DEVELOPMENT OF A METHOD TO DIGITIZE CLOTHING PATTERNS

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ABSTRACT

The study aims to develop a method to digitize a clothing pattern without a digitizer. For this study, we address the following objectives: formulate a hypothesis of the method, describe the method's algorithm, and perform testing and evaluation of the developed method. The idea of the developed method is as follows: digitizing the clothing patterns might be achieved without digitizer by applying modification tools of the pattern design systems to the digital simple geometrical forms constructed directly in the graphical environment of the system. Testing and evaluation of the developed method confirmed the initial hypothesis. The achieved result of the current study is the alternative method to digitize clothing patterns when it is necessary to avoid additional costs.

KEYWORDS

Digitizing, Pattern; Coordinates; Modification; Pattern design system.

INTRODUCTION

In the clothing industry, design, development, and procurement teams have been affected more than any other industry and are constantly under pressure to present more products with fewer resources in a shorter time. The diversity of garment designs created as new products is not found in any other industry and is almost independent of the size of the business.

With the rapid development of digital technologies in apparel design and manufacture, clothing enterprises have ushered in development opportunities in recent years. For clothing enterprises, digital transformation is an inevitable step to meet the development requirements of the information age. However, some clothing enterprises still adopt the traditional management concept [1]. Slow adaptation leads to the low efficiency and quality of enterprise management.

The skilled labor-dependent nature of apparel design, the globalization of the market, the proliferation of information, the typical iterative "optimization" trial-and-error process of apparel product development, the reduced time to market, and continuous pressures of cost are just some of the factors that add to the fashion industry's already complex activities. Digital prototypes in the textile and clothing industry are part of the technology adoption in the product development process, which involves various operators in different stages and places, with multiple skills and competencies and other necessities of formalizing and defining the results of their activities [2].

Recently, the growth of IT technology has created new products and service methods in various industries, including the apparel industry. Especially, technologies for automating apparel manufacturing are steadily being developed. The automation of apparel manufacturing is divided into two main groups: the automation of pattern-making and sewing. Again, the automation of pattern-making for ready-to-wear and custom-fitted clothing forms the automation of pattern-making [3].

Moreover, COVID-19 has increased the digitalization of the fashion market and the rise of the virtual world. As COVID-19 locked down many countries worldwide and prevented physical contact between designers and manufacturers, the crisis forced fashion industries to inevitably turn to digital and virtual fashion and provided an opportunity to redefine business models toward more sustainable digital innovation [4].

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CAD/CAM (Computer Aided Manufacture) systems allow rapid generation of a garment design. It can be adjusted quickly without diminishing creativity. Since any cost saving through computer-aided design has become a requirement in gaining a competitive advantage in clothing design, most universities have included CAD and pattern design systems education as a part of their clothing technology courses. They have been instrumental in reducing lead times, improving accuracy, and putting apparel products in retail stores closer to when consumers need them [2].

CAD systems are widely used in apparel design since they allow interactive manipulation of garment pieces faster and more efficiently than the normal drafting process for pattern making and grading. The CAD software shows advantages in avoiding manual work, raising precision and productivity, and organizing information flow. The computer systems integrate all processes into one joint flow, thus excluding the time-consuming manual preparation of patterns, creation of layouts, and relocation of written information.

The development of the CAD systems attempted to eliminate manual and time-consuming operations in the textile and apparel industry. Many researchers assume that the CAD/CAM technology would eliminate the need to manufacture multiple prototypes. However, clothing designers did not wholly accept this scenario except during garment construction and design.

Nowadays, a lot of effort is placed in designing CAD systems, which could be easily modified to meet individual specifications of individual garment manufacturing companies. With the current trends of production customization, the reduction in the numbers of models made for each clothing line and each clothing collection, the increase in the diversity of fabric and construction patterns, and due to global changes in fashion market trends, the use of the CAD/CAM systems will inevitably broaden in terms of applicability to new production stages. The general trend in improving the industrial apparel CAD systems is to alter pattern design to facilitate quick responses to market change [5]. Reducing the time to develop a model and the cost of material reduces the cost and production and provides additional time for the designer’s creative part to create clothes [6].

