From 2D Photos of Yourself to Virtual Try-On Dress on the Web

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This paper describes a complete methodology for cloning and dressing people by using a website. The input is simple photographs or body measurements that anybody can produce in any environment. Then the web-based virtual-try-on allows users to see them dressed. The basic methodology uses a pre-calculated generic database to produce personally sized bodies and animate garments on a web application.

Keywords: made to measure, generic database, body cloning, generic garment, Internet Web, virtual try-on, 3D clothing.

1   Introduction

The Internet along with the rapidly growing power of computing has emerged as a compelling channel for sale of garment products. A number of initiatives have arisen recently across the world, evolving around the concepts of Made-to-Measure manufacturing and shopping via the Internet. The combination of these new services is now possible by the emergence of technologies, systems and practices, such as 3D whole body scanners, automatic body measurement, the customisation of existing styles and Virtual-Try-On visualization techniques.

However, high product return rates persist, and most consumers are still either hesitant to purchase garments online or are unsatisfied with their online shopping experience (Beck, 2000). A number of recent studies identified the causes for consumer hesitancy, and of particular notes are the consumer's overwhelming concern with fit and correct sizing, and the inability to try on items. Following a survey by the French company Lectra (Lectra, 2000), an estimated 30% of online garment purchases are sent back by consumers.

Consumers that purchase garments online today base their purchase and size-selection decisions mostly on 2D photos of garments and sizing charts. This method is not precise enough and not interactive enough to provide right sizing as well as right choice to the consumer.

In this paper, we present the first link between human cloning and clothing on the web. We enable people to visualize themselves wearing a variety of garments at home via the Internet. Thanks to this technology, we can virtually try on several styles of garment depending on our preference and dimensions, and produce from our 3D garment the corresponding 2D patterns to send to the manufacturer. The main idea is to use both a generic body and generic garment database. An automatic fitting process of the 3D garment to the cloned 3D body and back to the 2D patterns is discussed. The methodology is based on five parts:

Photo-cloned body with acceptable level of accuracy: The clothing simulation is based on existing software used to dress and animate virtual mannequins. The important issue for the photo-cloned body is the ability for the consumer to try on the garments and to check the fit.

Even though the photographs are easy to input, it is faster or often preferable to directly give body dimensions. We propose another personalized body creation with the measurements input on the web interface.

Online cloth fitting and simulation: We give a methodology to fit the garments and dress the customer's 3D model with them. Physical simulation for cloth is not appropriate as calculation time is critical for the web application. Our approach is to use a database of pre-computed garment animations, which are then automatically fitted to the personally sized body.

Output of 2D patterns for manufacturing: By extracting the measurement data from the fitted garments, the corresponding 2D patterns are created and can be sent to manufacturers.

Online web interface module: A virtual showroom is provided for the user to try on the garments. A window displays the animation of her/his body walking with the garments.

Fig.1 shows the overall flow about our integrated methodology for the individualized garment try-on on the web. In Section 2, we describe our pre-processing of the generic database, which is the basic idea for the web-based approach. The photo cloning of bodies is described in Section 3. Section 4 is devoted to the creation of personally sized bodies based on user-input measurements. Then Section 5 explains how a made-to-measure garment can be constructed. The animation of the personalized garments is also explained. Section 6 describes the web interface with examples to show how the consumer can use the application. The possible manufacturing idea for the made-to-measure garment is described in Section 7. The main point for the manufacturing is how to create 2D patterns back from the 3D personalized garment. Finally, conclusion and future research is discussed.
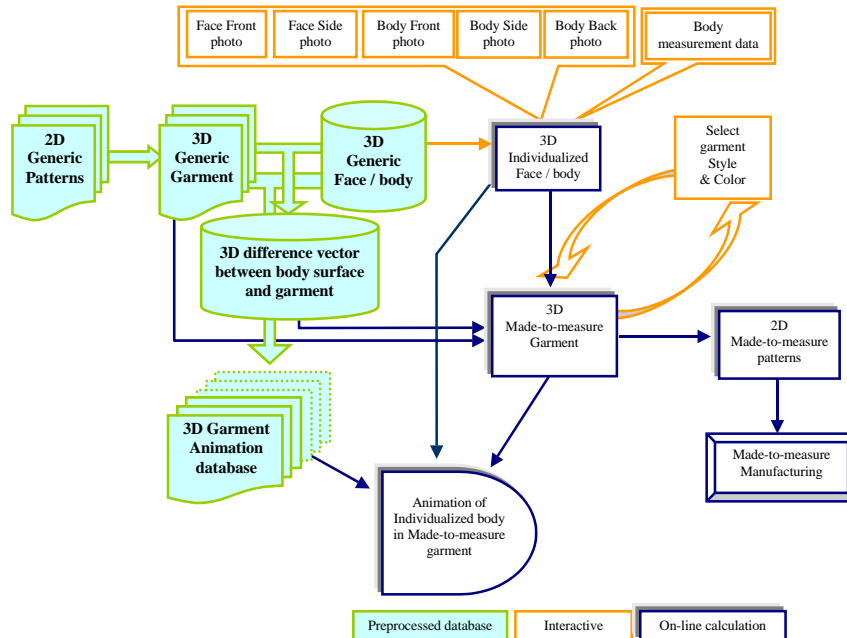
Fig1. Virtual-try-on overview with cloned body and made-to-measure garment

