Position and Personalize Advanced Human Body Models for Injury Prediction

NEWSLETTER 2

New internal release of the PIPER software

A new version of the PIPER software to position and personalize human body models (HBM) has been released in December, 2015 (it is available on Windows and Linux). This version includes the following main modules:

- A customizable parser, which allows importing/exporting existing leading HBM in various Finite Element format (Fig 1).
- 3D display to visualize the human body model, analyse the mesh quality. Environment models can also be visualised along.
- A module to define interactively a target position (Fig 2) and two associated modules that deform the HBM to match the target position. The first one is based on frame-based deformation [1] and the second implements the "contours based" transformation [2].
- A kriging module that allows deforming the HBM according to a set of control points.
- A mesh improver module to improve element quality after a deformation (based on the Mesquite library).

The evaluation of this version according to predefined performance metric is ongoing to identify the needs for improvement and priorities for new functionalities. A beta testing program will be launched this year. The software will be released under an Open Source GPL v3 license in 2017.

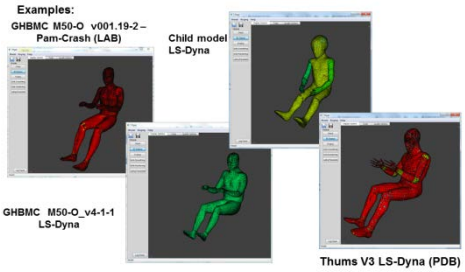


Fig. 1: Example of HBM imported in the application

Fig. 2: Definition of the target position

[1] B. Gilles, et al. Frame-based interactive simulation of complex deformable objects. Deformation Models, 7, Springer, pp.145-166, 2013. [2] D. Jani et al., Repositioning the knee joint in human body FE models using a graphics based technique, Traffic Injury Prevention, 13:640-649, 2012.

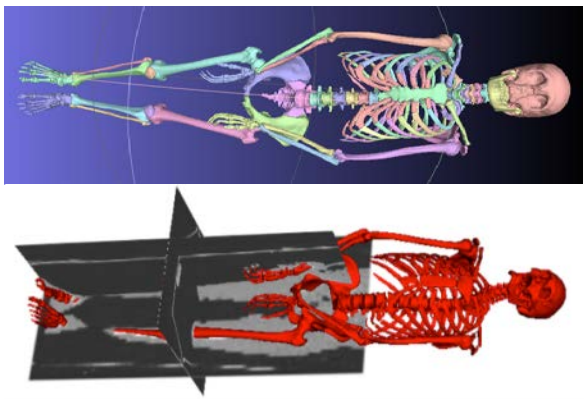
Semi-automatic segmentation pipeline for Statistical Shape Models

One aim of the PIPER project is to generate full body Statistical Shape Models (SSMs) that could be used to change the shape of HBMs. Several segmentations approaches have been tested to generate raw input data for SSMs. This included using semi-automatic interactive tools (e.g. Slicer3D, Simpleware), image to image registration (Elastix) to deform a labelled reference mask, and model to image registration.

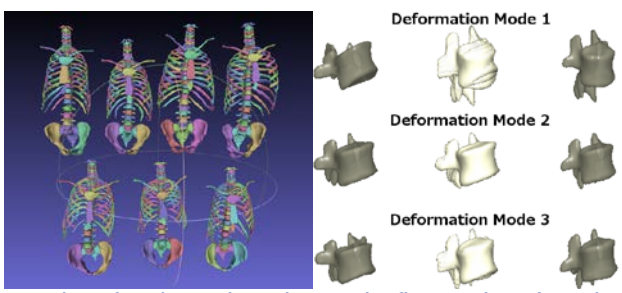
A segmentation pipeline based on model to image registration was finally selected for the project. In this process, a reference mesh that was obtained by semi-automatic segmentation is deformed interactively until it matches a target CT scan. The deformation is driven by a simulation in the SOFA Framework.

This segmentation pipeline was successfully tested **on 25 CT-scans** for registering individual bone meshes of the thorax, spine, pelvis and lower limb. The chosen approach proved to be efficient (about one hour to segment a subject) and adequate to generate the SSMs. **Multiple or individual bone SSMs can be created in minutes**.

The work will continue with the segmentation of more subjects (approximately 100). The meshes and the SSMs will be interfaced with the PIPER software and released publicly at the end of the project.



Reference model (top) and CT registration with atlas (bottom)



Samples of registered meshes and 3 first modes of Lumbar L1

Workshop Positioning and personalizing human body models

The first PIPER workshop entitled “Positioning and personalizing human body models” was held on September 8th 2015 in Bron (Lyon) by the PIPER partners, in conjunction with the Conference of the International Research Council on Biomechanics of Injury (IRCOBI).

The workshop aimed at presenting various efforts on these themes and gathering feedback from the audience. It included presentations of **the PIPER objectives, efforts and results** through oral communications and live demonstrations. **Other presentations** included an overview of the Virtual Vehicle Safety Assessment (VivA) project, and recent results and visions from the University of Michigan Transportation Research Institute and from the Kitware company.

The workshop gathered 72 participants representing various stakeholders from academia and industry, who showed considerable interest in the project dissemination plan and expected outcomes.

Live demonstration of the PIPER tool

All presentations are available on http://www.piper-project.eu/piper-workshop-presentations.html

Project overview: motivation, objectives and main steps

*In passive safety, **advanced Human Body Models (HBM) for injury prediction** based on the Finite Element method have the potential to represent the population variability and to provide more accurate injury predictions than alternatives using global injury criteria. However, these advanced HBM are underutilized in industrial R&D. Reasons include difficulties to position the models – which are typically only available in one posture – in actual vehicle environments, and the limited representation of the population variability (size, weight, etc.).*

*The main objective of the PIPER project is to **develop “user friendly” tools to position and personalize these advanced HBMs.** By facilitating the generation of population and subject-specific HBMs and their usage in production environments, the tools will enable new applications in industrial R&D for the design of restraint systems as well as in research. The main steps for the implementation include:*

- *Definition of the specifications for the personalizing and positioning tools. Improvement of child human models and accident reconstruction environments; evaluation of the tools in actual applications including adult and child biomechanics; definition of guidelines for use of the tools (Work Package 1, WP1).*
- *Development of predictors of posture and shape to help drive the personalisation and positioning tools based on imaging and postural data (WP2).*
- *Development of a modular framework to position and personalize human body models (WP3).*
- *Dissemination of results, facilitation of test by potential user (WP4).*

Key points and deliverables

The tools will be shared with the community using an Open Source License. It will ensure easy access and allow future evolutions and contributions from the community. The tools aim to be model neutral. The license (GPLv3) will allow business services around the tools.

Predictors of posture and shape will be based on statistical databases (e.g. geometrical) that will be released under a similar license. You are welcome to contact us if you think you have data that could be useful for these databases. The needs and priorities of the community are synthesized based on end users requests.

Key figures

4 **M€ Budget**

3 **M€ EC Funding**

42 **months, from 1st Nov. 2013**

Project participants

Université Claude Bernard Lyon 1 *Project Coordinator*		Centre Européen d'Etudes de Sécurite et d'Analyse des Risques	
GIE de Recherches et d'Etudes PSA Renault		Institut National de Recherche en Informatique et en Automatique	
Kungliga Tekniska Hoegskolan		Partnership for Dummy Technology and Biomechanics	
Technische Universität Berlin		University of Southampton	
Foundation for Innovation and Technology Transfer - Delhi		Lyon Ingénierie Projets	

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This project has received funding from the European Union’s Seventh Framework Programme for research, technological development and demonstration under grant agreement nr. 605544 (Collaborative project PIPER)