Statistical Human Body Form Classification: Methodology Development and Application

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Classification of objects is an exercise deeply rooted in the human psyche (Costa & Cesar, 2001). Humans mentally apply classification techniques to almost every object we see. Constructs like size, build, shape, and form are used when we visually analyze and classify the human body. Our minds are well suited to process a few bodies at a time but can be limited when tasked with processing large numbers of subjects. It is important to obtain meaningful classifications of body form for specific samples because form is closely related to the design of products that fit the human body (Bye, LaBat, & DeLong, 2006). This study intended to develop a statistical human body form classification methodology and apply that methodology to a sample of 117 male subject's 3D body scan data.

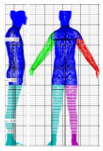
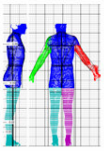
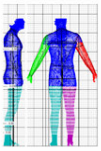
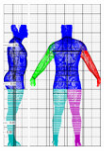
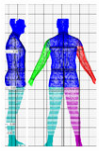
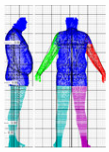
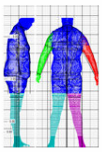
Four (4) research questions guided this exploratory study. They were 1) Will body form categories emerge from an unsupervised hierarchical clustering of 3D male body scan data?; 2) What are the statistical characteristics of each cluster?; 3) What are the visual characteristics of each cluster?; and 4) Do experts in the field of somatology recognize the various clusters from the statistical and visual characteristics generated? The study structure consisted of a pretest (to test the statistical methodology), a clustering of male body form exercise (to answer research questions one and two), and an expert recognition of clusters (to answer research questions three and four).

The pretest part of the study served three purposes. One purpose was to develop the methodology to normalize the individual 3D body scan data. The normalization process converts the raw 3D body scan data into a format that has a common X,Y,Z point of origin for each subject and an equal number of data points for each subject. Normalization was necessary to insure an accurate statistical comparison between subjects. The second purpose was to develop a data reduction methodology to reduce the number of data points from over one million contained in a raw 3D body scan data file to approximately 3,000 contained in a final data file for each subject. Data reduction was necessary to insure that the methodology could be performed on typical university computing systems while maintaining the statistical descriptive accuracy related to the individual subject's human form. The third purpose of the pretest was to apply the methodology to a sample of 10 male and 10 female subjects in an attempt to segregate the data along gender lines. The normalization, data reduction, and segregation exercises were successful and could be applied to the main data set.

To answer research questions one, two and three, the methodology established in the pretest was applied to a sample of 117 male subject's 3D body scan data. An unsupervised hierarchical classification was performed revealing seven defined clusters and answering research question one. Statistical characteristics like the number of subjects included, average age, average height, average weight, and average BMI were reported for each cluster answering

research question two. Front and side view images generated by 3D body scanning were obtained for the two most extreme subject members and the median subject member in each identified cluster. These 21 images were used by a panel of experts to generate written visual characteristics for each cluster thus answering research question three. The panel of experts used answers to research questions one, two, and three to aid in their task of answering research question four. The panel did recognize the clusters generated with two exceptions concerning clusters with fewer than 5 members that could possibly be merged into adjoining clusters. The overall result of this exploratory study was the methodology was successful at generating meaningful body form clusters utilizing 3D body scan data. The chart below shows the final results of the statistical methodology application and the expert panel analysis.

Expert Visual Analysis Summary Chart

Cluster	1	2	3	4	5	6	7
Subject M Image							
Diff. (Inches)							
Chest-Waist	4.22	8.86	10.89	11.95	6.21	3.53	2.57
Chest-Hip	0.12	2.24	4.83	4.59	-0.33	1.98	6.19
Hip-Waist	4.10	6.62	6.06	7.36	6.54	1.55	-3.62
Description							
Chest	Flat	Broad	Prominent	Prominent	Flat	Full	Full
Waist	Hi Defined	Low	High Defined	Defined	Full	Full	Full
Hip	Balanced	Balanced	Narrow	Balanced	Broad	Balanced	Balanced
Shoulders	Sloped	Square	Square	Square	Sloped	Square	Sloped
Buttocks	Flat	Prominent	Prominent	Prominent	Prominent	Flat	Flat
Tummy	Flat	Flat	Flat	Flat	Flat	Prominent	Prominent
Overall	Small	Similar to 3	Muscular	Similar to 3	Thick	Rectangular	Large

This study is most significant because it provides a foundational work to reduce processing time of body form classification studies using large amounts of data. Other significant contributions include the quantitative generation of meaningful categories from the body form data set of specific samples, the statistical data reduction technique application to raw 3D body scan data, and the opportunity to collaborate with fields like kinesiology, psychology, nutrition, and statistics. Future study includes expanding the methodology to different data sets and strengthening the current analysis methodology.

Bye, E., LaBat, K. L., & DeLong, M. R. (2006). Analysis of body measurement systems for apparel. *Clothing & Textile Research Journal, 24*(2), 66-79.

Costa, L. F., & Cesar, R. M. (2001). *Shape analysis and classification: Theory and practice.* New York: CRC Press.