RELATIONSHIP BETWEEN BASIC BODY SIZES AND BODY SHAPE

Peter TAMAS & Marianna HALASZ

Abstract: *Object-oriented, parametric feature based models describe 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 modeling features of the 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 mapping 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.*

1. Introduction

The presented method is about shape definition of virtual mannequin based on traditional tailors' data. The procedure is based on data mining techniques and is an integrated part of the Sylvie 3D system. Parametric body model photo- and 3D scanner based measuring techniques 3D designing methods are also integrated in the Sylvie system.

2. The Parametric Model

The parametric feature based model 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. Vertexes of tubes and half tubes like body parts are defined in coordinate systems connected to the main joints of body (Fig. 1).

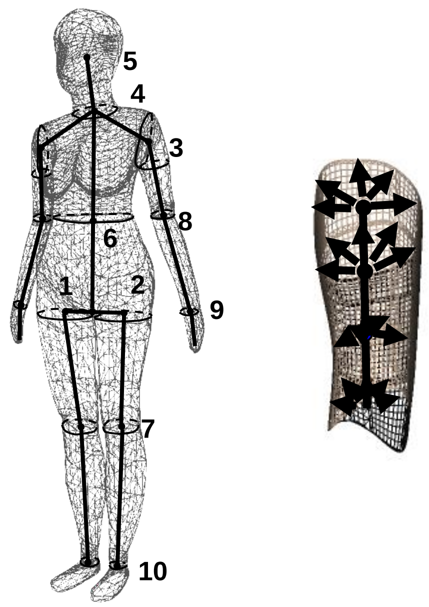

Figure 1: Simple Sceleton Model and Vertexes of Features

Corner points of surface patches can be defined as functions of measurable 66 body parameters or can be defined directly by point coordinates [1], [2].

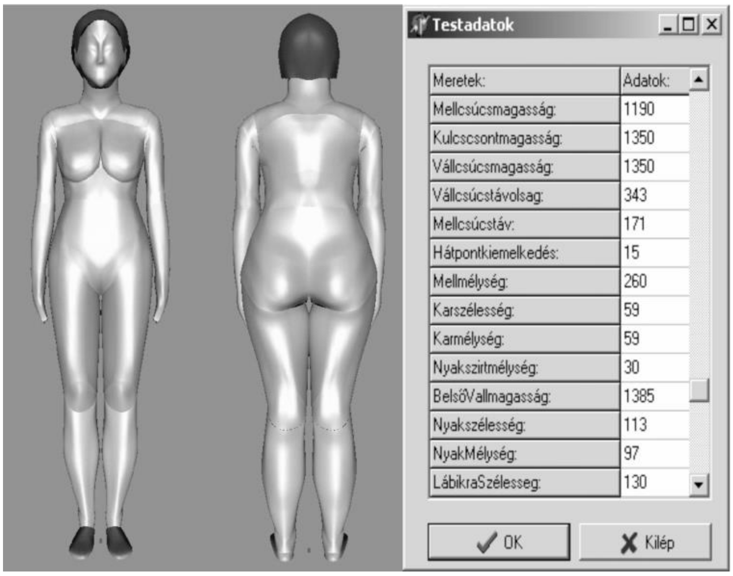

Figure 2: The Parametric Model in Different Sizes

3. Measuring Process

The shape of above described models can be defined by photos or 3D body scanner.

