# Chapter 1

# Introduction

Cloths not only reflect a persons social status but also act as a medium of communication in peoples daily life(Barnard 2002). In general, modern cloth making process involves five steps(Margolis 1964), choose a style, measure the body of a customer, adjust cloth patterns, assemble patterns and final try-on. For bespoke clothing, each pattern is cut slightly larger than desired size, before final assembling, patterns will be loosely stitched together and put onto the customer to further trim off the excess to achieve better fit.

In fashion industry, cloth patterns are the feasible solution of a fashion design concept. It is constituted by a set of 2D outlines which are the breakdowns of a complete cloth design(Rosen 2004). Cloth design process are usually carried out on an ideal figure which is called standard body template. In order to produce textile pieces that can be assembled to form a cloth for a costumer, cloth patterns need to be adjusted to a particular size for the customer by an experienced tailor. Nowadays, cloth pattern is the most important medium in fashion industry. Almost all the cloth designs are preserved or distributed in the form of cloth patterns. Cloth pattern also provides an intuitive instruction for users to implement a cloth. Moreover, by altering certain parts of a cloth pattern, the cloth can be adjusted into any desired size for any wearer.

## 1.1 Fashion Design and Manufacturing

"Fashion design is the art of the application of design and aesthetics or natural beauty to clothing and accessories. Typically, fashion refers to the phenomenon of a regular pattern of change in the prevailing mode of dress."(Steele 2005). In this thesis, the term "Fashion Design" only refers to cloth design. Cloth making is the process that transfers design concept into wearable objects. The history of cloth making follows tightly with the evolution of human. It is not known when human started to wear cloth, but the evidence shows that man start wearing cloth from 170,000 years ago(Dunn 2012). In Ancient times, clothes are usually made of natural elements such as animal skins or furs, plant leaves, bones and shells that was draped or tied onto body. The appearance of textile during the late stone age in Middle East(Lynch et al. 1985) not only improved both comfort and functionality of cloth at that time but also enabled human to produce wearable materials by themselves. The discovery of bone needles which can be dated to 61,000 BP(Backwell et al. 2008) reveals the evidence of sewn textiles or leathers used to make cloth at that age.

During Middle Ages, cloth has already become a symbol of wealth and social status. Fashion was the privilege of upper class only, who can afford to hire private dressmaker to make cloth for them(Crane 2012).

Modern fashion that every one could enjoy was brought to general public by Rose Bertin, who was the dressmaker to Marie Antoinette(2 November 1755  16 October 1793), Queen of France. It is said that she was the first one who starts the transition from low public profile private dressmakers to a well-know fashion designers. The cloth shop she opened in Paris had a considerable influence on Parisian style(Steele 1998). In 1863, Ebenezer Butterick invented the first graded sewing pattern for cloth making (Hannah 1919; O'Loughlin 1899). Soon after his invention, cloth pattern became massively popular, as they made modern fashions much more easier to be accessed by the rapidly expanding lower middle class. This innovation provides a standard for fashion designs to be preserved and spread with much lower cost, moreover, it allows a design to be adapted to different human figures with ease.

The term "Fashion Design" is usually refers to the process of constructing the cloth design concept and producing the samples on the standard body template. Figure1.1 demonstrates a standard body template which is the ideal human body that has ideal body proportion.

