Human Body Scanning Techniques for Clothing Design

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Global Contributor to Eco-Techno-Humanoporia
Agenda

- Introduction
  - Background
  - Objectives of the Study
- 3D Scanning Techniques: Static & Temporal
- Applications
- Discussion
Background: Anthropometry

- Ergonomic design of wearable products highly depends on anthropometric measurements in 1D, 2D, and 3D.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Female</th>
<th>Male</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>58.4&quot;</td>
<td>62.5&quot;</td>
<td>64.4&quot;</td>
<td>68.7&quot;</td>
</tr>
<tr>
<td>Weight</td>
<td>199.8</td>
<td>184.5</td>
<td>180.3</td>
<td>162.9</td>
</tr>
<tr>
<td>Standing Eye Height</td>
<td>58.5&quot;</td>
<td>60.5&quot;</td>
<td>60.5&quot;</td>
<td>60.5&quot;</td>
</tr>
<tr>
<td>Standing Shoulder Depth</td>
<td>44.7&quot;</td>
<td>NA</td>
<td>70.7&quot;</td>
<td>68.6&quot;</td>
</tr>
<tr>
<td>Standing Forearm Length</td>
<td>39.1&quot;</td>
<td>NA</td>
<td>31.8&quot;</td>
<td>35.4&quot;</td>
</tr>
<tr>
<td>Sitting Height</td>
<td>19.5&quot;</td>
<td>19.5&quot;</td>
<td>20.0&quot;</td>
<td>20.8&quot;</td>
</tr>
<tr>
<td>Sitting Shoulder Depth</td>
<td>11.5&quot;</td>
<td>11.5&quot;</td>
<td>11.5&quot;</td>
<td>11.5&quot;</td>
</tr>
<tr>
<td>Sitting Forearm Length</td>
<td>16.9&quot;</td>
<td>16.9&quot;</td>
<td>16.9&quot;</td>
<td>16.9&quot;</td>
</tr>
<tr>
<td>Sitting Knee Height</td>
<td>15.3&quot;</td>
<td>15.3&quot;</td>
<td>15.3&quot;</td>
<td>15.3&quot;</td>
</tr>
<tr>
<td>Head Circumference</td>
<td>14.0&quot;</td>
<td>13.2&quot;</td>
<td>12.2&quot;</td>
<td>12.2&quot;</td>
</tr>
<tr>
<td>Neck Circumference</td>
<td>7.9&quot;</td>
<td>7.9&quot;</td>
<td>7.9&quot;</td>
<td>7.9&quot;</td>
</tr>
<tr>
<td>Shoulder Width</td>
<td>11.5&quot;</td>
<td>11.5&quot;</td>
<td>11.5&quot;</td>
<td>11.5&quot;</td>
</tr>
<tr>
<td>Elbow Width</td>
<td>7.9&quot;</td>
<td>7.9&quot;</td>
<td>7.9&quot;</td>
<td>7.9&quot;</td>
</tr>
</tbody>
</table>

http://dominicjonesarch.weebly.com/
CAD Methods in Garment Design

- CAD methods have been utilized in garment design.


**Parametric human model**

**Encoding & decoding of garment feature template**
The human body surface data obtained in 3D have been used for 3D garment design.

The dynamics of the human body (deformation of human skin by motion) needs to be understood in depth for better design of functional wear with better fit, comfort, and performance.
Objectives of the Presentation

- Review static and temporal 3D (4D; dynamic) body scanning techniques.
- Reflect the potential application of temporal 3D body scanning techniques to ergonomic design of wearable products.
# 3D Scanning Techniques

