3-D body modeling for garment design

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Abstract

This paper describes an experimental procedure to exploit 3D-measurements in garment pattern design. The measuring device and its principle is shortly explained. Usually the measured raw 3D data cannot be used directly neither in garment design process nor in pattern design as a part of it. Some proposals of processing the raw data to get it more useful are given.

1. Introduction

The technology for more automated data capture in apparel design has two major parts. Noncontact digital body scanners are able to measure very dense network of 3D points from human body. Usually hundreds of thousands of points can be measured [7]. The other and obviously more difficult part is the exploitation of the measured data in such a way that better fitting garments can be made for individual clients or for special groups more easily.

At least four commercial digital body scanner systems are available nowadays. Two are from the United States (WB4 made by Cyberware and PMP made by Clothing Technology Corporation) and other two are from the Europe (SYMCAD made by Telmat and the 3D-body-scanner made by Techmat). Our basic measurement principle is similar to those used by Cyberware and Techmat. Light stripes are emitted from laser diodes onto scanning surface and the stripes are recorded by the CCD cameras. The PMP scanner uses a moire-based measurement method where structured-light is emitted from projectors onto human body and the sinusoidal light patters are recorded by the CCD cameras. In the method made by Telmat a camera captures the body silhouette from the front and the side. 50 to 60 special dimensions are calculated from the silhouette data. The important specifications needed by most applications are the size of the scanned volume, the measurement accuracy, the measuremet time (rapid data acquisition is an advantage, a person has less time to move), the environment conditions (normal office or some special environment) and the output data types.

Tape measurements are a major factor in the development of the basic pattern of a garment. They are also a reference for pattern corrections when individual garments are made. Tape measurements are 1-dimensional measures, lengths. The advantage of these lengths is that they have names, i.e. we know from where those have been measured, for example waistline. The disadvantage of these measures is that we do not know their positions in 3D-space. This partly causes the well known problem of fit, i.e. size of the garment and shape of the body do not match well. Fitting problems also occur because of the mistakes in the manual measuring process. The digital body scanners are able to produce large set of 3D point data. The individual points do not have attributes. To define lengths from the point set, the user of the software have to show where the needed space curves are or the software must be able to recognize them automatically. Robust automatic recognition is a hard problem because the shapes of the bodies varies a lot and a body is a smooth surface i.e. it does not have many local features that can be detected easily. In this case the user of the software can help interactively the recognition procedure. The big difficulty is that the pattern making procedures for garment design are not designed to exploit 3D information.

In computer graphics much attention has been paid to visual appearance of animation of clothed virtual models. It is important that the motions of a cloth will look as natural as possible. Usually these cloth modeling techniques use geometry and physics. These techniques can represent cloth models as triangular nets, with points of finite mass [2, 5, 6, 9]. The forces in that model are calculated in relation to other points. These tools can be used for designing garments in a virtual world. The designer creates a 2D shape using interactive graphics. The garment is put on a virtual body (geometric model) under physical laws (e.g. gravity). Corrections can be made if the garment does not fit well. These steps can be iterated as many times as needed. Tailors in the real world use this try on and make corrections procedure. The difficulty is to simulate the real world accurately enough. A cloth is flexible object with many dynamical and mechanical properties.

Some 3D CAD-softwares have so called flattening tools. With the help of the flattening procedures it is possible find out how to cut a correct piece of 2D material for the designed 3D object (for example 3D part of a car body is designed and it is necessary to know how to cut a correct piece of metal from a metal plate). Because the body scanners can produce 3D data the flattening tools can be used for making a pattern out of the skin surface. From the measured data the procedure creates basically too large patterns. A cloth shape does not usually follow the body shape accurately (there are exceptions). Nearly all local surface features can be removed from the measured data. The purpose of this is an individual mannequin (explained in section 3.) of the measured human body. The modified surface is the input for the flattening process. The output should be a basic pattern set that represents well the skin surface of the measured body. The digital mannequin is also better data for interactive length measurements than the original measured data. The usefulness of the idea is under an investigation and it is not possible to give real results yet. It has been proposed that the actual garment design work can also be done in 3D instead of 2D using a special interactive software interface [3, 4].