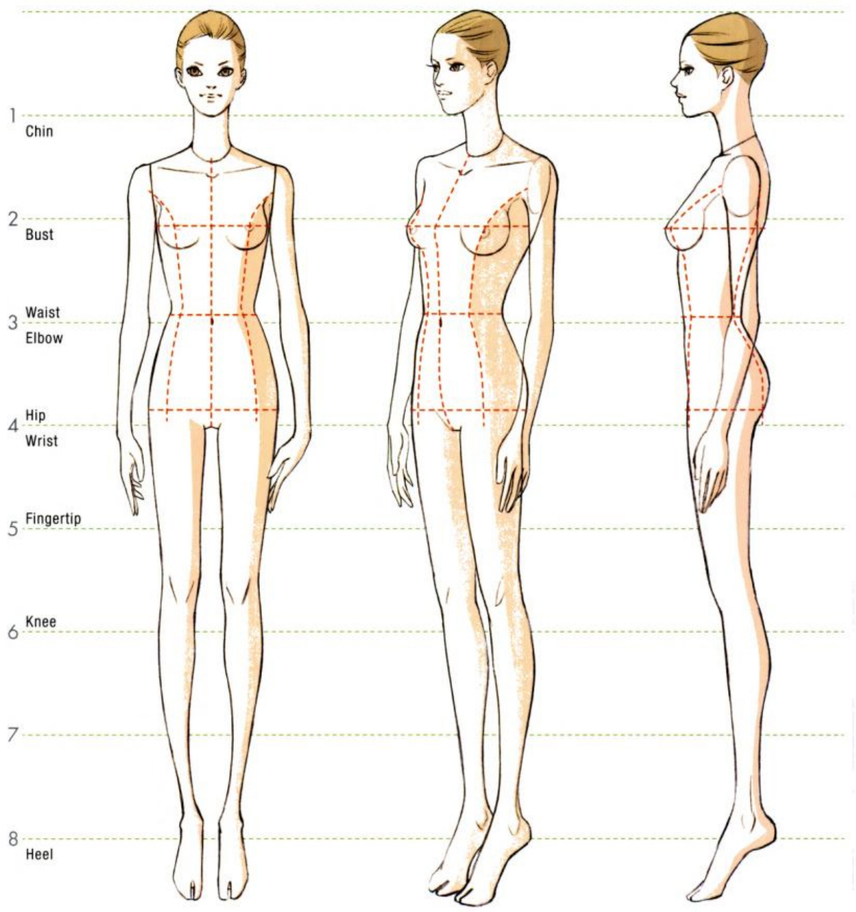


**Figure 1.1:** *Standard Body Template in fashion design(Rosen 2004)*

Modern fashion design process involves a five steps process to transfer a design idea into a wearable sample cloth (Stecker 1996) :

**Design Inspiration and Sketches**

Fashion designers constantly searching for the new idea to create new style. They record their inspiration of the new style by using rough and abstract sketches. Simple drawing allows more room for modifying and expressing their thoughts.

**Fabric Selection**

There are many types of textile materials with different method of interlacing and interloping fabric materials that provide different physical proprieties. Different types of textile materials also affect the appearance of cloth differently. Based on the type of cloth, designers select suitable textile materials for the design.

**Final Sketches**

By using standard body template, colours and details such as pockets, seam lines and other accessories are added onto the sketch. The final sketch is a detailed preview of the design worn by a model.

**Patternmaking**

Before patterns can be produced, fabrics are positioned or pinned on a dress form to reveal the structure of a garment design, this process is called “Draping”(Stecker 1996), it allows designer to visually exam the design on a human body. After the design has been draped, patternmaker decomposite draped cloth design and transfer it onto paper. Both cloth details such as seams, darts, cuttings and sewing instruction are indicated on the paper pattern.

**Samples and Flat Drawings**

After paper patterns are produced, they first pinned on top of the fabric for cutting and then removed allowing fabric pieces to be sewn together.

For design storage and distribution, both patterns and flat drawing are required. Flat drawing acts as a blueprint of a design which contains all the details for constructing clothes.

The aforementioned fashion design process involves many iterations of transferring design concept from 2D sketches to 3D draping, then back to 2D patterns. In other words, designers expresses their idea by 2D sketch, patternmaker reconstructs the 3D cloth structure in real world and decomposites the structure back to a set of 2D patterns. Finally, 3D sample cloth is produced based on 2D patterns. Often the resulting sample cloth reveals desired modification in the 3D form of the design that, in turn, the revisions of the 2D patterns also need to be carried out. Finally the new sample is created for further inspection. This iteration continues till the final sample is signed off by designer.

