Simulating Seat Back Interaction Using Realistic Body Contours

Matthew P. Reed
Jingwen Hu

Biosciences Group

UNIVERSITY OF MICHIGAN
TRANSPORTATION RESEARCH INSTITUTE

Introduction

- Dimensional mismatch between a seat and sitter can cause discomfort.
- Traditional anthropometric data do not provide guidance on three-dimensional body shape.
- Surface-scanning equipment has revolutionized anthropometry by allowing rapid recording of whole-body surface shapes

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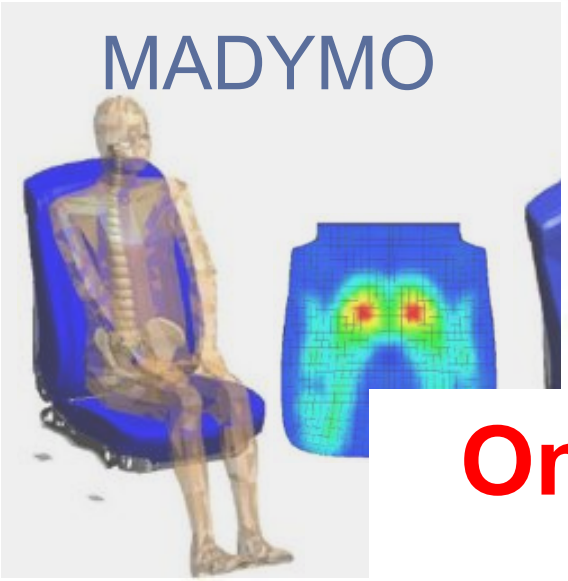
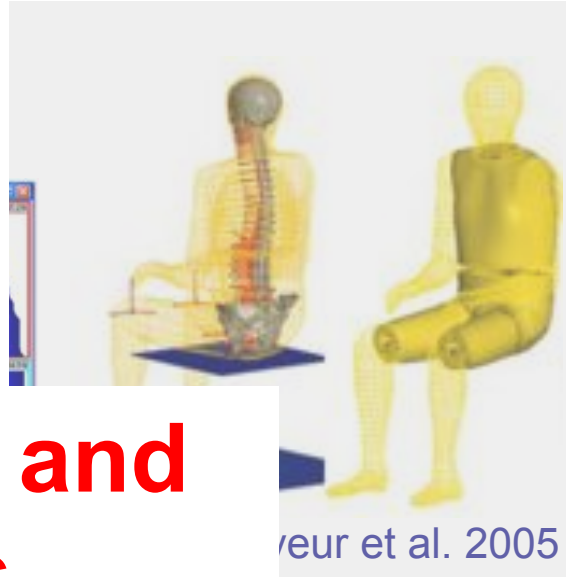
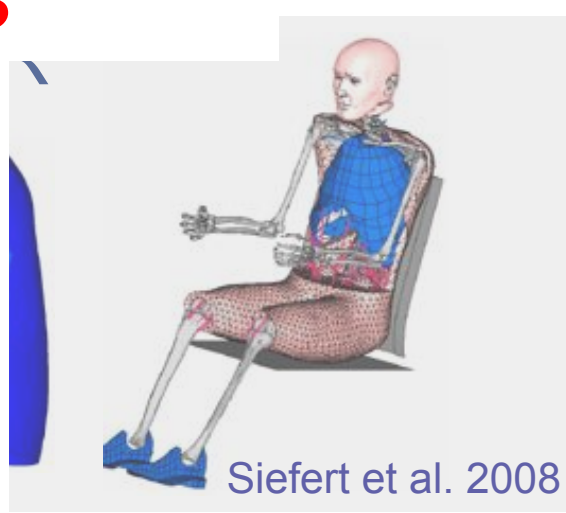
Realistic Body Shape Models





Only a few sizes and body shapes



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Objectives

Develop a methodology for using a statistical body shape model to conduct automated fit assessments for vehicle seats

Initial focus: Seat back fit

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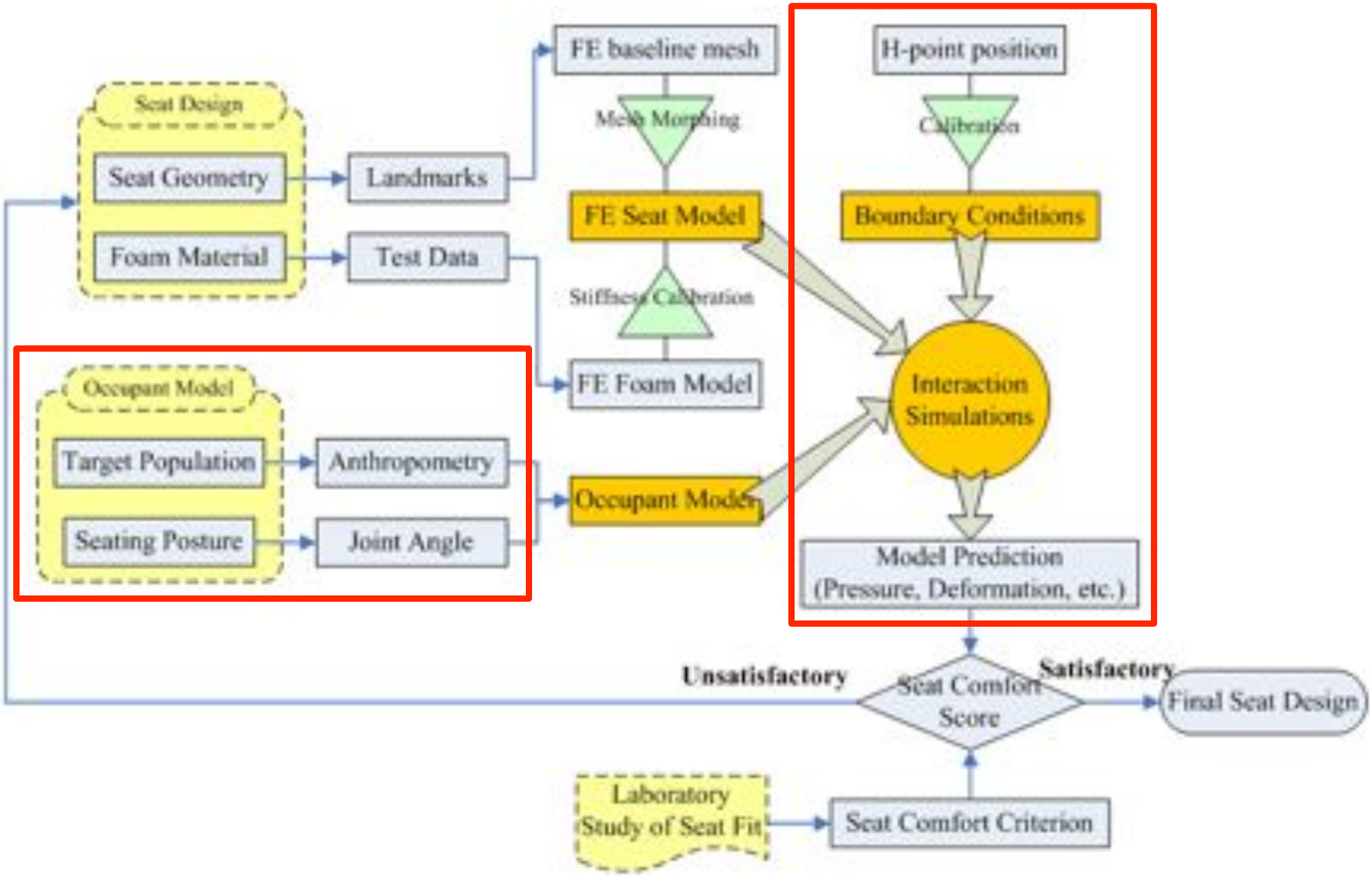
Method Overview



