Virtual fitting

TOOLBOX

In this dossier Anthropometry of Human Factors, Molenbroek et al. describe how we can generate a digital copy of the human body using 3D whole body scanning. This copy of the body can be dressed and the fit of garments can be evaluated. This process is called virtual fitting. In virtual fitting, 3D scans of the user (population) are matched with the digitized patterns of clothing and equipment. Virtual fitting is an emerging technology, however validation reports are scarce.

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Why Virtual Fitting

Virtual fitting seems a promising method to reduce the number on undesired garment returns. The Netherlands is currently record holder in the number of returns of goods; with fashion being most prominent. Inappropriate fit is a main argument for returning the goods. Technically it is achievable that the customer for new garments uploads his 3D body scan and personal preferences to the website of the clothing supplier. Then the virtual fitting can (1) determine the best fitting size, or (2) make the garment made-to-measure. 3D printing of garment patterns is also an option that may reduce the costs; it is feasible to convert body dimensions directly into tight fitting garment patterns (Daanen & Hong, 2008).

Smart garments that include sensors of physiological functions, such as heart activity, muscle activity, temperature or sweat only function when the garment has a tight fit. Similarly, actuators like vibrating elements or heating/cooling elements are only effective when the garments have a close interface with the body. Therefore, the future of successful smart garments is intertwined with the success of virtual fitting technique.

Other applications are virtual fitting of garments to optimize garment sizing systems. An example is given in this paper in military context. In sports, compression garments are used which claim to shift blood from the skin to the muscle. Although the effectivity is discussed, it is undisputed that in for instance swimming local pressure on the skin can modify performance. In this paper we show the example of virtually fitting a triathlon suit.

3D body scans

Every 3D body scan of sufficient quality can be used for virtual fitting. The Amsterdam Fashion Institute employs the relatively inexpensive SizeStream scanner for virtual fitting. The students often have a personal model to design for and there is a yearly competition in who makes the best match between real and virtual garments (Figure 1).

Figure 1. Work of Nina Wormer (Amsterdam Fashion Institute) combining real and virtual designs (Lectra software).

Virtual fitting is generally passive, this means for one body position. Since clothing has to fit in several body postures, the fitting process can be performed on several scans in extreme positions. The Fraunhofer institute in Tubingen (leader Prof. Michael Black) is also working with dynamic (or 4D) whole body scans to have dynamic fitting.

Also, a human model can be used for virtual fitting. These models are often derived from 3D scans using principle component analysis. The group of Agnes Psikuta published nice work on dynamic virtual fitting using human models (Psikuta, Frackiewicz-Kaczmarek, Frydrych, & Rossi, 2012).

Clothing patterns

In order to make a virtual fit, the clothing patterns have to be digitized and fed in the computer system. A simple example of patterns of trousers is shown in Figure 2.

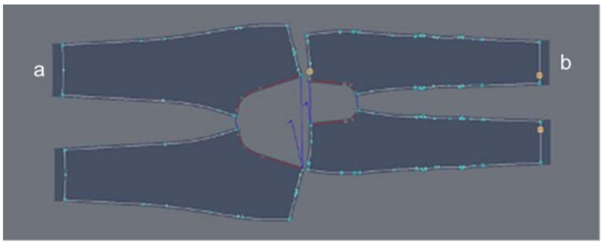

Figure 2. Example of the simplified clothing pattern of a pair of trousers. These four parts are sewn together. The sum of the distances a and b defines the minimal circumference of the trousers leg circumference at bottom, excluding seam allowances and should be sufficiently wide.

Most manufacturers of garments use computer aided design software for apparel in which the patterns of the garments are stored, e.g., Lectra, Gerber, Assyst. When the material has stretch properties, the dimensions of the patterns can be adapted. The dimensions of the clothing and equipment pattern should be related to body dimensions. For instance, the distance a+b in Figure 2 is related to foot size for the trousers in the Dutch armed forces.

Virtual Fitting of garments

The main suppliers of software that allow for virtual design of garments on a 3D body are: Optitex, Gerber, Lectra, Gemini, DCsuite, Clo3D, and Assyst. A recent overview was recently published (Daanen & Psikuta, 2017).