After cloth design process is completed, next step is to produce cloth for customers, and “Cloth Making” refers to the process of producing clothes based on cloth patterns. This process is aiming for producing clothes with certain sizes for actual customers and it is constituted by four steps:

**Measuring**

Different individual has different body shapes and proportions. In order to fit a cloth to a customer, body measurements need to be extracted. This step acquires measurements of the body parts that are associated with the cloth. Tape ruler is the most common tool for performing measuring on a customer.

**Pattern Grading**

Because cloth patterns and flat-drawing are developed on the standard body template, the size of each patterns need to be altered in order to fit a customer. Based on the measurements of customer, corresponding parts of patterns are adjusted to meet measurements.

**sewing**

After patterns are adjusted to desired size, fabric pieces are cut out slightly large than required size. Then patterns are stitched loosely to form the initial cloth.

**Try-on**

At this step, cloth is fitted to customer to further adjust the stitch and trim off the excess in order to achieve best fit. Finally, all the patterns are sewn together to form the final garment.

For the massively produced cloth, in order to make clothes that can be wore by general public, cloth patterns are scaled to several predefined sizes based on a size chart. Size chart contains body size data from a particular ethnic or group of people who shares the similar body proportion. The size chart various among different countries or areas, i.e. US Size Chart (ISO/TR-10652 1991), UK Size Chart (EN:13402 2001), Euro Size Chart (Ashdown 2007). Table1.2 illustrates converting rule between different size chart and major measurements used to define cloth size in a size chart.

| UK | USA | Europe | Bust | Waist | Hips |
|---|---|---|---|---|---|
| 8 | 4 | 34 | 31/32" - 79/81cm | 23/24" - 58/61cm | 33/34" - 84/86cm |
| 10 | 6 | 36 | 33/34" - 84/86cm | 25/26" - 64/66cm | 35/36" - 89/91cm |
| 12 | 8 | 38 | 35-36" - 89/91cm | 27/28" - 69/71cm | 37/38" - 94/96cm |
| 14 | 10 | 40 | 37/38" - 94/96cm | 29/30" - 74/76cm | 39/40" - 99/101cm |
| 16 | 12 | 42 | 39/40" - 99/101cm | 31/32" - 79/81cm | 41/42" - 104/106cm |
| 18 | 14 | 44 | 41/42" - 104/106cm | 33/34" - 84/86cm | 43/44" - 109/111cm |

**Figure 1.2:** *UK, US, Euro Size Chart convert table*

## 1.2 Virtual Clothing in Fashion Industry

Traditional fashion design and cloth making procedure are considered as highly skilled, labour intensive process that require many iterations to complete. Followed with the advancement of computer hardware and computer graphic techniques, constructing and evaluating cloth design in virtual environment instead of actually performing the cloth making process repetitively dramatically cuts down labour and time consummation required in traditional cloth design and cloth making process.

Virtual Clothing is the generic term of the process which constructs both visual effects and physical behaviours of textile objects(Volino & Thalmann 2000). It is the foundation of cloth CAD/CAM technologies which are widely used in fashion industry to assist the design of garment product. In terms of composition, cloth is constituted by a set of shape predetermined textile pieces which are assembled following a predefined order to cover a specific body area. The aim of virtual clothing techniques in fashion industry is to produce cloth patterns and evaluate cloth design effectively and efficiently.

In order to construct cloth in a virtual environment, two fundamental requirements need to be fulfilled, 2D cloth patterns from fashion designers and 3D virtual mannequins that are used for cloth assembling and 3D evaluation. In general, four steps are involved in the process of constructing virtual cloth, 2D cloth pattern generation, assembling 2D patterns to 3D cloth, 3D cloth simulation, comfort evaluation. The process of constructing virtual cloth generally follows the procedure of the making real cloth, however, because cloth patterns are created, edited, graded and pre-visualised in virtual environment, implementing cloth design into a real cloth for evaluation can be avoided, therefore, improve the efficiency and reduce the cost of fashion design.

There are various applications targeting to each stages of cloth design to improve the productivity of designers.

