AUTOMATIC DETERMINATION OF BODY SURFACE DATA

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Abstract

A 3D apparel design system is developed in the cooperation of the Department of Polymer Engineering and Department of Information Engineering at BUTE. The main part of this system is the line laser 3D surface reading device, which is to be introduced in our presentation. This equipment is capable of investigating both the dimensions of the human body and the behavior of draperies. In this process a thin horizontal laser line is projected on the examined surface and an image is taken with a CCD camera from a position higher or lower than the projection point. The distortion of the laser line reveals the shape and dimensions of the surface. The principle of operation, the set-up of the planned structure, measurement evaluation and results of the experiments will be detailed.

Key Words, 3D body scanner, image post processing, 3D apparel design, laser measurement technics

1. INTRODUCTION

Virtual clothing is the new trend in textile development. The evolution of the internet means that probably more and more people buy their clothes on the internet without any contact with the shops. For this reason several companies and universities carry out research on parts of this huge project. The most difficult point of this work is to build a 3 dimensional human body scanner. Human body is a difficult area to scan because it contains hillocks, valleys and covered points, too. Finally, people can't stay motionless for a long time. The main part of the 3D body scanner is picture processing, which should produce suitable accuracy in short time in spite of the limited resolution of pictures. The aim of this paper is to present a simple method for scanning, especially for human body scanning and to give an example of picture post processing (Szabó, Halász, 2004).

2. THE METHOD OF SCANNING

The triangulation measuring principle (*Fig. 1*) is used in the laser line measuring system. The basic measuring principle of this method is to use the triangulation relation between the projected point and the original point to calculate the position information of the points on the object surface.

The first step is to determine the γ angle from Eqn. (1), in which b_y gives rise to the projection of y distance. Variable y is the sought perpendicular distance from the basis plane. Variable T shows the distance between the optical unit and the basis plane. Distance T_v is the digression of laser from the camera in vertical direction (1). (Sajti, 2005)

$$\gamma = \arctan\left(\frac{b_y}{\sqrt{T^2 + T_v^2}}\right) \tag{1}$$

After γ is determined, angle ϕ is definable. Angle α can be calculated with the help of function tg (2).

$$\phi = 90 - \alpha - \gamma \tag{2}$$

The last step is to calculate the dimensions of the y distance with the aid of angle ϕ (3).

$$y = T - t = T - T_v \cdot \tan\phi \tag{3}$$

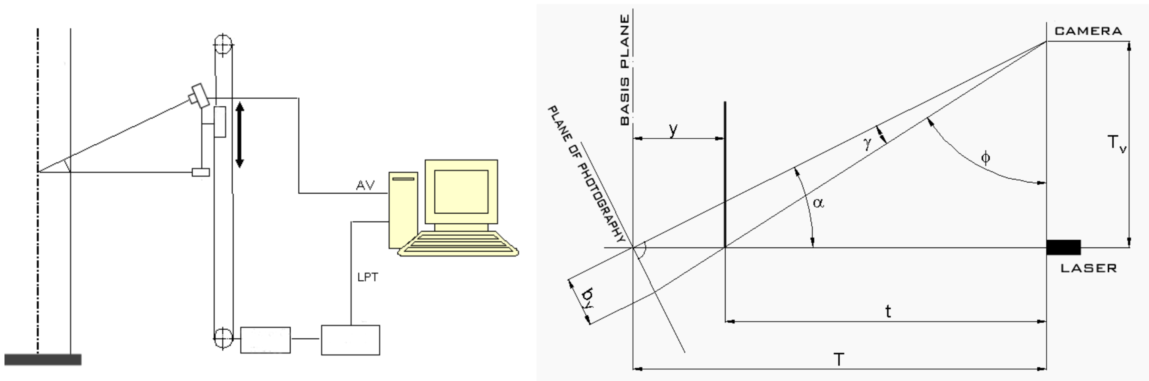

Figure 1 Operation principle of the 3D human body scanner

The CCD camera, which is placed at an angle to the light beam, is used to capture the deformed white line on the object surface. Then the computer transforms the pictures to a 3D computer model. In Figure 2 the result of the photography can be seen. The line is usually 2-3 mm thick without vibration. The optical unit moves up and down and hence resonance may occur, and as a result the laser line becomes thicker. For this reason the measuring program searches the centre of the white line with high accuracy.

