

## COMPUTER 3D RECONSTRUCTION OF HISTORICAL COSTUMES RAČUNALNA 3D REKONSTRUKCIJA POVJESNIH KOSTIMA

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### **ABSTRACT:**

*Nowadays, historical costumes are mostly made for the theater needs, the film industry, as exhibits in museums and as examples in educational institutions. Given the complexity of the construction and production of the models, the possibilities for design and the complete model prototype development using the 2D/3D CAD system for construction preparation and design of clothing are investigated. The possibilities of performing complex 3D simulation models of garments are investigated according to the influence of various physical and mechanical fabric properties. The possibilities for adapting and optimising the 3D simulation and tailoring parameters were also studied, with the aim of achieving desired effects on 3D models of historical costumes, simulating the performance of certain technological operations in the production of realistic models. Three models of women's historical costumes were engineered, whereby the reconstruction of the form of models and styles of clothing characteristic for the period from the beginning to the end of the 19th century was performed. With the application of different colours and textures of textile materials, variations for all three models were developed.*

**Ključne riječi:** povijesni kostim, CAD sustav, 3D rekonstrukcija, prototip, tekstura materijala

### **SAŽETAK:**

*U današnje vrijeme, povijesni kostimi većinom se izrađuju za potrebe kazališta, filmske industrije, kao eksponati u muzejima te kao ogledni primjeri u obrazovnim ustanovama. S obzirom na kompleksnost konstrukcije i izrade samih modela, istražene su mogućnosti razvoja dizajna i cjelovitog prototipa modela primjenom 2D/3D CAD sustava za konstrukcijsku pripremu i projektiranje odjeće. Istražene su mogućnosti izvođenja složenih 3D simulacija modela odjevnih predmeta pod utjecajem različitih fizikalnih i mehaničkih svojstava tekstilnih materijala. Također su istražene mogućnosti prilagodbe i optimiranja parametara 3D simulacije i parametara krojnih dijelova, s ciljem postizanja željenih efekata na 3D modelima povijesnih kostima, kojima se simulira izvođenje određenih tehnoloških operacija u izradi realnih modela. Računalno su projektirana tri modela ženskih povijesnih kostima, pri čemu je izvedena rekonstrukcija formi modela i stilova odijevanja karakteristična za razdoblje od početka do kraja 19. stoljeća. Aplikacijom različitih boja i tekstura tekstilnih materijala, izvedene su varijacije za sva tri modela.*

## 1. INTRODUCTION

The development of CAD systems for computer design, modeling and 3D garments simulations has been the subject of scientific research for a long time but, more recently, the growing application of commercial 2D/3D CAD systems in realistic conditions of new garment model development and production preparation can be noticed. In the segment of scientific research as well as in the application of commercial systems, the development of computer 3D garment models is mainly related to conventional clothing, while there are only few research works dealing with the possibilities of development and computer 3D reconstruction of historical garments [1,2]. Considering today's common and major Internet search of informations and a general tendency towards digitalisation, many museums and educational institutions are trying to digitize their collections, in order to make them accessible to a large number of people [3]. The digital representation of historical clothing is particularly interesting for educational institutions because there is very often a small number of sample specimens that have a limited lifetime and are available to a limited number of users [4-6]. The research and analysis of women's clothing in Europe during the 19th century, determined the major changes of style and form of women's dresses from the beginning to the end of the century [7]. The clothing has been very complex and consisted of many auxiliary elements, where specially highlighted elements were crinoline and bustle [4]. The experimental part of the paper explored the possibilities of computer 3D reconstruction of female historical costumes typical for the 19th century, using a 2D/3D CAD system for construction preparation. Given the complexity of garments block patterns and multi-layer garments, study explored the possibilities of optimizing the 3D simulation parameters and parameters of cutting parts, as well as the physical and mechanical properties of textile materials, with the aim of simulating the characteristic technological procedures, where in the real garment manufacturing process, the cutting parts reinforcement and garment volume are achieved using the underskirts and wire constructions.

## 2. CHARACTERISTICS OF WOMAN'S CLOTHING IN 19TH CENTURY

Throughout the 19th century various fashion styles appeared and changed. Starting with styles of dress that revealed a woman's body more than ever in history before, to fashion voluminous dress with large sleeves, extremely wide skirts, rich ornaments and decorations which occurred in mid-century, fig. 1.



