Morphotype of the human body in the textile industry: a clustering approach.

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1 Project's Presentation

This project is part of the Master in Scientific Computing and Mathematics for Information. One of the objectives of this master is to provide its students with advanced skills in data analysis. This work is an excellent opportunity to put into practice what has been learned throughout the master's degree.

1.1 Abstract

The variety of human morphologies is an important issue for the textile-apparel industry. Indeed, sizing systems currently used by companies have to be continuously updated or adapted to the population target.[1, 2]

For this reason, the Textile-Apparel-Industry requires a very accurate sizing system to minimize their costs and satisfy their customers. However, the specific constraints of human morphotologies complicate the sizing system definition procedure and distributors prefer to use standard sizing system rather than an intelligent system suitable to their customers.

Until now, the morphotypes of a population are extracted from measurement charts. However, new technologies such as 3D body scanning open new opportunities to enhance the morphotype generation from a sample of population especially with the 3D data of bodies.

The aim of this research is to define an exhaustive methodology to obtain a clustering of human morphology shapes representative of a population and to extract the most significant morphotype of each class. Clustering methods are implemented and the performances are evaluated using real data.

These algorithms are validated in the context of the development of a module that takes an individual's measurements as input and proposes his morphotype.

1.2 Main steps

1. State of the art of different techniques and methods.
2. Testing two promising algorithms.
3. Validation of these algorithms.

Related issues

- Same groups for men and women?
- Standardisation?

1.3 Tools to be used

- Statistics
- Machine learning (supervised and unsupervised)
- Clustering
- Topological Data Analysis

- Programming in Python

1.4 DiTeX: Data-Innovation for the Textile Industry

DiTeX is a joint research and development laboratory between the University of Technology of Troyes and the French Institute of Textiles and Clothing.

This laboratory develops statistical modelling and machine learning to analyse data from clothing and to respond to problems dealing, in particular, with the measurements of the human body: What is the effect of ageing? What are the types of morphologies?

1.4.1 University of Technology of Troyes

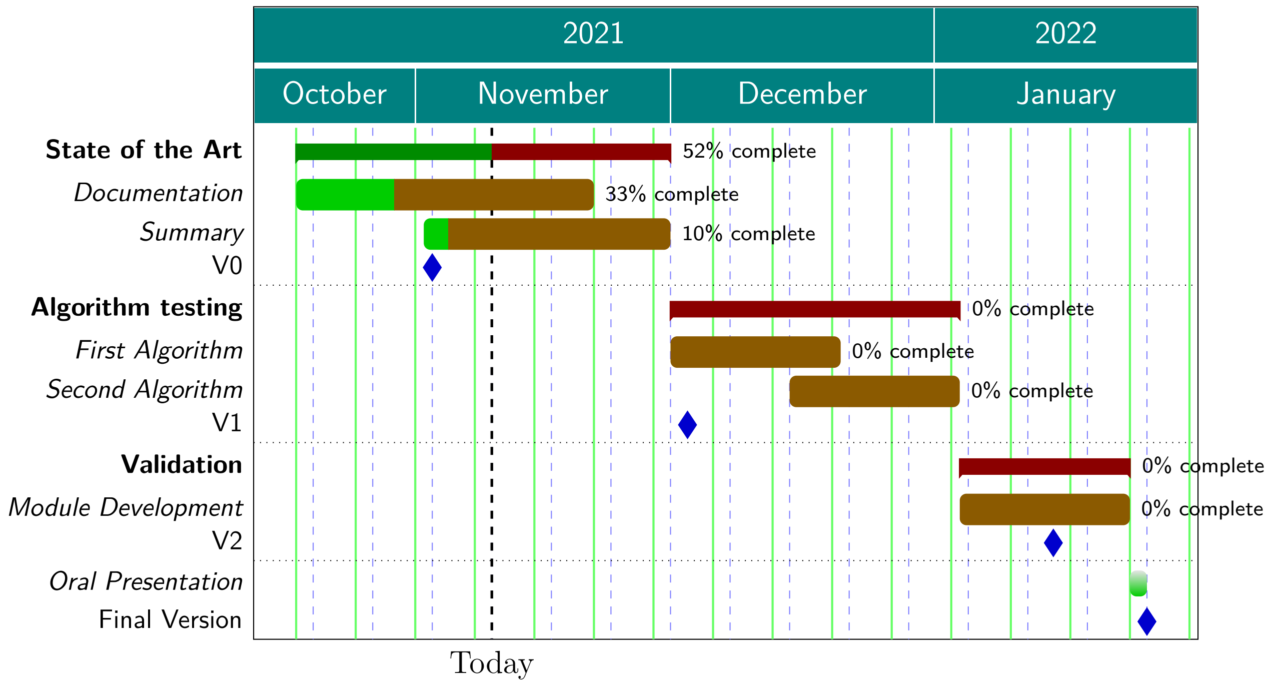
Founded in 1994, the University of Technology of Troyes (Université de Technologie de Troyes[3]; UTT) is a French university, in the Academy of Reims.

The UTT is part of the network of the three universities of technology, found by the University of Technology of Compiègne. Inspired by the American University of Pennsylvania in Philadelphia, these three universities (UTC, UTBM and UTT) are a French mixture between the universities of this country and its schools of engineers (Grandes Ecoles).

