3D Body Scanning as a Valuable Tool for User Centered Design

Alexandra De Raeve
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Content

- FTI-lab
- Introduction – Historical evolution of the fashion industry
- Ageing Society
- Mass customization
- Sizing systems
- Clothing comfort
- 3D body scanning Smartfit methodology
- Design requirements for the ageing population
- Conclusions and future research topics
FTI-lab University College Ghent
FTI-lab

• Leading provider product development services
• Fields of Expertise:
  – (Multi)functional & smart textile materials and related processing technologies
  – Bio-chemistry based textile processing
  – Digitisation & flexibilisation of product development and production processes
  – Cultivation & processing and application of hemp
  – Garment manufacturing
  – Thermophysiological & sensorial comfort
• 8 FTE researchers and +20 academics with various backgrounds
• Demonstration platform & prototyping infrastructure
Introduction

Historical Evolution of the Fashion Industry
Trends
Historical evolution

Haute Couture

Ready-to-wear

• 1900

• 1950

• 1970-1980 …
Megatrends

- Demographic changes
- Globalization
- Economic power shift
- Climate change
- Resource scarcity
- Break through technologies & digital revolution
- Mass customization
Demographic change: Ageing Society

Clothing Needs versus Availability
Ageing in Belgium and worldwide

Percentage of 65+

<table>
<thead>
<tr>
<th>Country</th>
<th>% in 1960</th>
<th>% in 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Japan</td>
<td>6</td>
<td>26.3</td>
</tr>
<tr>
<td>2. Italy</td>
<td>9</td>
<td>23</td>
</tr>
<tr>
<td>18. Belgium</td>
<td>12</td>
<td>18.5 (1/1/2017)</td>
</tr>
<tr>
<td>World</td>
<td>4.9</td>
<td>8.5</td>
</tr>
</tbody>
</table>
Silver Economy

• 3rd largest economy in the world ($ 7 trillion)

• Global growth of Silver Economy
  – Increase of $ 92 billion in 2013
  – Private spending power of 65+ estimated at $ 15 trillion by 2020

• Clothing and textiles are important aspects within the Silver Economy
Clothing & the elderly population

- Major concern: **DIGNITY & COMFORT**
- Other:
  - attractiveness;
  - masking physical imperfections;
  - adapted to changing physique;
  - prolonging independant functioning;
  - available in adequate supplies and price categories.
- Flanders and Europe: only a limited number of clothing meets these requirements
  → *Need for mass customized apparel*
Mass Customization
Mass customization

- Design and manufacture consumer goods and services for an extended market
- Products are customized according to distinct customer desires
- Products and services can be offered at a price comparable to mass production
- Challenge?
  Balance between added value through differentiation and reducing costs through mass production of commodities
Customization in Fashion
Need for strategic innovation in fashion business model

• Flexible, small batch oriented manufacturing processes
• Digitalisation of product development and processing
Ready-to-Wear size tables

Apparel product development & Fit
1D versus 3D
Current methods to create sizes and assess fit
Current methods to create sizes and assess fit
What’s the problem?

1-D Percentiles Are Not Additive!
3-D Models from 1-D Measures Add Undetected Error!

- **Sum of 5th %ile Parts** = 136.89 cm
  - 5th %ile Height = 152.50 cm
  - Difference = 15.61 cm
- **Sum of 95th %ile Parts** = 188.81 cm
  - 95th %ile Height = 173.06 cm
  - Difference = 15.75 cm

SAMPLE SIZE = 3235

*From Robinette and McConville 1982*
Clothing comfort

Thermophysiological perceptions
Sensory perceptions
Parameters influencing comfort
Comfort = Perception of well-being

Physiological conditions
- Thermophysiological comfort: thermo-regulation & moisture regulation
  - Fabric
  - Style
  - Fit

Sensorial comfort
- Fabric
- Fit
- Assembly technique

Psychological conditions
- Aesthetics
- Design/Style
- Fit
- Quality

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Thermal Balance

<table>
<thead>
<tr>
<th>Activity</th>
<th>Energy (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resting</td>
<td>90</td>
</tr>
<tr>
<td>Walking (1.6 km/h)</td>
<td>140-175</td>
</tr>
<tr>
<td>Walking (4.8 km/h)</td>
<td>280-350</td>
</tr>
<tr>
<td>Cycling (16 km/h)</td>
<td>420-490</td>
</tr>
<tr>
<td>Running (8 km/h)</td>
<td>700-770</td>
</tr>
<tr>
<td>Sprinting</td>
<td>1400-1500</td>
</tr>
</tbody>
</table>

Individual factors:
- metabolism, physical condition
- climate: temperature, humidity, wind, precipitation
- effort level
- clothing

Heat balance

Environmental
- Radiant
- Conductive
- Convection

Metabolic
- SEM/TME
- Thermogenesis
- Muscular activity
  - Postural
  - ADL
  - Exercise
Heat loss

Evaporation
(evaporating 1g $H_2O$: 2424 J)
difficult in tropical conditions

Convection/Conduction
(stops when $T_{environment} \sim T_{body}$)

