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SPECIAL APPLICATION OF 3D HUMAN MODELING BASED CAD/CAM SYSTEMS FOR CLOTHING INDUSTRY

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Abstract:

CAD/CAM systems have more and more importance in clothing industry. The most common approach is to use 2D methods for the solution of CAD problems and specialized CNC equipment and software for CAM realization. Recently, we are engaged with a special problem which is the designing and realization of corsets for spinal disorder correction. This is a special problem but, it seems to us, that the results may be used widely in clothing industry. The production of corsets for the correction of spinal disorders recently is concerned with painful procedure of getting geometrical models and mostly handwork based manufacturing. The production and the product are not flexible at all. Our recent research and development works are directed to get 3D models by scanners. An 1D motion and 4 video-cameras and a 6D robotic motion and laser length measurement device systems were developed. Based on the 3D models after medical corrections the corsets are to be manufactured by modern CAD/CAM systems. Rapid prototyping, dieless sheet metal forming (DSF) and other methods are considered and promising. Extended research on materials, the usage of sensors, etc. are planned. The results are important from anthropomorphic measurement aspect, too.

Keywords:

CAD/CAM in closing industry, 3D human modeling, robot use, robotic CAD/CAM, spinal disorders, corsets

1 INTRODUCTION

CAD/CAM system are increased on the textile industry. The methods can be extended for realizing devices for spinal disorder correction. Spinal disorder (Figure 1.) is dangerous and widespread disease for young girls, nowadays. Spinal disorders may be corrected by gymnastic, corsets and operations. Every case is individual. It is very important that the disorder should be detected as early as possible. After computer aided diagnostics (CADM Computer Aided Diagnostic in Medicine) if necessary an automatic custom-made corset could be realized to make corrections and avoid operations. The primary information for CAD/CAM system is obtained from the special 3D modeling of humans device. The corsets may be realized by specialized CNC machine tools but robots can be used for this purpose us well. Of course, this last, promising opportunity needs extended research work. One way to go on is to use the idea of DSF (Dieless Sheet-metal Forming).

Figure 1. Spinal disorder

2 PRESENT SITUATION OF CORSET MAKING

Nowadays corsets are made from thermoplastic polythene (Figure 2.) by unique made gypsum master. Wearing gypsum sampling is very hard physically as well as psychically. Our aim is to mollify distresses of patients. We want to reform the sampling, material and manufacturing of corsets, and the efficiency of treatment.

Figure 2. Corset

3 MEASURING PROCESS

We developed a filtering system based on the well known Moiré method [1]. Corsets are not only negative of the body surface. There are some supports defined by doctors. Measuring [2] and manufacturing the corset we use a special robotized 3D scanner.

3.1 Measuring by cubicle

We use two cooperating computer controlled equipments (a cubicle and a robot) for measuring the surface geometry of the human body. There is a computer controlled moving frame in cubicle. Line lasers installed on the frame scan along the body while cameras rigged on the frame store pictures of the illuminated body surface. The stored pictures are sent to the controlling computer. The machine processes pictures and defines the points of the body surface. There is a 6D robot equipped by a camera and a laser distance-meter measuring the hidden places for the frame (Figure 3). As we want to achieve necessary accuracy for garment trade, we had to calibrate photos of parallel cameras, in order to develop measuring methods as well as to analyze errors.

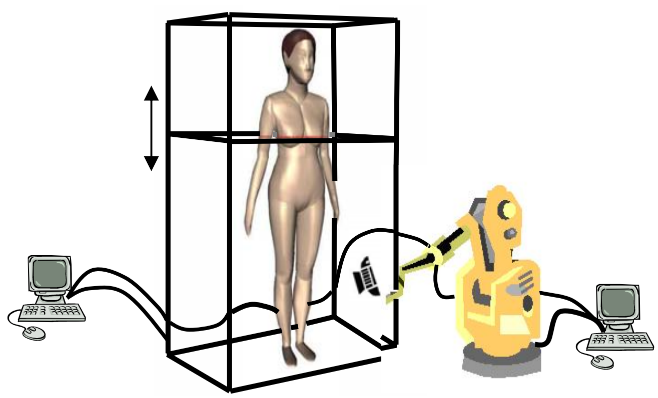

Figure 3. The Measuring Equipment.