3.1 Measuring on 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 for virtual trying on [3] (Fig. 3).

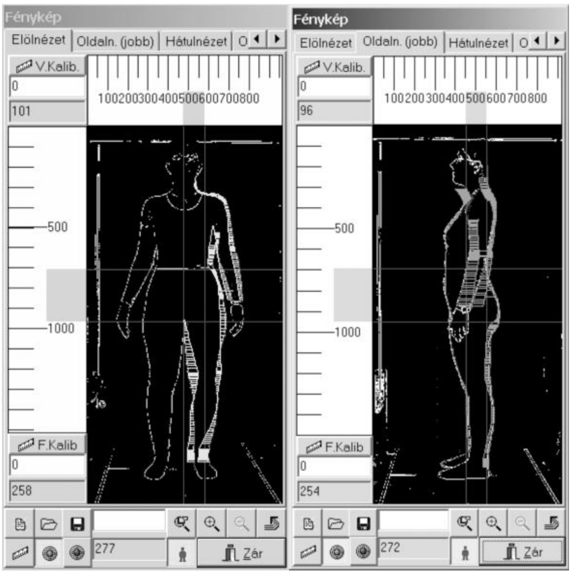

Figure 3: Differences between Profile Curves of Model and Photos

3.2 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 by Fourier based trigonometrical regression [4] (Fig. 4).

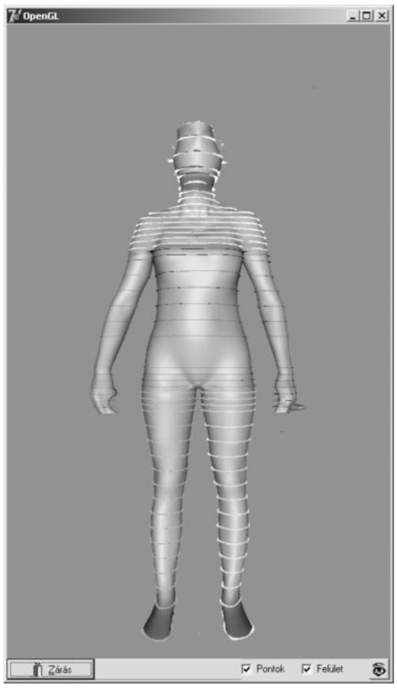

Figure 4: Approximated body by measuring feature

4. Relationship between Basic Body Sizes and Body Shape

Measuring by photos and scanners are time and equipment demanding tasks. This expert system is based on a series of measuring producing a 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 the Main table. Joint coordinates are computed from 3D scanned data and stored in the Joints table. Vertexes of Catmull Romm patches are computed from point clouds and stored in coordinate systems of joints in different tables corresponding to 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 to define positions of vertexes as the function of traditional body sizes.

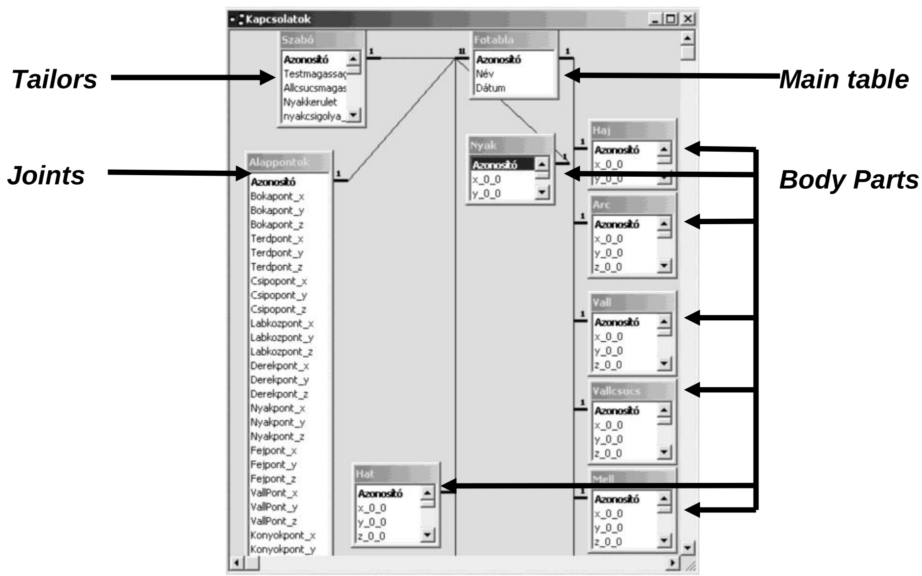

Figure 5: The database

4.2 Operation of the Expert System

All measured data are stored in the framework system. The expert system is based on the well-known data-mining technique *knn* - k-nearest-neighbor method and the interpolation [5]. 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 the minimum difference between the given data and vectors of tailors' parameters.) A multivariable interpolating polynomial of tailors' parameters is defined on k element set of selected measured k-nearest-neighbor coordinates of vertexes. The positions of vertexes are defined by value of the interpolating function at the position of given tailors' parameters (on right side of Fig. 6).