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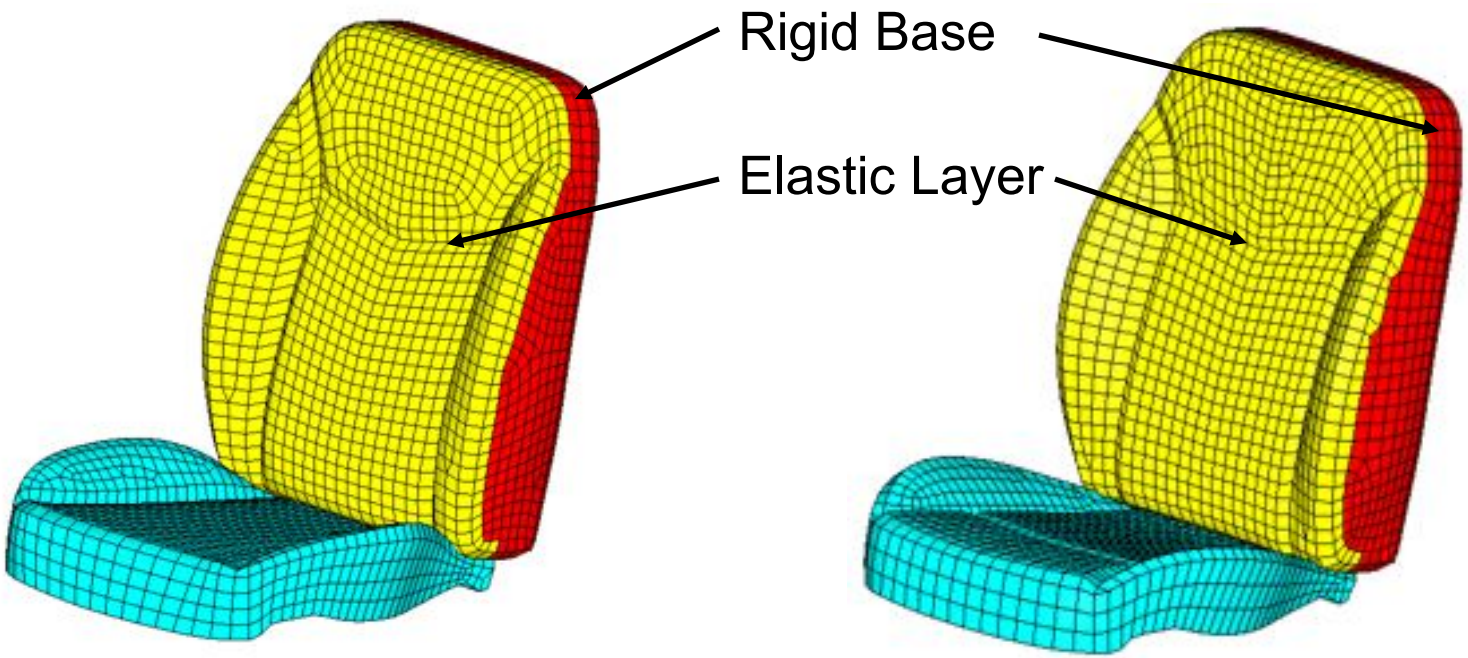
Simplified Finite-Element Seat Models

Shell element only, no real foam

Uniform thickness and material



"Old" "New"

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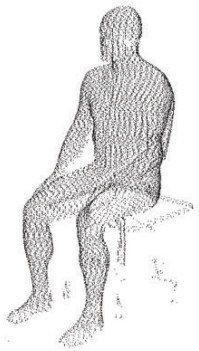
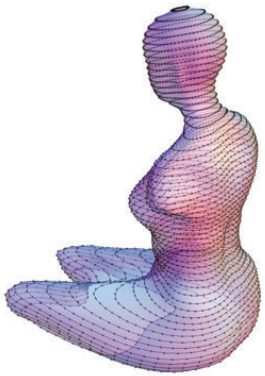
3D Seated External Body Contours

Extract Scan Data



Fit Surface Mesh



Estimate Joint Locations

Morph to 15 Postures

Principal Component Analysis

Regression

Predictors:

