+G
C12	Bicycle	23.4/15	Sedan	Volkswegen	2008	Female	73	156	G
C13	ETW	34.2/18	Sedan	Roewe	2015	Female	60	160	W
C14	ETW	32.4/22.6	Sedan	Roewe	2011	Male	69	171	A+G
C15	Bicycle	36/7.56	Sedan	Volkswegen	2008	Male	90	164	W+G
C16	ETW	50.5/23.1	SUV	Audi Q5	2012	Male	64	164	G
C17	ETW	30.6/34.2	SUV	Nissan	2015	Male	72	165	G
C18	ETW	39.3/16.9	Sedan	Elantra	2016	Male	66	160	G
C19	ETW	25.2/3.6	Sedan	FIAT	2015	Male	70	170	B+G
C20	ETW	40/19.4	Sedan	Changan	2015	Male	80	160	G
C21	ETW	21.3/22	Sedan	Buick	2011	Female	64	154	G
C22	ETW	28/18	SUV	Citroen	2013	Male	64	162	G
C23	Pedestrian	45/10.1	Sedan	Volkswagen	2015	Male	75	160	A+G
C24	Bicycle	35.3/5.9	SUV	Porsche	2018	Female	71	160	B+G
C25	Pedestrian	41.3/3.88	MPV	Changan	2016	Male	66	165	G
C26	Pedestrian	45/3.4	SUV	Dongfeng	2014	Female	60	155	B+G
C27	Pedestrian	41.7/11.38	Sedan	Dongfeng	2019	Male	73	170	W+G
C28	ETW	36/25	Sedan	Mazda	2019	Male	62	166	W+G
C29	ETW	40.5/18	Sedan	Kia	2016	Male	74	166	B+G
C30	Pedestrian	53.1/0	Sedan	Chevrolet	2011	Male	79	165	W+G

Table A2. Summary of head injury records and AIS code. (Association for the Advancement Automotive Medicine, 2005)

Case ID	Head injury records	AIS code	MAIS
C1	Scalp hematoma	110402.1	1
C2	Cerebral hematoma, SDH, SAH, STH,DAI	140638.3, 140652.4, 140695.3, 110402.1, 140628.4	4
C3	SDH, SAH,SF,STH	140652.4, 140695.3, 150400.2, 110402.1	4
C4	SDH, SAH,CCL,ICH, Brain swelling	140654.4, 140695.3, 140611.3, 140656.5, 140660.3	5
C5	Concussion	161002.2	2
C6	DAI, CCL, Scalp abrasions	140628.4, 140611.3, 110202.1	4
C7	Brain contusion	140402.3	3
C8	SAH, Brain stem hemorrhage, Intraventricular hemorrhage	140695.3, 140210.5, 140678.2	5
C9	Brain contusion, SL	140616.4, 110606.3	4
C10	Brain contusion	140624.4	4
C11	Scalp abrasions, CH	110202.1, 140640.4	4
C12	SDH, SAH, SF, STH, BH	140652.4, 160695.3, 150400.2, 110402.1, 140202.5	5
C13	No injury	No injury	0
C14	SDH, SAH, SF, DAI, BH	140652.4, 140695.3, 150200.3, 140628.4, 140202.5	5
C15	SF	150202.3	3
C16	STH, SL	110402.1, 110602.1	1
C17	SDH, Concussion, STH, Cerebral infarction	140652.4, 161002.2, 110402.1, 140676.3	4
C18	SAH, SDH, SF, STH	140695.3, 140652.4, 150206.4, 110402.1	4
C19	No injury	No injury	0
C20	SAH, SDH, ICH, SF, Pneumocystis, BH	140695.3, 140656.5, 140649.4, 150400.2, 140682.3, 140202.5	5
C21	SL, SF, Facial bruises, CH	110606.3, 251000.1, 210202.1, 140645.4	4
C22	SDH, SAH, SF	140418.4, 140695.3, 150400.2	4
C23	SL, CCL, Scalp hematoma	110600.1, 140614.3, 110402.1	3

C24	Scalp hematoma	110402.1	1
C25	SDH, SAH, ICH, CCL, SF	140652.4, 140695.3, 140632.4, 140616.4, 150400.2	4
C26	SDH, SF, Traumatic brain herniation, SL	140656.5, 150402.2, 140202.5, 110600.1	5
C27	SF, SAH, SL, Cerebral infarction	150206.4, 140695.3, 110602.1, 140676.3	4
C28	SDH, SAH, SF, Pneumocystis	140654.4, 140695.3, 150000.2, 140682.3	4
C29	SDH, SAH, SL, SF, CCL, STH, Pneumocystis	140654.4, 140695.3, 110600.1, 150000.2, 140618.5, 110402.1, 140682.3	4
C30	Scalp hematoma	110402.1	1

*SDH: subdural hematoma, SAH: subarachnoid hematoma, STH: soft tissue hematoma, DAI: Diffuse axonal injury, SF: skull fracture, CCL: cerebral contusion/laceration, ICH: intracranial hematoma, SL: Scalp laceration, CH: Cerebral hematoma, BH: Brain herniation, SH: Traumatic brain herniation.

