Development of a Methodology for Simulating Seat Back Interaction Using Realistic Body Contours

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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 (CAESAR project).

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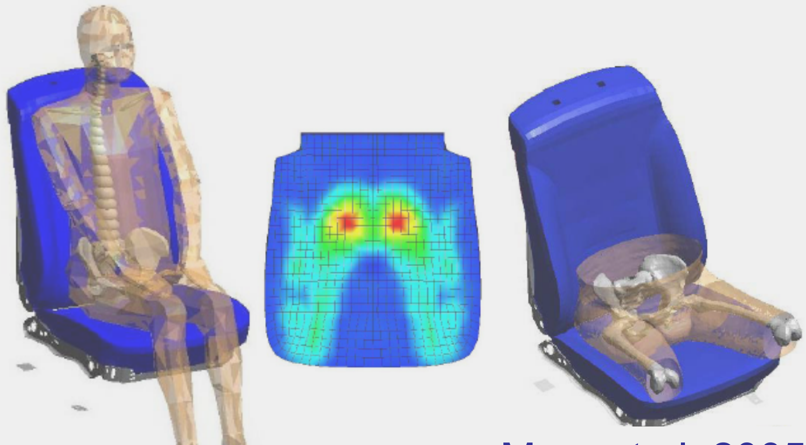
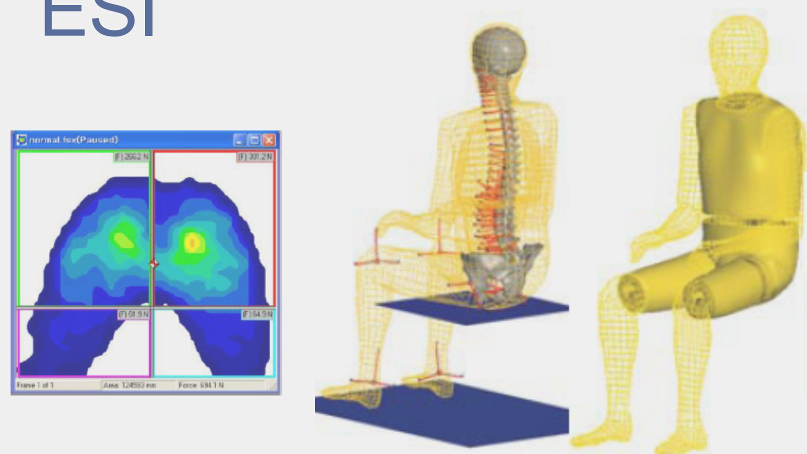
Limited Literature Review

- MADYMO



Marx et al. 2005

- ESI

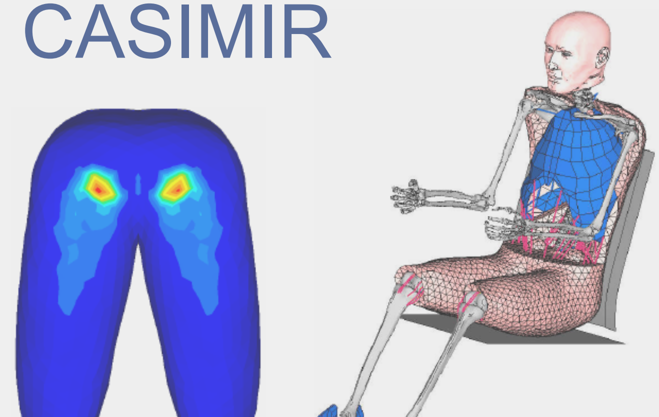


Montmayeur et al. 2005

- Hyundai-Kia

Kim et al. 2007

- CASIMIR



Siefert et al. 2008

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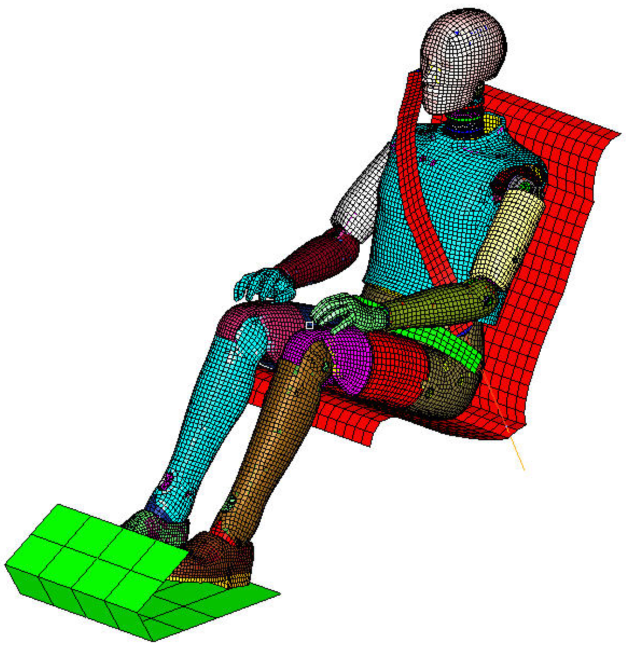
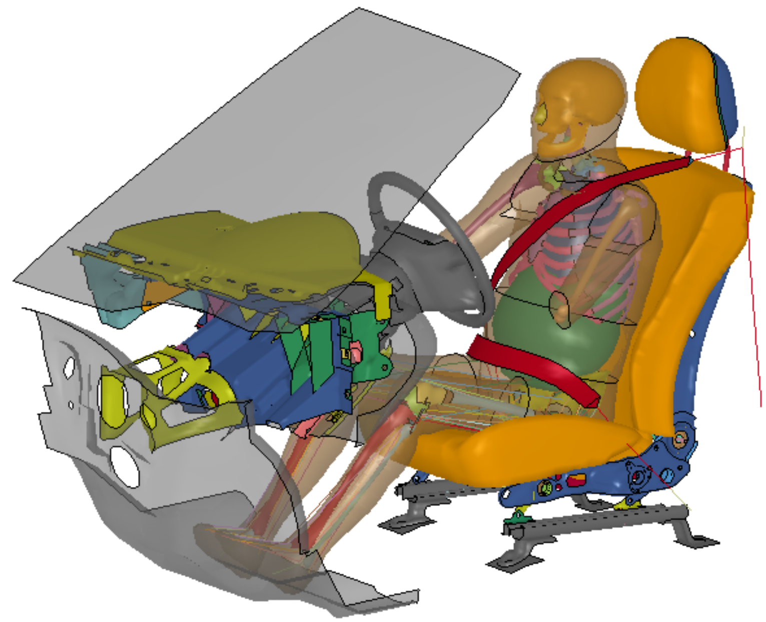
Virtual Fit Evaluation