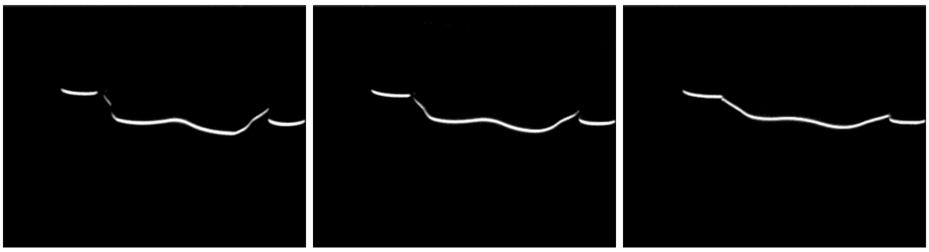

Figure 2 Results of the 3D body scanning

3. IMAGE POST PROCESSING

The pictures contain all important information absolutely necessary for measuring but the evaluation method is not easy. The essential expectation of the measuring device is velocity, since nobody can stand without moving for a long time.

3.1 Pixel-graphic way

During the system measures, some problems which can change the accuracy may occur. The program has to recognize and correct those. The main problem is vibration of the optical unit. The

mover step motor revolves cyclical so if the motor frequency comes near to the working frequency of the system, the optical unit will resonate and there will be two or three times thicker lines in the pictures. On the other hand, the brightness of the line will not be continuous. In a thick line with wave brightness it is much more difficult to find the basis point (e.g. central point of the line's cross-section).
The second problem is the environment of measurement. If it is possible, the process has to be completed in total darkness. That would be the perfect background but it is difficult to achieve. Hence, the pictures contain mistakes (small pints, reflecting lines, etc.).

The system uses a CCD camera with AV connection to the computer. It gives 720*576 pixel resolution in 16 bit greyscale mode. All pixels of the grey picture has R(ed), G(reen) and B(lue) code like the color but here all components are always equal. Thus, it is easier to work with these pictures because the program has to check only one component, for example red color. The value of the red color should change from 0 (black) to 255 (white). That is enough information to start the image post processing.

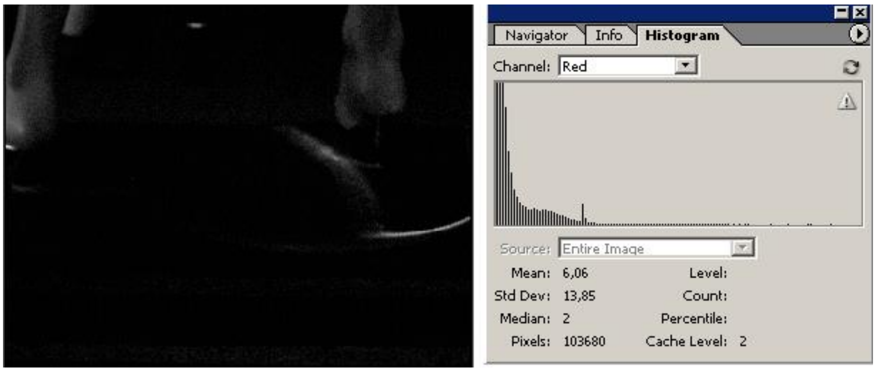

Figure 3 Histogram of the picture

The histogram of the pictures is very important for the post processing. The histogram is the relative incidence of the colors in the pictures (*Fig. 3*). It helps to find a threshold for finding the edge. It is essential because the program has to select the black (under threshold) or not black (equal or over threshold) pixels and computes the central of this white line. From the environment the pictures have a background colour, which is usually not completely black although the black color would be the best. Hence, the program searches the colour which occurs in the greatest number in the picture and chooses a threshold near this color but above it (Winkler, 1996).

The process starts from the first column of the picture and proceeds to the last column and examines the colour of the pixel. The result of this investigation gives a number between 0 and 255. 0 means black and 255 is the white colour. If the program has defined the threshold, it can search the beginning and the end pixel of the horizontal white line.

The process runs from two directions. First it moves from up to down and from down to up. So it has two points which show the boundary of the white line. From these two pixels the centre point can be computed and attached to a pixel coordinate. If this point can be found in the boundary of pixels, the computer will choose one with random method.

