An Example-based Human Body Modeling Method for Virtual Try-on System

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Abstract—A new framework for modeling human body according to the specified measurement dimensions is presented. Users are assisted in automatically generating a virtual model through modifying the standard one by controlling the parameters provided. Our approach consists of four major parts. First, 3D scanner data is preprocessed and provides basic body parameters to standard body models. Second, the system builds a series of standard body models combined the previous parameters and commercial software Poser. Third, measures individual body. Finally, modeling synthesis is accomplished by standard body models and the individual parameters using degree 3 NURBS curve. we demonstrate the method about the example-based human body modeling. By modification a set of parameters, our approach may eventually lead to the automatic generation of a variety of human models. In comparison with the existing similar systems, our methodology is efficient and accurate, and adapt to be used in Virtual Try On system on Internet.

Keywords- Virtual Try-On, 3D scanner data, Human body modeling, Example-based approach

I. INTRODUCTION

With the rapid development of computer graphics and internet technologies, 3D virtual garment and interactive design have been the significant research in the garment CAD system. In the past few years, internet has emerged as a compelling channel for sale of apparel. In 2013, Apparel & Accessories ranked as the fastest growing e-commerce category, with a 41% increase versus 2012(ZDNet Research), exceeded the Computer Software (up 37%) and Home & Garden (up 33%). However, the opposite problems are still very conspicuous at the same time. Consumers who purchase apparel online today decide mostly on 2D photos of garments and size charts ,and then exchanging a purchase owing to unfitness or wrong size happen frequently. Recognizing the insufficiency of this customer experience, the e-commerce proprietors have begun to improve functionalities on their sites. Virtual Try On system can achieve this goal, and win customer's trust with an realistic feel for the details of garments.

The most common technologies in Virtual Try-On system is modeling human bodies. Some research about it has been successfully used in commercial sites abroad. Landsend.com(USA) uses My Virtual Model, which provides a virtual mannequin by customer's properties ,and besides save the model in database for the next time. Consumers can try on the selected garments by mouse action simply as far as satisfaction. In the same manner, Nordstrom is using 3D technology from California based 3Dshopping.com , which provides 360 degree viewing, enabling complete rotation of apparel item. Inland CAD system comparatively put most emphases on 2D pattern design in the past decade, and realizes the function of Replacing Textile in photograph merely. The visual contrast between Virtual Try On system(left) and the Replacing Textile function(right) is shown in Fig .1. From the diverse realistic behavior, we can find the model of body is important in virtual garment, which can facilitate people to make the decision in e-commerce.

Figure 1.Virtual try on system (left) vs. replacing textile function (right)

Unlike earlier anthropometric modelers, we directly make use of exist human body data. Arguably, the captured body geometry of real people provides the best available resource to model and estimate correlations between measurements and the shape.

In this work, we show how example-based techniques can be used to regulate the realism of the human body shape when building the body model that satisfy a number of measurements on various sizes.

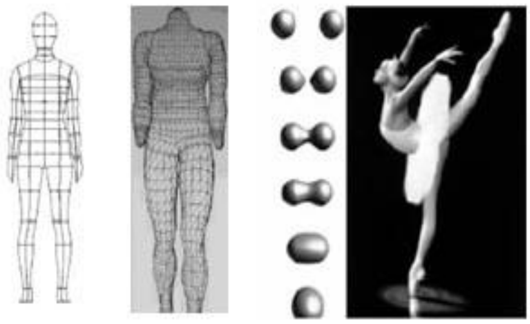
Based on statistical analysis of example models, we demonstrate the use of shape measures in controlling the global shape of the model. The benefits of such method have three advantages. First, a user can easily and rapidly control the result model by changing intuitive parameters. Second, very realistic geometries are produced. Finally, the generated models are readily usable in a visualization or simulation environment.

II. RELATED WORK

Wherever The problem of modeling human body is a central task of computer graphics. At this time ,a variety of human body modeling methodologies are available, that can be classified into creative and reconstructive approaches. Every approach almost can be subdivided again to wireframe model, surface model, entity model, and multi-ply model[1] ,as shown in Fig .2.

Anatomically-based modelers[2] can simulate underlying muscles, bones, and generalized tissue. They fall into the creative category of human modeling approaches. The interactive design is allowed in the anatomy-based modelers; however, these modelers require a relatively slow production time.

