# RECONSTRUCTION OF HISTORICAL TEXTILE FABRICS AND DRESSES IN VIRTUAL REALITY

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**ABSTRACT**
Main aim is to create a method of virtual reconstruction of historical clothes. We applied 2D CAD, Clo3D, and CG tools to find the relationship between outline shape of skirt, properties and construction of garments and textile materials. We used contemporary fabrics which are similar to historical prototypes by changing physical and mechanical properties. New method includes 3D -to-2D flattening; finding the air gaps in "avatar - skirt" system; choosing textile materials and number of underskirt garments; generating of digital replica. The adequacy of historical prototypes to its virtual replica is full due to CAD, new developed modules, and data base.
**Key-Words**: digital replica, historical skirt, textile materials

## 1. INTRODUCTION

The influence of historical costume on contemporary culture and life-style is huge for several reasons. Fashion history is a major component in European society which is needing new forms and ways of historical costume presentation. Every season famous fashion houses and ordinary designers are transforming the important elements of historical costume related to styles, silhouettes, details, textile fabrics, and others into the wearable garments. Because many museums have huge collections of historical costume, its presentation faces the problem of limitation of money, exhibition space, and labor resources. Using the digital replica in public exhibition is the appropriate decision of saving the real historical artifacts from thief. Virtual reality (VR) and augmented reality are no longer science fiction, the area of its application is spreading and looking for new directions in science, manufacturing, culture etc. The main advantage of the both segments is numerical dematerialization of complicated materialistic objects from different points of view.

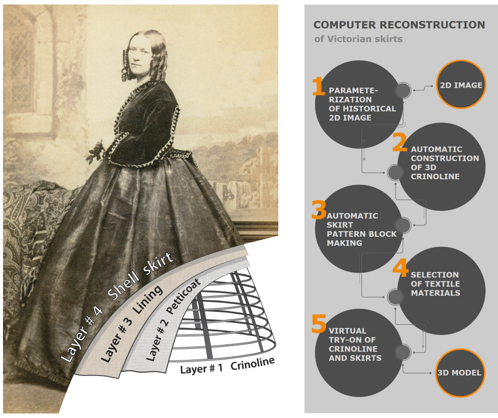
So, numerical dematerialization becomes the only way of saving, reconstruction, presenting and shearing around the world the important part of culture heritage - textile fabrics and costume as national and culture indicators. Computer reconstruction of historical costumes is important direction of contemporary research which is allowing to save historical artifacts in digital format for future generation. But most explorations in this direction are focusing on digital replica of historical costumes generating when the prototypes are in good conditions [1-6]. But the huge part of historical costume has been lost and only the 2D paintings, sketches and photos allow to see this important part of historical heritage now. So, mentioned images is only one resource to do the reconstruction of costume. 2D images could not allow to get full volume of the information about the construction and structure because many important parts are hiding from the observer look. To involve this part of historical heritage in digital reconstruction, new methods should be developed.

Main aim of this project is to develop the new method of virtual reconstruction as multidisciplinary approach which will allow to get the digital replica of historical costume in VR by joining an anthropometry, textile science, physical and 3D geometrical modeling, mechanic of textile materials, IT.

## 2. MATERIAL AND METHOD OF THE APPROACH

### 2.1 Object of virtual reconstruction

Figure 1, a shows the Victorian skirt as the object of virtual reconstruction which was taken from [7]. 2D image has the title "Lady in silk dress with crinoline and velvet bolero jacket. Photograph by «J. Douglas & son». Glasgow, 1860-s".




a b

**Figure 1.** Dress of the 1860s (a) [7] and flowchart of its virtual reconstruction (b).

According to [8,9], the costume from 1980s could has up to four layers, which are shown on Figure 1,a: #1 cage crinoline (CC), #2 petticoat, #3 lining, #4 shell skirt. To get the replica of that skirt, next requirements of fit should be done [8-11]: dimensions of skirt and CC should be adequate; skirt should be located on CC without stress folds or unnecessary creases; CC hoops could not be seen across skirt, and surface of skirt should be smooth after draping.

### 2.2 Algorithm of reconstruction and software

Figure 1,b shows five steps of reconstruction. We used three kinds of CAD: AutoCAD, Autodesk Inventor, and Clo3D. AutoCAD has been applied to parameterize the skirt outline shape and its flattering of CC surface (steps 1 and 3) because this software is a versatile tool with huge possibilities of non-parametric and parametric 2D drawing. Autodesk Inventor has been chosen for automatic modeling of CC (step 2) due to the function of parametric 3D modeling of rigid objects based on their 2D projections. Clo3D has been applied for 3D reconstruction and analysis of #1+#4 system (steps 4 and 5) for studying virtual clothing by means of special functions (pressure points, stress map, strain map, fit map).

