National Textile Center
FY 2004 New Project Proposal

Project No.

S04-CR01

Competency: Management Systems

Improved Apparel Sizing: Fit and Anthropometric 3D Scan Data

Project Team:
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Objective:

The 3-D body scanner is a new tool that is being used in research for the apparel industry and holds promise to revolutionize the way apparel is manufactured and sold. An anthropometric survey of the civilian U.S. population (CAESAR) using this technology has been conducted and a second one is nearing completion (SizeUSA) [1,2]. These are the first attempts to collect anthropometric data from a representative U.S. adult population relevant to apparel since the 1940's, and are made possible with body scanning technology. These data have the potential to provide new insights into issues of sizing and fit of apparel. The apparel industry has not had access to reliable, representative data from body scans, so tools and methodologies to harness, apply, and interpret this information are critically needed [3]. The current NTC-funded body scan research project at Cornell has focused on the development of mathematical models and statistical techniques for analysis of fit using body scan data. Our research is developing ways to objectively quantify and assess fit for the segment of the population identified by an apparel company as its target market using body scan data to visualize and quantify garment fit. Multiple scans of 203 research participants were analyzed to quantify fit issues for two different size categories of women's pants. By merging and analyzing two 3D entities (a minimally clothed body and the same body in a garment) we have begun to describe the complexity of fit in terms of its surface and volumetric characteristics. However in order to translate this information into valid recommendations for determining optimal sizing groups within a target market, it is necessary to relate these data to the configuration of the target market in the U.S. population.

The proposed project will extend our original research by developing methodologies for applying a combination of fit data and anthropometric population data to the problem of developing effective sizing systems for apparel products. Our research will identify sets of critical measurements for effective sizing for specific target markets and the process to apply them in the development of base patterns, grade rules, and sizing systems. These objective measures of the target population will replace the traditional method of pattern and sizing system development based on one fit model, standard grade rules, and descriptive demographic data, such as age and income. Specifically, we will:

1. Link our mathematical model of fit analysis based on scan data to anthropometric data of the U.S. population.
    A. Establish relationships between body characteristics of that portion of the target market that are poorly fitted and a statistically representative sample of the target market in the U.S. population.
    B. Determine each possible pattern making and grading decision variable in the sizing system that improves fit for the greatest number of targeted individuals from the population.
2. Extend and improve our fit analysis process based on scans of different target markets and apparel styles.
3. Identify and generalize critical scan measurements, anthropometric data, analysis methods, and strategies in order to develop a process by which apparel firms can interpret body scan data to optimize an existing sizing system for a specific target market.

Relevance to NTC Mission:

One of the greatest challenges facing apparel companies today is finding a cost-effective method to provide quality fit in apparel. Repeatedly studies of degree of satisfaction with apparel have found that about 50% of women cannot find satisfactorily fitting clothes [4,5]. Lack of good fit is often the reason given by consumers for deciding not to purchase clothing, and it is estimated that as much as 35% of clothing purchased from catalogs is returned because of problems with fit [6].

The creation of an effective ready-to-wear sizing system is a complex undertaking. The great variation in sizes and shapes of people in the population and the need to keep stock keeping units (SKU's) to a minimum in order to control inventory costs are in direct conflict with one another. Because of the variation in the population, a change in the base pattern shape or the grading of a pattern has the potential to improve the fit of the garment for one segment of the population at the expense of another segment.

Two issues have limited the ability of apparel companies to make informed decisions about their sizing systems. First, there is a lack of data on fit characteristics of garments for a variety of different body sizes and shapes. Apparel companies typically only attempt to fit one body type, developing base patterns and grade rules matching the proportions of their fit model, while the marketing of apparel typically focuses on the age, income, and lifestyle choices of the target market. Second, there has been a lack of current anthropometric data to describe the civilian population. Three dimensional scanning systems can provide both anthropometric and fit information but the tools and processes to analyze and apply these data are still needed. Developing quantitative models of fit applicable to multiple target markets and styles and new analysis processes that link fit data and anthropometric data will ultimately result in better sizing and fit methodologies. Reduction in unsold or discounted inventory achieved by improved fit will boost the competitiveness of the U.S. apparel industry.

State of the Art:

NTC has funded four research projects employing 3D body scanning technology: *Automated Garment Development from Body Scan Data* [7]; *Virtual Fit Models Via Body Scan Analysis* [8]; *Virtual 3D Draping of Apparel* [9]; and our current project, *Using Body Scan Data to Improve Garment Fit* [10]. These NTC projects are focused on creating and using standard formats for scan and measurement data [7]; analysis of scan data to identify and categorize different body shapes [8], and visualizing, unwrapping and modifying 3D surfaces on 3D body scan data to create custom fitted patterns [9]. Our current NTC-funded project is focused on visual and statistical analysis of fit using scans with minimal clothes and test pants and multiple types of measurements: circumference (linear), surface and slice areas, and volumes. Work has also been completed on consumer acceptance of body scan technology [12,14,15]. Analysis of body surface area generated from body scans has been compared to other methods of quantifying surface area [15]. Many studies have been conducted to establish reliable protocols for collection and use of scan data. [17,18,19].