Table A3. Summary of head velocities at the time before the head-to-vehicle and ground impact

Case ID	Time to Impact (ms)	Head linear velocity (m/s)			Head angular velocity (rad/s)		
		v_x	v_y	v_z	ω_x	ω_y	ω_z
C1	132	1.62	-3.92	-3.58	-35.48	-1.41	8.13
	1100	0.236	-4.533	-1.747	7.78	6.78	3.25
C2	162	-0.987	-6.516	-6.087	3.61	-19.15	-3.6
	403	-2.684	-6.35	-5.4	7.28	-3.65	-4.16
C3	683	0.548	-1.405	-4.26	0.013	1.014	-1.139
C4	400	1.326	-3.844	-5.517	-6.45	-1.326	-0.786
C5	499	0.757	-10	-7.107	-5.624	-0.096	0.92
C6	113	-1.85	0.73	-8.63	-61.76	-9.6	23.68
	1223	-0.305	-5.46	-3.15	14.46	-8.94	6.03
C7	804	0.86	-2.61	-7.07	10.9	0.76	1.61
C8	50	-4.1013	-14.02	-10.014	-93.76	-23.97	-9.652
	725	-3.117	-17.94	-4.71	0.024	-0.01	-3.25
C9	134	0.96	11.29	-8.73	-46.21	-3.52	0.44
	1139	0.74	-11.14	-5.36	-1.098	0.67	-2.35
C10	127	-1.82	7.46	-3.85	-30.89	0.16	-3.68
	1005	1.239	-5.772	-8.17	20.08	21.44	-4.85
C11	114	-0.791	-3.3494	-9.869	-64.716	-10.884	20.695
	993	-0.534	-7.339	-4.968	1.726	-1.326	-9.232
C12	826	2.845	3.169	-8.944	-22.25	8.703	-2.92
C13	301	-0.527	-4.262	-1.346	-6.605	0.65	9.404
C14	260	-0.854	1.3233	-1.346	-13.001	-4.327	5.829
	868	1.281	-5.891	-6.201	21.399	-16.6	6.943
C15	179	-0.28	6.7319	-4.2105	-19.79	-6.32	5.387
C16	1330	0.059	-4.764	-2.747	2.76	15.386	-3.691
	785	2.318	-2.279	-6.491	37.01	-9.789	5.175
C17	578	-6.159	8.219	-3.38	-3.61	-3.57	-9.69
C18	672	0.132	-2.971	-3.243	-7.87	0.84	18.25
C19	296	-0.32	0.517	-1.976	-6.921	-1.067	0.097
	1061	-0.11	-1.797	-1.866	-2.783	3.603	-0.37
C20	760	0.838	-2.017	-3.829	27.54	-0.412	0.54
C21	521	1.241	-6.518	-7.064	1.771	-1.92	-3.44
C22	867	0.6824	-5.6066	-5.0505	18.3916	-19.596	0.4512
C23	128	1.7666	-6.818	-7.0086	-25.59	-6.29	7.68
	654	3.7184	-5.8952	-2.7516	-2.95	-3.75	1.6
C24	235	0.0659	-0.7344	-4.7066	10.92	0.602	-0.05
	645	-1.1112	4.2457	-2.0985	16.94	-4.59	0.19
C25	1070	8.0777	-2.1697	-8.121	-11.93	58.76	-19.34
C26	76	1.6215	3.4809	-7.4496	-54.036	-1.275	-8.004
	1026	0.661	-7.1075	-5.9919	51.81	-8.114	5.484
C27	152	0.9808	6.8129	-2.2648	-21.29	-20.35	-1.97
	684	1.676	-2.073	-7.205	6.661	0.847	2.766
C28	300	0.9221	-2.6294	-0.0923	-10.37	5.2	-4.96
	862	3.0155	-6.5896	-5.3771	-0.57	1.91	4.19
C29	206	-2.405	0.424	-4.077	-12.055	7.993	6.319
	1706	-0.3588	-3.3464	-2.1135	-1.6328	11.114	-9.4361
C30	95	-1.0795	7.2519	-9.0019	-70.75	-9.03	2.02
	1269	-1.3353	-11.474	-3.2994	-7.54	2.08	1.35

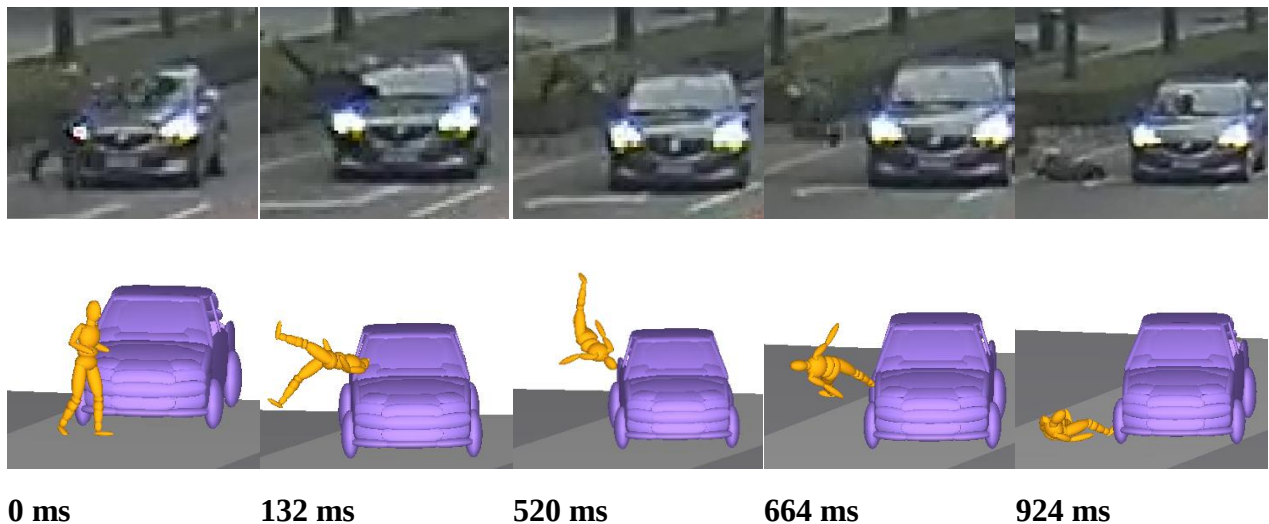
Table A4. Summary of calculated head injury parameters for cases reconstructed

