大量客製化：服裝合身度的分析

Mass Customization: Apparel Fitting Analysis

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摘要

當美國服裝工業面臨著全球化的競爭及市場需求詭譎多變之時，其消費者在尋求具合身性服裝的過程中受盡挫折。根據人體量測而建立的尺碼系統不但可以幫助消費者輕易找到自己尺寸的衣服，而且可以符合他們對合身度的要求。尤其是將三度空間人體量測的數據輸入電腦輔助設計系統中，更可以創造出具合身度的訂製服，可惜的是，目前將電腦科技運用在大量客製化的過程中，仍有一些技巧性的問題懸而未決。此研究主要是對服裝合身度的探討，經過分析所搜尋資料後，建議及結論產生。

關鍵字：大量客製化，服裝合身度，補正，人體計測。

ABSTRACT

While the US apparel industry is facing the challenges of global competition and volatile demand in the fashion market, consumers are frustrated by the search process needed to find good-fitting garments. The sizing system based on body measurement will help consumers easily find correct sizes of garments and meet their fitting requirements. The body measurements extracted from the 3-D body scanners and entered into apparel CAD systems will effectively create good-fitting garments for both consumers who buy ready-to-wear apparel and those who are interested in customized garments. However, the technical problems with apparel mass customization have not been completely overcome yet. This paper presents an overview of the most significant issues related to apparel fitting. After an extensive literature search, an analysis of the quantitative data is made, some recommendations are provided, and certain conclusions are reached.

Keywords: mass customization, apparel fitting, apparel alteration, body measurements.

Introduction

The US apparel industry is facing the dynamics of global competition and volatile demand of consumers in the business environment. The apparel industry, which is labor-intensive, tries to cut production costs by shifting operations to less-developed countries. These less-developed countries with the advantage of lower-wage employees, take more than half of the market share in the United States. As a result of foreign-made goods flooding into the United States, a great trade deficit has existed over years (Lin, Moore, Kincade & Avery, 2002). Along with this global competition, the US apparel industry is facing the challenges of volatile demand in the fashion market. Apparel firms provide products combining diverse styles, sizes, and colors in order to satisfy rapid changes in consumer tastes. Although they carry a variety of merchandise in stock, consumers are not happy with shopping and complain about the inability to select desirable products (Lee, Kunz, Fiore & Campell,

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2002). Consumers are not only frustrated by the merchandise available in the market, but also by the search process needed to find good-fitting garments. When consumers waste time in fitting rooms and are not able to choose the appropriate sized garments, manufacturers and retailers may suffer from lost sales and brand dissatisfaction (DesMarteau, 2000). Therefore, helping consumers easily find the correct sizes of garments and meeting their fitting requirements have been important issues in the industry. Specific body measurements printed on the size labels of women's ready-to-wear apparel will speed up the search process (Chun-Yoon & Jasper, 1996). However, the measurements used in developing the current size labeling system are various among apparel firms. The purpose of this paper is to investigate the reasons for the lack of a sizing system based on body measurement, the sizes surveyed by the apparel industry, and the supporting apparel technologies enabling effectively meeting consumers' needs for fitting. The analysis of problems related to apparel fitting in mass customization is made, and further research recommendations are provided.

Lack of standardized sizing systems in the apparel industry

The sizing system based on body measurement will help consumers easily find correct sizes of garments and alleviate fitting problems. The current size labeling system utilizes numbers and letters (Table 1), but not specific body measurements. By reading the sizes, consumers are supposed to choose apparel products that fit their body (Chun-Yoon & Jasper, 1996). However, consumers are always frustrated because apparel firms use their own measurements to develop the sizing system. Some companies prefer to make garments with a loose fit, while others make closer to the body. A single size of one company can vary inches in many dimensions from that of another (Iowa State University Extension, 2002). The lack of standardized sizing systems causes serious fitting problems. A study conducted by Kurt Salmon Associate (KSA), the leading apparel consultant corporation, showed that more than 60 percent of men and women are not able to find good-fitting garments. Fifty percent of the manufacturers make garments based on a standard or a live fitting model size instead of the anthropometric body measurement. Worse, 57% of them claim their apparel products do not fit the body shape of standard sizes. Other research also indicated that the primary reasons for catalog and e-retailer returns are fitting problems (Made4Me Corporation, 2002).

