Application of 3D Modeling in the Fashion Industry

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Abstract—This paper presents an application of 3D modeling in the fashion industry, with an emphasis on augmented reality. The benefits of 3D modeling and augmented reality in the fashion industry are discussed in detail. The purpose is to show this way of product presentation as the future of the fashion industry. This paper aims to present 3D modeling garment design using the CLO3D software tool. Using software environments for 3D clothing modeling combined with augmented reality creates a new world of digital fashion, where it is possible to wear digital fashion items in the Metaverse, but also to create and sell them as NFTs in markets.

Keywords - fashion industry, digital fashion, 3D modeling, augmented reality, NFT

I. INTRODUCTION

Traditional principles of fashion product development result in a large amount of fabric waste, the production of an unnecessary number of samples, shipping and transportation costs. If we take into account that the fashion industry produces 20% of global wastewater and 8-10% of global carbon emissions [1], it is concluded that the introduction of changes in the entire industry, in order to be more in line with the global goals of sustainable development, is inevitable. Including technology and different software in product development in the fashion industry has a high potential to at least reduce if not fully solve those problems.

Digital fashion is a visual representation of clothing using computer technologies and 3D software. The industry is currently on the rise due to ethical awareness and the use of digital fashion technologies, such as artificial intelligence to create products with complex social and technical software. [2]. Using software environments for 3D clothing modeling improves productivity. A fashion item gets from the fashion designer to the end user faster. All this reduces production, storage and sampling costs.

The term digital fashion was first introduced to the fashion industry in the early 21st century with the rise of e-commerce. Marketers used the term to describe e-commerce platforms that sold fashion products. Digital fashion products were often referred to as wearables, which are referred to as a type of portable computing hardware [3]. With the development of 3D and virtual technologies, the definition has expanded to include all fashion concepts that are integrated with experimental technologies in clothing and fashion accessories, including 3D printing, body scanning and virtual design [4].

The application of 3D technologies is becoming more and more present in various industries. Thus, in the fashion industry, 3D modeling is experiencing a blast, because it brings a significant increase in efficiency and effectiveness.

The goal of this document is to showcase the future of the fashion industry through the practical example of 3D modeling. This paper covers both the theoretical and practical aspects of using 3D modeling and augmented reality in fashion. It aims to provide a comprehensive understanding of the garment design process using the CLO3D software tool. The document covers the entire process of creating a new garment, demonstrating how the combination of 3D modeling and augmented reality can create a new world of digital fashion. Ultimately, the goal of this document is to emphasize the potential of 3D modeling and augmented reality to transform the fashion industry.

II. DIGITAL TECHNOLOGIES IN THE FASHION INDUSTRY

The fashion industry, like most other industries, tries to keep up with developing technology and apply the most modern concepts. Some of the technologies used in the fashion industry today are [5]: Artificial intelligence (AI), the Internet of Things (IoT), Blockchain, 3D printing, On-

line vector editors, Sustainability, Virtual reality (VR) and Augmented reality (AR).

A. Artificial intelligence

The application of Artificial intelligence in the fashion industry most often refers to the application of Chatbots on the websites of fashion brands and smart mirrors based on the application of augmented reality. Chatbots are a very common feature of many fashion brand websites. They serve as a personal assistant, they are there to answer questions related to delivery, but also to help the user choose the perfect fashion combination for an important occasion. In addition, artificial intelligence is used to predict future trends. Another interesting application can be seen in neural networks, which are trained to understand the style, colors and materials that a particular user likes and based on this, they can conclude whether the user would like a new product.

Some other practical examples can be found in Burberry‘s usage of AI to boost sales and customer satisfaction. In 2015, the company announced that their investment in personalized customer management programs had resulted in a 50% increase in repeat custom. If Burberry knows that a customer has recently bought a particular coat, for example, then assistants may be encouraged by the app to show them a handbag that is popular with other buyers of the coat [6].