Case ID	Head kinematic-based criteria				Tissue level injury criteria			
	Ang_vel (rad/s)	Ang_acc (rad/s ²)	Lin_acc (g)	HIC ₁₅	Pressure (kPa)	MPS	CSDM (0.15)	CSDM (0.25)
C1	20.5	6080	137	321	344	0.65	0.18	0.009
C2	68.3	31382	411	2162	1198	1.64	0.953	0.659
C3	63.1	12693	216	1423	1313	2	0.975	0.847
C4	85.7	14052	394	2998	1480	2.46	0.96	0.614
C5	25	20465	166	1522	397	0.84	0.586	0.358
C6	68.03	26527.7	176.8	1170.4	479.4	0.755	0.412	0.0972
C7	20.4	11702	370	1808	2402	1.22	0.633	0.243
C8	97.262	20152	319.58	3311	3032.67	2.28	0.996	0.975
C9	70.1	24614	279	1841	2638	1.387	0.831	0.699
C10	51	31859	530	2897	3618	0.77	0.888	0.494
C11	21.3	22900	319	2630.3	195.1	0.822	0.5298	0.1813
C12	48.9	36688	513	2889	3587	0.729	0.855	0.4673
C13	25	5550	160	214	319	0.77	0.561	0.189
C14	52.6	33469	372	2399	1467	2.165	0.9367	0.5924
C15	43.5	17093	230	817	637	0.8	0.619	0.231
C16	48.7	29500	388	4238	1123	2.02	0.906	0.603
C17	66.2	21629	213	1153	971	2.248	0.9607	0.7552
C18	38.614	14428	254.69	1440	408.7	1.047	0.802	0.412
C19	17.12	6730.8	157.89	377.5	177.71	0.966	0.621	0.282
C20	19.1	24900	530.33	2389	1128.48	1.822	0.7392	0.3917
C21	35.84	25817	290.8	1217	803.8	1.884	0.714	0.376
C22	43.395	23263	330.32	3031	2160	0.9642	0.8421	0.4247
C23	35.24	17137.9	298.67	1476.2	815.1	1.228	0.9186	0.3018
C24	34.73	10615.1	154.89	759.9	78.44	0.322	0.037	0.00097
C25	32.527	14802	246	1200	372.9	1.71	0.683	0.304
C26	65.21	19676	175.38	1000.4	271.8	0.956	0.5372	0.245
C27	27.54	14337	358.23	2916	936.7	1.899	0.9739	0.8128
C28	37.52	25603.2	176.08	1103.8	612.3	1.91	0.9419	0.7524
C29	15.16	12802.1	163.75	486.7	591.9	1.47	0.8562	0.49085
C30	14.4	9770	73	103	621.6	1.016	0.6101	0.3604
No head AIS 4+	Min	14.4	5550	73	103	78.4	0.32	0.04
	Ave	28.7	12267	187.8	823.1	417.1	0.93	0.56
	Max	43.5	20465	298.7	1522	815.1	1.71	0.92
Head AIS 4+	Min	15.2	11702	163.8	486.7	195.1	0.73	0.41
	Ave	50.3	23178	326.3	2153.2	1500.5	1.57	0.82
	Max	97.3	36688	530.3	4238	3618	2.46	0.996
*Magnitude of the difference	21.6	10911	138.5	1330.1	1083.4	0.64	0.26	0.291

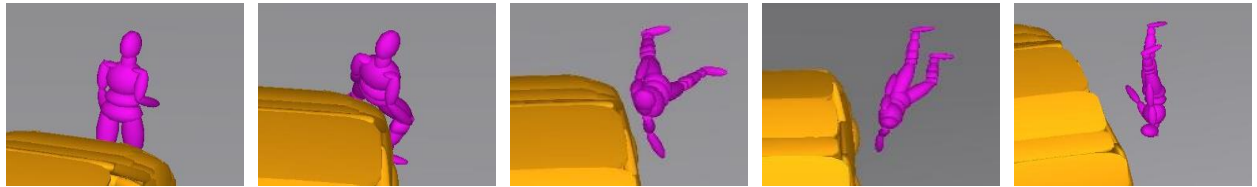
* Magnitude of the difference=Average_(AIS≥4)-Average_(AIS<4)

Figure A1: Comparison of reconstructed kinematics with video screenshots.

Case ID: C1



Case ID: C2



0 ms

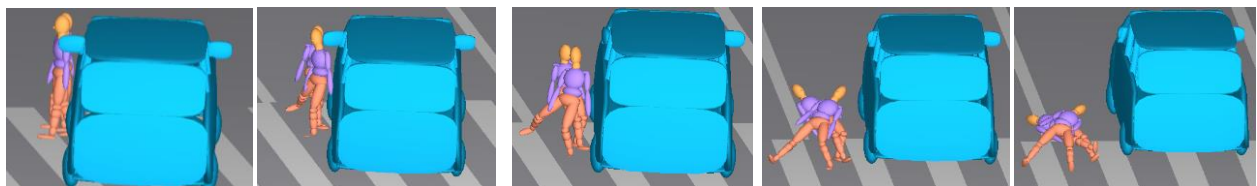
160 ms

280 ms

360 ms

480 ms

Case ID: C3



0 ms

120 ms

280 ms

480 ms

600 ms

Case ID: C4



0 ms

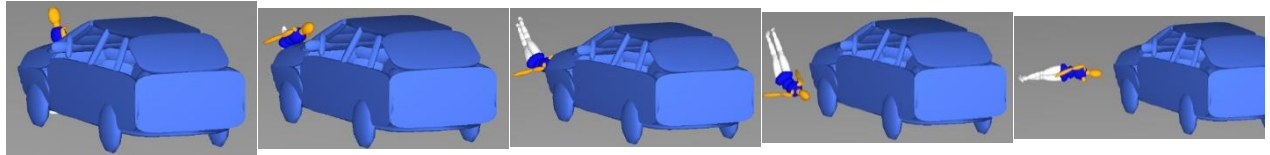
180 ms

280 ms

398 ms

780 ms

Case ID: C5



0 ms

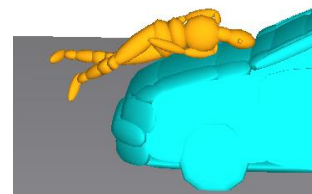
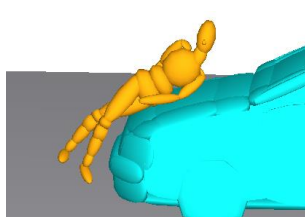
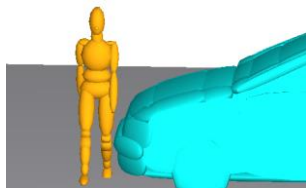
208 ms

