DEVELOPMENT OF THE IMAGE POST PROCESSING OF A 3D HUMAN BODY SCANNER

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ABSTRACT

The 3D human body scan system is developed in the cooperation of the Department of Polymer Engineering and the Department of Information Engineering at BUTE. One of the main parts of this system is a line laser 3D surface reading device. This equipment is capable of investigating the dimensions of the human body.

The feed data device of the machine is a CCD camera which sends all the data in unpacked (bmp) picture format to the computer. The measure process demands that the processing device should be enough fast and exact for apparel purpose. In this paper we show a new method which can reeducates the time of the image post processing without loosing of the data.

KEYWORDS

3Dbody scanner, image post processing, 3D apparel design

1 INTRODUCTION

The 3D system is developed in the cooperation of the Department of Polymer Engineering and Department of Information Engineering at BUTE. One of the main parts of this system is the 3D body scanner, a line laser 3D surface reading device. This equipment is capable of investigating the dimensions of the human body. One of the most important parts of the system is the equipment for scanning 3D surfaces. The input of the system is a CCD camera, which transfer the recorded data as a picture (BMP) to the computer, which process the data. The measurement requires fast and precise processing of huge amount of data.

In the present paper we show the structure and the scheme of scanner, the problem concerning the image processing, and the possible solution of these problems. In this paper we point out how it is possible optimize the process with the reduction of data.

2 THE STRUCTURE AND SCHEME OF THE BODY SCANNER

The scanner is built up of 3 major parts (figure 1). The first, it contains the mechanical structures of the machine. The Alvaria frame, which is made of aluminum, is responsible for the adequate stability, low weight, simple and fast re-building of the machine, moreover the good surface quality and the required moving accuracy of the optical unit. The elements are fixed to each other with fast fixing “hammers”. For the fixation, the utile, which are not standard, were made in the laboratory of the Department of Polymer Engineering. For the move of the optical unit a step motor and cogged belt drive is responsible, which is to assure the adequate positioning of the unit.

The next main element of the scanner is the optical unit, which is of the laser diode and the CCD camera. They close fixed angle and are exact distance far, and during the scanning they are moved vertically, simultaneously. Both diode and camera can be set precisely and reproducibly in 3 degrees of the freedom.

The 3rd one is the computer aided controller, data receiver and processing unit. The drive of step motor receives the controlling sign from serial port of the computer, and the CCD camera sends the recorded pictures to a PCTV card, which saves them, in predefined periods. Although the architect is still under construction, it has been already possible to make test runs. A multi-task operation system induced controlling problems; the reduction of image processing time; the improved precision could be the possible ways of developing.

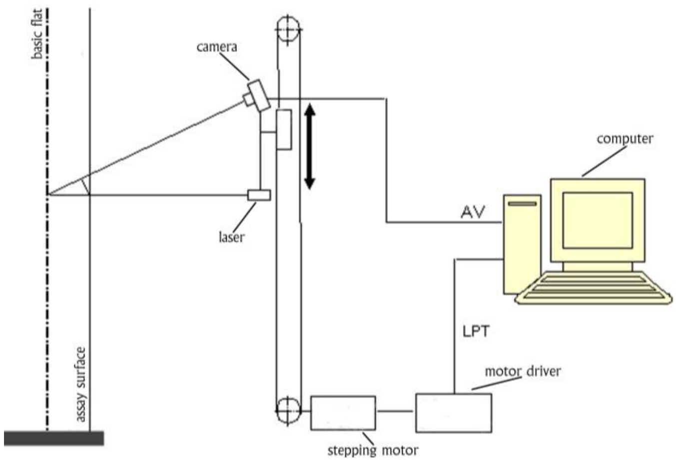

Fig.1. Theoretic scheme of 3D Body Scanner

The theory of the measurement (figure 2) is based on the theory of Linnik-Schmaltz surface scanning instrument [4]. During the scanning, the laser resource projects a horizontal red line on the investigated surface, which is in front of the basic vertical plane, and a CCD camera takes pictures from a higher position. The light-line has a deformed shape depending on the geometry of the specimen. The basic plane, the camera, the projector and the surface has defined positions, and these data, and pictures make possible to calculate the lighted section of the volumetric geometry. The vertical move of the scanner, which is frequent enough, makes possible the whole body scanning.