ANALYSIS OF PUBLISHED DATA AND STATING THE PROBLEM

Digital transformation of apparel design

The digital transformation of apparel design and manufacturing has been under discussion for at least a decade. Several scientific works are dedicated to this question [1-6, 15]. They discuss different aspects of clothing digitalization: from sketch vectorization [3] to CAD/CAM applications in textile research [5] and garment development [2, 4]. Some researchers focus on the digital fashion market [1] and its virtual representation based on 3D scanning and 3D dynamic model development [4]. They are unanimous on the advisability of digital transformation of apparel design on all steps of garment development and its manufacturing.

On the other hand, each one focuses on one specific design procedure [3, 5] or the general aspects of the management while implementing digital solutions in apparel design, manufacturing, and online marketing [1, 2, 4, 7].

The paper [1] introduces the basic concept of digital enterprise management, analyses the shortcomings of the current clothing enterprise management, and discusses the key points of digital transformation of clothing enterprise management combined with the characteristics of clothing enterprises. Another work [7] describes the results of the patterns of digitization survey designed to assess how companies are implementing digital transformation. The survey covers the various strategies companies employ, the technologies they invest in, and, in particular, the actions they take to overcome the organizational resistance that is common in most large-scale transformations.

Several works focus on the comparative analyses of the popular CAD systems [6, 8]. The rapidly evolving software market offers a wide range of clothing CAD systems to consider when choosing one. The developers provide both initial application systems that serve as practical help in individual activities, such as housewives, and powerful complexes of clothing and material support for large enterprises, providing the ability to adjust to the regional market characteristics and take into account the features of the enterprise. Such systems are functional but usually not cheap. Consequently, making the right choice when choosing a CAD system is sometimes difficult. According to [6], when considering several factors, the most important are cost and functionality.

The CAD system usually includes the cost of the computer, digitizer, plotter, etc. While the computer is necessary, a digitizer is needed when a clothing enterprise has a lot of paper patterns requiring digitalization. Due to the COVID-19 pandemic, engineering professions adapt to the new working conditions at home. It means having digital patterns and CAD systems at home for clothing patternmakers. Consequently, from time to time, they need to digitize some clothing blocks at home, while the digitizer is usually a massive and very costly thing. Besides that, reducing time spent digitizing is crucial since it directly translates to improved productivity.

Ways of digitizing patterns

Pattern digitizing is a vital step of manufacture process in multiple industries, such as apparel. Researchers compare and discuss various ways of digitizing patterns and their advantages and disadvantages [8].

There are numerous ways to digitize patterns. Among them are digitizer tables, roll-up digitizers, scanners, pattern digitizing software (photo digitizing software).

Every clothing designer / patternmaker and design studio should be seen as a different case as they have unalike requirements and priorities. Therefore, one of the methods above may better meet their digitizing needs. However, most users will have similar advantages and disadvantages while digitizing by each method.

Digitizing tables or "Table digitizers" are electromagnetic tables used with a particular mouse to traverse the patterns' outline one point at a time. There are various buttons on the digitizing mouse for inputting a different type of point to the pattern design system that runs on the computer linked to the digitizer. Before starting to digitize, a user must calibrate the digitizer. Accuracy depends on the user's attention and experience and the pattern itself. Patternmaker fixes patterns on the table surface using adhesive tapes and then remove them.

Although it is among the most widely used digitizing methods, table digitizers have some crucial disadvantages. Probably the most crucial aspect is speed. Digitizing is slow since a patternmaker does it manually, one point at a time, and also due to the usage of adhesive tapes. Users lose considerable time, especially when there are many patterns to digitize in one batch and such batches are repeated often.

Table digitizers are also expensive and heavy devices, making them inconvenient, particularly in small workplaces. Transferring pattern pieces into a CAD system via a digitizer is tedious and frustrating. The fact that one can evaluate the result only after the digitizing process is finished leads to inaccuracies or untidy curve runs. Purchasing a digitizer table is expensive and requires a significant amount of space.

Roll-up digitizers are thin, flexible, and lightweight. They are stretched on a flat surface and rolled up after finishing digitizing. Roll-up digitizers cost less compared to table digitizers. Although users can roll them up, they still require a flat surface of their size, and digitizing speed is as slow as table digitizers.

