Human Body Measuring and 3D Modelling

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Abstract: Object-oriented, parametric feature based model describes the human body with appropriate accuracy. Vertexes of modelling features for rag-trade are defined by automatically calibrated 3D scanner produced points of the human body.
The relationship between basic body sizes and modelling features of body can be explored by procedures based on data mining methods. A reduced set of basic body parameters used by tailors and dressmakers can be defined by distances of model-points and numerically computed length of rectified surface curves. The function between basic parameters and modeling feature parameters which maps the set of basic tailoring parameter vectors into set of vertex coordinate vectors can be determined by interpolation of k-closest neighbors.
Ready made cloth geometry derived from body part models inherits shapes and data automatically. Geometry can be designed by 3D methods. Shape of patterns depending on deformation can be computed by the numeric approximation of isometric lay out mapping.

Keywords: human body modeling, 3D scanner, data mining, ready-made clothes, 3D internet

1 Introduction

All our knowledge is in 3D, no wonder that it is a natural need from the customers that they would like to communicate with computers in a very same way; in 3D. The three-dimensional opportunities of informatics help significantly the communication and the representation of the information [1]. Cell phones are also available with 3D interface and by moving them, in 3D, it creates a link between our tools for informatics and their 3D content. The improvements in input devices are about to change the traditional keyboard and mouse interfaces [2], and require a more effective communication channel for data input. In order to track the the movement of humans/objects in real-world, detection equipement is needed. It is a hard task to follow changes in the real-world. For this reason different type of trackers are used: electromagnetic, mechanical, inertial, vision-based, ultrasound and hybrid systems (combination of two or more). Each type of tracker has different operation conditions and can be used for different type of tasks. The overall goal of each tracker is to provide high accuracy, low latency, low jitter and robustness. These are crucial for a successful applications [3]. Sometimes it is needed to track the whole human body motion, even including the fingers. We will focus on this case, as this type of tracking can be used as a 3D input device. With using only vision based tracking, the uncomofortable, movement limiting suits/markers can be avoided. One example application of such a 3D input device can be the so called Intelligent Space (iSpace): a space (e.g. room, corridor), which can be equipped with distributed actuators, sensors and robots who jointly “understand” and monitor the actions taken place in the space and thus able to influence the events or help the humans staying in the space [4].

Shape definition of virtual mannequin based on traditional tailors’ data was the aim of presented method. The procedure is based on data mining techniques and integrated part of the Sylvie 3D system. Parametric body model photo- and 3D scanner based measuring techniques 3D designing methods are also integrated in Sylvie system, which will be introduced in the following.

2 The Parametric Model

The parametric feature based models built on tubes and half tubes like elements cut along axis, consisting of Bezier patches continuously connected in first order, realized by the generalized two-dimensional Catmull-Romm spline describes the human body with appropriate accuracy according to the demands of rag-trade and is suitable for computer visualization. Vertices of tube and half tube like body parts are defined in coordinate systems connected to the main joints of body (Fig. 1).

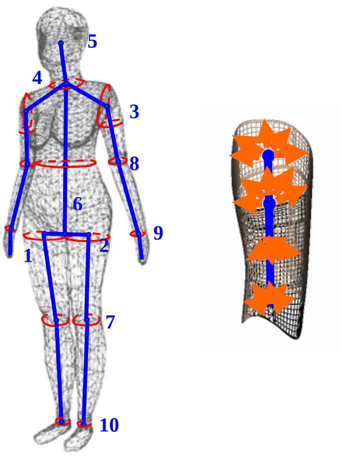

Figure 1
Simple Sceleton Model and Vertices of Features

Corner points of surface patches can be defined as functions of measurable 66 body parameters or can be defined directly by point coordinates [5], [6].

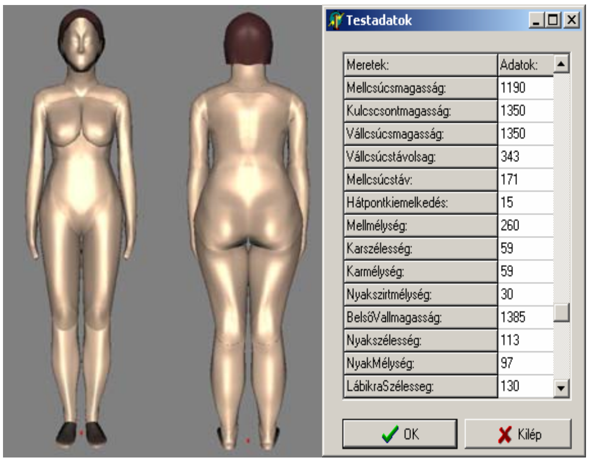

Figure 2
The Parametric Model in Different Sizes

3 Measuring Process

Shape of above described model can be defined by photos or 3D body scanner.