- thigh angle
- recline
- flexion
- stature
- BMI

Posturable Body Shape Model

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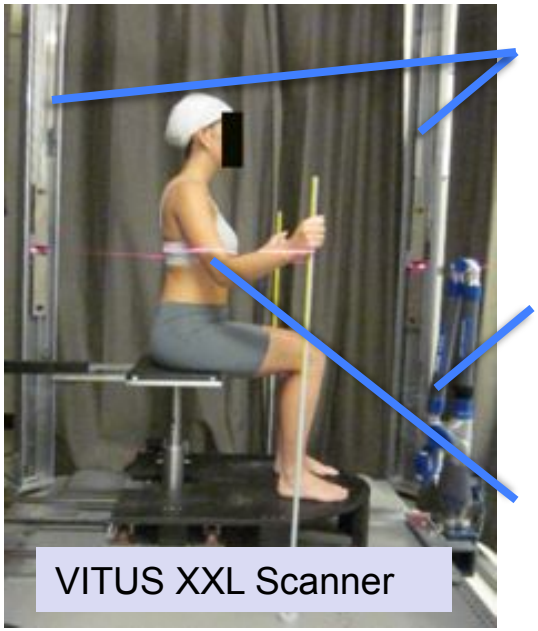
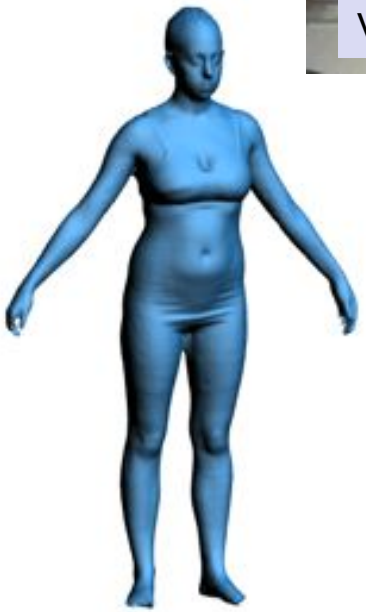
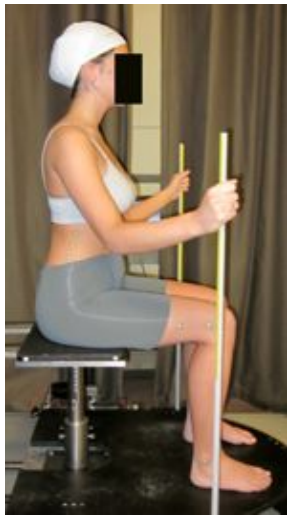
3D Anthropometry Methods: Laser Scanning

- standard anthropometry
- whole-body laser scanner
- optical landmarks
- additional landmarks with FARO Arm
- multiple standing and seated postures







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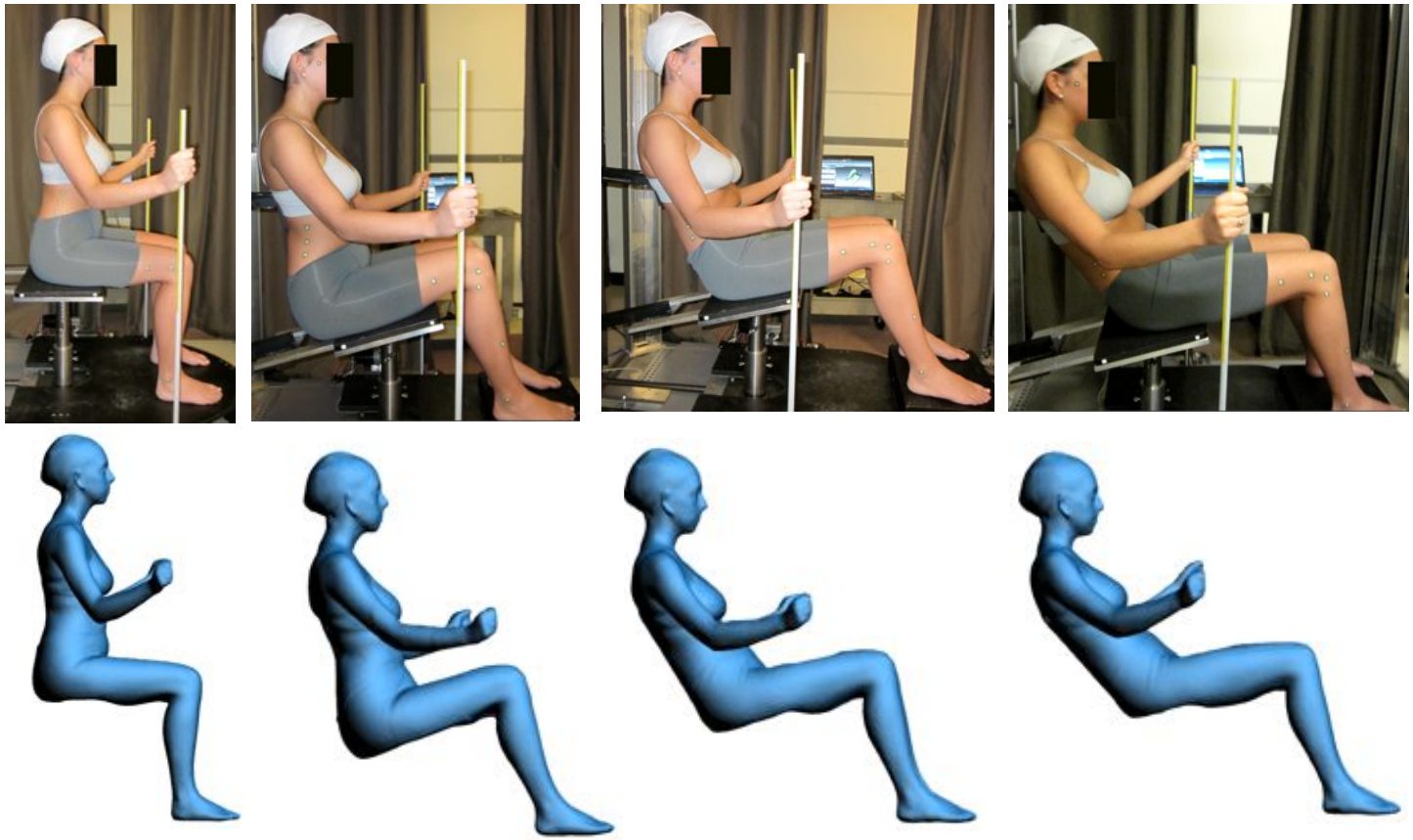
3D Anthropometry Methods: Laser Scanning