Radiation
Product characteristics supporting thermal regulation

- Thermal conductivity
- Windproofing capacity
- Water vapour permeability → closely related
- Creation of a micro climate
Thermal conductivity

• The heat flux through a textile material is a combination of conduction (function of thickness and conductivity) and radiation (higher in low fibre volumes)

• Mainly function of material thickness

• Layers of air (stationary) increase the insulating capacity (0.85 clo)
Windproofing capacity

- Wind compresses the material $\rightarrow$ thickness $\downarrow$ insulating capacity $\downarrow$
- Brings stationary air in the clothing system in motion $\rightarrow$ losses by convection $\uparrow$
- $v_{\text{air}} = 0.15 \text{ m/s} \rightarrow$ insulating ability air layer = 0.85 clo
- $v_{\text{air}} = 15 \text{ m/s} \rightarrow$ insulating ability air layer = 0.15 clo
- Coating will improve windproofing capacity but water vapour permeability will decrease
Water Vapour Permeability

• Sweating is an important mechanism to remove excess heat from the body
• Heat is deprived of the body to evaporate moisture from the skin
Sweating

- Non perceptible: sweat is transported as vapour through the pores of the textile material → water vapour permeability
- Perceptible: clothing in contact with the body becomes wet → absorption and transportation (wicking) of moisture
- Accumulated moisture → insulating capacity
Product characteristics supporting tactility

- Bending stiffness
- Coefficient of friction
- Compressibility
- Thermal conductivity/heat flux
- Moisture management
- Thickness
- Weight
- Elasticity
Parameters influencing comfort

- Fibre related parameters (20 %)
  - Chemistry/Morphology
  - Fineness, crimp and section
  - Length
  - Density
  - Friction property
  - Finishing
- Construction related parameters (80 %)
Construction related parameters (material)

• Yarn
  – Yarn type (staple fiber, continuous filament, textured)
  – Linear density
  – Twist

• Fabric
  – Production method (woven fabric, knitted fabric, non woven)
  – Construction (weave, density)
  – Weight
  – Thickness/voluminousity
  – Roughness

• Dyeing & Finishing process
  – Heat treatment
  – Brushing
  – Calandering
  – Softening
  – Coating
3D Body Scanning

- Determining the body dimensions and shapes of the Belgian population
- Development of standard size charts
- Development of 3D virtual manikins (avatars)
Set Up

Sample ± 2500 persons age 3 – 70 years
Measurements extracted ± 180 per person
The hourglass figure is no longer relevant

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**The Different Shapes**

- **Hourglass**: 8.40%
  - Bust and hips are basically the same circumference - though the bust can be up to 1” larger than the hips. The waist is then 9” or more smaller than the bust.

- **Spoon**: 20.92%
  - Where the hips are 2” or more larger than the bust. The waist is less than 9.25” smaller than the bust.

- **Rectangle**: 46.12%
  - Where the bust and hips are basically the same circumference. The waist is less than 9” smaller than the bust.

- **Triangle**: 13.83%
  - The bust is 3.6” or larger than the hips and the waist is less than 9” smaller than the bust.

Results are from 6318 women scanned

Source: Alvanon
One size, different shape

<table>
<thead>
<tr>
<th>AGE</th>
<th>CHEST</th>
<th>WAIST</th>
<th>HIPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>91</td>
<td>71</td>
<td>95</td>
</tr>
<tr>
<td>30</td>
<td>87</td>
<td>68</td>
<td>92</td>
</tr>
<tr>
<td>40</td>
<td>89</td>
<td>70</td>
<td>94</td>
</tr>
</tbody>
</table>

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Age matters, body shapes change

**Breasts**

- **Stage 0:** Before ageing starts... breasts are ideally round.
- **Stage 1:** A sign that ageing has begun. The upper part of the breasts splits.
- **Stage 2:** As the breasts begin to sag, the nipples begin to point downward.
- **Stage 3:** The breasts continue to sag, turning outward. They also continue to become softer.

**Hips**

- **Stage 0:** Before ageing starts... when viewed sideways, it makes a beautiful semicircle.
- **Stage 1:** Signs that ageing has begun. The lower portion of the hips sags downward.
- **Stage 2:** The waist loses its definition. The peak of the hips moves downward.
- **Stage 3:** The hip area sags and turns inward.
### Body measurement tables FEMALE

Garments for full or upper body, primary dimension BUST Girth, intervals according EN 13402-3 (2013)

<table>
<thead>
<tr>
<th>SIZE</th>
<th>32</th>
<th>34</th>
<th>36</th>
<th>38</th>
<th>40</th>
<th>42</th>
<th>44</th>
<th>46</th>
<th>48</th>
<th>50</th>
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</thead>
<tbody>
<tr>
<td>BUST</td>
<td>74-78</td>
<td>78-82</td>
<td>82-86</td>
<td>86-90</td>
<td>90-94</td>
<td>94-98</td>
<td>98-102</td>
<td>102-107</td>
<td>107-113</td>
<td>113-119</td>
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**14-17**