Lately, a lot of the reconstruction approaches has been investigated to build 3D geometry of human automatically by capturing existing shape [3]. As mentioned by Seo H and Magnenat-Thalmann N [4], the disadvantage of these techniques is that it is very difficult to automatically modify the reconstructed models to different shapes following the user intends.



(a) wireframe model (b) surface model (c) entity model

(d) multi-ply model

Figure 2. Four kinds of body model

Example-based techniques [4-6] are good alternatives to overcome this disadvantage, since they provide high-level control of the target model while maintaining the quality that exist in example models. Our modeling algorithm borrows some idea from the example-based shape modeling.

The overall system is illustrated in Fig .3, which largely comprises four steps. At the first step, we get original data from 3D range scanner, and then obtain body geometries parameters through the feature detection algorithm. After a lot of statistics work, we can provide step 2 generic human body feature information. We don't simulate complicated skeleton or skin as some previous researchers done, contrarily we use the model from commercial graphics packages Poser[7] in step 2. In step 3, we measure individual body by conventional tape or some advanced ways without contacting. Finally, we should accomplish synthesis model based on the previous standard bodies model and individual body geometries.

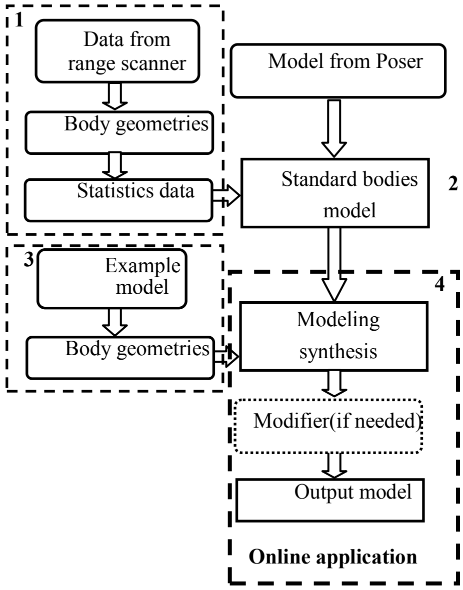


Figure 3. Overview of the proposed approach

In our example-based shape modeling, the computing time is greatly shortened as the standard models are utilized.

III. 3D SCANNER DATA AND EXTRACTION

Statistics data used in this paper were obtained from Tecmath scanner. Texture data was not available and is not within the scope of this work. All subjects are in an erect posture with arms and legs slightly apart, and are lightly clothed, which allowed us to carry out veracious measurements.

Arguably, the sizing parameters or anthropometric measurements allow the most complete control over the shape of the body but providing all measurements required to detail the model would be almost impractical. Here, eight body parameters (5 girths and 3 lengths) are chosen as sizing information. Supporting dozens of measurements is beyond the likelihood of Internet application. Instead, our application focuses on eight primary measurements, as described in table 1, that have been defined as the primary body measurements for product-independent size assignment. Using such a small measurement set not only provides compact parameters for the body geometry representation but also allows to be obtained easily by anyone, enabling applications such as an online clothing store, where a user is asked to enter his/her measurements for customized apparel design. Throughout this paper, we assume that these key measurements are provided as input.

In this section, we only introduce the extraction algorithm for oxter points and bust girth due to unemphatic content, and you can get more detail from correlative literatures[8].

TABLE I. ANTHROPOMETRIC SEMANTIC DESCRIPTION

Body measurement	Definition
Stature(L1)	Vertical distance between the crown of the head and the ground
Crotch length(L2)	The vertical distance between the crotch level at center of body and the ground
Arm length(L3)	The distance from the armscye shoulder line intersection over the elbow to the far end of the prominent wrist bone in line with small finger
Neck girth(G1)	The girth of the neck-base
Bust girth(G2)	Maximum circumference of the trunk measured at best height
Under-bust girth(G3)	Horizontal girth of the body immediately below the breasts
Waist girth(G4)	Horizontal girth at waist height
Hip girth(G5)	Horizontal girth of the trunk measured at hip height