In section 2. the experimental body measuring is described. Section 3. gives some ideas how to utilize the measured data. The paper concludes with a discussion in section 4.

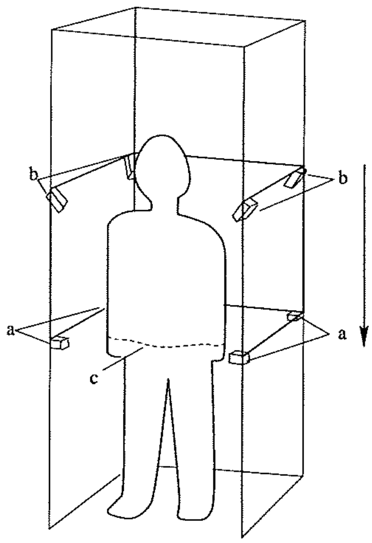

Figure 1: Principle of measuring device. Laser devices (a) projects the stripe (c) on the body. The stripes are recorded by the cameras (b).

2. Measuring of bodies

The bodies were measured using light striping principle [1]. The experimental measuring device is presented in figure 1. Four videocameras and laser devices were attatched to a moving case. The scanning was done by moving the case in vertical direction from top to down. Legs and head weren't in the scope of interest, so they weren't measured. Depending on the speed of the movement cross sections of the body could be collected every 1-10 millimeters. Because standing stable a longer period is not always an easy task for older people the measurement should be done in a quite short time. On the other hand, adding the speed sets more requirements on image grabbing equipments and other mechanics. It also adds vibrations in the measuring device. As a compromise the measuring speed was adjusted so that the distance between adjacent cross sections was a little bit less than two millimeters. This corresponds to 20-25 seconds measuring time depending on the length of the body.
During the measurements the room was darkened so that only the light stripes were visible in the video frames. Video sequences were recorded into AVI-formatted files and processed later frame by frame. Processing consisted of several steps. In order to get one cross section measured the points belonging to the stripes were extracted from the four images. After that the points were projected to the plane defined by the laser devices. This projection was based on the principle discribed in [8]. This point set corresponds to one cross section. The same procedure was done on every cross section level. Different cross sections were put on the top of each other to form the final measuring result. As a result from the measurement three dimensional point clouds were obtained. Because of the huge amount of data only every fifth cross section was used in calculations, which corresponds to 8.7 mm cross section intervals (see figure 2 and 3).

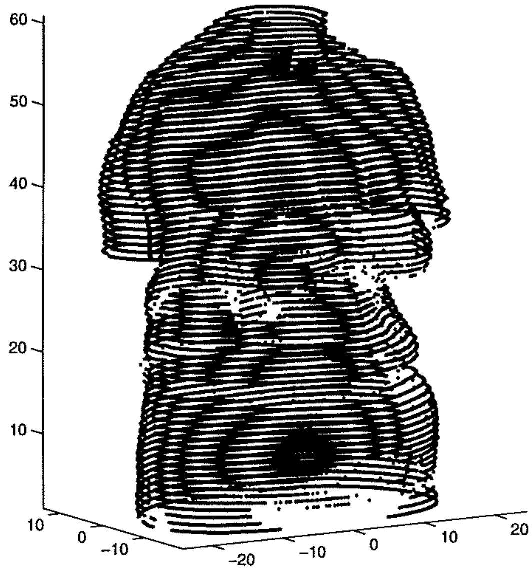

Figure 2: Measured point set 1. The Moire effect is caused by the density of the points. Measuring itself is not based on it.

