Simulation of a real accident with a pedestrian using a FE human model: potential from the view of Integrated Safety

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I. INTRODUCTION

Pedestrian and cyclist casualties represented about 25% of the fatalities in traffic accidents in Germany in 2012 [1]. Since about half of the frontal collisions with a pedestrian are non- or partially braked [2], Advanced Emergency Braking (AEB) systems are expected to have a great potential for the improvement of the protection. Based on a real world accident reconstruction, this study tries to assess not only the decrease of the impact speed with an AEB system but also the influence of such a system on the injury risk.

II. METHODS

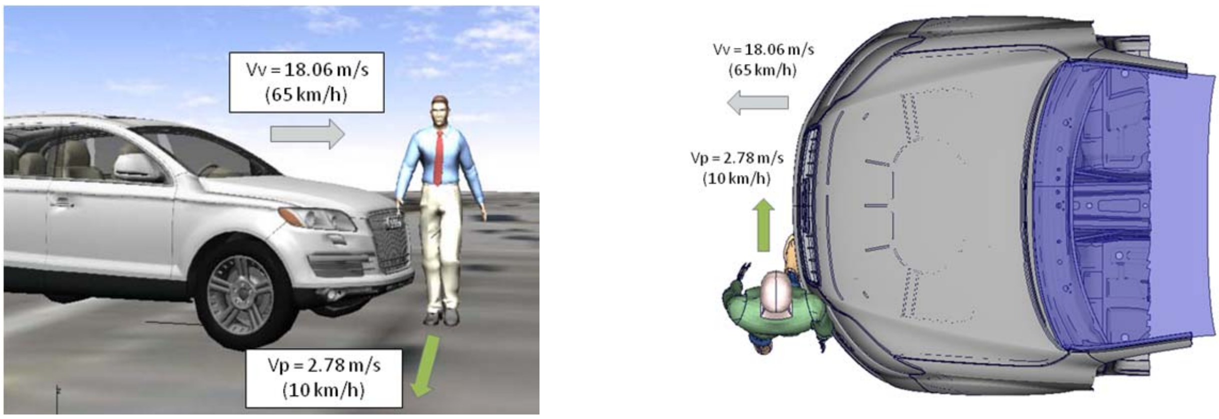
A real world pedestrian accident of the Audi Accident Research Unit (AARU) database was analyzed and simulations with the Finite Element (FE) human model THUMS v3 (Total Human Model for Safety) [3] were performed in order to get a better understanding of the accident as well as of the injury mechanisms.

Description of the accident

The selected accident involves a SUV Audi Q7. Based on the accident analysis, the velocity of the vehicle was assessed to be 65 km/h with no braking before and at the beginning of impact. The pedestrian survived the accident but sustained severe injuries (MAIS 4): several fractures to the head, the pelvis and the right tibia as well as contusions to the head, the thorax and the right knee (Figure 2a).

Computational Modeling

The circumstances of the accident were exactly reproduced in the simulation, including the impact location, impact speed, the kinematics of the pedestrian, etc. An initial velocity of 65 km/h was implemented to a FE model of an Audi Q7 (Figure 1). The human model THUMS was scaled in order to fit the size and the weight of the victim. The position of impact and the posture of the pedestrian model were optimized in order to fit both the deformation of the vehicle and the injuries of the pedestrian. The risk of fractures of the FE model is then consistent with the injuries of the real pedestrian. Based on this first step, further investigations were performed in order to assess the influence of an AEB system.



(a) (b)

Fig. 1 - Configuration of the real accident (a) and boundary conditions of the simulations with THUMS (b)

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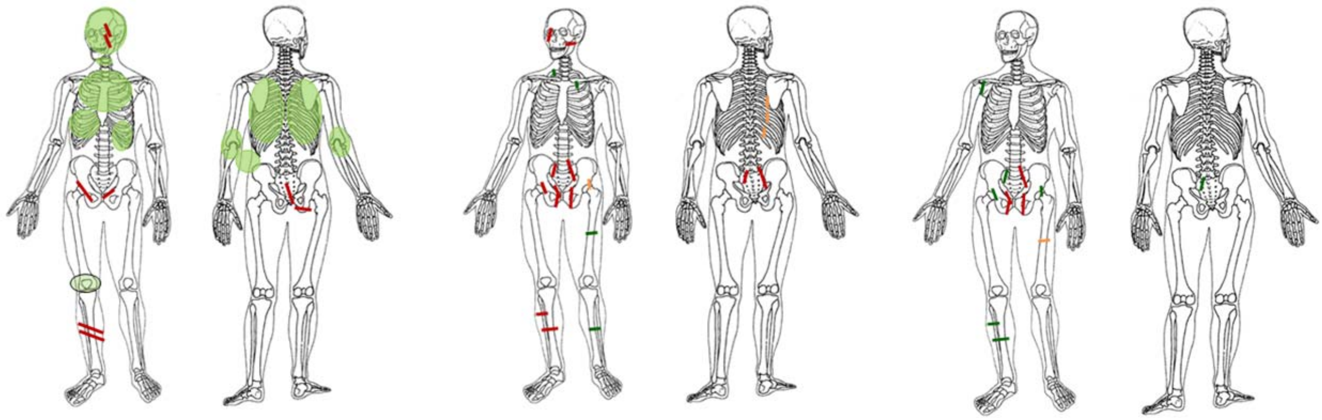
III. INITIAL FINDINGS

The optimized configuration of the impact corresponds to a walking posture with the left leg rearward. The comparison of the head impact location on both the real and the FE-model windscreens reinforces the consistency of the kinematics provided by the model. The deformations of the vehicle are then consistent with the damaged vehicle and most of the fractures predicted by the human model THUMS are consistent with the ones of the victim (Figure 2). However, a slight over-estimation of the pelvic fractures is noticed in the human model.



(a) (b) (c)

Fig. 2 - Assessment of the injuries of the real pedestrian (a) and of the human model at 65 km/h (b) and with an AEB system at 40 km/h (c)

According to the configuration of the accident, an impact velocity of 40 km/h is expected with an AEB system. A new simulation with the previous pedestrian location and posture and a velocity of 40 km/h was then performed. The number as well as the severity of the injuries assessed by THUMS is clearly lower with an AEB system (Figure 2): no head fractures, lower likelihood and lower severity of fractures for the rest of the body.

IV. DISCUSSION

As a result, the injuries of the victim were reproduced with a good degree of accuracy. This accuracy could be improved with a further optimization of the boundary conditions (stance of the pedestrian, location of impact, vehicle velocity, etc.) using, for instance, a Design of Experiments.

The study concludes with a comparison of possible passive methods as opposed to the AEB method simulated in this case study, thereby giving an indication of the field effectiveness of both approaches. AEB systems are expected to offer real benefits for pedestrian safety. This study highlighted some of these benefits through an example of a real accident. The methodology used will be generalized for the reconstruction of other accidents in order to contribute to a better understanding of the injury mechanisms with and without an AEB system.

V. REFERENCES

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