HUMAN BODY'S SHAPE AND DATA

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Abstract: *The output of 3D scanners is stream of geometrical data (point-cloud triangle mesh). It is usually a problem in apparel industry because there is no clear functionality between the body dimensions and the stream-like data. Traditional body dimensions are used in apparel industry frequently. Presentation is about a virtual measuring technique which realizes functionality between traditional data and 3D scanned data. A data mining based expert system is also presented as a two-way linkage between the different data. It is proven that our system is good for content based comparison results of different type 3D scanners*

Keywords: *3D scanners, virtual measuring, body dimensions, body modeling, data mining, expert system*

1. Introduction

Since 1983 the researchers at BME (Budapest University of Technology and Economics) have been engaged in the development of computer-aided modelling and 3D body scanning systems for the clothing industry and medical purpose, resulting in a number of patents, PhD dissertations, and some applications for industrial and educational purposes. The researchers at University of Maribor have been engaged in the research, modelling and simulation of garments, designing a especial garments and thermo-physiological measurements resulting in a number of publications, research reports, and PhD theses.

2. Convept of 3D Scanning

The essence of the method is that the laser line emitters illuminate the sections created with horizontal planes of the body surface. The body contour obtained this way is recorded with cameras positioned at a given distance above the plane of lasers and focus on the intersection of the vertical centroid line and the plane defined by the lasers (Figure 1). The spatial position of the points of the contour can be determined from the height of the contour plane by processing the photograph.

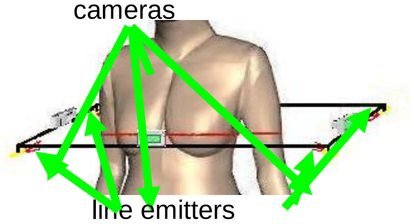

Figure 1. *Principle of scanning*

In order to achieve the necessary accuracy for garment trade, it is necessary to calibrate photos of parallel cameras, in order to develop measuring methods as well as to analyse errors [1].
The planar section points of the body surface supplemented with the actual height data of the measuring frame result in a spatial point set. The height (z) coordinate of the surface points is provided by the height data of the frame drive, and coordinates x and y can be determined with image processing (Figure 2).

Figure 2. *Resulting pointcloud*

The structure of the human body is characterized by the fact that the number of body parts that can be characterized with closed contours on the ground, at the end of the hand, and at the height of the crotch, armpit and crown changes step-like (Figure 3).

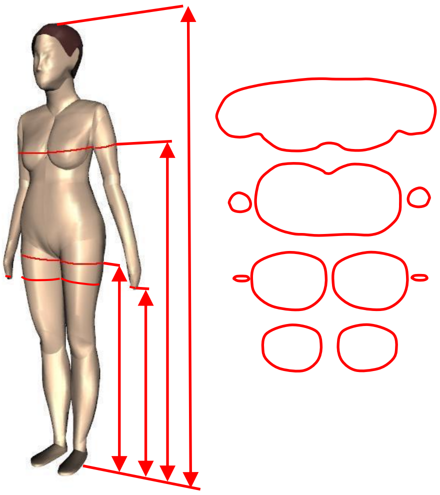

Figure 3. *Cross sections of base body parts*

3. Separation of the Bodyparts

The points recorded by the cameras of the measuring frame are used for the automatic separation of the body parts. Based on the calibration the real x and y coordinates of the planar section points can be determined from the image points and together with z coordinate provide the points of the body surface in 3D (Figure 2). Examining the set of points level by level the first step is to determine the centroid of all points at the given level; this will be the origin of the coordinate system. The direction of x and y coordinate axes in plane is the same as the axes defined during calibration.

3.1 Statistics of point-coordinates

A histogram [2] can be prepared based on the number of coordinates with the given x coordinate – by dividing the interval of axis x visible in the image into parts (Figure 4).

