

Statistical Analysis of Body Shapes for Parametric Human Body Modeling

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I. INTRODUCTION

Finite-element (FE) human body models (HBM) enable high-fidelity representations of anatomy in crash simulations. Most current FE HBMs are based on the anatomy of one or a few individuals, including details of the skeleton, soft tissues, and overall body shape [1]. As part of a broader effort to develop parametric HBMs that can represent a wide range of body sizes, shapes, and postures, a statistical analysis of exterior body shape in supported seated postures was conducted. Previous large-scale studies of body shapes in seated postures have been limited to unsupported postures [2].

II. METHODS

A VITUS XXL laser scanner was used to record the body shapes of 126 men (stature 1584 to 1965 mm, BMI 18 to 39 kg/m²) in four seated postures depicted in Figure 1. The ~500k 3D surface points obtained in each scan were processed to fill holes and create a watertight mesh. A total of 92 surface landmarks were manually extracted from each scan. A template mesh with 35052 vertices was fit to each scan to facilitate statistical analysis.



Figure 1. Representative scans from different subjects in four postures from upright to highly reclined. Principal component (PC) analysis was used to reduce the dimension of the data; 200 PCs were retained, representing >99% of the variance in the vertex coordinates. A regression analysis was conducted predicting PC scores from stature, body mass index, and the ratio of sitting height to stature, along with the locations of landmarks on the torso and head. This approach enables landmark location predictions from other datasets (for example, gathered in vehicles) to be used to represent a wide range of driver and passenger postures.

III. INITIAL FINDINGS

Figure 2 shows predictions for a range of body sizes and postures defined by recline and lumbar flexion.

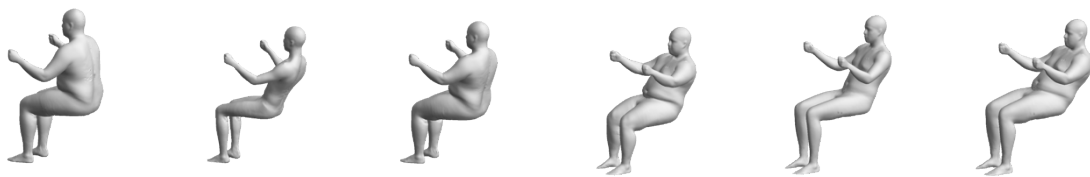


Figure 2. Predicted body shapes and postures using stature, body weight, torso recline, and lumbar flexion as inputs.

IV. DISCUSSION

This rich dataset and analysis methodology enables rapid generation of whole-body surfaces. Using the surface mesh from the target FE HBM as the scan fitting template enables immediate prediction of the FE HBM surface configuration without additional mapping steps. Further work is needed to develop methods to morph interior structures accurately and further study of female body shapes is needed.

V. REFERENCES

- [1] Hu J et al., Focusing on vulnerable populations in crashes: recent advances in finite element human models for injury biomechanics research. *J. of Automotive Safety and Energy*. 3(4):295-307, 2012.
- [2] Robinette et al. CAESAR Final Report. USAF, 2002.

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