- ATD Model



- Human Model



Limited size and body shape

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Objectives

- To introduce a methodology for using a statistical body shape model to conduct automated fit assessments for vehicle seat backrest
  - Fit vs. pressure
  - Seatback vs. seat cushion
  - Parametric model vs. single model

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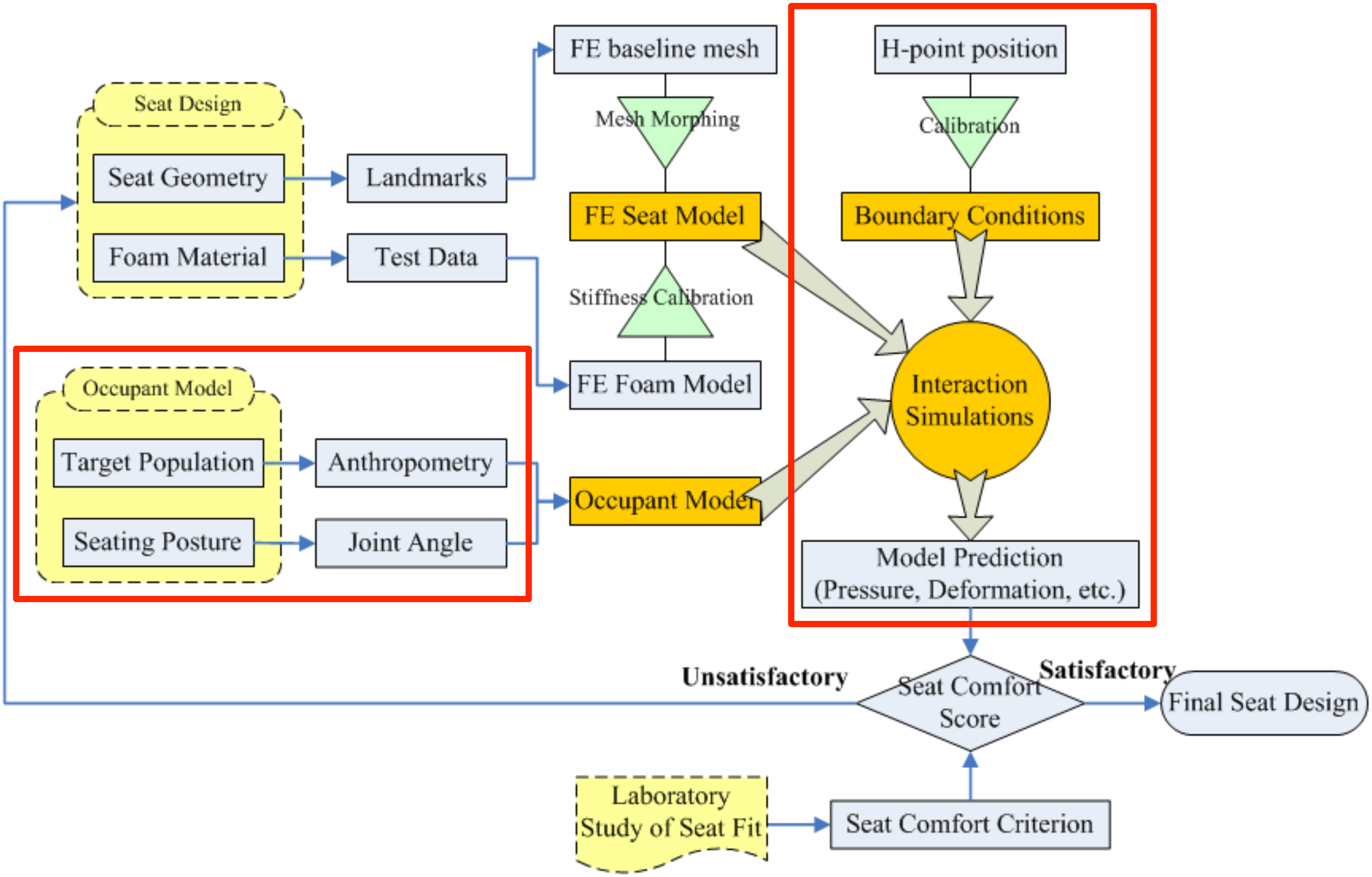
Method Overview



