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ANALYSIS OF MODERN COMPUTER TECHNOLOGIES USED FOR VIRTUAL FITTING OF CLOTHES

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Abstract. The aim of the research is to analyze modern services used for online selection of clothes of the desired size, and to determine the effective ways of their implementation. A comparative analysis of functional services on virtual fitting of clothes on the electronic mannequin has been carried out, and the systematization of various methods of realization of virtual fitting of clothes has been performed in order to provide an assessment of quality of the finished products, namely, to predict the size of clothes, to form the recommendations on the feeling of comfort clothes, and to provide the assessment of anthropometric conformity with the accordance of the form of clothes design and the consideration of anthropometric characteristics of the human body. The main components that influence the quality of formation of assessment of anthropometric conformity have been determined.

Keywords: *3D technology, electronic mannequin, online fitting room, visualization of clothes.*

Introduction

The last few decades are characterized by an active spike in the development of information and computer technologies, which are in high demand in various fields and are not only a tool for creation, but also a subject of new knowledge. Today, there are a number of computer programs, developed to design the clothes, which improve the level of efficiency and speed of the garment industry. Rapid pace of life forms new requirements for computer programs, developed to design the clothes, therefore, there is a need to update and to improve existing technologies, which leads to the emergence of innovative competitive projects and startups.

It is well-known that success and profitability of any enterprise depend on the speed of production processes along with the minimization of the use of raw materials. In the garment industry, special attention is paid to the three-dimensional designing of clothes, since the achievements of modern 3D technologies have changed even the way of clothes production. Modern computer technologies make it possible to develop the models and the collections of clothes very quickly, as well as to create complete systems of analysis of the quality of their production. The development and the improvement of clothes visualization in three-dimensional space is an actual and priority direction of scientific researches, aimed to solve the problem of virtual fitting of clothes size for the consumer and to accord the form

of clothes with anthropometric characteristics of the human body, considering the ergonomic requirements.

Analysis of the recent researches and publications

Many specialists in scientific and industrial spheres of the fashion industry carry out the researches in the field of virtual visualization of clothes on the figure. It is expected that three-dimensional designing will increase the demand for individual clothes production due to the possibility of creation of its own virtual mannequin. The method of construction of electronic mannequin and clothing for virtual fitting is well-known, according to which the design of 3D objects takes place on the basis of determination of dimensional parameters by analysis of the contour of a human body or its clothes in photographs [1]. In order to design electronic mannequin of the human figure, this document [2] addresses a method for collection of anthropometric data of the human body using the three-dimensional scanning and generation of a parametric three-dimensional pattern of the human body, which corresponds to its parameters.

Using the advantages of 3D technologies, namely, the visualization of clothes of different assortment ranges on an electronic mannequin, it is possible to accumulate databases of 3D mannequins and models of clothing, as well as to determine the optimal values for adjusting the basic designs of clothes, taking into account the properties of the materials [3]. Fitting of clothes is an important factor in the concept of visual fitting in order to meet the consumers` need in comfortable clothes, therefore, the researches on the development of recommendations for the formation of different volume and silhouette forms of sewing products, taking into account the properties of fabrics, are still relevant. The author, MengNa Guo, in his thesis [4] conducts studies on improving the comfort of clothes, defines indicators that form a sense of comfort clothes, and analyzes a number of tactile sensations of comfort clothes in accordance with physical and mechanical properties of textile materials.

Recently, more and more attention is paid to the level of dynamic matching of a product to the person`s figure. Such kind of analysis may be useful in providing advice to consumers as to the assessment of the product quality for online sales. The authors in their work [5] propose contactless method of measuring the product pressure in different positions along with the use of a three-dimensional deformation grid, drawn on the clothes. The degree of the clothes pressure on the human body is determined by the way of analysis of deformation of the circular gratings and information about the flection on the surface of the garment. The scientists [6] propose a method for recognizing the design of the clothes and the human figure for virtual fitting, using an image-based tracking method, based on optical flow that allows the users to see themselves in the selected clothes in real time. The authors have optimized the system of human figure tracking modules by adjusting the indicators, which now speeds up the display of the figure on the computer screen in different poses.