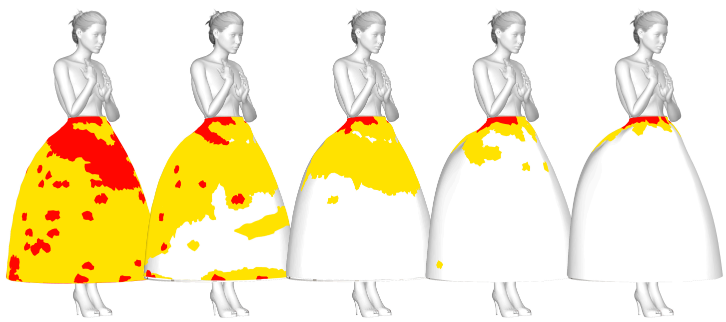
### 2.3 Reconstruction of cage crinoline

To calculate the parameters of CC, we developed the special method by using the schedule of parameters relating to CC shape (A-group) and CC construction (B-group). Parameters from B-group can be found after the exploration of additional resources published [12-13]. We have got the parameters of CC after 67 images parameterization dated by 1850s – 1860s [12-14]. New data base has been used to create the module of automatic design by means of Autodesk Inventor.

### 2.4 Skirt pattern block making

We applied the rules of descriptive geometry [15-17] to convert 3D surface of CC into 2D flattering parts of skirt. The conical segmental parts of CC were similar to the gored sections of skirt pattern block in 1850s-1860s [9]. To transform the segments of CC into the gored sections of skirt pattern block, we have calculated the ease allowance which should be added to the gored sections of skirt in terms of freely draping and folding on CC surface. The ease allowances in skirt pattern block and the air gaps locating between the skirt and CC have strong relationship. To find the combination of the both values, the virtual experiment has been done which results Figure 2 shows:

1. 3D CC from 1859s [18] has been generated and flattened.
2. To get #1+#4 system in Clo3D, virtual try-on has been done (Figure 2,a).
3. The air gap has been increased in 5 mm step-by-step (Figure 2, b-e).
4. The fit of skirt has been evaluated by function «fit map» which indicates the tightness of 3D skirt by showing "Cant' Wear" and "Tight" areas on its surface which were marked in red and yellow respectively. The criteria of this step is to find the air gap when the skirt of virtual system will have one area "Cant' Wear" and one area "Tight".



a b c d e

**Figure 2.** Virtual systems #1+#4 with different air gaps, mm: a – 0, b –5, c– 10, d– 15, e –20.

Figure 2 shown, when the air gap becomes bigger, the number and square of "can`t wear" and "tight" areas become smaller. The air gap 20 mm (Figure 2, e) provides the best conditions of interaction between CC and skirt as in historical prototype.

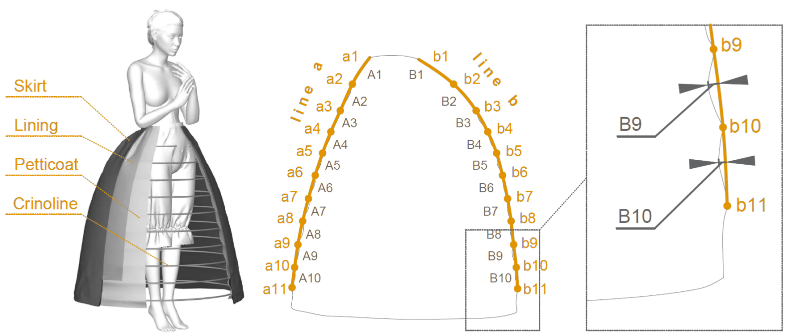
## 2.5 Criteria of textile materials selection

Traditionally before modeling of virtual clothing, the properties of real fabrics should be tested. But the digital textile materials very seldom could be considered as the full copies of real prototypes [19-21] and its behavior in VR isn't adequate to real situations. Besides, the properties of historical fabrics could not be evaluated by KES and FAST because their structure and properties have changed under influence of time, environment conditions and conservation treatment [22-24]. By this reason, we have applied original approach to simulate the behavior of historical fabrics by using contemporary ones which based on the similar looks of two systems: first, historical image (Figure 1), and second, digital replica. Contemporary analogues of historical ones have been chosen on case-by-case basis by using the reverse engineering technology.

Accordance with [8,9,25], the skirts from 1860s were made from next fabrics: lining from silk, and petticoat from cotton. From Clo3D library, we have chosen the contemporary fabrics which are similar to historical prototypes in terms of types, content and density [26]: for shell – Crepe De Chine (SS001), Taffeta (S007), Charmeuse (S002), Duchess Satin (S003), Faille (S009); for lining – 60s Muslin (M008), 30s Muslin (M007), Cotton Sateen

(C010), 20s Muslin (M006); for petticoat – 40s Chambray (C004), 50s Cotton Poplin (C003), 40s Cotton Poplin (C009), Oxford Muslin (M005). To establish the adequacy between the both fabrics, we have done the virtual experiment with next steps which are illustrated on Figure 3.

