Effectiveness of 3D scanning in establishing side seam placement for pattern design

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Abstract

As woven garments are cut from flat pieces of cloth, pattern cutting methods must create flat 2D shapes that are constructed to form 3D garments that fit a particular body shape. The placement of side seams represents a key division of the pattern where the front and back portions of a garment relating to a particular body measurement are distributed to create a balanced garment. During most pattern creation methods the distribution of the measurement into back and front arcs is proportionally determined by the author, however body scanning provides new opportunities to understand the body and derive these arcs during the measurement process. TC2 measurement software provides the facility to automatically derive arcs based on non-disclosed divisions of the body along a vertical plane. This research tests the automated division of key circumferences into arcs using the TC2 software, against methods guided by practitioner experience and placed using non-automated 3D software. Focusing on circumferences of the bust, waist and hip, analysis of the arcs derived by the scanner from a number of standard female body forms and 10 scans of female subjects, will be tested against those determined by a panel of experts. These methods form the basis for an understanding of how circumference division can be automated and allow for the testing of these methods on a variety of different scans and the comparison of the arcs against those proposed or applied in standard industry practice. It will be possible to see how closely these methods match or contrast with these imposed systems. This exploration provides a clear link to body pattern relationships and provides a foundation from which to advance mass customization utilizing body scanning technology and automated arc definition.

Keywords: 3d body scanning, Anthropometrics, Pattern Construction

1. Introduction

The automation of pattern construction driven by anthropometric analysis of the human body has, with recent developments in body scan capture and software programs, become a key area of focus for future garment development. Construction of the block, the basic unstyled pattern development tool, is often achieved using a proprietary drafting system which instructs on the creation of a shape based on body measurement, proportional rules and the inclusion of ease [1]. These systems are nuanced and require some familiarity on behalf of the practitioner to apply successfully. They are historically based on common practice, as data on anthropometric measures from the population were not available to guide the development of these systems. Therefore they exhibit a fair amount of variation, as different practitioners develop independent theories based on their own experiences.

As patterns are accepted to relate directly to the body and historically have been developed through draping as well as drafting [2, 3], there is growing recognition that it should be possible to create these shapes directly from the body surface within virtual environments [4, 5]. More recently methods have been proposed that provide more technologically developed solutions [6, 7] though these still leave questions regarding pattern theory. This lack of theory highlights the striking number of assumptions that are required to generate patterns and provide the basis for discussion of the issues that need to be resolved in order to make effective automation of pattern shapes possible.

Pattern drafting systems can provide the basis for development of automated systems, but also employ assumptions that must be reduced to a provable theory. The importance of the side seam, and inclusion of a method of identifying and patterning to the side seam is one such theoretical issue. Armstrong [8] is one of the few authors whose pattern methods require arc measurements to suitably define the back and front parts of a typical pattern. Other methods, including Aldrich [9], Bunka Fashion [10] and Beazley & Bond [11] all recommend the collection of whole circumferences, which are then divided into the commonly used front and back pattern pieces according to undisclosed proportions during the pattern construction process. The proportions considered to be appropriate within many of the major pattern methods for creating the bodice for a standard UK size 12 dress form vary from 49-58% for the front waist arc and 50-55% for the front bust arc. This indicates a variation in proportional techniques for dividing the arcs that would make it difficult to automate this process from purely practiced research.

Without explicit development of theory regarding patterns and proportions it is difficult to create a valid and reliable process for automating the process of pattern creation. This paper addresses some of the difficulties of establishing arc divisions from scan data, based on automated measurement placement and addresses one of the key required theoretical underpinnings to enable suitable pattern automation in developing systems. The focus will be predominantly on sideseam placement relative to the arc divisions of the bust, waist and hip which represent key dimensions in the construction of garment patterns.

2. Current understanding of patterns and sideseam placment

Tao and Bruniaux [6] document developments in the creation of garments using 3D draping techniques; moving between 2D and 3D systems they propose methods for automated development of trouser patterns using virtual avatars. Whilst the method shows how person/pattern relationships can be controlled, the reliance on 2D pattern methods as a benchmark do not address fundamental areas of practice in pattern construction which can make this process more accessible. Using only a single pattern construction system removes the difficulties of individual practices imposed by varied methods [1] and also the learned practice of different pattern makers, who will adjust drafts based on learned experience.

2.1. Defining the sideseam placement

The developing technologies of the late 90's that made it possible to capture and create the human body in virtual environments supported developments in automated pattern generation. Kang and Kim [12] provide an early example of how the 3D body surface can be used to create 2D pattern shapes with a direct relationship to the body surface. However this method does not address either the addition of ease or the fundamental identification of seam placement.

