

From 3D to 2D Imaging of the Surface of a Figure and Clothing

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Abstract: The article focuses on the principle of designing clothes based on obtained data and a method of measuring the surface of the human body using available technology in 2D and 3D applications and progressive methods and technologies. The first step in obtaining 3D data and the subsequent work in CATIA 3D program is achieved using MaNescan system. The procedure for creating what is known as a “wrap” of the human body in 3D is described in the article, and the procedure for its unfolding is consequently explained. There is also an example of designing clothing layers on a body with the possibility for subsequent unfolding. The principles applied in this thesis can be used when unfolding any part of the human body and hence when defining and creating new model designs of clothing.

Keywords: Layering of clothing in 3D, MaNescan system, Measuring the human body, MiT_MaNescan, Scanning characteristics, Unfolding the body surface in 2D, Wire model of a figure.

1 INTRODUCTION

Goods that are intended for direct human use cannot be produced without the study and knowledge of our population, particularly the shape and dimensional specifics. Mass production makes products for unknown customers. To do so, the typology of figures and then the size range need to be known. The bases for their determination are somatometric measurements that define body dimensions, defined in advance, for thousands of men and women using either a **contact** or **contactless method**. The **contactless method** can be characterized as measuring without direct contact between the measuring instrument and the measured body. This article shows how to attain an image of the object (figure) and materials for production of clothing, underwear, etc. There have been many contactless scanning systems. For example, the BodyFit 3Dsystem interactively allows the automatic measuring of more than 30 pre-defined body dimensions. This can be done on the basis of image analysis of pre-defined postures of the person within the measured area [1]. In this article this complex procedure is carried out using a system called MaNescan.

2 MANESCAN SYSTEM

The system is designed for contactless scanning of the human body surface and it has been set up and performed using special MiT_MaNescan software at the Textile Faculty of Technical University in Liberec so that it can be used for various applications. MaNescan consists of a rotating stand on which is placed initially a calibration object and subsequently the figure to be scanned. There is also a T-shaped shoulder stand, on the left shoulder of which a laser is placed, and on the right shoulder is placed a sensor, namely, a digital camera. The positioning of the laser, camera and rotating equipment create what is known as a triangulation triangle. See diagram in fig. 1 [2].

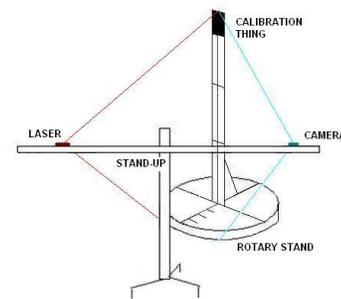


Fig. 1 Scheme of MaNescan workplace [1]

The output of scanning is a set of calibration images and images of figure silhouette contours. Pictures of individual scans represent profiles of cuts of the body surface from a specific angle. An example of an image of a scanned line is in fig. 2a. The images are assessed using MiT_MaNescan program – the output is a set of points in the form of x, y, z coordinates. A model of a figure in digital form is created by loading this set of points into 3D CAD program as shown in fig. 2b.

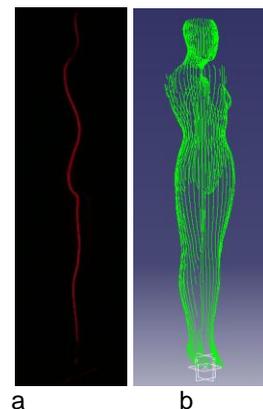


Fig. 2 a) Example of the image of a scanned line of a figure; b) Model of a figure – female body figurine in 3D CAD program [2]

Based on a 3D figure prepared this way, we can not only measure the body dimensions, but also find the somatoscopic characteristics and body posture and carry out experiments in

unfolding the body surface.

3 METHODOLOGY FOR UNFOLDING HUMAN BODY SURFACE

Unfolding the surface of figure model – in this case, a female figurine – was performed using a 3D CATIA programs in Digitizer Shape Editor, Generative Shape Design and FreeStyle modules using their functions. The stages of the procedure are based on:

- the adjustment of the loaded points and the creation of a “mesh” surface
- the creation of levels and cuts onto the bodies by definition of somatometric points
- the creation of a wire model

3.1 Creation of a figure surface “mesh”

The “mesh” itself cannot be unfolded into a flat surface, that is why a wire model of a figure had to be created and the figure had to be covered with an unfolded surface. After displaying the figure surface, the missing places on the surface are visible. These are caused by laser blind spots on the figure due to the shape of the body. Filling in such missing places can be achieved in a CAD program using networks of triangles and the resultant surface can be depicted as in fig. 3.