AVERAGE
HEIGHT
165 CM

<table>
<thead>
<tr>
<th>18-25</th>
<th>26-50</th>
<th>51-70</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVERAGE</td>
<td>AVERAGE</td>
<td>AVERAGE</td>
</tr>
<tr>
<td>HEIGHT</td>
<td>LENGTH</td>
<td>HEIGHT</td>
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<tr>
<td>166 CM</td>
<td>166 CM</td>
<td>164 CM</td>
</tr>
</tbody>
</table>

Total number of measurement tables = 7
Body measurement tables FEMALE
Garments for lower body, primary dimension HIP GIRTH, intervals according EN 13402-3 (2013)

<table>
<thead>
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<th>36</th>
<th>38</th>
<th>40</th>
<th>42</th>
<th>44</th>
<th>46</th>
<th>48</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUST Girth</td>
<td>80-84</td>
<td>84-88</td>
<td>88-92</td>
<td>92-96</td>
<td>96-100</td>
<td>100-104</td>
<td>104-108</td>
<td>108-112</td>
<td>112-117</td>
<td>117-122</td>
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<td>14-17</td>
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<tr>
<td>Average Height</td>
<td>165 CM</td>
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<td>Average Height</td>
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<td>164 CM</td>
<td>164 CM</td>
<td>164 CM</td>
</tr>
</tbody>
</table>

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Body measurement tables

Female body evolution size 40

Hip intersection
Waist intersection

14 - 17

Female body evolution size 44

Hip intersection
Waist intersection
Body measurement tables

Upper versus lower body size 40

Upper versus lower body size 48

26 - 50  FEMALE  26 - 50
Body measurement tables

Upper versus lower body size 46

18 - 25  FEMALE  51 - 70

Upper versus lower body size 46

IDC  Smart Living for Elderly 2017
Male body shape evolution

Male body evolution size 48

Male body evolution size 54

18 - 25

Hip intersection
Waist intersection
Hip intersection
Waist intersection

IDC Smart Living for Elderly 2017
1990 VERSUS 2013 – female 26-50
1990 VERSUS 2013 – female 26-50

Size 38
1990

Size 38
2014
Allometric grading technique

• Establish a relationship between body form and grading technique
• Grade according to body characteristics, not proportional (e.g. sloped waist)
Design Requirements for the Ageing Population

Inventory of needs and requirements
Methodology

• Focus groups elderly:
  – Living at home without care needs
  – Living at home with care needs
  – Living in nursing home

• Focus groups professionals
  – Professionals in home care
  – Professionals in nursing homes
Inclusion & exclusion criteria

• Elderly:
  – Willing to speak about clothing in public
  – No cognitive disabilities

• Professionals:
  – Willing to speak about their experiences with clothing while nursing elderly people
  – Offer help to dress and undress elderly daily
Rendering results

elderly

professionals

similarities

IDG - Smart Living for Elderly 2017
Results

• Requirements:
  – Easy to maintain, quality
  – Easy to wash
  – Easy to iron
  – Maintain shape after several washing cycles
  – Elderly in nursing homes: industrial washable
  – Comfortable
• Willing to pay more for quality
  – Shop adapted to their needs
  – Good service
• Fitted but higher waistbands
• Elastic fabrics
• Clothing for Wheelchair users:
  – Skirts and trousers should be longer
  – Need for a high waist (cover the back)
• Difficult to pull on shirts and dresses:
  – Shirts are not elastic and arms must be taken to far to the back
  – Dresses need to be pulled over the head
  – Two piece dresses would be more convenient
• Buttons and zippers are too small which complicates closing and opening
• Adaptations must be discreet, not stigmatizing
• Transition to adapted clothing is difficult
Elderly wear their clothing ‘their own way’: high-rise fit not adapted!
Conclusion
Customizing for specific target groups

<table>
<thead>
<tr>
<th>Pose</th>
<th>Arm length (shoulder to wrist)</th>
<th>Arm girth (biceps)</th>
<th>Waistband slightly inclined</th>
<th>Waistband strongly inclined</th>
<th>Chest girth (maximum)</th>
<th>Back width (under arms)</th>
<th>Back length (to waistband)</th>
</tr>
</thead>
<tbody>
<tr>
<td>strained</td>
<td>64</td>
<td>26.8</td>
<td>85.4</td>
<td>85.4</td>
<td>110.6</td>
<td>44.1</td>
<td>48.5</td>
</tr>
<tr>
<td>relaxed</td>
<td>59.1</td>
<td>32</td>
<td>84.9</td>
<td>94.7</td>
<td>106.8</td>
<td>37.7</td>
<td>52.4</td>
</tr>
</tbody>
</table>
Customizing for specific target groups: elderly

- Adapted workwear and personal protective garments
- Adapted hospital gowns

...
Acknowledgements

We would like to thank the Flemish agency for innovation and entrepreneurship.
Thank you for your attention

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