- Scanning requires 12 seconds, plus an additional minute for hand scanning in some postures
- Seated postures span a wide range of recline and lumbar spine flexion



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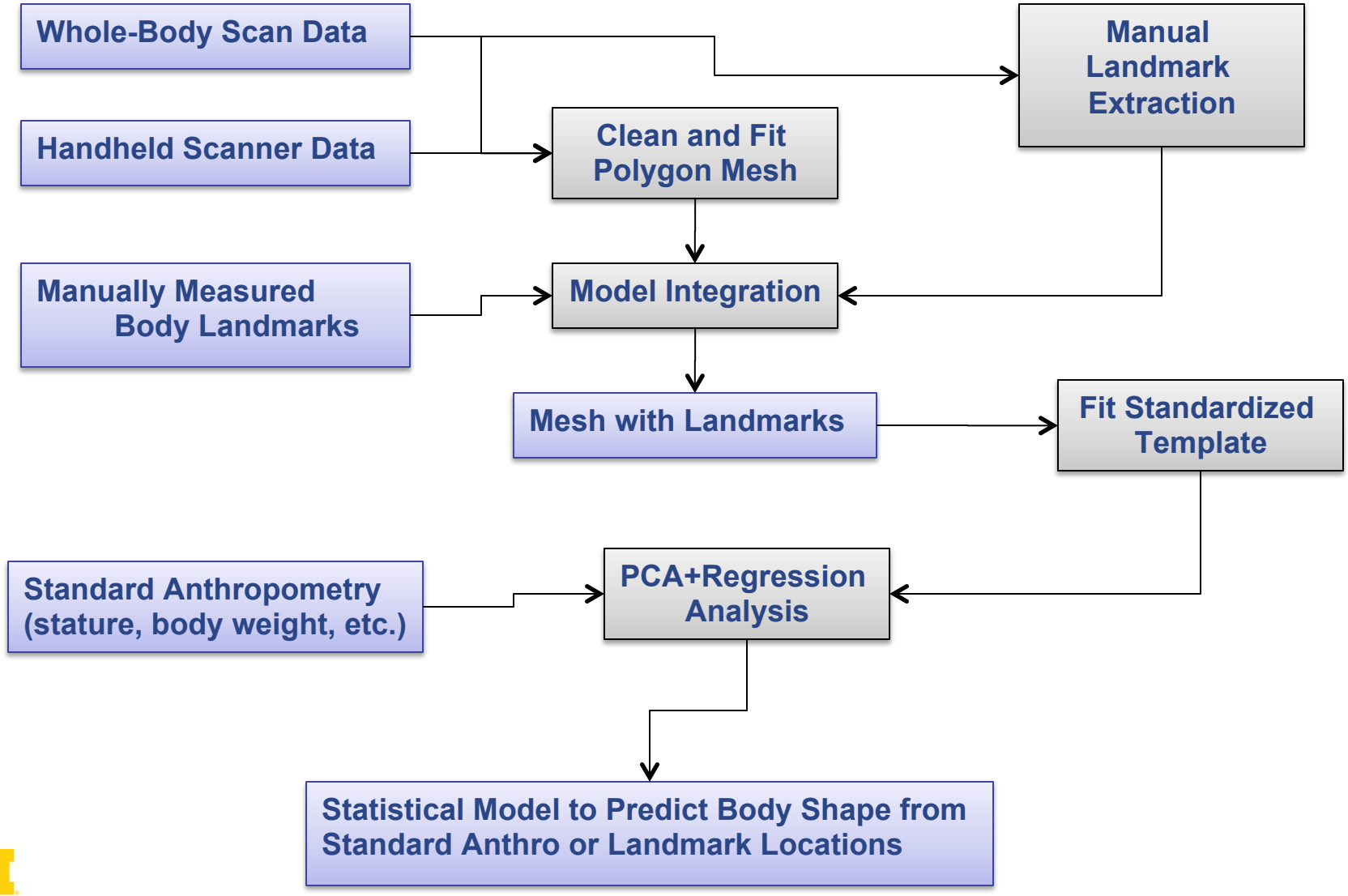
Body Shape Modeling



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Process Overview: Scan Data

Template for Seated Analysis showing 137 Landmarks 68072 polygons, 34038 vertices

Template Fit to Data from a Scan (blue)

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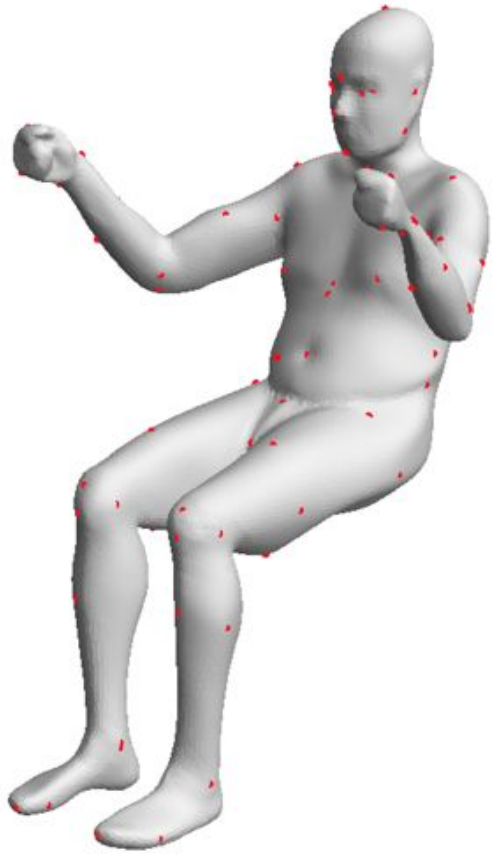
Process Overview: Scan Data