Scanner digitizers are scanner-like devices that scan the image of patterns from a close distance and employ image processing techniques to process the scanned image. They are much faster than the previous three digitizers but also come at a higher price. Depending on their size, they may claim some of the workspaces. Also, they may not always fit all the patterns, so patterns may have to be digitized one or two pieces at a time.

Pattern digitizing software (photo digitizer) uses image processing algorithms like scanner digitizers, but the difference is that it captures the image using a digital camera rather than a scanner. The software processes the captured image. It extracts features such as pattern outlines, notches, internal lines, and grain lines from the image. Using a camera means the captured image's quality will depend on the lighting conditions, camera quality, and camera position, demanding more sophisticated image processing algorithms.

Several programs provide a solution to the inconvenience and inaccuracy of tablet digitizers. Among them are ProfileFitPattern Photo program [9], JULIVI "Fotodigitayzer» [10], Kuris Photo Digitizer [11], Eastman Photo Digitizer [12], Autometrix Photo Digitizer [13], and others. The digitized outcome matches the accuracy of measurements of a result digitized with a digitizer tablet. A patternmaker can compare the digitized curves directly on-screen with the original, so the accuracy of the curve is significantly greater. The advantages of photo digitizers are that no expensive digitizer table is required, the space requirement for a digitizer tablet is omitted, and flexible and location-independent digitizing. One may expect that this kind of digitizing system may be costly. It is partly actual since each vendor may charge a different amount for calibration-free photo digitizers. Besides that, clothing patternmakers do not have enough methods to implement such digital tools at home when necessary, for example, due to the force majeure conditions such as the COVID19 pandemic, etc.

That is why it is advisable to have a method to digitize a clothing pattern without any pattern digitizer when it is necessary to avoid additional costs.

THE PURPOSE AND OBJECTIVES OF THE STUDY

The study aims to develop a method to digitize a clothing pattern without a digitizer. For this study, we address the following objectives:

- to formulate a hypothesis of the method;
- to describe the algorithm of the method;
- to perform testing and evaluation of the developed method.

METHODS

The hypothesis of the developed method is as follows: digitizing of the clothing patterns might be performed without any digitizer (tablet or photo, etc.) by applying modification tools of the CAD/CAM systems (pattern design systems) to the digital simple geometrical forms that are constructed directly in the graphical environment of the PDS. We consider a rectangular as a chosen form for the alteration. "Julivi" is the pattern design system selected for the study. The system "Julivi" allows constructing the rectangular patterns using built-in macros. Moreover, a range of system tools enables measurements and any possible alterations of the clothing blocks.

The main points and lines that construct a pattern are defined, and names are assigned to apply the alteration method, as shown in Figure 1.

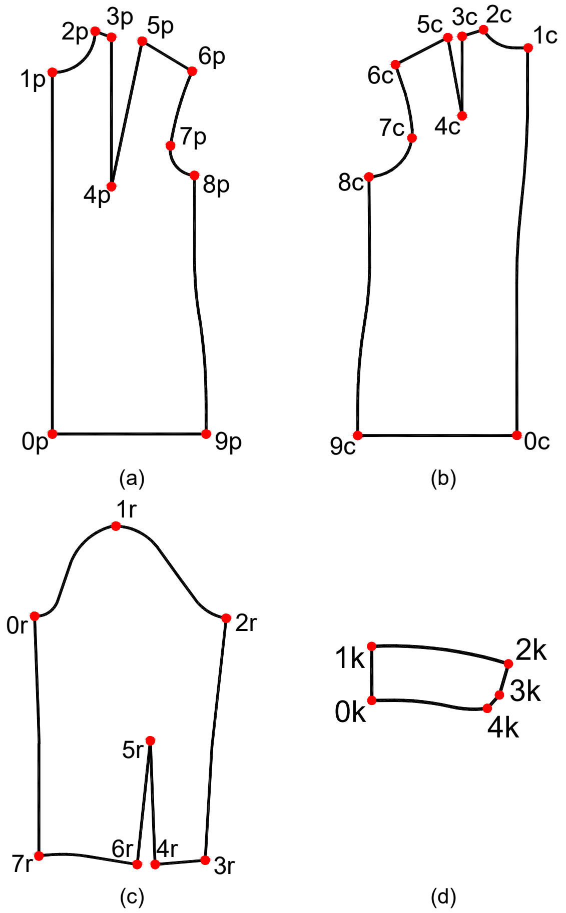


Figure 1. The main points of the original patterns: front, back, sleeve, and collar.

