Study on Electronic Made to Measure

Xiujin Shi, Kuikui Liu, Jiajin Le
College of Computer Science & Technology
Donghua University
Shanghai, P.R. China

***Abstract*—Electronic Made to Measure (eMTM) is a new mode of clothing production, mainly obtains body size data through the three-dimensional human body measure. The paper describes a new method to extract human body size data from two photos and some sample human bodies, and then realizes a prototype system based on the Oracle database and Java, XML etc. and it shows the method that can meet the requirement of eMTM applications.**

Keywords—eMTM; clothing; victual human body; system design

I. INTRODUCTION

MTM (Made to Measure) tailored approach is a fully customer-centric way of clothing production, it combines anthropometry, style selection, size analysis, costume design etc, in order to achieve fast and efficient production of customized clothing[1]. Therefore, MTM can meet clothing fitness requirements, and it can meet not only the fitness requirements of the integral entity but also the fitness requirements of the individual entity. However, due to the fact that production process of each MTM system is relatively independent, there is no way to form a complete industrial production chain, and some parts are still in manual production stage. For example, in MTM one key step--- finding out differences of key parts between individual and the template, and adjusting the template manual , these processes rely on the operators' knowledge structure and work experience, so it limits MTM's industrial applications. Therefore, the industrialized production of MTM garment has now become an important issue to be addressed in digital garment industry development.

The emergence of three dimensional scanner used in garment production has made custom clothing possible by using digital computer technology. Electronic Made to Measure (eMTM) clothing is an emerging way of clothing production in 21st century. It uses modern three-dimensional body scanning technology, computer technology and network technology in the clothing production anthropometric, body analysis, style selection, costume design, clothing purchase, and it combines all aspects of clothing production to achieve fast and efficient digital clothing production chain. Acting as a new mode of clothing production eMTM has become the focus of research in the field of clothing production at home and abroad, and it will be an important direction of development in the future of digital clothing production.

This project has been supported by the Shanghai Science & Technology Committee of Defense, under contract number 045107026.

II. RESEARCH BACKGROUND

At present, more than twenty academies and a dozen large-scale clothing manufacturing enterprises have already participated in the research of eMTM system. The European textile clothing organization (EURATEX) proposed a plan that aims to achieve a new electronic commerce E-Tailor which uses 3D body scanner with modern network technology and clothing CAD technology to establish eMTM production [2]. Japan and America have already exploited their own eMTM system respectively too, and the systems have been applied in market for test. Such as Baird Menswear suit company of Britain, 80 percent of suits which are sold to internal and external market finished by eMTM system, and the clothing series contain thousands upon thousands combinations with different styles, color and specification. EMTM system is also used in mass-customization widely. In 2002, the American navy advanced "Navy Uniform Project". And this project utilizing eMTM system has succeeded in customizing altogether forty shapes of body for 40,000 soldiers [3].

In China, Tianjin Polytechnic University [4], Xi'an Engineering Science and Technology Institute [5], Sichuan University [6], Beijing Institute of Clothing Technology [7], Donghua University [8-9] and many other academies and institutions are researching eMTM system, and a number of prototype systems have been developed.

III. OUR RESEARCH

To meet the convenience application property of eMTM, the system provides many ways to generate personalized three-dimensional human body: one is using 3D scanner to scan the human body, reading the output data directly to generate a personalized three-dimensional human body; the other is changing the shape of standard body to be personalized three-dimensional human body model in accordance with customer's three-dimensional human body personal data. It is clear that the second approach must have a standard template of the human body. Through the United States $[TC]^2$ company 3D scanner, more than 900 women in east China were scanned and a series of human body samples data are collected. The shape of each sample data is analyzed by using genetic algorithm cluster analysis method [8] to obtain a series of human body parts templates. These templates covered eastern China female body shape characteristics, as a reference to generate three-dimensional human body.

A. *Extraction of Human Body Characteristics Information based on the Photos*

It needs customers providing personal human body characteristic information to generate themselves 3D human body when we use the human body template technology .The way of using photos is very convenient. Chinese Academy of Sciences Institute of Automation, Zhejiang University used 4 photos and 3 photos to give characteristic information, but there are strict and complex requirements of the shooting. After research, based on the four data: human body front and side pictures, vital statistics, and height, we can also obtain the characteristics of individual data. According to the digital image processed photos, extracting the body contour and combining the four data above, human body shape characteristics information can be obtained. The photo shooting is also very simple, and a normal camera can also work.