<table>
<thead>
<tr>
<th>Classification</th>
<th>Laser scanning</th>
<th>Structured light scanning</th>
<th>Stereo photogrammetry scanning</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Examples</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laser scanning</td>
<td>Head &amp; Face Color 3D Scanner (Cyberware Inc., USA)</td>
<td>TC2-19R body scanner ([TC]², USA)</td>
<td>Active: 3dMD systems (3dMD, USA)</td>
</tr>
<tr>
<td></td>
<td>FastSCAN (Polhemus, USA)</td>
<td>Artec Eva (Artec 3D, Luxembourg)</td>
<td></td>
</tr>
<tr>
<td><strong>Techniques</strong></td>
<td>Application of a laser beam (spot or stripe) across the target surface</td>
<td>Projection of organized patterns of white light, such as grids, dots, or stripes to the target surface</td>
<td>Software approach that creates a stereo pair from 2 pictures taken from the same object</td>
</tr>
<tr>
<td></td>
<td>• Accurate</td>
<td>• Color texture well recorded</td>
<td>• Passive: requiring high resolution single-lens reflex cameras to capture enough surface detail, and careful control of lighting conditions</td>
</tr>
<tr>
<td></td>
<td>• Time demanding, difficult to use on living, breathing people, especially children</td>
<td>• Hard to scan symmetric body surfaces at the same time due to light pattern interference</td>
<td>• Active: flexible to lighting conditions; able to easily capture darker skins, fast, high data quality</td>
</tr>
<tr>
<td><strong>Strengths/ Limitations</strong></td>
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</tbody>
</table>
Laser 3D Scanning

- Project a laser beam spot or stripe across the target surface and detect the surface location by trigonometry
- Limitation: Ineffective for scanning an object in motion

FastSCAN (Polhemus, USA)
Structured Light-Based 3D Scanning

- Project structured patterns of grids, dots, or stripes to the target surface and capture the distorted light over the object by 1 camera for surface generation.
- Limitation: Inefficient to scan symmetric body surfaces due to light pattern interference.

Cartesia body scanner (Spacevision, Japan)
Stereo Photogrammetry-Based 3D Scanning

- Project unstructured patterns of dots or speckles on an object and capture the images of the object by 2 cameras for generation of surface reconstruction.
  - High data quality (< 0.2 mm RMS error)
  - Fast (up to 60 fps)
  - Easily capturing darker skins
  - Flexible to lighting conditions

3dMD face scanner (3dMD, USA)
Temporal Scanning: Structured Light-Based

Artec 3D body scanner
(Artec Group, Luxembourg)
Chest Deformation by Breathing

Normal Breathing  Heavy Breathing  Breathing After Exercise
Chest Deformation: Contour Profile

Normal Breathing
Frames 58 & 70

Heavy Breathing
Frames 26 & 37

Breathing After Exercise
Frames 15 & 20
Chest Deformation: Cross-Sectional Profile

Normal Breathing
Frames 58 & 70

Heavy Breathing
Frames 26 & 37

Breathing After Exercise
Frames 15 & 20
Chest Deformation: Histogram

Normal Breathing
Frames 58 & 70

Heavy Breathing
Frames 26 & 37

Breathing After Exercise
Frames 15 & 20
Mobility Changes by Cloth Material

- Lunging in yoga pants & jeans
- Bending over in yoga pants & jeans
- Squatting in yoga pants & jeans
Mobility Changes: Contour Profile

Superimposition of subject bending over with standard A-pose

Shape change with different body poses.
Writing Comparison w/ and w/o Fitbit
Micro Motion Analysis (60 fps)

- Ultra-dense analysis techniques of the subject’s skin dynamics with posture, pose, and functional movement
- Provides the bridge between automated traditional point tracking and sparse meshing techniques to expressing movement in terms of dense surface deformation
Dynamic Anthropometry for Foot
The **stereo photogrammetry-based scanning technique** is superior to the laser-based and structured light-based techniques in terms of **time and data quality to capture an object in motion**.

- Structured light-based Artec 3D body scanner
- Stereo photogrammetry-based 3dMD body scanner
The *stereo photogrammetry-based scanning technique* is superior to the laser-based and structured light-based techniques in terms of time and data quality to capture an object in motion.

The *temporal 3D canning technique* enables to capture human body surfaces in motion with a certain frame rate (up to 60 fps), which is applicable to dynamic body dimensions for ergonomic design of wearable products such as sportswear and shoes to improve the comfort and performance of wearer.

The *temporal 3D scanning technique* has high potential in R&D of dynamic anthropometry, human modeling, and product design.
Discussion

- The temporal 3D scanning technique has high potential in R&D of dynamic anthropometry, human modeling, and product design.

4D Scanner
Thank you for your attention!