We used two different digitizing methods, such as photo digitizing and digitizing by graphic tools of PDS itself. We performed a comparative analysis of measurements for the patterns of women's clothing. The original patterns were compared to their digital twins to compare the accuracy of the developed method. The lengths of the digital patterns' constructive lines were measured by PDS "Julivi" tools and compared to the measurements of the same lines of the original patterns. Besides that, a comparison of the clothing blocks' areas was performed. Pattern design system "Julivi" automatically forms a "Specification" that lists the areas of digital patterns.

RESULTS AND DISCUSSION

Algorithm of the method

The algorithm of the developed method is as follows.

1. Constructing a simple geometrical form in a graphical environment of a pattern design system by its tools (figure 2, a)
2. Determining the number of main points of the pattern and inputting the same number of points to divide the lines of the original rectangular into the number of segments (figure 2, b). The names of the points are the same as those assigned for the actual pattern points.
3. Determining the coordinates of the points of the original pattern in the Cartesian coordinate system. The center of coordinates is one of the main points, which a patternmaker may choose as they see fit.
4. Determining the coordinates of the points of the digital rectangular in the Cartesian coordinate system. The center of coordinates is the point of the same name as in the original pattern.
5. Calculating Δx, Δy – the difference in coordinates of the points of the same names belonging to the original pattern and the digital geometric figure.
6. Shift the points of the digital geometric figure by the value of Δx, Δy using the pattern design system.
7. Determining the minimum number of additional points on the curved sections of the original pattern and inputting them into the curved sections of the original patterns and their digital twins.
8. Determining the coordinates of additional points, calculating the values Δx, Δy for them, and shifting the extra points of the digital geometric figure by the value of Δx, Δy using the pattern design system (figure 3, figure 4, c).

An example of using the method is at the link https://youtu.be/d1Fya_F8uqg.

Testing the method

The first step of testing the method is digitizing the original patterns (Figure 1) with a photo digitizer using the pattern design system "Julivi" (Figure 5).

The second step of testing is digitizing the patterns of the front, back, sleeve, and collar, using the developed method (Figure 6(c), Figure 7(c) and comparing the patterns' areas and segments' lengths (Table 1, Table 2).

Table 1 and Table 2 compare the method of digitizing; one can see that the developed process guarantees a higher digitizing accuracy than a photo digitizer.

Red marks in the tables show the differences that overcome the permissible rates. As the differences ensured by the developed method are acceptable, we may conclude that this method may be used as an alternative method of digitizing patterns instead of the photo digitizer or any other digitizer.