The authors in the research described companies like ‘Edited’ and ‘Stylumia’ which offer solutions that support the strategic decisions of fashion brands and fashion retailers by analyzing big data using artificial intelligence. The convergence of big data and artificial intelligence scales personalized services on the web as examples of ‘Coded Couture’, ‘StitchFix’ and ‘Thread’. The insights gained from artificial intelligence and big data help create new fashion retailing platforms such as ‘Botshop’ and ‘Lyst’. Also, artificial intelligence and big data assist with design. ‘Ivyrevel’ designs digital fashion, assisted by a macroscopic perspective on fashion trends, markets and consumers through the analysis of big data [7].

B. Internet of things

The Internet of Things means connecting different types of devices to the Internet, most often sensors and actuators [8]. Using these devices, it is possible to create smart environments that can automate the execution of everyday tasks. IoT enables data sharing, inventory management, security and increased efficiency and productivity [8]. Many companies allow customers to literally use the Internet to share data with them daily. This includes clothing with digital capabilities/properties, such as smart clothing, multi-functional designs, sports clothing that responds to environmental influences and more. An example is smartwatches, which are dominated by brands such as "FitBit" and "Apple", from which we can conclude that wearable technology dominates the market of fashion accessories.

There are many examples related to health monitoring, for example, there is a T-shirt, a product of the company of the same name "Hexoskin", which serves as an EKG - monitors heart rate and body temperature. Also, some socks count steps and calories.

Some instance of firms employing IoT within the fashion industry is Coded Couture by IVYREVEL, which is a Swedish-based brand that partnered with Google to design a Coded Couture app. This app is responsible for tracking your activities in order to design a dress. In accordance with where you go, be it any popular nightclub or an acclaimed restaurant, the app will suggest adding elements like diamonds or a traditional style or a particular color, etc. [9].

C. Blockchain and NFTs

Blockchain is a complex mathematical algorithm whose goal is to enable maximum security of financial transactions using cryptographic methods. It provides a distributed, immutable, transparent and secure financial ledger where all money transactions are reliably recorded. Each transaction represents one block, where the blocks are connected by a chain [8]. Blockchain offers a cryptographic seal, i.e. a serial number representing a physical identifier, which is associated with the "digital twin" of an individual product. Records can be kept at each stage of production. Every time a product moves through the supply chain, it is recorded on the blockchain. This can prevent counterfeiting and the diversion of goods.

In the fashion industry, we can see the application of blockchain in tracking and keeping records of clothing and supply chains. This is where technology is used to track and manage inventory. According to the fashion industry, a major blockchain application is to track materials and products throughout different manufacturing stages, ranging from initial raw materials management to finished product management. As an instance of the fashion product with the use of environmentally friendly materials, the promise of blockchain is it does not require the involvement of any additional inspections or certifications. Instead, once the information is recorded in the blockchain system, it is immutable and publicly visible [10]. This simplifies the information disclosure processes and ensures reliable environmental effort claims [11].

In 2021, a blockchain consortium called Aura was launched, signing up leading labels such as Prada, Louis Vuitton and Cartier. The Aura Blockchain Consortium allows consumers to access product history and proof of authenticity of luxury goods from sourcing to sales, all the way to second-hand markets [12].

When it comes to the fashion industry, transactions on an e-commerce platform are made secure, easier and

faster with blockchain, but blockchain also allows us to control and monitor all articles, directly from the stage of production to their purchase by the end consumer [13]. So all the business segments of a fashion brand that has an online store can be supported by blockchain. Blockchain can enable us to scan a QR code on your new shirt and just see all the information about its origin, from materials, confirmation of authenticity and sustainability, to the country of origin as well as all the transaction details. In the fashion industry, stakeholders involved in all the required processes are suppliers of raw materials, designers or fashion companies, manufacturers, distributors, sellers and customers. Each stakeholder in the supply chain presents their requirements and conditions in the smart contracts [14]. Customers have insight into the product's origin and value [8].

NFTs (non-fungible tokens) are unique cryptographic tokens that exist on a blockchain and cannot be replicated. They can represent digital or real-world items like artwork and real estate [15]. When it comes to the fashion industry, utilizing NFTs as a marketing tactic in the fashion industry can contribute to brand equity in various scenarios [16]. Fashion brands are getting involved with NFTs increasingly, including well-known luxury brands such as Gucci and Burberry, but also brands like Nike [17].