The task of the frame is the definition of the points on a two-dimensional curve based on photos. Points of the curve are defined by picture processing methods. The question is only how to define the 3D position of points upon the photo. In order to find the non-linear bijection between the photo and the 3D plane, we used calibration process [2]. There is an automated corner based calibration process integrated. Determination of corner coordinates starts at the corner closest to the actual camera. If we define the point of the edge image in the coordinate system connected to the left-bottom corner of the photo, then regression lines can be defined for every *xs* on section $x<x_s$ and $x>x_s$. Let the error of the regression H is a function of x_s! In other words $H(x_s)$ is the sum of the differences of y_i point coordinates and the $a*x_i+b$ lines with unknown parameters (x_i are point coordinates) in front of the corner and behind the corner Eq. (1).

$$H(x_s) = \sum_{x_i<x_s}(y_i-(a_{x<x_s}x_i+b_{x<x_s}))^2+\sum_{x_i>x_s}(y_i-(a_{x>x_s}x_i+b_{x>x_s}x_i))^2 \tag{1}$$

After calibration surface points of body should be defined by picture processing methods, but the result will be better, if regressed curves are searched. Surface curves on body parts are approached by Fourier series [3]. The angles as the independent variable of the curves are determined from the centre of gravity of point set and the position of points on actual level. Approximating function (R) is the distance from centre of gravity as the function of the angle from x-axis (φ). Only the first $2*n+1$ members of Fourier series are considered where the n is defined differently on different body parts. Unknown Fourier coefficients are determined by least square method. If there are N points on the actual level where the distance and the angle of k-the point is (R_k,φ_k), then ai, bi coefficients are defined by the minimum of (2). Figure 4. shows the results of the cubicle measuring.

$$\sum_{k=1}^{N}\left\{R_k-\left[\frac{1}{2}a_0+\sum_{i=1}^{n}a_i\cos(i\varphi_k)+\sum_{i=1}^{n}b_i\sin(i\varphi_k)\right]\right\}^2=\min \tag{2}$$

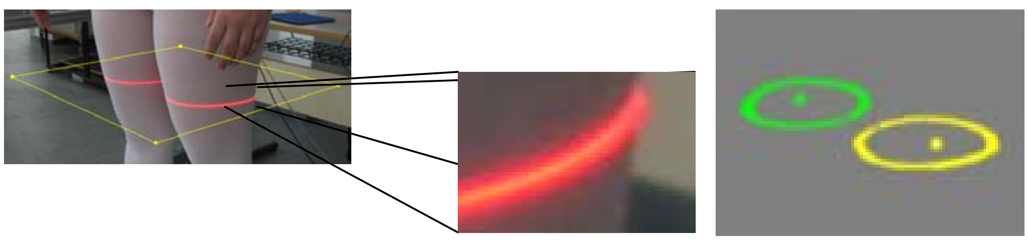

Figure 4. Cubicle measuring

4 MODELLING BODIES

Measured 3D points are used to define the body model. Similarly to the parameterised model [6] body surface sectioned measuring features (Leg, trunk arm, shoulder, neck, head Figure 5). Surface of features interpolated NURBS. Vertexes of surfaces are defined by the measured points. Positions of vertexes of features and surfaces (Figure 6. b.) are determined from curves approximating point cloud (Figure 6. a.).

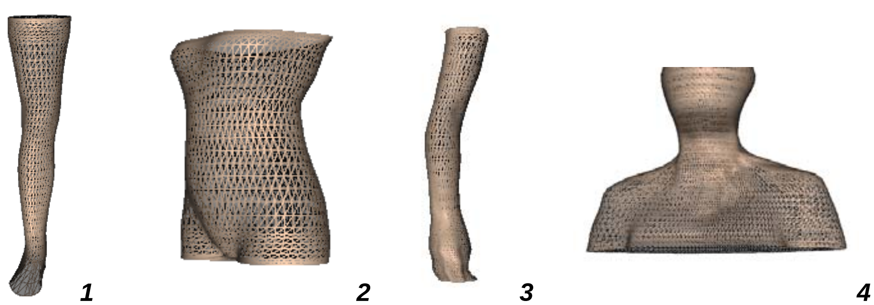

Figure 5. Bodypart features

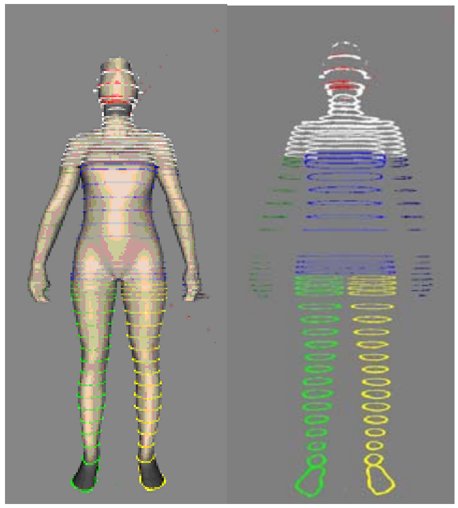

Figure 6. Measured body model

5 MANUFACTURING OF CORSETS

Nowadays the corsets are manufactured by creating torsos from artificial wood based on gypsum models. Torsos are made using a specialized CNC machine tool. Then vacuum forming is applied. The recent research work make possible to realize CAD/CAM principles using CNC machine tools on robots for manufacturing omitting the stage of gypsum models. Even a rather modern approach has chances to be applied, when the torso-making is also omitted. 3D model information is useable for dieless forming 3D freeform sheets. Recently promising research results were published [7] from the field of DSF of polymers. But the publications on this topics have a very low number. So, we should make some original research which gave promising results. Some of our experience will be given below.

