International Journal of Industrial Ergonomics 65 (2018) 46–59

Contents lists available at ScienceDirect

International Journal of Industrial Ergonomics

journal homepage: www.elsevier.com/locate/ergon

Parametric design of garment flat based on body dimension

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ARTICLE INFO

Article history:
Received 16 September 2016
Received in revised form
3 September 2017
Accepted 18 January 2018

Keywords:
Garment flat
Parametric design
Anthropometric measurement
Golden ratio
Jean
Body dimension

ABSTRACT

Garment flats have a wide application in product development production and designing stages. However, the traditional drawing methods of garment flat are very time-consuming, and need professional drawing skills. In this paper, a parametric design method was proposed based on body dimension to draw garment flats. The relations among human body, flats and garment show that a garment flat has a close relation with human body and real garment. Graphic analysis shows that a garment flat is constrained by two kinds of parameters: geometric and dimensional parameters. Then, the parametric relation model between garment flat and human body dimensions was constructed. According to the parametric relation model, all the dimensions of a garment flat can be represented by several dimensional parameters and style parameters. Finally, an application program (JFRS, 2016) based on the proposed method was developed to generate garment flats. The result shows that the proposed method is more effective than traditional methods. Moreover, the engineering design methods have been successfully applied to improve design efficiency in artistic design in this research. This is a novel research idea in the field of fashion design, and could be further applied in other design domains.

1. Introduction

Body dimension is important for product development and evaluation (Sutalaksana and Widyanti, 2016), such as, firefighters' uniform pants (J. Park and Langseth-Schmidt, 2016), furniture (Carneiro et al., 2017; Castellucci et al., 2016), labor-saving tools (Mugisa et al., 2016; Vyavahare and Kallurkar, 2016), pillow (Cai and Chen, 2016), seat (Guo et al., 2016; Zerehsaz et al., 2016), helicopter cockpit (W. W. Lee et al., 2013). In clothing industry, human body dimension is essential for garment pattern making (Liu et al., 2016b, 2017c; Widyanti et al., 2017; Wu et al., 2015) and relates to garment fit directly (Liu et al., 2017a, 2017b). However, the traditional drawing methods of garment flat are not based on body dimension but designers' experience. At present, there are two methods to draw garment flat: hand drawing and computer-aided drawing. Hand drawing requires sophisticated and artistic skills; while, computer-aided drawing requires analytical thinking and continuous comparison of the prototype to what is being drawn. Both these two drawing methods require designers draw garment flat line by line. This process is very time-consuming. Generally, it requires several hours for a designer to draw a complex garment flat. In this case, it is difficult to draw garment flat by computer automatically. With the rapid development of E-commerce, the demand of garment related products is large and growing (Y. Y. Lee et al., 2013). It is necessary to develop a rapid generation technology for garment flats. In this research, a novel drawing method of garment flat based on body dimension was proposed.

Garment flat drawing is an essential part in the fashion design process. Generally, a garment flat is used in pattern making documentation, tech packs, specifications, cost sheets, line sheets and production-related presentations (Chang-Suk et al., 2010; Robson et al., 2011). Designers use garment flats to efficiently convey their design ideas and garment details to related departments. It is essential that garment flats are drawn accurately to avoid misunderstanding and costly mistakes in sampling and production.

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https://doi.org/10.1016/j.ergon.2018.01.013
0169-8141/

Garment flats are very different from fashion illustrations needed for a presentation. Garment flats do not need much movement or shading, as it can be distracting. A neatly detailed flat simply implies how well in detail can you illustrate your design requirements to the product development production departments. Black and white sketches can be easier to "read" and provide a clearer representation of designers' ideas. Thus, flats are usually composed of black lines, because it is easier for people to follow visual guidelines. Also, garment flat drawing is completely different from garment pattern making. Garment pattern makers make patterns using 3D or 2D methods according to body dimensions (Liu et al., 2016a, 2016b, 2016c, 2017c). However, flats are drawn based on garment proportions rather than body dimensions. Prototypes are measured by trained persons and tech packs are prepared accordingly, including flats. At present, there are two methods to draw garment flat: hand drawing and computer-aided drawing. Hand drawing requires sophisticated and artistic skills; while, computer-aided drawing requires analytical thinking and continuous comparison of the prototype to what is being drawn. It requires several hours for a designer to draw a complex garment flat.

