Journal of Textile Science and Technology, 2024, 10, 1-24
https://www.scirp.org/journal/jtst
ISSN Online: 2379-1551
ISSN Print: 2379-1543

A Comparative Study of 3D Virtual Pattern and Traditional Pattern Making

Md. Ahshan Habib[1*], Md. Shamsul Alam[2]

[1]Department of Fashion Design & Technology, Sonargaon University, Dhaka, Bangladesh
[2]Department of Apparel Manufacture & Technology, Sonargaon University, Dhaka, Bangladesh
Email: *habib.fdt@su.edu.bd

How to cite this paper: Habib, M.A. and Alam, M.S. (2024) A Comparative Study of 3D Virtual Pattern and Traditional Pattern Making. *Journal of Textile Science and Technology*, **10**, 1-24.
https://doi.org/10.4236/jtst.2024.101001

Received: September 25, 2023
Accepted: December 5, 2023
Published: December 8, 2023

Abstract

Pattern making plays a key role in the aspect of fashion design and garment production, as it serves as the transformative process that turns a simple drawing into a consistent accumulation of garments. The process of creating conventional or manual patterns requires a significant amount of time and a specialized skill set in various areas such as grading, marker planning, and fabric utilization. This study examines the potential of 3D technology and virtual fashion designing software in optimizing the efficiency and cost-effectiveness of pattern production processes. The proposed methodology is characterized by a higher level of comprehensiveness and reliability, resulting in time efficiency and providing a diverse range of design options. The user is not expected to possess comprehensive knowledge of traditional pattern creation procedures prior to engaging in the task. The software offers a range of capabilities including draping, 3D-to-2D and 2D-to-3D unfolding, fabric drivability analysis, ease allowance calculation, add-fullness manipulation, style development, grading, and virtual garment try-on. The strategy will cause a shift in the viewpoints and methodologies of business professionals when it comes to the use of 3D fashion design software. Upon recognizing the potential time, financial, and resource-saving benefits associated with the integration of 3D technology into their design development process, individuals will be motivated to select for its utilization over conventional pattern making methods. Individuals will possess the capacity to transfer their cognitive processes and engage in introspection regarding their professional endeavors and current activities through the utilization of 3D virtual pattern-making and fashion design technologies. To enhance the efficacy and ecological sustainability of designs, designers have the potential to integrate 3D technology with virtual fashion software, thereby compliant advantages for both commercial enterprises and the environment.

Keywords

Pattern-Making, 3D Pattern Making, Virtual Fashion, 3D-to-2D Unfolding, Sustainable Designs

1. Introduction

The whole process of cloth making depends on the art of pattern making [1]. It is an art form that involves edging and manipulating a flat piece of fabric to fit the outlines of the human body. It acts as a link between design and production. A pattern, which represents the design in the form of garment elements, allows a designer to translate the drawing into a finished item of clothing [2]. Drawing out a blueprint for any garment is called pattern making [3]. Patterns are used as a template to cut fabric and match the measurements required for sewing a garment.

Patterns are used to ensure that 2D clothes fit properly on a 3D body. A pattern is a prototype used in the fashion industry to trace pieces of a garment onto fabric so that they can be cut out and put together. Patterns are often made of paper, but if they need to be more durable to withstand constant use, they can also be made of a stiffer, stronger material such as paperboard or cardboard. A pattern is created by compiling all the details of each element of garments manufacturing. In other words, the patterns serve as representative models for each component part of the garment. Each element of a garment has its own pattern. A pattern is needed to provide proper garment fitting. The most important factor affecting whether a garment is ultimately accepted or rejected is fit. Design drawings must take into account the different forms and proportions of each unique consumer to provide a good personalized fit. The technique of creating three-dimensional digital clothing designs using specialized software is known as "3D pattern making". It involves creating, altering and modifying pattern pieces in a virtual environment. 3D pattern manufacturing offers several advantages over traditional 2D manual pattern construction, including faster design iterations, improved visualization, and the ability to simulate garment fit and behavior in a virtual environment. This helps the garment industry to produce clothes more efficiently and accurately while saving money.

Clo3D/CLO3D is a 3D tool for designing and visualizing clothing developed by CLO Virtual Fashion Inc. The fashion and apparel industry is the primary target market for the development of virtual 3D clothing prototypes and simulations. Designers can use various tools and features provided by Clo3D to create and look realistic 3D clothes. The objectives of the study are to look at the advantages of Clo3D and compare them to more traditional manual pattern-cutting techniques. The program uses sophisticated algorithms and physics-based models to simulate the behavior of textiles and their interaction with the body. 3D printing is becoming increasingly popular in the fashion industry due to its ability to streamline the design process, save costs, and improve the communication and visualization of garment concepts. It has evolved into an important tool for fashion designers, pattern makers and garment manufacturers to bring their designs to usual product in a virtual environment.

Objectives of the Study

To improve virtual pattern making, fashion design, prototyping and product development processes, Clo3D software was developed for the fashion and textile sectors. The main objectives of the study are to assessment and dissimilarity virtual pattern making with traditional manual pattern making, identify advantages of virtual pattern making that traditional pattern making lacks, and determine how Clo3D will impact the environment and sustainability of the apparel industry. The purpose of the study is to examine the capabilities and features of Clo3D software for virtual pattern making and fashion design, as well as how they impact prototyping and product design and have the potential to improve the product development process. Additionally, it seeks to maximize the use of Clo3D in the fashion and textile sectors for environmental impact and sustainability. In addition, Clo3D increases the general efficiency and level of competition in the industry. To improve their capabilities, productivity and overall contribution to the product development process, pattern makers can decide to study Clo3D. It is also possible for businesses to measure the return on investment (ROI) of using Clo3D in their product development process.

