OPTICAL METHOD FOR DETERMINATION OF HUMAN BODY MEASUREMENTS IN THE APPAREL INDUSTRY

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Summary

In this paper we are presenting a new measuring method elaborated for the apparel industry. The Department of Polymer Engineering and Textile Technology of Budapest University of Technology and Economics, along with the researchers of the Laboratory of Informatics of the Faculty of Mechanical Engineering have been engaged in the development of a 3D modeling system for the apparel industry, in the course of which the measures of the human body are essentially needed for the elaboration of specially built 3D body modeling, furthermore for the designing of 2D patterns. Instead of the conventional, mechanical measuring method we have elaborated a rapid, synchronic and objective measuring method working on optical principle. According to our procedure multidirectional digital recordings of the model are processed, from which all measures necessary for the designing of made-to-measure patterns and for the building-up of the 3D body modeling can be determined with the accuracy required in the apparel industry. In this paper we are presenting the method for evaluating digital recordings and its results, as well as their comparison to the results of the conventional, hand-operated method, and we estimate the application possibilities of the measuring method.

1 INTRODUCTION

The researchers of the Department of Polymer Engineering and Textile Technology of Budapest University of Technology and Economics, along with those of the Laboratory of Informatics of the Faculty of Mechanical Engineering have been engaged since 1983 in the development of 3D modeling systems for the apparel industry. We are constantly improving our modeling system, at the present we are working on the elaboration of the 3D modeling module and made-to-measure pattern designing module. Since 2000 the Ministry of Education is sponsoring the "Multi-medial, three-dimensional modeling system for the apparel industry" research program FKFP-0028/2000.

The measures of the human body are essentially needed for the elaboration of specially built 3D body modeling and for the designing of 2D patterns. Until recently the conventional, mechanical, hand-operated measuring method was used for the measuring process, which, however is not suitable anymore from the developing of the 3D modeling system and the mass measuring point of view. Its disadvantages are:

– it is very time-consuming (the determination of the measures shown in Fig.1. takes more than 1 hour!), which is very stressful for the model as well,
– the mechanical touch required for the determination of the measures and the measuring pressure related to that, in the case of a human being originate a deformation which causes an undesirable lack of precision, and this can be unpleasant for the model as well,

– the determination of certain measures does not occur synchronically, that is why the inevitable movement and the modification of body posture – bearing of the model produce measure inaccuracy,
– the execution of the mechanical measuring requires a high-level professional anthropometrical knowledge from the person who performs the measuring, furthermore for the determination of the measures an expensive, special measuring instrument is needed, the so-called anthropometer,
– through the measuring process subjective elements appear as well, the result of the measure depends on the person who performs it, but the result fluctuates even in the case of the same person who measures.

For the reasons mentioned above this method is applicable only in research stage, for the purpose of comparison, control, the elimination of the enumerated disadvantages is possible with other methods, purposively optical measuring methods.

2 THE NEW MEASURING METHOD

2.1 The requirements of the new measuring method

- Rapidity, the measuring is not to take longer than a few seconds, and not to be stressful for the person who is being measured.
- Free from touching, the measuring is preferably not to happen with the touch of the person, improving by this the precision and avoiding the unpleasant touch for the person who is being measured.
- Synchronic, that is the required measures are to be determined at the same moment, given the measured person's bearing, for the unintentional movement of the person who is being measured not to produce inaccuracy.
- Is to be performable with the use of simple, not too expensive instruments, is not to require special clothing, special light conditions.
- The accuracy suitable for garment trade purpose, which has a relative value of +/-0,5 %, is situated in the absolute +/- 10 mm value in the case of big measures, e.g. body height, while in the case of small measures, e.g. neck width, the limit is +/- 0,5 mm absolute deviation, which represents a sufficient accuracy even in the case of measures smaller than 100 mm.
- Is to be suitable for series measuring, and through its application all the measures required are to be determinable.
- The measure is to be objective, and the result is not to be dependent on the person who measures.

2.2 The characteristics of the new method

For the performance of the requirements of the measuring method the optical methods are the most applicable. Through the research we applied two methods based on optical principle. One is the "shadow moiré" method, with the help of which there can be determined the co-ordinates in 3D of any point of the body. This data is required for the building-up of base body models, which will be set in the system. The details are the topic of a different paper. However, this method is only applicable in research conditions, it is inadequate to routine-type series measuring.