**2D Pattern Editing**

Computer aided cloth pattern design system such as Kaledo(Lectra 2014) and Cameo(Wid Ginger Software 2013) have been widely used in various fashion brands across the world. Traditionally, cloth patterns are usually made of paper boards cut out by patternmakers. In order to make cloth for different customers with different body shapes and proportions, the standard cloth patterns need to be adjusted into different sizes by experienced tailors based on the measurements of customer. With the help of cloth pattern CAD/CAM system, creating, editing and grading cloth patterns can be performed in virtual environment. Especially in large-scale cloth production, cloth pattern CAD/CAM methods not only save the materials but also provides an intuitive and convenience approach for cloth pattern manipulation.

**Cloth 3D visualization**

Cloth 3D visualization techniques generate 3D cloth object in virtual environment either based on 2D cloth patterns(Fontana et al. 2005; Marvelous 2014; Optitex 2014) or designer's sketches(Turquin et al. 2007). Traditionally, visualizing 2D cloth patterns requires the most iterations and labours in traditional fashion design process. Any changes on 3D form need to be amended on 2D patterns, and a new sample cloth needs to be produced in order to visualize the amendments. These iterations between 2D and 2D perspective consume materials and time. 3D visualization techniques eliminate these costs by creating and assembling cloth patterns in virtual environment. Cloth pattern can be edited and visualized without need of actually producing cloth from textile pieces, which saves both time, materials and labours.

**Virtual Try-on**

Virtual try on techniques enables designers to fit cloth onto avatars with different body shapes and proportions to review the appearance, fit and degree of comfort of clothes. It also allows customers to visually try clothes without walking into local shops. Different from aforementioned virtual clothing applications which focus at cloth design on the standard body template, this type of techniques usually involves body measurements acquisition from real customers, 3D body reconstruction, cloth modelling and cloth simulation. It provides the most intuitive visual experiences of a cloth design. Moreover, thanks to the advancement of 3D scanning techniques, the body shape and its measurements can be acquired automatically from customers. Combining with the 2D pattern editing techniques, fashion designers are able to produce custom made cloth with much higher efficiency and lower costs.

**Textile Engineering**

Textile is a type of complex structure materials which is made of fabric threads that are inter laced or looped together. Cloth simulation utilises physical models to describe mechanical and structural properties of textiles and provides an effective tool for textile engineers to create, simulate and analyse the dynamic properties of textiles constructed with various weaving techniques and materials.

## 1.3 Virtual Clothing in Computer Animation

Differ from virtual clothing techniques in fashion industry, virtual clothing techniques in computer animation mainly aim at producing realistic appearance of 3D cloth objects. In animation, apart from the character's body and facial expression, costumes also play a very important role in acting. It is the symbol of social statue and personality of characters.