D. 3D printing

3D printing can be applied in the fashion industry.

Even though it takes many hours to create, the benefits are less waste and much less labor intensive than other types of production. 3D printing takes fashion to a new level of conceptual art. [8]

It is also interesting that we can meet digital knitting, which has made great progress in the world of 3D printing and offers countless customization options. Dutch designer Iris van Herpen was one of the first to use 3D printing in the fashion industry. She already managed to impress everyone at the 2022 Met Gala with her extraordinary 3D-printed creations which were worn by Teyana Taylor, Winnie Harlow and Fredrik Robertsson [18].

Dutch designer Iris van Herpen made 3D-printed garments more accessible, as she introduced 3D printing as a "staple piece" to the haute couture fashion scene almost one decade ago. Today 3D-printed fashion items are increasingly popular and have trickled down from being solely used within haute couture fashion to being used for jewellery, bikinis and shoes and thus have become available for a wider audience. Traditional garment manufacturing processes produce offcuts (unwanted surplus material) as patterns are transferred onto fabrics, leaving enough space to cut the shapes out of the material. Contrarily, for the 3D-printing manufacturing process, only the necessary amount of raw material is used, resulting in zero waste [19].

E. Online vector editors

Many online vector editors are used today as a replacement for Adobe Illustrator. They allow downloading, embedding, or sharing links of designs with the public in SVG format. Some of them are Vectr, Boki SVG Editor and Repsketch. They use pre-made templates created by graphic or fashion designers. They also include design details such as different types of collars, sleeves, or pockets. They make the process of designing clothes easier and faster because they eliminate the need to sketch everything from scratch [20].

F. Sustainability

We witness that 92 million tons of clothes end up in waste every year. The fashion industry is responsible for up to 10% of global CO2 emissions, 20% of world industrial wastewater, 24% of insecticides and 11% of pesticides used. As a result, more and more brands are opting for sustainable production and more consumers are choosing environmentally conscious brands over "fast" fashion brands [21].

One solution for reducing waste from garment manufacturing is 3D designing. Programs like CLO3D, Marvelous Designer, Adobe Illustrator, Browzwear, Tuka3D and Romans CAD facilitate the design process and reduce waste. With 100% accurate digital samples, every idea can be explored most sustainably. Also, these programs are used to create digital clothing.

For example, Levi Strauss & Co.'s website proclaimed, "Sustainability is sewn into the fabric of everything we do from how our clothing is made to the work we do to help protect our planet." The site relates the term "sustainability" to the company's "long history of caring" for women (by introducing the first blue jeans for women), apparel workers (via the company's code of conduct related to labor contracting) and the environment (via water quality standards and a restricted substances list applied to contracted manufacturing facilities). The range of possible meanings, associations and practices that are said to fall under the category of "sustainable fashion" is expansive [22].

G. Virtual and Augmented reality

Combining the physical and online worlds of retail is one of the most interesting applications of Virtual Reality in the fashion industry. Using VR [23], customers can virtually try on clothes. Thanks to the customized measurement functionality, this application provides high precision and augmented reality technology is also used [24]. Augmented reality (AR) is an interactive experience of a real-world environment, where real-world objects are enhanced with computer-generated perceptual information [25]. That perceptual information activates all the senses, so the experience is more realistic.

Many companies are increasingly implementing VR and AR. OBSESS is a platform that enables brands to create 360-degree 3D shopping experiences on their websites, mobile apps and social channels through the 3D Commerce Cloud. CLO is a tool that allows brands to instantly edit designs and instantly review changes. This can help to improve the quality of the design by checking the silhouette and making changes before the construction process. In this way, waste is minimized and errors in the samples are reduced. Selling digital clothing is also becoming more popular.