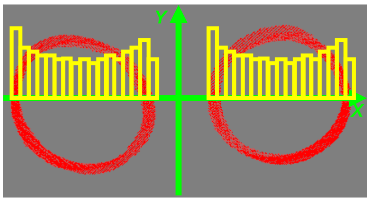

Figure 4. *Histogram of the number of surface points as a function of x coordinate at a given level*

The groups formed this way determine which points belong to which body parts. Figure 5 shows the classification of points of the measurement illustrated in Figure 3 according to body parts.
Furthermore, image processing like activities can be carried out on the grouped body points in order to filter disturbing light effects coming from the environment.
In the first step only those spatial points are considered the distance of which from the axis of the body (the vertical centroid axis of all points) do not exceed 0.75 m. Attention has to be paid to this when positioning the person to be measured.

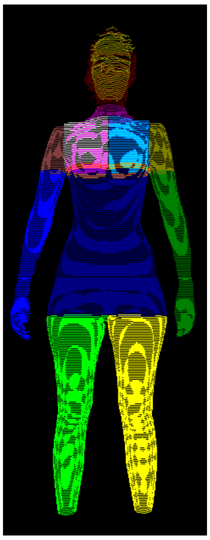

Figure 5. *Histogram of the number of surface points as a function of x coordinate at a given level*

3.2 3D Filtering

After the determination which point belongs to which body part image processing activity continues in the space the aim of which is to filter wrong points. The centroid (*S*), the expected value of the distance (*M*) and the deviation (*D*) of the points from the centroid of each group at each level is determined. Only those points are considered at the body parts the deviation of the distance from centroid *S* of which does not exceed expected distance M with more than a given multiple of deviation *D* (Figure 6). The value of the multiple (*szor*) changes from body part to body part based on experimental calculations.
As the strongly enlarged image in Figure 7 shows, the width of illuminated surface curves is 6 to 8 pixels depending on the resolution applied.

Figure 6. *Filtering of body parts*

The points of the curve could be determined with conventional image processing methods; however the surface curves were approximated with trigonometric regression, sections of Fourier series [3]. The independent variable of the approximating function is angle φ belonging to the point. φ is the angle between the line defined by the centroid of the point and the point array and axis *x*. This angle can be calculated directly from the centroid of the point array and the actual point. This way the image can be filtered further and the surface curve can be approximated as well. Figure 8 shows the approximating curve defined this way in the cross section of the thigh. The question how large the error of the regression approximation of the 6 to 8 pixel wide laser line is arises.

4. Measuring on the Model

There are different types of dimensions to be measured on the body model. The easiest dimension type is the height of a defined point of the body e.g. tarsus on Figure 9. The position of the tarsus point is defined automatically by separation. The value of z coordinate is the same as the higher points of leg or length of legs. The other types of dimensions are perimeter sizes at a defined body position. Such dimensions are perimeter of thigh at the tarsus or perimeter of body at the armpit. The perimeters are measured with numeric integral of the rectified curve the cross section of the actual body parts. Program has to search of special point of body the define the third type of dimensions. Perimeter of knee can be measured only after searching for the knee joint. Determination of perimeter of hip and perimeter of waist should be defined an interval and the maximum value will be the perimeter of the hip and the minimum will be the perimeter of waist. There is a Windows application to measure different body sizes (Figure 10).