Sometimes a small error-patch can be found in the picture far away from the important white line. (e.g. see *Fig. 4*). In this case the program computes a bad centre point. It can happen quite easily, since the environment is usually not completely dark. Some picture manipulation (change of brightness and contrast) can help to reduce these mistakes. The program has to determine the distance between two pixels. If the distance is significantly bigger than that of the white line, the program will modify the threshold. In this case the program will duplicate the value of threshold. Before the scanning process the user has to supply the program with this information (tube in *Fig. 4*).

The program has been written in Visual Basic 6. This programming language is very simple and easy to understand, but it is not recommended for image post processing because it is very slow.

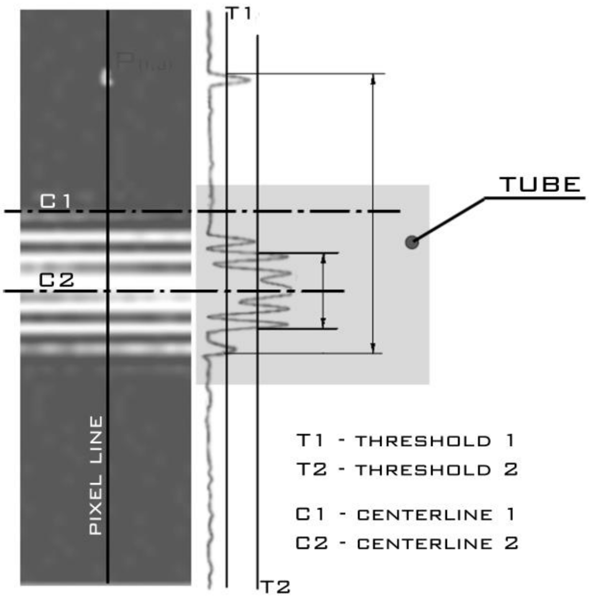

Figure 4 An example of pixel-graphic post processing of an image

3.2 Method with higher accuracy

The accuracy of the measuring system requires higher and higher resolution but larger pictures need larger storage place, more computing time, and hence increase the possibility of making a mistake. The next step is to determine the exact point of intersection of the threshold and the curve. Points have to be bound together with a certain curve. For this purpose, three types of methods can be applied usually: Coons-Hermite interpolation, Bézier approximation and B-spline approximation. In this work the B-spline interpolation was chosen as the optimal procedure (Halász, 1994).

The references reveal methods which can be applied to determine the points of the curves. The B-spline interpolation is different from approximation, because in this case the curve touches the points earlier. It is very important, because the best accuracy can be achieved in this situation. This is the reason why the best method for this work is the B-spline interpolation, which can calculate the curve from four known points. For computing the base functions have to be specified. Luckily C. de Boor, M. Cox and L. Mansfield defined the base functions of B-spline, shown in Eqns. (4), (5), (6), (7) (Csirmaz, 2004).

$$B_0(t) = \frac{(1-t)^3}{6} \tag{4}$$

$$B_1(t) = \frac{1+3(1-t)+3t(1-t)^2}{6} \tag{5}$$

$$B_2(t) = \frac{1+3t+3(1-t)t^2}{6} \tag{6}$$

$$B_3(t) = \frac{t^3}{6} \tag{7}$$

The equation of the curve can be calculated from a cubic, periodical B-spline function. The equation after reduced with a fraction is shown in Eqn. (8).

$$r(t) = \frac{1-3t+3t^2-t^3}{6} * p^*_{i-1} + \frac{4-6t^2+3t^3}{6} * p^*_{i} + \frac{1+3t+3t^2-t^3}{6} * p^*_{i+1} + \frac{t^3}{6} * p^*_{i+2} \tag{8}$$

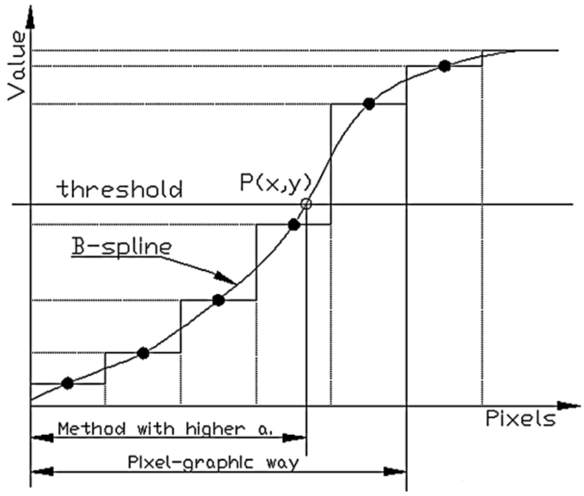

Figure 5 Compare the two methods

If the program knows the positions of those two pixels it can calculate the cubic equation of the curve between the two pixels. For the curve the program is acquainted with four positions of point. Then the computer can formulate the cubic equation of the curve (9):