2. Literature Review

There is no similarity measurement between two female/male figures for a single size [4]. The information obtained from the dropped pattern can be used in drawing the flat pattern, or it can be made from measurements alone. Flat pattern making is the fastest and most efficient method yet developed for creating design patterns that control the uniformity of size and fit of mass-produced garments [5]. Three basic pattern making concepts and methods are the basis of flat pattern making: dart manipulation (changing the dart), fulling (increasing the amount of fabric in the design), and contouring (fitting into the hollows of a model's form) [6]. Each method requires slightly different tools to complete the job. Draping, also known as modeling, is the process of draping, pinning, welding, gathering and cutting fabric on a model or garment stand [1]. The material is removed after draping and set flat. Using a French curve and ruler, the lines are fine-tuned. The patterns from the fabric are transferred at the next stage using pattern paper. After that several functions is required like fabric spreading, cutting. Cut panels are required in the sewing section for the production [7]. The first figure in **Figure 1** illustrates the equipment required for pattern making, while the second figure illustrates the equipment for draping.

A flat pattern is created on a flat surface, as suggested by its name. Digital or virtual flat designs must be created using CAD and other fashion design applications such as Clo3D. We do not have enough modern technology to meet the

Figure 1. Tools for pattern making and draping [6].

buyers' requirements. At the present, RMG market is extremely competitive for our country in concern of Digital or virtual aspects [8]. The apparel business faces competitiveness worldwide; production may take three to six months where fashion is changing in a week. So, to sustain the international apparel market need to be constructed product design within minimum possible time [9].

The methods are the same whether we create flat patterns physically or digitally [10]. Because it connects the designer's ideas from a two-dimensional image to a three-dimensional expression of form, proportion and silhouette, the ability to create patterns is crucial to the entire fashion production process [11]. Patterns are of comparable value to a fashion designer as blueprints to an architect. Pattern drafting considerations related to fabric manipulation determine whether a garment has more volume or less fullness [12]. The initial step in drafting any pattern is to design a basic block [13]. A basic foundation pattern designed to accommodate a common form is called a block pattern [5]. To create a quick design for a specific clothing style, use basic blocks. A master plan is created by tracing off the basic blocks and then overlaying the design development. The master plan serves as a blueprint for development [14].

Comparable an architectural blueprint, a master plan for pattern development serves as the basis for all designs. The master plan starts with basic pattern blocks, which have no design features. It enables visual pattern planning and design considerations for position or depth before adapting basic construction pieces [15]. When creating basic, foundational or design patterns, pattern drafting is a method of pattern making that relies on measurements obtained from a shape or model. The basic pattern set draft serves as an illustration. A pattern-construction method known as flat pattern making depend on already made patterns. To develop design patterns, the work pattern is modified using slash or pivotal techniques [16].

A fit pattern is usually used interchangeably with the term "basic block". A basic block is a pattern blank for a piece of clothing that does not include any seam allowances or style lines in the context of the garment. A basic block has no seam allowances so it can be used to adjust designs based on a successful model or to create new patterns using dimensions from a specific dress-form, customer or model [17]. Among the most difficult and technically demanding tasks involved in garment manufacturing. At this point, pattern makers and designers work together to create patterns.

Virtual Pattern

In the fashion business, digital pattern production is currently replacing hand-drawn designs on draft paper as the more conventional and preferred method. Users can see the final design of the digital model while creating a virtual pattern, which is up to 30% more precise and productive in terms of time and cost [18]. The technique of creating a 3D prototype from a 2D digital pattern is known as 3D in fashion design where 3D technology is used [19]. 3D rendering is one of the most modern technologies. Rendering is something we can benefit from using Clo3D. Using this technology, marketers can instantly make design changes and evaluate the results. By checking the fit and silhouette before the design process, the quality of the design can be increased. This reduces waste and inaccuracies in sampling before finalization [5]. We can turn 2D drawings into 3D graphics with the help of the virtual design program Clo3D. It's a great tool for evaluating fit, seeing things in use, and trying different fabric and color options. In addition, patterns can be exported in various formats [20]. Understanding the current status of manual pattern making and use of 3D fashion design software in the apparel industry is the main objective. The CLO approach was evaluated to meet the requirements of input, output, control system, human resource, technology, time, decision making and communication system.

3. Methodology

3.1. Data Collection

The primary aim of data collecting is to gain an understanding of the present condition of manual pattern-making and the utilization of 3D fashion design software within the garment sector. This study predominantly relies on secondary data obtained from many online sources, including scholarly journals, books, previous research endeavors, web portals specifically dedicated to the clothes and garment sector, the official Clo3D website, and web portals that offer assistance and resources for Clo3D.

3.2. Analysis of the Data

This study examines the analysis of acquired data based on many needs, including input, output, control systems, human resources, technology, time, decision-making, and communication systems. The primary analysis and discussions have been conducted using material sourced from the Clo3D website and renowned fashion and fashion-related blog web portals. This study has addressed the multifaceted concerns pertaining to the garment company and the achievements and advancement of these sectors. The present study relies on secondary data taken from the Clo3D website, which is deemed very reliable and precise, hence minimizing the potential for inauthenticity. One potential drawback of this study is the absence of primary data collection from key stakeholders such as garment factory owners, fashion designers, technicians, pattern makers, and Clo3D experts. This includes the lack of surveys or interviews conducted with these individuals and the subsequent absence of their responses.

The evaluation and analysis of their ideas and proposals were not possible. However, the present study necessitates the utilization of genuine and precise data, therefore prompting our emphasis on and reliance upon secondary data sources. One further limitation associated with the utilization of primary data gathering methods, such as questionnaires and interviews, is the potential for respondents to produce socially desirable responses. In the majority of instances, the individual's personal information was not divulged, a circumstance that might prove highly advantageous.