The authors in their work [7] use a statistical method to study the changes in the shape of the clothes of various assortments and the human figure. They are proposed a system for virtual fitting that performs a comparative analysis of the values of air gaps between a real assessment of the human body and a virtual model. The scientists [8] have conducted a study of air gaps in women`s shoulder clothes of the costume group, in which the connection between the properties of fabrics and the volume and silhouette shape of the product has been determined. Also the recommendations for taking into account the properties of fabrics in order to predict the size of the clothes in virtual fitting have been proposed.

The work of the authors [9] presents the analysis of the most well-known companies, engaged in the development of virtual fitting rooms (Creazione (Italy), Browzwear (Singapore), IDesigner (Korea), Lectra Systems (France), Dressformer (Russia)). The analysis showed a high level of reality of the proposed 3D models of products, but there are some inaccuracies in the technology of determination of the conformity of a three-dimensional visual prototype with a real product, taking into account the properties of the fabric and individual anthropometric features. The team of Astrafit (Ukraine) [10] has conducted an analytical analysis of economic indicators of online stores as to the use of virtual fitting rooms, and has determined that 70% of returns of clothes are caused by improperly selected size of the clothes, which results in the decrease in purchases via the Internet. The solution to the problem of virtual determination of the necessary size of clothes will increase the store confidence, as well as the volume of its sales.

Statement of the problem

The conducted analysis shows the activity of the researches on visualization of clothes in three-dimensional space, as well as the presence of various methods for assessing the visualization of the product in online mode, which differ in type of production, volume, equipment with technical means, input information and method of its processing. The use of virtual fitting room has several benefits for company management, and also affects the attraction of new customers. However, existing electronic mannequins have not yet been fully refined, since the human body has a complex geometry, and existing information does not take into account the features of the figures of different types and is not enough for commercial use. In addition, when using the service for virtual fitting of clothes, the consumer faces with the complexity of process of input the values of the main anthropometric parameters and the features of its own figure, therefore, the aim of the article is to analyze the existing services and to determine the effective ways to improve the programs for virtual fitting of clothes.

Results and discussion

The last years are characterized by rapid and effective growth of online trade of different types of products. Shopping through the Internet is becoming a popular phenomenon. The developers are trying to be as effective as possible and offer new services to the users. One of such new services is the service of online fitting of clothes of necessary size – Virtual Fitting Room. The essence of such new service is to evaluate anthropometric conformity of products to the parameters of human figure, taking into account ergonomic requirements. The principle of work of such systems of fitting is as follows: measuring of anthropometric data or scanning (photographing) human figure; construction of electronic mannequin; creation of "three-dimensional" clothes; wearing of three-dimensional clothes on a three-dimensional mannequin. Mannequin is the main part of the technology of three-dimensional designing of clothes and the main tool for visual assessment of clothes. In order to obtain such a mannequin, the anthropometric information, which gives an idea about proportions, shape and dimensions of the human body, is required. Electronic mannequins are offered by various developers, namely: Optitex (Israel) – Runway Designer module, Gerber (USA) – AccuMark 3D module, Lectra Systems (France) – Modaris 3D Fit module, JULIVI (Ukraine) – JULIVI CLO3D module, ASSYST (Germany) – Vidya module, DressingSim (Japan) – LookStailorX module, and so on.

In garment industry, the process of designing the clothes depends on the skills and experience of the specialist. Upon completion of the clothes design, drawings of details of the clothes are being developed. Typically, this process is implemented in 2D using CAD software. New technologies of three-dimensional design provide an opportunity to get a copy of human figure and clothes on the monitor screen, to visualize their harmonious combination with further development of product templates. Let`s consider the main CAD capabilities, which include 3D module, using the following criteria: scanning of the figure and selection of electronic mannequin; wearing of developed templates on a three-dimensional mannequin; selection of physical and mechanical properties; assessment of virtual product fitting; and the ability to animate the model.

Scanning of the figure and selection of electronic mannequin is an exact duplication of the human figure by means of special devices with further reflection in the virtual space. Anthropometric data is presented in the form of a detailed set of dimensional features, along with scanned human figures. The quality of the scanned image depends on the software and number of cameras, which results in flattening of visualization of the scanned human body. Research and collection of data on dimensional features of women`s, men`s and children`s figures are carried in many countries of the world using various equipment for three-dimensional scanning, namely: infrared, laser, optical and radio wave scanners. The companies that study the human figures by scanning are: Alvanon (USA), Telmat Industrie (France), Human Solutions (Germany), Konica Minolta VIVID 910 (USA), and so on.