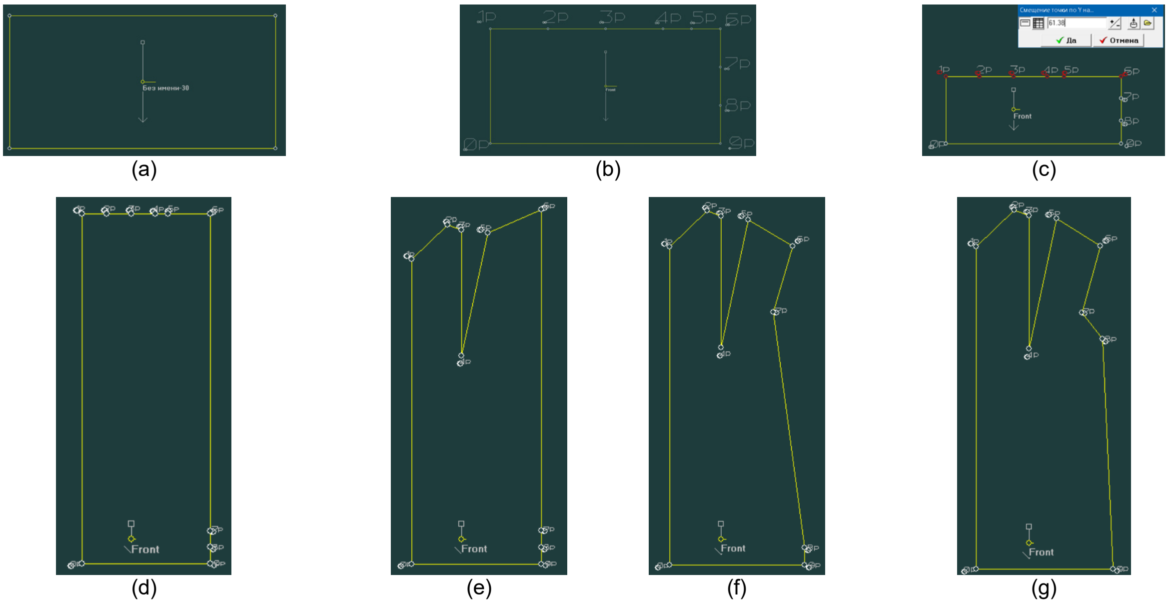


Figure 2. Digitizing the front block: (a) a rectangular (step 1); (b) main points (step 2); (c)-(g) shifting