2   Generic database: bodies and garments

The most important idea for our approach is to use a pre-calculated generic database for bodies and garments and adapt them to the personal data (photos or measurement data). For the web application, fast calculation is a critical issue. Our method requires as much pre-calculation as possible for the generic database and then minimize the calculation to make the given generic data to be personalized. We discuss how to prepare the generic body and garment database for several styles.

2.1   *Generic body and animation*

There are numerous possible methods to make a personalized virtual human for the face (Akimoto et al., 1993) (Blanz et al., 1999) (DeCarlo et al., 1996) (DeCarlo et al., 1998) (Escher et al., 1997) (Fua et al., 1996) (Guenter et al., 1998) (Ip et al., 1996) (Kurihara et al., 1991) (Lee et al., 2000) (Lee et al., 1995) (Nagel et al., 1998) (Pighin et al., 1998) (Proesmans et al., 1997) (Saji et al., 2000) and the body (Addleman, 1997) (Gu et al., 1998) (Hilton et al., 1999) (Kakadiaris et al., 1995 & 1996) (Plänkers et al., 1999) (Zheng, 1994). Here we discuss the creation of the face, body skeleton and body surface. The most popular methods used for both body constructions and animations are to use generic models. The generic model can be one, several or numerous (Blanz et al., 1999) to be adapted to the personal shape and texture. The main advantage of using generic models is that we can give

necessary information as a pre-processing and the on-line calculation can be done quickly and it gives the animation information automatically. The basic idea is to consider an avatar as a combined set of data, including the 3D shape and the structure to animate it. The human modelling approach starts from default virtual human templates, including shape and animation structures, and modifies the shape to create a new virtual actor described in Section 3. More detail about the seamless generic body can be found in other texts (H-anim, 2000) and (Lee et al., 2000).

For the generic body animation, we apply a walking motion obtained from the VICON^{TM} motion capture system. Six cameras with the sample rate of 120Hz are used along with 25mm markers.

- Several steps are involved in obtaining the animation for the body:
- Obtain a skeleton and its animation data from marker positions.
- Modify the posture of the skeleton together with the skin to locate them properly.
- Convert the original motion data to the new skeleton.
- Attach the skin to the skeleton.
- Perform animation with skin deformation.

After performing all steps necessary, we have a generic body with seamless surface and real-time skin deformation capacity whenever skeleton joints are animated with given animation parameters.

2.2 Generic 3D garment using 2D patterns and simulation

As described in (Volino et al., 2000), we use a similar approach for garment reconstruction and animation on a moving body surface. The garment is made from 2D patterns of garment surfaces. The approach for garment simulation that is going to be used takes its inspiration from the traditional garment industry, where garments are created from two-dimensional patterns and then seamed together. A 3D garment simulator includes the mechanical model, collision engine, rendering and animation. The patterns need then to be discretized into a triangular mesh. Once the patterns have been placed around the body, a mechanical simulation is invoked to make the patterns come together along the seaming lines. Consequently, the patterns are attached and seamed, obtaining the shape influenced by the body shape. The mechanical simulation gives the animation of the garment on the body, accounting for the collision response and friction with the body surface. The final visual look of the garment is displayed through its material properties i.e. colours, shininess, and texture which are some of the rendering parameters. Geometrical complexity is another very important consideration, as the rendering time as well as the computation time for the animations is directly proportional to the number of polygons to be displayed.