B. *Generation of Three-dimensional Human Body based on Components Assembly Technology*

Unlike other studies using the same standard human body template method, generation of a series of template is a more scientific approach. At the same time, the body of these templates is not viewed as a whole, the physical parts of the body are divided into the chest, waist, hip three sections, each composed of several sections, to generate a series of components template respectively. When generating three-dimensional human body character, suitable components are matched respectively according to customer's body shape characteristics data, and then on this basis change and regulate human body model according to the regulations. This method reduces the difficulty of amending the template, and the generated human body will be more in line with the customer's individual personality characteristics.

C. *The Storage of Three-dimensional Human Body Model*

The system uses X3D data format. It is a new standard developed by the Web3D organizations, and this standard inherits from VRML97 and combines XML, JAVA and other advanced technologies to make VRML file format more powerful, more efficient computing power for 3D rendering quality and transmission speed. Figure 1 is the generated three dimensional human body model X3D document fragment.

D. *XML based Human Body Data Exchange Format*

China has 1.3 billion people, 34 provinces and cities, when three-dimensional measurement of human body develop in these all cities, exchange standards and integration of the three-dimensional anthropometric data obtained from different measuring tools in different provinces is inevitable. It is important to promote standardization of data exchange applications in the initial stage of 3D anthropometric data development .It will be invaluable in development of eMTM garment and Chinese standard series (SizeChina). According to the relevant national standards in clothing and body measurement ,referring e-government documents exchange of the national standard-setting methods, we researched and formulated XML-based applications-oriented eMTM anthropometric data representation and exchange norms.

E. *Architecture based on J2EE Technology*

EMTM application is a web-based e-customized apparel production process, so in the design of application-oriented platform eMTM, J2EE architecture is selected to create a system platform, with good security, portability, scalability and reliability.

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE X3D PUBLIC "ISO//Web3D//DTD X3D 3.0//EN"   "http://www.web3d.org/specifications/x3d-3.0.dtd">
<X3D version="3.1" profile="Full">
 <head>
   <meta name="title" content="c:/test.x3d"/>
 </head>
 <Scene>
        <Shape >
                <PointSet  DEF="Torso">
                   <Coordinate  DEF="Torso_FACES01-COORD"  point="0.1219698 1.160076 -70.09375, 0.4945336
                </PointSet>
        </Shape>
        <Shape>
                <PointSet  DEF="RightArm">
                   <Coordinate  DEF="RightLeg_FACES01-COORD"  point="-14.96302 1.890583 -7.75, -13.47384
                </PointSet>
        </Shape>

        ..................

