Education in Anthropometry within Industrial Design Engineering

From 1D to 4D

Dr Johan FM Molenbroek
Associate Professor Applied Ergonomics & Design
delft

- 400  Roman-period of protecting the Rhine as way of transport to England ends
- 1244  Delft received city rights
- 1584  Prince Willem was shot by Balthazar Gerards
- 1842  Delft university started as polytechnical school by King Willem II
- 1964  IDE school starts within architecture
- 2001  IDE has 1700 students in her 5 year curriculum and 300 staff; 180 MSc/y
- 2001  Delft starts with bachelor/master system
- 02-02-02  Prince Willem Alexander marries Maxima Zorregieta from Argentina
How to make a product 1

• Tailor made
  1 maker → 1 client knowing and seeing each other

• Small series
  1 maker → 10 clients
  Knowing and seeing each other still possible
How to make a product 2

Series production or Mass production

A company with departments in Marketing Design Ergonomics Production Distribution

→For numerous rather unknown consumers
Result on current market

- Intended use
- Reasonable expected use
- Unuse
- Misuse

- Manuals
- Designer
- Consumers union
- Marketing +
- Ergonomics -
- Complaints
- Discomfort
- Accidents
Examples of usage

• 20 ways of how to open a cup of coffee milk creamer
• Only 1 was meant by the designer

See www.io.tudelft.nl/aed/ under usage evaluation
Examples of usage

• Trying to gripping something on the ceiling on a normal office chair
Examples of usage

• Reasonable usage of an office chair
Examples of usage

• A director with her secretary on her lap
Sketch of man-product-interaction in designing a mp3 player
Anthropometry in press

• Example 1:
  Biometry for identification

• Example 2:
  Legs of 134 cm
Anthropometry in press 2

- A prisoner escaped in June 2003 through a window of 17.5 cm (7 inch) high and 50 cm (20 inch) wide.

- Therefore it was decided that all windows should have bars.

- Comparing to the dimensions of our students there are indeed a few who can pass!
Trends in anthropometry

• From static to dynamic
• From 1D to 2D, 3D and more Dimensional
• From using once in the design process to using continuously
• From tables through digital human models to mock-ups and test persons
• From mono disciplinary to interdisciplinary (RSI)
Anthropometry on the web

- Is difficult to find because of price per measurement per person (10 dollar)

- An investigation with n=1000 and v=50 will cost half a million dollars

- But a few sources you can find at our website

- [www.dined.nl](http://www.dined.nl)
The growth of anthropometry

- 1D
- 2D
- 3D
- 4D

- Percentiles
- Ellipses
- We need a tool to describe the density in 3D space in the context of man-product-interaction (fit)
- We need in tool to describe the changes in time of this fit
sizes from delft

• What we measured in the past
• What we want to measure in the future
• What we estimated because of lack of data
One dimensional anthropometry

- We saw famous tables of Flying Personnel 1954, DIN 33402, Anthropometric Source Book from ARP 1978 and ERGODATA in Paris

- DINED → Made in Holland

- Tables Look easy but solves only 1D simple problems:
  - It will be too wide or too narrow for x% But not:
  - It will not fit for x%
An estimation of 27 body dimension of Dutch adults
Which is used as a national standard since 1986
Mean 1794 mm for aged 20-60 is still valid but limited in use
Dined after 16 years usage

**Negative**
- 1D
- Too much trust
- Data needs update
- No data about children
- No data about elderly
- Easy to misuse

**Positive**
- Very popular
- Widely distributed
- Free of costs
- On the web
- Interactively
- Became national standard
- Easily to use
Some principles in using anthropometric data

- After years of observing our 1600 students in industrial design engineering
- After questioning them about the use of anthropometry
- During my dissertation Made to Measure

- We found some principles about how people work with anthropometry
- We created some idea’s about what to research
  - Especially what is fit and how to estimate or measure it
Overview of Anthropometric Design Types

- Procrustus
- Design for the tall

- Ego design
- Design for Adjustability

- Design for the mean
- Design for More types

- Design for the small
- Design for All

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Johan Molenbroek

TU Delft
How to cope with 2D or more dimensions simultaneously?

