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BLOCK PATTERN GENERATION OF THE SCANNED HISTORICAL GARMENTS

ГЕНЕРИРОВАНИЕ РАЗВЕРТОК СКАНИРОВАННОЙ ИСТОРИЧЕСКОЙ ОДЕЖДЫ*

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This study presents a new method for generating block patterns of historical costumes. The method uses 3D scanning and UV mapping to extract flat patterns of historical garments from their 3D models. UV mapping is a technology that allows the coordinates of points on a 3D model's surface (X, Y and Z) to be translated into a flat coordinate system (U and V). UV maps of a 1900 frock coat were generated and transformed into block patterns. The block pattern of the coat was compared to a one made by using traditional methods in 2D and 3D environments. This exploration allows modern computer technologies to be applied for studying and reconstructing historical costumes, as well as for obtaining new research insights valuable for dress history and cultural heritage.

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В статье представлен новый метод генерирования разверток сканированных исторических костюмов. Метод основан на UV-преобразовании сканированных поверхностей для извлечения 2D-чертежей деталей исторической одежды из их 3D-моделей. UV-преобразование – это технология, которая позволяет переводить координаты точек на поверхности 3D-модели (X, Y и Z) в плоскую систему координат (U и V). UV-карты сюртука 1900 года сгенерированы и преобразованы в чертежи конструкции. Сгенерированный чертеж сюртука сопоставлен с полученным традиционными методами в 2D- и 3D-среде. Данное исследование позволяет применять современные компьютерные технологии для воссоздания исторических костюмов, а также для получения новых исследовательских данных, ценных для истории костюма и культурного наследия в целом.

Keywords: digital twin, avatar, UV-mapping, historical costume, 3D scanning, digitization.

Ключевые слова: цифровой двойник, аватар, UV-преобразование, сюртук, платье, 3D-сканирование, цифровизация.

Flattening of historical garments surface into sewing pattern blocks is an important step in the reconstruction [1]. Traditional way of pattern extracting from ready-to-wear clothes includes the measurements of shell layer, coping the shape of the pieces and its drawing on the graph paper [2...4]. This time-consuming work is usually done manually, which often leads to poor accuracy of the patterns obtained. Instead of real garments this method could be transformed into virtual reality due to application of three-dimentional (3D) scanning technology for generating the digital twins (DTs) of the historical costumes [5...8]. DTs is the virtual copy of real object containing millions of points with its XYZ coordinates; for this reason, the reproduction^' garment outer surface in virtual reality could be done more accurately. The digitalization of historical garment provides a starting point for extracting the block patterns from scanned clone of garment automatically or semi-automatically and using computer technologies. This method allows to operate with historical heritage in safety manner.

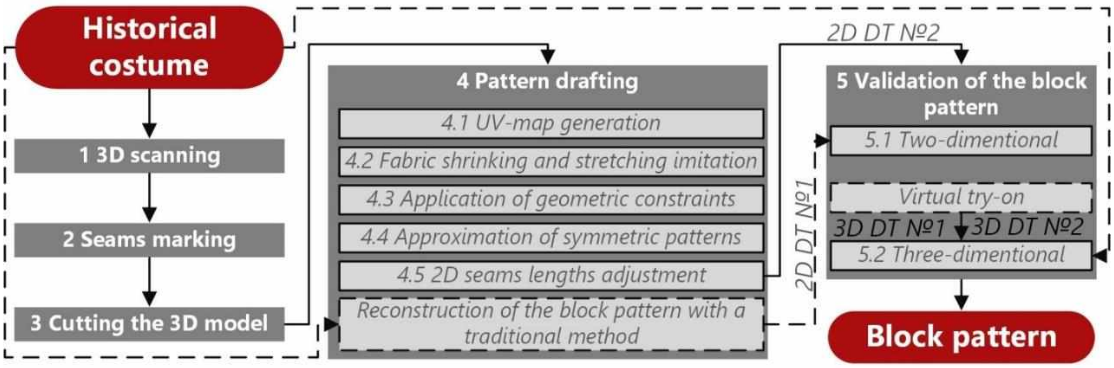


Fig. 1

The aim of this study is to develop a computer method of automated extraction of block patterns from the scanned DTs of historical garments by using the UV-mapping technology. This method will allow to transform the 3D garment shape consisting from several pieces into the 2D image. This method includes next steps: marking seams, dividing the mesh into parts as garment pieces and laying out the triangles of each piece on a flat surface.

