What is the most appropriate way to define a 3D waist level?

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Background

In the fashion industry, body measurements are mainly used for drafting pattern pieces, generating grading and sizing rules, helping make manufacturing decisions, customizing clothing, and assisting in selecting a size to purchase (Gupta, 2014). Within all the commonly used body measurements, waist girth plays an essential role because it is used for both tops and bottoms. The development of three-dimensional (3D) body scanners makes it possible to collect 3D body measurements digitally. Automated measurement programs are developed to extract body measurements from 3D body models, which makes the measuring process a lot faster. Most commercial automated measurement programs refer to manual body measurement standards, such as ISO 8559-1 (ISO, 2017) and ASTM D5219 (ASTM International, 2015), to define the locations of measurements. However, there has been some challenge implementing manual waist definitions for 3D measurement. This is because the 3D body scanner measures bodies non-invasively with no physical contact between the measurer and subject, while many manual measurement protocols require a subject to bend her/his body to identify the waist level. Researchers and 3D measurement developers have been seeking alternative ways that determine the waist relative to surface geometry (Gill, 2011; Han et al., 2010). Gill et al. (2014) compared 16 waist levels defined in the $[TC]^2$ program with waist level defined by ISO 7250 (ISO, 2008). They found that the center waist region defined by the standard can be mimicked by the range between the level of the narrowest point on the torso and the level of a proportional length. However, none of the alternatives seems to be ideal, especially when trying to find the waist level for plus-size people or others who do not have a well-defined waistline.

Objective

No standards have been developed to define body measurements in a 3D environment. Determining the waist level on a 3D model is especially difficult. Different people refer to different alternative waist definitions, which makes it hard to compare measurements across databases and platforms. The purpose of this project is to conduct a pilot study on exploring some commonly used 3D waist definitions and analyzing them to see which one provides the best and most consistent results across different age groups that tend to share different body shapes.

Methodology

Four candidate waist definitions, namely small-of-back, narrowest-front, center-b/w-bust-hips, and proportion-waist, were selected for this study (Table 1). Seventy-eight sample scans were chosen from the SizeUSA database (a large scale 3D body scan database). For each sample model, four waist levels were marked based on the four candidate waist definitions. The research then reviewed the waist marks for each sample and voted for waist definitions that best represent the real waist level. For example, in Figure 1a, four waist levels were marked on the body model with yellow lines. The research looked through the four lines and determined that the proportion-waist defined the location that best represented the real

waist level. The proportion-waist mark was highlighted, and a vote was recorded for the proportion-waist method. There are situations when more than one waist definition may share the same waist level, and the research thought that waist level was the best one. In this case, the vote was added to more than one method. The waist definition that won the most votes was considered as the most appropriate waist definition for the 3D environment.

Table 1 Methods of Finding a Waist Level in a Computer Program

Method name	Description
Small-of-back	The point where the spine had the largest indent when viewed from the side (Han, Nam, & Hwang Shin, 2010)
Narrowest-front	The narrowest part of the torso between the hips and the bust.
Center-b/w-bust-hips	The centerline between the levels at the most protruding point at the front (bust level) and back (hips level) from the side view of a body.
Proportion-waist	The center of the central waist region with a proportional length (such as small of back height minus 4 cm) being the lower limit and the narrowest front point on the torso being the upper limit (Gill et al., 2014)

Results and conclusion

The results (Figure 1b) showed that none of the four methods was overwhelmingly dominant. Center-b/w-bust-hips was the best method (covered 37.3% of the sample population) among the four to determine the 3D waist level, followed by the small-of-back method (covered 32.4% of the sample population). The best method was dependent on age range, with (1) center-b/w-bust-hips being the best method for age range 18-25 (tie with proportion-waist), 36-45, and 46-55 (tie with small-of-back), (2) proportion-waist being the best method for age range 18-25 (tie with center-b/w-bust-hips), and (3) small-of-back being the best method for age range 26-35, 46-55 (tie with center-b/w-bust-hips), 55-65, and 66+. The conclusion was made that the Center-b/w-bust-hips was the most appropriate way to define the waist level on a 3D model. However, a new waist definition with better performance is demanded.

Limitation and future research

The best waist definition was selected by the researcher based on personal experience, which may be biased. It is more valid to ask multiple people, both from industry and academia, to evaluate and vote for the best waist definition. Also, it may be interesting to study if the best 3D waist definition varies between different body shape groups and different size groups.

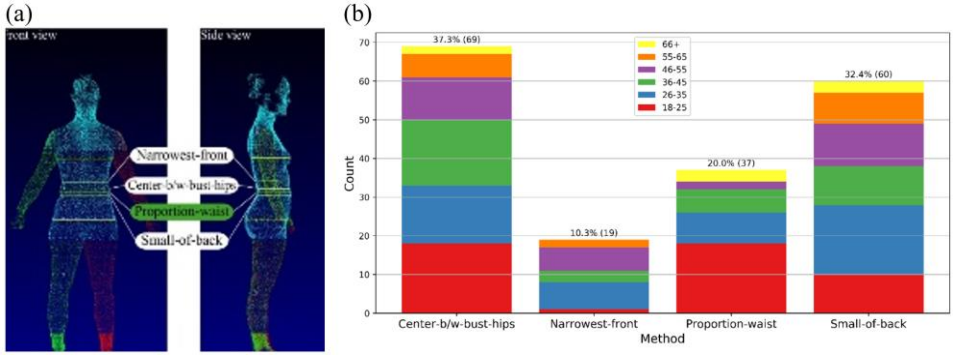

Figure 1. Example of voting for the best waist definition (a) and votes count for all methods(b)

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