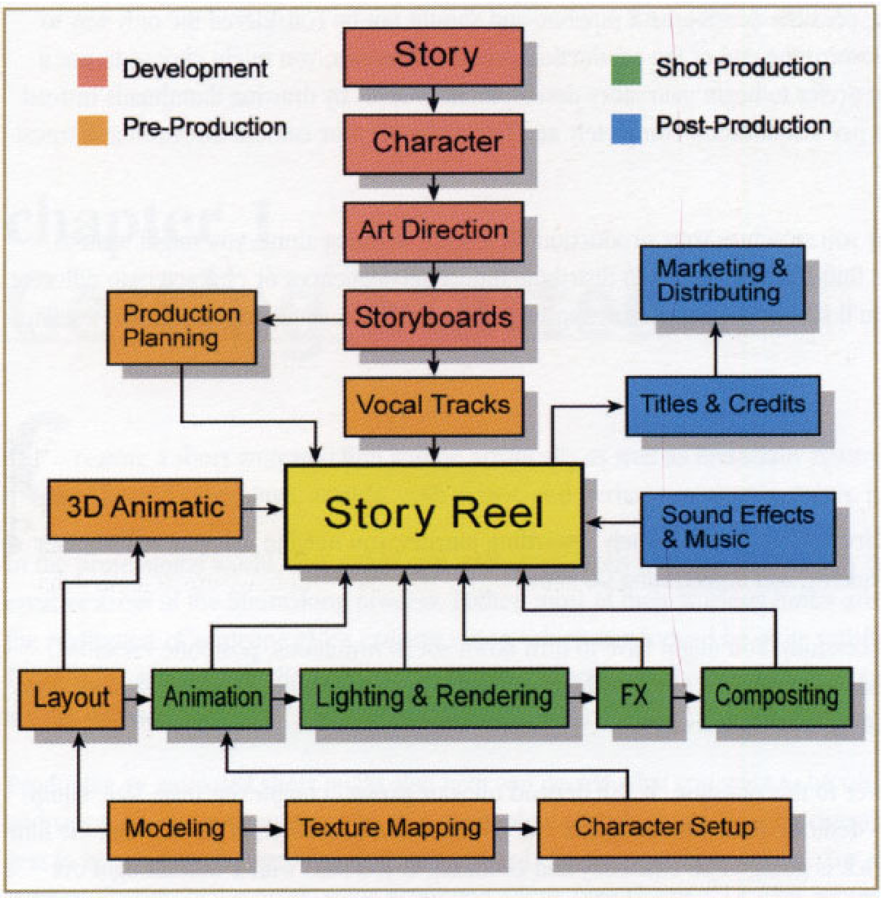


**Figure 1.3:** *Animation production pipeline(Chang 2014)*

Figure 1.3 demonstrates the production pipeline of animation film. The process of creating outfits starts from character( Character Design ) phase which is at very early stage of the development process. Outfits are designed together with characters. In the modelling stage, clothes are modelled after the completion of character modelling. At this point, animators utilise various modelling method to build 3D cloth. During character setup, deformers are assigned to character model to drive its movement. Depends on the requirement of the film, some clothes are driven by skeleton system. For realistic clothes, they are simulated by cloth simulation module. Therefore, based on the animation production pipeline, virtual clothing in computer animation is constituted by two parts, cloth modelling and cloth simulation

### 1.3.1 Cloth Modelling

Cloth modelling is the process of constructing geometrical shape of cloth in a virtual environment. Due to the vast variety of the character designs, the intuitiveness and controllability of cloth modelling method are crucial to animation artists. In computer animation, beside the pattern based cloth modelling method which is widely used in fashion industry, the most popular modelling method for cloth is general-purpose geometric modelling method due to its intuitiveness and ease of use. By using this method, cloth can be modelled same way as other objects are modelled such as character, building and vehicles. Without the need of tailoring knowledge, this type of method operates directly on the basic element of the geometrical representation of clothes, therefore, it gives the user maximum controllability throughout the modelling process and the appearance of 3D cloth can be viewed throughout the entire modelling process. However, the quality of cloth model depends on the artistic scenes of its modeller. Different modeller may produce different cloth from same cloth design. Moreover, because cloth is a soft object that follows the profile of character body, it cannot be dressed onto another character which has different body shapes and proportions without major modifications. In order to modify a cloth for a different character, heavy workload is required to perform such a process.

On the contrary, pattern based cloth modelling method operates on cloth patterns. Cloth patterns define the appearance of cloth, thus the consistency of the style of a cloth modelled different animators can be maintained. However, to form a 3D cloth from 2D cloth patterns requires expertises in tailoring and few animation artists possess such a skill. Moreover, in order to evaluate a cloth, the pattern assembling process need to be completed to form the 3D cloth and any modification that are required need to be executed on 2D cloth patterns which makes editing a cloth notoriously tedious due to the repetition of modelling process for modifying cloth patterns.

### 1.3.2 Cloth Simulation

Cloth simulation is the process of reproducing dynamic behaviours of cloth objects in a virtual environment. Based on methods used for driving deformation of a cloth, in general, there are two types of cloth simulation methods used in the computer animation.