Scanned Mesh and Landmarks



Landmark-Morphed Template

Fitted Scan

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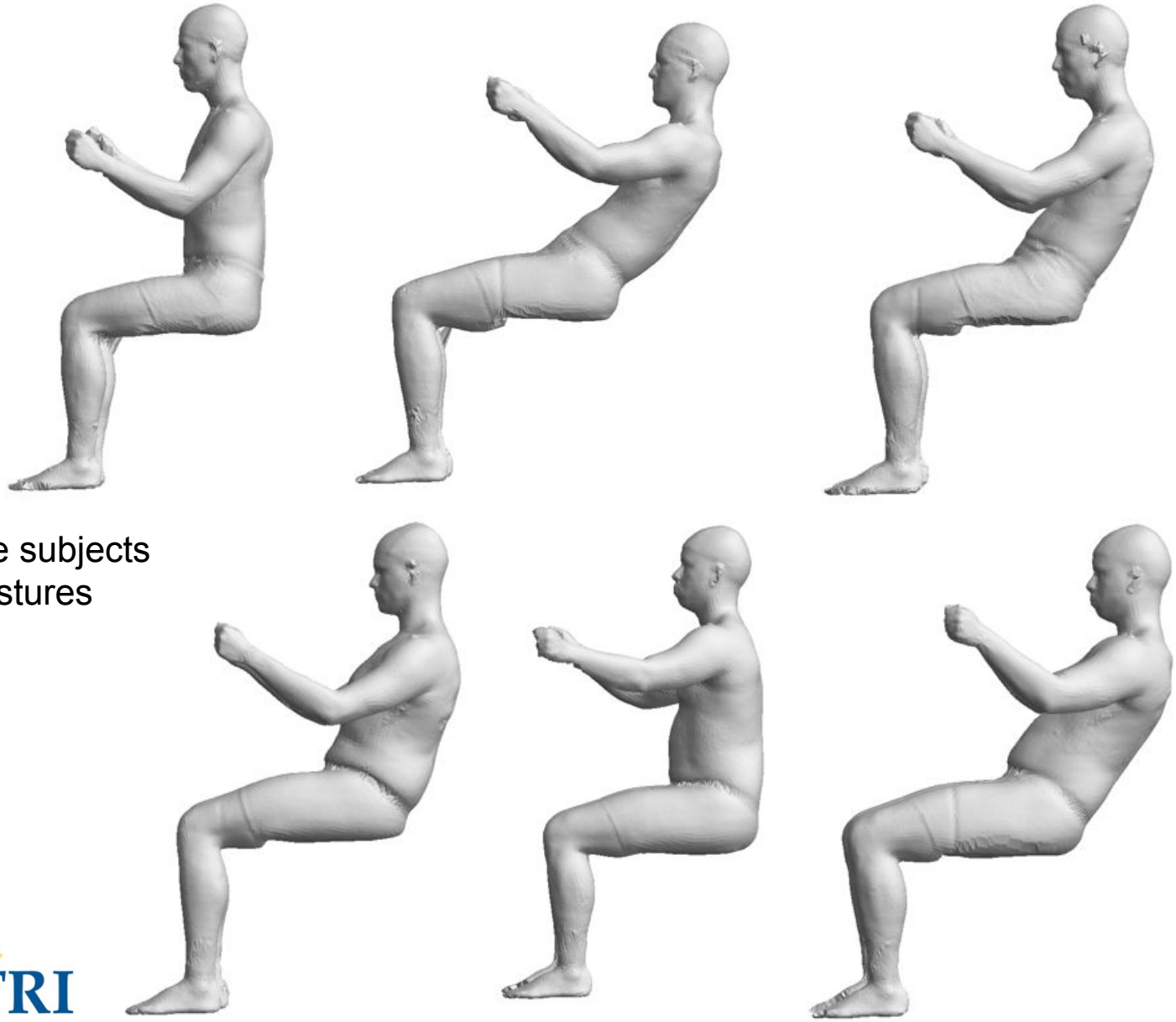
Process Overview: Template Fits



Multiple subjects
and postures

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Surface Analysis

Output of regression model to predict seated body shape
(based on 338 scans from 126 men)

Stature 1600 mm

Stature 1900 mm

Median US Male
Stature 1755 mm
BMI 27.3 kg/m^2

BMI 18 kg/m^2

BMI 40 kg/m^2

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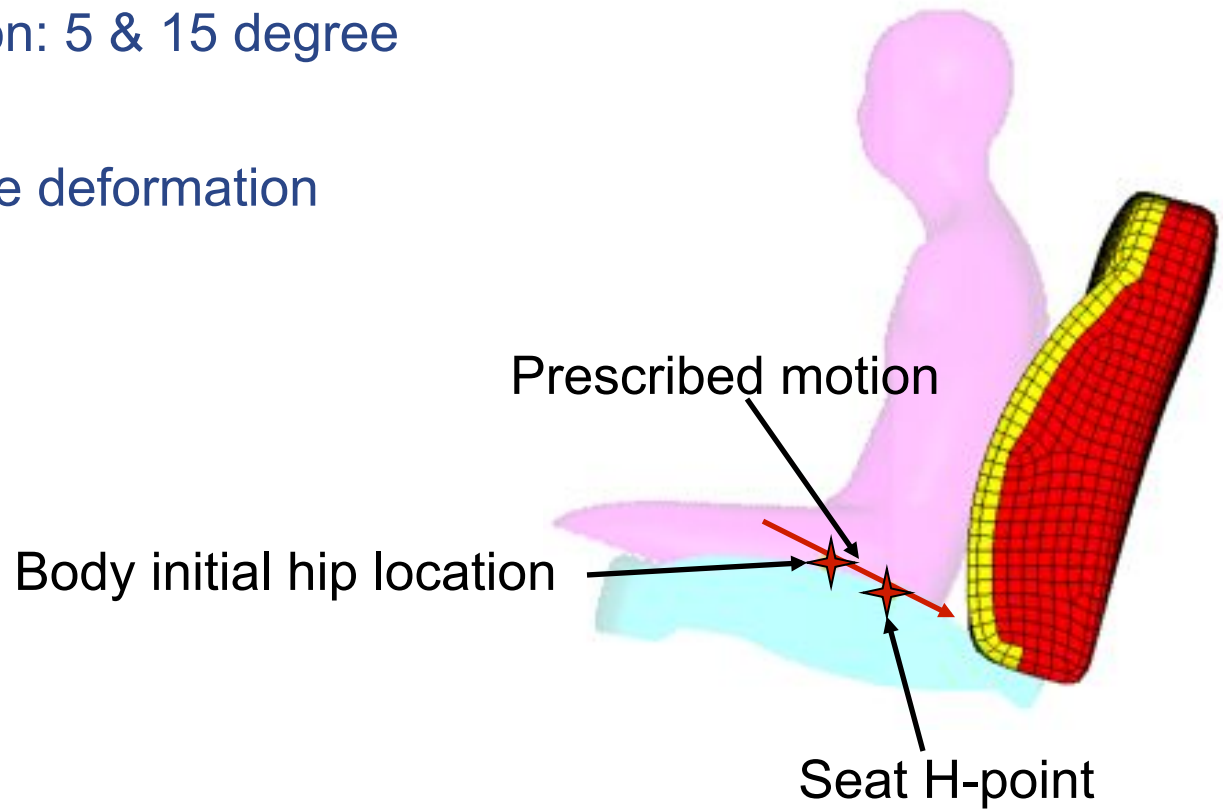
Pilot Simulation Setup