1.4.2 French Institute of Textiles and Clothing

The French Institute of Textiles and Clothing (Institut Français du Textile et de l'Habillement[4]; IFTH) is an industrial technical centre created by decree on 14 April 20001. Its mission is to promote and assist progress in the textile and clothing sectors.

1.5 Roadmap



2 State of the Art

2.1 Female body shapes

Body shapes are often categorised in the fashion industry into one of four elementary geometric shapes, though there are very wide ranges of actual sizes within each shape:

- **Rectangular**

  The waist is less than 23cm smaller than the hips and bust. Body fat is distributed predominantly in the abdomen, buttocks, chest, and face. This overall fat distribution creates the typical ruler (straight) shape.

- **Inverted triangle**

  The shoulders are broader than the hips. The legs and thighs tend to be slim, while the chest looks larger compared with the rest of the body. Fat is mainly distributed in the chest and face.

- **Spoon** (pear)

  The hips are wider than the bust. The distribution of fat varies, with fat tending to deposit first in the buttocks, hips, and thighs. As body fat percentage increases, an increasing proportion of body fat is distributed around the waist and upper abdomen.

- **Hourglass**

  The hips and bust are almost of equal size, and the waist is narrower than both. Body fat distribution tends to be around both the upper body and lower body. This body type enlarges the arms, chest, hips, and rear before other parts, such as the waist and upper abdomen.

A study of the shapes of over 6,000 women, carried out by researchers at the North Carolina State University circa 2005[1, 5, 6], for apparel, found that 46% were rectangular, just over 20% spoon, just under 14% inverted triangle, and 8% hourglass.

Several similar classifications of women's body shape exist. These include:

- Sheldon: "Somatotype: {Plumper: Endomorph, Muscular: Mesomorph, Slender: Ectomorph}", 1940s
- Douty's "Body Build Scale: {1,2,3,4,5}", 1968
- Bonnie August's "Body I.D. Scale: {A,X,H,V,W,Y,T,O,b,d,i,r}", 1981
- Simmons, Istook, & Devarajan "Female Figure Identification Technique (FFIT)[1, 5, 6]: {Hourglass, Bottom Hourglass, Top Hourglass, Spoon, Rectangle, Diamond, Oval, Triangle, Inverted Triangle}", 2002
- Connell's "Body Shape Assessment Scale: {Hourglass, Pear, Rectangle, Inverted Triangle}", 2006
- Rasband: {Ideal, Triangular, Inverted Triangular, Rectangular, Hourglass, Diamond, Tubular, Rounded}, 2006

- Lee JY, Istook CL, Nam YJ, "Comparison of body shape between USA and Korean women: {Hourglass, Bottom Hourglass, Top Hourglass, Spoon, Triangle, Inverted Triangle, Rectangle}", 2007.

2.1.1 FFIT for Apparel measurements

The "Female Figure Identification Technique for Apparel"[1, 5, 6] uses the following formula to identify an individual's body type (Sizes are in millimeters):

- **Hourglass**

  (bust - hips $\geqslant$ 25) and (hips - bust $<$ 91) and ((bust - waist $\geqslant$ 230) or (hips - waist $\geqslant$ 250))

- **Bottom hourglass**

  (hips - bust $\geqslant$ 91) and (hips - bust $<$ 250) and (bust - waist $\geqslant$ 230) and ($\frac{\text{high hip}}{\text{waist}} < 1.193$))

- **Bottom hourglass**

  (bust - hips $>$ 25) and (bust - hips $<$ 250) and (bust - waist $\geqslant$ 230)

- **Spoon**

  (hips - bust $>$ 51) and (hips - waist $\geqslant$ 180) and ($\frac{\text{high hip}}{\text{waist}} \geqslant 1.1930$)

- **Triangle**

  (hips - bust $\geqslant$ 91) and (hips - waist $<$ 230)

- **Inverted Triangle**

  (bust - hips $\geqslant$ 91) and (bust - waist $<$ 230)

- **Rectangle**

  (hips - bust $<$ 91) and (bust - hips $<$ 91) and (bust - waist $\geqslant$ 230) and (hips - waist $<$ 250)

References

[1] K. Simmons, C. L. Istook, and P. Devarajan, "Female Figure Identification Technique (FFIT) for Apparel - Part I: Describing female shapes," *Journal of Textile and Apparel. Technology and Management*, vol. 4, no. 1, Summer 2004.

[2] M. Hamad, S. Thomassey, and P. Bruniaux, "A new sizing system based on 3D shape descriptor for morphology clustering," *Computers & Industrial Engineerings*, vol. 113, pp. 683–692, 2017.

[3] "Wikipedia article: University of technology of troyes." https://en.wikipedia.org/wiki/University_of_Technology_of_Troyes.

[4] "Wikipedia article: Institut français du textile et de l'habillement." https://fr.wikipedia.org/wiki/Institut_fran%C3%A7ais_du_textile_et_de_l%27habillement.

[5] K. Simmons, C. L. Istook, and P. Devarajan, "Female Figure Identification Technique (FFIT) for Apparel - Part II: Development of shape sorting software," *Journal of Textile and Apparel. Technology and Management*, vol. 4, no. 1, Summer 2004.

[6] C. L. Istook and P. Devarajan, "Validation of 'female Figure Identification Technique (FFIT) for Apparel©' software," *Journal of Textile and Apparel. Technology and Management*, vol. 4, no. 1, Summer 2004.