Wearing of developed templates on a three-dimensional mannequin is the method of simplified modeling, in which the templates are placed around the virtual figure and connected in a certain sequence, given by a specialist. Virtual dressing accelerates the process of production of the clothes, replacing the production of a sample model and, if necessary, the adjustments on the mannequin. Such an opportunity is provided by CAD Gerber (USA), JULIVI (Ukraine), Optitex (Israel)**,** Lectra Systems (Spain), IDesigner (Korea), and others.

Also there is a different approach to solving the problems of three-dimensional design – the development of virtual prototype of clothes design in three-dimensional space with its further deployment on the flat. Such approach is offered by DressingSim (Korea), Tukatech (USA), and other programs.

The purpose of physical and mechanical properties of the materials – the process of determination of physical and mechanical properties of the material, aimed to achieve maximum reality of dressed models of clothes, is offered by JULIVI (Ukraine), Optitex (Israel). The modeling of fabric is an important step in the process of design and visualization, since the complexity of forms, draperies and plaits forms the imagination and perception of the model on the figure.

Assessment of the quality of virtual product fitting is an analysis of dimensions of the structural components, the location of the dividing lines, additions, and the interaction of the fabric with the surface of the mannequin. In such a way, the additions for free fitting are determined, the balance of the product, as well as the directions of the main dividing lines, are estimated, and also the areas with the greatest pressure of clothing on the body are determined, etc. Such an opportunity is offered by Gerber (USA), JULIVI (Ukraine), Optitex (Israel), and IDesigner (Korea).

Formation of the design and assessment of the appearance of a clothing model means the ability to apply decorative elements, to select color range and texture of the materials. Using the software, it is possible to match texture and pattern on fabric, furniture, to edit the

length of the product in order to assess the proportion of the model, etc. It is possible to visualize any pattern of the fabric or decorative element of the product in 3D, considering the properties of the materials (Optitex, Israel), to calculate the places and shape of the structural and decorative elements of clothes, taking into account the backing and glue pads (CAD JULIVI, Ukraine) [11].

The ability to animate the virtual model means a movement of electronic mannequin in the virtual space. Interactive abilities allow accessing the movements and visualizing the clothes in dynamics. The best results are demonstrated by Optitex, Israel.

The conducted analysis has shown that today some modern programs implement the process of three-dimensional designing of clothes with further deployment and obtainment of patterns, however, most of modern systems offer virtual fitting for visual assessment of fitting and appearance. Also not all CAD have the animation function, which demonstrates the incompleteness of information base and the need for the researches in this direction.

The technology of three-dimensional design of the human body surface and the assortment of clothes has become an industrial instrument for measuring and comparing three-dimensional objects at different stages of production. Virtual dressing system is becoming a real invention not only for garment industry, but also for retailers. It is an important stage in creation of technological services, which form the structure of online sales. Consumers, who buy clothes today, base their purchasing and size decisions mainly on 2D photos and dimension tables. However, the inconsistency in the size of clothes in online shops, and the different size charts around the world complicate the process of size determination that results in the improperly purchasing of goods.

Online shops understand the value of virtual fitting, introduce the function of choosing the size of clothes on their sites. Nowadays, there are programs that have been created as a separate narrow-spectrum software product for fitting of clothes on the figure for online sales or for creation of electronic mannequin of the figure by scanning. The programs that offer the service of virtual fitting of clothes are Astrafit (Ukraine), Looklet (Sweden), Metail (UK), 3D-A-PORTER (UK), Body Labs (UK), Dressformer (Russia), 3D-Look (Ukraine), Clothes Horse (UK), Fitnect (Hungary), Sizolution (Russia), Fit Analytics (Germany), and others. A lot of programs offer contactless methods for studying the human body surface in order to create 3D consumer mannequin (body scanners, cameras and other gadgets); a small number of companies use a standard measuring tape. There are considered in more details the possibilities of the next programs for virtual fitting of clothes: Metail (UK), Looklet (Sweden), Fitnect (Hungary), True Fit (USA), Virtusize (Sweden), 3D LOOK (Ukraine), Sizolution (Russia), Astrafit (Ukraine).