While body scanning has great potential implications for the apparel industry, commercial application for the most part has been promotional in nature, such as by Levi's and Land's End. Body scanning is being used by a few early adopters in the apparel industry for custom fit of apparel such as Brooks Brothers and possen.com. Other potential commercial uses of scan data in the industry are virtual fit, automated size selection, and style consultation [11]. Although these services are already being offered using traditional manual measurements, much development must occur before scan data can be used economically.

The current Cornell body scan research project is in its last year of NTC funding and provides a solid foundation for the new project proposal. Our contribution differs from other existing research using body scan data in that we focus on improving current ready-to-wear sizing systems by developing protocols and methodologies to analyze fit using visual and statistical body scan data, merged scans to visualize *misfit*, and new measurements—surface and slice area and volume—that garner the power of scan data.

We scanned research subjects in a minimally clothed state and also wearing test garments. In doing so, we captured 3D data for visual and statistical analysis of garment fit in relation to the enclosed human figure. By scanning 203 subjects in a target market, we have a solid baseline for understanding the current body configuration of women in this target market who can find acceptable fit in ready-to-wear pants and the issues that lead to misfit [10]. Analysis of previously unexplored measures has the potential to provide the data needed to develop highly effective sizing systems. A set of over 50 body and pant measurements that are potentially critical to good pant fit are being analyzed in combination with the test pant size

specifications and grade rules supplied by our industry partner, Liz Claiborne. The result will be a mathematical model defining critical variables necessary to fit the greatest number of people in a target market that can be applied to an existing sizing system.

We are currently investigating several additional mathematical approaches from other disciplines for analysis of these data. In the biological sciences, Gielis's "superformula" offers great potential in mathematically defining pseudo-elliptical shapes [19]. Using this procedure, we may be able to analyze shape parameters relevant to fit in cross sections generated from body scans. In addition, Statistical Parameter Mapping used in the medical research field for determining volumetric statistical comparisons seems directly applicable to body scan research aims [20].

Approach:

The SizeUSA study being conducted by $[TC]^2$ will collect 12,000 scans of a representative sample of adult men and women in the United States. Statistically representative numbers of age and ethnic groups were recruited for this study in order to represent the civilian U.S. population as accurately as possible. As a SizeUSA member, our industry partner Liz Claiborne will receive a set of linear, proportional, and angular body measurements taken from the body scans. Some additional measurements are included in this agreement; others will be contracted from $[TC]^2$ as needed. Based on our fit analysis, we will select and compare a set of the relevant body measurements from our sample of 203 research participants with the SizeUSA's sample of women aged 34-55 years numbering about 2,500. The analysis of fit will allow us to pinpoint body characteristics not well fitted in the test garment. These findings will be assessed in relation to a representative population to determine the frequency in which such body characteristics occur in the U.S. population. This allows us to adjust the sizing system to provide best fit for the greatest number of individuals.

We will also extend our fit analysis in two ways. First, we will continue to visually and statistically assess fit through scans of an expanded number of garment types, styles, and target markets and apply these results to improve and extend the mathematical model. The use of surface area, slice area, and volume measurements from scan data provides information unique to our research that harnesses the additional powers of body scan data.

Second, we will develop a process that can be readily used by apparel firms with access to target market scan data. The process will identify critical scan measurements, analysis methods, and strategies that will help in the selection, application, and interpretation of scan data to individual companies' pattern development, grade rules, and sizing systems.

This Year's Goal:

To compare data from our current NTC project scan data with anthropometric population data collected in the SizeUSA project for women aged 34-55 years.

To begin developing a process for apparel firms to interpret and apply scan data in the development and assessment of their pattern making, grading, and sizing systems.

Outreach to Industry:

This project will immediately provide:

1. Application of SizeUSA anthropometric data that will benefit industry members and educate other industry professionals about the anthropometry of today's U.S. adult population.
2. Information transfer to the industry of the process for interpreting 3D scan data and applying it to improve existing sizing systems.
3. An updated website of information on the current state of body scan research at http://www.explore.cornell.edu/bodyscanner

Involvement of industry partner Liz Claiborne and $[TC]^2$ in the project will broaden the distribution of the information in concept and practice.

New Resources Required:

We will add $[TC]^2$ as consulting partners in this project as we compare our scan data with the statistically representative SizeUSA scan data. We will purchase software for further manipulation and analysis of 3D data.