Master thesis

A generator of computer models of the human body for the reconstruction of road accidents

Daniel Wdowicz
Biomechanics & Biorobotics
Academic year 2018/2019

Supervisor: dr hab. inż. Cezary Rzymkowski, prof. PW

1. Introduction

The work of forensic experts is reliant largely on analysis of evidence found by the police at the site of an vehicle accident. However, with the growing popularity of dedicated software for crash simulations, it is now possible to recreate the event even while having limited data. Robust models of car-human interactions are currently being developed, which allow for a great degree of accuracy when it comes to determining the course of a specific accident.

The aim of this study was to create and validate a generator of human body models intended for the use in pedestrian road accident simulation and forensic reconstruction. After the investigation of the relevant papers, a set of simplifying assumptions for the generator was established.

2. Database & Model generator

Regression formulas for the geometric dimensions and mass parameters of the generated body model, as well as joint and segment stiffnesses were defined. The parameters for human body models were based on well-documented measurements of anthropometric dimensions of US and German Army Air Force personnel, coupled with a database on a Polish civilian population.

#	DIMENSION	#	DIMENSION
0	Weight	16	Hip Breadth, Standing
1	Standing Height	17	Shoulder to Elbow Length
2	Shoulder Height	18	Forearm-Hand Length
3	Armpit Height	19	Biceps Circumference
4	Waist Height	20	Elbow Circumference
5	Seated Height	21	Forearm Circumference
6	Head Length	22	Waist Circumference
7	Head Breadth	23	Knee Height, Seated
8	Head to Chin Height	24	Thigh Circumference
9	Neck Circumference	25	Upper Leg Circumference
10	Shoulder Breadth	26	Knee Circumference
11	Chest Depth	27	Calf Circumference
12	Chest Breadth	28	Ankle Circumference
13	Waist Depth	29	Ankle Height, Outside
14	Waist Breadth	30	Foot Breadth
15	Buttock Depth	31	Foot Length

Figure: 32 anthropometric dimensions on which the human body model was based

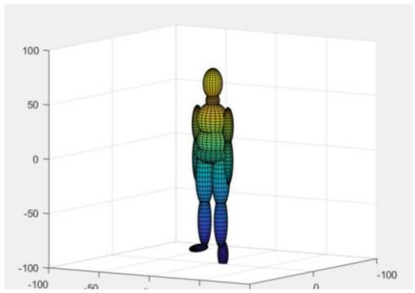

Figure: Geometry of the human body model visualised in Matlab

Human body model generator was developed using Matlab software. The input for the script-generator was stature and mass of a model, while the output was an XML file, which contained all necessary information about the model.

XML files could later be processed using MADYMO software in order to create a multibody model of a human body, which model could later be using in vehicle accident applications.

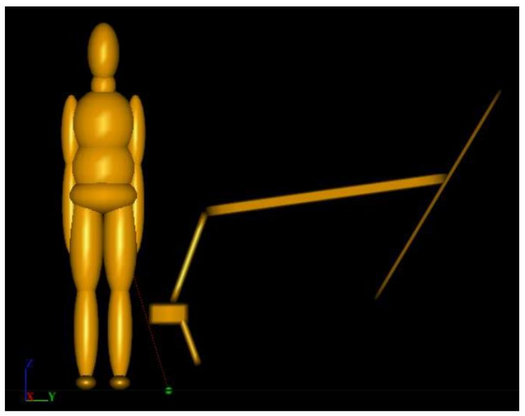

Figure: Simulation setup used to validate the response of the created multi-body human body model

3. Model validation

In order to validate the parameters and accuracy of the computer models, multiple simulations of pedestrian accidents were carried out using MADYMO software. The simulations were based on well-documented tests with cadavers.

Test #	Car-front	Bumper-system	Velocity (km/h)	Age/Sex	Weight (kg)	Length (cm)
T1	**C1**	Standard	25	54m	75	180
T2	**C1**	Standard	25	74m	56	167
T3	**C1**	Standard	32	48m	62	170
T4	C1	Standard	32	**58m**	85	185

Figure: A sample of four configurations of tests with cadavers, on which MADYMO simulations were based

The results of the simulations, most primarily body projection distance, were compared with results obtained from experimental formulas often used by forensic experts.

4. Conclusions

- Validation simulations showed a high degree of accuracy of the generated human body model
- Further steps of development of both generator and the model have been specified
- There remains a need for validation of the model against the backdrop of different pedestrian accident configurations