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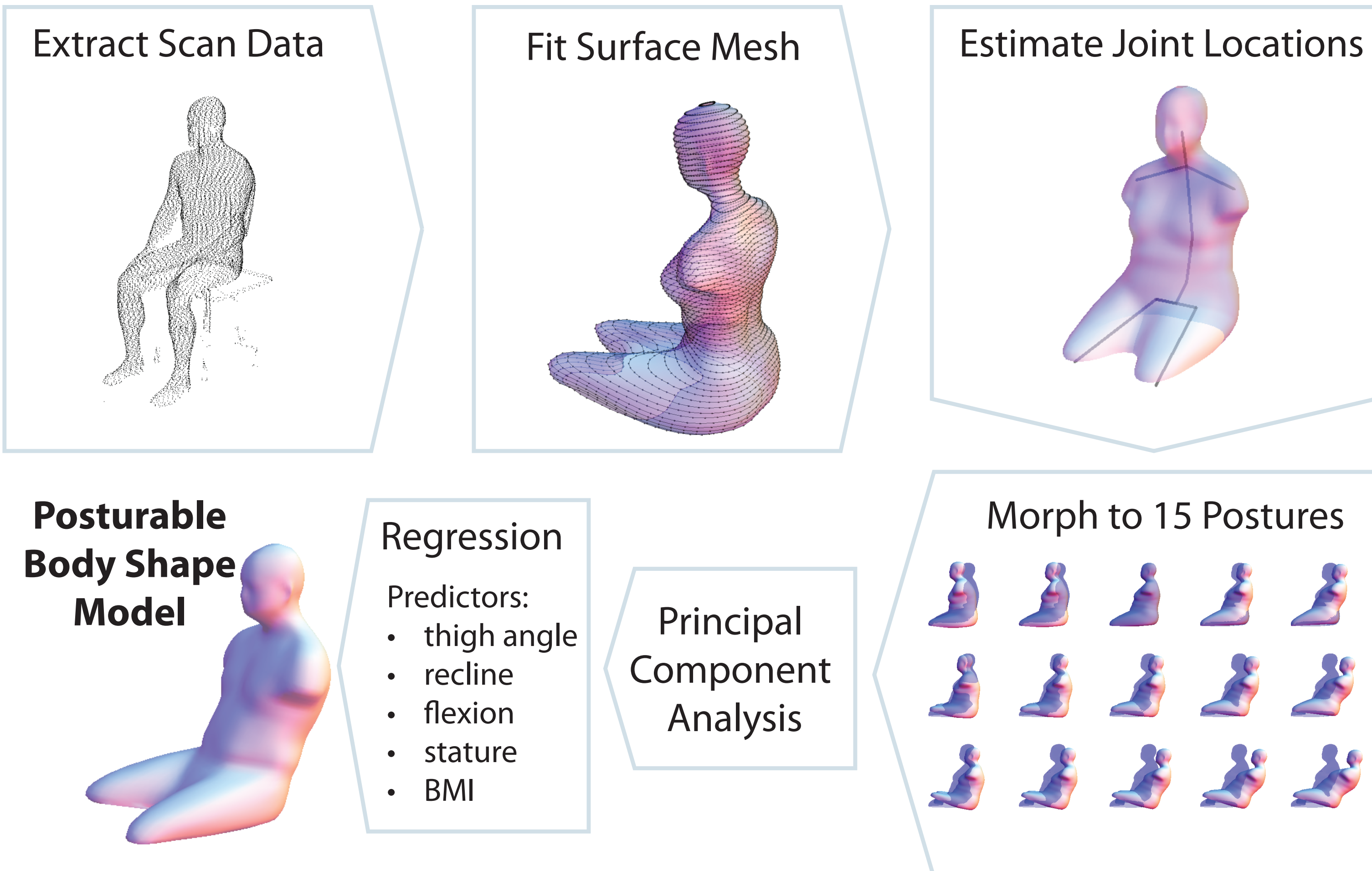
3D Seated External Body Contours



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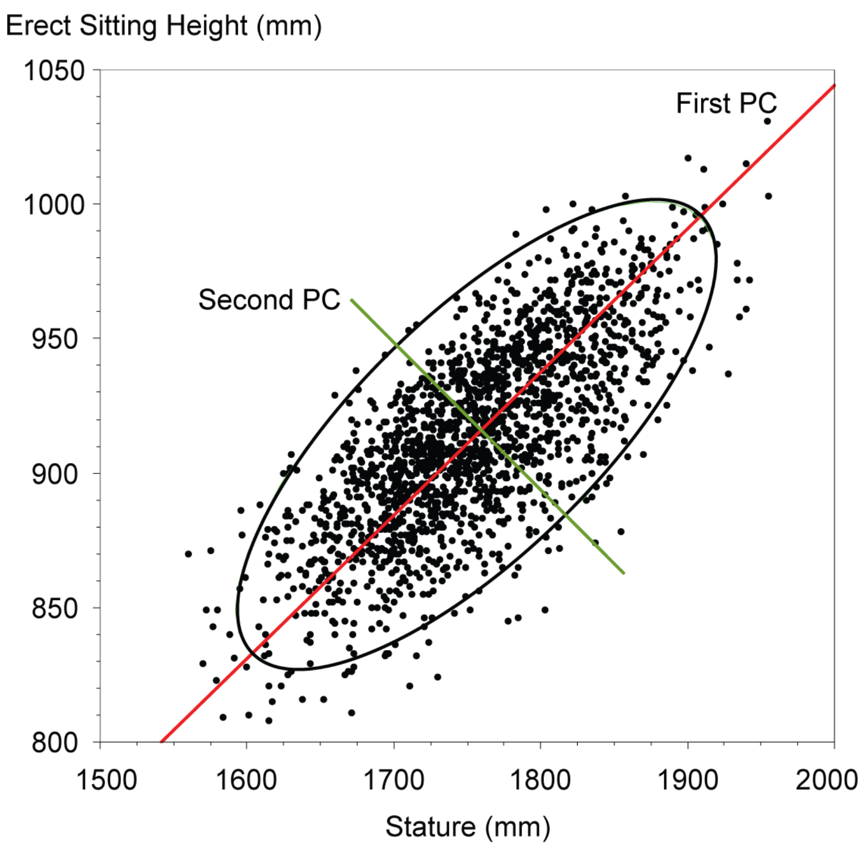
Principal Component Analysis

What:

Project multidimensional data into a lower-dimension space defined by independent, orthogonal vectors

Why:

1. Compression: Represent most of the data variance using a smaller number of variables
2. Understand the primary modes of variance (size and shape in geometric data)