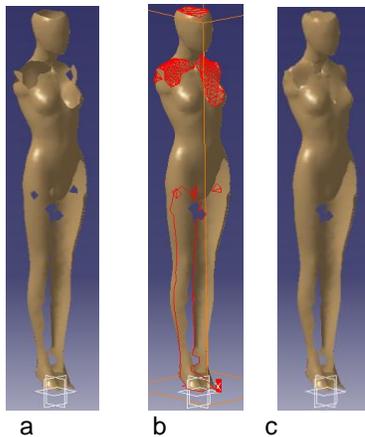


Fig. 3 Image of body figure surface using “mesh”: a) imaging of missing places; b) imaging of triangle network; c) imaging of final surface of the body in 3D [3]

3.2 Definition of somatometric points, levels and cuts on a figure

Due to the fact that the human body surface is not a geometric figure, the surface of the figure must be divided into segments. Based on these, the parts that can be unfolded into 2D can be defined step by step. To determine these segments somatometric points through which horizontal levels (i.e. above chest, chest, waist, upper hip and crotch) and vertical lines (i.e. a “medial” line dividing the body into left and right halves, “sagittal” line going through the chest point parallel with the medial line and the “frontal” line dividing the body into front and back parts), are defined on the figure. The cuts made at selected lines define the shape of the body surface fig. 4. The resulting lines are the basis for unfolding the figure surface.

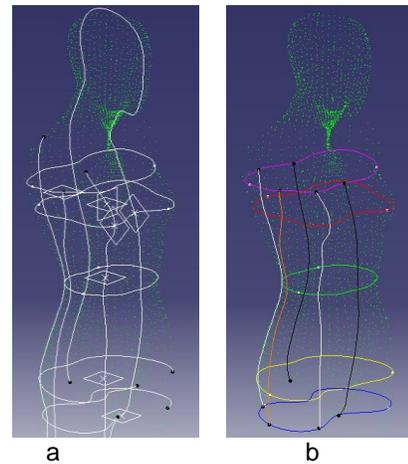
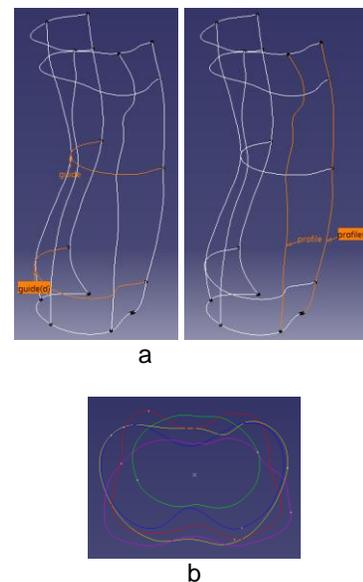


Fig. 4 a) Image of the lines on the body surface; b) Image of the cuts on the body surface: medial (black), sagittal (white), frontal (orange), over chest (pink), chest (red), waist (green), upper hip (yellow), crotch (blue) [3]

It is known that dimensions calculated on the basis of weight and radius of a hypothetical sphere are comparable to body measurements in the following respects: back length is about 1cm longer than the radius of the sphere, upper limb length is longer by up to 5cm, lower limb side length is the same, back width is about 0.7cm narrower, chest circumference is about 1cm larger, waist circumference is about 1.9cm smaller and seat circumference is up to 2.5cm smaller.

3.3 Creating wire model

When unfolding the body surface, the symmetry of the body is taken into account. That is why we work only with a half of the body when preparing to unfold. Division into the left and right parts of the body is enabled by defining the medial line. To create a wire model, the horizontal and vertical lines must be defined for guidance and the medial and sagittal lines must be separated into front and back, see fig. 5a, and top view of cuts of the body, see fig. 5b. The wire model of the body surface is gradually covered based on the definition of the individual segments. An image of the surface cover of a part of the torso is shown in fig. 5c.