To minimise distortion of the map, special functions of software are used by relaxing vertices and unifying the distances between them.

Fig. 1 shows the flowchart of the developed method of authomatic sewing patterns generation.

The developed method includes five steps. Firstly, the real costume should be scanned to get 3D DT as the cloud of points. During steps 2 and 3, the scanned DT should be prepared for application of UV-mapping polygonal modelling tools. Step 4 "Pattern drafting" includes UV-map generation and its transformation into a flat patterns combining as shell block (2D DT №2). In the final step, the accuracy of the 2D DT №2 is evaluated twice: firstly, by its comparison with the patterns done by means of traditional hand method (control patterns 2D DT №1); secondly, by generating of virtual costumes 3D DT №1 and 3D DT №2 by using 2D DT №1 and 2D DT №2 respectively.

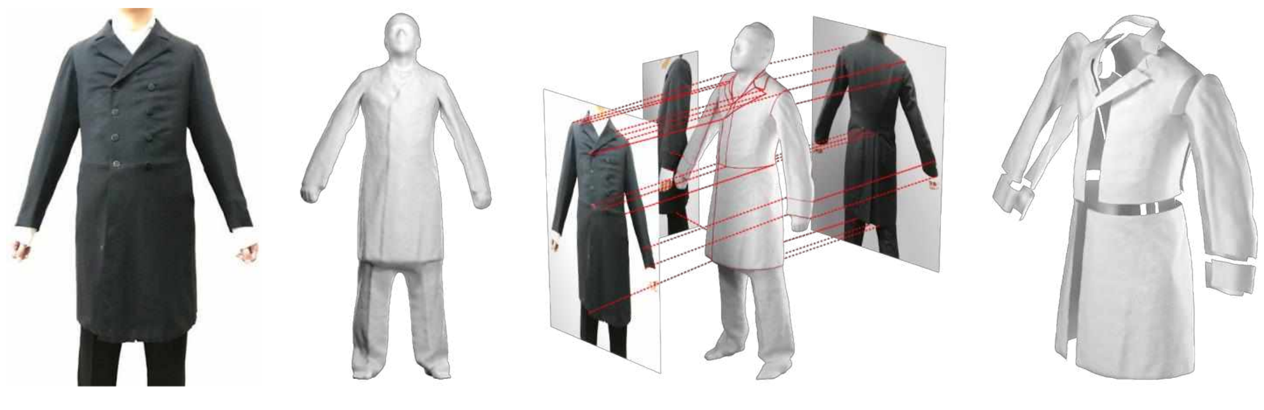
The research has been done with VITUS Smart LC3 3D scanner (Human Solutions), Anthroscan software, 3dsMax software, Auto CAD, and Clo3D.

There search object was carried out on the frock coat (Fig. 2-a) from the Collection of Garment Design Department of Ivanovo State Polytechnic University. The coat with typical structure dated from the first decade of the XXth century, is well preserved and has no marks of repair. The coat consists of the front, side, back, skirt, collar and two-piece sleeves with cuffs. The coat was made of a dense plain-dyed woolen broadcloth (density ≈ 400 g/m^2, thickness ≈ 0.9 mm) and has a cotton lining of the front, the back (density ≈ 190 g/m^2, thickness ≈ 0.34 mm) and the sleeves (density ≈ 105 g/m^2, thickness ≈ 0.21 mm). The front is strengthened with a linen canvas (density ≈ 170 g/m^2, thickness ≈ 0.34 mm). In this study the pattern of shell fabrics were reconstructed.