- 24 automated simulations for male only
- Height: 165, 175, 185 cm
- BMI: 20 & 35
- Thigh angle: same at the cushion
- Lumbar spine flexion: 5 & 15 degree
- Two seat models
- Output: seat surface deformation



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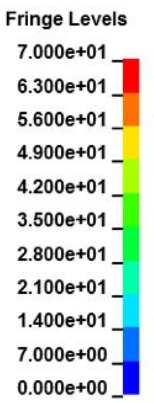
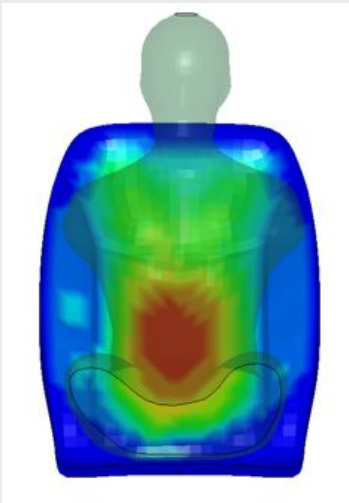
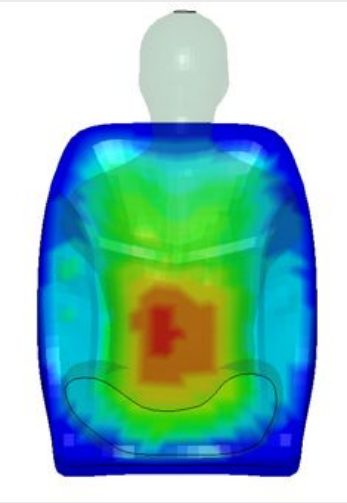
Simulation Results



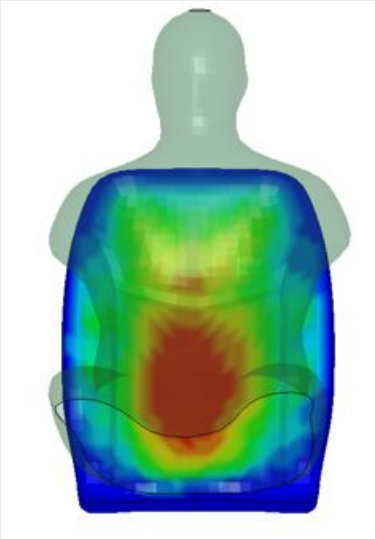


Old seat

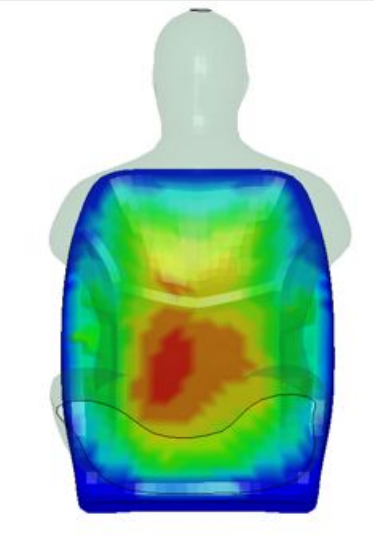


New seat

H165, BMI20, Lspine flexion 15°



Old seat



New seat

H185, BMI35, Lspine flexion15°

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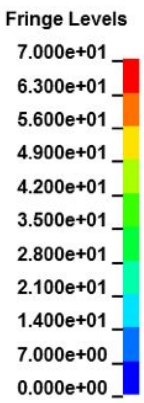
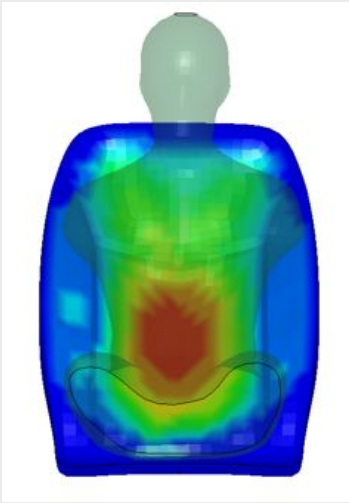
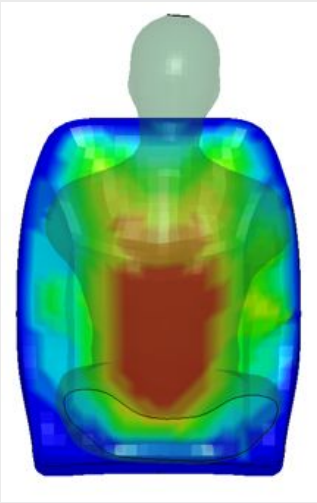
Simulation Results

Lumbar Spine flexion 15 deg vs. 5 deg re “nominal”