A. Oxter points

1. Setting δ (a small real number)as step, choose horizontal section of trunk from head to feet direction, and P_s is the intersection of surface and the section, $P_s = \{P_s \mid |y(P) - (y(S_m) + 0.862Height)| < \delta\}$.
2. Seek the depressed points at the (i)th horizontal section，and mark with $P_{i-R-flex}$， $P_{i-L-flex}$.
3. Seek the depressed points at the (i+1)th horizontal section，and mark with $P_{i+1-R-flex}, P_{i+1-L-flex}$.
4. If $\{P_{i-L-flex} \mid D(P_{i-L-flex}, P_{i(j+0)-L-flex}) < \delta$ and $D(P_{i+1-L-flex}, P_{(i+1)(j+0)-L-flex}) > \delta\}$ is true, then sets $P_{i-L-flex}$ as the Oxter point of left ,and mark with Po_{LA}.
5. Uniformity, if $\{P_{i-R-flex} \mid D(P_{i-R-flex}, P_{i(j+0)-R-flex}) < \delta$ and $D(P_{i+1-R-flex}, P_{(i+1)(j+0)-R-flex}) > \delta\}$ is true, then set $P_{i-R-flex}$ as the Oxter point of right ,and mark with Po_{RA}..

B. Bust girth

1. Setting upper limit of seek range is the cross section including points Po_{LA} , Po_{RA} ,and lower one is waist. We mark this range with S_t .Set δ as step length, and chooses horizontal section in S_t from upper limit to lower one.
2. Calculate the different girths of close section in defined range S_t, mark with G_i.
3. If $G = Max(G_i)$,, G is the bust girth we needed.

IV. STANDARD BODIES MODEL

The difficulty in modeling bodies comes from the inherent complexity of skin and muscles, as well as variety of appearances among different individuals. While there are now available a number of ways to easily obtaining character surface models from the commercial graphics packages such as Poser, implanting the skeleton structure and defining appropriate skinning data, which facilitate the Virtual Try On system to accomplish an lively model efficiently.

In this section, our methodology builds on a series of standard body models that have been designed primarily for real-time applications. These models obtain all structural components, such as bones and skin from Poser, and should be adjust local feature by statistics data coming from 3D scanner. Based on adding details or features to an existing generic model, such approach concerns mainly the individualized shape and visual realism using high quality textures. We propose the creation of five standard models for each sex: Extra Small, Small, Medium, Large, Extra Large (plus some special model).

V. INDIVIDUAL BODY MEASUREMENT

The three-dimensional anthropometric data can be obtained by two major methods, one of which is direct and the other is indirect. The direct method measures body using ruler or gauge while the indirect method is photo measurement[9] or laser-scanner[10]. In this study, for the convenience of the experiment, we adopt the direct measurement method using a conventional tape measure. People usually should provide 8-12 parameters including length and girth to adjust the standard body models, and then she would view the virtual model of herself.

VI. MODELING SYNTHESIS

Once the system is provided with standard body models prepared in Section 4 and individual parameters provided in Section 5 , we can do following synthesis work for each component of the body vector through interpolation. Practically, there are so many methods can be used to accomplish interpolation, however we choose NURBS curve due to flexibility and accuracy.

First, we calculate Q_k according to the formula

$$Q_k = \sum_{i=1}^{m} W_i (l_i - L_i)^2 + \sum_{j=1}^{n} W_j (g_j - G_j)^2 ,\ k \in [1,6]$$

W_i , W_j are the weights of different body parameters, L_i, G_i are length and girth of standard body models, and l_i, g_i are opposite ones of individual body. In the proposed approach $m = 3, n = 5$.

Second we choose $Q = Min(Q_k)$, and select the opposite standard body model as the basic model.

Third, modify basic model according to the individual parameters using NURBS curve. NURBS curve (Non-Uniform Rational B-Splines) , is mathematical representations of 3-D geometry that can accurately describe any shape from a simple 2-D line, curve to the most complex 3-D organic free-form surface. Because of its advantages, NURBS models can be used in any process from illustration and animation to virtual modeling .The define of degree 3 NURBS curve is:

$$C(u) = \frac{\sum_{i=0}^{n} W_j P_j N_{j,3}(u)}{\sum_{i=0}^{n} W_j N_{j,3}(u)}, (0 \le u \le 1)$$

In this formula, P_j is the control point. One of easiest ways to change the shape of a NURBS curve is to move its control points. $N_{j,3}(u)$ is the basis function of degree 3 NURBS curve. W_j is the weight of P_j.