The control pattern block2D DT №l was made by hand by means of laying the coat on the flat surface and copying the contours of each piece by special adhesive paper.

The 3D DT and UV maps were generated by using 3dsMax software. The process includes four steps, which are as follows.

1. Generating of 3D DT (Fig. 2-b). The coat was put on a human body (height is 176.7 cm, chest girth is 90.2 cm, waist girth is 75.4 cm). The shirt, vest and trousers dating to the same time-period were put underneath the coat. To scan and to measure the 3D DT, VITUS Smart LC3 3D scanner (Human Solutions) and Anthroscan software were used.



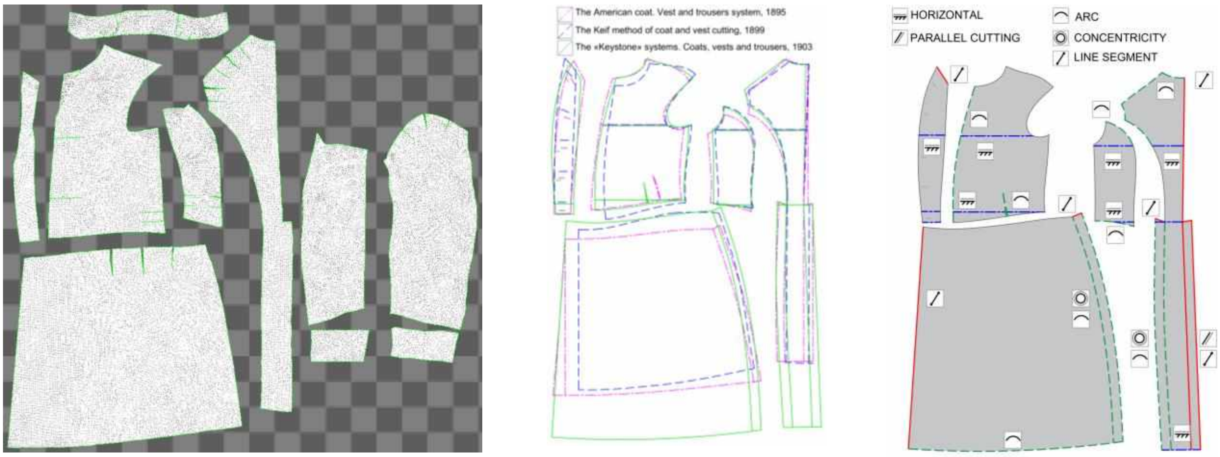
a) b) c) d)

Fig. 2

2. Marking of the visible coat seams (Fig. 2-c). Three photographs of the coat (front, side and back views) were placed around the 3DDT. The seams on the photographs were marked by using “spline” command and projected onto the surface of the 3D DT by means of “geometry projection” script.

3. Virtual cutting of the 3D DT along the seams and divided into front, sleeves, skirt, and cuffs (Fig.2-d).

4.Drafting of the patterns. The patterns 2D DT №2 were extracted from the 3D DT and prepared for future modification through the following procedure. The UV maps of 10 pieces were generated by using the "unwrap UVW" modifier, "planar projection" tool and "relax until flat" command (Fig. 3-a).



a) b) c)

Fig. 3

Historical manuals of pattern cutting were analyzed in terms of determination of the areas in which fabrics were intentionally shrunk and stretched during ironing to shape the coat, on the one side, and typical configuration of edges and internal lines, on the other side [9].The edges and internal lines of several historical patterns were determined in five possible geometric constraints - straight horizontal (chest and waist internal lines), arcs, concentricity, parallel cutting, and line segment (Fig. 3-b,c). Based on these results, the contour lines of UV-maps of extracted pieces and the corresponding edges of the pattern pieces were corrected and converted into straight lines and arcs by using the "brush" and "quick transform" commands (Fig. 3-c).