Here we discuss the generic 3D garment using generic 2D patterns that define the style (Fig. 2). We perform calculation of the generic garment fitting to our generic body and build a database according to the style such as trousers, skirts, pullovers, one-piece dresses, etc.

The garment animation is calculated on a moving generic body with given skeleton animation sequences. For each time frame, we save the garment surface information, which is used later in Section 4 to get Made-to-Measure garment simulation for the online calculation.
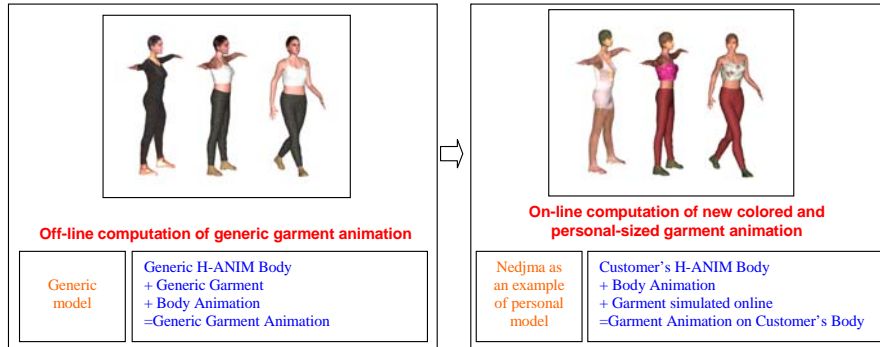

Fig2. Individual chooses the garment style and colour and then the personalized avatar model wears the garment and animation follows.

3   Cloning yourself

It is our goal to develop a technique that enables an easy acquisition of the personalized avatar model with acceptable accuracy to be produced at a low cost and properly animated. Many possible methods can acquire input data for modelling from a high-end laser scanner to low-end still photographs. Each of them has its advantages and disadvantages. In our method, we use photographs as input: front and side views for the face and front, side and back views for the body.

Our method is a feature-based modelling of animatable human body. With the generic model described in section 2.1, we modify the shape and skin colour to be adapted to given photographs. Shape modifications are transmitted to the attached animation structures in order to keep the set of data consistent. We obtain a "ready to animate" virtual human as the output of the modelling process. Our approach optimizes the modelling of virtual humans in order to animate him/her. Feature based approach is useful to provide easy input in robust way and to take the animation structure while the shape resembles the input shape.

The methodology is composed of two major components: face-cloning and body-cloning. The outline of the human cloning is shown in

Fig3. Detailed information for the face cloning can be found in other papers (Akimoto et al., 1993) (Ip et al., 1996) (Kurihara et al., 1991) (Pighin et al., 1998). The body-cloning component uses feature point specification, which enables automatic silhouette detection of the body with an arbitrary background, and then a body modification by using feature points and body silhouette respectively. The final integrated human model with cloned face and body together has photograph-realistic H-Anim humanoid.
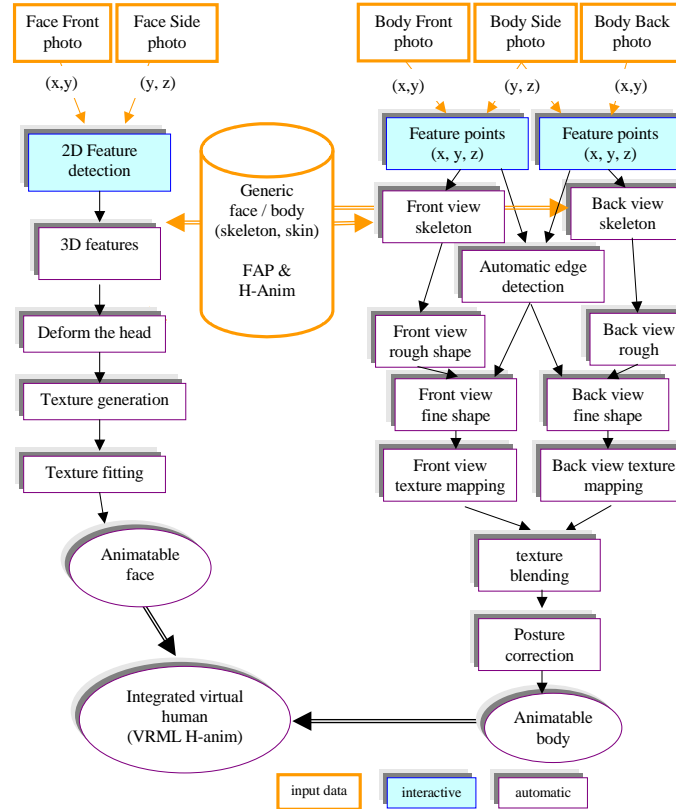
Fig3. Face and body cloning outline

Even though the input data is limited to only three photographs for the body, the error is acceptable. This will be discussed in the following section.