Metail (UK) [12] – the program offers the visualization of clothes on a parametric 3D mannequin, which is set by the main parameters of the user: height, weight, chest girt, hip shape and leg length. The proposed mannequin is a realistic copy of the human figure. The user has the possibility to look through the 3D models of figures (avatars) in real time and to select the model, which is the most similar to his own figure. During the virtual fitting the clothes are visualized, considering the behavior of the fabric; it is possible to turn the mannequin and to see the clothes from all sides. The result of the fitting is the selection of the most suitable size and model, however, it should be noted that it is impossible to make a virtual fitting of the clothes of sizes, which differ from the recommended one.

Looklet (Sweden) [13] – service on creation of virtual image and formation of personal virtual studio with functions and possibilities for clothes visualization and creation of

personal image. Selection of 3D model takes place interactively, taking into account the simulation of fabric behavior in clothes in particular position. In addition, there is a possibility to look through and to select color of hair, makeup and accessories. Technology allows photographing clothes without necessary preliminary preparation for a photo shoot. Visualization takes place as a result of formed database of women`s, men`s and children`s scanned figures in different projections, properties and structures of fabrics. At the final stage, the software combines all the elements of the image, simulating the virtual fitting.

Fitnect (Hungary) [14] – a service for visualization of clothes in virtual reality. The proposed software perceives the user`s figure and imposes a three-dimensional model of clothes over it, taking into account the dynamic behavior of fabric. The result of the system`s work is the visualization of clothes on a virtual copy of the consumer`s body in real time, the creation of personal image and the assessment of quality of clothes fitting from different angles. Technology allows the user to make photos of his personal image in different sets of clothes.

True Fit (USA) [15] – the program solves the question of virtual fitting by collecting information about fashion trends, styles of clothes, fabrics etc. of many well-known brands of clothes (Macy's, Uniqlo, Nordstrom, Levi's etc.) and individual data on the figures and preferences of many consumers. The formation of 3D mannequin is based on the users` information – in particular, about height, weight and age, and the dressing of the product is based on the selected size and brand of clothes. The result of fitting is the determination of desired size of the selected model of clothes. The same principle of virtual fitting is realized in the online shop of the famous brand of clothes H&M.

Virtusize (Sweden) [16] – a service for virtual selection of the required size of clothes, based on the measurements of personal clothes of users and their preferences (figure 1).

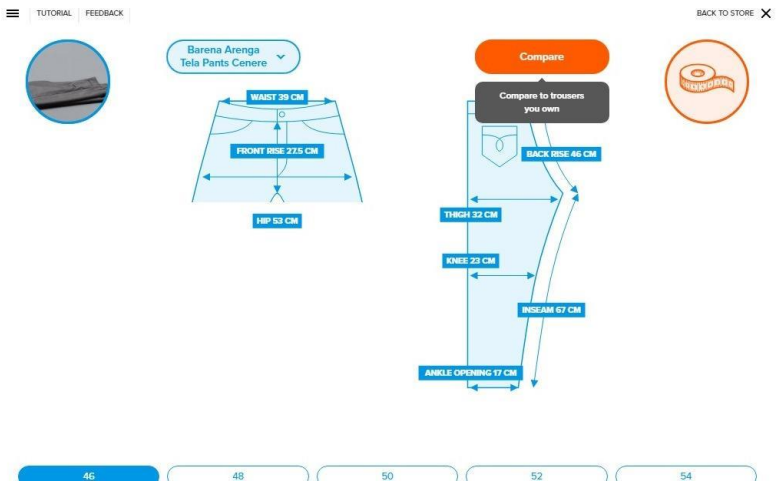
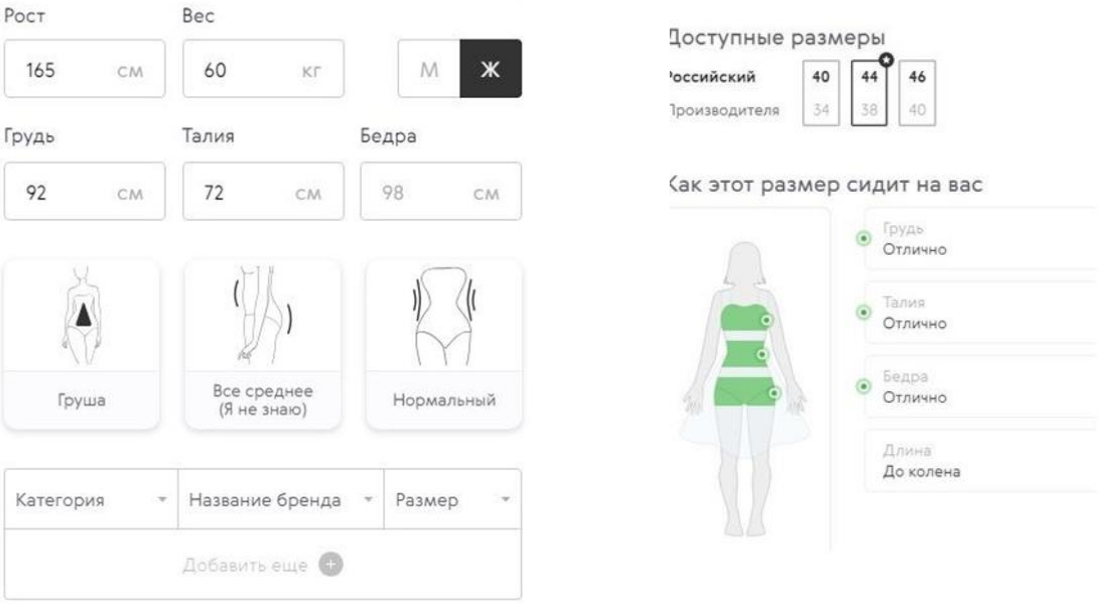


