Identifying Landmarks on Various Body Shapes from the 3D Body Scan

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Introduction

An automatic body measurement method using 3D body scan technology has been used for mass customization in the apparel industry. However, most automatic body scan measurement methods often show landmark location errors when dealing with nonstandard body figures (Ashdown and Dunne, 2006).

The purpose of this study is to provide algorithms of the automatic landmarks identification that are applicable for describing any various body shapes. In this study, algorithms were developed for automatic identifications of the five landmarks on the torso: nipples, underbust, waist, abdomen, and hip. In this poster, we described only three landmarks: nipples, underbust, waist.

Methodology and approaches

In this study, a methodology of identifying landmarks was based on analyses of the maximum value, the minimum value, the radical value, and the cross sections. In addition, statistical position of each landmark was used when any distinct geometrical feature and criterion was not identified. Algorithms of the automatic landmark identification were implemented with C++. The coordinate system was used: the leftward direction is to be the x-axis, the upward direction, the y-axis; and forward direction, the z-axis. The x, y, z value of a landmark is referred to as width location, height location and depth location, respectively.

The developed algorithms of the automatic landmark identification in this study were tested with a data set of various subjects that were selected from Size Korea National Sizing Survey. The W84 body scanner (Cyberware Co. Ltd., USA) was used in this study. The automatically identified landmarks were compared to the manually marked points. One-way ANOVA and Duncan test for multiple comparisons were used to verify if there were any MAD value differences among body figure groups in the significance level set at P>0.05 level (a=0.05). The MAD of each measurement was compared with the allowable technical errors in the ANSUR Natick/TR-89-044 technical reference (Gordon et al., 1989).

Results

Waist point identification

In this study, two different methods were used for identifying landmarks on waist: ‘waist concave point method’ was used for waist type X while the ‘mean waist height method’ was for waist type H.

The definition of the waist is the most concave position on the front of toto front silhouette. The front silhouette was a set of point with maximum and minimum x-value on each cross section. But some people may not have the concave point on toto and other people’s waist shape was not same with the concave point. Therefore, first, waist shapes were classified then different waist identification methods were developed for each waist shape.

To classify the waist shapes, this study used three points on the front silhouette; point of underbust height (P underbust height (y value) and P underbust height (y value) for women. The middle hip height was determined by waist and hip height. The middle hip position was determined at least not to be above the waist height using statistical waist height range. The ratio of ‘vertical distance between waist and crotch’ to ‘vertical distance between underbust and crotch’ was calculated for women. Mean-3σ ratio, 55.6% as mid hip position was used for women. For men, Phip height (y value) was determined at armpit height (y value) and Punderbust height (y value) was determined at middle hip height (y value); men’s mean-3σ ratio of ‘vertical distance between waist and crotch’ to ‘vertical distance between back neck and crotch’.

After the waist classification, two waist shapes were categorized: hourglass waist shape (X) and rectangular waist shape (H). The hourglass waist shape (X) had the concave point that was determined as the waist point while the rectangular waist shape (H) did not have any geometrical body surface features around the waist. In physical measuring of waist shape H, the position of bottom rib or elbow height could be used to determine the waist location. However, waist landmarks in the body scan system are identified with two different methods. One method is based on “the small of the back point” and the other is based on “statistical mean value of the waist.” The two different methods were tested in this study.

The small of the back” was defined as the point where the spine had the largest indent in side view. The result showed that the small of the back point had no correlation with the waist point and the deviation of the height difference between small of back point and actual waist point was large among the subjects. The mean difference was -30.4mm and the standard deviation was 28.1mm.

When the statistical mean waist height (y value) was based on ‘mean ratio of waist-crotch distance to back neck-crotch distance’, the statistic approach of defining waist was more accurate than using “the small of the back point”. Therefore, the statistic approach was used as for the waist shape H.

Bust point identification

The height of nipple (=Y axis) was determined as a ‘first point where slope degree change from minus to plus value (Pslop)’ on the side silhouette (Sil) from up (armpit height) to down (Punderbust height (Sil))). It was successful to identify the bust point because generally the slope degree changes on the bust point even flat shape of the bust.

The width location (=X axis) of the nipple point on the side silhouette was much different from that of actual nipple point. The side silhouette point had a tendency to be positioned inward than the actual nipple point. The difference in width location was calculated between side silhouette nipple point (Pside Sil)) and actual nipple point. As a result, the actual nipple point was more outward than the side silhouette nipple point by 18–35mm. The nipple point of obese body type was more inward than that of normal type.

Therefore, this study adjusted the width position of the side silhouette nipple point to be mean ratio position of ‘distance between nipple points’ to ‘bust width’.

There were differences in bust height and width position between ‘automatically identified (AI) bust point’ and ‘manually marked (MM) bust point’ by sex and body figure. The MAD of height was less than the allowable error, 10mm according to ANSUR (Gordon CC et al, 1989). The MAD of width was small and much less than that of the non-adjusted bust point of side silhouette point. By body figure, the height MAD of overweight was significantly smaller than other body types. It is considered that the overweight has more prominent breast and the bust point position is clear. The width MD was not significantly different among body types.

Underbust point identification

The underbust point was identified on a sagittal section. Among many sagittal sections, we used a sagittal section (SS underbust) which passing through the nipple point because the underbust position was clearly revealed at the section and in physical measurement also the underbust point was determined at just under the breast of nipple point.

There was no significant difference among body shapes in the underbust category. The MAD of height was small and was less than the allowable error 11mm according to ANSUR. It is considered that the accuracy was good because the shape characteristic was clear and there was no big body shape difference in underbust part.

References


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