We validate the result of the body cloning in two ways. First, we compare laser-scanned data and photo-cloned data in 3D. The laser-scanned data provide three input photographs (front, side, and back views) for the photo-cloning and the output 3D data from photo-cloning and the laser-scanned 3D data are compared using 3D error measurement. Second, we use tailor's measurements with a real-person. We measure several body parts of the person and the photo-cloned body is measured for the same body parts for the comparison. Fig4 shows two examples of people used for the photo-cloning. "Nedjma" is much taller than "Sabrina" and Sabrina is thinner.

(a) Nedjma

(b) Sabrina

Fig4. Cloning examples with five photographs

4   Body creation based on measurements

Sometimes people are not able to or not willing to provide their photos for the body cloning. In this case, we allow the user to input their key measurement data and create a virtual human of these measurements. Based on modification of the generic body model by deforming several parts of the body, the system is composed of several modules working in a pipeline.

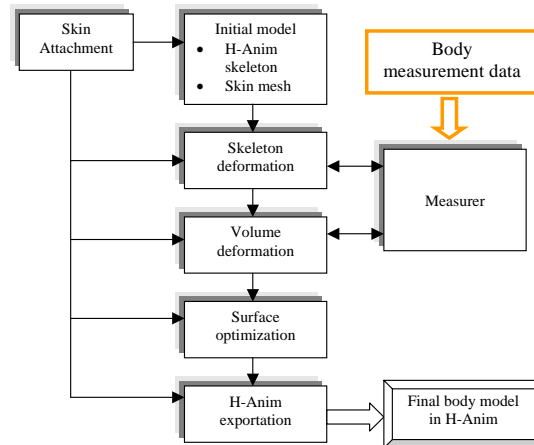Fig5 gives an overview of the pipeline.

Fig5. Overview of the body creation process

4.1   Body model

Our generic body model is composed of a skin mesh and a skeleton. The skeleton hierarchy we have chosen to use is the H-Anim Level of Articulation (LoA) 2 one (Hanim, 2000) as is the case with the photo-cloning (Section 3).

4.2   Adjusting the limbs

The idea of adjusting the limb lengths and volumes is to firstly define the dependency of the skin part to the skeleton or attach the skin part to the skeleton and then apply the necessary transformation on the bone to derive the natural

deformation on the corresponding skin part. The height, the length of the legs and arms fall into this category.

The attachment is considered as assigning for each vertex of the mesh its affecting bones and corresponding weights (Fig.6). To say that a vertex is "weighted" with respect to a bone means that the vertex will move as the bone is rotated in order to stay aligned with it. At 100 percent weighting, for instance, the vertex follows the bone rigidly. This method combines for each vertex the transformation matrix of the bones in accordance to their weight.
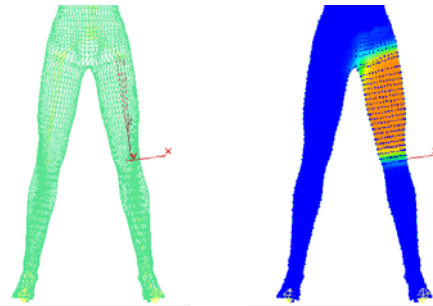

Fig6. Skin attachment. The 'l_hip' bone (left) and the skin part that are attached to it or affected by the bone (right)

Fig 10 (d) shows the modification of the limb volume and length we obtained by skeletal deformation. Given the desired measurement value $T_{desired}$ and the current measurement value $T_{current}$, a scale transformation $s = \dfrac{T_{desired}}{T_{current}}$ will be applied to the corresponding bone to get the desired measurement on the body.

4.3   Adjusting the volumes of body parts

For some parts of the body that concern the volume measurements, deformation means more than the simple transformation of associated bones. Breast or chest, abdomen and hips are such examples.