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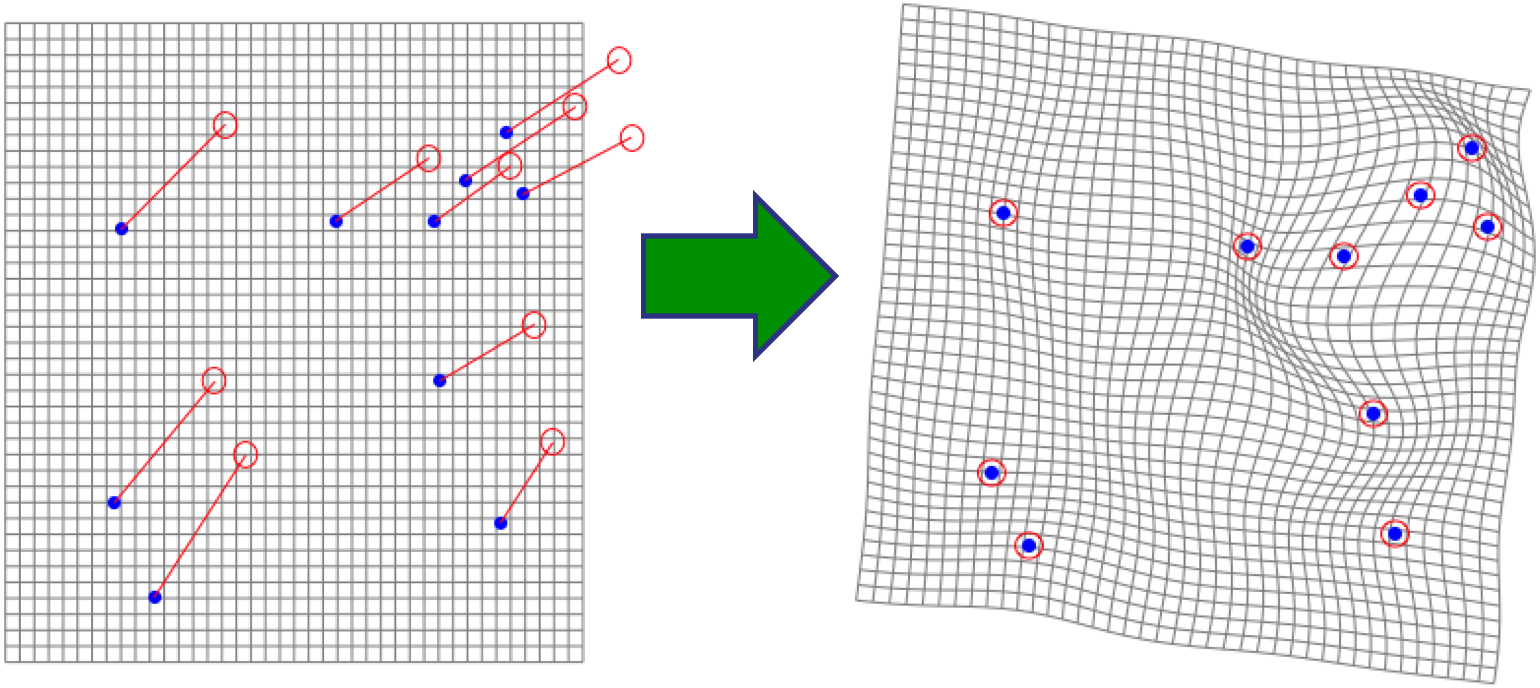
Radial Basis Function Morphing

- To rapidly change the baseline mesh into another geometry



Map the blue points to the red circles
The grid illustrates the calculated deformation

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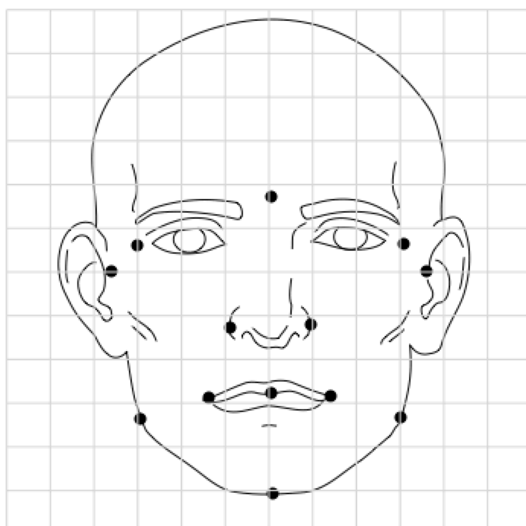
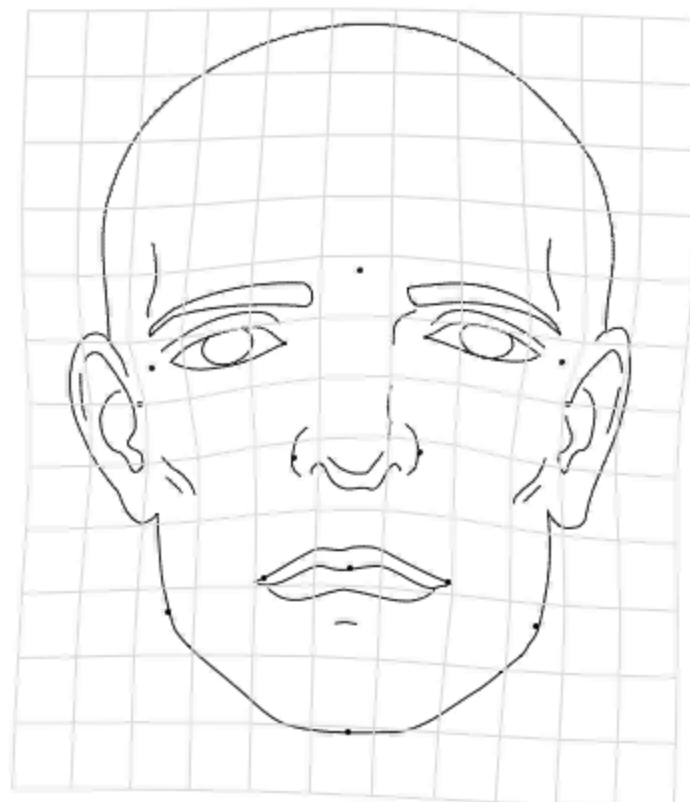
Radial Basis Function Morphing

To generate a morphing function, we use homologous configurations of points as the source and target