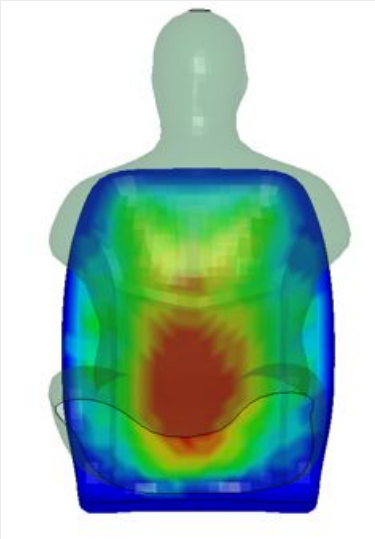


15°

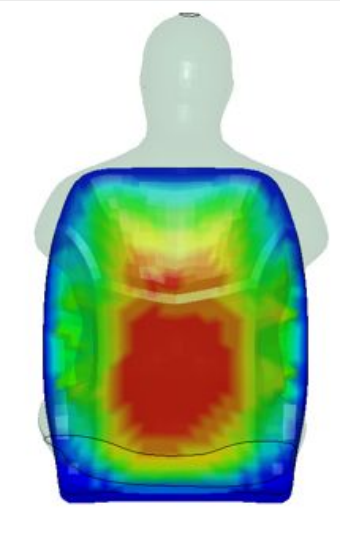


5°

Old seat, H165, BMI20



15°



5°

New seat, H185, BMI35

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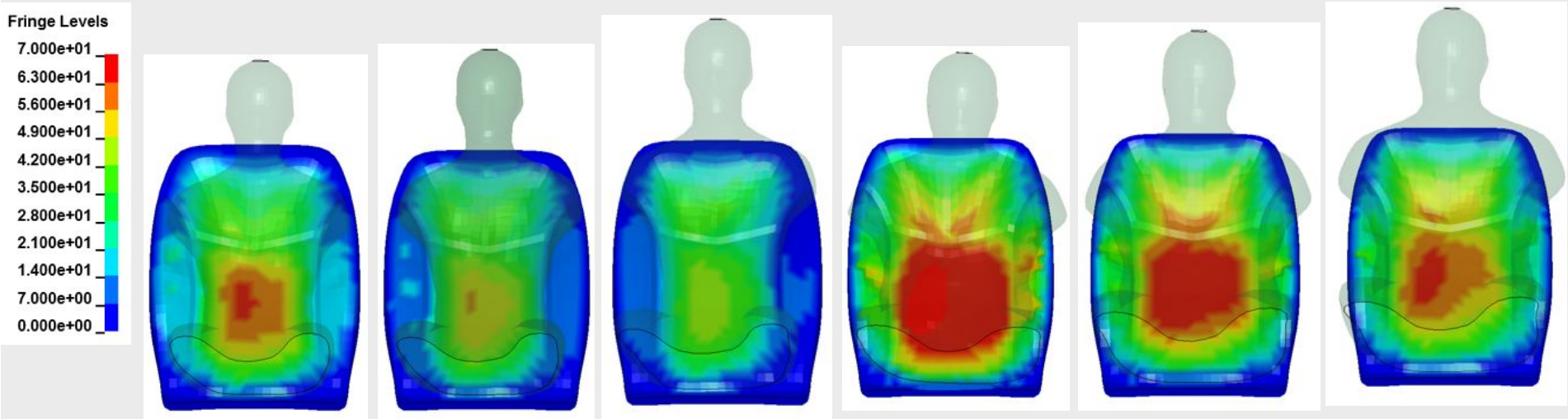
Simulation Results



H165, BMI20 | H175, BMI20 | H185, BMI20 | H165, BMI35 | H175, BMI35 | H185, BMI35

New seat, Lumbar spine flexion 15°

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Summary

- Automated methods for rapidly assembling a simulation with a large number of human body models and seat back models were developed.
- A simple prescriptive method for defining seatback interaction showed sensitivity for differentiating seat fit among seats and body shapes.

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Limitations

- The method is limited by the accuracy of the positioning model, which is only pseudo-physics-based to emphasize speed over accuracy.
- The ultimate success of the method is dependent on the development of a quantitative, reliable method to predict subjective responses from the physical interaction between the sitter and seatback.

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Next Steps

- Improve the human body shape model by adding more subjects and both improving and validating the posturing functionality. [Ongoing]
- Conduct a laboratory study with human volunteers to quantify the relationships between subjective fit and objective measures of seatback interaction. [Ongoing]
- Validate the FE method for simulating seatback interaction based on the framework developed in the current study. [Future Work]

