Anthropometry: *A New R Package for Analysis of Anthropometric Data*

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Outline

Introduction

- **Ergonomics** is the science that investigates the interactions between human beings and the elements of a system.

- **Anthropometry** refers to the study of the measurements and dimensions of the human body.

- A major issue when developing new patterns and products that fit the target population well is the **lack of up-to-date anthropometric data**.

- **New 3D body scanner technologies** constitute a step forward in the way of collecting anthropometric data.

- The great potential of these systems has contributed to conduct **new large-scale anthropometric surveys** in different countries, e.g. in **Spain**.

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Data

- The Spanish Ministry of Health sponsored a 3D anthropometric study of the Spanish female population in 2006.

- Sample of 10415 Spanish females (12-70 years old), randomly selected.

- Main goals:

  - * To generate anthropometric data from the females in Spain in order to develop a standard clothing sizing system.

  - * To encourage an image of healthy beauty in society by means of mannequins that are representative of the population.

- In order to tackle both these objectives, Statistics plays an essential role.

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Methods

- Clothing development process

  - Clustering.

  - Statistical shape analysis.

  - Statistical concept of data depth.

- Accommodation problem:
  Human modelling in worplaces

  - Statistical archetype analysis.

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Clustering

- In every anthropometric problem, body size variability is characterized using a limited number of anthropometric cases.

- Our statistical methods seek to define central and boundary cases for the clothing sizing system design problem and the workplace design problem.

- Clothing sizing systems divide a population into homogeneous size groups based on some key body dimensions, Each clothing size is defined from a central person (prototype).

- Clustering is the natural statistical approach to try to define an efficient sizing system and to elicit prototypes. Five methods based on clustering procedures.

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Archetype analysis

- In designing a working environment, the most common approach is to search for boundary (extreme) cases. This is the accommodation problem.

- The supposition is that the accommodation of boundaries will facilitate the accommodation of interior points (with less-extreme dimensions).

- The archetypal analysis is the statistical tool to obtain extreme observations.

- A new archetypal concept is presented: archetypoids.

- Two methods based on archetypal and archetypoid analysis.

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R package

- There are no general software applications or statistical packages available on the Internet to tackle anthropometric problems.

- **Anthropometry** is the first available functionality using anthropometric data in R and in any other open source project.

- All the statistical methodologies, anthropometric databases and this R package were announced in my PhD thesis (freely available in a Spanish institutional open archive).

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Using the package I

- Example to find prototypes in a sample of the Spanish Survey.

```
> library('Anthropometry')

> set.seed(1900)
> rand <- sample(1:600,20)
> dataComp <- sampleSpanishSurvey[rand, c(2, 3, 5)]
> numVar <- dim(dataComp)[2]

> numClust <- 3 ; alpha <- 0.01 ; lambda <- 0.5 ; niter <- 5
> algSteps <- 7 ; ah <- c(28, 25, 25) ; orness <- 0.7

> weightsTrimowa <- weightsMixtureUB(orness, numVar)
> set.seed(1900)
> Trimowa <- trimowa(dataComp, weightsTrimowa, numClust, alpha, niter,
                  algSteps, ah, verbose = FALSE)

> prototypesTrimowa <- anthrCases('anthropometry', 'trimowa',
                              Trimowa, oneSize = TRUE)
```

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Using the package II

```
> dataComp[which(rownames(dataComp) %in% prototypesTrimowa ),]
```

Label women	neck to ground	waist	bust
BADJZ136	134.3	71.1	82.7
TORE073	136.1	87.6	97.9
MONCO65	133.1	96.8	106.5

BADJZ136   TORE073   MONCO65

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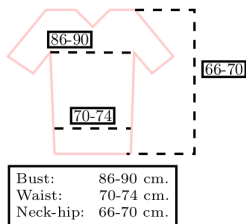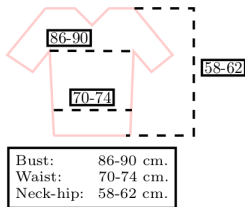Using the package
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Practical application I: Clothing design I

- The clustering methodologies have followed the same scheme:

  1. The data matrix was segmented using a primary control dimension (bust or waist).

  2. A further segmentation was carried out using other secondary control anthropometric variables.

  3. The number of size groups generally obtained with these methods was three, because this number is quite well aligned to clothing industry practice.

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Practical application I: Clothing design II

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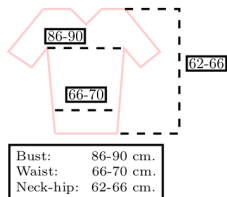
Practical application II: Workplaces design

- The archetypoid analysis makes it possible to identify real boundary cases (extreme body measurements).

- The accommodation problem is considered in all human-computer interaction problems (e.g. the design of plane cockpits or truck cabins).

- When designing these workstations, it is common to use only a few human figure models (extreme cases, our archetypoids) as virtual test individuals.

- Archetypoids are capable of representing people with a wide range of body sizes and shapes.

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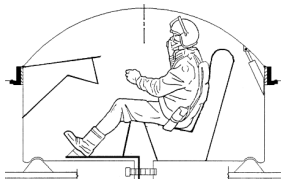
Conclusions

- New 3D whole-body scanners make it possible to obtain accurate, reproducible and up-to-date anthropometric data.

- These databases constitute very valuable information to effectively design better-fitting clothing and workstations.

- Therefore, rigorous statistical methodologies and software applications must be developed to make the most of them.

- **Anthropometry** brings together different statistical methodologies, which have been especially developed to deal with anthropometric data.

- **Anthropometry** is a positive contribution to Ergonomics and Anthropometry to tackle some statistical problems related to both fields.

- The latest version of **Anthropometry** is always available from the CRAN.

- The vignette of the package is submitted in third revision.

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Anthropometry: An R Package for Analysis of Anthropometric Data

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Abstract

The development of powerful new 3D scanning techniques has enabled the generation of large up-to-date anthropometric databases which provide highly valued data to improve the ergonomic design of products adapted to the user population. As a consequence, Ergonomics and Anthropometry are two increasingly quantitative fields, so advanced statistical methodologies and modern software tools are required to get the maximum benefit from anthropometric data.

This paper presents a new R package, called **Anthropometry**, which is available on the Comprehensive R Archive Network. It brings together some statistical methodologies concerning clustering, statistical shape analysis, statistical archetypal analysis and the statistical concept of data depth, which have been especially developed to deal with anthropometric data. They are proposed with the aim of providing effective solutions to some common anthropometric problems, such as clothing design or workstation design (focusing on the particular case of aircraft cockpits). The utility of the package is shown by analyzing the anthropometric data obtained from a survey of the Spanish female population performed in 2006 and from the 1967 United States Air Force survey. This manuscript is contained in **Anthropometry** as a vignette.

Keywords: R, anthropometric data, clustering, statistical shape analysis, archetypal analysis, data depth.

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