the points (step 6).

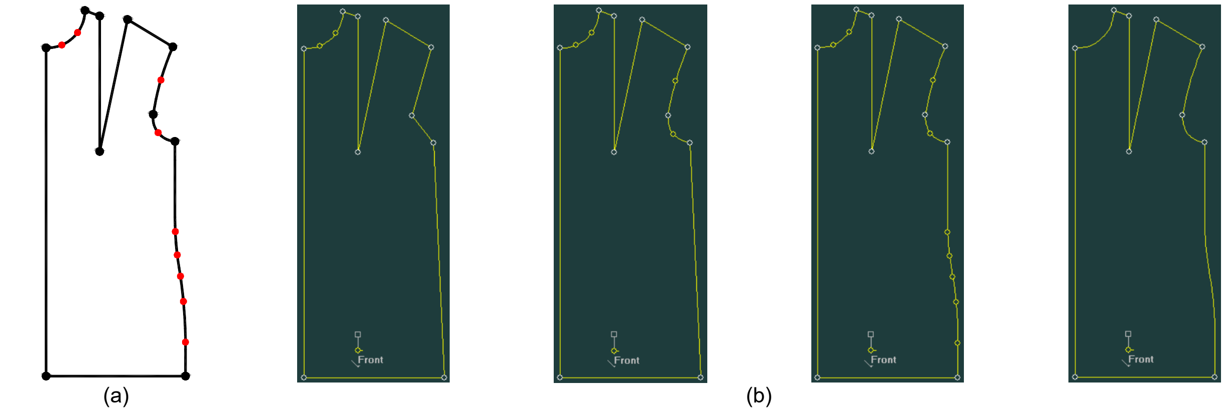
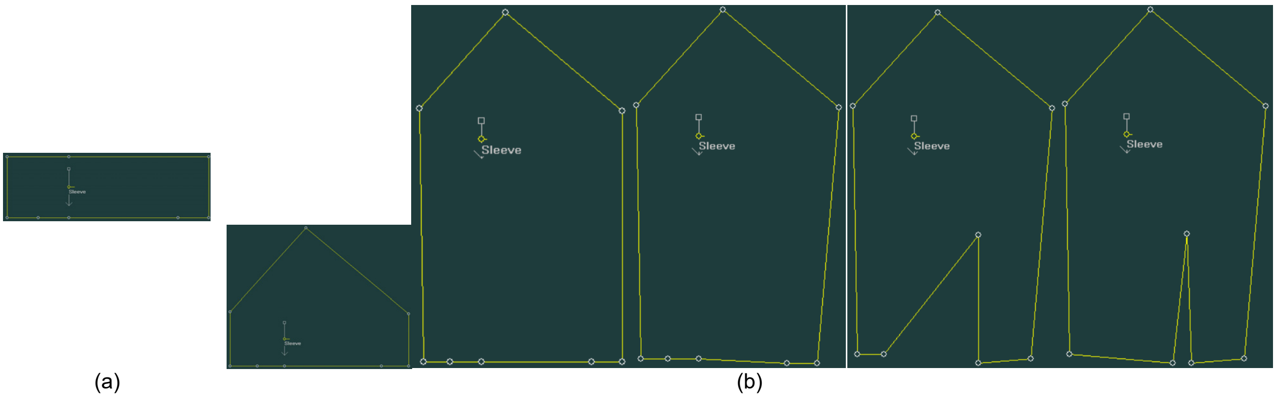
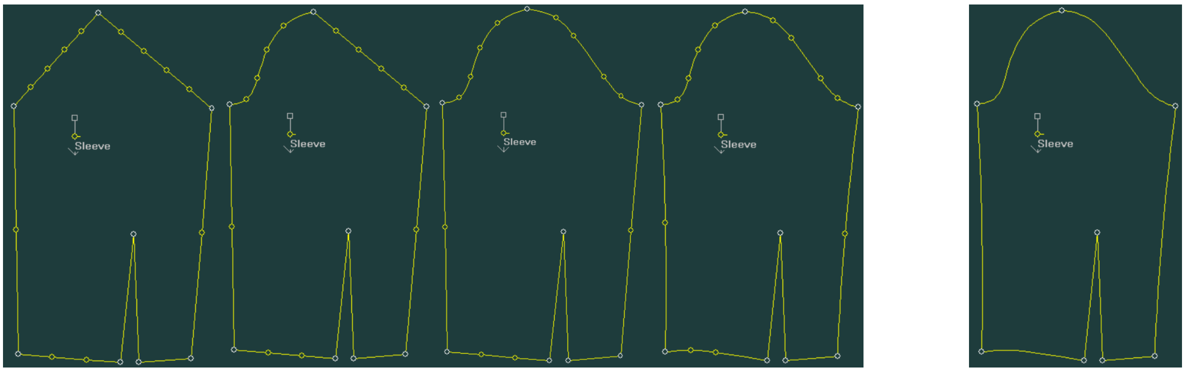