Figure 1. An example of clothing measures for virtual fitting with the use of the Virtusize service.

3D LOOK (Ukraine) [17] – a program that offers visualization of clothes on 3D mannequin that is made on photos in two projections, which are loaded by the consumer. The method of taking pictures is described in the service manual, but it is difficult for ordinary consumer. The optical technology, statistical simulation and algorithms of three-dimensional designing, aimed to form electronic mannequin, based on determination of the main anthropometric points, are used. The result of fitting is an electronic mannequin, which shows

the size of the chosen model. The analysis of the program reveals the presence of errors in the main anthropometric parameters during the construction of electronic mannequin, and, as a result – inaccurate prediction of the degree of anthropometric matching of clothes.

Sizolution (Russia) [18] – a service that allows predicting the size and fitting of clothes. The technology of the service offers 2D image of the user`s figure, which is formed by introducing the anthropometric parameters: height, chest girth, waist, hip circumference and additional information about the user`s figure, namely, the type of the figure and weight (figure 2, a). The software allows the user to make 3D mannequin using the photos, which can be imported into the program. The result of the virtual fitting is the projected size of the model with the reflection of the degree of fitting on the main parts of the body (figure 2, b).



a) b)

Figure 2. The result of the virtual fitting with the use of the Sizolution service.

Astrafit (Ukraine) [10] – virtual fitting of clothes is offered on a flat image of the user`s figure, made on the basis of anthropometric parameters of the human body: height, chest girth, waist, hip circumference, which are the initial parameters for fitting. The algorithms have been developed and the research on matching of clothes on real figures has been carried out; the new approach to the determination of assessment and recommendations for the comfort of clothes has been introduced. The process of fitting and displaying of the result is fast, during which the user can navigate to all sizes of model and compare the results according to size range, determining the quality of fitting and anthropometric matching based on digital data and additional information. The result is achieved by assessing the fitting of clothes on the basis of studying the air gaps between the body and clothes. The zones of the biggest contact of clothes on the main parts of the human body are determined. As a result of virtual fitting, the selected model is compared in accordance with 10-point scale for all sizes, and the maximum number of points gets the size that meets the set requirements most of all. The length of the product on the mannequin is formed by the actual measurements of the product, taking into account the elasticity of the fabric on an individual figure (figure 3).