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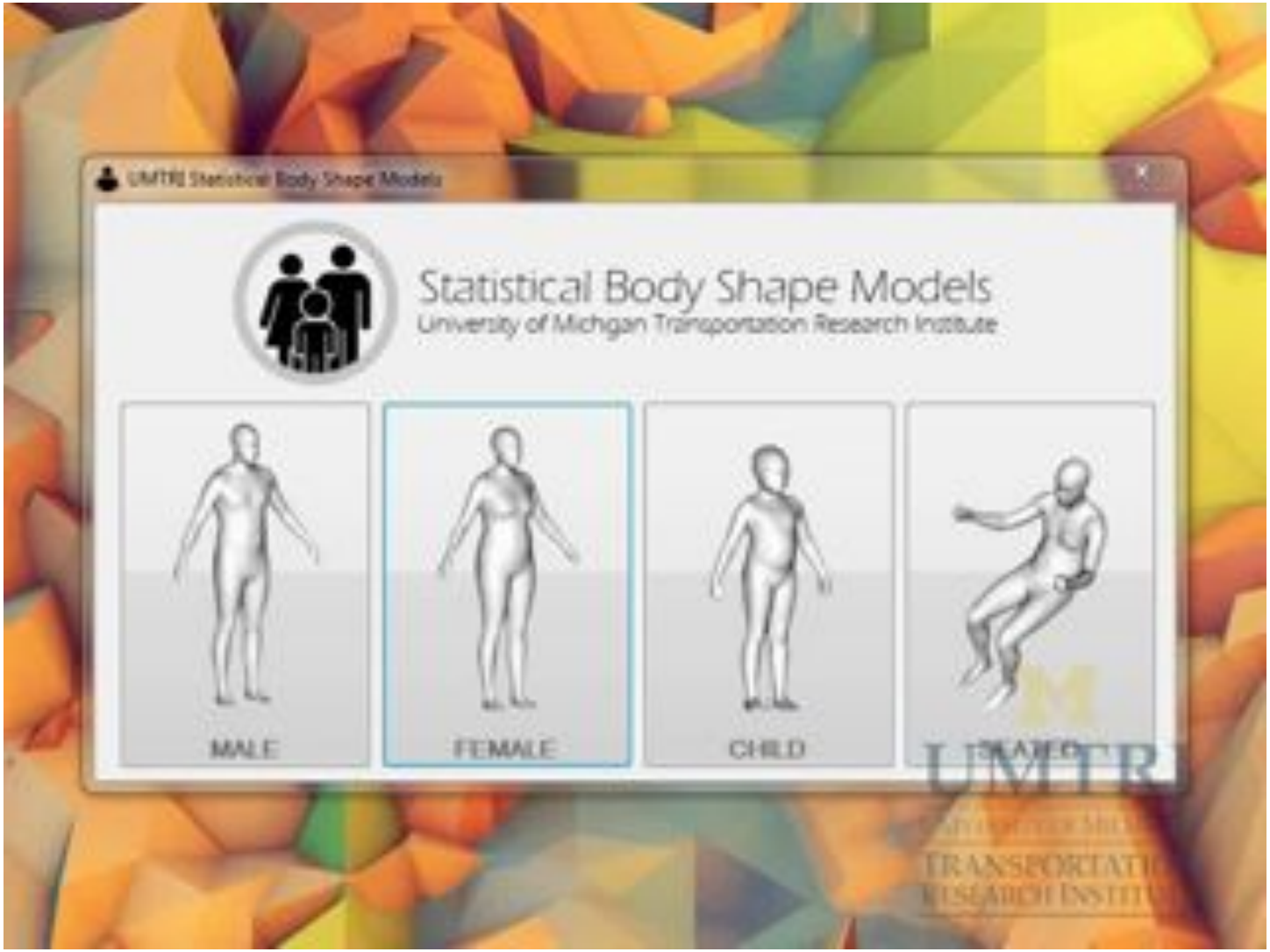
UMTRI Human Models (2014)

Examples of statistical body shape models developed at UMTRI



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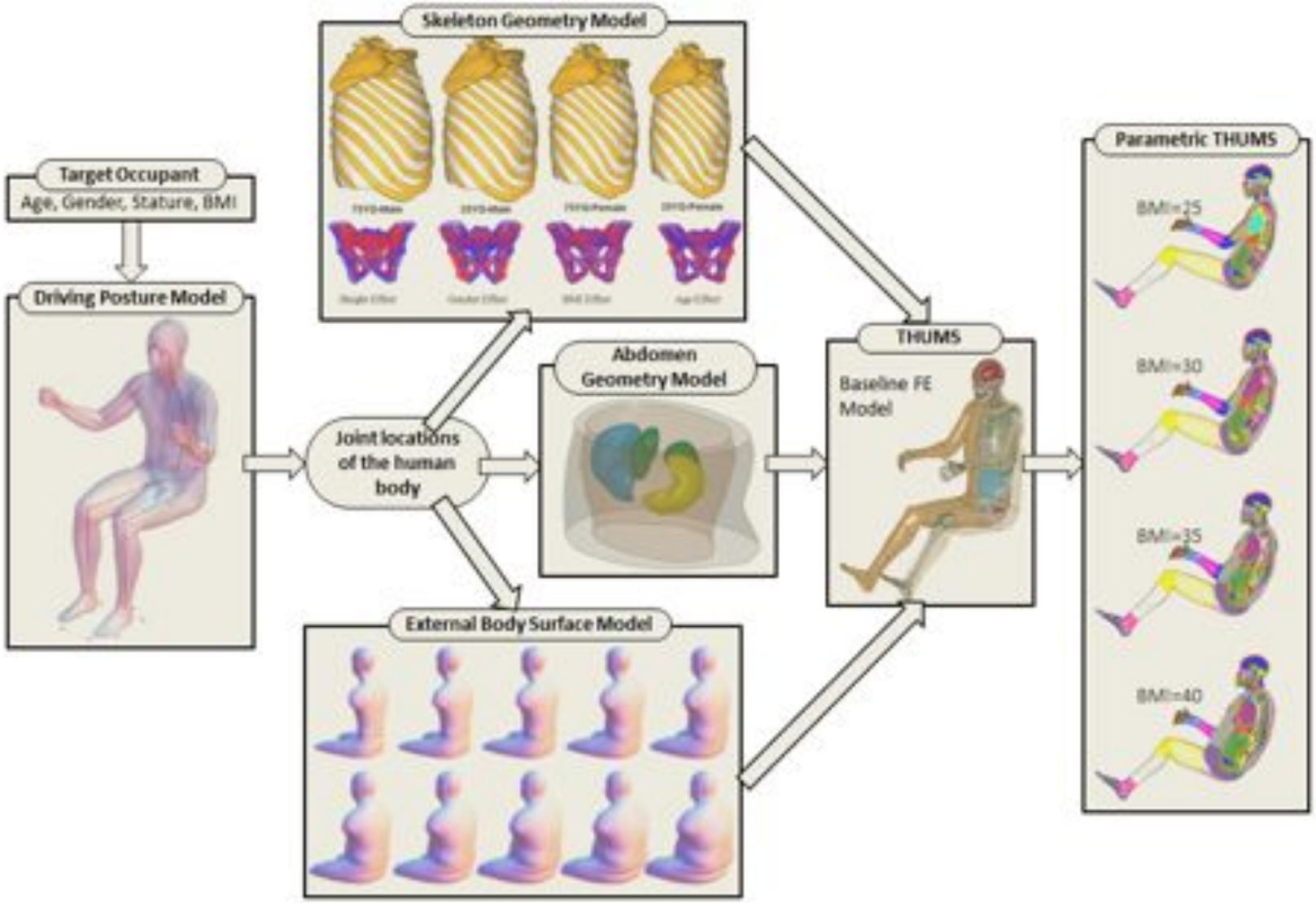
More Detailed Human Model



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Acknowledgements

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Jingwen Hu, PhD
jwhu@umich.edu

Matthew Reed, PhD
mreed@umich.edu

UNIVERSITY OF MICHIGAN
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