Here we use NURBS curve to adjust the surface model of female bust, and actually other part of human body also can use it. We split this work into two steps: curve 1 describes the feature of bust surface lengthways, and curve 1 describes the feature of bust surface breadthways. We set $P_{(i,j)}$ as the point of body surface, and assume the world coordinates x,y of $P_{(i,j)}$ are invariables, however z should be controlled by two curves as Fig .4. We segment both curves into 20 parts, and get the intersection using the formula of degree 3 NURBS curve. These intersections will influence the points $P_{(i,j)}$,and we mark these new ones as $P'_{(i,j)}$. Set difference $d_x = P'_{(i,j)x} - P_{(i,j)x}$,and ratio $r_v = \frac{d_x}{\max(d_{x0}, d_{x1}, ... d_{x20})}$. In the same way ,we can get r_h ,which describes the change in coordinates y . Now coordinates z we needed can be calculated by $P'_{(i,j)z} = P_{(i,j)z} + Vertical \cdot r_v - Horizontal \cdot (1 - r_h) \cdot r_v$. Here *Vertical, Horizontal* is the control weights of curve 1 and curve 2 ,which can be modified by user. Fig .4 is the mesh model for simulation.

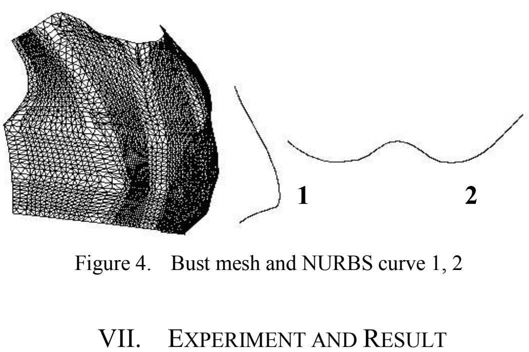


Figure 4. Bust mesh and NURBS curve 1, 2

VII. EXPERIMENT AND RESULT

We have used the proposed model method to produce variously sized human body models. The system runs on a PC with Windows7 environment. With a set of measurements input listed in table 2, Fig .5 shows these models after translation with method.

In order to reduce the computation time as much as possible at runtime, the example model size was implemented using a pre-calculated lookup table. The evaluation upon receiving the user input parameters takes less than five seconds on a 2.5GHz Intel(R) Core(TM)i5-2450M CPU with 4G memory. So the synthesized models are immediately controllable using motion sequence.

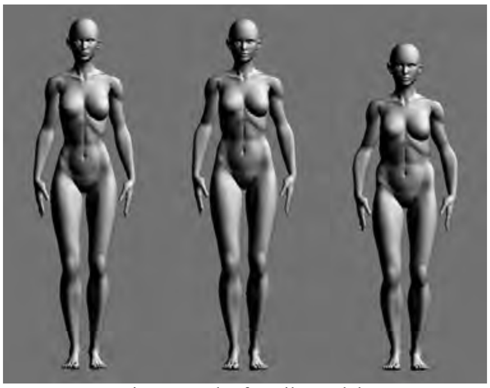


Figure 5. The femails models

TABLE II. MEASUREMENTS PARAMETERS

Parameter	Left	Middle	Right
Stature	161	161	155
Waist girth	51	55	60
Back length	34	30	30
Bust girth	78	78	85
Hip girth	85	85	90
Neck girth	34	34	34
Whole shoulder length	33	38	40
Half shoulder length	12	15	21
Front length	24	28	29
Back length	23	27	28

VIII. CONCLUSION AND DISCUSSION

We have described a new framework to generate example-base whole human bodies according to the specified measurement. Our contributions include: (1) the example-based parameterization approach of human bodies from the unorganized scanning points and commercial software Poser (2)the modeling synthesis method is standard model-matching in advance and modification by 2 degree 3 NURBS curve again. The constructed and synthesized body models by our approach are example-based, so not only feature nodes and curves but also feature patches are modeled. These feature entities give great benefits to the successive design automation of customized clothes in the next step.

There is one hidden assumption during the feature point extraction, the posture of the scanned human body is similar. If the posture is quite different, the feature extraction method may give incorrect resultant points that will lead to the failure of body parameters. In this case, a possible future work is to employ a more robust feature extraction algorithm for the key feature points.

Our parametric design algorithm is example-based, so if the specified dimensions are out of range ,the resultant synthesized human body will just be an approximation of the given sizing parameters; in other words, cannot achieve the exact given dimensions. In this case, one possible future work is to build more standard body models in database, especially unnatural ones for the special people ,and further modify the feature curves to satisfy the given dimensions.

Finally, another research possibility is related to the input. Current input of the human construction approach presented is conventional tape measure. Photo is another convenience input for constructing a three-dimensional model of a human body. Therefore, we are going to develop a new method of human model construction by this input.

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