        <Shape>
                <PointSet  DEF="LeftLeg">
                   <Coordinate  DEF="RightArm_FACES01-COORD"  point="-16.14955 1.052403 -132.5188, -15.93895
                </PointSet>
        </Shape>
 </Scene>
</X3D>
```

Figure 1. X3D file segment for 3D human model

In the system design platform, database and other components are concentrated in the server-side. On client side only web browser is needed without having to install any other external components. Data and documents which customers need to make inquiries and analysis are from the same data source, thereby ensuring the timeliness of data and integrity. The system integrate middle-tier framework designed to meet the needs without too much cost and high availability, high reliability, and scalability of applications. By providing a unified development platform, J2EE multi-tier application reduce the cost and complexity of development and enhance the system's security mechanisms, improve the performance of the system.

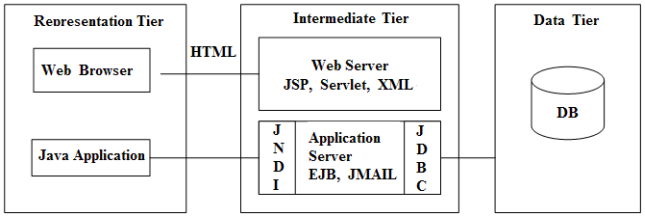

Figure 2. Logic structure of eMTM system

IV. EMTM PROTOTYPE SYSTEM DESIGN

A. *Logic Flow of the System*

In accordance with the objectives of the system, by referring the structure of the system eMTM proposed by EURATEX, the flow diagram design is shown in Figure 3 below. First of all, collecting a large number of the human body scan data, creating human body sample database based on the 3D data, then in connection with the characteristics of section of the human body conduct analysis of the shape of human body sample data collected, and then basing on the results of shape analysis generate a range of parts of human body clothing. Customers submit personal human body data (Such as photographs, 3D scanning documents etc) system will analyze and perform data modeling of the data provided by the customers, generate 3D human body model; on this basis

system will generate a prototype slip clothing, and it will provide very good support for costume design (such as three-dimensional apparel CAD), clothing production (such as clothing apparel prototype slip generation and draping), clothing sales (such as virtual clothing try). Three-dimensional apparel design CAD is based on anthropometric model. Through interactive three-dimensional design, on the human body model use the line outlined by the shape and structure of clothing line, and using the appropriate software to generate a model of 2D piece of clothing.

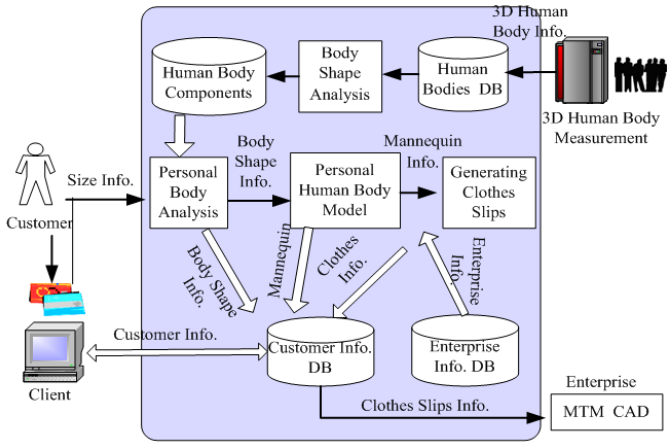

Figure 3. Logic flow of the system

B. System Architecture

The prototype system framework uses three-tier architecture: Database server stores system database, it provides data support to the application server; client side through web browser or smart card access the system running on the application server, in this way it gets the service it needs; and application server acts as a link between database and client, basically the whole system platform is meant to provide service to the client. It responds to client requests and through the access interface between it and database server gets the data which needs to be processed, processing the data and then sends the results to the client.

Of course on the perspective of eMTM, some high level customers can be given VIP card, customer in eMTM chain store can use card to link to eMTM system. Application server is deployed as the main engine to generate three-dimensional human body. Database management subsystem and smart card subsystem are also deployed on the application server.

C. System Function

Entire system platform integrates fore ground Web application subsystem, back ground database management subsystem, human body shape analysis and human body model generation engine subsystem and smart card application subsystem, as shown in Figure 4 below.

1) Web Application Subsystem

Web application subsystem provides user interface interaction between client and system, it provides customers with flexible and convenient user interface and encapsulates related algorithms, provides interface with other subsystems.

Through this platform customer can register and log into the system, and then apply for body shape analysis and upload personal body data to be analyzed, administrator audit customer's application, after the approval of application, client's body information will be sent to the human body shape analysis and modeling engine subsystem, then generate customer's personal body information, personalize clothing prototype information. Client can search and download this information.

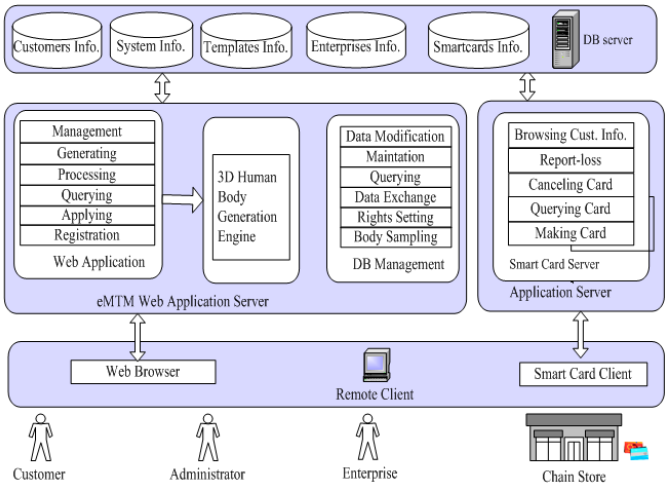

Figure 4. System function structure

Web application subsystem mainly includes client registration, application, search and administrator manages application, manage clients, generate prototype clothing slip etc.

2) Shape Analysis and Human Body Generation Engine Subsystem

Clients can choose to provide their own data files of three dimensional body scanning (VRML, ORD or X3D format), Anthropometric personal information (including measurements, height and photographs of two sides) or other system files for human data exchange, when the client submits personal body shape information to the system, it will execute appropriate processing according to different types of data sources. With three dimensional body scanning data files directly generated three dimensional human body model; The other two ways, system starts with photos or human data exchange document to extract human body characteristics information, then according to human body characteristics information, from the human body template library select the matching corresponding human body parts template, automatically modify these human body parts template according to the customer's body shape data, assemble the parts to generate personalized garment for human body model. These human body template are then stored in the database. Client can search and download this information through Web platform subsystem.