As the generic model is based on characteristic lines or contours and thus naturally forms a regular grid, we use parametric curves to smoothly deform these parts locally. The deformation in this case takes place in two directions: one along the vertical direction and the other along the horizontal one. Fig.7 shows an example of the deformation of breast region of the mesh.

Along the vertical lines, 6 points are sensibly selected as the B-spline control points. The first and last points are fixed in order not to create discontinuities on the surface. The second and the fifth points as well are just present to give a regular aspect to the surface, i.e. a curve that grows gradually. The third and the fourth points undergo a translation of factor F, as shown in Fig.8. All the other points in the line are sampled using the Boor Cox algorithm (Foley et al., 1995)
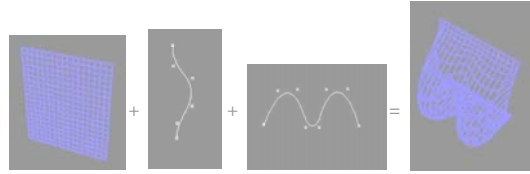
Fig7. The deformation on the breast

Along the horizontal direction, the points should be located in such a way that it preserves the shape of the breast. The translations of the control points form a function f, whose evolution takes the shape of the breast as shown in Fig.8 (b). In other words, the value of the factor F is dependent on the column to which the deformation is applied, multiplied by the degree of displacement desired by the user. Whenever the user increases or decreases the size via the user interface, the resulting measurement values are shown. Fig. 10 (a) illustrates some of the results we obtained.
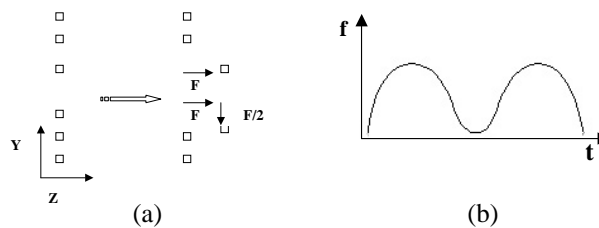

Fig8. (a) Translation of control points along the vertical direction. (b) Function of displacement factor along the horizontal direction

The abdomen region is deformed similarly except that we use Bézier curve in this case. The displacement factor along the horizontal direction in this case takes the form of the abdomen. The resulting modified shapes are shown in Fig.10 (b). This approach is similar to the one described in (Seo et al., 2000).

For the bottom part, a simple method of deformation based on the FFD (Free Form Deformation) is used. The bounding box of the bottom is regularly sampled to obtain 4x4x4=64 control points of the Bézier volume. As we move any of the control points, the enclosed surface will be deformed accordingly. We discovered that only certain points of the volume are necessary in most cases. We thus obtain the differently sized bottoms by simultaneously moving these points, which are the four central points of the back face of the Bézier volume as shown in Fig.9.
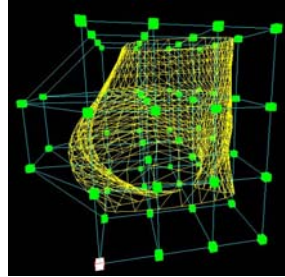
Fig9. Automatic displacement with 4 control points

Some of the various female bodies that are produced are illustrated in figure 10.

(a)   (b)
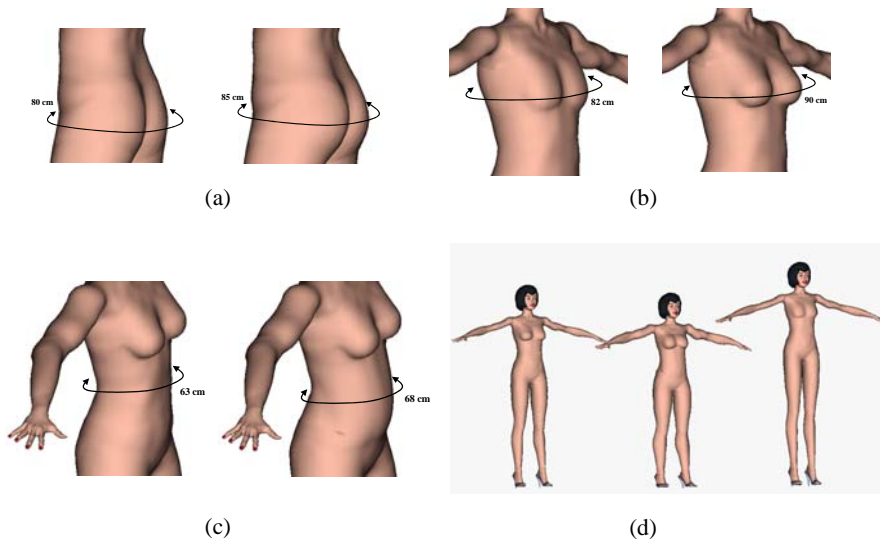

(c)   (d)

