Generalizing Statistical Body Shape Models to Alternative Avatars

B-K Daniel Park, PhD
Han K. Kim, PhD
Matt P. Reed, PhD
Need for Statistical Body Shape Models (SBSMs)

50th percentile model cannot represent various human body shapes
How to generate SBSMs

Statistically analyze and parameterize variances of source data sets

1. Collect Data
   Sample scans or CT images of population

2. Standardize
   Fit template model to individual data

3. Analyze Data
   Statistically analyze data using PCA

4. Parameterize
   Associate predictors to parameterization model
UMTRI SBSMs

UMTRI developed various types of statistical body shape models

Predictors:
- Body dimensions

Predictors:
- + Age and gender

Predictors:
- + and Pose!!

*Online SBSM: http://childshape.org
Backgrounds and Objective

• Limitation of SBSMs
  – Hard to convert to different mesh structure since it is based on a specific template model

• Main Objective
  – To propose a method to convert SBSM into alternative avatar that has different geometric structure, so benefits of SBSMs can be used in different software environments.
    1) Understand the discrepancy of heterogeneous geometric structures
    2) Build mapping information to store relationship of meshes
    3) Generate subject-specific avatar using mapping information
Need for Generalizing SBSMs

How can we convert a mesh structure to another kind?

**UMTRI**
- PCAR Female Model
  - 19K Vertices
  - 25K Polygons

**CATIA v6**
- Human Body Mesh
  - 7K Vertices
  - 15K Polygons
BACKGROUND

Generate a statistical model for CATIA v6 mesh

CATIA v6 Human Body Mesh
7K Vertices
15K Polygons
Overall Procedure

Five steps to convert SBSM to arbitrary avatar

Step 1. Fit SBSM Model to Avatar in the body shape space of SBSM

Step 2. Find Corresponding Elements for Each Vertex

Step 3. Define Local Coordinate System (LCS) based on the matched element

Step 4. Convert Coordinates using LCSs by projecting the coordinates to the system

Step 5. Apply Converted Coordinates to a Model
Step 1 & 2. Fit Model and Find Correspondences

- Fit a SBSM to the original mesh of CATIA manikin in body shape space
- Find the nearest SBSM triangle for each vertex on CATIA mesh

Account for clothing effect
Step 3 & 4. Define LCS and Map Coordinates

- Define local coordinate system (LCS) based on nearest triangle
- Store local coordinates of the CATIA vertices using the LCS (Figure)
Step 3 & 4. Define LCS and Map Coordinates

- Problems of LCS using Cartesian coordinates
  - Badly-conditioned triangles yield distortions on converted surface
  - Solved by applying Barycentric coordinate system to define a point on a triangle
Step 3 & 4. Define LCS and Map Coordinates

Comparison between Cartesian and Barycentric LCSs
Step 5. Apply Mapping to Subject-specific SBSMs

Apply mapping information based on subject-specific SBSMs’ Meshes
Result: Implementation Demo

Numerical data and measurements related to human body dimensions and physical characteristics.
Result: Segmentation and Rigging

Converted Avatar  Estimated Skeleton  Adjusted Posture in CATIA
Result: Key Frame Animation Example
Application: Subject-specific CATIA Manikin Generation using MS Kinect

Kinect-scan data conversion

Scanning using Kinect

Scan data

Fitted SBSM to Scan

Converted to CATIA Manikin

Age: 34.3 YO
Weight: 74 kg
Height: 157 cm
Conclusions

• **Generalizing SBSM to alternative avatars**
  – Subject-specific SBSMs were converted to alternative avatars using mapping information that explains discrepancy of two geometric structures
  – Barycentric local coordinate system was used for reliable conversion
  – Building mapping information takes a few seconds, and mesh conversion is in real time

• **Limitation**
  – Badly-conditioned mesh might result in anomalies

• **Future Works**
  – Apply to various types of commercial software systems
  – 3D finite elemental model conversion
THANK YOU!

Daniel Park, PhD (keonpark@umich.edu)
Matt Reed, PhD (mreed@umich.edu)
Han Kim, PhD (hankk@umich.edu)