Physical cloth simulation utilises a physical model such as mass-spring model or energy model to describe mechanical properties of a piece of cloth. By using the mechanical model developed from the real world, this method is able to reproduce realistic dynamic behaviours of clothing. However, because the detail of cloth deformation is determined by the number of the basic elements of the geometrical representation of cloth, this process requires large amount of computational power and time to generate fine detailed cloth deformation.

Hybrid cloth simulation methods utilise other types of deformation models such as data-driven method or geometrical modelling method to generate fine deformation details of cloth instead of performing high resolution physical simulation. The global deformation of cloth is usually generated by using coarse physical simulation. The efficiency of cloth simulation can be improved significantly by using hybrid cloth simulation method rather than performing physical simulation solely.

## 1.4 Motivation

In the past, the number of characters that can be handled in a virtual environment is limited by the computational power of hardware. In order to cope with this limitation, cloth of a virtual character is usually considered as a second layer skin of a character. Therefore, character and its cloth cannot be separated. However, because texture and dynamic properties of clothes are much differ from skins, the bound between the cloth and the character makes cloth simulation infeasible.

The latest advancement of computer hardware results an increase of the computational power. The physical simulation of cloth became possible. Although cloth can be modelled and simulated separately from character skin, the current methods for constructing cloth for virtual character still requires large amount of manual operations. In order to reuse a cloth to different characters, substantial amount of work need to be carried out. The duplication of effort cannot be eliminated when dressing different characters with different body shapes and proportions.

For virtual clothing in fashion industry, pattern based cloth modelling techniques are widely used . While in film and gaming industry, most artists still rely on the general-purpose modelling software packages such as Maya, Softimage, 3D Studio MAX to construct cloth for their characters.

In general, the workflow of pattern based cloth modelling technique consists of two steps, 2D pattern generation and pattern assembling. The first step correlates to the patternmaking process in real cloth production. Patternmaking in fashion industry is a highly skilled task, that only the well trained experts are able to master. However, few animation artists possess this skill which makes it difficult for animators to produce correct cloth pattern for a cloth. Moreover, body shapes and proportions varies largely among animation characters, and often, animation characters have very exaggerated body proportion which is far away from the normal human body proportion. In order to dress a character, cloth patterns need to be resized to cope with the body of character. In real world, this process is done by either professional patternmaker or experienced tailor. However, in computer animation, size chart used for resizing cloth pattern in fashion industry no longer applies to animation character.

During cloth modelling process, there are two key factors directly related to the appearance of a modelled cloth, the preservation of cloth design and the fitting of the cloth. In order to achieve these two objectives to improve the reusability of a modelled cloth, several techniques have been developed for modelling clothes for different characters with different body shapes and proportions, such as geometric morphing techniques (Ebert et al. 2006; SmithMicro 2012) and constrained optimization method (Brouet et al. 2012). For geometric morphing techniques, although it can fit clothes to different characters, but the design of cloth can be largely different from its original when topology of character models are largely different. Furthermore, Brouet et al. (2012) have proposed series of methods that directly operate the geometry of the 3D cloth on the new character in order to fit the cloth while maintaining the cloth design. However, the final 2D cloth design patterns need to be extracted by using surface flattening techniques(Sheffer et al. 2005). It not only requires an excess computation, but also the shape of the pattern can not be preserved from the surface flattening process.

With the fast development of computer power, more and more characters can be handled simultaneously. Modelling is a very labour intensive process in the film production pipeline.

The tediousness and unintuitiveness of current cloth modelling method have become the bottleneck of improving the reusablity of cloth models which further affect the cost of film production. Moreover, for pattern based cloth modelling method, the requirement of deep tailoring knowledge has become the largest Obstacle for applying it into animation production. The research presented in this thesis aims at providing an efficient and easy-to-use pattern based cloth modelling method for computer animation. By automating the process which requires tailoring knowledge in pattern based cloth modelling method, the large amount of cloth designs exist in the fashion industry will become usable for the construction of cloth for animation character. Also, by defining cloth shape in 2D cloth patterns, clothes can be stored and distributed with ease. Moreover, this method adjusts cloth pattern sizes and shapes based on the character body measurements, cloth designs can be reused and retargeted to different characters while maintaining its style.