Table 1: Women's sizing system

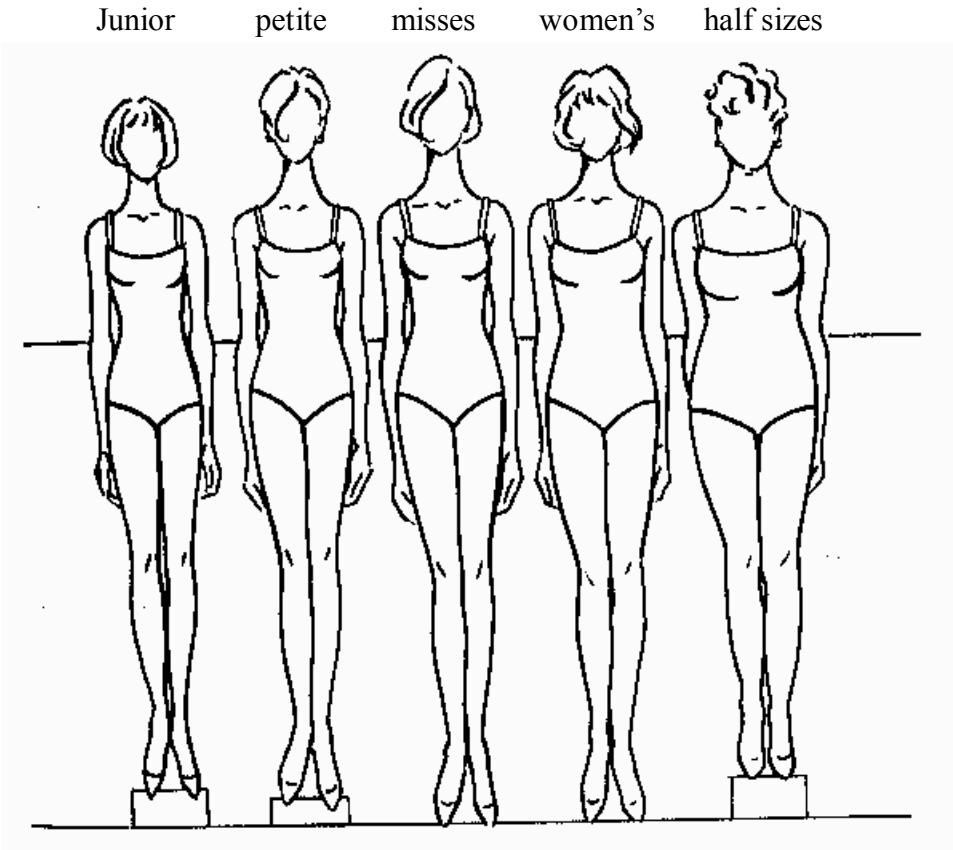
Size Range	Sizes
Petites	2 to 14 or 16 P (2-4) S (4-6; 6-8) M (8-10; 10-12) L (12-14; 14-16)
Women's Petites	14 to 22 or 24 1XP (14-16) 2XP (16-18; 18-20) 3XP (18-20; 22-24)
Half-sizes	14 1/2 to 24 1/2
Misses/Missy	2 to 18 or 20
Juniors	1 or 3 to 15
Women's/Plus Sizes	14 to 24 or 26
Talls	8 to 20 or 22

Source: Iowa State University Extension (2002)

The lack of standardized sizing systems in the apparel industry results from different dress forms used to make basic patterns, known as slopers or block patterns, for garments. Apparel firms may create the initial garment by draping the fabric on the dress form representing the standard size of their target consumers. The fabric is molded into the desired shape, cut and pinned in place. Once the silhouette and construction details are completed, the fabric pieces are removed from the dress form and traced on paper. The sloper is done when the finalized marks such as notches and grain lines are made on the paper pattern (Burns & Bryant, 1997). Because the molds of dress forms are traditionally made by hand and covered with knit fabric, it is

possible to have different sizes and shapes. Especially, dress forms made of fiberglass are less easily to meet measurement standards required by apparel firms (DesMarteau, 2000). Furthermore, apparel firms use their own measurements to make garments for a standard or a live-fitting model size representing a particular target market. Sizes certainly can vary from one manufacturer to another. The body shapes illustrated in Figure 1 symbolize the standard sizes of different target markets. The more mature and large-proportioned body type under the "women's" size range has a fuller abdomen and lower bust than that middle body type under the "Misses" size range, which has a well-proportioned figure (Price & Zamkoff, 1996).

