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.
Realistic Body Shape Models

Only a few sizes and body shapes
Objectives

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

Initial focus: Seat back fit
Method Overview

[Diagram showing the method overview with steps including Seat Design, FE baseline mesh, FE Seat Model, and H-point position, among others.]

UMTRI
Simplified Finite-Element Seat Models

Shell element only, no real foam
Uniform thickness and material

“Old”

“New”
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
- Principal Component Analysis
- Morph to 15 Postures
3D Anthropometry Methods: Laser Scanning

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

Laser towers (4)
Hand-held laser scanner to augment towers
Red laser beam

VITUS XXL Scanner
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
Body Shape Modeling

Whole-Body Scan Data

Handheld Scanner Data

Clean and Fit Polygon Mesh

Manual Landmark Extraction

Model Integration

Mesh with Landmarks

Fit Standardized Template

PCA+Regression Analysis

Statistical Model to Predict Body Shape from Standard Anthro or Landmark Locations

Manually Measured Body Landmarks

Standard Anthropometry (stature, body weight, etc.)
Process Overview: Scan Data

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

Template Fit to Data from a Scan (blue)
Process Overview: Scan Data

Scanned Mesh and Landmarks  Landmark-Morphed Template  Fitted Scan
Process Overview: Template Fits

Multiple subjects and postures
Surface Analysis

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

- Stature 1600 mm
- Stature 1755 mm (Median US Male)
- Stature 1900 mm
- BMI 18 kg/m²
- BMI 27.3 kg/m²
- BMI 40 kg/m²
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

[Diagram showing body initial hip location, prescribed motion, and seat H-point]
Simulation Results

Old seat
H165, BMI20, Lspine flexion 15°

New seat

Old seat
H185, BMI35, Lspine flexion 15°
Simulation Results

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

15°
Old seat, H165, BMI20

5°

15°
New seat, H185, BMI35

5°
Simulation Results

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

New seat, Lumbar spine flexion 15°
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.
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.
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]
UMTRI Human Models (2014)

Examples of statistical body shape models developed at UMTRI
More Detailed Human Model
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