4. Pattern Making Software

To efficiently manufacture, pattern and produce garment products, pattern making software is employed. It is adaptable and can be applied to various industries including fashion design, tailoring and home decoration. It helps designers create precise designs faster than conventional paper and pencil sketching methods to its user-friendly interface and powerful features. This program is very helpful for home decorating, fashion designing and sewing. Digital drafts in pattern making software allow designers to work faster, improving the production process. Designers can quickly modify patterns to tools like auto-grading, auto-spacing and quick editing options. Techniques like nesting and optimal fabric usage are also used. A graphic library makes it easy to access design elements like prints and logos, while 3D visualization tools provide designers with accurate visual representations [21]. Compared to conventional design methods, 3D fashion design has shown exceptional efficiency. 2D to 3D virtual try-on technology can help designers determine whether clothing styles are practical, 3D to 3D fashion design technology can help designers adjust 3D clothing, and 3D to 2D flat technology can help pattern makers create clothing patterns. With virtual pattern making software, fewer samples, faster prototypes and significantly better quality are produced before the cycle [22].

4.1. Features of Clo3d That Provide for Effective Pattern Making

Pattern drawing, fabric form manipulation, and a database of measurements for various body types and sizes are just a few of the many capabilities that Clo3d's fashion design software provides for pattern creation. Users can then accurately size the garment and guarantee a good fit for it. Grading and auto-grading features make it easy and fast to create different shapes from a single design. The marker maker function efficiently arranges fabrics on large pieces, saving costs and time for bulk production or manufacturing. The fabric selection tool enables users to print textiles directly onto avatars or digitally draw on their patterns. This makes it possible to see how the garment will look before investing in making it. To be used as a reference or for the actual cutting activity, Clo3d provides printing capabilities [5].

4.2. Parametric Pattern Creation

Parametric pattern-cutting technology is an excellent solution and extremely useful for those who do not have much skill in traditional pattern making. However, it can be a solution for those who have a passion for fashion design and are interested in how clothes are made, as well as for general users who want to make clothes. Anyone with knowledge of the software can use it to automatically generate patterns known as parametric patterns by inputting data into a specific option in the Clo3D application. As an alternative, the program can generate parametric patterns in response to specific measurement requirements. The parametric pattern is automatically positioned and stitched once it is created according to the given parameters [23]. **Figure 2** illustrates how the parametric pattern creation method is used in CLO3D software, demonstrating how easy it is to enter human image dimensions and automatically generate the pattern in parametric pattern creation.

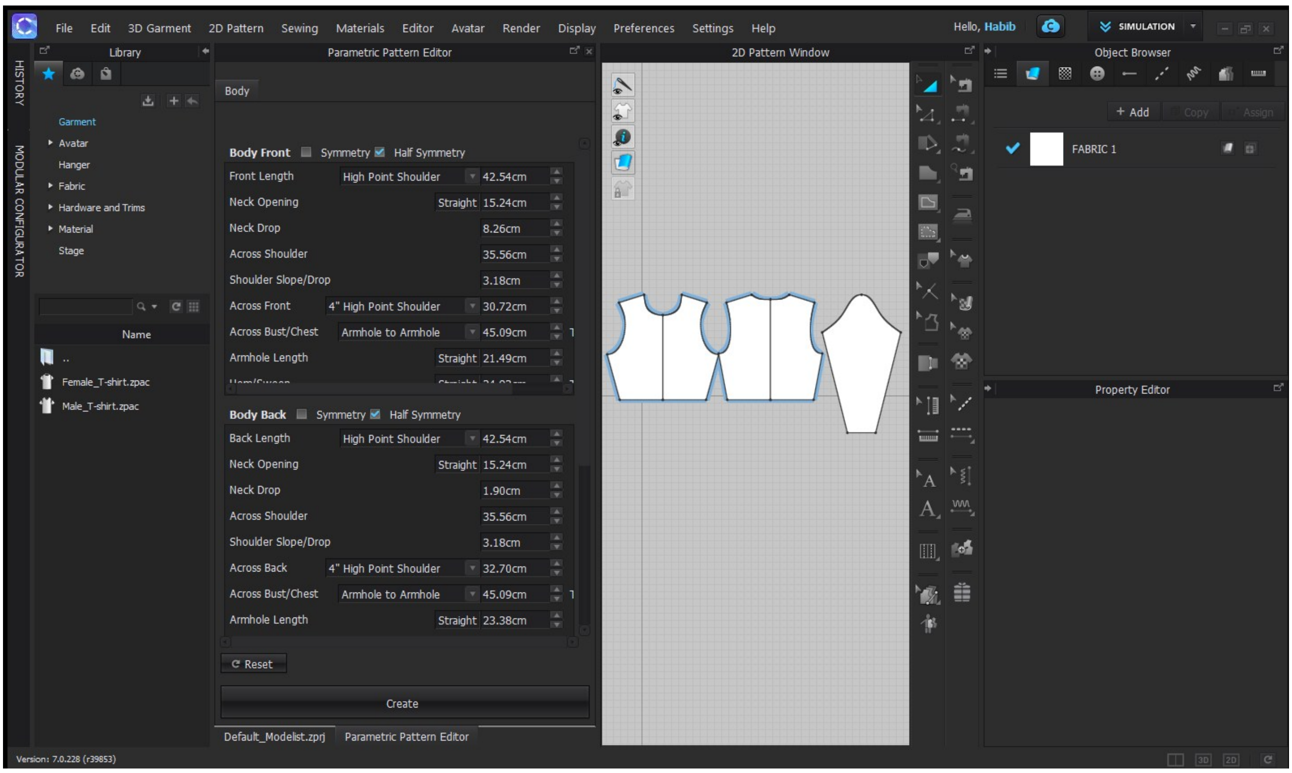

Figure 2. Parametric Pattern making window in CLO3D.

4.3. Digitize Manual Patterns

Manual patterns are mapped or traced using an electronic point finder (cursor) throughout the digitizing and scanning process [24]. A portable device similar to a mouse that, when engaged, electronically transmits pattern forms to an electronic worktable, converts the data into digital form for use on a computer, and stores the converted pattern parameters for later use [25].