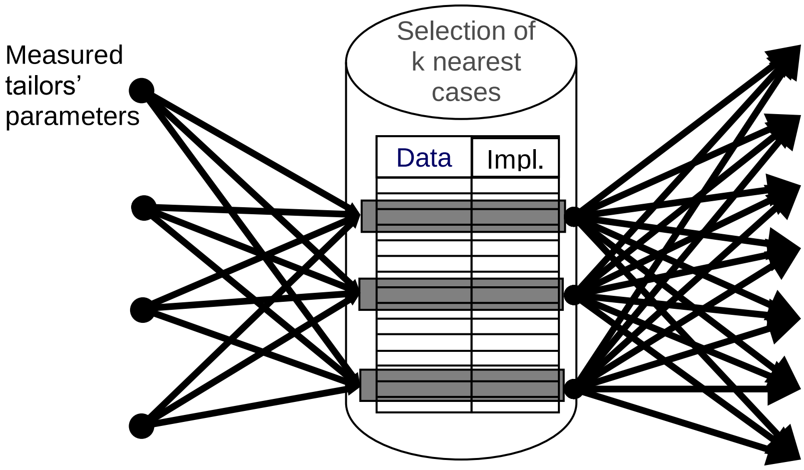

Figure 6: Scheme of knn system

All used data are stored in 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).

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

Similarly P coordinates of Catmull-Romm vertexes are points of an interval of P dimension (2).

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

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

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

As numerical stability of all data is projected on the interval of [*0,1*] using α_j and β_j functions (4).

$$\begin{aligned} &\alpha_i : \left[x_i^{\min}, x_i^{\max}\right] \rightarrow [0,1]; \alpha_i(\underline{x}) = \underline{\xi}; && i = 1 \ldots n,\ j = 1 \ldots P \\ & && \underline{x} \in X, \underline{y} \in Y \qquad (4) \\ &\beta_j : \left[y_j^{\min}, y_j^{\max}\right] \rightarrow [0,1]; \beta_j(\underline{y}) = \underline{\eta}; && \underline{\xi} \in [0,1]^N, \underline{\eta} \in [0,1]^P \end{aligned}$$

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

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

The method to define Φ^* function is shown in following section.

On a given set of data the ϕ^* is to be determined by third order polynomials (6)

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

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

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

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

In this case the *3∗N* neighboring records are selected from the database. If the $a_{i,j}$, $b_{i\,j}$, $c_{i\,j}$ coefficients of interpolating function are determined then ϕ and vertexes are determined too as the functions of parameters.

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

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

If there are *2∗N* neighboring records and $a_{i,j}$, $b_{i\,j}$ coefficients are determined then ϕ is defined.

If none of the above is successful then ϕ must be the nearest neighbor.

The above principles are integrated in the framework and the result is shown in Fig 7.