• You need knowledge about
  • Interaction between man- and product → observational research
  • Difference between man and product dimension
  • The misuse of percentiles in 2D and 3D
  • Correlations
  • Bivariate distributions
  • Scatter plots
  • Raw data

• See the following master project: a racing kart
A kart seat of IDE master student Gerard van Ooijen
Application of Ellipse was developed and used by students

Hipwidth

x

Chest width
A second example is school furniture

- In 1992 the European Market needed to be harmonised and new standards were stimulated by the EU
- The old standard in NL was from 1977
- The secular trend was 2.7 mm per year in height in NL
- So discussion with European colleagues was about the Dutch heights,
- But Netherlands was with 15 million citizen only 5% EU in 2000
- So the use of P95 in EU would exclude NL
secular trend Dutch body height
average 1.5 mm per year
Dutch secular trend 1965-1995
2.7-1.8 mm per year
2 D Anthropometry for school furniture was used in CEN-standard 1990-2004
A third example is child safety
anthropometry can prove the boundaries
Industrial design engineering

- Concept of ide is to integrate four disciplines as user centred design to create products for people
  - + Engineering
  - + Ergonomics
  - + Aesthetics
  - + Product innovation and marketing
- So every creation is continuously tested with simulated and real users during the design process by iteration

- Remark: the faculty of architecture in Delft has no ergonomics
Samples measured in Delft 1

- Experiences in measuring children and elderly during students course 1979-1986
  body measures and body joint motions
- Project A: 822 elderly (age 50-106) living in nursing homes 1982
  (30 variables incl 3 stages of limitations); Report with guidelines
- Project B: 354 students (age 18-35) IDE in 1985-1986
- Project A and B resulted in a PhD-book “Made to measure” 1994
  Johan FM Molenbroek (Dutch) and several articles (english)
Samples measured in Delft 2

- Project C: 2400 children (age 3 month- 12 years) measured on 40 variables (anthropometrics )
- Project C resulted in a PhD-book “Childdevelopment ... LPA Steenbekkers 1993 (English)
- Project D: guidelines for a size system for wheelchairs for children (GMD)
- Project E: 600 healthy elderly (aged 50+) compared with 150 young adult people (aged 20-30) on 79 variables (physical + sensorial + cognitive)
- Project E resulted in a book “Design relevant characteristics of ageing users” Steenbekkers...Molenbroek 1998 (english)
Main knowledge in Delft

- Sampling strategies
- How to measure special usergroups
- Data handling
- Functional versus static anthropometry
- How to transfer knowledge to designers and evaluators through human modelling
- Cooperations with industrie/societies
- Design for all
Methods in Delft

- Conventional anthropometer in 1D
- Semi-automatic in 1D
- Photographs (slides) in 2D for wheelchair users (unpublished)
- Preparation for 3D photogrammetry
- In cooperation with the Hong Kong Poly 2000 Chinese people should be measured, starting with their heads
Currently it is easy to modify a digital body, but the designer need to know what is the real variety in size and shape.
Every DHM has its own constraints:

Ramsis is designed for cars not for bicycles or not for walkers
With Ramsis or Safework or Jack you can easily evaluate your design.

But it needs investment in time and money and pre-knowledge.
ADAPS 1979-2005

ADAPS = Anthropometric Design Assessment Program System

Anthropometric human models using products

goal: assessment of dimensions of a product in relation to the user
Checklist ADAPS part 1
made by my colleague Iemkje Ruiter

Checklist for the use of ADAPS

Before using the program
What are you going to use the man-model for
- preparing a program of requirements
- assessment concepts/existing product
- something else...?

Target group
- what does the target group look like (think of sex, age, ethnicity)
- are you able to find a man-model that represents this group
- how well does the man-model you selected represent the target group
  - (what do you know about the target group)
  - (what do you know about the man-model)
  - (what about dimensions and ranges of motion of the joints)
Checklist ADAPS part 2
made by my colleague Iemkje Ruiter

User-product interaction
- what will the users do with the product
- what does the product ask of the user
- what postures do users assume during the use of the product
  - (different users might assume different postures)
- which dimensions of user and product are important during the interaction
- which problems are to be expected
- which part of the target group might have difficulties using the product

Assessment criteria
- When is the interaction between user and product critical
- What criteria do you use to decide whether the use of the product is acceptable or not
  - (search your literature when necessary)
Working with ADAPS
Translating postures
• How do you translate human postures into man-model postures
  - (be aware that this is your interpretation, someone else might do this in a different way)