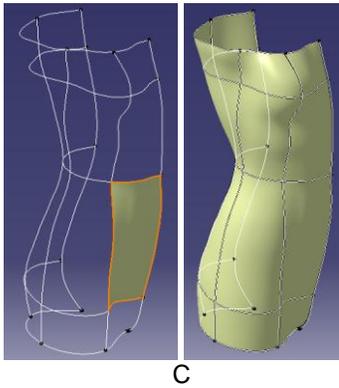


Fig. 5 Wire model of a figure – a) imaging of guiding lines; b) Top view of cuts of the body; c) Coverage of surface of the body with surface [3]

3.4 Unfolding body surface

The created body surface can be unfolded maintaining the lengths of each arc and angle the same. A flat surface area of part of the torso can be obtained by unfolding as depicted in fig. 6.

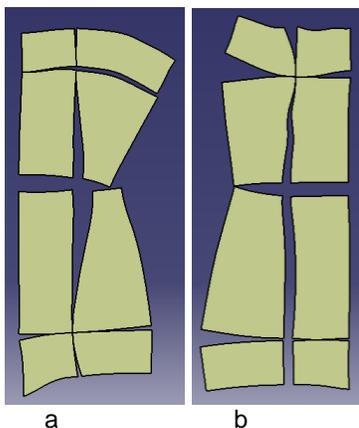


Fig. 6 Unfolding the torso part in 2D – a) back part of torso; b) front part of torso [3]

This method of unfolding the body surface is suitable for making elasticated underwear that fit tightly to the body, for example. The wire model must be simplified for outer clothing. Simplification corresponds to an actual method of measuring the body dimensions. The simplification can be seen especially in the top view of the wire model, see fig. 7a, 7b, 7c. The simplified shapes of the body surface and the unfolding of their parts are shown in fig. 7d.

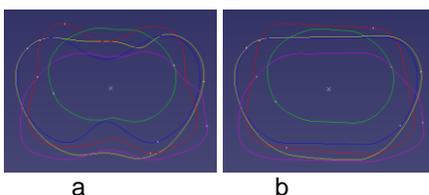


Fig. 7 Simplified shapes of the torso – a) Top view of cuts of the body; b) Simplified top view of cuts of the body; c) Simplified wire model of torso; d) Unfolding of simplified back and front parts of the body in 2D [3]

4 APPLICATION OF UNFOLDING – PROCEDURE FROM BODY TO CLOTHING

The aspects of clothing which determines the proportions are expressed by its constituent parts. They express not only aesthetic awareness, taste and fashion influences, but also the effects of material and technological processing. Based on the techniques applied in current practice and construction methodologies, we cannot define real values for individual aspects because they are expressed by the sum of the constituent parts.

4.1 Additions in Unified Methodology of Clothing Construction

An totally new approach was applied in the Unified Methodology for the Construction of Clothing [4] due to new directions of clothing construction connected with the usage of computer technology. The system of “additions” associated with constituent parts and their unified understanding are of great importance for the unification and standardization of clothing [5]. These additions are quantities that modify the values of a relevant body dimension to the values of a constructional line segment and they are structured with regard to the functions as follows:

- Additions for free movement
- Additions for thickness of material layers
- Technological additions

Additions for free movement

The following additions fall into the group of additions that are expressed by one resulting PV value set on the basis of the analysis of individual additions:

- Physiological-hygiene additions PF
- Dynamic (motor) additions PD
- Additions for free movement of silhouette PSi
- Model additions PM [5]

Additions for thickness of material layers

Clothing of each figure is usually made up of several layers (e.g. undershirt, shirt, sweater, coat) that are made from a combination of top, lining and inserted materials. The type of material, its thickness and number of layers all have an effect on the length of the constructional line segments of the

constructed clothing. These changes are expressed in the Unified Methodology by the addition for thickness of material layers PP. Its value depends on the number of layers which form the constructed clothing and on the number of layers that lie under the constructed clothing [5]. This phenomenon can be explained simply on an arc as in fig. 8 [5].

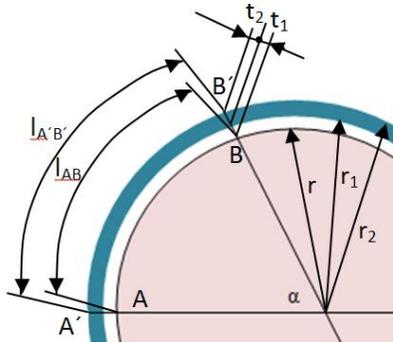


Fig. 8 Diagram for calculating the length of arc of constructed clothing

Calculation of the length of the arc for constructed clothing is expressed by the following formula:

$$l = 2\pi r \frac{\alpha}{360} \quad (1)$$

where:

r – is arc radius (of the body)

α – is central angle of the arc (on the body)