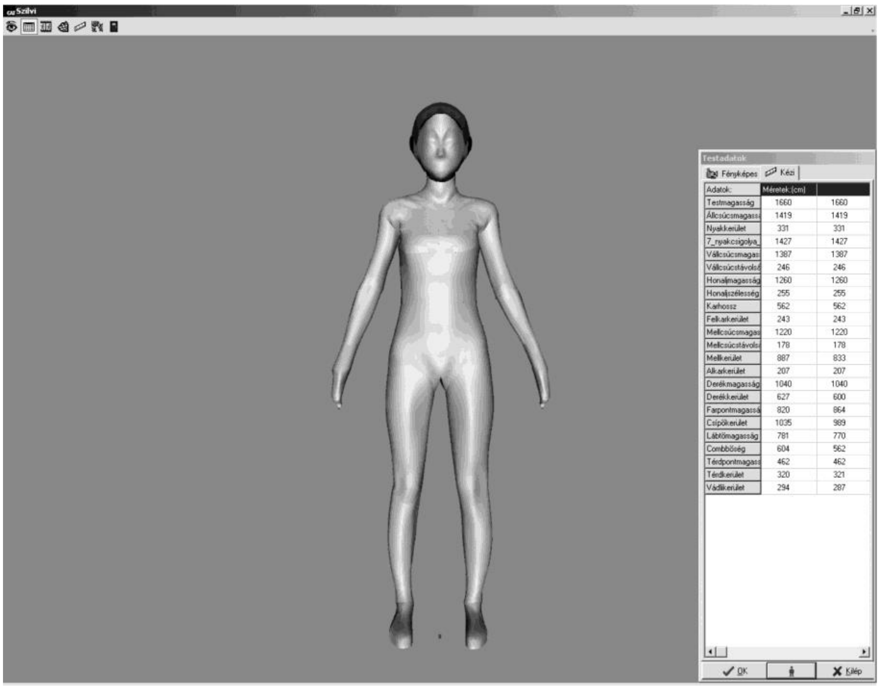

Figure 7: Model definded by tailors' data

5. 3D Cloths Design

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 [3], [6].

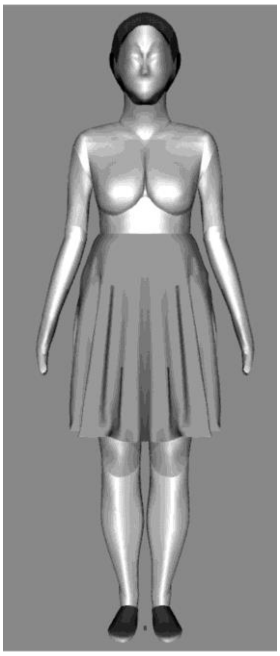

Figure 8: Shirt draping simulation

References

[1] Tamás P.; et al: Feature based modelling of human body, *IN-TECH-ED '02 Innovation-Technics-Education in the Textile and Garment Industry*, pp 170-174. HUISBN 963 9397 016, Budapest/Hungary, April 2002., konferencia kiadvány (2002)

[2] Tamás P.; et al: 3D Body Modelling in Clothing Design, *Gépészet 2002 ,Proceedings conference on mechanical engineering*, p p.570-573, ISBN 963 699 1650, Technical University of Budapest, May 2002., Budapest University of Technology and Economics, Budapest (2002)

[3] Tamás P.; et al: 3D Dress Design, *5th World Textile Conference AUTEX,* pp 436-441, ISBN 86-435-0709-1, Portoroz Slovenia, Jun 2005, University of Maribor, Maribor (2005)

[4] Tamás P.; et al.: 3D Measuring of the Human Body by Robots, *5th International Conference Innovation and Modelling of Clothing Engineering Processes – IMCEP 2007*, pp 109-115; ISBN 978-961-248-047-9, Moravske Toplice, Slovenia, October 2007, University of Maribor, Maribor (2007)

[5] Stoyan G.; Takó G.: *Numerikus módszerek*, Typotex, ISBN-13 978-963-7546-77-8, Budapest (2000)

[6] Tamás P.; et al: Silvy 3D Drape Tester New System for Measuring Fabric Drape – Novi mjerni sustav ya odredivanje drapiranja tekstilnih plosnih proiyvoda, *Tekstil,* **Vol. 55** (2006), pp 497-509, ISSN 0492-5882

Author(s):

Dr. Peter TAMAS, Ph.D.
Budapest University of Technology and Economics, Department of Mechatronics, Optics and Information Engineering
Műegyetem rkp. 3-9., 1111, Budapest, Hungary
Phone: +(36) (1) 4632495 Fax: +(36) (1) 4631689 E-mail: tamas@inflab.bme.hu

Dr. Marianna HALASZ, Ph.D.
Budapest University of Technology and Economics, Department of Polimer Engineering
Műegyetem rkp. 3-9., 1111, Budapest, Hungary
Phone: +(36) (1) 4632650 Fax: +(36) (1) 4631689 E-mail: hama@eik.bme.hu