## 1.5 Research Aims and Objectives

Although the geometric cloth modelling method provides lots of controllability to the animation artists, the quality and diversity of clothes is largely limited by the skill of animation artists. The current pattern based cloth modelling method requires many repetition for creating and editing 3D cloth. However, its ability of using a large amount of existing cloth design patterns in fashion industry and stores cloth design in a uniformed form which can be reused later is still a very attractive advantage to animation artists.

The research presented in this thesis focuses at bridging the gap between real cloth making techniques and cloth modelling method in computer animation to provide an easy-to-use and intuitive pattern based cloth modelling methods for animation production use allowing animation artists to directly use existing cloth design patterns in fashion industry.

This method includes several techniques: character body measuring method which utilises a novel fast geodesic algorithm to extract length measurements, a evolutionary cloth pattern adjustment framework for automatic cloth pattern adjusting and cloth pattern assembling method. Given a character model and 2D patterns of a cloth design from fashion industry, the method presented in this thesis is able to fit the cloth to any character while maintaining the original cloth design. Moreover, once cloth pattern is created, it can be used on different character with little manual operation. The objective of this thesis are to:

1. Review recent works on different virtual clothing techniques for both

fashion industry and animation production and analyse their advantages and disadvantages for modelling cloth for characters with different body shapes and proportions.

2. Develop an efficient measuring technique for characters regardless of their postures.

3. Develop a measuring technique for the point cloud character model to cope with the increasing number of 3D scanned character models.

4. Develop a technique to adjust each cloth pattern automatically based on the measurements and preserve the style of cloth.

## 1.6 Contributions

The cloth modelling method presented in this thesis consists of two major parts, character measuring and cloth pattern adjustment. For character measuring, a geodesic based measuring method has been developed for length measurements and convex-hull is used for measure the circumference of character. In order to improve the efficiency of geodesic calculation, a linear time complexity approximate geodesic algorithm is also proposed. For cloth pattern resizing, in order to cope with the vast shapes and proportions difference among animation characters, a pattern adjustment genetic algorithm have been developed. The contributions of this thesis are as follows

1. A detailed review of work covering traditional cloth making techniques, recent research progress on computer-aided cloth design, and existing cloth modelling and simulation techniques.

2. This thesis describes an automatic pattern based cloth modelling method which bridges the gap between traditional tailoring techniques and cloth modelling techniques in computer animation. This enables the usage of

a large amount of existing cloth design in fashion industry to animation artists.

3. This thesis also describes a geodesic curvature flow based geodesic scheme for the measurements extraction. This scheme consists of two algorithms, one with high measuring accuracy and the other incorporates a small bounded error into the geodesic calculation to achieve faster measurement with linear time complexity.

4. A pattern adjusting genetic algorithm is proposed. Considering the measurement, seam-line among the patterns as well as the shape of each pattern, the original design of cloth can be preserved through out the fitting process. This is the first attempt to utilize the genetic algorithm in 2D cloth pattern adjusting problem for dressing different characters.

## 1.7 Thesis Outline

The reminder of the thesis is organised as follow:

Chapter 2 reviews the techniques related to the research presented in this thesis. Firstly, the history of tailoring techniques are introduced. Secondly a brief introduction of the anthropometry is conducted which is the key element to gain the correct human body measurement data from character model. Thirdly, the related works in cloth modelling and cloth simulation are reviewed. Finally, the recent research achievements in geodesic calculation and genetic algorithm are reviewed.

Chapter 3 introduces character body measuring method which utilises convex-hull computation for circumference measurements and a geodesic computation scheme for length measurements. Two geodesic algorithms that have different measuring accuracy and efficiency are described in detail. Finally, experiments that validate the accuracy of geodesic computation and its efficiency are demonstrated. The comparison between the presented algorithms and two most popular geodesic algorithms are presented.