417 ms

489 ms

2000 ms

Case ID: C6

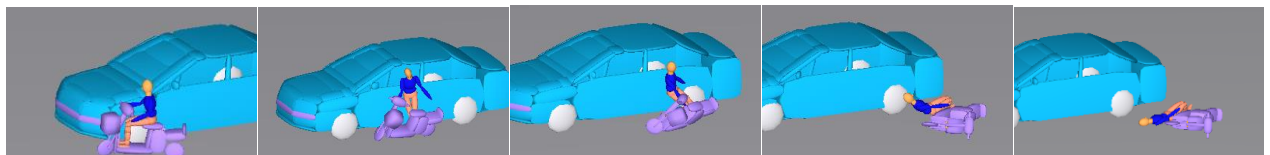


0 ms

80 ms

114 ms

Case ID: C7



0 ms

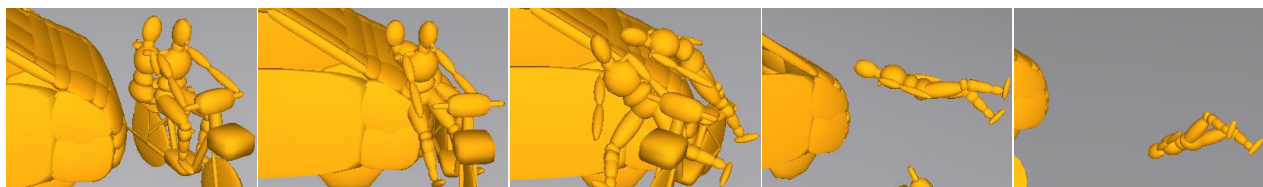
200 ms

360 ms

520 ms

600 ms

Case ID: C8



0 ms

50 ms

100 ms

325 ms

400 ms

Case ID: C9



0 ms

400 ms

800 ms

960 ms

1100 ms

Case ID: C10



0 ms

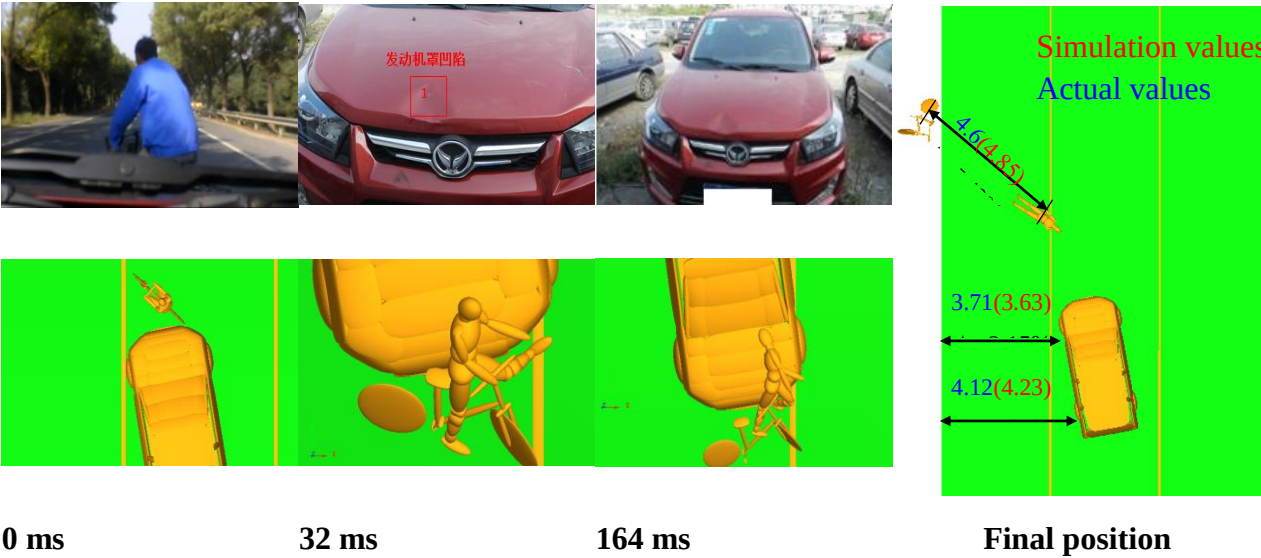
126 ms

258 ms

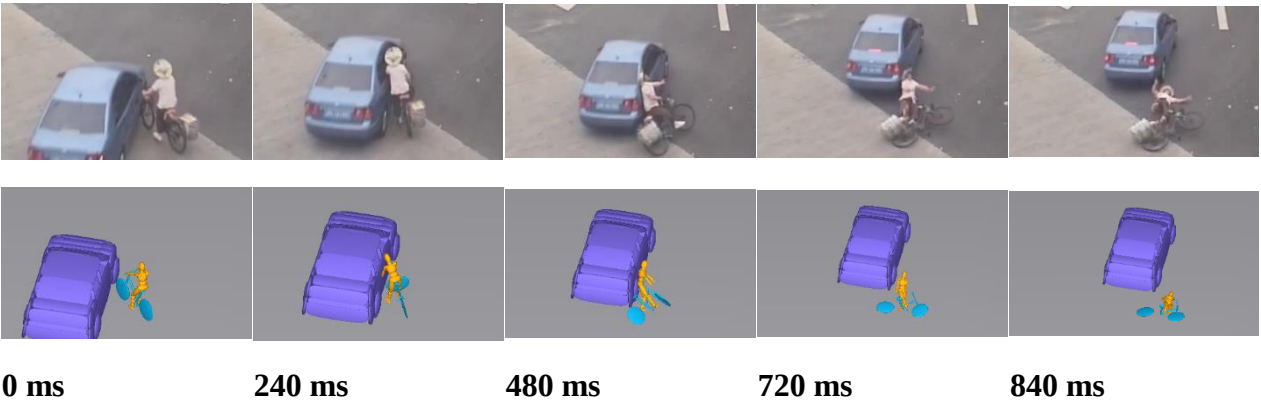