Figure 1：



When the grading rules are applied to a sloper, a standard size is scaled mechanically and proportionally up to larger or down to smaller sizes. These graded sizes are not able to perfectly fit the human body (Price & Zamkoff, 1996). Moreover, the grading rules have proved to lack a basis for body measurement. For example, most grading rules assume that the difference between the principal circumferences, hip to bust or bust to waist, is constant for all sizes; this is not supported by actual body measurement. In addition, the assumption of the bust points maintaining the same vertical position in the bodice for all sizes is incorrect against the anthropometric data collected by the U.S. Army. The fact is that the bust point is getting lower as the size increases in most cases. Indeed, the grading rules will not work properly unless well-trained pattern makers check the fits of all sizes (DesMarteau, 2000).

A well-trained pattern maker is not only able to

avoid fitting problems rooted in grading rules, but also able to avoid problems occurring on a sloper. Most apparel firms start with an existing pattern, a sloper or a similar style from a previous season to develop patterns for new styles designed rather than draping on dress forms. They utilize a sloper or a similar style to develop a new style by adding design details such as a collar or pocket to the existing pattern (Burns & Bryant, 1997). The flat pattern-making process of adjusting an existing pattern is faster, but fitting problems occurring on a sloper can be copied to new styles. Some fitting problems are probably invisible in solid fabrics or styles with a loose fit; they may become obvious in a plaid fabric or a tightly fitting style. A pattern maker with formal training in pattern making, draping, construction, and industry experience is able to develop slopers properly and save many fitting sessions. As the fashion trends move toward more tailored and fitted garments, pattern makers are challenged to develop patterns for styles that tightly fit. They have to focus more on fitting devices that have seldom been used by many firms for the past few years (DesMarteau, 2000).

Size surveys participated in by the apparel industry

The apparel industry has tried to offer products with a better fit by training pattern makers in expanding pattern-making skills on one hand and participating in anthropometric size surveys on the other hand. In the apparel industry, accurate body measurements are the first important step to create garments and the foundation for consumers' fitting requirements. Tailors and designers made and altered customized garments by using measuring tapes to obtain body measurements in the past. The measurement data would be inaccurate depending on how and who took the measurements (Istook, 2000). As the production process changed from made-to-measure to ready-to-wear, the Voluntary Product Standard PS 42-70 database used to develop the sizing system for the ready-to-wear apparel came out in 1939-1940 and was revised in 1971 by the Department of Commerce Bureau of Standards. Because most of the original data of this nationwide anthropometric survey on the US civilian population is no longer available and people's body shapes have changed since the 1940s, measurement information based on the US military population becomes useful for pattern making and apparel construction (Goldsberry, Shim & Reich, 1996). The only anthropometric survey on the civilian population since the 1940s is the Civilian American and European Surface Anthropometry Resource (CAESAR) conducted by the Society of Automotive Engineers (SAE), the US Air Force and partners from the apparel manufacturing, retailing industries and other industries. Anthropometric surveys on civilian population are rare because the costs of conducting a statistically significant size study are incredibly tremendous. The physical method of the measuring procedure takes considerable time to landmark, measure, and record per subject. The numbers of subjects have to reach thousands to approach statistical validation (Textile Clothing Technology Corporation, 2002). Compared with manual measuring procedures, using a 3-D scanning system has the advantages of lower costs and more details provided about the body shape. Also, it is an easy way to transfer accurate measurement information about the size and shape of the human body to apparel Computer Aided Design (CAD) systems. The CAESAR project began collecting data by using the body scanning system developed by Cyberware in 1998, and it was completed in 2001. CAESAR had scanned 2500 U.S. and 2500 European males and females aged between 18 and 65. Many apparel firms participating in this project have acquired the measurement information already (American Society for Testing and Materials, 2002).