The requirements mentioned above are however entirely performed by the other measuring method based on optical principle, which is presented in this paper. According to this new method, we prepare digital recordings from the front, the side and the back of the person who is measured, wearing his (her) own light, skin-tight clothes (e.g. for women bra and panties), under normal, scattered light exposure. Through the recording, next to the person who is being measured we place a metric horizontally and one vertically in the recording plane, and we record the person along with these, in order that during the evaluation of the recordings the measures can be certifiable. For the measuring the followings are needed: a digital camera with an adequate objective, metrics, a room with normal lighting and at least 8 meters long, a computer and a software adequate for the evaluation. After the verification and recording of the interpretability of digital recordings, the measuring process finished for the person who was measured. Thereafter, the recordings can be evaluated anytime with the computer. As an example Fig. 1. shows such a recording.

Fig. 1.
Digital recording from the front and the side

2.3 Evaluation of digital recordings

From the digital recordings it can be determined with the computer, e.g. in AUTO CAD the distance projected in the plane of the recording of any two points from the recording. Fig. 2. shows that, for example in the case of women's body what measures need to be determined. The designation of the measures marked with numbers in Fig. 2. is comprises in Tab.1. In every case we measure the Z direction, height measures from the ground. In the frontal recording the X direction width measures, and in the side recording the Y direction depth measures can be measured.

In Tab. 1. we comprised the results of the computerized evaluation of the recording shown in Fig. 1., as well as, in the cases it was possible, the results of the mechanical, hand-operated measuring, for the purpose of comparison. The circumference measures appeared in the table were determined with calculation, using the projected measures. These circumference measures are needed in the designing of 2D patterns. Throughout the calculation we assumed that the circumference of the body can be approximated with an ellipse, like in the case of mechanical measuring the measuring band encircles the body, and its semi-axis can be determined from the frontal and side recordings. For the determination of the circumference of the ellipse we applied the following approximating formula:

$$K = \pi \cdot \left[1{,}5 \cdot (a + b) - \sqrt{a \cdot b}\right]$$

where a and b are the semi-axis of the ellipse.

Ser. nr.	Designation	Measure from the recording	Mecha-nical measure	Ser. nr.	Designation	Measure from the recording	Mecha-nical measure
1	Body height	171,5	171,6	26	Hip breadth	33.8	-
2	Height of neck nape	148,1	147,3	27	Thigh breadth	16.1	-
3	Height of neck base point	138.5	139.7	28	Knee breadth	11,0	-
4	Acromion height	135,0	139,8	29	Calf breadth	12.5	-
5	Armpit height	122,0	130,7	30	Ankle breadth	5.9	-
6	Breast tip height	119,0	124,6	31	Head depth	21,0	-
7	Elbow height	108,7	-	32	Neck depth	9.7	-
8	Waist height	108.5	108,5	33	Arm depth	9,0	-
9	Buttock point height	85.2	88,5	34	Breast depth	22,5	-
10	Under buttock furrow height	78,0	88,5	35	Chest depth	19.0	-
11	Hip-bone point height	101.5	-	36	Waist depth	18.8	-
12	Assumed height	151,0	-	37	Hip depth	24,2	-
13	Wrist height	81,1	-	38	Thigh depth	17,1	-
14	Leg length	78.0	82.0	39	Knee depth	12,0	-
15	Fingertip height	63,0	-	40	Calf depth	12,8	-
16	Ankle height	7.4	-	41	Ankle depth	6,3	-
17	Knee point height	47.5	51.3	42	Foot length	24,5	-
18	Clavicle height	135,0	138,9	43	Back point prominence	3,4	-
19	Head breadth	16,9	-	44	Buttock point prominence	4.7	-
20	Neck breadth	11.3	-		Calculated value		
21	Acromion distance	34.3	-	45	Neck width	33,0	32,0
22	Armpit breadth	29.0	-	46	Breast width	81,2	81,0
23	Breast tip distance	17.1	17,0	47	Waist width	67,6	65,0
24	Arm breadth	8,0	-	48	Hip width	91,7	93,0
25	Waist breadth	24.1	-	49	Thigh width	52,2	52,0

Tab. 1.
Measures taken from woman's body

3 THE APPLICATION OF RESULTS

With the elaborated method it can be determined any measure of the body, which is needed for the building-up of the 3D body model of the analyzed person for garment trade purpose, and for the designing of 2D patterns for made-to-measure clothes.