The left and right patterns (central front, front, side back, back, skirt) were overlapped and averaged by the approximation of straight lines and NURBS curves.

The seam lengths were measured in the 3DDT to find the similar lengths of 2D-patterns edges. Eq. (l) was used to calculate the edges lengths:

$$L_{2D} = \frac{\sum_{i=1}^{n} L_{i3D} + \Delta L_1 + \Delta L_2 + \Delta L_3}{n},$$

$$\Delta L_{1min} \geq \Delta L_1 \geq \Delta L_{1max} \qquad (1)$$

where L_{2D} is the edge length of pattern, n is the number of corresponding seams in 3D DT(one - for asymmetrical pieces such as front and skirt, two - for symmetrical pieces such as sleeves, cuffs and lapels), L_{3D} is the length of 3D DT seam, ΔL_1 is the value by which the edge was shrunk or stretched during ironing, ΔL_2 is the overall size of pleats in the seam. ΔL_3 is the shrinkage of fabric caused by puckering during the sewing, ΔL_{lmin} and Δf_{lmax} are the extreme (maximum) values of shrinking and stretching respectively (see [5]).

The validation of developed method has been done twice: firstly, by comparison of flat patterns, and secondly, by comparison of virtual DT of coats generating from the both patterns.

Fig.4 shows the comparison of flat patterns. The both patterns were drafted and compared in AutoCAD. The UV map of each piece cut along the edges (dashed wedges in Fig. 4) and the "relax until flat" command was applied once again.

The both compared patterns were overlapped and compared in 26 zones of lapel (#1), front (#2-5), s ack (#6-8. 24), back (#10,11,25,26), skirt (#22,23), upper sleeve (#15,18), down sleeve (#14,16). upper cuff (#1 own cuff (#17), collar (#12,13). As Fig.4 shows, 2D DT №l is not identical to 2D DT №2 in hatched areas: the minimum difference between the both patterns is 3.3 cm^2 (in #12) and maximum difference is 40 cm^2 (in #20). T major reasons of the deviations are the next:

1. the incorrect shape of 3D DT in armpit areas due to the 3D scanner VITUS Smart LC3

and Anthroscan software were developed for whole-body scanning and full height avatar modelling, and not for digitization clothing;

2. the errors during the seams projecting from the photographs.