For example, Louis Vuitton designed "skins" for characters from the game League of Legends. Ralph Lauren has partnered with the Bitmoji app, where customers can create their own Bitmoji look with Polo Ralph Lauren brand outfits. The fashion retailer Tommy Hilfiger was among the first to provide VR headsets in stores, enabling their consumers to enjoy their 2015 autumn/winter fashion show as a 360-degree experience. In 2017, Coach installed VR headsets in their stores to provide full access to their latest fashion show and Oasis also used VR headsets to promote their collaboration with the Zoological Society in London, whereby consumers could experience a virtual safari sitting in a jeep [26].

Augmented reality in the fashion industry allows companies to build their brand by providing an immersive experience (this involves generating a three-dimensional image that gives the impression of surrounding the user). The most common examples of applications are in the form of smart mirrors and applications. AR mirrors can be seen today in various fashion stores around the world. Many modern houses like H&M, Zara, Ralph & Lauren and Burberry have already installed smart mirrors in their stores. The mirror uses radio frequency identification with augmented reality technology. When the user brings a piece of clothing in front of the mirror, it scans and saves an image of it. The mirror then scans the user to create a virtual model wearing that scanned piece of clothing. Also, the virtual model shown in the mirror moves in real-time to show a 360 view. The first fashion brand to use smart mirrors was Uniqlo in San Francisco in 2012. UNIQLO “created a seamless retail experience that allowed consumers to try on the full range of colors for a variety of UNIQLO Fall/Winter jackets”. Additionally, Neiman Marcus installed what they called the “memory mirror”, which showed customers’ outfits in 360 degrees and what they would look like in different colors, also allowing customers to share images and videos through email, social media, or with sales staff for further recommendations [19]. This type of shopping experience keeps customers longer because they like to see the product on themselves before buying and also use interesting technology.

Applications based on AR technologies used by fashion companies work by scanning the body or a part of the body with the help of the device's (mobile phone or tablet) camera. The software then overlays the selected garment over the scanned part of the body, so that the user can get an impression of how the garment would fit in the real world. An example of such an application is Converse’s “The Sampler”.

AR technologies, such as magic mirrors, create a connection with these younger generations that are often time pressured and live a busy lifestyle, as it allows them to make decisions faster, without having to queue and wait for changing rooms to become available and/or see how different colors of the same garment suit them. Consumers thus have the opportunity to select garments according to their needs and preferences and gain a real-life experience of what the product may look like on themselves [26].

III. 3D MODELING IN THE FASHION INDUSTRY

3D modeling is the process of creating a mathematical representation of a three-dimensional object. The result of this process is a 3D model [27]. It can be said that 3D modeling is a process that precedes the process of 3D printing. 3D modeling is part of a new phase in the development of the fashion industry, which will allow a clear and precise overview of the final product. Instead of using physical samples to create e-commerce photos, photorealistic designs could completely replace the current trend for photos of real, tangible products on websites. 3D design can help reduce waste by producing better, more thoroughly researched garments [28].

Artists, fashion designers and designers would draw a sketch of the future product, including the color and only then proceed to implement it. This approach had several drawbacks. It was impossible to predict how the material would work on a particular garment and in general, a two-dimensional drawing can never give a completely clear idea of the future garment. 3D modeling allows all manipulations to be performed in a special software environment, taking into account all characteristics, both material and shape, environment, interior, etc. It is much easier to realize products that have a photorealistic display. In addition, the client can make changes according to their taste and this will not incur any costs [29].

A. 3D Tools

There are many 3D modeling tools available today. Blender is one of the most famous 3D software. It was previously used to create video games, but today it is used in the creation of animated films, visual effects, 3D printed models, motion graphics, interactive 3D applications, virtual reality, etc. Blender features include 3D modeling, UV mapping, texturing, digital drawing, rendering, motion graphics, video editing and compositing. It is also widely used in the fashion industry.

Autodesk Maya is one of the best software for animation creators. It is used to create interactive 3D applications, video games, animated films, TV series and visual

effects. It is used in the simulation of fluids, fabrics, fur, etc.

ZBrush is a digital design tool that combines 3D modeling, texturing and painting. It had an impact on the film and VFX industry. Iti is used for: 3D painting, illustration, polygon painting and rendering.