Figure 3. Alteration of the curved sections of the pattern: (a) inputting the extra points (step 7); (b) shifting the extra points (step 8).





(c) (d)

Figure 4. Digitizing a sleeve pattern: (a) an initial rectangular pattern; (b) points relocations; (c) digitizing curves; (d) completely digitized pattern of the sleeve.

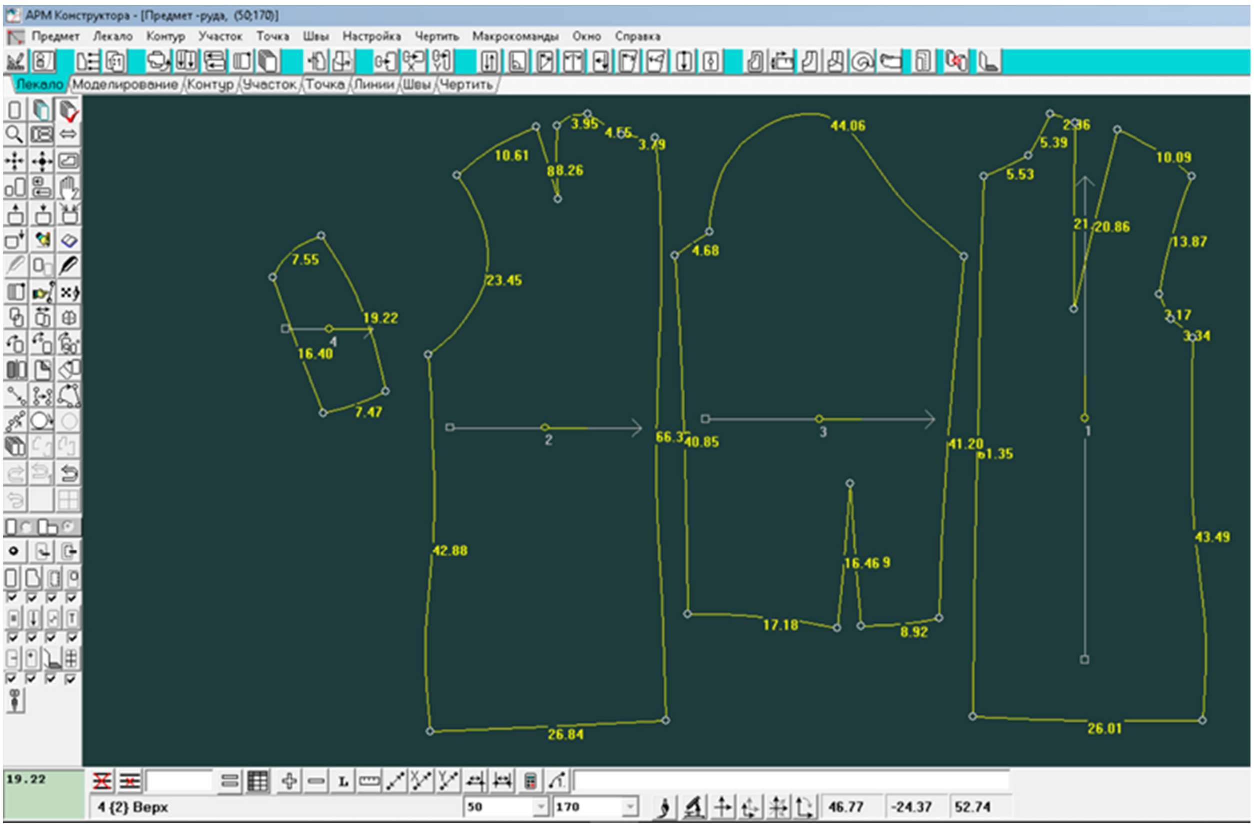
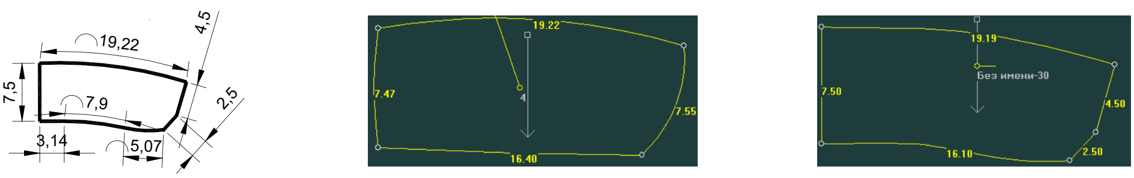
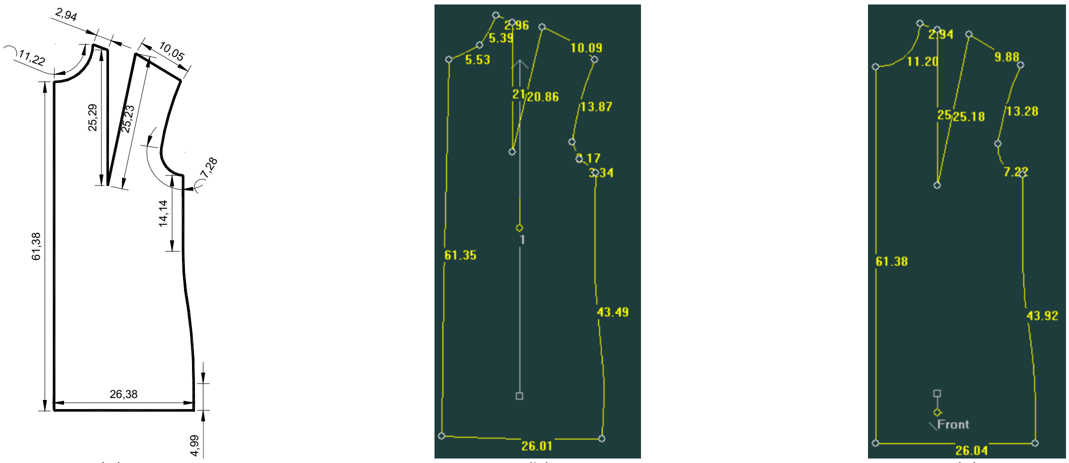


Figure 5. Digital clothing blocks obtained using photo digitizer (M2).



(a) (b) (c)

Figure 6. Collar: a) original pattern (M1); b) digitized with photo digitizer (M2); c) developed method (M3)



(a) (b) (c)

Figure 7. Front: a) original pattern (M1); b) digitized with photo digitizer (M2); c) developed method (M3).

Table 1. Comparison of the segments' lengths.