Fig10. (a) Deformation of the bottom to obtain different sizes. (b) Deformation of the breast to obtain different sizes. (c) Deformation of the abdomen to obtain different sizes. (d) Variously sized female bodies.

5   Fitting generic garment animation to personally sized bodies

Given a body created from a generic model, our method modifies the animation of the generic garment. As described in the previous sections, the program generates bodies from a generic model using the measurement data or photos. The same fitting process applied to the body (from generic to personally sized body) will be also applied on garments. Each generic body goes with a set of generic garments. The generic garment animation is modified to the personally sized body.

On each frame of the garment animation, the vertex position of the garment is adapted to the skin surface of the personally sized body. The method consists on applying a local scale factor on garment vertices. This local scale factor is

computed from the transformation matrix of the bones and the influence regions. This is done in two steps.

- The first step consists of defining the influence regions. This has been pre-calculated during the pre-processing phase. This is needed to compute the local scale factor from the transformation matrix of the bones. Around the bones, we define influence regions based on the distance between the garment surface and the bones. The computation of these influential areas is made with the "Da Vinci posture".
- The second step is the fitting of the garment surface to the body generated from the measurements or by the cloning program. It is part of the online calculation. Given a personally sized body, and by using the influence region of the bones, the local scale factor is defined for each garment vertex. This scale factor is then used to modify the animation of the generic garment.

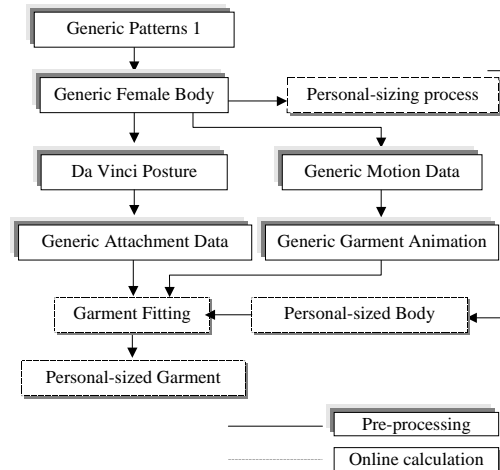The following diagram gives an overview of the dataflow.

Fig11. Dataflow diagram for one generic female body and one specific generic pattern

On the Fig. 11, we have defined the modules for pre-processing (construction of the generic garment database) and online calculation that will be executed for the personally sized bodies.

5.1   Influence regions on garments

The influence region is generated in the "Da Vinci" posture. These regions are defined on the garment; each vertex has a list of weights defined for each bone (Fig. 12). This weight defines how much the position of a vertex depends on the bone. This weight has to be defined for each bone, and is inversely proportional to the distance between the vertex and the bone. This data is defined at once in the pre-processing calculation and is used as is during the on-line calculation. The influence regions on garment are used as generic data. The local scale factor for garment vertex is computed by combining the different local coordinate systems of the bones weighted by the influence value.
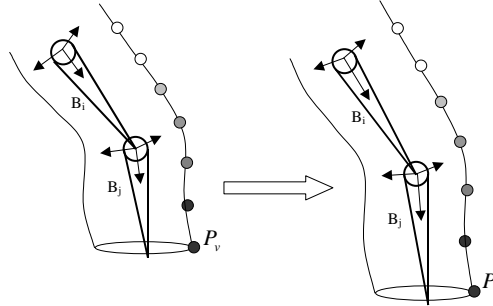
Fig12. Influence regions on garments

On the Fig.12, P_v is a vertex on the garment. The colour of the vertices along the edge shows the influence areas of the two bones B_i and B_j. In order to avoid discontinuity when fitting the generic garment to the personally sized body, the region boundaries are smooth.