The Lectra Modaris system compares differences between circumferences of the naked body and dressed body on a horizontal plane and color codes the difference. Some other packages, like Clo3D and DC Suite, visualize the distance between the skin and the garment perpendicular to the skin, which is a better method (Figure 3 left). When the clothing is tight fitting, an option can be selected to visualize the strain in the garments (Figure 3 right). A third method is to make the clothing transparent to visualize the interface between the human subject and military garments (Figure 4). Software for virtual fitting is often focusing on visual representation of fit; quantitative analyses are lacking.

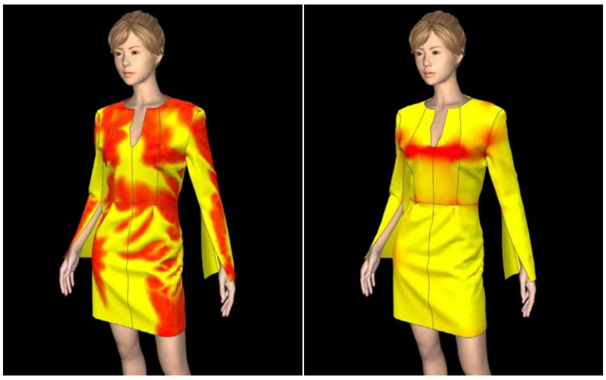

Figure 3. Left: distance analysis, distance between the skin and the garment perpendicular to the skin. Right: strain in the garment using DCSuite.

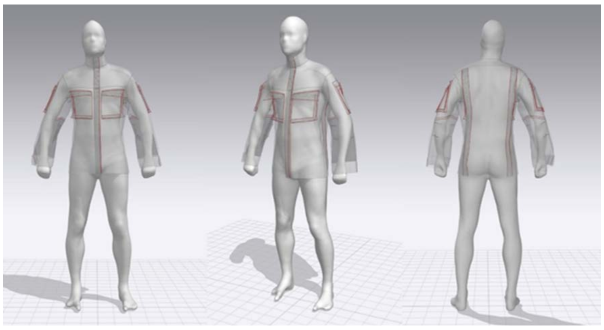

Figure 4. Visualization of the fit of a military jacket on a selected military subject using Clo3D. The clothing is made transparent to visualize the interface with the human body.

Virtual fitting can be used in the design phase (e.g. Figure 4) or in the evaluation phase. Figure 5 shows an example of the evaluation of fit related to the sizes of the garment (from NATO STANREC 4833).

Next to visual assessment of fit, a quantitative assessment can be made. An interesting option is to calculate the trapped air in between the skin and clothing (Havenith, Zhang, Hatcher, & Daanen, 2010) and to set a threshold for what is acceptable and what not. More specific fit allowances can be used at predefined locations at the human body. In Figure 4 for example, the jacket seems to be a bit tight at the level of the hip and loose at the level of the lower arm.

Virtual Fitting of triathlon suit

This virtual fitting case is published by Vedder and Daanen (2015) and concerns the Huub triathlon suits that were worn by all medalists in the Rio Olympics. Neoprene suits that cover most of the body are used during triathlon training and competition. This is not only to reduce heat loss to the water, but also to compress the underlying skin to minimize skin movements and thus reduce drag (Toussaint et al., 1989). Deformation of the body using different swimming suits affects swimming performance (Van Geer et al., 2012). It is, therefore,