Clo3D can serve as a digitization table for digitizing manual patterns. It imports scale pictures as a backdrop image into the 2D workspace, allowing manual tracing over them. Using the above camera, the pattern is arranged on a flat table, and the shape is imported using a picture tracing tool. Although simpler and less expensive than a wide-format scanner, it may not be as accurate if not checked at every stage of the process [26] [27] [28]. **Figure 3**, process-1 shows the manual digitizing and process-2 shows the Digitizing Pattern in Clo3D.

4.4. Grading

The process of grading involves the expansion of clothing designs without modifying their fundamental structure to accommodate various body types. The integration of a size chart with basic blocks is a common practice in garment manufacture, aimed at creating proportionate sizes of clothing that are most suitable for the target clientele [23]. Design experts commonly employ sample sizes in their work. Instead of generating a new pattern for each size, the original pattern will be evaluated and graded. According to previous research [29], it has been observed that there is a positive correlation between the size and the growth in the technique. Conversely, a decrease in size is associated with a decline in the method. The process of grading garment designs includes modifying sample

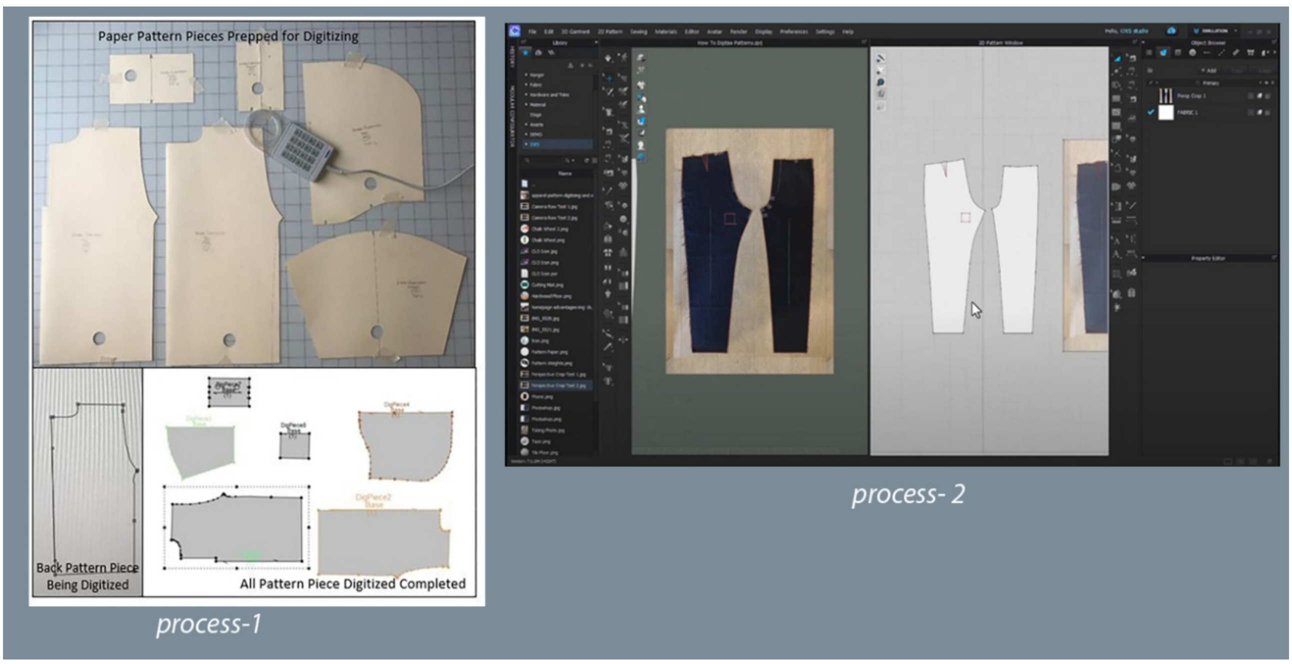

Figure 3. Digitizing Pattern manually and Clo3D.

patterns to meet certain size specifications while maintaining the original style, appearance, and structure [30]. The Clo3D software system provides users with a choice between two distinct approaches to pattern grading. There are two methods of pattern grading: two-dimensional or manual pattern grading, and three-dimensional or computer-aided pattern grading. After the completion of the base size pattern, including the processes of creation, fitting, finalization, and necessary modifications to meet our requirements, we can proceed with pattern grading. This involves adjusting the basic size pattern in order to generate patterns for other sizes [31]. Clo3D provides a range of remarkable grading capabilities, including automatic grading and edit grading, which have the potential to significantly enhance efficiency and productivity within our industry. The transition between different shapes within a pattern can be expedited through the utilization of mouse clicks and key presses. The pattern grading process of Clo3D is depicted in **Figure 4**.

Within the Clo3D software, the auto-grading technique is employed to generate novel patterns of varying dimensions based on pre-existing patterns. This functionality can be advantageous for designers and pattern makers, as it effectively minimizes errors and obviates the necessity for human grading. The assessment of patterns will be conducted automatically, with the grading criteria being determined by the size of the avatar. Auto-grading relies exclusively on CLO avatars, as they are important for ensuring accurate and consistent patterns. To optimise the outcomes, it is recommended to adjust the dimensions of the avatar, apply 3D attire to it, and establish a particle distance of 20 mm [32].