In our 3D modeling system for the apparel industry we build analytically the body model. For this purpose we use the rules of the anatomical building-up of the body and the data measured with optical method, appropriate only for research, for the 3D body surface generation, much more complicated than the above. This means that we build in a base body model in the system, which is parameterized based on the measures which influence most typically the body figure. According to our supposition it is sufficient to give these parameters, that is the most relevant measures, the values of the measures of the analyzed person, and we obtain the body model of that person. After the elaboration of this measuring method we engage ourselves in demonstrating this supposition. According to our conception there are needed separate base body models by all means, classified by body types, e.g. child, woman and man's body. The subject of further research is that beyond these, for which groups of body types we have to build-up a separate base body model. The analytical building-up of the body model is that, which makes it possible for the measuring method applicable in the apparel industry to be the method presented above, a simple, rapid, optical method. In accordance with our actual point of view, the measures shown in Fig. 1. and comprised in Tab. 1. are the ones needed and sufficient in order to obtain the analyzed person's 3D body model in the above mentioned mode, respectively to design the 2D patterns of made-to-measure clothes. And these measures can unequivocally be determined with the presented measuring method.

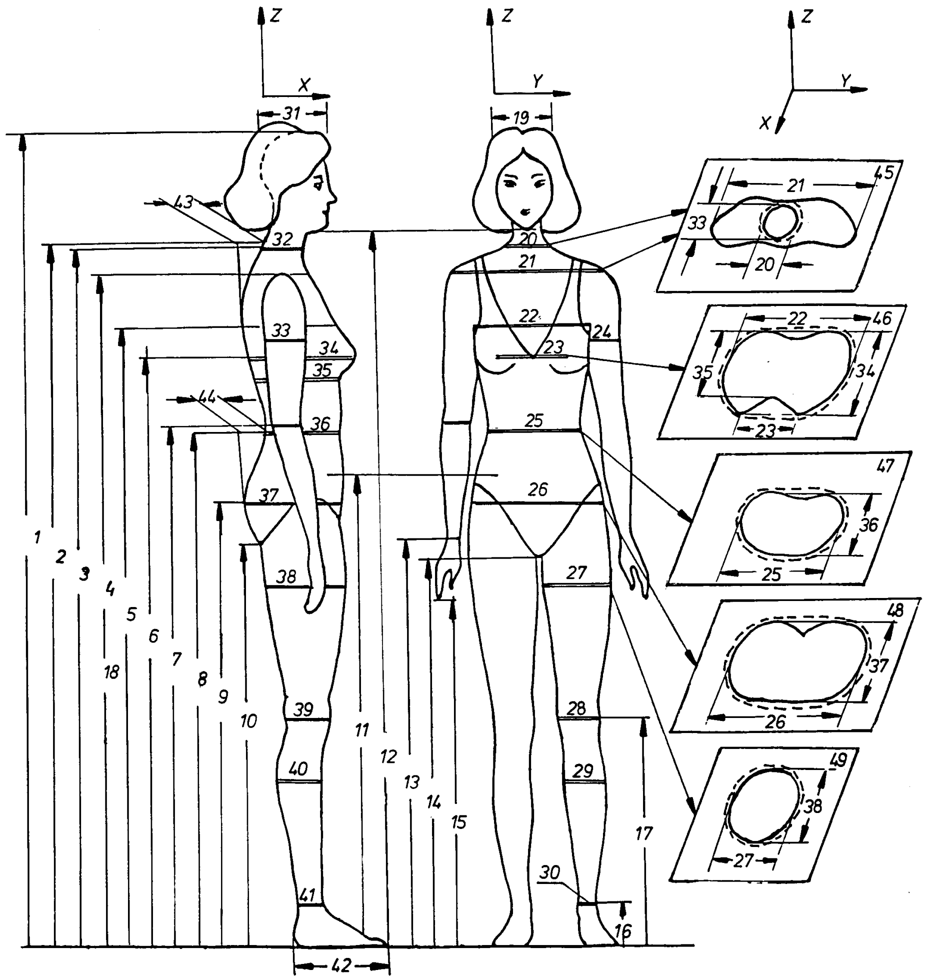

Fig. 2. Measuring of woman's body

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