Analysis of major western pattern cutting methods for bodices conducted by Gill [13] establishes that most bodice patterns apply proscribed divisions to whole circumferences to create the front and back arcs that define current patterns. An exception to this are the methods of Armstrong [8] who defines arcs in the measurement process, though these measurements are collected from the body form and no clear details of side seam location on individual bodies is provided [13] The placement of the side seams on the body forms are determined by the manufacturer relying on common practice; this placement can be arbitrary. Manufacturing variation can also affect the placement of side seams of the body form, and their creation is essentially a manual process, and the reliability of the placement is dependent on the skill of the technician. Recent manufacturing processes in the industry have introduced better quality control and more reliable results (Alvanon,com).

2.2. Function of side seams in pattern construction

Side seams are not universally used in apparel (tubular knits do not have vertical seams, and for some tailored garments a side panel displaces the seam to the side front and side back[14]); however they are fairly ubiquitous. The use of a seam at the side of the body limits the width of panels of the garment and limits the distance that woven fabric panels need to wrap around the body. This has advantages in controlling grain of the fabric, and also results in panel sizes that can be cut efficiently saving fabric in the layout (marker). However an improperly placed side seam can result in an imbalance in the hang of the garment, or in an awkward visual division of the body. The importance of balance during pattern construction is mentioned in the Bunka guides [10], but is rarely given consideration in many of the existing guides which impose a balance subject to the authors preferences and period of methods development [1].

The body is symmetrical across the sagittal plane, as the right and left side of the body are essentially mirror images for most healthy people. However the same is not true for the body divided on the frontal plane. The front half of the body is shaped entirely differently than the back of the body. The balance of the body from front to back is also an area of great proportional variation in the population. This proportional variation is not captured in simple circumferential measures. For example two women with the same bust circumference measurement may have a different distribution of body shape; one woman may have a flat back and full bust, while another has a flatter bust and well-developed shoulders and back. Arc measurements from side seam to side seam would be different for these two women, and the widths of front and back panels at the bust would vary in well-fitted, balanced patterns developed for them. However current practice in pattern construction dictate that alterations for individual morphologies are made during the pattern testing and fitting process [8, 9, 15], rather than at the stage of pattern development.

Side seam placement on individual bodies is not a simple process. No clear body landmarks exist that can reliably capture the side seam placement that will result in a balanced garment. Unlike most body measurements the arc measurement is based on an apparel construct that has no 'natural' placement related to body configuration. This lack of a clear body landmark is evident when one investigates side seam placement definitions in the literature, though apparel practitioners regularly make the decision of side seam placement they disagree on how this should be done.

2.3. Definitions of the side seam

Most apparel practicioners would agree that the side seam should be vertical, i.e. perpendicular to the ground [16, 17]. Many use some part of the armscye as a landmark. For example, Farmer and Gotwals [16] identify the center of the armscye as the appropriate landmark. Both Hazen [18] and Rasband [17], say that the side seam should extend from the center of the underarm. Other methods concentrate on body proportions. Liechty et al.[15], claim the side seam should "divide the body in becoming proportions." and the instructions in Vogue Fitting, say that the side seam should be "centered on the body" from the side view [19]. Liechty et al. [15] also says that the side seam should appear to intersect the waistline at a 90 angle, and that it should be placed so that it creates an equal visual distance from the front, side, and back, i.e. the side seams should not be visible from the front or back view of the body and should be centered on the side view of the body.

In a study from 2007 of side seam placement seven apparel practitioners with at least ten years of experience were asked how they would place a side seam [20](Ashdown, 2007). Six of the seven judges indicated that they used at least two methods. The following methods were described:

(1) centering on the profile at a body landmark (under the arm, at the waist, at the hip);

(2) generating a vertical line from a landmark (the ear lobe, the shoulder point, the position of fingers in relaxed posture at side, the center of the armscye, the hip joint); or

(3) looking for balance among front and back points of greatest protrusion (shoulder blade to bust, bust to hip, shoulder to hip, and leg position).

Given the variety of responses, it is clear that there is no generally accepted (correct) placement of the side seam. As an apparel construct, it has been defined by professional practice, with individual preferences in methods of selection. In order to effectively automate this process it is necessary to agree on an appropriate scan measurement procedure.

2.4. Future development

Current measurement definitions for scanning are grounded in the protocols of ergonomics [21] and pay little attention to the application of merasurments in clothing. The requirements to engage with measurement application ensures that practitioner knowledge must play a role in how we look to automate pattern construction and the determination of suitable divisions that will provide data that can drive the many means of pattern development. Until existing methods of automated pattern generation [6, 12] engage with variation in pattern practices [1] there will remain a disconnect between data collected from the body and its application in the development of clothing.