3) Database Management Subsystem

Database management subsystem is the background maintenance and management module for the entire system, its main function includes: all database information comprehensive inquires, backup and recovery, data

modification, permissions settings, data exchange, three dimensional human body data sampling etc.

Maintenance of all database table information in the database is done in this module, including data maintenance and data modification etc. At the same time user permissions is also done in this module. When eMTM system needs to exchange data with clothing enterprise CAD system or other related systems, database management subsystem can provide XML based data transmission.

4) Smart Card Application Subsystem

Smart card application subsystem is mainly made up of client side use of smart card and server side use of smart card.

Server side smart card application program deals with updating client's card to VIP card, its procedure is first to read clients information from the database (including name, age, identity and other major social attributes information and measurements, height, body type, such as human body parts characteristics information) and writes it into smart card, and takes information of the card and stores it into a smart card information table, and updates card number information in client's basic information table. It also includes smart card management operations.

Client side smart card application includes card reader and client side application program, card reader reads client's information from the card and displays it on the client side user interface, in way it links with eMTM chain clothing store and the system recommends to the customer the right clothing according to the customer body shape information provided. When the client needs more specific human body information or needs custom clothing, then client side application needs to connect to the eMTM remote platform system through internet..

V. PROTOTYPE SYSTEM IMPLEMENTATION

We have developed the prototype system under Windows environment by using Oracle 9i database standard edition, Apache Tomcat 4.1 and JDK1.5.0_06. We developed the engine of generating 3D human body by using MySql 4.0.18 database to store human body templates and Java 3D SDK to implement virtual human body modeling capabilities. Figure 5 shows personalized three dimensional human body model generate for the customer. Figure 6 shows obtained two dimensional prototype slips of clothes.

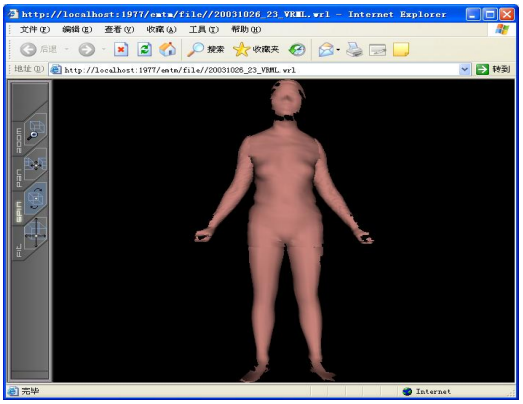

Figure 5. Personal 3D virtual human model

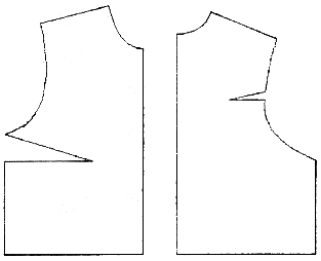

Figure 6. 2D prototype slips of clothes

VI. CONCLUSION

Experiments show that eMTM prototype system has a reasonable design scheme and right technical line. The research of this eMTM prototype system allows clients to provide their personal body information files using three different ways, and execute different processes to generate personal 3D virtual human model and lastly to generate prototype slips of clothes. Among these three ways, one way only needs two photos and several simple data to meet eMTM application diverse needs, easy to promote, while at present other researches in China only provide one way which is also comparatively complicated. This eMTM prototype system research through the collection of human body shape data form a series of three dimensional virtual human body template, the system based on these body parts template generate three dimensional virtual human body, and can also be used as basic in future research as standard No. in China clothing series - SizeChina.

ACKNOWLEDGMENT

Some graduated students have done much hard work in this project; they are Zhan Yujian, Zhang Zenglin, and Fan Qinling.

REFERENCES

[1] Z.Q. Wan, "Garment Production Managemnt", Shanghai, Chinese Textile Press, pp. 57－80, 2001.

[2] G. A. Kartsounis and N.Magnenat-Thalmann, "Euratex(2001-5),The European Textile/Clothing Industry on the eve of the New Millennium", Brussels, Euratex, 2001.

[3] http://buperscd.technology.navy.mil/bup_updt/upd_CD/BUPERS/Unireg/4.PDF

[4] M. Hu, Y. Li, and X.M. Zhang, "Feature□based 3D human modelling", Journal of Tianjin Polytechnic University, vol.21, pp.83-85, May 2003.

[5] L. Wu, X. Zhang, X.L. Ren, and Y. Li, "Study of parameterized mannequin based on 3-Dimensional body scanning", Journal of Xi'an University of Engineering Science and Technology, vol.19, pp.415-419, Apr. 2005.

[6] F.J. Meng, "Development of 3D Modeling System for Individualized Human Body", Sichuan University, 2005.

[7] B. Li, X.F. LI, and Z.D. Liu, "Development of Mannequins Based on 3D Point Cloud Data". Journal of Beijing Institute of Clothing, vol.28, pp.7-12, Jan. 2008.

[8] Z.L Zhang and X.P. Shi, "GA- based Algorithm Clustering Analysis in Body Analysis", Control & Automation, vol.22, pp.175-177, Nov. 2005.

[9] X.J. Shi, "The Design and Implementation of System Platform for Clothing Electronic Made to Measure", Donghua University, 2006