3.1 Measuring in Photos

The difference between the model outlines projected on the view plane and contours defined in the front and left view photos is a function of body parameters and the minimum place of this function defines a virtual mannequin well approximating the real body shape according to the rag-trade demands, so it is good both for designing ready made clothes and as virtual trying on [7] (Fig. 3).

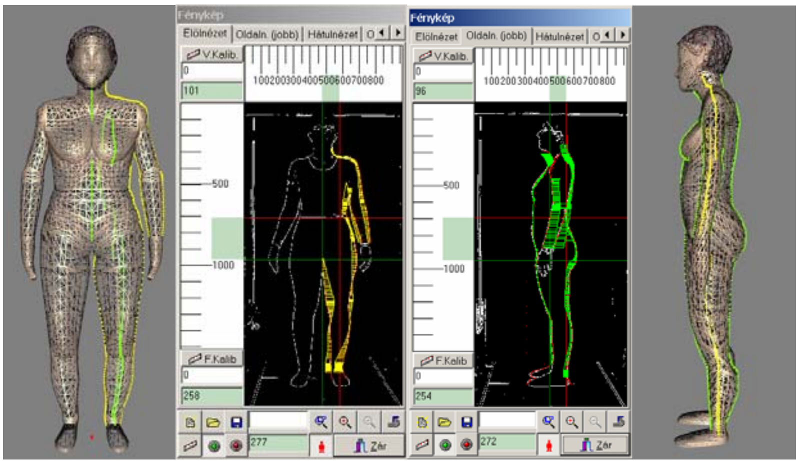

Figure 3
Differences between Profile Curves of Model and Photos

3.1 Measuring by 3D Scanner

The vertexes of measuring features for rag-trade can be defined by automatically calibrated 3D scanner produced points of the human body if the approximating point-cloud is processed by 3D noise filtering, statistical clustering upon body parts, and surface curves are approximated Fourier based trigonometrical regression [8] (Fig. 4).

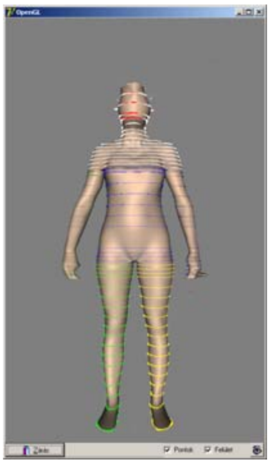

Figure 4
Approximated body by measuring feature

4 Relationship between Basic Body Sizes and Shape

Measuring by photos and scanner are time and equipment demanding tasks. An expert system is based on series of measuring producing digital body model upon traditional tailors1 data by data-mining techniques.

4.1 Measuring Database

Measuring data are stored in a database. Main data of measuring processes as personal identification and data are stored on Main table. Joint coordinates are computed from 3D scanned data and stored in Joints table. Vertices of Catmull Romm patches are computed from point cloud and stored in coordinate systems of joints in different tables corresponding body parts. Traditional tailors' data are measured as distances of points or length of surface curves in body model shown in Fig. 4. Data are stored in Tailors table (Fig. 5)

The aim of database is the definition positions of vertices as the function of traditional body sizes.