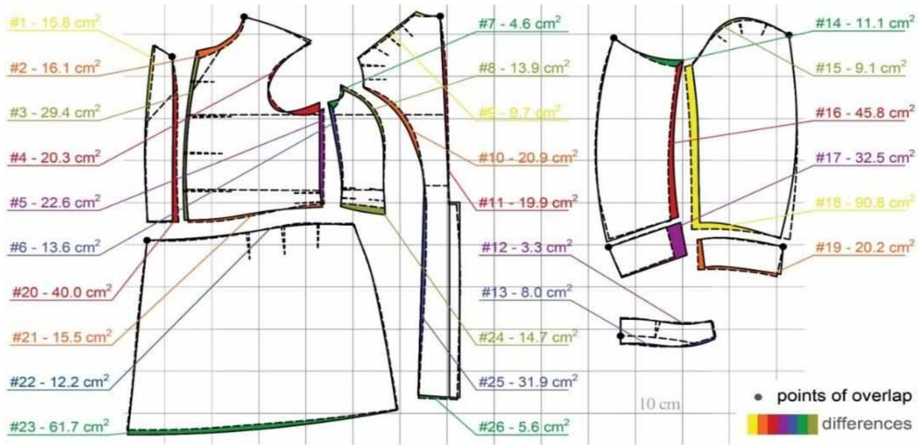


Fig. 4

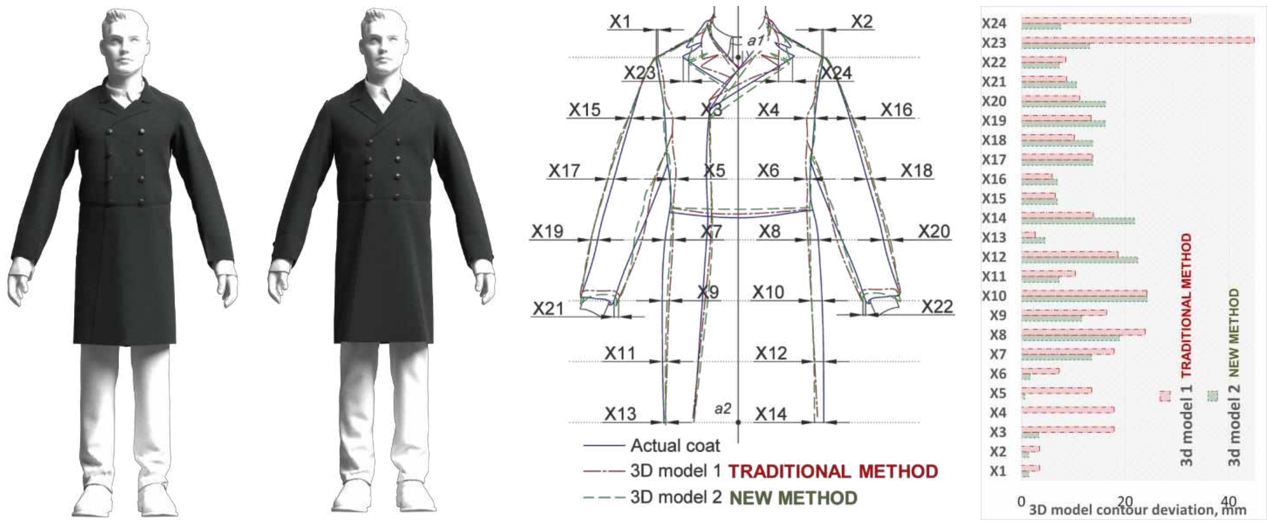
To solve this problem and minimize the error by capturing the position of the seams directly, other canning devices can be applied, for example, to get color textures of clothing.

2D DT №1 and 2 were exported into Clo3D software for generating two 3D PT №1 and №2 respective he following digital textile materials were chosen from Clo3D library as Table 1 shown.

Table 1

Materials	Name	Number in Clo3D library	Content	Density, g/m^2	Thickness, mm
Shell fabric	Coatweight Twill	W002	wool	345	0.84
Paddings	Linen canvas	H001	linen	173,39	0,36
Lining of front and back	Cotton Gabardine	C001	cotton	189	0,35
Lining of sleeves	Cotton Poplin	C003	cotton	105	0,21

Fig. 5 shows both virtual twins. The contours of both 3D virtual twins and the real coat were overlapped (Fig. 5-c) and the deviations between their contours were measured (Fig. 5-d).



a b c d

Fig. 5

The average deviation was 14.4 mm for 3D DT №1 and 10.1 mm in 3D DT №2. The lower value c deviation between the 3D DT №2 and the real coat means that the coat was reconstructed more adequately.

Firstly, 3D digital twins of historical men coat used to reconstruct the flat patterns. The results show that 31 scanning technology can be effectively applied for generating the patterns directly from virtual clone. The accuracy of the patterns extracted from 3D virtual clone is comparable to the ones made by hand using a traditional method of clothes surface. Thus, 3D scanning and UV mapping technologies joining together open the new way for digitization of cultural heritage and studying historical costumes from an engineering standpoint.

C O N C L U S I O N S

A new method of patterns generating from 3D digital twin of historical costumes was developed. The method uses three technologies - 3D scanning, polygonal modelling and UV-mapping - to unwrap the outer surface of clothes and reconstruct the flat patterns.

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