Example: Use morphing to illustrate face shapes characterized by 13 landmarks



reference



20 men

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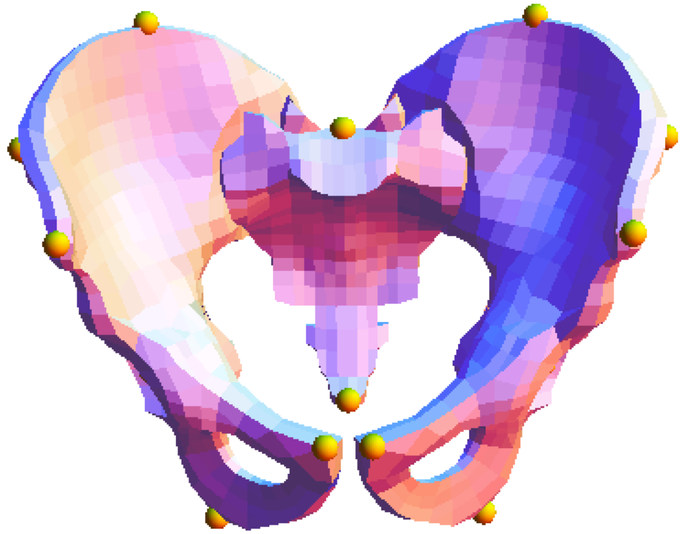
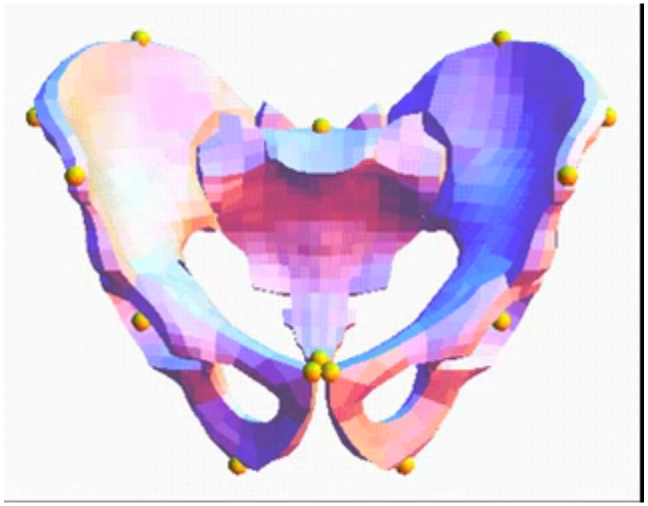
Radial Basis Function Morphing

To generate a morphing function, we use homologous configurations of points as the source and target

Example: Adult male pelvis shapes (16 landmarks)



reference



46 men

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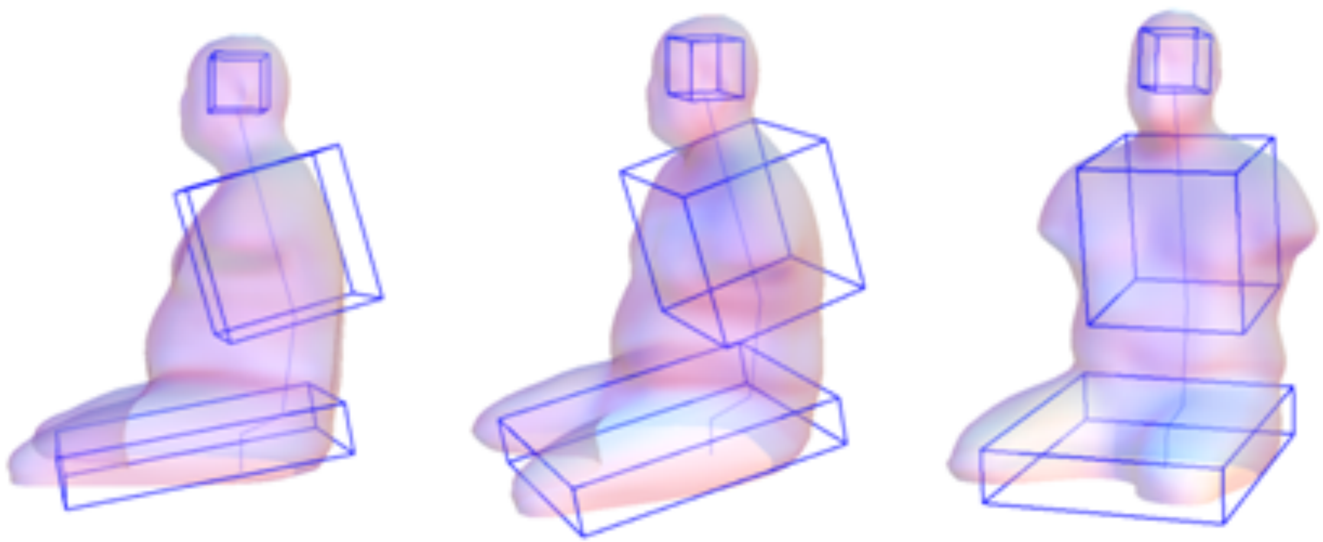
3D Seated External Body Contours

- Occupant positioning and posture by RBF morphing



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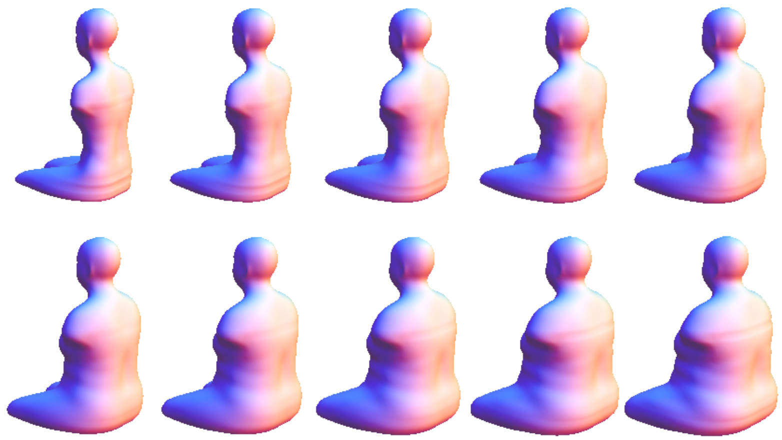
3D Seated External Body Contours

•Statistical models of seated body shape predicted by *height, BMI, thigh angle, and lumbar spine flexion angle*, based on U.S. CAESAR data

Seated torso shape model based on body dimensions and posture



Parametric Seated Whole-Body Model (same height varying BMI)