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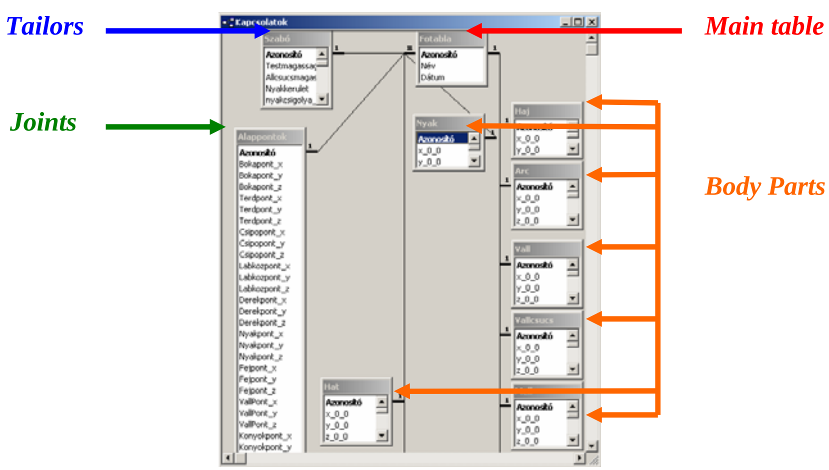

Figure 5
The database

4.2 Operation of the Expert System

Every measured data are learned by the frame-work system. The expert system is based on the known data-mining technique *knn* - k-nearest-neighbor method and the interpolation [9]. In other words for a given set of measured tailor parameters (on the left side of Fig 6.) the *k* nearest cases are picked from the database upon the distance of tailors' parameter vector. (That measures where the difference between the given data and vectors of tailors' parameters are the least.) A multivariable interpolating polynomial of tailors' parameters is defined on k element set of selected measured k-nearest-neighbor coordinates of vertices. The interested positions of vertices are defined by value of the interpolating function at the position of given tailors' parameters (on right side of Fig. 6).

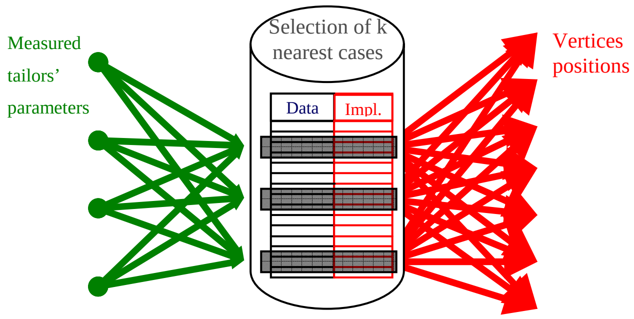

Figure 6
Scheme of knn system

All used data are stored numerical form in the database. Data of implications are also numerical data.

Basic data (tailor parameters) are defined on an interval of N dimension where the limits are defined. $[x_i^{min}, x_i^{max}]$. Every combination of tailors' parameters is a point of that interval (1).

$$\left[x_1^{\min}, x_1^{\max}\right] \mathrm{x} \left[x_2^{\min}, x_2^{\max}\right] \mathrm{x} \ldots \mathrm{x} \left[x_{\mathrm{N}}^{\min}, x_N^{\max}\right] = \mathrm{X} \qquad (1)$$

Similarly P coordinates of Catmull-Romm vertices are point of an interval of P dimension (2).

$$\left[y_1^{\min}, y_1^{\max}\right] \mathrm{x} \left[y_2^{\min}, y_2^{\max}\right] \mathrm{x} \ldots \mathrm{x} \left[y_{\mathrm{P}}^{\min}, y_P^{\max}\right] = \mathrm{Y} \qquad (2)$$

Implication is based on Φ function which gives the vertices coordinates on the tailors' data (3). Function is defined by data of database.

$$\Phi : X \rightarrow Y; \Phi(\underline{x}) = \underline{y}; \qquad \underline{x} \in X, \underline{y} \in Y \qquad (3)$$

Because of the numerical stability all data are projected on interval of [*0,1*] by help of the α_j and β_j functions (4).

$$\alpha_i : \left[x_i^{\min}, x_i^{\max}\right] \rightarrow [0,1]; \alpha_i(\underline{x}) = \underline{\xi}; \qquad i = 1 \ldots n, j = 1 \ldots P$$

$$\underline{x} \in X, \underline{y} \in Y \qquad (4)$$

$$\beta_j : \left[y_j^{\min}, y_j^{\max}\right] \rightarrow [0,1]; \beta_j(\underline{y}) = \underline{\eta}; \qquad \underline{\xi} \in [0,1]^N, \underline{\eta} \in [0,1]^P$$

By normalized data the ϕ^* function is searched (5). From ϕ^* function the ϕ function can be computed.

$$\Phi^* : [0,1]^N \rightarrow [0,1]^P; \Phi^*(\underline{\xi}) = \underline{\eta}; \qquad \underline{\xi} \in [0,1]^N, \underline{\eta} \in [0,1]^P \qquad (5)$$

Definition method of definition of ϕ^* function is shown in following section.