1. We designed four 3D CC with 6, 16, 32 and 64 hoops.
2. We have flattened CC to get the pattern block of skirts, to do virtual try-on in Clo3D, and to get multilayer systems: #1+#4, #1+#2+#4 and #1+#2+#3+#4. Figure 4, a shows the virtual system #1+#2+#3+#4.
3. To transform the looks of petticoat, lining and skirt, we have combined the chosen fabrics step-by-step. To evaluate the formability of textile materials, we drawn the lines a and b across prominent points of hoops, measured the deflections A1-A11 and B1-B11 of shell skirt between the hoops and calculated the averages (Figure 3, b, c).




a b c

**Figure 3.** Virtual system #1+#2+#3+#4 (a) and scheme of measuring shell fabric deflection between hoops (b, c).

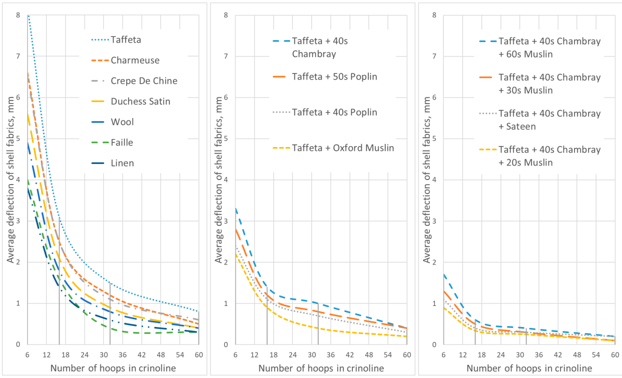
## 3. EXPERIMENTAL RESULTS AND DISCUSSION

### 3.1 Textile materials evaluation

To evaluate the ability of textile fabrics to cover the surface of CC without wrinkles and folding, we establish the deflections A1-A11 and B1-B11 equal to less than 1 mm. Figure 4 shows the average deflection values of shell fabrics for virtual systems when the number of hoops and textile fabrics combination were different. Figure 4 shown, that when the number of hoops becomes bigger then 18, the surface of digital replica has the same look as the prototype. The smooth surface of system #1+#2+#3+#4 can be got when CC has 12 hoops. On these results, we are able to find the combination of fabrics and number of hoops for digital replica generating.

### 3.2 Virtual try-on of crinoline and skirts

Since the photo (Figure 1, a) is the only source of information about the prototype, we do not know precisely how many garments were worn under the shell skirt. That is why we made three 3D models with different possible constructions of the costume and combinations of textiles: #1 with 32 hoops +#4 from "Duchess Satin""; #1 with 16 hoops +#2 from "Oxford Muslin"+#4 from "Charmeuse"; #1 with 6 hoops +#2 from "50s Poplin"+#3 from "20s Muslin"+ #4 from "Taffeta". To build the woman avatar, we used the body measurements from [27]: height – 5 ft 7 in (170 cm), bust girth – 35 in (88,9 cm), waist girth – 24 in (61 cm), hip girth – 44 in (112 cm). Basic pattern blocks of the bolero jacket, chemise and breeches have been copied from [28,29,30]. For all three 3D models we used the same jacket, chemise and breeches. Figure 5 shows the digital replicas with different construction.




a b c

**Figure 4.** Relations between the deflection of shell fabrics and the number of CC hoops in next systems: (a) #1+#4,
(b) #1+#2+#4, (c) #1+#2+#3+#4.


a b c

**Figure 5.** Digital replicas with different construction: (a) #1+#4, (b) #1+#2+#4, (c) #1+#2+#3+#4.

To evaluate the accuracy of digital replicas, we used the method published [31-32] by overlapping the contours of replicas (Figure 5) and prototype (Figure 1, a) and measuring ten distances between the front and back contours. The average deviation for evaluated skirts were: #1+#4 is 15 mm, #1+#2+#4 is 13 mm, #1+#2+#3+#4 is 12 mm. So, all 3D replicas are fairly accurate, but when the number of wearing garments under shell skirt becomes bigger, the accuracy of final object is higher.

## 4. CONCLUSION

The adequacy of historical prototypes to its virtual replicas is full due to high automatic level of decision making by means of CAD, new developed modules, and data bases. The application of such kinds of tools for reconstruction of visible and invisible elements of costume can push the costume history into VR for researching, teaching, increasing the content of museum collections, online presentations, and applying in contemporary design. Our method enriches the presentation of historical costume by adding the original approach which allows to transform 2D image into 3D virtual replica. Our project is demonstrating the contemporary approach to historical costume re-creation by means of CAD and computer graphics tools for reconstruction, conversation and exposition in 3D format. By applying mentioned technologies, the virtual historical clothes can be redesigned in regard to the lost prototypes with very high quality requirements as well.

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