Parametric product design involves the use of one or several key feature parameters to represent the whole product construction. Using this method, the product development efficiency improves significantly. At present, this technology is widely applied in the development of industrial products; for instance, mechanical products (Myung and Han, 2001), 3D human body models (Baek and Lee, 2012; Kim and Park, 2004; Koo et al., 2015; S. Park et al., 2015; Wang, 2005), garment patterns (Kim, 2012; Xiu et al., 2011), filigree jewelry (Stamati et al., 2011), 3D tire molds (Chu et al., 2006) and dies (Lin et al., 2008). However, there are few reports of studies on parametric design of garment flats. Ji et al. proposed a garment technical drawing system to obtain different flats by changing different parts of a garment flat (Ji et al., 2002). Xu et al. developed a web-based design support system (Xu et al., 2016). This system mainly consists of three parts: a sketch representation and composing method, a graphic user interface and a controller. Users can adjust several parameters through the internet to generate skirt flats rapidly and automatically. However, their research does not integrate human body dimensions into flat drawing. By integrating body dimensions into flat drawing and pattern making, the flat and its corresponding pattern have mutual affinity. Thus, using computer-aided design technology, the garment flat can be generated along with the generation of its corresponding garment pattern. To this end, a parametric method was proposed to draw garment flats rapidly. Parametric design belongs to the category of engineering design; however, garment flat drawing belongs to the category of artistic design. This artistic design knowledge should be translated into specific design rules; thus, this kind of knowledge can be read by computers. After this, computer graph technology can be applied to draw garment flat according to these specific design rules.

The acquisition of design rules requires two steps: knowledge extraction and knowledge expression. Two studies were carried out to obtain design knowledge: a questionnaire was used to collect knowledge of Jean style classifications from 20 fashion designers, and anthropometric measurements were generated from 3D scans for 120 women aged 20–25 years. These measurements were used to extract the knowledge of human body dimensions for drawing jean flats. After this, factor analysis, correlation analysis and regression analysis were applied to analyze the collected data. As linear models are the most common in garment pattern making (Xiu et al., 2011), while, the golden ratio is widely applied in the field of artistic design, data analysis results with these two techniques were integrated to represent the jean design knowledge. Finally, the jean design rules are expressed by parametric formulas. Based on these parametric formulas, a jean flat recommendation system was developed. The input items of the developed system are body dimensions' parameters and the jean style's parameters, for example, human stature and jean silhouette; while, the output item is jean flat. Using the developed system, jean flats can be generated rapidly and automatically.

The first aim of this research was to design garment flats rapidly and automatically to enhance design efficiency and reduce product development costs. The second one is to use engineering design to solve the problem in art design. This paper is organized as follows: the first part introduces our general scheme about parametric design of jean flats; the second part presents how to establish three geometric constraint parameters and three dimensional constraint parameters. The third part states how to use these six parameters to represent the whole jean flat by parametric formulas. The fourth part shows results of application and validation. The last part presents some conclusions and possible further works.

2. General scheme for parametric design of a jean flats

2.1. Novel design concept of jean flats

Garment flats focus on the tangible apparel or the actual garment which is to be produced. It is always about the actual garment, rather than a general idea of a garment. Flat drawing requires designers to have professional knowledge on fashion design, for example, aesthetics, ergonomics, and painting. Currently, there are two methods to draw garment flats. One is drawing by hand, which is called "manually drafted"; the other is the use of specially designed software that is called "computer aided drafting". Both types of technical drawing require a superior drawing skill. The current drawing methods of garment flat are time-consuming and inefficient. Thus, a novel drawing method was proposed to generate flats rapidly and automatically based on anthropometric measurements.

A garment flat's size has a close relationship with human body dimensions. As shown in Fig. 1, a jean flat's size (Jean waist height type is high and jean length is long) have one-to-one relationships with human body dimensions in the height direction. Meanwhile, the widest parts of jean cross sections are equal to the widths of the corresponding positions of the jean flats. And the real jean dimensions are equal to human body dimensions, plus ease allowances. Thus, the relationships between the dimensions of a jean flat and human body can be represented by mathematical formulas. In other words, a jean flat's size can be deduced from human body dimensions. By adjusting body dimensions, various jean flats can be generated. This is the basic idea of this research. The proposed method is completely different from the traditional method of manually drawing garment flats.

2.2. General schemes

The general scheme of the mentioned parametric design for jean flats is described in Fig. 2. Its basic steps are given below.

Firstly, constraint factors which influence the shape of a garment flat were analyzed. Results showed geometric constraint and dimensional constraint.

Secondly, two studies were carried out to establish which parameters impact the geometric constraint and dimensional constraint respectively. In the first study, a questionnaire was used to survey 20 fashion designers for obtaining knowledge of jean style classification. In the second study, 120 young females were measured to collect anthropometric data. The collected data were analyzed by factor and correlation analysis for acquiring key dimensional constraint parameters of the jean flats.