On a given set of data the ϕ^* is searched as a third order polynomial (6)

$$\phi^*{}_j(\underline{x}^*) = \sum_{i=1}^{N} (\mathrm{a}_{\mathrm{i,j}}\xi_i^3 + \mathrm{b}_{\mathrm{i,j}}\xi_i^2 + \mathrm{c}_{\mathrm{i,j}}\xi_i + \mathrm{d}_{\mathrm{i,j}}) \qquad j = 1 \cdots P \qquad (6)$$

The nearest $4*N$ records (in Euclidean norm) are selected and ϕ^* interpolating function is tried to be computed (there are $4*N$ equations and the same number of unknowns). If the computation was successful and coefficients $a_{i,j}$, $b_{i\,j}$, $c_{i\,j}$, $d_{i\,j}$ are defined than ϕ is also defined and vertices as the functions of parameters are defined.

If computation was not successful (there were not enough data or the system of equations is almost singular) then ϕ^* function is searched in second order in the following (7) form.

$$\phi^*{}_j(\underline{x}^*) = \sum_{i=1}^{N} (\mathrm{a}_{\mathrm{i,j}}\xi_i^2 + \mathrm{b}_{\mathrm{i,j}}\xi_i + \mathrm{c}_{\mathrm{i,j}}) \qquad j = 1 \ldots P \qquad (7)$$

In this case the $3*N$ neighboring record are selected from the database. If the $a_{i,j}$, $b_{i\,j}$, $c_{i\,j}$ coefficients of interpolating function were defined ϕ is also defined and vertices as the functions of parameters are defined.

If computation was not successful (there were not enough data or the system of equations is almost singular) then ϕ^* function is searched in first order in the following (8) form.

$$\phi^*{}_j(\underline{x}^*) = \sum_{i=1}^{N} (\mathrm{a}_{\mathrm{i,j}}\xi_i + \mathrm{b}_{\mathrm{i,j}}) \qquad j = 1 \ldots P \qquad (8)$$

If there were $2*N$ neighboring record and definition of $a_{i,j}$, $b_{i\,j}$ coefficients were successful then ϕ is defined.

If neither this was successful there is no other solution the ϕ function is defined by the nearest neighbor.

Above principles are integrated into the framework system. A searched result is shown in Fig 7.

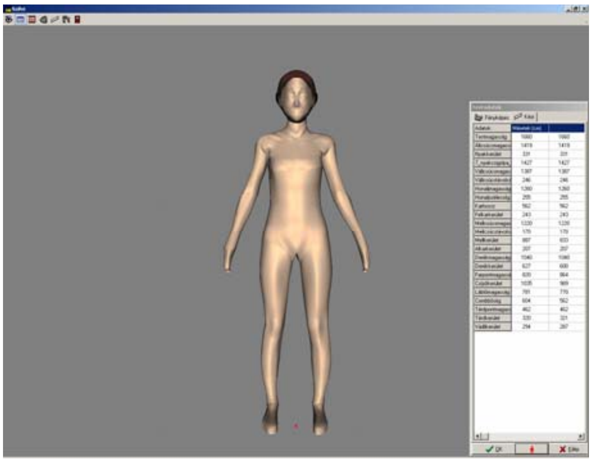

Figure 7
Scheme of knn system

5 Cloths Design in 3D

Ready made cloth geometry derived from body part models inherits shapes and data automatically. Geometry can be designed by 3D methods upon draft of profile curves and can be modified by linearly interpolated moving of vertexes in normal direction. Shape of patterns depending on deformation can be computed by the numeric approximation of isometric lay out mapping [7], [9].

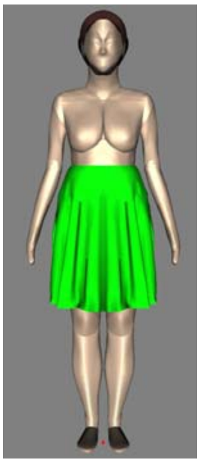

Figure 8
Shirt draping simulation

Conclusions

Presented methods and results can be the basis of a national research of body sizes. It cold be used not only in cloths design but on field of higiene too.

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