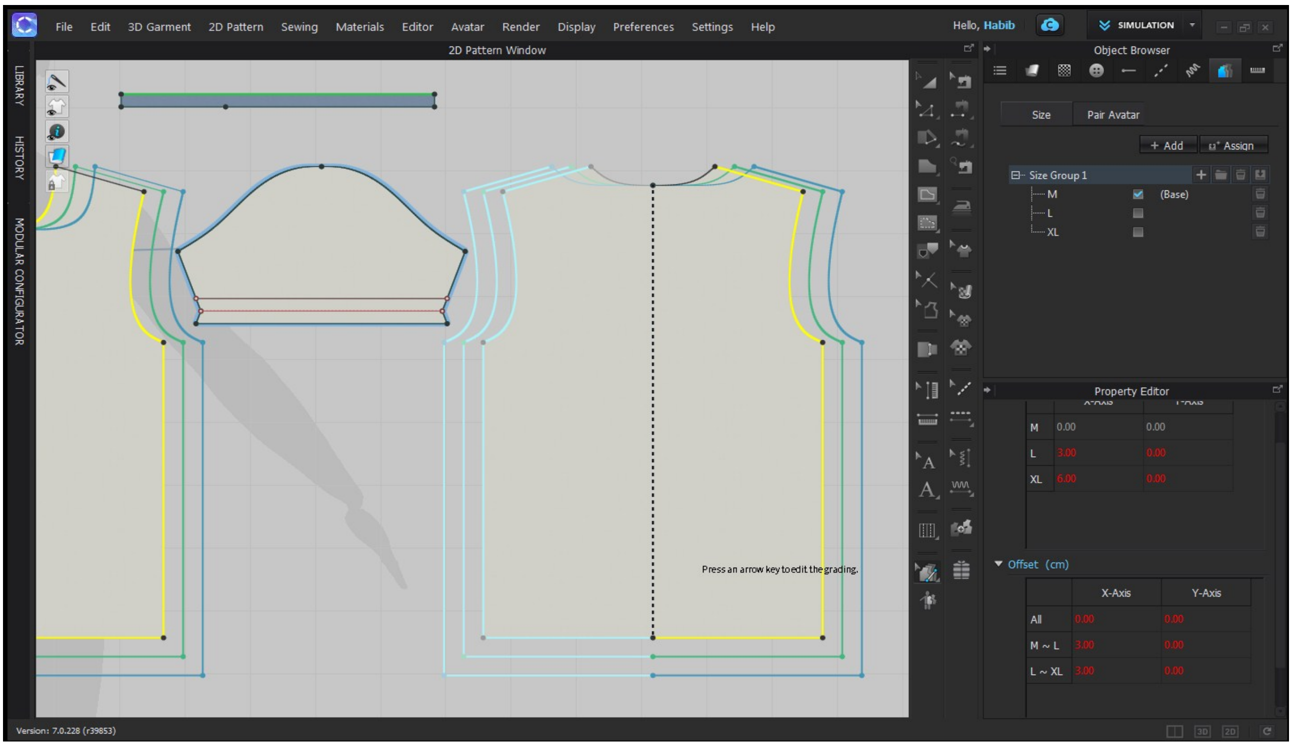

Figure 4. Pattern Grading in Clo3D.

Using the tool's integrated pattern grading, designers may select the original pattern, specify the size or range, and let Clo3D do the rest. This automated method guarantees accurate outcomes and a fitted garment while conserving time and minimizing errors. If adjustments are required, they can be made, reducing errors and ensuring a seamless procedure. Figure 5 shows how to apply clothing to a mature female figure in steps 1 and 2, how to apply clothing automatically to a baby girl in stages 2 and 3, and how to use Clo3D to show the results of the automated grading in steps 4 and 5, respectively.

4.5. Walk Pattern

Two sections of different patterns can be compared in real time length by momentarily aligning them. Designers can construct a virtual walk pattern for their garment designs using Clo3D's robust walk pattern capabilities. Designers can swiftly compare two distinct patterns with various segment lengths using Clo3D, which permits real-time pattern alterations when constructing walking patterns [33]. Figure 6 depicts the Clo3D walk pattern function.

4.6. Marker Making

The term "marker" refers to a grouping of pattern elements that can be physically created on marking paper, placed on a fixed sheet of paper and photographed, or digitally recorded for use by a computer [34]. While creating the dress's pattern,