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3. Methodology

This work used body scanning technology to capture data from dress stands and from real bodies to explore methods for determining the placement of sideseams using automated techniques.

3.1. Comparison of practitioners sideseam location

Body scans were captured using either a TC2 KX16 or a Human Solutions Vitus XXL scanner, scans in their raw format were taken into geomagic and converted to similar file types to produce tiff images from which sideseam placement could be visually judged by a panel of 5 experienced apparel practitioners. (Let's collect information on years of experience for each of us and report average, min and max. Mine is 43 years) [SG = 19yrs]- [TB = 40+?]- [PW=27?]-[KB=??]

3.2. Comparison of TC2 automated sideseam location

All scans were then processed into a BIN format where body models could be created in TC2 KX16 software, using this software extraction parameters were explored which automatically defined divisions of the body into arcs at the key dimensions of bust, waist and hip. These arc divisions and their correspondent landmarks suggested divisions of the body which would provide the markers for automated sideseam placement. The side on visual of the scan with the arc lines marked was captured and using Corel Photopaint X5 converted to a Jpeg image. Horizontal lines were marked on each scan image aligned with the right side waist point, to indicate the orientation of side seam division and provide a means to visually determine the proposed orientation against the bust and hip divisions.

3.3. Comparison of measurement divisions from TC2 software

Further to this arc measurements alongside full circumferences were output from each of the scans to determine the amount of the circumference considered to be within the front and back arc portions for each of the different scans.

3.4. Comparison of arcs by pattern practice

Utilizing existing data of measurements determined from major methods of bodice pattern creation [13] further analysis was undertaken to establish arc divisions within the pattern as a percentage of the overall pattern circumferences at the waist and bust.

4. Results and Discussion

The following sections outline the findings from the individual aspects of the study and provide details in how these inform considerations for future development in terms of practice and technology.

4.1. Comparison of practitioner's sideseam location

4.2. Side seam division from the TC2 software

Using the measurement extraction parameters from TC2 software key dimensions were determined on the forms and the following images show how sideseam divisions would occur using the arcs in relation to a horizontal line from the side waist points.