***Figure 7**. Enlargement of the illuminated surface*

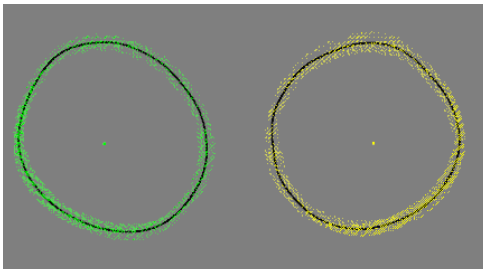

***Figure 8**. Fourier approximation of thigh cross sections*

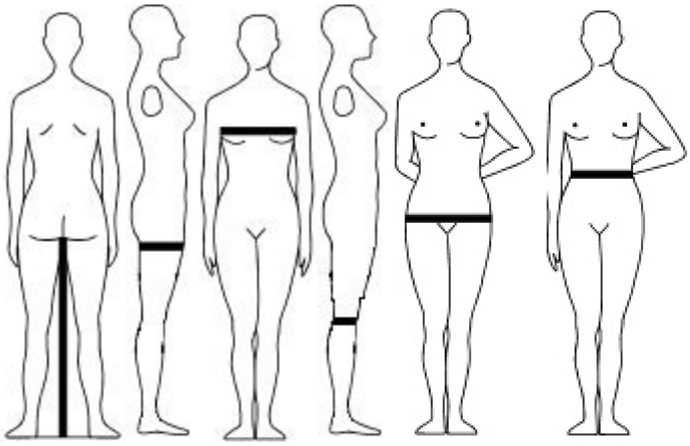

***Figure 9**. Different body sizes*

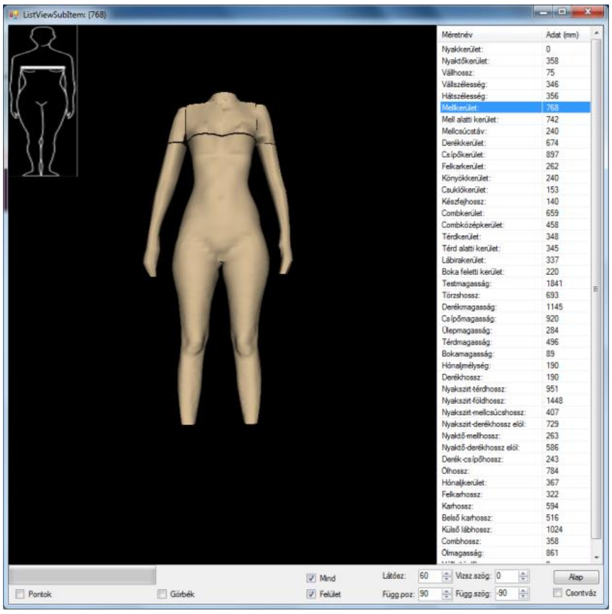

***Figure 10**. Virtual surface of the body and measuring of body's data*

5. Relationship between Basic Body Sizes and Shape

An expert system is based on series of measuring producing digital body model upon traditional tailors' data by data-mining techniques.
Measuring data, joint coordinates are computed from 3D scanned data vertices of interpolating patches computed from point cloud are stored in a database. Traditional tailors' data measured as distances of points or length of surface curves in body model shown in Fig. 10. are stored also in database. The aim of database is the definition positions of vertices as the function of traditional body sizes.
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 [4]. In other words for a given set of measured tailor parameters (on the left side of Fig 11) 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 [5]. 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. 11).

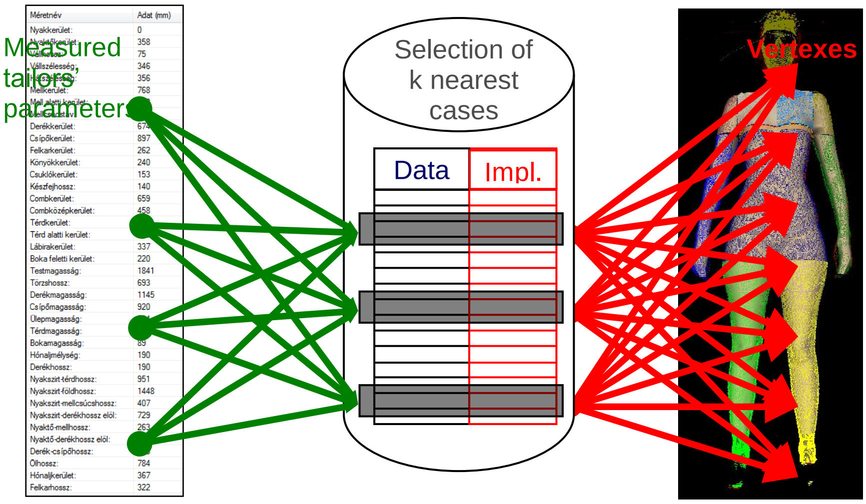

***Figure 11**. Expert system of body's data*

Acknowledgements

This work was supported by the National Development Agency (NDA, H), Ministry of Science, Education and Sports of the Republic of Croatia (HR) and the Slovenian Research Agency (ARRS, SI) as part of the project GERINCO2 (TECH_08-A1/2-2008-0121, NDA), as well as of the S&T projects SI-20/2009 (NDA) and HR-37/2008 (NDA) respectively.

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