Figure 1: Overview of woman's clothing in 19th century: a)1807., b)1859., c)1880. [8]

The first two decades of the 19th century, women wore light clothes, so called "Robe en chemise" type, simple, lightweight and often transparent dresses inspired by ancient Greek [7]. In the third decade of the 19th century, long high-waisted dresses were replaced by heavy and very ornate gowns with hourglass shape. The sleeves were changed through the century. At first they were very short,

revealing the hands, then began wider and longer to extremely voluminous so-called. "Gigot" sleeves, and ended with narrow and funnel shape. Although the shape and depth of the neckline varied, women's clothing often had a wide neckline with no jewelry around the neck, to emphasize the whiteness of skin. The cape was often worn over the dress. An important part of the garment was the corset, which formed the desired shape of the waist, while the width of the skirt was achieved using the crinoline underskirt, sl. 2a. By the end of the century, around 1880, women's silhouette came back in fashion, with narrow waistline and narrow skirts with a bustle on the back, sl. 2b i 2c. Although the elements of women's clothing changed dramatically throughout this century, the waist was increasingly emphasized over time, and by the end of the century it became increasingly tighter using different types of corsets [7].

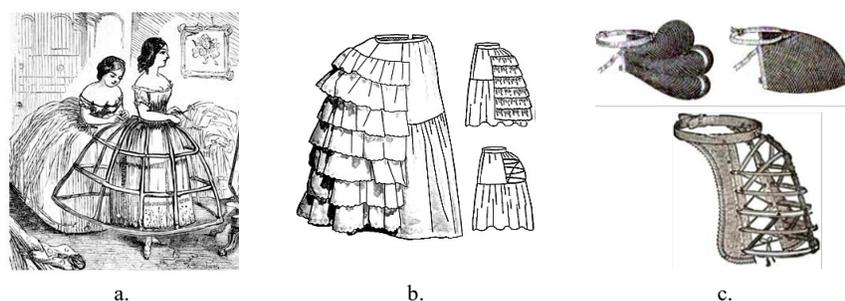


Figure 2: Underskirts of women's dresses: a) Crinoline, b) Bustle as an underskirt, c) Bustle as an independent element [8]

### 3. COMPUTER RECONSTRUCTION OF HISTORICAL WOMEN'S CLOTHES

Featured elements such as crinoline and bustle were the inspiration for computer 2D/3D design and reconstruction of historical costumes. Three garment models were designed: simple empire, characteristic for the beginning of the 19th century, and more complex models of crinoline and bustle which marked the middle and the end of the century, sl. 1. Conventional approach to computer garment design involves construction and modeling of block patterns and defining the values of previously determined physical and mechanical properties of textile material, the properties of cutting parts and 3D simulation parameters. Additionally it is necessary to adjust 3D body model for particular garment size or according to individual measurements. Described computer construction methodology can be successfully applied to conventional and fashion clothing, whereby a sufficiently high quality and realistic simulated 3D prototype models with applied material textures, can be obtained and used to assess appropriateness of the design and the quality and accuracy of the garment pattern construction and modelling. Many fashion brands are trying to offer personalized clothing items over the Internet, whereby 3D simulations are used to visualize garment item on a body model, or an avatar that is customized according to the user's measurements. Unlike simpler contemporary clothing, historical models, crinoline and bustle, require carefully studied methodology of computer designing for the purpose of model reconstruction, especially in terms of achieving the desired garment form and simulation of reinforced garment parts. 2D/3D systems for computer clothing design have not yet been developed to a level that would enable a completely realistic garment simulation, and a special challenge is the simulation of complex multilayer models such as crinolines and bustles, where in the real manufacturing process a voluminous shape of the lower garment part is achieved using additional underskirts and wire constructions. Also, in real manufacturing process, most of the upper parts of the corset are additionally reinforced with interlining and wires sewn in vertical seams. In this sense, when choosing the type of textile material for the computer

reconstruction of one historical costume model, it is necessary to determine the physical and mechanical properties for several types of textile materials that are used today and according to their characteristics would be applied to a particular parts of the historical costume, tab. 1.