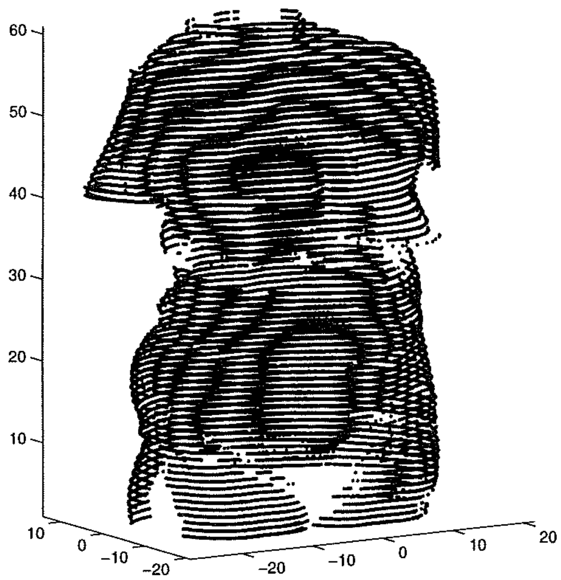

Figure 3: Measured point set 2.

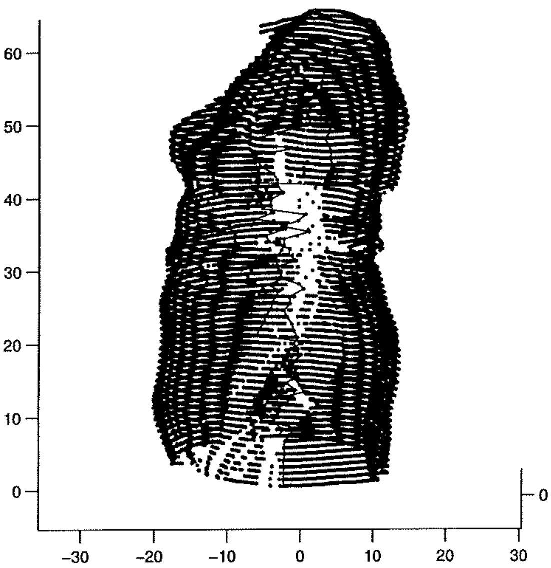

Figure 4: Measured point set 3.

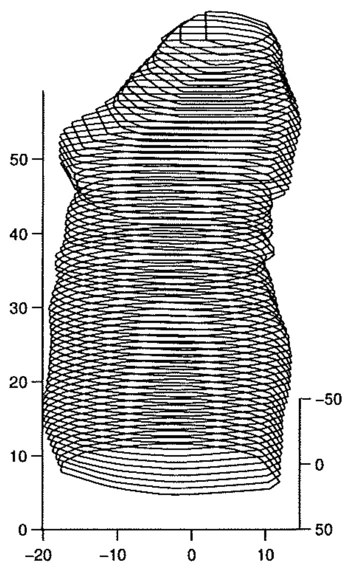

Figure 5: Local horizontal variations removed.

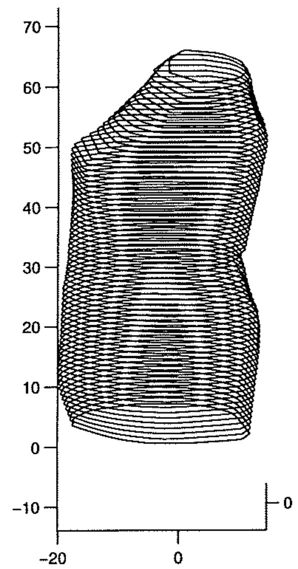

Figure 6: Also local vertical variations removed.

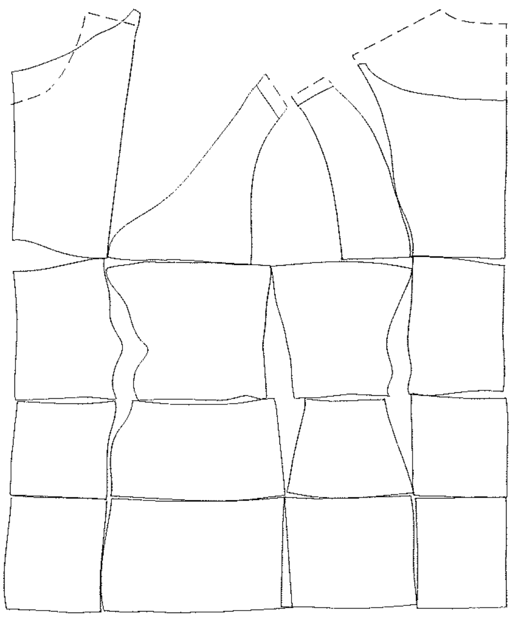

Figure 7: Flattened body surface from the original data.