Part	Line	M1, cm	M2, cm	M3, cm	Δ_{1-2}		Δ_{1-3}	
					cm	*%*	*cm*	*%*
Front	0p-1p	61.38	61.35	61.38	0.03	0.05	0.00	0.00
	1p-2p	11.22	10.92	11.20	**0.30**	2.67	0.02	0.18
	2p-3p	2.94	2.96	2.94	-0.02	-0.68	0.00	0.00
	3p-4p	25.29	21.05	25.29	**4.24**	**16.77**	0.00	0.00
	4p-5p	25.23	20.86	25.18	**4.37**	**17.32**	0.05	0.20
	5p-6p	10.05	10.09	9.88	-0.04	-0.40	0.17	1.69
	6p-7p	13.18	13.87	13.28	-0.69	-5.24	-0.10	-0.76
	7p-8p	7.28	6.51	7.22	**0.77**	**10.58**	0.06	0.82
	8p-9p	43.91	43.49	43.92	**0.42**	0.96	-0.01	-0.02
	9p-0p	26.38	26.01	26.04	**0.37**	1.40	**0.34**	1.29
Back	0c-1c	65.77	66.30	65.76	**-0.53**	-0.81	0.01	0.02
	1c-2c	8.71	8.34	9.07	**0.37**	4.25	**-0.36**	-4.13
	2c-3c	3.79	3.95	3.78	-0.16	-4.22	0.01	0.26
	3c-4c	13.48	8.26	13.47	**5.22**	**38.72**	0.01	0.07
	4c-5c	13.48	8.51	13.48	**4.97**	**36.87**	0.00	0.00
	5c-6c	9.99	10.61	9.99	**-0.62**	**-6.21**	0.00	0.00
	6c-7c	12.81	13.05	12.81	**-0.24**	-1.87	0.00	0.00
	7c-8c	10.70	10.49	10.63	**0.21**	1.96	0.07	0.65
	8c-9c	43.95	42.88	43.94	**1.07**	2.43	0.01	0.02
	9c-0c	26.97	26.84	26.97	0.13	0.48	0.00	0.00
Sleeve	0r- 1r	21.91	24.29	22.41	**-2.38**	**-10.86**	**-0.50**	-2.28
	1r-2r	26.25	24.5	25.62	**1.75**	**6.67**	**0.63**	2.40
	2r-3r	41.62	41.20	41.62	**0.42**	1.01	0.00	0.00
	3r-4r	8.61	8.92	8.61	**-0.31**	-3.60	0.00	0.00
	4r-5r	21.21	16.19	21.21	**5.02**	**23.67**	0.00	0.00
	5r-6r	21.32	16.46	21.31	**4.86**	**22.80**	0.01	0.05
	6r-7r	17.00	17.18	16.98	**-0.18**	-1.06	0.02	0.12
	7r-0r	41.09	40.85	41.09	**0.24**	0.58	0.00	0.00
Collar	0k-1k	7.50	7.47	7.50	0.03	0.40	0.00	0.00
	1k-2k	19.22	19.22	19.19	0.00	0.00	0.03	0.16
	2k-3k	4.50	5.13	4.50	**-0.63**	**-14.00**	0.00	0.00
	3k-4k	2.50	2.42	2.50	0.08	3.20	0.00	0.00
	4k-0k	16.11	16.40	16.10	**-0.29**	-1.80	0.01	0.06

Table 2. Comparison of the patterns' areas.

Part	Line	S_{M1}, cm^2	S_{M2}, cm^2	S_{M3}, cm^2	Δ_{1-2}, %	Δ_{1-3}, %
Front	0p-1p	1478.138	1523.120	1481.360	-3.043	-0.218
Back	0c-1c	1591.888	1627.370	1592.230	-2.229	-0.021
Sleeve	0r-1r	1503.026	1549.050	1496.460	-3.062	0.437
Collar	0k-1k	134.326	146.960	133.440	**-9.405**	0.660

CONCLUSIONS

The achieved result of the current study is the alternative method to digitize a clothing pattern without any digitizer. Testing and evaluation of the developed method confirmed the initial hypothesis.

The implementation of the method slightly increases the duration of the digitizing while the accuracy is assured at the highest level of precision. The most prominent advantage of the method is no need to purchase the digitizer.

It is necessary to highlight that the method is compatible with any pattern design system available at the design studio or even at a designer's home.

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