525 ms

850 ms

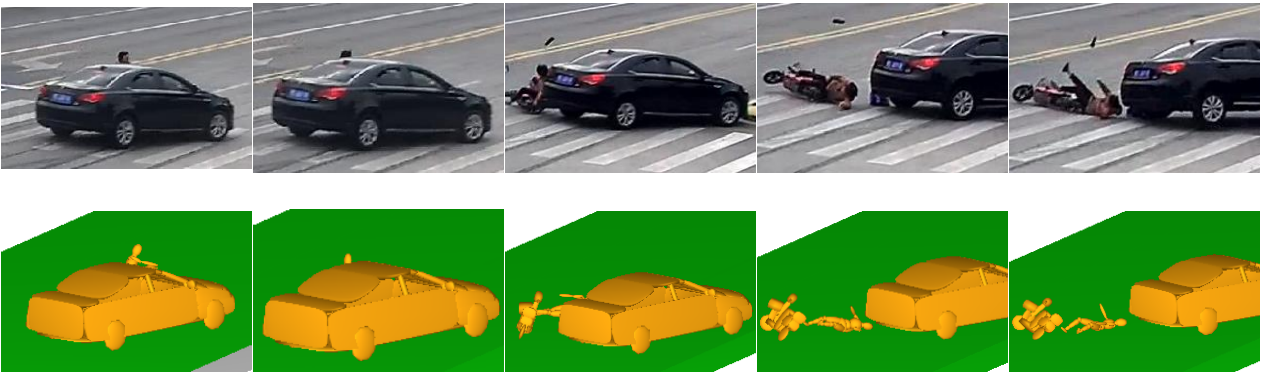
Case ID: C11



Case ID: C12



Case ID: C13



0 ms

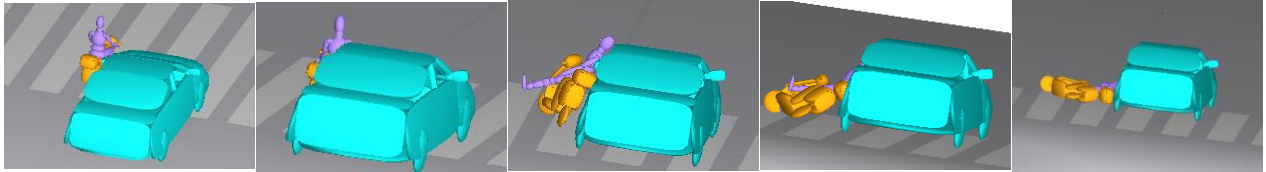
80 ms

320 ms

480 ms

560 ms

Case ID: C14



0 ms

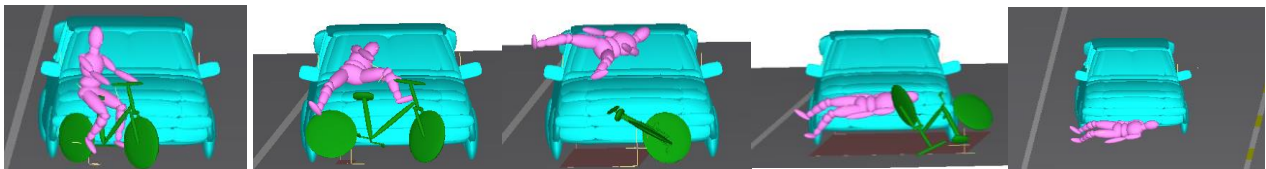
75 ms

240 ms

840 ms

982 ms

Case ID: C15



0 ms

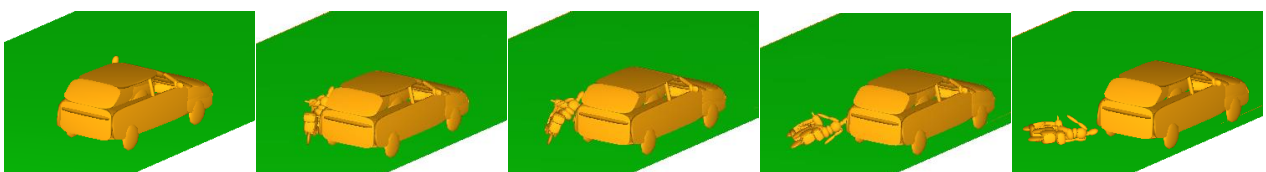
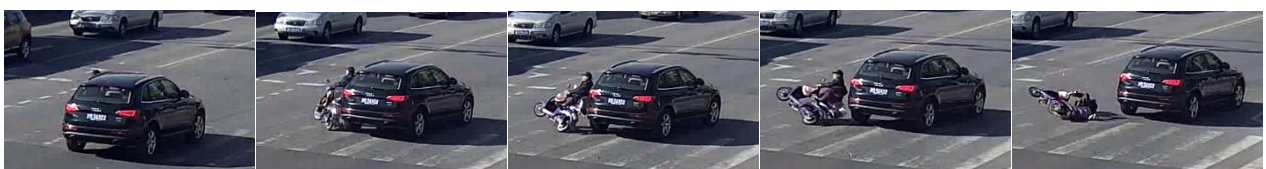
185 ms