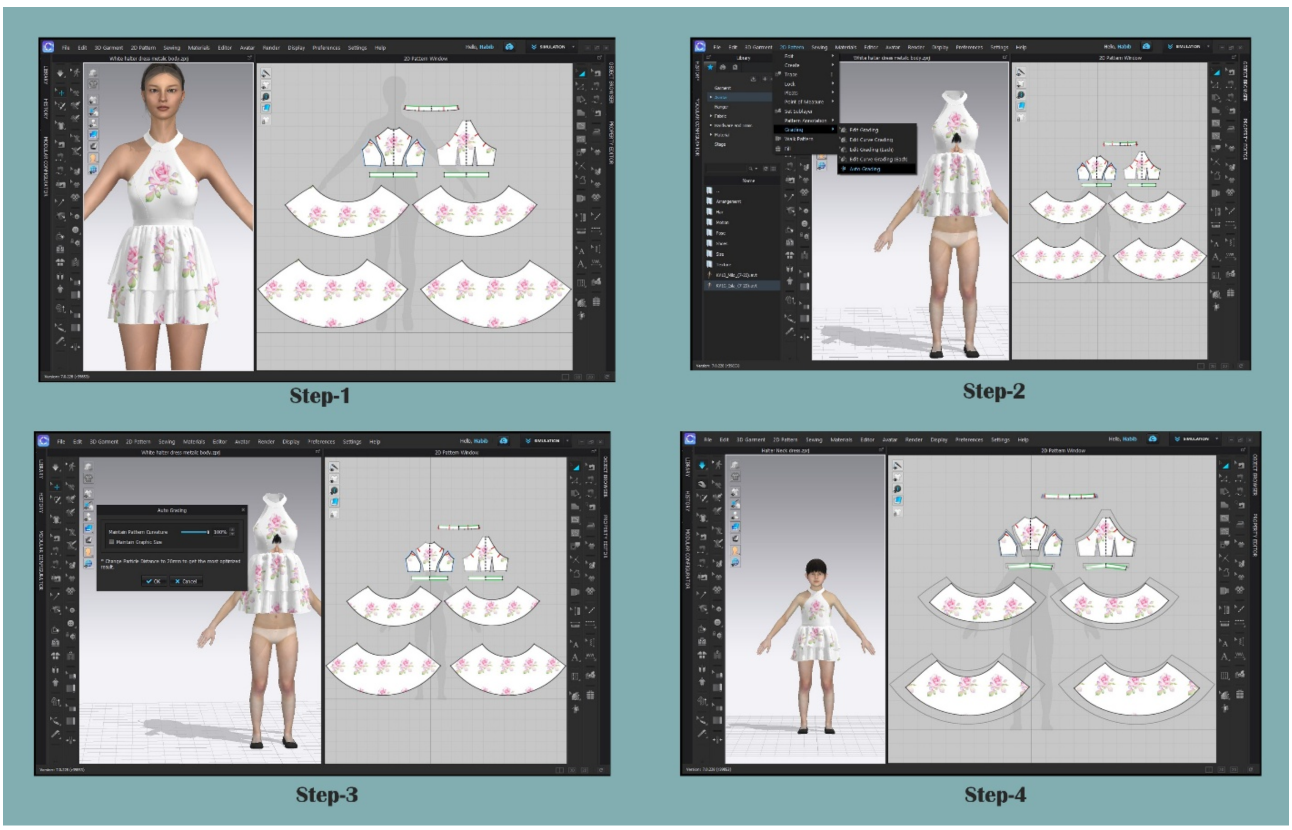

Figure 5. Auto Grading in Clo3D.

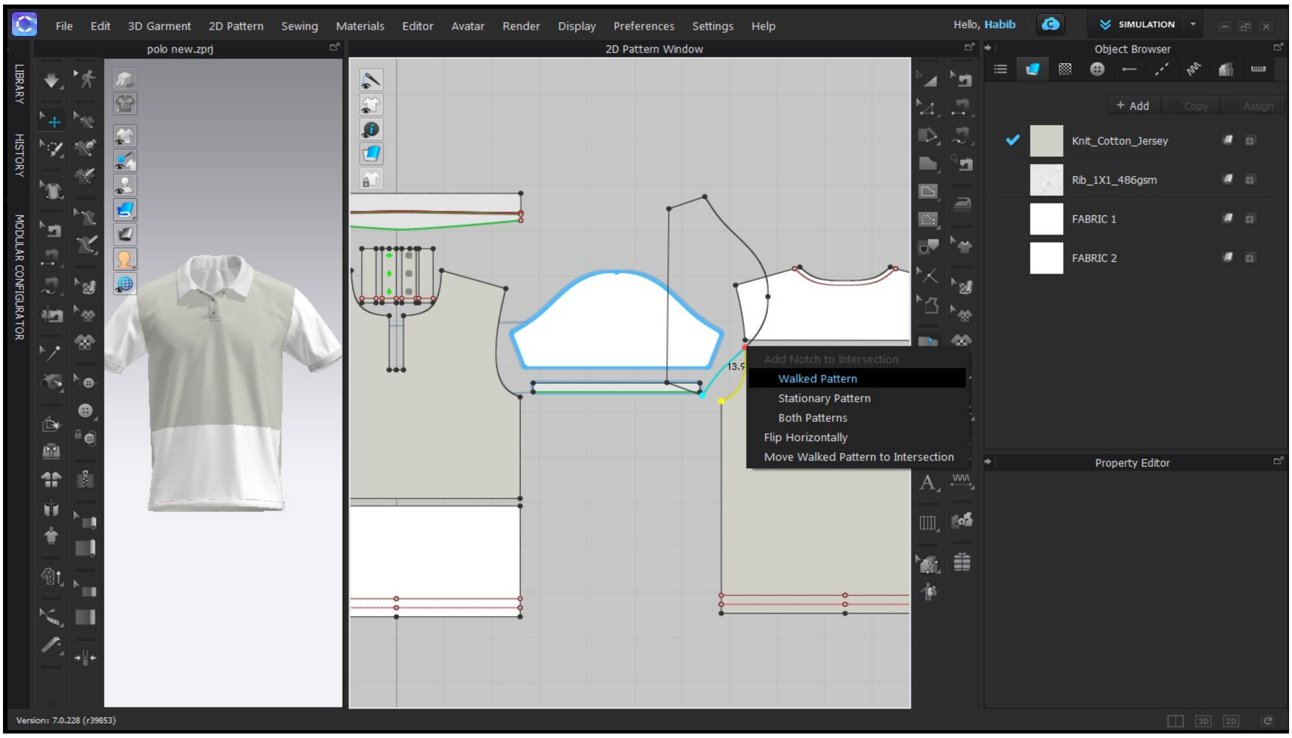

Figure 6. Walk pattern in Clo3d.

Clo3D can help with marker development by providing features and tools made specifically for marker creation. A marker is a grouping of fabric scraps from which various garment components will be cut.

4.7. Automated Marker Making

Using an automatic method based on pattern parts, Clo3D can quickly produce a marker. Time is saved and efficiency is boosted because the marker is automatically created based on the pattern pieces. Clo3D's marker-making tools take into account fabric usage and grain lines, allowing designers to see how the fabric will be laid out on the marker and make the appropriate adjustments. Waste is decreased and fabric usage is increased as a result [32]. **Figure 7** illustrates automatic marker marking in Clo3d, which is accessed from the Print Layout section tab.