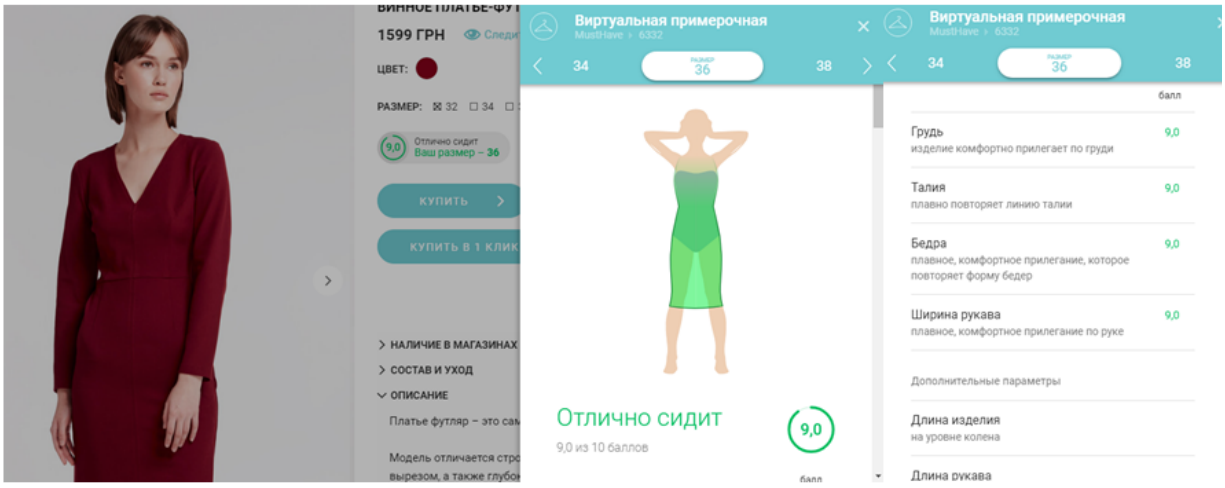


Figure 3. The result of the virtual fitting with the use of the Astrafit service.

New technologies of Astrafit allow the owners to improve online trading and to compete in a fast growing market with proven and developed possibilities, aimed to satisfy the consumer`s preferences. A number of functions and capabilities are proposed, focused on determination of the quality of fitting by the way of virtual fitting of clothes on the user`s electronic mannequin, on predicting the size of clothes, on formation of recommendations regarding the comfort of clothes, on collection of anthropometric data for construction of 2D mannequin, on possibility of obtaining basic linear parameters of clothes, as well as on presentation of information about the product, taking into account the elasticity of the fabric.

The analysis has shown that some online sites that propose clothes offer a table of measurements for a particular product, but such information is not the same for different models, that is, the developers of websites determine the criteria of parameters importance for a particular product at their own discretion [19]. The quality of virtual visualization of the clothes design is an important prerequisite for solving the sample tasks. It is determined that, in most services, the photos in several projections are the basis for the construction of three-dimensional model of clothes. Such photos are taken on the appropriate photographic plate that has a graphic marking and a coordinate grid, with the help of which the received image is recognized. Next, the contour lines of the product are marked for further analysis of the shape and parameters of the clothes. Such a technology has led to the creation of a marketing innovative virtual application – “Additional reality” [20], which “enlivens” the objects, including clothes, by superposing additional information in the form of images, videos, texts, moving 3D objects, structure of the fabric, etc. on the real objects.

Also, the next-generation advanced technologies in the field of 3D design offer virtual smart mirrors (Oak Labs company), which allow the customers to visualize clothes on their own figure, looking in the mirror. The program provides the possibility of virtual fitting of clothes of different sizes and colors, and also recommends other models of clothes for fitting and purchasing.

The conducted analysis of the technologies for visualization of clothes in three-dimensional space has demonstrated the activity of researches in this area, as the number of services is increasing. Virtual fitting rooms can be divided into flat (2D) and volume (3D) fitting rooms in accordance with the criterion of visual display. They differ in the content of the base data of consumers` figures and clothes. So there is a need to improve the existing

programs for fitting of clothes in order to predict the size of the clothes realistically and to accord the form of clothes model with anthropometric characteristics of the human body, considering the ergonomic requirements.

Conclusions

Different variants of virtual clothes fitting rooms have been analyzed, and the main components that influence the quality of assessing the anthropometric conformity of clothes have been outlined, among which the most important are: the development of mathematical algorithms of high quality; determination of the basic anthropometric characteristics of the users` figures; simulation of realistic image of clothes (conformity of 3D model of the product with actual prototype, or conformity of three-dimensional data with the linear dimensions of the actual product).

The research identified the lack of information about the examined product as a lot of companies that offer the service for virtual fitting do not provide information on figure and clothes parameters, which makes it more difficult to understand for the analysis purposes. However, there are services, the calculations of which are based on manually obtained data, but this process is not automated, it takes a lot of time, and the quality of the obtained results depends on the qualification of the specialist who conducts the measurements of the figure. It is identified that it is promising to introduce the mechanism of transformation of data, provided in the table of the product measurements, into the main parameters for virtual fitting, which will enable to automate the system of measurements and to avoid mechanical errors.

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