250 ms

500 ms

650 ms

Case ID: C16



0 ms

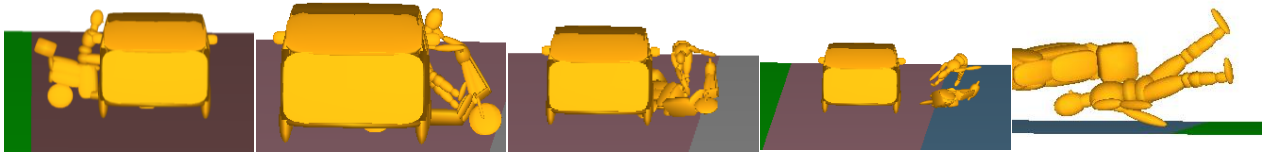
200 ms

490 ms

530 ms

740 ms

Case ID: C17



0 ms

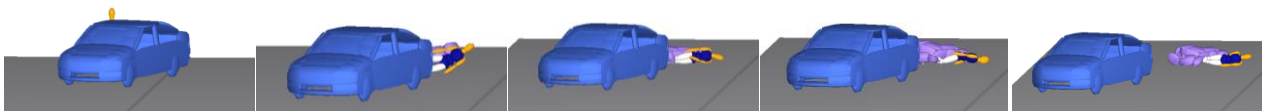
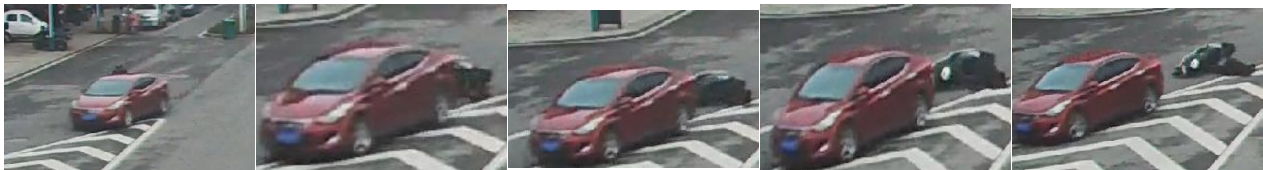
50 ms

100 ms

200 ms

575 ms

Case ID: C18



0 ms

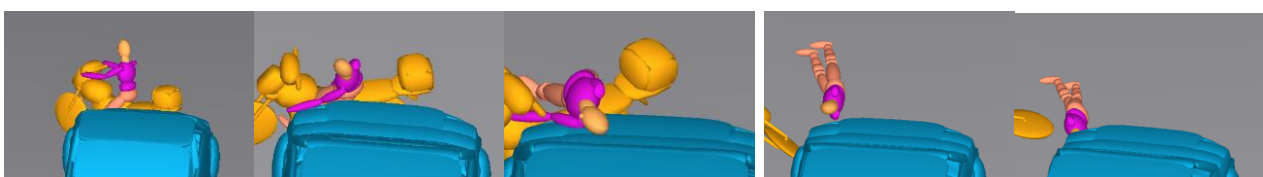
120 ms

160 ms

240 ms

360 ms

Case ID: C19



0 ms

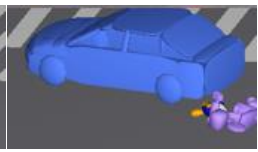
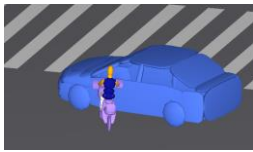
193 ms

298 ms

696 ms

844 ms

Case ID: C20



0 ms

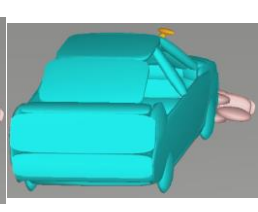
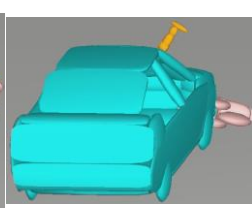
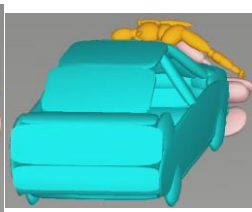
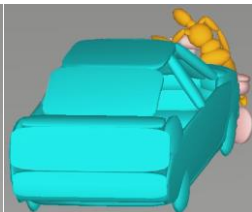
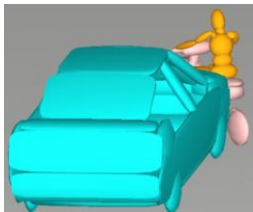
310 ms