4.8. Clo3d Pattern Nesting and Fabrics Consumption

Designers can organize several designs on a single piece of cloth using Clo3D's built-in pattern nesting functionality. In order to help designers properly predict their fabric requirements, Clo3D automatically aligns patterns using certain pattern nesting techniques and presents a summary of fabric consumption. Designers and pattern makers must utilize this tool to maximize fabric utilization and save waste. Designers can use pattern nesting because it offers real-time viewing, change, and precise fabric cost predictions. By making the cost calculation of the fabric more straightforward and guaranteeing that the right quantity is ordered

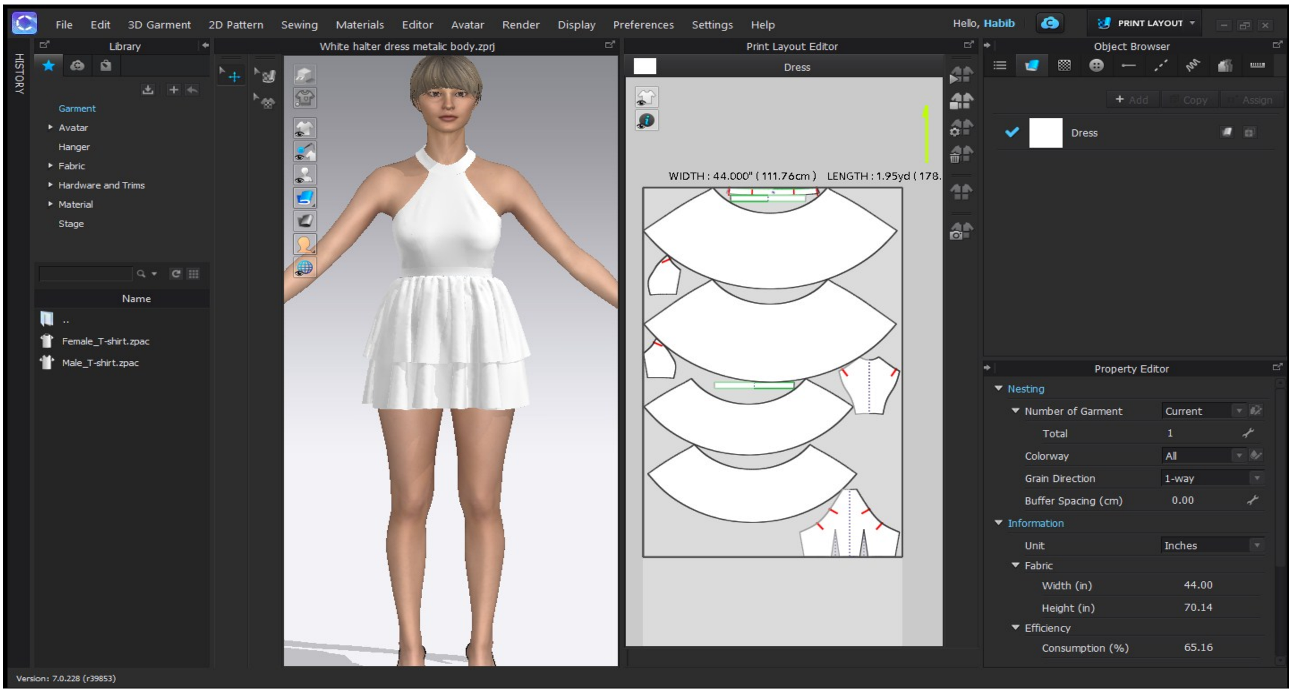

Figure 7. Automated Marker and pattern Nesting in Clo3d.

for the design, this increases efficiency and effectiveness in these activities. The pattern nesting of Clo3d is displayed in Figure 6.

5. Mirror Pattern

Clo3D makes mirrored pattern parts quicker and simpler than traditional manual pattern construction, saving designers and pattern makers time and effort. This tool, which allows vertical or horizontal axis mirroring, allows a quick test of design adjustments. This technique aids in the creation of more visually pleasing and high-quality clothing by analyzing the look and fit of new pattern elements in both 2D and 3D. Figure 8 depicts the mirror pattern creation window in Clo3d.

6. (POM) Point of Measure

Using the Point of Measure (POM) standard from Clo3D, a measurement standard for apparel, designers can specify measurement points on 2D pattern components. Then, utilizing this data, size charts, grading, and garment tech packs are created. The 2D POM feature ensures accurate scale and a snug fit on the human body, lowering production risk and enhancing the garment's overall quality and fit. The creation of the proper shape and pattern is essential to the Clo3D garment manufacturing process. Figure 9 represents the Point of Measure (POM) window in Clo3D.

6.1. Trace Tool

Pattern analysis is vitally significant for design development [35]. Drawing shapes

