3-D BODY MODELLING IN CLOTHING DESIGN

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Abstract

Development of computers has created the conditions for consideration real 3D body data in clothing design. 3D modelling of human body is the first step of spatial clothing design. Model of human body is created. Parts of the body are modelled in an object-oriented way parameterized by significant dimensions measured in different photos. The system being developed supports spread body surfaces on plane in addition to individual body dimensions. Spreading cloth parts on the body by material property modelling solves virtual fitting inversely.

***Key words**: Clothing design, 3D body modelling*

3D MODELIRANJE TELESA V PROCESU OBLIKOVANJA OBLAČIL

Povzetek

Razvoj računalniške strojne in programske opreme je omogočil pogoje za uporabo realnih 3D podatkov o človeškem telesu za potreba oblikovanja in konstrukcije oblačil. 3D modeliranje človeškega telesa predstavlja prvi korak k prostorskemu oblikovanju oblačil. V prispevku je opisan postopek modeliranja telesa, katerega deli so modelirani na objektno orientiran način in z uporabo številnih fotografij parametrizirani z značilnimi merami.V okviru raziskave razviti program omogoča pridobitev značilnih izmer človeškega telesa in ravninsko projekcijo površine telesa. Omogočena je tudi postavitev krojnih delov okrog telesa, kar z upoštevanjem mehanskofizikalnih lastnosti tekstilnega materiala podpira prikaz virtualnega pristajanja oblačila.

***Ključne besede:** oblikovanje oblačil, 3D modeliranje človeškega telesa*

1. STRUCTURE OF THE SYSTEM

Traditional clothing design systems are based on two-dimensional geometrical construction. Development of computers has created the technique of real 3D body data in clothing design.
The following part describes the structure of a 3D system:

- Cloths design is based on individual body sizes. Digital pictures are created from different viewpoints by an input device (e.g. camera). Data of pictures define body sizes.
- Model of the human body is defined by the processed data of the photos and solves as the basis of the virtual mannequin.
- Dressing features of model parts are based on mechanical properties as well as material patterns.
- Virtual mannequin is dressed in prepared model parts with defined geometrical and material properties.

System in function in figure 1.

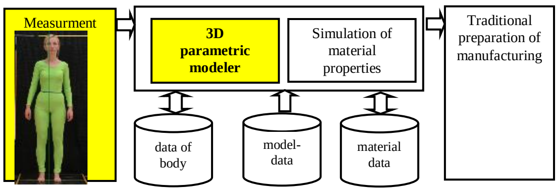

Fig. 1 Main parts of the system

2. 3D PARAMETRIC MODELLER

Development highly focuses on 3D parametric modelling. 3D modelling of human body is the first step in spatial clothing design. 3D model is required to be able to:

- shape up the body upon individual-, automated measured dimensions,
- follow different anthropometrical builds,
- apply and support methods of traditional made-to-measure,
- visualize design results, manage virtual trying on.

Model of human body is created according to the demand above. Parts of the body are modelled in an object-oriented way para-meterized by significant dimensions.

Surfaces of body parts modelled spline-surfaces defined by characteristic points. Surfaces consist of patches connected to each other in a first order continuous way. Shape of the patches is defined by position of the corner points.

Fig. 2 Surface patches

There are two basic types of body parts considering symmetry of human body

The tube like body part is the first one for the paired parts as arms, legs. A right-left pair of tube like parts should be mounted into the model. The second one is the half tube like body part. A pair of the half tube like body part models one symmetric body part as trunk chest.

Beams defined by the coordinates of the endpoints serve as the skeleton of body parts. Surface of body parts around the beams modelled by NURBS surfaces are characterized by poles. Connection between the part surfaces are defined by 3D curves.

Bezier interpolation is used for modelling patches. Shape of patches defined by $P_{i,j}$ control points or poles as we can see in figure 3.

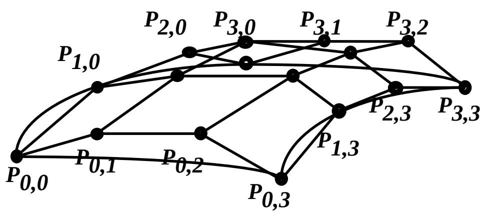

Fig. 3 The Bezier patch

If the interpolation is defined in the given point grid ($P_{i,j}$) and the coordinates one after the other $X_{i,j}$, $Y_{i,j}$, $Z_{i,j}$ (wher i=0..3 and j=0..3) then the $P_{0,0}$, $P_{0,3}$, $P_{3,3}$ and $P_{3,0}$ are corner points. Neighbouring points are defined by derivatives in u and v directions. For example in $P_{0,0}$ corner $P_{0,1}$ defined by tangent in u direction, $P_{1,0}$ defined by tangent in v direction and $P_{1,1}$ defined by mixed partial derivatives.