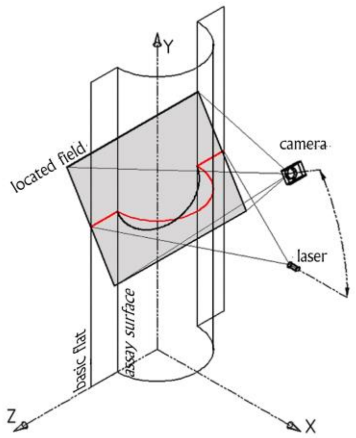

Fig.2. The scheme of the measurement

3 IMAGE PROCESSING SYSTEMS

3.1 The task of image processing in case of a Sylvie® 3D Body Scanner

The recorded pictures are grey-scale and digital ones and transferred to the computer. Each picture, taken by the CCD camera, contains the laser light-line deformed to the scanned surface (figure 3). With the processing of thee pictures we can obtain the scanned person 3D-body sizes.

3.1.1 The amount of the data processing entity

The resolution of the recorded pictures is 720*576 pixels. For total scan of an average size adult approximately 320 pictures are needed, half of them is in front, and the rest is from backside, because the scan must run from both directions. Each image has the size about 1200 kByte (24bit), it means that the total amount of the data of the scan-run is close to 400 MBytes. However the computer science is well developed, but this amount of data still could cause difficulties. That's why one should think how it is possible to reduce the data size without loosing any relevant information.

Fig.3. Typical pictures during measuring

3.1.2 The quality of the processed pictures

The digital images can be utilized for measurements, because after the size calibration of the horizontal (x coordinate) and vertical pixels (y coordinate), the distance of any two points of the digital picture can be determined. The problem concerning the scanned pictures is that the red laser light is a grey-scale line on the black and white pictures (figure 3). The purpose of the image processing is to achieve that thin-line which defines the surface the most proper way.

At the same time, you can find other bright spots on the picture (e.g. figure 4. P(i,j)), which are disorder signs (interferences) during the image processing. The disorder should be removed as much as it is possible.

3.2 Methods of the image processing

The simplest way would be if we approached the lane, resulted from the laser line, with the upper or lower edge of it. The pixel is processed vertically as pixel-column (y coordinate). During the edge-searching we test when the grayness-index of pixels bestrides a threshold. Reaching the threshold is done. The quality of the solution depends on the wide of the lane, and the chosen threshold. The more spots are on the picture, the wider the lane is; the less precise the result is. To achieve the needed precision this method cannot be utilized.

To have a more correct solution, first of all we have to record the grayness-index of the whole pixel-column, and we plot it in function of y coordinates (figure 4). The envelope of the diagram is more-or less a Gauss curve, it means that the grayness index has a absolute maximum value. It is obvious hypothesis that the needed curve is the maximum points of pixel-columns.

First approximation is that the searched pixel is the brightest, having the highest grayness index, in the pixel column. At first sight we don't need to do anything else, just choose this point. But due to the highly focused light the pictures are "burnt", it means that we can find more totally white pixels. As the direct method of the detection of the maximum point of the Gaussian curve, so approximation is needed.

We assume that, the lane is symmetric, so the maximum of the bell-shaped curve is on the center-line. First we determine the upper and lower edges of the lane, then we bisect their distance and we declare as the maximum point. We have developed two methods for determining of the edges of the lane.

3.2.1 Pixel testing for edge-detection

The first method of the detection is to find the upper and lower contour points based on the grayness-index of the pixel columns (figure 4). The maximum is defined as the bisection of their distance. If the maximum point is exactly on the bound of two pixels, one random generator makes the choice between them (figure 6.).

If we don't take into account the spots out of the strip during the contour-searching (e.g. figure 4. point P(i,j)), it can happen with the chosen threshold (figure 4. T1) that the center line of the strip is not correct (figure 4., C1). That's why we use a gap, which has a thickness equals to the thickness of the lane. If the distance of the certain contour points is larger than the thickness of the gap, the threshold value will be raised automatically (figure 4. T2), and the scanning of contour points restarts. This method is applicable to remove the major amount of the noise of the picture.