$$P_k(t) = at^3 + bt^2 + ct + d \quad (9)$$

If the threshold and this equation are used, the point of intersection is well determinable with higher accuracy precision than in the pixel method (*Fig. 5.*). If the method can work with very high precision without pixel dependency, the image post processing requires a smaller resolution picture. Hence, the efficiency of processing is improved what reduces the resolution of the picture. (*Fig. 6.*)

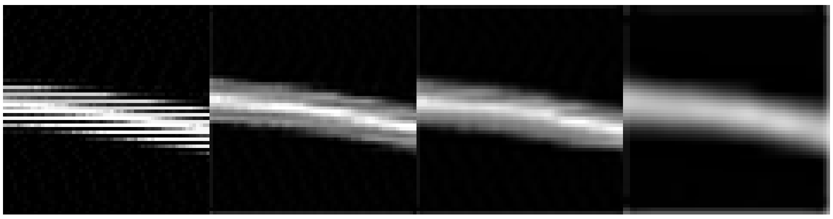

Figure 6 Same pictures with different resolutions (720*576, 540*400, 350*260, and 160*120 pixel)

At the end of the measuring the program can represent the all points in 3D. You can use this result for properties measuring, surface modelling, and animation

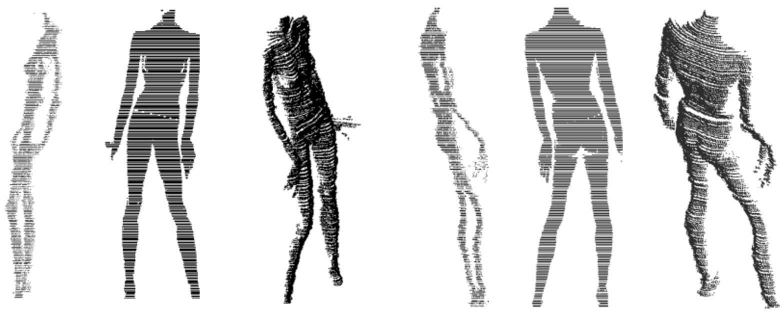

Figure 7 Results of new process

4. CONCLUSION

In this paper, the problems of image post processing of 3D scanned images have been discussed. Finally, a model was found that requires photos with less resolution. The time of processing was reduced, smaller hard disk storage place is required, and the mathematical base is strong and work well and altogether these features make this method very useful. Hence, post processing of pictures is very efficient. Particular cases and their solution have been presented.

5. REFERENCES

Csirmaz, L. (2004). Nagy pontosságú képfeldolgozás (High Accuracy Image Processing), Available from: http://www.renyi.hu/~csimarz/alkmat1.pdf, [22.03.2005].

Winkler, G. (1996). Image Analysis, Random Fields and Dynamic Monte Carlo Methods, Heidelberg, Springer

Lánczos, K. (1976). *A geometriai térfogalom fejlődése (Development of geometrical space concept),* Gondolat Kiadó, Budapest

Fisher, R., Perkins, S., Walker, A., Wolfart, E., (2005). *Hypermedia image processing reference*, Available from: http://www.dai.ed.ac.uk/HIPR2 , [02.03.2005].

Ammeraal, L. (1986), *Programming Principles in Computer Graphics,* John Wiley & Sons.

Halász, M. (1994), *A számítógéppel segített konfekcióipari szériázás elméleti alapjai*, PhD work. Budapest University of Technology and Economics, Faculty of Mechanical Engineering

Szabó, L., Halász, M. (2004), *Line-laser surface scanning machine planning for the 3D apparel industry,* Gépészet 2004, 4th conference on mechanical engineering, Budapest, Hungary, 27-28 May 2004, p. 490-494.

Sajti, R. (2005), *Mérések az emberi test ruhaipari célú meghatározásához (Measuring human body properties for the apparel industry)* diploma work, Budapest University of Technology and Economics, Faculty of Mechanical Engineering

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