The supporting technology enabling effective mass customization

The sizing system based on body measurement will help consumers easily find correctly sized garments and satisfy their needs for fitting. The body measurements obtained through the supporting technologies will effectively create good-fitting garments for both consumers who buy ready-to-wear apparel and those who are interested in customized garments. According to Lee et al. (2002), apparel mass customization is a process in which customers are aided with the technologies to meet individual design tastes or fitting requirements. In other words, those consumers who are interested in customizing apparel can individually choose from a variety of product styles, fabrics, and colors, and combine them to create a unique design by using apparel technologies. Meanwhile, with the help of a well-trained assistant to obtain body measurements, the customers are able to achieve personalized size and fit. The customers pay for the products, and the orders are sent to the production facility. Since apparel products have been prepared for individual customers based on unique order specifications, manufacturers or retailers may avoid losing sales and reduce stock. When apparel products are made to order, apparel companies are able to adjust their product line and leave behind no inventory.

Enabling the effective meeting individual needs for fitting, supporting apparel technologies include 3-D body scanners and apparel CAD systems with the functions of garment design, pattern making, pattern grading and pattern alteration. The primary types of 3-D body scanning systems are laser and light devices capturing the surface of the human body and extracting body measurements without physical contact with the body. Then, the extracted body measurements are automatically applied to alteration systems of CAD to adjust existing patterns to individual patterns. The current alteration systems of CAD are generally developed by drafting patterns directly according to body measurements, applying a mathematical formula to adjust existing patterns to fit specific body measurements, or following sizing and alteration rules to alter graded patterns to fit specific body measurements (Istook, 2002). Newly developed CAD systems are even capable of integrating 2-D pattern making and grading with 3-D visualization. Users drape 2-D patterns on 3-D virtual dress forms, check designs, make pattern revisions, and modify graded patterns (Istook, 2000).

The recent cases of applying the technologies are Levi-Strauss and Brooks Brothers. Both of the apparel companies uses the 3-D body scanning system developed by Textile Clothing Technology Corporation. Unlike the Levi's 3-D body scanning system stored in 1999, in which the scanning system collects approximately 100,000 points of measurement data, Brooks Brother's 3-D scanning system captures more than 200,000 data points. The actual scanning process takes about twelve seconds compared with the Levi's fifteen seconds (Haisley, 2002; DesMarteau, 1999). Particularly, Brooks Brother's 3-D scanning system has integrated with an alteration process. Its made-to-measure program called "e-measure" applies standardized alterations to existing patterns after the measurement data is transferred to the CAD system (Rabon, 2000).

Fitting problems with apparel mass customization

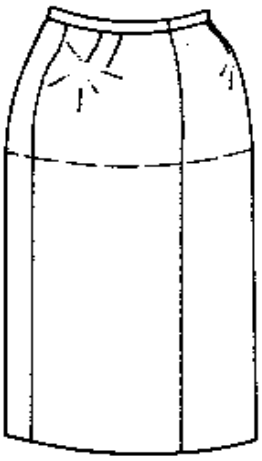
The concept of mass customization is to customize apparel to meet individualized design taste or fitting requirements. Unfortunately, customers are not always satisfied with the products that are customized. Apparel companies, such as Levi-Strauss, have tested mass customization service, but have not yet successfully turned a profit. The high rate of customer returns could be a result of fitting problems (Lee et. al, 2002).

Aiming at creating good-fitting garments, the process of mass customization is to obtain body measurements by either measuring tapes or body scanners. After the body measurements are extracted

and entered into a CAD system, where existing patterns are stored, an existing pattern is converted to an individualized pattern. The replacement of manual measuring methods by the 3-D scanning system has been due to cost and data accuracy considerations. However, body measurements extracted from body scanners can be incorrect as well. Respiration, for example, is an obvious factor that can affect scanned data of upper torso measurements. A subject measured at maximum inhalation may be several inches larger than exhalation in the breadth measurement. Similarly, lower body measurements can be varied significantly by foot position. Most body scanning systems require subjects to stand with their feet several inches away in order to identify the crotch point (Mckinnon & Istook, 2002).