5.2   *Calculation of the garment using influence regions*

This method is used for the online calculation. This calculation has to be fast and robust. We have chosen a geometric method that fulfils these two requirements. For a given frame, the position of a vertex is calculated by applying a local scale factor. This local scale factor is defined by combining the weighted transformation matrix of the bones. The resulting position of a vertex P_v is given by the following equation where M_i is the transformation matrix of the bone, K_i is the weight of the bone, and O_i is the position of the garment vertex in the local coordinate system of the bone.

$$P_v = \sum_i (M_i \cdot K_i \cdot O_i)$$

On the Fig.12, B_i and B_v are the two main bones of the legs. By modifying the length of bone B_j, we move the vertex P_v. As P_v is close to the bone B_i, this vertex position will be mainly affected by this bone.

6   Web interface

The Web interface provides the user with all the functionalities to define his/her body (by measurements or with photos), to choose his/her garment and to visualize himself/herself walking in this garment.

Fig13. User interface of the Virtual-Try-On web site

The user interface is divided into 3 modules. First, the user is required to complete a page to define his/her measurements or give his/her photos to the photo-cloned program. A second page follows where the user chooses one of the garments available in the library. Some properties of the garment can be customized such as the texture. In the last stage, after the online processing, the users can see themselves walking with the garment in the Virtual Fitting Room.

This Virtual Fitting Room is a 3D viewer. Using the menu, the user can move the point of view. For the 3D viewer, there are a considerable number of 3D technologies (Web3d, 2000). We use a Shout3D (Shout3d, 2000) loader for our virtual-try-on on the web. Our Web application fulfils the major considerations that determines the quality of the virtual fitting room application:

- *Quality of the animation*: this depends largely on the number of frames that can be redrawn on the display during a unit of time.
- I*nteractive possibilities*: our graphical interface allows the user to move around the scene and visualize the objects through modification of viewing parameters.
- *Response time*: this should be minimal. The user is not willing to spend more than a few minutes in the Virtual Fitting Room. Our 3D models are optimized to make the whole process of dressing the customer and displaying the animations as fast as possible. By using pre-computed generic bodies and garments, we have dramatically reduced the time for online calculation. The animation of garment provides good realism, including wrinkles, while the computation time takes no more than thirty seconds.

7   From 3D garment to 2D patterns

By the on-line calculation, the user is able to create the 2D patterns from the personally sized garment. As described in a previous section, the user gives his/her measurements or uses photos to generate the personally sized body. Using this generated model, the generic garment is then modified. And in the final step, the user retrieves the size of personally sized 2D pattern that can be directly used to create the real garment. In this section, we describe how we generate the size of the patterns.

In our model, we keep the information on the 2D patterns that has been used to generate the garment. Both 2D patterns and the garment have some feature points on the seaming. Fig. 14 shows two examples.
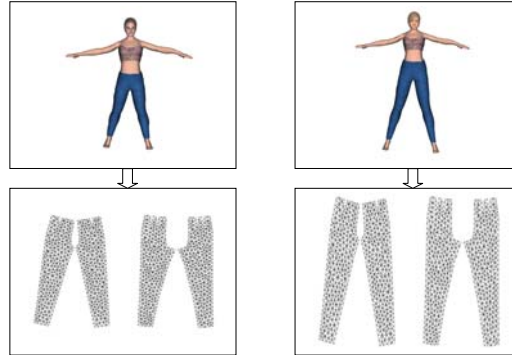

Fig14. Feature points.

These feature points are located on the seams mainly on the corners. By measuring the distance of the edges joining two feature points, we extract the length of the corresponding seaming. These lengths are then applied to the 2D patterns. In some cases the extracted lengths of two symmetric seams are not equal, we use the average length.

8   Conclusion and future research

In this paper, we have developed a methodology to see ourselves at any angle in privacy and try several different styles of garments. We have introduced this idea for Made-to-measure garment simulation on an individualized body using an online web application. The key points we have shown here are the acquisition of personal virtual body from easy input such as photographs or measurement, the 3D-garment made to exact measurements calculated from 3D virtual cloned body or measurement-oriented body, and then the optimized Made-to-measure garment simulation on the web. Finally, the 2D patterns are generated from the personally sized garments. These 2D measurements could be directly sent to the cloth manufactures. The speed optimization for on-line calculation comes from wide use of generic database of bodies and garments. This research works as a prototype. To have it working on daily basis, it needs to optimize every step.

Acknowledgements

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