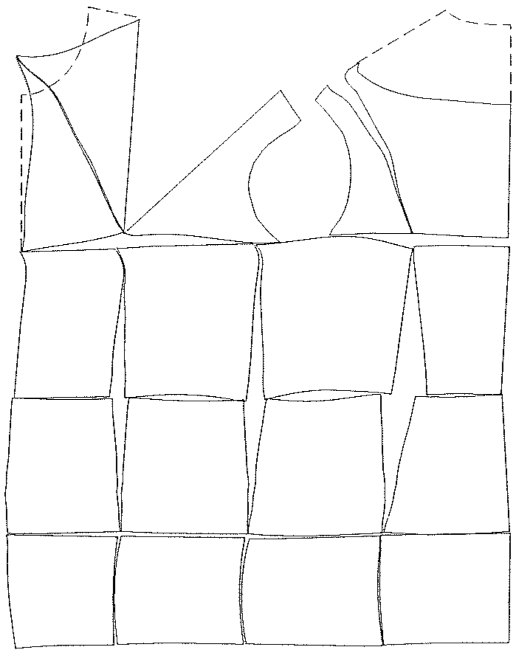

Figure 8: Flattened body surface after data processing.

3. An individual mannequin

The process we have used for cleaning the measured data to get an individual mannequin is based on the following ideas. All the unnecessary local shape variations are removed. The local point sets of modified areas are changed from the original to the smooth surfaces. The output point set should be regularly spaced. Usually the procedure that creates a surface from point set needs a regularly spaced data. We have used tools from computational geometry and signal processing fields. The basic algorithms are based on convex hulls, local maximum preserving filtering and B-spline fitting. The results can be seen in Figures 4-6. Figure 4 has the original data. In Figure 5 the local horizontal variations has been removed. In Figure 6 also the local vertical variations has been removed.

In Figure 7 is presented the flattening result from original data, and in Figure 8 are the flattened pieces of the mannequin presented in Figure 6. The flattening from 3D surface to 2D parts was done using 3D DesignConcept CAD program made by Computer Design Inc. The used program is not originally meant for garment design. The main problem in the flattening process is the complex shape of the human body. It is non-developable, and that's why approximations have to be done. There are many ways to approximate the flattening. In our case the surface was approximated by small triangles which the program transformed from the body surface to a plane. The complex human body brings also another difficulty into the flattening process: the great amount of data, which made the total process time-consuming. The regions to be flattened have to be defined by visual estimate. The solid lines in Figures 7 and 8 presents the borders of the flattened surface. The dashed lines in the upper part of the body are corrections made by first author. The reason for the corrections was the missing data of the neck. In Figure 8 the bust dart has been pivoted into the same position than in Figure 7 in order to make the comparison of the patterns easier. The layout of the pattern pieces was done by visual assessment.

When analyzing Figure 7 and Figure 8 a garment pattern expert can see that the flattened data is not directly usable as a garment pattern. Because the basic pattern does not contour the hollow areas of the body, the flattened original data (Figure 7) is of minimal use in pattern construction. Even if the result is nearer to the traditional basic pattern, the flattened cleaned data (Figure 8) is not directly usable either. Nevertheless the flattened pattern pieces of the individual mannequin give valuable information for further development of the exploitation of 3D data in pattern drafting.

In this example the tape measurements and standard measurement charts did not provide reasonable good information for pattern drafting, at least not without major pattern corrections. This was known already in advance by pattern drafting experience; the measured persons were selected from a group of older people.

4. Discussion

The body scanning devices are already available. The existing pattern design procedures are not designed to exploit 3D data. These techniques are being developed. It is hard to say now how 3D measurements will be used in the future in the garment design practice. Interest of made-to-measure systems is high in the field of clothing science and technology. That's why the research on this area is necessary in order to find solutions to the problem of better fit.

5. References

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