$$X(u,v)=\sum_{i=\ddot{o}}^{n}\binom{n}{i}*u^{i}*(1-u)^{n-i}v^{j}*(1-v)^{n-j}*X_{i,j}$$
$$Y(u,v)=\sum_{i=\ddot{o}}^{n}\binom{n}{i}*u^{i}*(1-u)^{n-i}v^{j}*(1-v)^{n-j}*Y_{i,j}$$
$$X(u,v)=\sum_{i=\ddot{o}}^{n}\binom{n}{i}*u^{i}*(1-u)^{n-i}v^{j}*(1-v)^{n-j}*Z_{i,j}$$

where u,v $\in$*[0,1],* *(EQ.1)*

Joining patches to each other insured by suitable positions of points.

In the inner part of patches pole positions are defined by points of actual and the neighbouring patches.

$$\begin{aligned}
P_{0,1} &= P_{0,0}+\left(P_{0,3}-P_{0,0}^{left}\right)/6\\
P_{0,2} &= P_{0,3}-\left(P_{0,3}^{right}-P_{0,0}\right)/6\\
P_{3,1} &= P_{3,0}+\left(P_{3,3}-P_{3,0}^{left}\right)/6\\
P_{3,2} &= P_{3,3}-\left(P_{3,3}^{right}-P_{3,0}\right)/6\\
P_{1,0} &= P_{0,0}+\left(P_{3,0}-P_{0,0}^{front}\right)/6\\
P_{2,0} &= P_{3,0}-\left(P_{3,0}^{back}-P_{0,0}\right)/6 \qquad \textit{(EQ.2)}\\
P_{1,3} &= P_{0,3}+\left(P_{3,3}-P_{0,3}^{front}\right)/6\\
P_{2,3} &= P_{3,3}-\left(P_{3,3}^{back}-P_{0,3}\right)/6\\
P_{1,1} &= P_{0,0}+\left(P_{1,0}-P_{0,0}\right)+\left(P_{0,1}-P_{0,0}\right)\\
P_{1,2} &= P_{0,3}+\left(P_{0,2}-P_{0,3}\right)+\left(P_{1,3}-P_{0,3}\right)\\
P_{2,1} &= P_{3,0}+\left(P_{2,0}-P_{3,0}\right)-\left(P_{3,1}-P_{3,0}\right)\\
P_{2,2} &= P_{3,3}+\left(P_{3,2}-P_{3,3}\right)+\left(P_{2,3}-P_{3,3}\right)
\end{aligned}$$

In case of part boundaries there is a different strategy for the tube like and the half tube like elements.

The constraint for the direction of tangents at right angles to edge is at tube like parts:

$$\begin{aligned}
P_{1,0} &= P_{0,0}+\left(P_{3,0}-P_{0,0}\right)/3\\
P_{1,3} &= P_{0,3}+\left(P_{3,3}-P_{0,3}\right)/3 \qquad \textit{(EQ.3)}
\end{aligned}$$

In case of half tube like parts there can be two perpandicular edges

For example if P0,0-P0,3 and P0,0-P3,0 curves are part edges then

$$\begin{aligned}
P_{0,1} &= P_{0,0}+\left(P_{0,3}-P_{0,0}\right)/3\\
P_{0,2} &= P_{0,3}-\left(P_{0,3}^{jobb}-P_{0,0}\right)/6\\
P_{1,0} &= P_{0,0}+\left(P_{3,0}-P_{0,0}\right)/3\\
P_{2,0} &= P_{3,0}-\left(P_{3,0}^{mögött}-P_{0,0}\right)/6 \qquad \textit{(EQ.3)}
\end{aligned}$$

Poles of body NURBS are defined by digitized points of 2D photos as we can study in figure 4. of a leg.

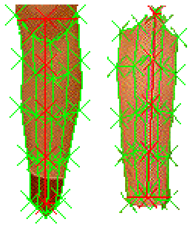

Fig. 4 Photo of a leg and the defining poles

The measured points define the shape of the leg. The position of the measured points is described as a function of the characteristic sizes of the leg. So the shape of the leg can be defined by the position of the ankle and the knee, the length of the leg and the characteristic sizes of the leg in crosswise and perpendicular direction.
The interpolation NURBS leg surface created from characteristic data means an approach of measured points. Figure 5 shows the inter-polated shaded leg surface and mesh surface.