Due to the thickness and number of material layers, the length of the arc extends. The extension is found from the difference between the arc lengths:

$$PP = l_{A'B'} - l_{AB} \quad (2)$$

$$PP = 2\pi r_2 \frac{\alpha}{360} - 2\pi r \frac{\alpha}{360} \quad (3)$$

$$PP = (r_2 - r) \cdot \alpha \quad (4)$$

the difference between the radii determines the thickness of the material layers, i.e.:

$$t = r_2 - r \quad (5)$$

$$PP = t \cdot \alpha \quad (6)$$

Technological additions

These kinds of additions include the changes (shrinkage or expansion of the material) caused by thermal or moisture-thermal processing. They are designated as technological and are expressed by a total PT value. The resulting value of the constructional line segment \overline{AB} is expressed by the following formula:

$$\overline{AB} = (\overline{AB}) + PV + PP \quad (7)$$

where:

(\overline{AB}) - length of the constructional line segment without addition

PV – total value of the addition for free movement

PP – total value of the addition for thickness of material layers

The length of constructional line segment with technological addition $\overline{AB'}$ is expressed by the following formula:

$$\overline{AB'} = \overline{AB} + PT \quad (8)$$

PT – total value of technological addition [3].

4.2 Layering of clothing in 3D CAD program

Depending on the layers of the clothing, the parameters of the body are modified to the parameters of the clothing by the values of PV and PP additions. The difference of girth dimensions, or arc dimensions on the body and girth of i -th layer of the clothing can be simply determined from a circular girth.

$$O = 2\pi r \Rightarrow r = \frac{O}{2\pi} \quad (9)$$

$$O_i = 2\pi r_i \Rightarrow r_i = \frac{O_i}{2\pi} \quad (10)$$

where:

O - girth measured on the body

O_i - girth of i -th layer of clothing on the body (girth of the body increased by PV and PP additions)

r – body girth radius

r_i – radius of the girth of i -th clothing layer on the body

The outer ring of the girths “ d_i ” defines the distance of i -th layer from the body, so:

$$d_i = r_i - r \quad (11)$$

Based on the unfolded body surface, by setting the number of clothing layers and the girth dimensions and the distances between the body and the i -th layer, we can create clothing layers on the body as shown in 3D fig. 9.

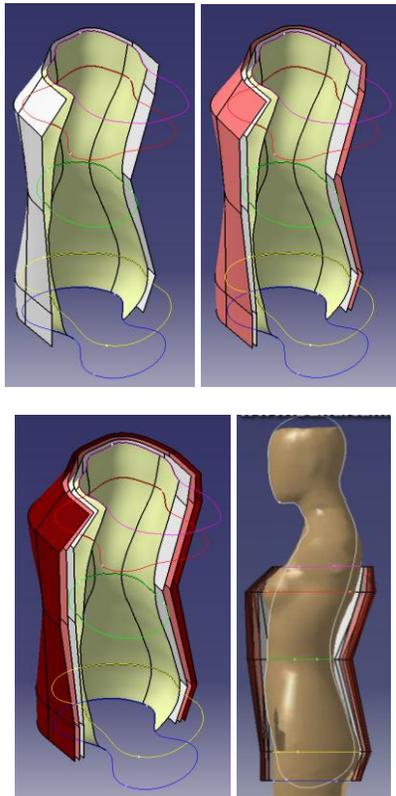


Fig. 9 Imaging of the clothing layers on the body in 3D

Each i -th layer of clothing can be unfolded from a 3D model to a flat surface the same way as described in chapter 2.4. By defining other areas on the body (arms, legs, head), their unfolding can be performed in a similar way as described in chapter 2. A pre-condition is a high-quality scan of the whole body surface.

5 RESULTS AND DISCUSSION

This article refers to the direction in which the research of many scientists, artists, anthropologists and clothing experts is oriented nowadays. It solves the question of how to scan the human body surface and the procedure for going from body to clothing. The results and procedures are some of the new progressive technologies that have started to be applied in the production of clothing as well as in other fields. Thanks to this solution, the next target for research has been identified: namely, the question of how to create a clothing model directly on a figure in 3D software. Everything, however, depends on not only the capabilities of using and managing program products, but also on the economic potential of companies. The current situation in the world, however, suggests that technological and computerized capabilities will soon surpass the economic potential of companies. But the solution will certainly fulfill the ideas, aims, demands and expectations that are present on the threshold of the third millennium.

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