Solver- and Model-Agnostic Method to Transfer Pre-Crash Occupant Kinematics to an In-Crash Occupant Model for Continuous Occupant Assessment

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I. INTRODUCTION

The occupant kinematics in the pre-crash phase influences their kinematics in the in-crash phase. Active Human Body models (HBMs), which are available in Finite Element (FE) and Multibody (MB) codes, can be used for simulation. As the pre-crash phase usually lasts a few seconds, it causes high computational costs for FE codes. On the other hand, the level of detail in FE models might be an advantage for in-crash assessment. One possibility is to simulate the pre-crash phase with an MB HBM and transfer its kinematics to an FE HBM at the beginning of the in-crash phase. This study presents a method to transfer the kinematics from pre- to in-crash simulation between an MB and an FE model.

II. METHODS

The kinematics of the pre-crash human body model (HBM A) is prescribed to the in-crash model (HBM B) with the method demonstrated in Fig. 1.

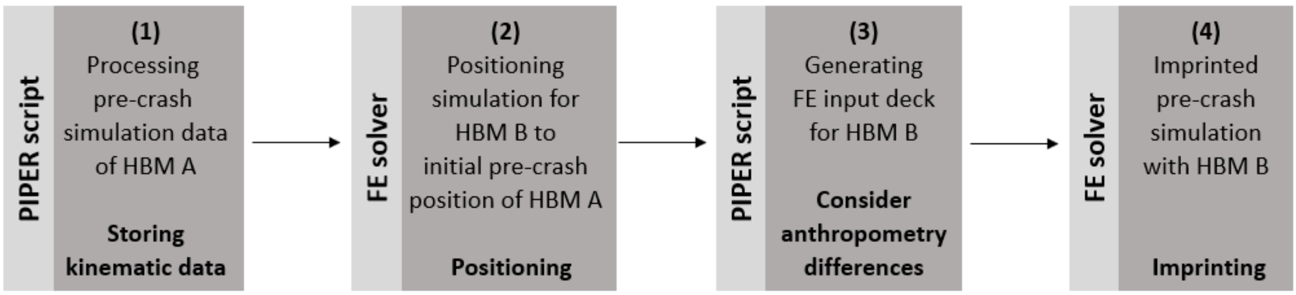

Fig. 1. Schematic workflow of the method divided into four steps.

First, the trajectories of selected anatomical landmarks [1] from the pre-crash simulation of HBM A are required (step 1). Before the kinematics can be imprinted to the in-crash model (HBM B), it is necessary to position HBM B to the initial position of HBM A (step 2). The positioning process follows the method described in [2]. In the next step (3) the kinematics of HBM A are imprinted onto HBM B. Where the anthropometries of the models differ, the kinematics of HBM A (trajectories of selected anatomical landmarks) are scaled to the anthropometry of HBM B using a marionette-like vector structure based on the selected landmarks. The goal is to imprint the kinematics of HBM A by moving the individual vectors of HBM A and B parallel to each other in three dimensions. Hence, the coordinates for each vector at each timestep define the trajectories which are prescribed to HBM B.

Finally, these scaled trajectories are used to re-run the pre-crash simulation (step 4) with HBM B and to imprint the scaled kinematics of HBM A. At the final timestep of that pre-crash simulation, the prescription of the trajectories ends, and the in-crash simulation can be initialized with correct HBM position and velocity.

The method is solver code-agnostic, and it also works for MB and FE human models if the required output is defined beforehand. A script, executable in PIPER [3], was developed in order to apply the method in a user-friendly way.

III. RESULTS

The method is demonstrated by applying it on an MB-to-FE transition from Simcenter Madymo active HBM [4] to THUMS V3 AM50 (Fig. 2). The demonstrated kinematics are of minor magnitude due to the active HBM, but

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nevertheless a proper performance of the method can be demonstrated. The restraint system is deactivated for the imprinted calculations. Soft tissue parts were turned off for visualization but were considered in the calculation. Fig. 2 demonstrates the expected parallel vectors. This structure illustrates the method of anthropometry scaling based on angular data.

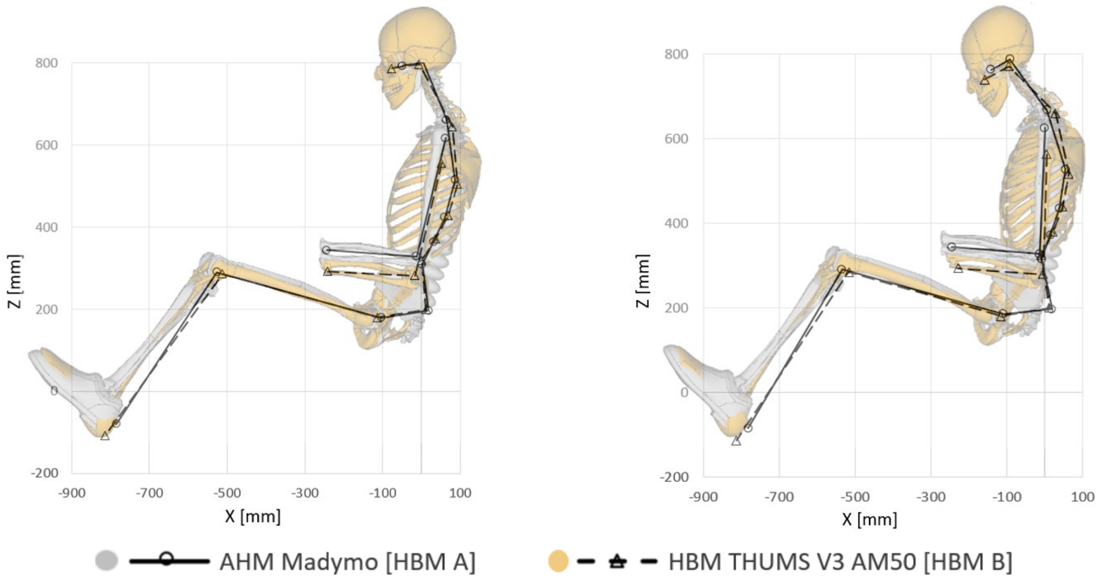

Fig. 2. Comparison of HBM and 2D vector structure at t=250 ms (left) and at t=500 ms (right).

IV. Discussion

The presented method demonstrates that a continuous simulation of the pre-crash and the in-crash phases with different occupant models can be carried out. It is possible to transfer pre-crash kinematics from an MB HBM to an in-crash focused FE HBM. Some minor deviations can be observed, caused by the modelling approach (elastic beams between bony landmarks and guidance) to prescribe the kinematics and avoid numerical issues.

The prescription of trajectories to the in-crash occupant allows interaction with its environment while maintaining all model characteristics (including validation).

V. Acknowledgements

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VI. References

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