Chapter 4 introduces an automatic cloth modelling and re-targeting method. The main functionalities of this method are outlined. This method utilises the genetic algorithm to adjust each cloth pattern in order to fit a cloth onto a character. The design of this genetic algorithm is explained in detail. A pattern assembling method is also introduced here. Finally, the same cloth design is fitted on to different characters with largely different body sizes and proportions using this method and the results are discussed.

chapter 5 draws the conclusions and the future works are discussed.

# Bibliography


S. Ashdown (2007). *Sizing in Clothing*. Woodhead Publishing Series in Textiles. Elsevier Science.

L. Backwell, et al. (2008). 'Middle Stone Age bone tools from the Howiesons Poort layers, Sibudu Cave, South Africa'. *Journal of Archaeological Science* **35**(6):1566 – 1580.

M. Barnard (2002). *Fashion as Communication*. Routledge.

R. Brouet, et al. (2012). 'Design Preserving Garment Transfer'. *ACM Trans. Graph.* **31**(4):36:1–36:11.

A. Chang (2014). 'What Goes On Behind Those Closed Doors'. Website. http://http://www.media-freaks.com/articles/3d-animation-studios-what-goes-on-behind-those-closed-doors.

D. Crane (2012). *Fashion and Its Social Agendas: Class, Gender, and Identity in Clothing*. University of Chicago Press.

R. Dunn (2012). 'Of lice and men: a very intimate history'. *New Scientist* **216**(2889):36 – 39.

A. Ebert, et al. (2006). 'Rule-based Morphing Techniques for Interactive Clothing Catalogs'. In G.-P. Bonneau, T. Ertl, & G. Nielson (eds.), *Scientific Visualization: The Visual Extraction of Knowledge from Data*, Mathematics and Visualization, pp. 329–343. Springer Berlin Heidelberg.

EN:13402 (2001). *Size designation of clothes*.

M. Fontana, et al. (2005). '3D virtual apparel design for industrial applications'. *Computer-Aided Design* **37**(6):609 – 622. {CAD} Methods in Garment Design.

G. M. Hannah (1919). 'Dressmaker's Pattern Outfit'. US Patent No.1313496.

ISO/TR-10652 (1991). *Standard sizing systems for clothes*.

Lectra (2014). 'Kaledo'. Software. Lectra Inc.

T. F. Lynch, et al. (1985). 'Chronology of Guitarrero Cave, Peru'. *Science* **229**(4716):864–867.

A. Margolis (1964). *The complete book of tailoring*. Doubleday.

Marvelous (2014). 'Marvelous Designer'. Software. Marvelous Inc.

R. O'Loughlin (1899). 'Pattern for Garment'. US Patent No.632361.

optitex (2014). 'Optitex PDS 11'. Software. Optitex Inc.

S. Rosen (2004). *Patternmaking: a comprehensive reference for fashion design*. Pearson Custom Library: Fashion Series. Pearson Prentice Hall.

A. Sheffer, et al. (2005). 'ABF++: fast and robust angle based flattening'. *ACM TRANSACTIONS ON GRAPHICS* **24**:311–330.

SmithMicro (2012). 'Poser2012'. Software. SmithMicro Inc.

P. Stecker (1996). *The Fashion Design Manual*. Macmillan Education Australia.

V. Steele (1998). *Paris Fashion: A Cultural History*. Bloomsbury Academic.

V. Steele (2005). *Encyclopedia of clothing and fashion*. Scribner library of daily life. Charles Scribner's Sons.

E. Turquin, et al. (2007). 'A Sketch-Based Interface for Clothing Virtual Characters'. *IEEE Computer Graphics and Applications* **27**(1):72–81.

P. Volino & N. Thalmann (2000). *Virtual Clothing: Theory and Practice*. Springer-Verlag GmbH.

Wid Ginger Software (2013). 'Cameo v5'. Software. Wid Ginger Software Inc.