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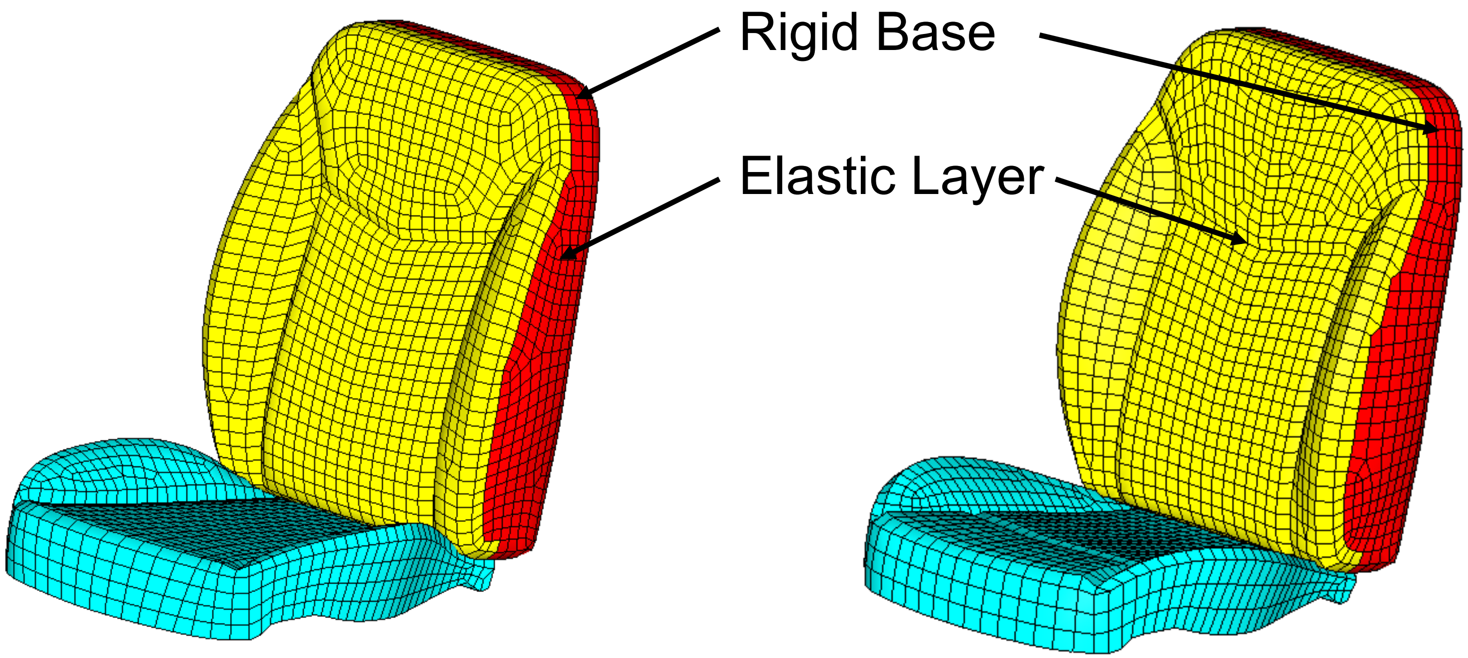
Simplified Seat Models

- Shell element only, no real foam
- Uniform thickness and material



JS41_old JS41_new

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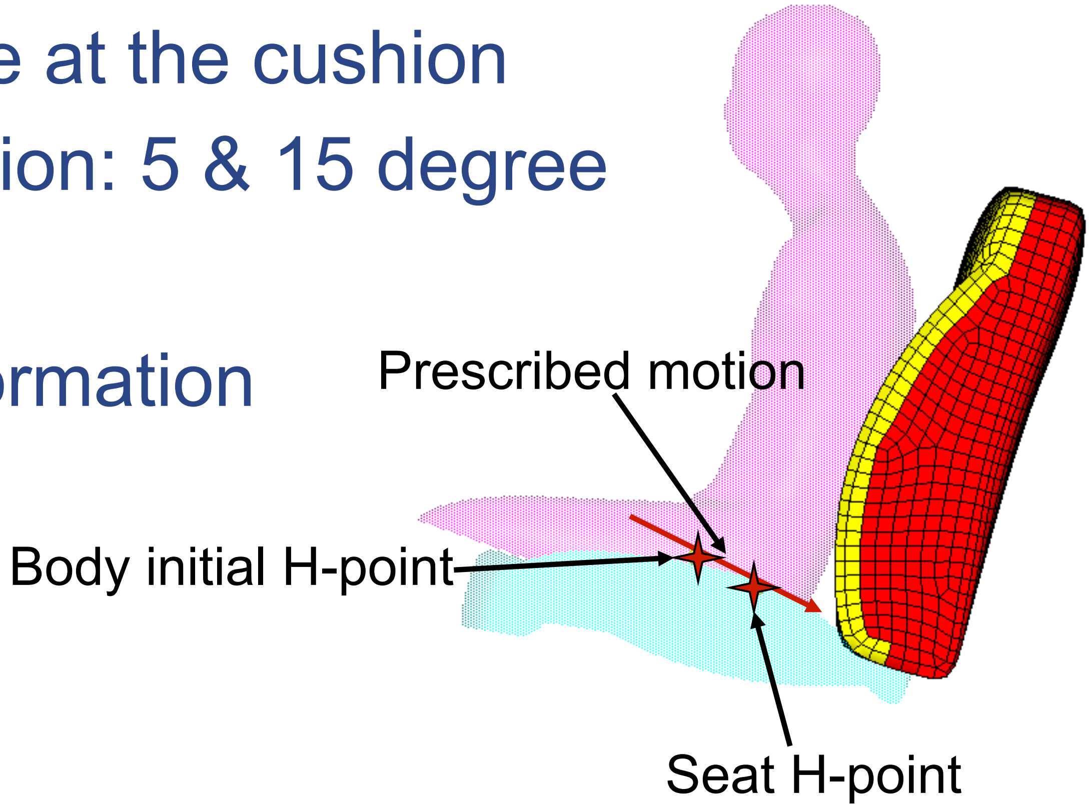
Simulation Setup

- 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: foam deformation



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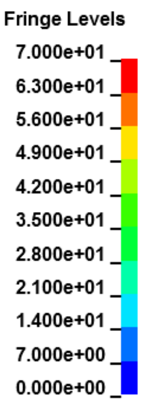
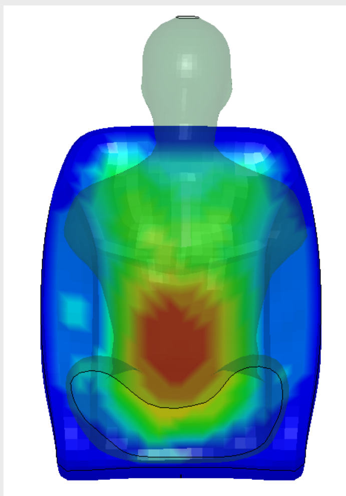
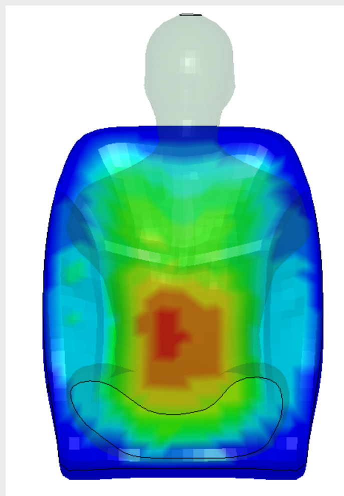
Simulation Results