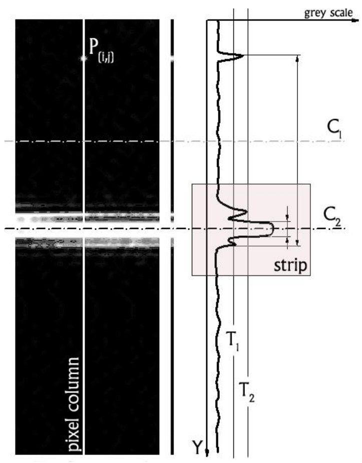

Fig.4. Grey scale changing in pixel column ($P_{(i,j)}$ smudge (noise), C_1, C_2 centerlines, T_1, T_2 thresholds)

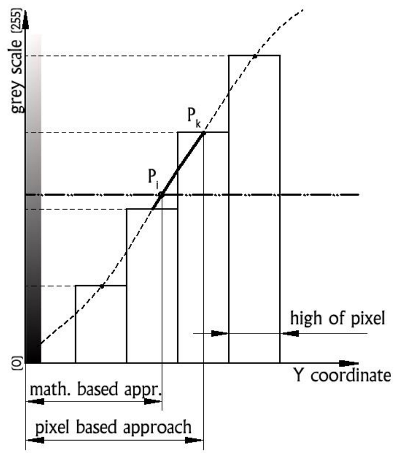

Fig. 5. Comparison of edge-detection procedures

Based on our experience we can say that it is a simple and fast process but precise enough. Figure 6. shows the estimated position of the contour.

3.2.2 Searching of contours by interpolation

This method is more precise then the previous one. The first step is the same as before, we have to obtain the grey scale of the pixel column, than we place a curve on these points. (figure 5.) We are looking for the intersection of the threshold of the contour-searching and the grayness curve, then we apply mathematical methods to calculate the exact position of the intersection [5].

To describe the grayness curve we use B-spline interpolation [6]. To know the equation of the curve between two points, the two endpoints (figure 6, P_2 and P_3) and points next to them is needed (P_1 and P_4). Four points make it possible to calculate the parametric (t), cubic equation (figure 6. V_2(t) equations) separately to X and Y coordinates.

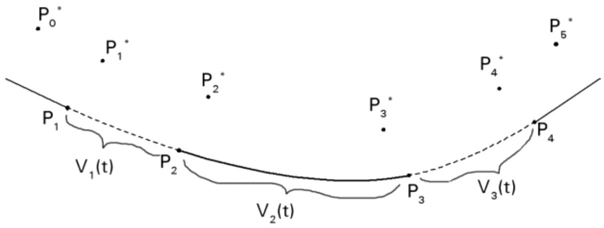

Fig.6. Notations of B-spline and referring points

The equations of the needed curve-section $V_2(t)$ can be written as:

$$V_2(t) = \frac{1}{6}\left[\left(-t^3 + 3t^2 - 3t + 1\right)P_1^* + \left(3t^3 - 6t^2 + 4\right)P_2^* + \left(-3t^3 + 3t^2 + 3t + 1\right)P_3^* + \left(t^3\right)P_4^*\right] \qquad (1)$$

Equation (1) contains 4 parameters and to define them the following equations can be used.

$$V_1(t) = \frac{1}{6}\left[\left(-t^3 + 3t^2 - 3t + 1\right)P_o^* + \left(3t^3 - 6t^2 + 4\right)P_1^* + \left(-3t^3 + 3t^2 + 3t + 1\right)P_2^* + \left(t^3\right)P_3^*\right] \qquad (2)$$

$$V_3(t) = \frac{1}{6}\left[\left(-t^3 + 3t^2 - 3t + 1\right)P_2^* + \left(3t^3 - 6t^2 + 4\right)P_3^* + \left(-3t^3 + 3t^2 + 3t + 1\right)P_4^* + \left(t^3\right)P_5^*\right] \qquad (3)$$

