Development of the GHBMC 5th Percentile Female Finite Element Model

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Abstract

To mitigate the societal impact of vehicle crash, researchers are using a variety of tools, including finite element models. Such models are often developed to represent a 50th percentile male occupant. In order to address a greater portion of the driving public, there is interest in developing such models for other cohorts. This study focuses on the female driver in the 5th percentile of height and weight. In the past, 5th percentile female (F05) models have been developed by scaling data from existing average male models, since scan data for such a specific target anthropometry is limited. However, as part of the Global Human Body Models Consortium project, comprehensive image and anthropometrical data of the F05 were acquired for the specific purpose of finite element model development. The objective of this study is to review the data collected for this effort, including medical imaging, CAD construction, and meshing techniques employed for model development.

An individual representing the F05 in terms of height (149.9cm) and weight (48.0±0.63kg) was selected. Fifteen external anthropomorphic measurements were acquired to determine eligibility. Surface topography and 52 external bony landmarks were also acquired via a 3D digitizer. Computed tomography (CT), Magnetic Resonance Imaging (MRI), Upright MRI, and external anthropometry were obtained in supine, seated, and standing positions with image data deemed anatomically normal by a collaborating radiologist. Soft tissue and bony anatomy that are represented in the F05 finite element model were segmented using supine MRI and CT respectively. After developing STL data from medical imaging, NURBS surfaces with tangential continuity were constructed over all segmented data. Seated MRI and bony landmark data were then leveraged for model assembly. Following assembly, CAD dataset was utilized for mesh development of the GHBMC F05 occupant model.

The selected subject closely represented the F05 in terms of height and weight, deviating less than 2% in those measures. For all 15 anthropomorphic measurements, the average subject deviation across all measures was 4.1%. A total of 66 scan series were collected across all modalities for a total of 14,170 images. Abdominal organ volumes and cortical bone thickness were compared to literature sources for verification. The alpha version of the model consists of 850 parts, 2.3 million elements, and 1.3 million nodes. Material definitions have been applied for each part based on experimental data found in the literature. In terms of element quality, stringent thresholds were placed on several criteria: jacobian (>0.3 for all solid elements and

>0.4 for all shells), tet-collapse (>0.2 for all elements), and a minimum time step value of 0.1 μs. Initial validation will be focused on regional performance and then will be extended to whole body responses. Once validated, the data obtained from this model will be valuable for the development of vehicle safety devices. To date, the data set used for the development of this model is the first of its kind, acquired with the explicit purpose of developing a full-body finite element model of the F05 for the enhancement of injury prediction.