430 ms

830 ms

1050 ms

Case ID: C21



0 ms

70 ms

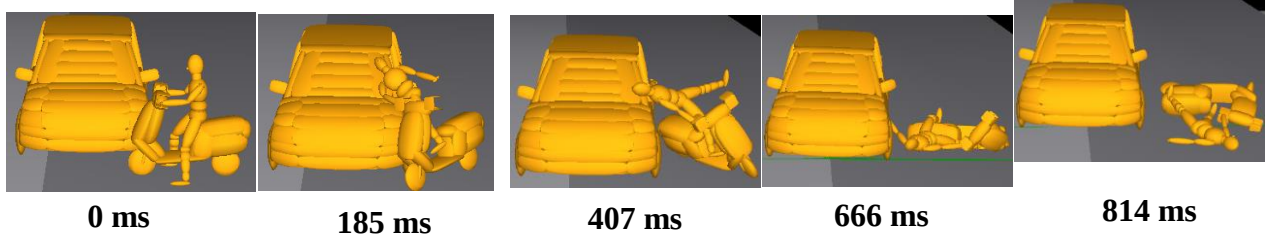
238 ms

466 ms

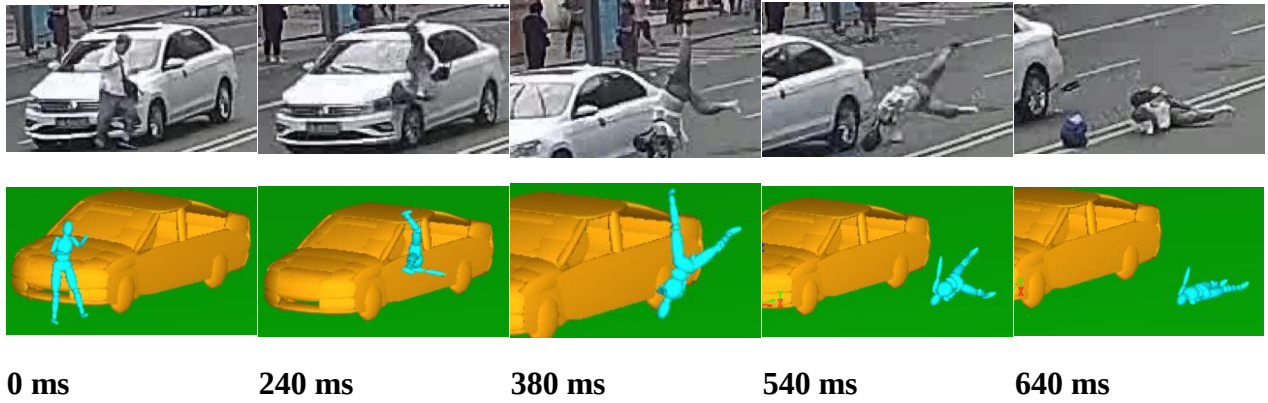
550 ms

Case ID: C22

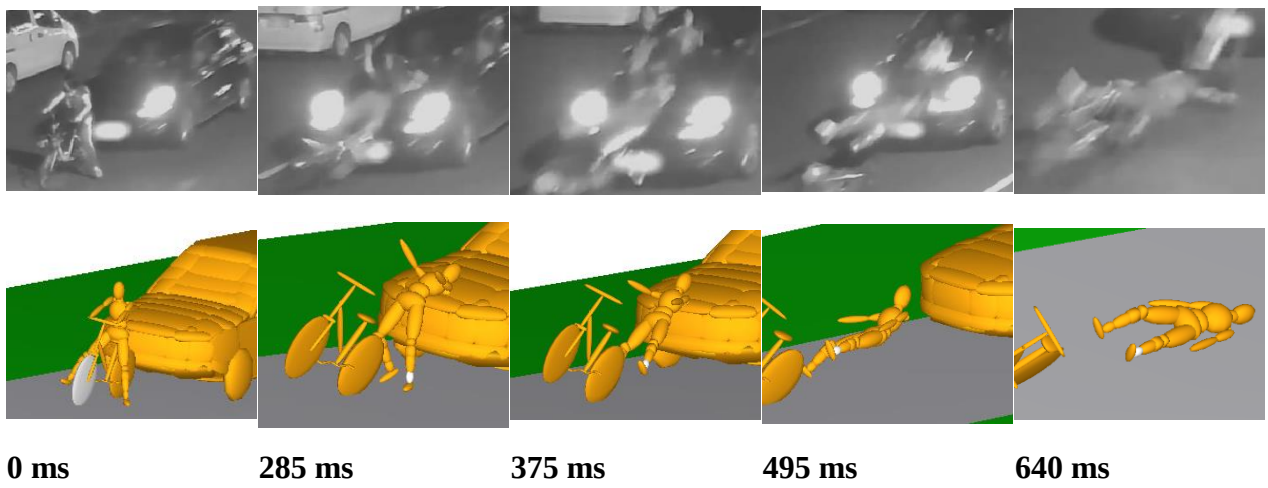




Case ID: C23

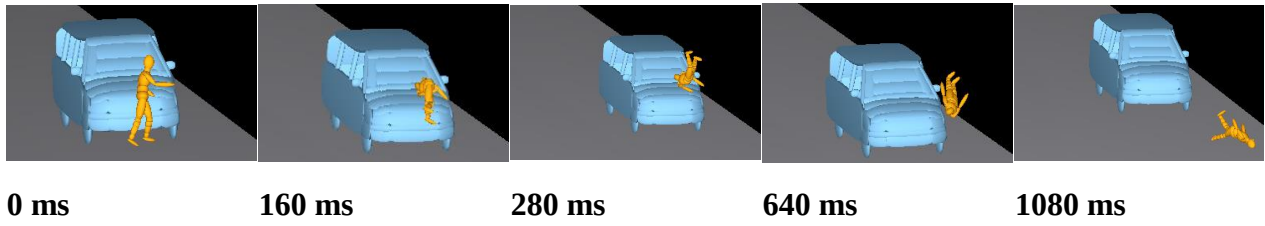