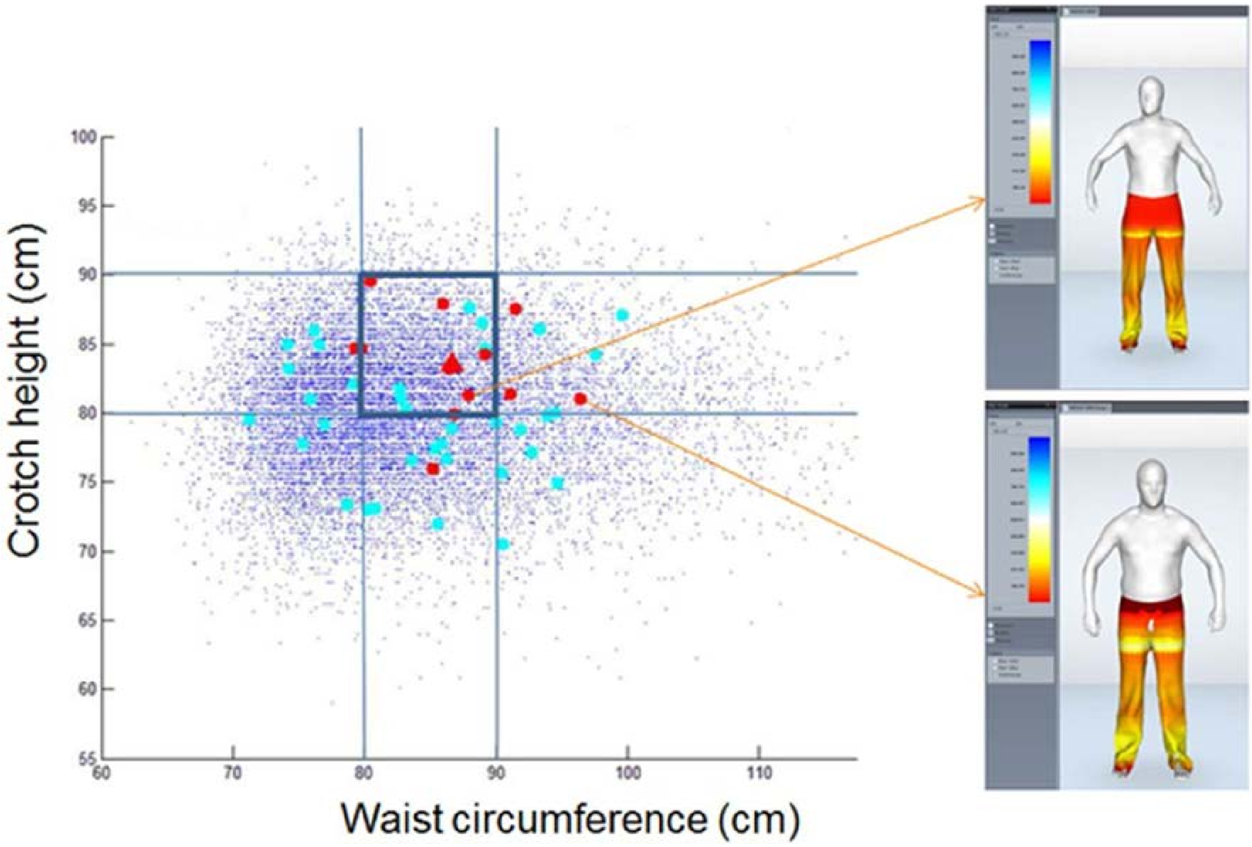

Figure 5. Example of virtual fitting of military trousers using Lectra Modaris software. Each small blue dot in the left panel represents the crotch height and waist circumference of a Dutch soldier. The large red dots represent the dimensions of subjects that selected trousers size 8090/8090 in the physical fitting session. This size indication means that both waist circumference and crotch height are in the range of 80 cm to 90 cm. The light blue dots represent subjects that selected another trousers size. The 3D scans of two soldiers in the right panels are derived from the database. Both soldiers selected NATO size 8090/8090 during clothing fitting tests. The subject in the upper right panel had a waist circumference of 88 cm and crotch height of 82 cm and showed a good virtual fit (no blue or dark red color). The subject in the lower right panel had a waist circumference of 96 cm and crotch height of 82 cm. The trousers were too tight at waist level (dark red color). Trouser length was not considered in fit analysis since the bottom parts are tied up.

imperative that the suit carefully follows the body shape. New virtual design tools like Optitex, Clo3D, Lectra, DCSuite and others enable the design or adjustment of garments using 3D scans of the athlete as a starting point (Daanen & Ter Haar, 2013). It is the aim to evaluate the use of such a virtual design system for fit of a triathlon suit on an athlete with focus on material properties.
The body scan of the subject was made using a SizeStream scanner (www.sizestream.com). Figure 6 shows the patterns of the suit and Figure 7 shows the connected edges. The panels were carefully located around the 3D scan.
The suit consisted of neoprene with the exception of panels 4 and 12. The neoprene parts of the legs were made of thicker neoprene to increase buoyancy. Changing the stretch stiffness of panel 6 and 14 from flexible to stiff, changed the profile and fit of the suit, which can be seen in Figure 8.