For the experiments the same KUKA KR6 robot was used as for the measurements. We had only the opportunity of using one robot. No other supporting robot could be considered. This application is a light force one. We experimented the 2 and ½ D processing method. The materials were: polietilen sheets of proper size.

Different aspects of the above are discussed in [2,3]. For the solution of robot control problems [1] was used.

6 DSF EXPERIMENTS

We should develop the following equipment for DSF realizing:

- We should develop a fixture for sheet holding. It was a properly sized iron frame with fixing holes.(see:Figure 7)
- We developed and realised a forming tool which made possible 3D motion of the forming had.
- We installed the proper equipment for the warming and temperature measurement of the sheet.

Until our experiments, we could only get information on DSF of polymer materials in cool condition. For us it was clear, mostly from the practice of corsets making, that in our case warming is necessary. It was a long way to find the proper temperatures and technological data to get the proper quality of the parts. As an example: a truncated cone forming result is shown (see: Figure 8) which was formed by not proper temperature and data.

After finding the proper regimes, we could realize this part in high quality.

Then, we began to produce trough-like polyetilen parts. The experience gained by the cones was very useful. In a very short time we could find the proper warming regime and data to get good quality parts.
In this case we were faced with other problem. The method of fixation of the part affected very much the quality. The sheet should have fixation stripe close to the forming actions. This is an indication for that fact, that if no two sided processing is used, some additional measures are necessary for providing good quality.
We also made experiments on DSF forming of copper sheets. The sheets were 0.5 [mm] thick. No warming was applied. We formed through-like parts. The experiences were similar than in the case of polyethilen parts.

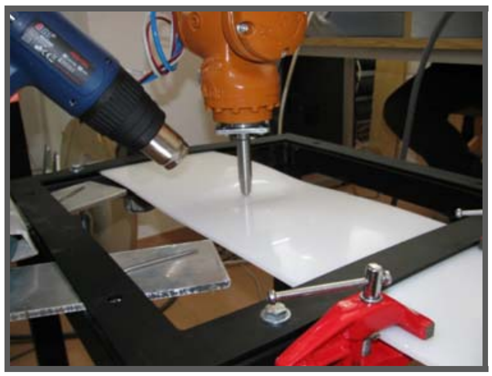

Figure 7. Polyetilen sheet forming by KUKA KR6 robot

Figure 8. Some of the first experiments

Our experiments demonstrated that DSF can be used for making individual sheets of free form in certain size domain with proper selection of auxiliary fixing elements and technological data. (Figure 9.)
Based on our research experiments we have the following consequences:

- Robot KUKA KR6 is very much suitable to realize DSF alone in one sided manner.
- The choice of instrument has basic influence on the success. A tool with 3 degrees of freedom is preferable.
- The fixation of sheets to get proper quality is not a trivially solvable task. It should be solved for individual cases. But, in most of the cases it can be solved with good results.
- In the case of polyetilen forming light warming is necessary. The technological data should be determined by individual experiments. Happily, the quality of parts made by this DSF is not very sensitive to the accuracy of technological data (including the temperature).
- The results of experiments are very bid far.

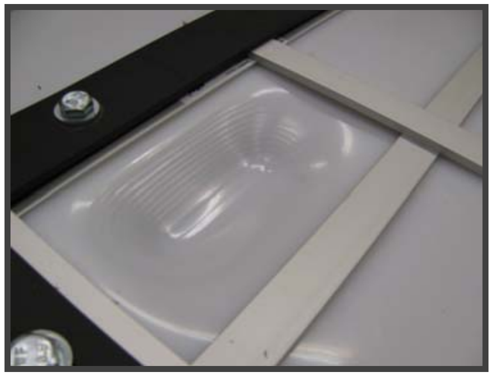

Figure 9. DSF of a trough-like part

7 CONCLUSIONS

CAD/CAM use in clothing industry is an important research, development and application field. Especially promising field is to use scanned 3D human modeling input data, obtained by proper specialized equipment. A special field of application of such systems is the corset making for spinal diseases. For this goal we made experiments to use DSF technology to realize free form polyethylene sheets. The CAD/CAM systems based on 3D human modeling devices and modern technological solutions may get wide application in different fields of clothing industry. We hope that the results outlined in the paper will help to find the most promising research and development fields.

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