

## Modelling of Car Occupant Muscle Responses in a Finite Element Human Body Model

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Over 30 000 fatalities related to the road transport system are reported in Europe annually. Of these fatalities, the largest share is car occupants, even though significant improvements in vehicle safety have been achieved by the implementation of in-crash restraints and pre-crash driver support systems. Integration of pre-crash and in-crash safety systems provides a potential for further reduction of car occupant fatalities. For virtual development of integrated systems, numerical occupant models are needed. At the present, finite element (FE) human body models (HBM) are commonly used for crash simulations, but not for pre-crash scenarios due to the lack of active muscles. This presentation addresses a method to include postural muscle responses in an FE HBM for simulation of integrated safety systems.

A whole body FE HBM, the Total HUMAN Model for Safety AM50 version 3.0 (Toyota Motor Corporation 2008) is used, hereafter denoted THUMS<sup>®</sup>. The anthropometry and seating position of the THUMS<sup>®</sup> is based on the 50<sup>th</sup> percentile male reported by Robbins et al. (1983); it consists of approximately 68 100 solid elements, 75 700 shell elements, and 3400 one-dimensional elements. The model contains rigid bodies (e.g., the vertebrae) and deformable bodies (e.g., the intervertebral discs, ribs, skin, and internal organs). However, the original THUMS<sup>®</sup> does not contain any active muscles. Therefore, 394 Hill-type line muscle elements have been added to the model to represent the musculature of the trunk, neck, and upper and lower extremities, see Figure 1(a).

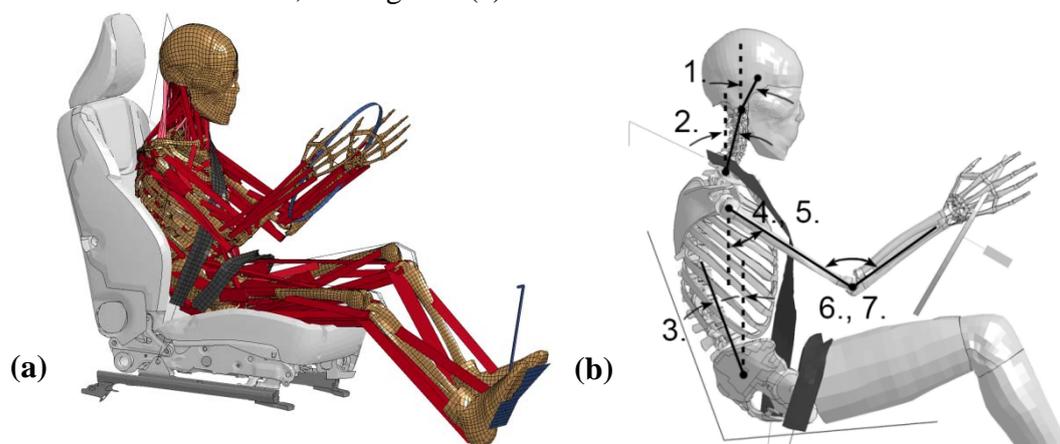


Figure 1(a): The FE HBM engaged in a driver emergency braking of  $11 \text{ m/s}^2$  [1].

(b): Spine segment and joint angles used for feedback postural control in the FE HBM with active muscles [2].

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Postural control for the upper body muscles is achieved by seven PID feedback controllers, for the angles 1–7 shown in Figure 1(b), representing vestibular and proprioceptive feedback. For each of the angles, the deviation from the reference value for the controllers is used to generate correcting moment requests for the flexors and extensors of the controlled segments. The request is scaled with the maximum strength of the muscles and is then passed through a muscle activation dynamics model consisting of two first order filters. For the lower extremities, postural feedback control is not yet implemented and open loop muscle activations are applied to model driver braking [1].

Validation of the model shows that postural feedback control can be utilized to model driver and passenger responses to autonomous braking interventions, with standard and pre-tensioned restraints [2]. For modelling of driver braking, an hypothesized anticipatory postural response was implemented through changes of the reference position of the feedback controllers [1].

Present development of the model is aiming at including postural control also in the lateral direction, to enable the model to be used for modelling of pre-crash scenarios with lateral and oblique components, such as emergency steering avoidance.

## **REFERENCES**

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