Rhino (Rhinoceros or Rhino3D) is a commercial 3D computer graphics and computer-aided design (CAD) software. It is used for computer-aided design (CAD), computer-aided manufacturing (CAM), rapid prototyping, 3D printing and engineering in industries including architecture, industrial design, product design and multimedia and graphic design [30].

As far as the fashion industry is concerned, the most common tools for 3D modeling are CLO3D, Marvelous Designer, Blender, Adobe Illustrator + Optitex 3D, Browzwear, Tuka3D, Romans CAD and The Fabricant Studio.

CLO3D is a 3D fashion design software program that creates virtual, realistic visualization of clothing with the latest simulation technologies for the fashion industry. It allows quick visualization of the design. By utilizing virtual sampling techniques, the time it takes to bring a product to the market can be reduced significantly. It is used by designers, small businesses and fashion industry titans to achieve a seamless digital workflow. With 100% accurate digital samples, every idea can be explored most sustainably.

Marvelous Designer is a fabric simulation program that creates dynamic 3D clothing for games, movies, 3D art and 3D animation. In the real world, clothing patterns are what seamstresses use to create clothing. Marvelous Designer adapted the traditional fabric manufacturing method into 3D fabric modeling. It provides the most accurate and fastest fabric simulation.

Browzwear is a leading provider of 3D fashion design, development and merchandising solutions. It represents a complete solution for 3D fashion. With the help of Browzwear, fashion brands are transitioning to realistic digital samples that remove barriers to productivity, accelerate time to market and improve sustainability. Leading fashion brands and manufacturers around the world use Browzwear products to accelerate product development and business growth.

Tuka3D is a 3D fashion design software founded by the company "Tukatech". It comes with a fabric and trim library that is frequently updated to reflect the development of new trends, as well as a color library. It can also be used in conjunction with graphic design applications such as Adobe Photoshop or Illustrator to create designs that will aid in 3D virtual prototyping. The main focus is on the fit of the clothes, i.e. the assessment of looseness or tightness of clothing in a virtual 3D environment.

The Fabricant Studio is a platform where anyone, anywhere can become a digital fashion creator and participate in the digital fashion economy. It enables designing digital clothing in the Metaverse, wearing digital clothing with the help of augmented reality and selling it as NFT [31]. The Fabricant Studio is a Web3 fashion house dedicated to building a modern industry that is inclusive, fair and accessible to all, providing a collaborative ecosystem where creators own and profit from their work and unlimited self-expression using imagination.

Romans CAD is one of the best CAD software used in the footwear and leather goods industry. This CAD software includes functions such as cost reduction and accelerated performance, is adaptable to user needs and uses modern design tools. The virtual prototype contributes to a huge cost reduction and allows collections to be approved two to three times faster.

B. 3D fashion design

The following components are required to create a 3D clothing pattern:

- A model of a person called an avatar – the designer can explicitly set all parameters of the figure;
- Pattern sewing – ready-made patterns can be imported into software programs or created from scratch directly in the program;
- Fabric parameters, accessories, prints.

Based on the components, the designer creates the product and models the behavior of the avatar (movements) to evaluate how the clothes will behave in real life.

In the future, 3D modeling could mean that instead of distributing a finished product to consumers, designers could sell data files with 3D design models online. One disadvantage is that this may encourage some consumers to modify existing product designs to their liking, produce them for their use, or distribute them.

Any 3D designer will confirm that the most difficult part of the job is to make the product as realistic as possible and then use the templates for tailoring on an industrial scale. Despite all the obvious advantages of using 3D technology, when creating the first samples of the collection, a small part of the fabrics and resources are saved.

3D technology reduces the risk of buying things that do not suit the customer. In the traditional approach, brand catalogs use photographs of garments on models. Technically, there is no way to consider the specific characteristics of each person's figure, so we mostly see photos of models in standard clothing sizes. In comparison, in 3D modeling, it is possible to show clothes without a person, which allows the shopper to imagine the clothes more accurately. All this reduces the risk of buying clothes from online stores and then returning or throwing them in the trash. All these factors reduce the amount of clothing that is thrown away and not properly disposed of for various reasons [28].