- Old seat vs. New seat



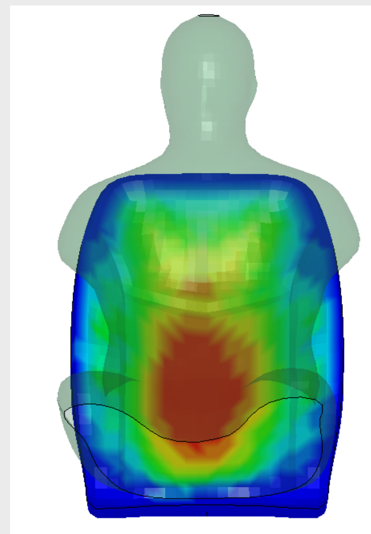


Old seat

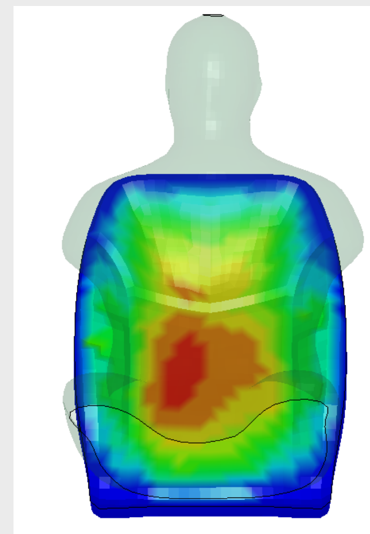


New seat

H165, BMI20, Lspine flexion 15°



Old seat



New seat

H185, BMI35, Lspine flexion15°

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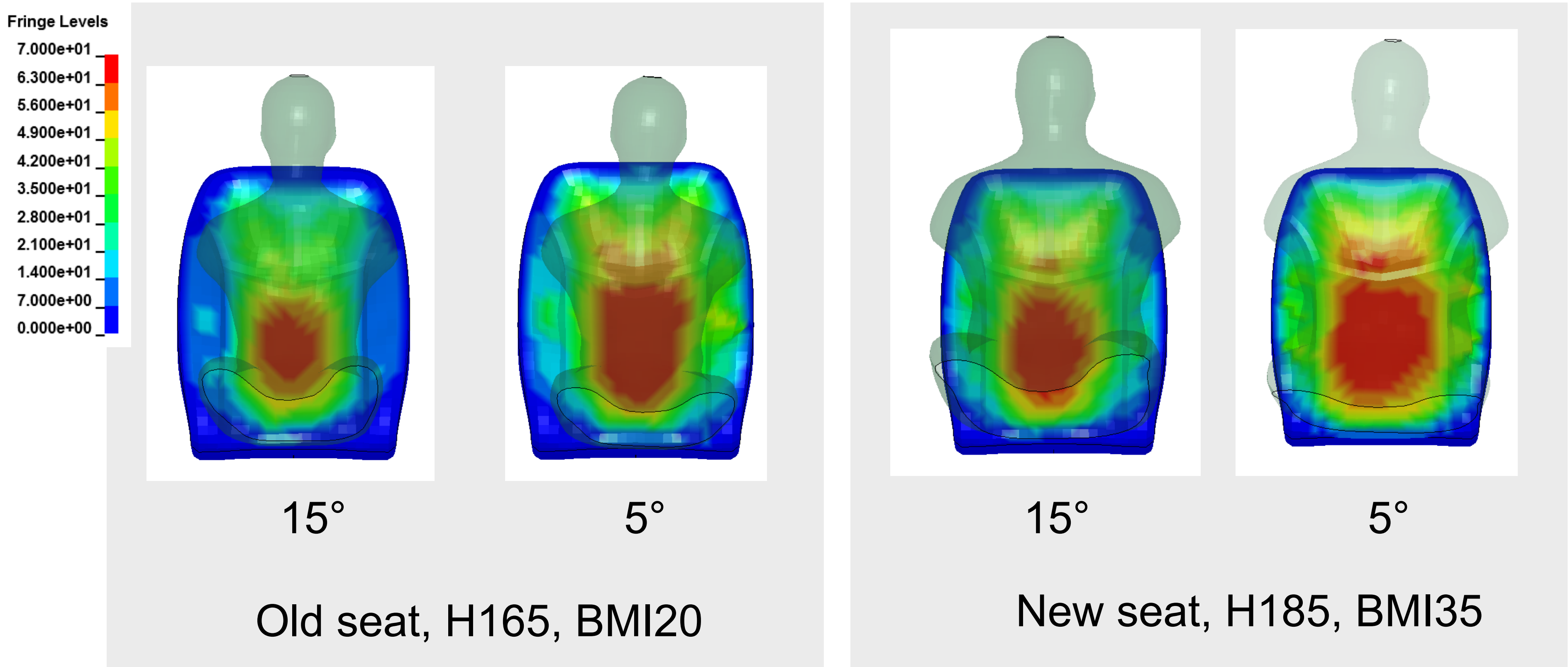
Simulation Results