Case ID: C24

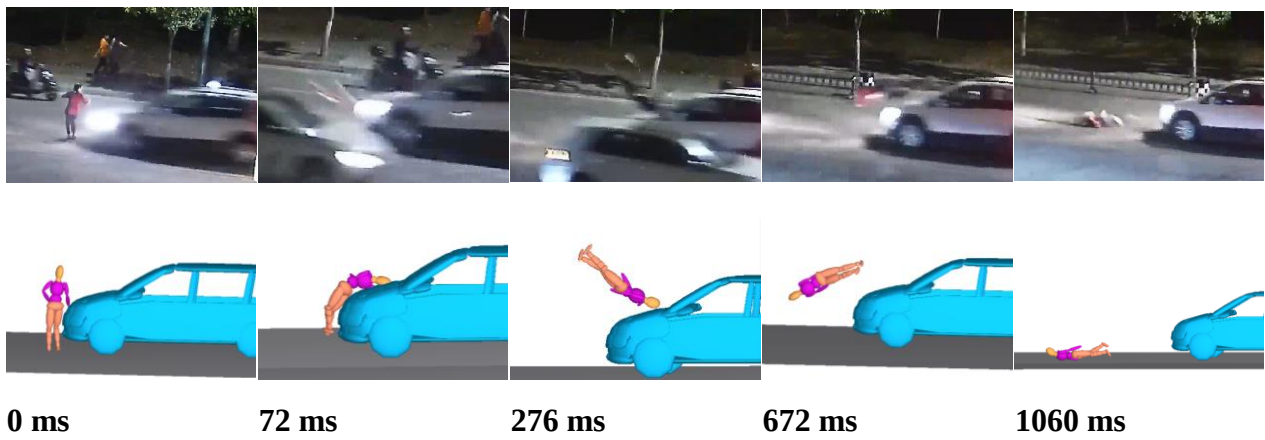


Case ID: C25

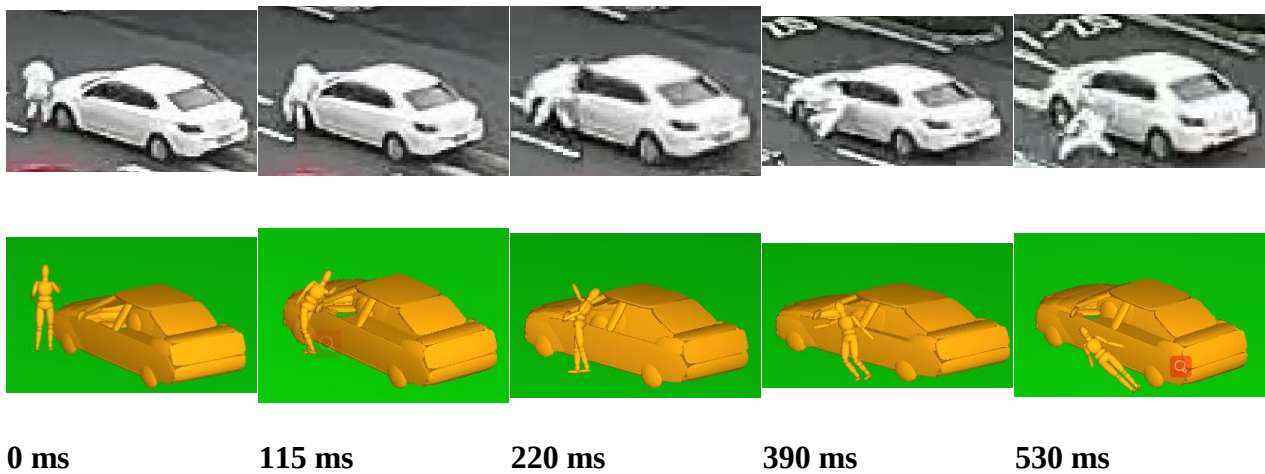




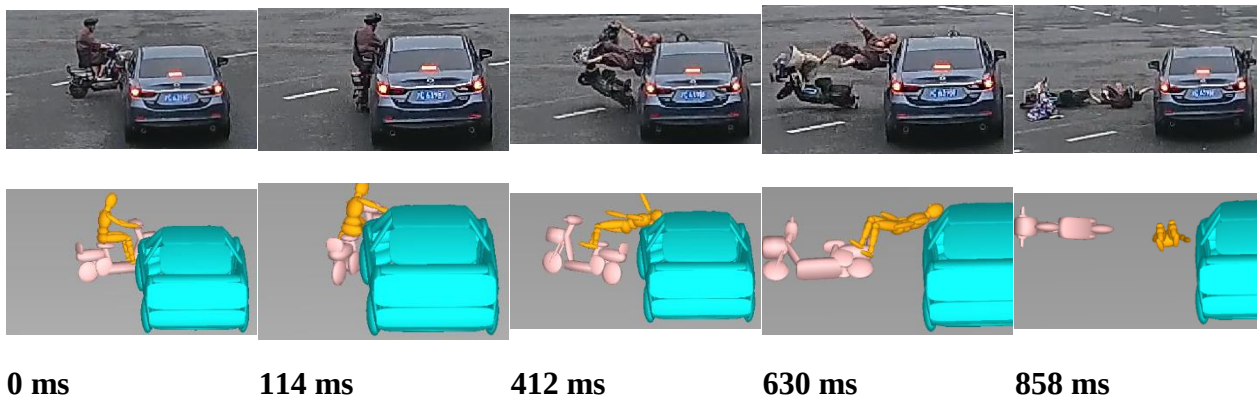
Case ID: C26



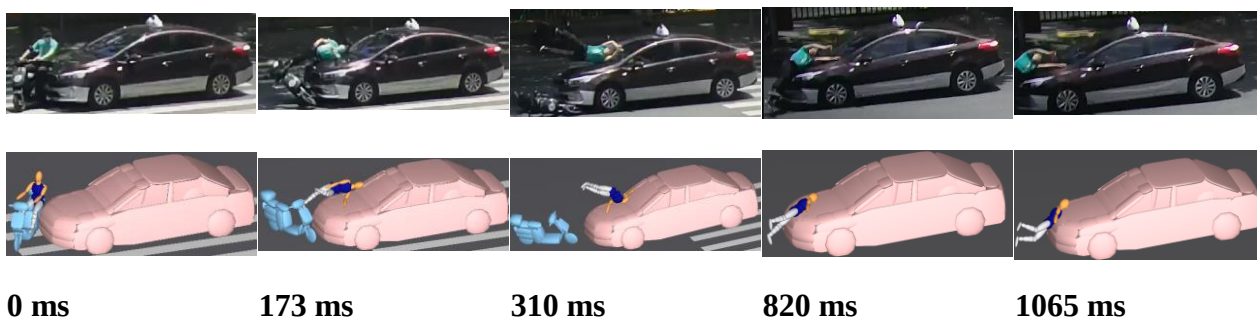
Case ID: C27



Case ID: C28



Case ID: C29



Case ID: C30

