THOMO

Development of a Finite Element Model of the Human Thorax and Upper Extremities

NEWSLETTER

Description of the THOMO WP2

The WP2 is dedicated to the acquisition of new biomechanical human data regarding the thorax. It includes dynamic tests on the complete thorax with different loadings and acquisition of geometrical ribcage data using CT-scans and µ-CT scans. These new data will be used in order to improve the knowledge of the mechanical behavior of the ribcage and rib fracture mechanisms.

Test Matrix (CEESAR)
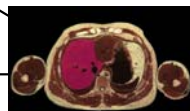
A set of eighteen post-mortem human subjects have been planned in the following conditions.

50th percentile male

0 DEGRE
- *Unfolded airbag (n=1)*
- *2 pt-belt (n=1),*
- *4-pt harness (n=1)*
- *Hub test (n=1)*

For THORAX project

5th percentile female

60 DEGREES
Hub (n=3, 1 speed)

90 DEGREES
Hub (n=3, 1 speed)

60 DEGREES
Hub (n=4, 2 speeds)

90 DEGREES
Hub (n=4, 2 speeds)
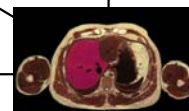
To date, nine tests have been performed with success on the 50th percentile male, including three tests for the Thorax project in frontal impact (through COVER). The other tests have been performed in pure and oblique impact directions, with the same specimen instrumentation, i.e. with more than one hundred strain gages glued on the ribcage. The first results have been analyzed in order to understand the rib fracture mechanisms and to define rib strain patterns, depending on the loading direction and violence. The second set of PMHS will be dedicated to the 5th percentile female, for which the same methodology will be applied in order to compare with the results of the 50th percentile male.
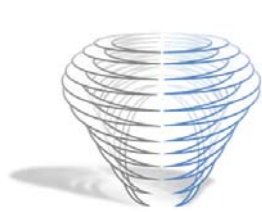
Data acquisition on the ribcage
(University of Valenciennes and Hainaut-Cambrésis)

One task of THOMO was to define a method to determine relevant parameters of the human ribcage to be incorporated in a refine finite-element model. Three different acquisition devices were used to measure the whole geometry of the skeleton. First, a clinical CT-scan was performed on human cadavers donated for research, to get the global geometry of the ribcage, including ribs, sternum, cartilage and vertebrae. Step 2 consisted of harvesting each rib separately from the ribcage and of characterizing ribs geometry thanks to a 3D laser scan. Step 3 was performed with a micro-CT, which aims at acquiring a refine geometry of 40 mm segments all along the ribs, including the structural geometry (i.e. cortical and trabecular bone).

These 3 datasets were merged to build a geometrical thorax model in a multilevel scale approach (thorax, rib, bone structure). From this complete geometrical acquisition, a finite element model was obtained. Internal and external surfaces of the cortical bone were determined and a neutral (i.e. average) surface was defined as a reference to apply an optimized shell meshing and to assign localized real cortical thicknesses.
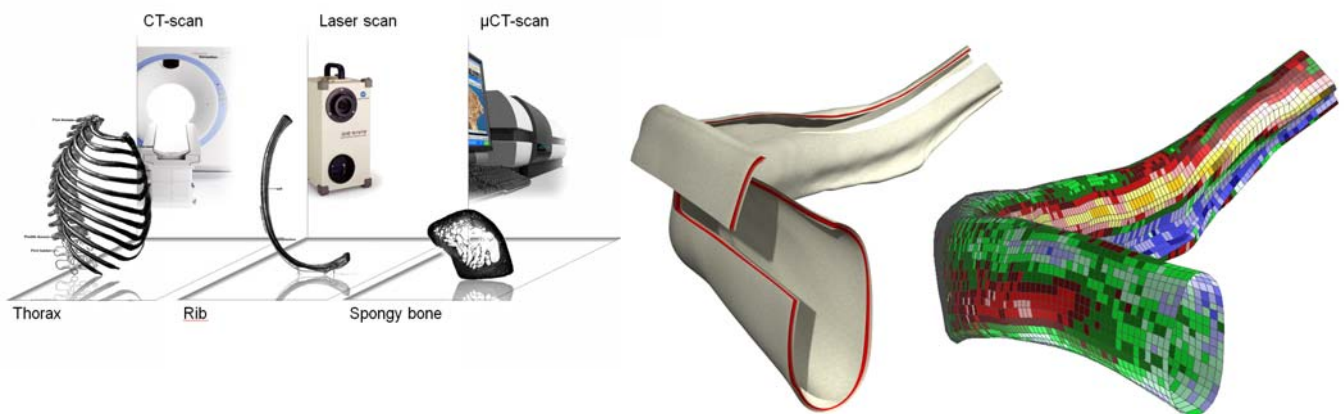
The main advantages of this approach, linking together medical imaging, 3D reconstruction and FE modelling, is to provide a FE model which is personalized, biofidelic, CPU-time efficient, and which takes into account the entire geometry and bone distribution.

Next Steering Committee: 12-13 July, 2010, in Plzen, Czech Republic.

Organizations