IV. APPLICATION OF 3D MODELING IN THE FASHION INDUSTRY USING CLO3D

In this chapter, the process of creating a garment in the "CLO3D" software program will be detailed and explained. CLO is a 3D fashion design software program that creates virtual, realistic visualization of clothing with cutting-edge simulation technologies for the fashion industry. CLO is the most advanced, intuitive and cohesive software of its kind.

CLO is a very easy-to-use interface that allows visualizing designs quickly and without any problems. Virtual sampling significantly shortens the time it takes to bring a product to the market. It is used by designers, small businesses and fashion industry titans to achieve a seamless digital workflow. With 100% accurate digital samples, every idea can be explored most sustainably - at no cost. It visualizes the fabric, cut and silhouette of the design with dignity and precision. CLO is a good 3D software to increase creativity and productivity in the clothing industry and can save not only time in the design process but also the cost of prototyping. CLO also makes an environmental contribution to the world of fashion, as designing with virtual garments reduces sample production, shipping and material waste. The main advantage of using CLO is that it saves a lot of time in the design process and reduces production costs. For example, when designing a collection, everything can be visualized, which helps improve communication between designers and potential customers.

A. Steps in making a garment

1) Choice of avatar

The first step is choosing an avatar. Avatar can be selected in the Library tab and the desired model. In this case, the selected model is Mara, but any other model from the offered ones can be downloaded and chosen.

By right-clicking on the model and holding it, the model can be rotated in a circle of 360 degrees from all perspectives. By pressing and holding the scroll button on the mouse, we can manually move within the window. It is also possible to customize the model. In the displayed folders, there are features of the model that can be changed: hairstyle, movements, pose, shoes, size and texture (underwear of the model). There is also the possibility of changing the hairstyle. In this case, the blue bun "FV2_Bun_C_SP_V1_BLD.zacs" is selected. In case we want to change the model's shoes, we can do so by going to the Shoes folder, downloading the desired pair and selecting it. In this case, the pair "FV2_Open_Toe_Pump_BK.zacs" is selected. In addition, the model's pose was changed to "FV2_02_Aforsize.pos".

2) Tailoring of the garment

The next step is cutting. In the 2D window, we select the Polygon and zoom in on the shadow of the model by scrolling the mouse down.

Then, by clicking the mouse, we just connect the dots until we get back to the starting point. So we make the base part of our cut. We can also add other cut elements. In this case, we add sleeves and staff. If we are dissatisfied with the cut, we can delete it completely and start again, by marking the cut that does not suit us on the 3D window and pressing the Delete button. Another option is to click on the Edit Pattern tab in the 2D window. It allows the flexibility of the seams and movement as we see fit. In Figure 1, select the Transform Pattern tab and go to the Symmetric Pattern option.

Figure 1. Making a cut and symmetrical addition

To add internal cuts, use the Internal Polygon/Line tab. After symmetrically adding all parts, we get a complete front cut, shown in Figure 2.

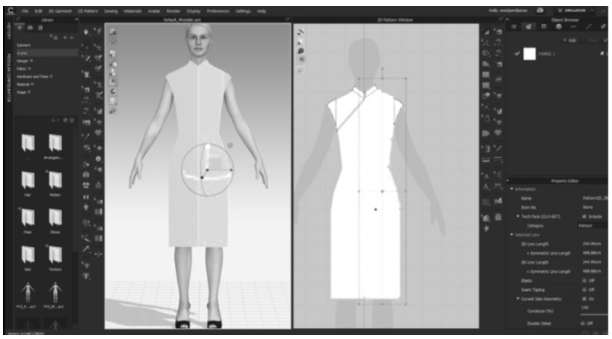

Figure 2. The final cut of the front of the dress

Now we need to do the same for the back cut. First, we need to move the finished part of the model. We do this with the help of the Transform Pattern, by marking all the parts and just dragging to the side. Following the same procedure as before, we also get the back part of the dress.