Second, the supporting technologies are expected to allow scanning data of measurements to be automatically integrated with pattern alternation. With patterns stored in the software for alteration, the CAD system selects the most appropriate pattern among them and converts it into an individual pattern for a personal fit. Currently, the CAD software can make the selection of an existing pattern; even though the CAD software is not quite sophisticated enough to choose the most correct and appropriate pattern yet. The majority of apparel firms assign pattern makers or sales associates to do the work. No matter who does the selection, the body shape of the customer has to be evaluated. Without evaluation of a customer's body shape, the customer's size will not be well identified and an existing pattern will not be altered properly to an individualized pattern. For instance, a customer may have prominent hipbones as showed on the Figure 2. This appearance indicates that the bone structure has a larger and more angular appearance than an average body shape. A pattern maker has to evaluate the body shape and decide how to alter an existing pattern. However, most pattern makers in the industry are not required to know how to alter their patterns because they usually produce garments to fit the standard sizes of their companies. Many pattern makers may have no idea how body measurements relate to the development of fitting a specific customer.

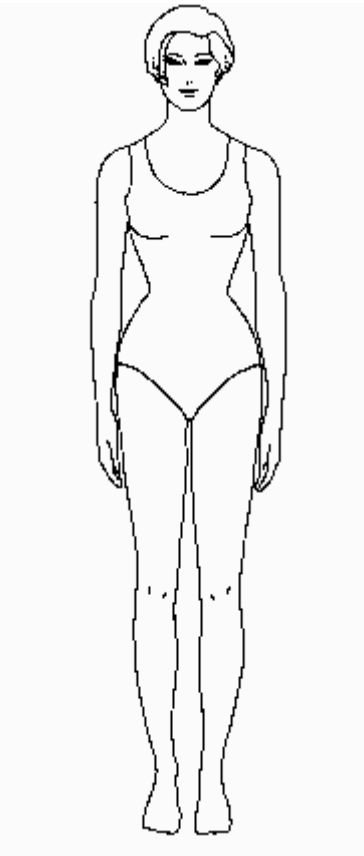
Figure 2：



After the most correct and appropriate pattern is chosen, the alteration activities begin with deciding where the pattern has to be adjusted. The CAD system is able to determine which location on the pattern needs to be adjusted for the specific body with a smaller waist. It is also capable of calculating the difference in waistline between the unusual body type and an average type and adjusting a skirt pattern by decreasing the extra waist width; the amount is equally distributed at side seams and darts. The alterations can become very complicated and limited in efficiency when there is an asymmetric body shape or unusual body type. For example, the hourglass body type showed on Figure 3 has a smaller waist combined with a thin, large hip, or prominent hipbones. Although the amount of waist width has to be decreased at the side seams and darts, the reduction of the amount distributed to side seams

and darts is not equal. Following alteration rules, a pattern maker has to manually allocate the amount of extra waist width. The more asymmetric the body shape, the more complicated the alterations are to process. These activities require pattern makers with a strong knowledge of garment design, grading garment construction, as well as understanding of computer work.

Figure 3：



Third, the most critical factor in causing fitting problems with mass customization is the existing patterns. The measurement data extracted from body scanning are supposed to be directly used to draft customized patterns for customized garments at the beginning. However, this current process of pattern development focuses on altering existing patterns. Since the existing patterns are produced with current standards and the grading rules behind measurement standards do not create good-fitting garments, the process of mass customization will increase the fitting problems.

Recommendations and conclusions

The objective of the sizing system based on body measurement is to help consumers easily find correct sized garments and satisfy their needs for fitting. The body measurements obtained through the supporting technologies will effectively create good-fitting garments for both consumers who buy ready-to-wear apparel and those who are interested in customized garments. Although apparel mass customization aided with the supporting technologies, including 3-D body scanners and CAD systems, allow apparel firms to effectively meet personal needs for fitting, technical problems with mass customization have not been completely overcome yet. The apparel industry and researchers have worked together to improve the accuracy of scanning data and focus on automatic data transferring from 3-D scanning systems to CAD alteration. However, specific matters such as selection of the most appropriate pattern, evaluation of body shape, and simplicity of alterations can be further improved. The selection of the most appropriate pattern done by the CAD system needs to be developed profoundly. More information about body shapes has to come along with measurement data that enables the creation of good-fitting garments for specific body shapes. Finally, the alterations have to be simplified to compensate for pattern-making skills. Otherwise, the industry has to make more effort in teaching pattern makers the correct way to achieve a good-fitting garment.

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