- Lumbar Spine flexion 15 deg vs. 5 deg



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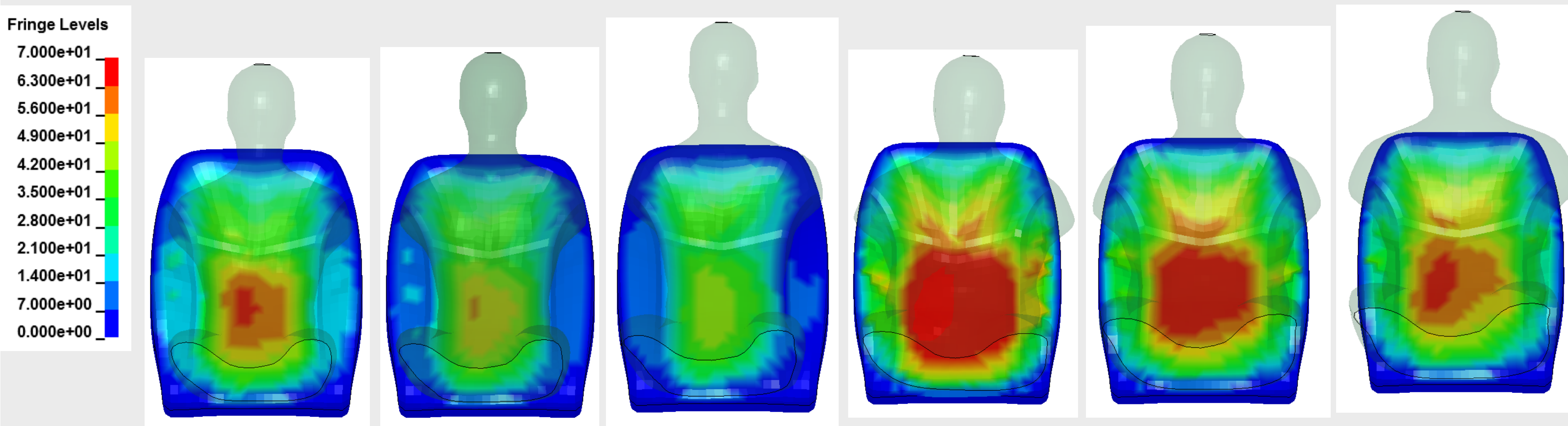
Simulation Results

- Torso shape



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

New seat, Lumbar spine flexion 15°

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Summary

- A method was developed to include posturing capability in a statistical model of torso shape.
- 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 of body shape morphing and simulation is not validated yet.
- Joint characteristics of the human body model is not simulated.
- 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.
- Refine the human body FE model by including more hard/soft tissues and proper joint characteristics.
- Conduct a laboratory study with human volunteers to quantify the relationships between subjective fit and objective measures of seatback interaction.
- Validate the FE method for simulating seatback interaction based on the framework developed in the current study.

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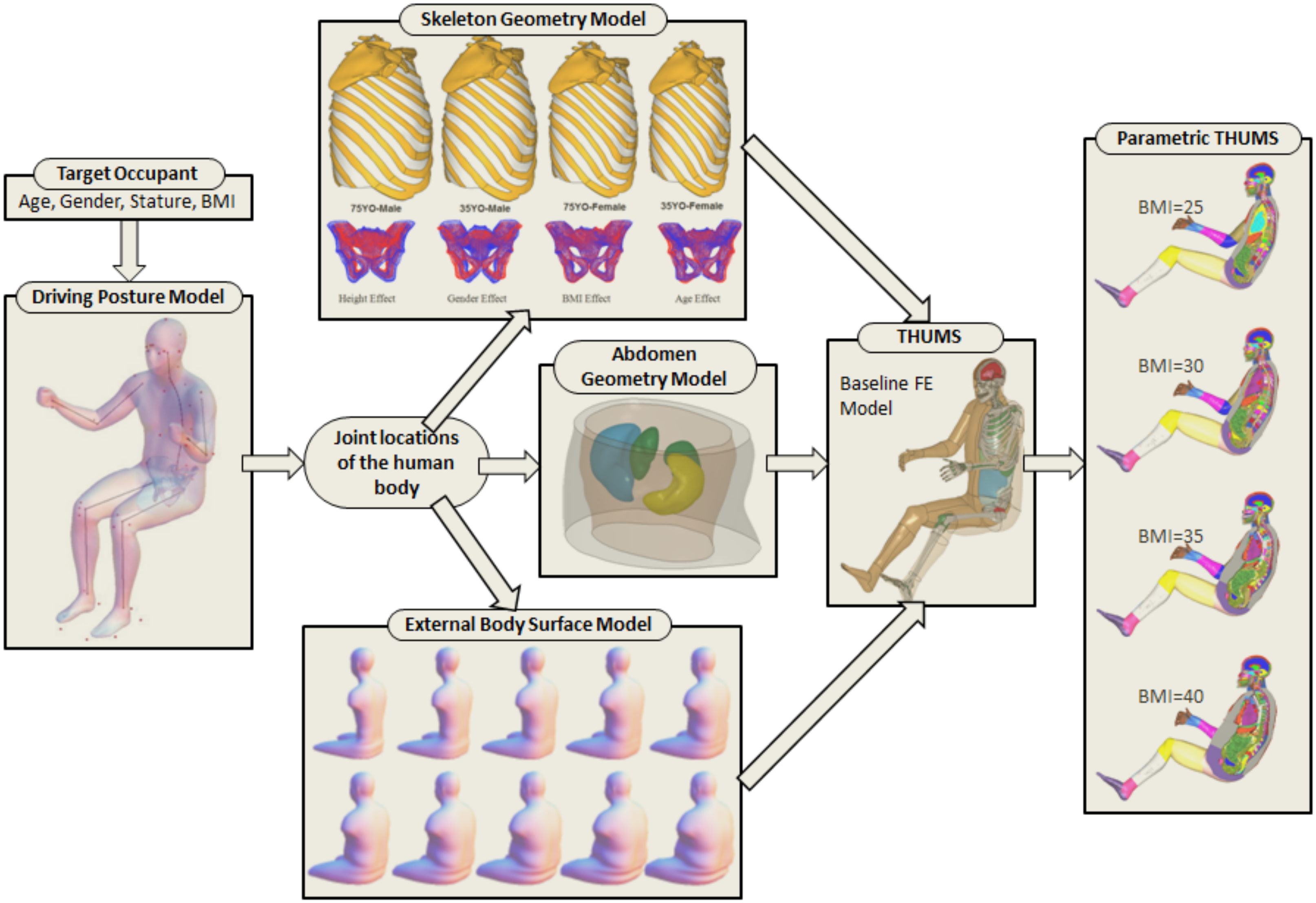
More Detailed Human Model



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