3) Trying on the garment

Next, the procedure of transferring the back of the dress back is applied. First, in the 3D window, go to the Avatar Display tab, then to Show Arrangement Points. We are shown blue dots around the model. In the 2D window, we mark the whole back of the dress, with the Transform Pattern (we can drag with the mouse and mark the whole back or by clicking manually on the parts with Shift, so that they are all marked) finally we click on one blue dot, as shown.

Now we have received a prototype, which we can

change and correct errors in the form of the length and width of the parts of the dress. Using the Edit Pattern we can adjust the length of certain parts. By clicking on the line, then right-clicking on it and selecting the Change Length option, a window opens in which we can enter the desired length of the part. If we hold the left click on the Edit Pattern, we can select various other options, such as Edit Curve Point, Edit Curvature and Smooth Curve, based on which we can round straight lines or straighten curves. In Figure 3, again using Avatar Display -> Show Arrangement Points, we adjust the fit to the model's body shape.

Figure 3. Adapting the cut to the model's body shape

4) Sewing a garment

Next, from the toolbar of the 2D window, we select the Segment Sewing option and connect the parts that we plan to sew. The seams mustn't cross, i.e. the lines joining the parts are straight and not going in an X, because in that case, the seam will not turn out well. And the last step is the GPU (assembly of parts). At the end of this part and after fine adjustments, the dress should look like in Figure 4.

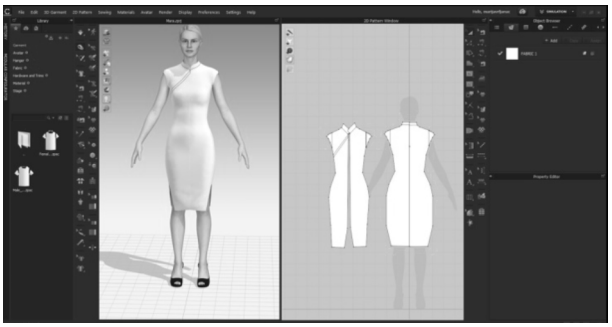

Figure 4. Assembled dress

5) Dyeing the garment

In Figure 5, we select the material by selecting the Fabric option from the Library menu. Then we scroll until we get to the "Silk_Duchess_Satin. fab" material. Double-click to select it. Next, we apply the material to the dress. We do this by physically holding the left click of the mouse and dragging the material onto the parts of the dress that we want to be made of that material. We can repeat the procedure if we use several types of materials.

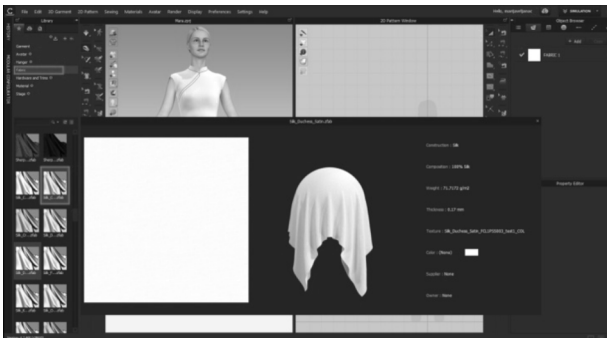

Figure 5. Choice of materials

After that, we can add the patterns we want. In the 3D window, select the option Graphics (3D Pattern). Next, we add any image, preferably a PNG image with a transparent background. In this case, it is a pattern with roses. The pattern can be easily adjusted to our liking. In the end, it should all look like in Figure 6, where the pattern itself is spread out and carefully glued in 4 parts.

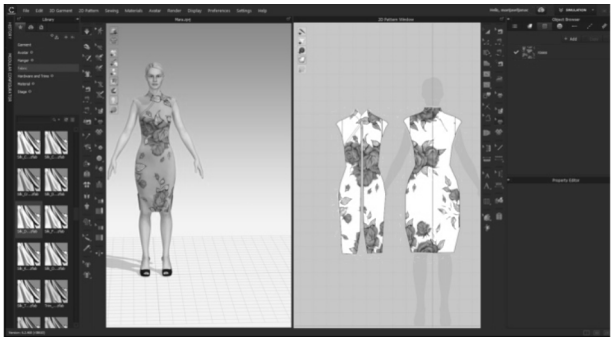

Figure 6. Finished adding the pattern

6) Adding details

Now we can add some more details, like buttons, zippers, etc. The button is selected by clicking on the "Button" tab in the 3D toolbar. We can also customize the button, which is shown - in this case, its color has been changed. This was done by first clicking on the button in the Object Browser, then in Property Editor -> Basic Parameters -> Color in the color palette, we selected the one we want.