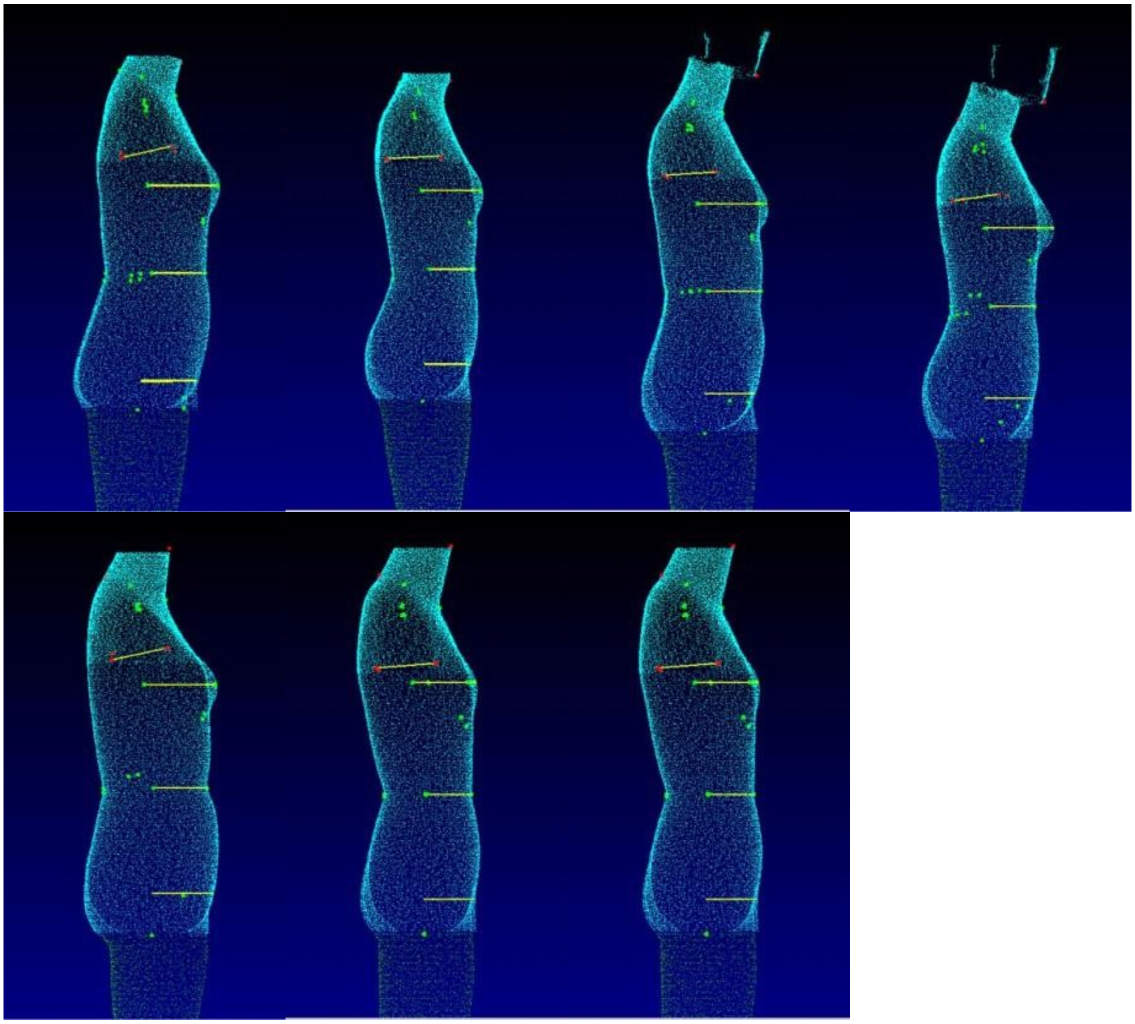

Figure 1: Images of sideseam placement on the dress form scans [scans from left to right: 1.AsianAlva; 2.DressRite_size8; 3.MMU-WMS012C-0807; 4.MMU-WMS012S-0807; 5.WMS0006-0507; 6.Wolf_m1959_size14; 7. Wolf1997_size3]

Each of the dress forms shows a different posture and when sideseam division is horizontally placed, it does not align with the divisions of the body at the bust and hip. There is also a different balance to the centre of the armhole area on the scans as determined by the depth of the armscye relative to the front and back armpit points.

4.3. Measurement divisions from TC2 software

Table. 1. Arc divisions from TC2 output

	Front Bust Arc %	Back Bust Arc %	Front Waist Arc %	Back Waist Arc %	Front Hip Arc %	Back Hip Arc %
AsianAlva	54.02	45.98	50.27	49.73	48.75	51.25
DressRite_size8	54.57	45.43	49.96	50.04	48.22	51.78
MMU-WMS012C-0807	54.14	45.86	49.83	50.17	48.95	51.05
MMU-WMS012S-0807	54.26	45.74	49.95	50.05	48.13	51.87
WMS0006-0507	54.96	45.04	50.30	49.70	48.42	51.58
Wolf_m1959_size14	53.03	46.97	49.93	50.07	48.15	51.85
Wolf1997_size3	51.10	48.90	50.14	49.86	47.63	52.37
Average	53.73	46.27	50.05	49.95	48.32	51.68

The arcs defined by the TC2 software provide measurements which show the proposed proportions of the body in the back and front of full circumferences. Whilst the waist shows a near equal division in the population chosen, possibly due to the limited nature of dress forms in reflecting current bodies, the bust suggests as would be expected a larger portion to the front, clearly influenced by projection of the bust. Similarly the hips show a larger projection to the back arc which would be relative to the projection of the buttocks. These arcs however do not address the idea of balance within the garment or consider in their division the control areas of the body from which garments hang.

4.4. Analysis of bodice patterns

Analysis of bodice patterns constructed using 9 different methods of flat drafting systems provided the opportunity to establish relative arc divisions that occurred during the draft process. The following (Table 1) shows the variation in arc percentages within these drafts when constructed for a UK size 12 dress form, as the methods of determining arcs is not explicit it is currently unclear which methods would always provide stable divisions and which would change relative to different measurements of the dress form.

Table. 2. Arcs determined in current bodice construction methods

	Fr Waist Arc	Bk Waist Arc	Fr Bust arc	Bk Bust arc
Total girth on dress form	**70.2**		**90.6**	
Armstrong 2006	50.72	49.28	55.53	44.47
Aldrich 2004	50.13	49.87	52.75	47.25
Bray 2003	56.20	43.80	54.41	45.59
Beazley and Bond 2003	53.33	46.67	52.52	47.48
Shoben and Ward 1987	48.70	51.30	50.20	49.80
Bunka 2008	57.67	42.33	54.04	45.96
Haggar 2004	48.79	51.21	50.00	50.00
Kunick 1984	54.95	45.05	53.11	46.89
Campbell 1980	50.68	49.32	53.29	46.71
Average	52.35	47.65	52.87	47.13
Min	48.70	42.33	50.00	44.47
Max	57.67	51.30	55.53	50.00

5. Conclusions

Current practice indicates that there needs to be a more evolved approach to determining arc division within body scanning systems and the facility to define side seams driven by garment considerations is important. Current pattern construction methods show a variation in proposed arc proportions and in many cases these do not adhere to the arcs defined automatically in TC2 scan software.

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