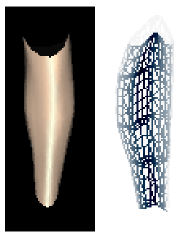

Fig. 5 Front view of shaded model of the leg. and left view of mesh

Whole body can be modelled in the same way. Connected parts defined by 2-3 parameters generate the surface model of human body.

3. BODYMODEL

Different body parts as feet, ankles, legs, knees, trunk, stomach, chests, back, shoulders, neck, head, upper arms, elbows, forearms and hands alike can be modelled by the method described above.

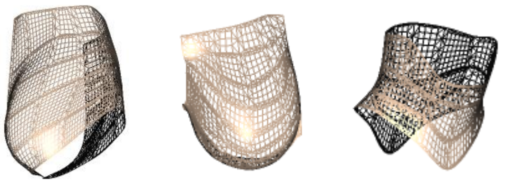

Fig. 6 The trunk and chest are half tube like and neck is tube like.

Positions of body part poles are defined as functions of body parameters like the body height, jaw-bone height, height and width of shoulders, waist height and waist line, hip height and measurement, sizes of tights etc.

There are about 100 parameters of human body after assembling. We can get the model of a particular person by definition the actual body parameters.

4. MEASUREMENT

There are two ways of photo measuring. Users are able to define main parameters on the calibrated photos. Unfortunately requires mach measuring work and the results proved to be unreliable.
We can make our task easier if we use only poles of body parts can defined as a contour point in a photo.
Consider the leg as an example. Figure 7 shows the front view, left view and the back view of a leg. Curves defined by photos are drawn continuous grey lines. Poles indicated by black crosses are measured automatically. Dotted curves and grey poles are not defined by photos, but they interpolated by measured points. The whole 3D geometry of a human body is modelled by contours of two photos the front view and the left view.

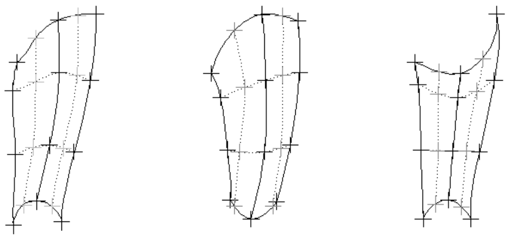

Fig. 7 Data of photo models

By picture processing body sizes can be defined automatically with no errors.
Figure 8 shows the measuring software the manual usage is on the left side and the automated contour processing is in the right side.

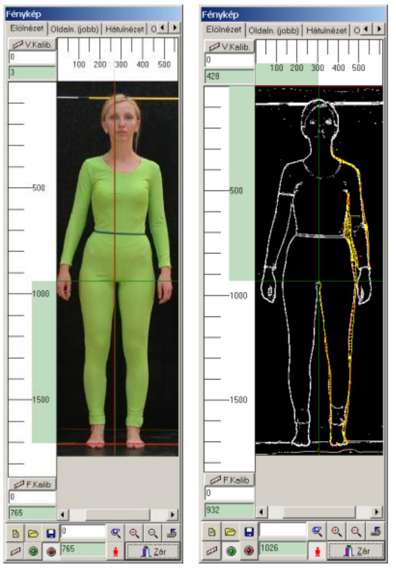

Fig. 8 Measuring application

Upon measured data individual body model can be created by modifying body part parameters.

- Mechanical model can simulate dressing feature of cloth parts
- Parameters provide simulation of body movement as a robot.
- Data can be defined by two-dimensional photos.
- Plastic visualization and unified description are based on NURBS surfaces.

The system models body parts by objects of Borland Delphi. As Open GL system is used for visualization, it is possible to consider illumination reflection as well as material pattern visualization.

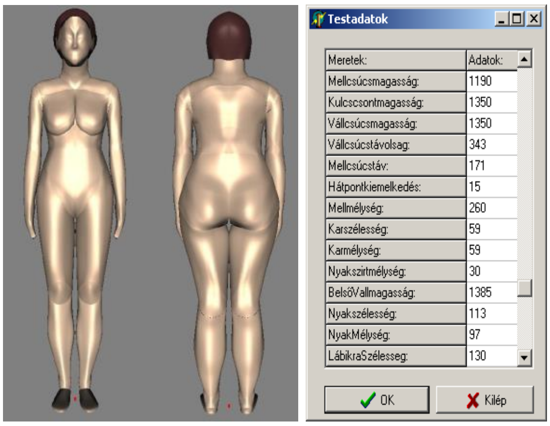

Fig. 9 Extremes

5. CONCLUSION

On the one hand the system being developed supports spread body surfaces on plane in addition to individual body dimensions. On the other hand spreading cloth parts on the body by the help of material properties modelling replaces fitting in a virtual way.

6. ACKNOWLEDGEMENT

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