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).
Limited Literature Review

- MADYMO
  - Marx et al. 2005

- ESI
  - Montmayeur et al. 2005

- Hyundai-Kia
  - Kim et al. 2007

- CASIMIR
  - Siefert et al. 2008
Virtual Fit Evaluation

- ATD Model
- Human Model

Limited size and body shape
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
3D Seated External Body Contours

- Extract Scan Data
- Fit Surface Mesh
- Estimate Joint Locations
- Posturable Body Shape Model
- Regression Predictors:
  - thigh angle
  - recline
  - flexion
  - stature
  - BMI
- Morph to 15 Postures
- Principal Component Analysis

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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)
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
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.
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)

46 men
3D Seated External Body Contours

- Occupant positioning and posture by RBF morphing
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)
Simplified Seat Models

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

JS41_old

Rigid Base

Elastic Layer

JS41_new
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
Simulation Results

- **Old seat vs. New seat**

  - **Old seat:** H165, BMI20, Lspine flexion 15°
  - **New seat:** H185, BMI35, Lspine flexion 15°
Simulation Results

- Lumbar Spine flexion 15 deg vs. 5 deg

Old seat, H165, BMI20

New seat, H185, BMI35
Simulation Results

• Torso shape

New seat, Lumbar spine flexion 15°
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.
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.
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.
More Detailed Human Model

- Target Occupant: Age, Gender, Stature, BMI
- Driving Posture Model
- Joint locations of the human body
- External Body Surface Model
- Skeleton Geometry Model
- Abdomen Geometry Model
- Baseline FE Model
- THUMS
- Parametric THUMS: BMI=25, BMI=30, BMI=35, BMI=40

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