Virtual fit software was able to provide insight in the effects of changing material properties on fit and appearance of triathlon suits. Experiments, for instance using 3D scans of subjects wearing suits with different material properties, should be performed in order to investigate the validity of the tool.

Virtual fitting of rigid products

For rigid bodies, such as helmets, a simple way to assess fit is to make a photo of a subject with and without the product, to superimpose the two images and make the product transparent (Figure 9). A simple camera and an inexpensive tool like Fantamorph (www.fantamorph.com) can do the job. However, it has to be realized that hair is an issue that should be considered. A compressing wig cap may mitigate the problem.

3D information is more accurate and informative. The approach is similar to photos: 3D scans of the body and product can be aligned and the distance between the body and product can be calculated. 3D fitting of helmets is performed at TNO in Soesterberg (Oudenhuijzen, Wolfs, & Ter Haar, 2017).

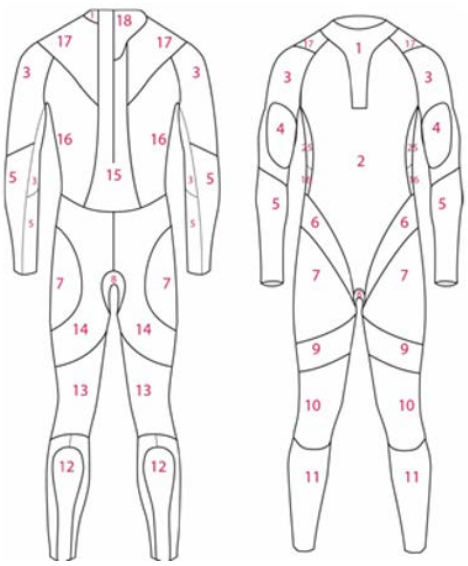

Figure 6. Pattern of the swimming suit.

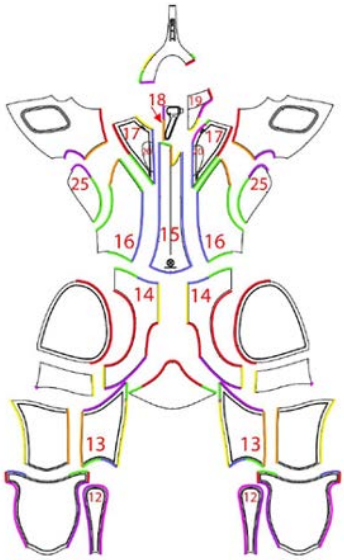

Figure 7. Connected edges of the swimming suit.

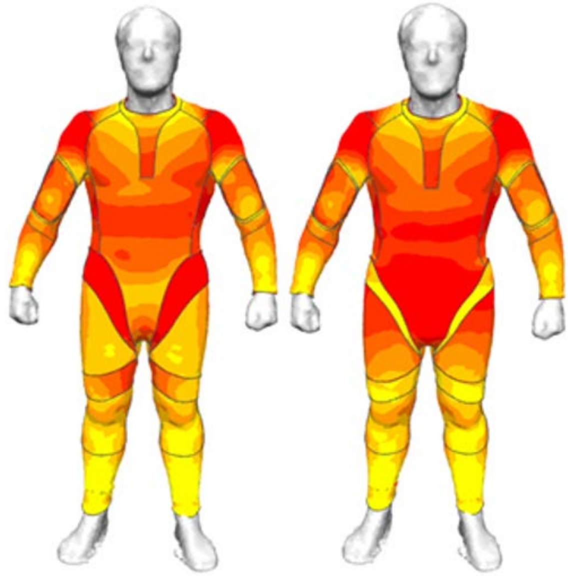

Figure 8. Strain in the triathlon suit with 1608 (warp) and 1756 (weft) (left) and 100 (warp and weft) (right) as stress stiffness parameters for panel 6. Please note that the shape of panel 6 is much smaller in the right panel and that consequently there is more strain (more red color) in the neighboring panels. Yellow = 0% strain, red=100% strain.

Conclusion

Virtual fitting is a promising technique to improve the relation between body dimensions and garment dimensions, thus enabling garments to turn into smart measurement devices and systems to efficiently exchange information and heat with the human body.

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Figure 9. Superimposed images of a photo of a head and head/helmet combination to provide insight in fit.

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