Table 1: Values of textile materials physical and mechanical properties determined using KES system for objective textile evaluation

Parameter	Material I	Material II	Material III	Material IV	Measuring unit
Sample	20x20				cm
Material Composition	100 % PES	75% wool, 15% PES, 10% EA	97% PES, 3% EA	100% wool	/
Elongation X	3,90	9,05	7,02	3,02	%
Elongation Y	31,28	11,49	7,75	9,58	%
Shear	0,46	0,50	0,69	0,73	cN/cm/deg
Bend	0,02	0,02	0,05	0,03	cNm <sup>2</sup> /cm
Weight	0,84	1,79	1,78	1,62	g/cm <sup>2</sup>
Thickness	0,36	0,53	0,51	0,44	mm

In addition, due to the need for simulation of reinforcement on individual cutting parts, as well as the simulation of the voluminous lower part of the crinoline or bustle, it is necessary to investigate and optimize the 3D simulation parameters and parameters of cutting parts, which will correlate to achieve the desired appearance of the reconstructed 3D model.

### 3.1. Optimization of 3D simulation parameters and textile materials properties

Parameters of 3D simulations and cutting parts include defining properties and relations between cutting parts that need to be joined around the body model in the simulation process, in order to visualize the realistic virtual 3D garment prototype at the end of simulation. Adjustment of the particular parameters values greatly depends on the type and complexity of the garment model and requires engineer's thinking about the interaction of particular parameters and influence on the 3D simulation outcome [9]. In this sense, in order to achieve form rigidity of individual cutting parts that are in the real manufacturing process reinforced with interlining and seam wires, it is necessary to adjust the mechanical properties of textile materials and joining segments properties seams, fig. 3. Also, in order to achieve garment volume of crinolines or bustles in the lower part, it is necessary to optimize the airflow parameter in the correlation with seam shrinkage and the polygon mesh density that defines surface of the particular cutting part.

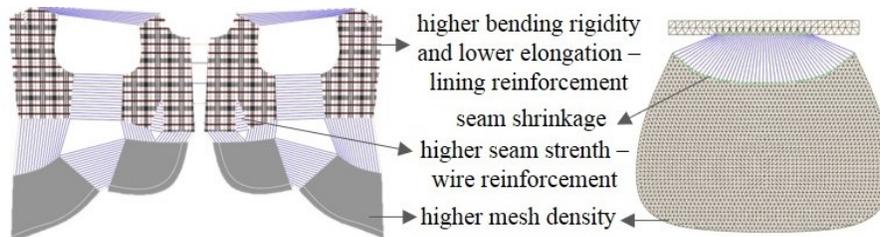


Figure 3: Adjustment of textile materials mechanical properties and simulation parameters on particular cutting parts with applied textures

#### 4. RESULTS

Figure 4 presents three reconstructed, virtual models of female historical costumes, characteristic for the 19th century: empire, crinoline and bustle. The style, form and applied textures of textile materials on the achieved reconstructed models are sufficiently realistic to present historic costumes in the digital form.



Figure 4: Reconstructed virtual 3D prototypes of historical costumes with applied colors and textures: a) empire, b) crinoline, c) bustle

## 5. CONCLUSION

Digitalisation of historical costumes in the sense of computer design and 3D reconstruction of the particular historical period model requires an interdisciplinary approach because of mentioned problematics. It is necessary to investigate a certain historical period from the aspect of fashion trends, social order, dress style, clothing construction and modelling methods, as well as the types of textile materials, textures, auxiliary accessories and ornaments that were applied on clothing. The modern era has a tendency to digitize whole preserved historical materials, including historical costumes. Possibilities of 2D/3D CAD systems are nowadays used for computer design and development of new garment models and prototypes, in order to reduce construction preparation operating time as well as to reduce number of test samples and total cost of new collections development. The development of the computer systems and the software tools used for 3D garment simulation are still not at a sufficient level in the case of design and reconstruction of historical costumes. But with careful study, engineering approach and systematic investigation of particular parameters interaction CAD systems can be used for successful 2D/3D reconstruction of a more complex models. The major problem of CAD systems, which significantly impacts workin process, is related to the contact mechanics problems of textiles in multilayered garment models, the inability to precisely define the values of certain simulation parameters on selected cutting parts, particularly when it is necessary to define different parameters on the same individual cutting part which need to be in correlation. This specifically refers to the simultaneous adjustment of the polygon mesh density which defines the surface of the cutting part and thereby determine the possibility of spatial deformation in relation to the targeted rigidity of the cutting part. Interactive positioning of the cutting parts around the body model before the simulation process is still largely dependent on the user's expertise and experience, and given that this part of the process can not be automated, there is repeatability problem of the ultimate 3D simulation results. 3D simulation parameters are still limited in providing the ability to simulate complex 3D models that are often present in historical costumes, but adequate visualization of the model can still be achieved at a sufficient level and used as a way to teach, digitize and enrich the museum collections and create online content.

## 6. LITERATURE

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