Also, as part of the finesse, we can iron our dresses. We do this by selecting the Steam option in the 2D toolbar. It is possible to expand or narrow parts of the material. In the "Brush" pop-up window, in the "Shrinkage" section, if you want to expand the dress, drag it to the right (u +) and if, as in this case, you want to shrink it, drag the mouse to the left (u -).

7) Final layout

At the very end, after the final changes (finely adjusting the cut, changing the pose to "FV2_02_Attention.pos") and changing the color of the material to black, our dress looks as shown below. Figure 7 is a GIF animation, where the model rotates 360 degrees, so the dress can be seen from all angles.

Figure 7. The final result

V. CONCLUSION

Considering the rapid development of technology, it can be seen that in the future, 3D modeling tools will prevail over traditional ones, at least when it comes to the fashion industry. The rise in popularity of social media and the demand for constant content has put an end to seasonal fashion. Saving time, materials and waste during sampling represent the productive and sustainable advantages these technologies provide. 3D design is not only a technological revolution, but it is also a human revolution. Investing in the training of digital tailors and designers is inevitable.

Fashion designers have an increasingly realistic representation of the behavior of the fabric itself, which can indicate potential errors, which can be quickly and simply corrected before the actual production process. All this promotes creativity and innovation, providing a path to a new world of fashion, where the expression of style knows no boundaries. People who value their uniqueness and taste will find it much easier and safer for the environment to order a unique digital item than to order a real garment that consumes a lot of energy to make and has a high chance of becoming trash.

The development of 3D technologies for the creation of clothes enables the reduction of fabric consumption and the use of fossil energy sources when sewing clothes in the following stages: creating the first samples (minimal impact), reducing the risk of buying inappropriate clothes (medium impact), moving clothes from a real object that can be felt into digital (maximum impact). Observing minimalism in clothes, humanity gets the opportunity to show its individuality and style by creating digital masterpieces of clothes and trying them on in virtual salons and posting pictures on social networks [28].

The combination of 3D modeling and augmented reality creates a new world of fashion - the world of digital fashion. In that world, there is not much room for sampling errors, waste materials, storage and inventory costs. The process of design, production and shipping is significantly accelerated and fashion items arrive from the designer to the end users much faster. The existence of possibility for people to develop digital fashion items themselves encourages creativity and investment in education and raises culture to a higher level.

The next steps could be a combination of AR and 3D modeling. So, for example, as one of the possible solutions in the future, one can imagine that directly on the website of the fashion brand there is an option for the user to make their own clothes and try them on.

The idea is that there is a section of the site that has software for the 3D modeling of fashion items. The software would essentially consist of the basic and simplified features of the 3D modeling tools for fashion items, listed in Chapter III A. 3D tools. There would be six basic components from which the user could further choose the sub-components that suit them. Those components would be:

- Model – the user first chooses from the list a male or female model who will wear the item of clothing;
- Garment – the type of garment the user wants to make;
- Cut – the cut of the garment, with the possibility of adjusting the dimensions;
- Material – the material which the garment will be made of;
- Prints – patterns and designs that can be applied to a garment;
- Hardware and Trims – metal parts like zippers and decorations like buttons.

The entire software, of course, although simplified, works on the same principle as existing 3D tools for modeling fashion items, such as CLO3D or Marvelous Designer.

Another detail that would be included in the solution is the "Try it on!" button, which appears after the design is finished. Clicking on the button turns on the user's webcam

if they are using a website, or the camera on their phone if they are using a mobile application. With the help of augmented reality (AR) technologies, the user is allowed to try on a garment that they have previously created.

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