$$V_1(t = o) = \frac{1}{6}\left[P_o^* + 4P_1^* + P_2^*\right] = P_1 \qquad (4)$$

$$V_2(t = o) = \frac{1}{6}\left[P_1^* + 4P_2^* + P_3^*\right] = P_2 \qquad (5)$$

$$V_2(t = 1) = \frac{1}{6}\left[P_2^* + 4P_3^* + P_4^*\right] = P_3 \qquad (6)$$

$$V_3(t = 1) = \frac{1}{6}\left[P_3^* + 4P_4^* + P_5^*\right] = P_4 \qquad (7)$$

The used equation system for B-spline interpolation can be solved with Gauss-elimination, but in this case only we need to calculate only the equation of the curve of two points, therefore the unknown parameters for the last 4 equations $P_1^*, P_2^*, P_3^*, P_4^*$ can be calculate as the function of P_1, P_2, P_3, P_4 points. If their value we put into $V_2(t)$ equation, we can obtain the equation of the searched curve in the interval of $t \in (O,1)$.

If we know the equation of the curve section we can calculate the threshold value and the curves intersections with high precision. We have to do it in case of determining of both upper and lower contour points, then the half of the connecting straight line is the maximum point.

This method makes the calculation tasks of the image processing increase, on the other hand, due to the radical decrease of the resolution (e.g. from 720x576 to 320x240) (figure 7.), the decreased amount of data makes the needed time less. This decrease in resolution makes the processing faster at more levels. The smaller picture can be saved faster, loading and processing time is shorter, etc. It means that this method is significantly faster than the previous method.

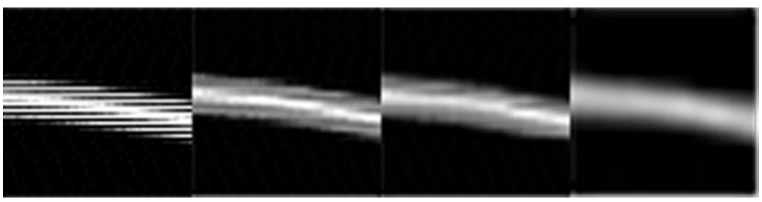

Fig.7. View of laser line at resolution decrease

After the necessary calculations we have the contour of all the horizontal slices of the body, which makes possible to build up the virtual model of the body, and the needed sizes can be measured.

4 CONCLUSIONS

The image processing of the Sylvie 3d body scanner is to define the middle line of the grey scale Strip resulted by the laser. The first step is to find the upper and lower contours, and we applied and compared two different methods for it.

First method is based on the investigation of pixels, which is simple with reliable results. The precision for textile industry is suitable, if the resolution is high enough. The precision can be improved by the increasing the resolution, but it, results increasing size of the pictures, makes the processing longer.

The other way is the interpolation of curves on the contour, which is more accurate then the first method due to the calculation process. The disadvantage is the longer calculating time which is not significant due to the modern computers. The advantage is that we can assure the adequate precision beside lower resolutions, resulted in smaller amount of the recorded data, and also the processing is less, which makes the whole working time less.

The used instrument had less than 5% percent error during the test runs, which is acceptable for the textile industry.

REFERENCES

1. M. Halász, Á. Antal: Application of Moiré method for anthropometrical analysis, Proceedings of the third conference on mechanical engineering, Budapest, May 30-31, 2002. p. 795-798.
2. B. Sandag, M. Halász: Determination of human body measurements with conventional measuring and optical method; InTechEd'02, Budapest, April 24-25, 2002 p. 858-862.
3. L. Szabó, M. Halász: Line-laser surface scanning machine planning for the 3D apparel industry; Gépészet 2004, Budapest, 2004, p. 490-494.
4. G. Vöneky, G. Juráwt: Hossz- és szögmérőműszerek a gépiparban; Budapest, Műszaki Könyvkiadó, 1955
5. L. Csirmaz: Nagy pontosságú képfeldolgozás (High Accuracy Image Processing) Available from: http://www.renyi.hu/~csimarz/alkmat1.pdf, [22.03.2005].
6. G. Renner: Új interpolációs módszerek a számítógéppel segített tervezésben; Kandidátusi értekezés, Budapest, 1989.
7. L. Szabó, M. Halász: Automatic determination of body surface data; AUTEX 2005, 5th world textile conference, Portoros,Slovenia 27-29 June, 2005 p. 715-719.

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