Possibilities of the ADAPS program
• think of the following often omitted - possibilities of ADAPS:
  - the sight-axis could be rotated
  - shoulders can move
  - use the second model creatively, for example to display two man-models with different heights at the same time

Assessment
Have a critical attitude towards the man-model
• to what extent are the dimensions of the man-model to be trusted
• what about the ranges of motion of the joints
  - (for example, all ADAPS man-models have the same ranges of motion of the joints)

Have a critical attitude towards the process
• be aware of the assumptions you have made during the process
• try to get insight into the assumptions you made and their influence onto the predictions you make
  - (how accurate are your predictions)
3D shapes of ears for a headset can not be scanned so easy yet!
A promising method is 3D Stereo photogrammetry with 12-16 camera’s and a projector on a rigid frame.

It uses images of an object taken from different positions after projecting points on that surface.
The camera system

• 3D Body Focus system of Geo Delta in Delft as prototype
Calibration of the system

- Geo Delta has developed a special circular bar-code
- On every location on this sphere the 3D-coordinates can be read digital
Projection of points on the surface
Texture projection
Advantage above scanners

- children, elderly or other subjects don’t need to sit still
- The camera’s and flash lights fire simultaneously and make a 3D picture in a few milliseconds
- So the motion is frozen
- The fastest laser scanner needs several seconds to complete a scan
3 D Body Focus system with 16 camera’s and a projector on a rigid frame
Automatic detection and identification of projected dots; automatic generation of a 3D Model
Applications with 3D data

- Diaper design
- Breast replacements
- Cranio-facial surgery
- Dynamic anthropology
- Shapes and dimension for the design of head wear

- Error <1 mm
- Volume change of less than 0.2% an ESA-astronauts leg in outer space in 1992
WEAR
World Engineering Anthropometric Resources

• More raw data is needed to make new discoveries and focus to user needs,
• Search capability needed, including 3-D search, to find data amongst vast data resources;
• User needs and level of expertise must be accommodated
• Need an international collaborative working group to bring it all together i.e. like space behind the ear and other critical head shapes and dimensions

not only about dimensions but especially about 3D-shapes can be investigated by observational (ethnographic) investigations dynamic anthropometry which is essential for comfortable use of many products
**Tasks**

- Environment
- Users
- Origin
- Sex
- Educational level
- Product constraints
- Life cycle of the product and delay before production

**Database in 1-D 3-D raw data**

- Visual index
- Dictionary of measurements on morphology
- Databases in biomechanics
  - joint
  - strength
  - motion
  - visual field
- Digital Man Model Tools
- Digital Products Prototype
- Definitions
  - Glossary + pictures (domain of validity)
- Examples
  - Case studies
- Standards
- Tutorials
- Ergonomic guidelines

**Online system**

- Private database
- Estimate of missing data
- Statistical tools
  - Query tools
- User action log
- Measurement and sample selection Aid tool
- Editor of results
- Statistical Modeling Secular trend
- Fit scores database linked to products

**Input**

**Output**

- Basic statistical results
  - 1-D 3-D Tables, mean, σ, histo...
- Reports about fit mapping
- Population "customized" definition
- 3D models anatomical
  - 1- reference points
  - 2- arcs
  - 3- surface IGES
  - 4-individual scan data
- Design criteria

**Maintenance and Update of databases**

**WEAR Workshop**

- Paris-June 2002

**I-wear Ideal wear**

Http://ovrt.nist.gov/projects/WEAR

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Future: Four dimensional anthropometry

- To visualize growth as an increase in volume and mass
- To visualize the decrease in height, volume and mass as it happens in elderly or in diseases
- We could emphasize those key surfaces which should have ease or no ease in using ie when designing prostheses, clothing etc
Project office chairs in Hong kong

Usage observation
Measuring
User involvement
Questionnaires

Subject 1
Subject 2
Subject 3

Roger Ball
Anne Jochems
Miriam Reitenbach

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Johan Molenbroek
TU Delft
Conclusions

- Anthropometry is essential in product development
- There is a market for (low cost) 2, 3D and 4D data and tools for Small and Medium Sized Enterprises
- Photogrammetry is an innovative 3D measurement tool
- Current design tools are not suitable for applying 3 and 4D data
- New advanced design tools need to be developed and taught at engineers and researchers during their (lifelong) education