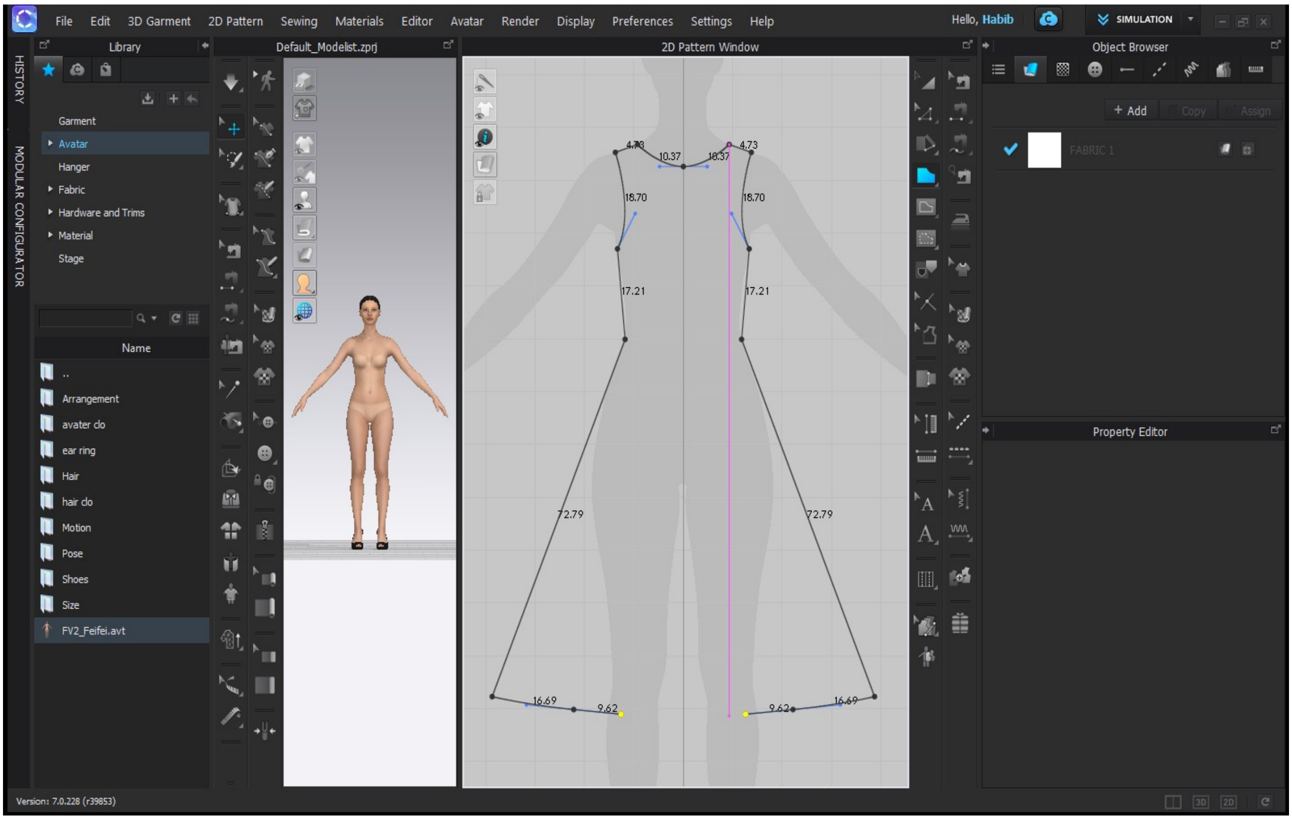

Figure 8. Mirror Pattern making in Clo3D.

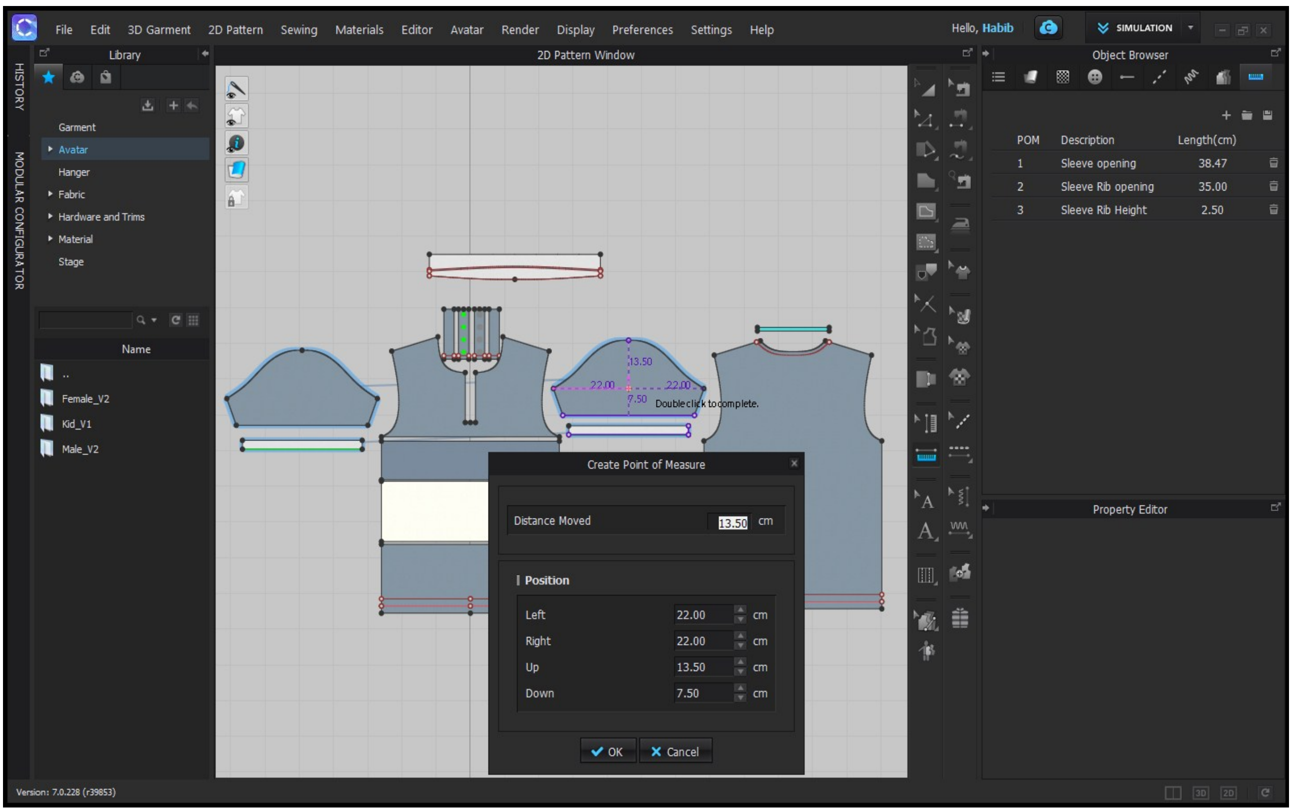

Figure 9. Point of Measure (POM).

from the master plan during pattern creation may be necessary for later development. The 3D tracing tool from Clo3D, which enables users to swiftly produce new pattern pieces based on pre-existing forms and patterns, can be particularly helpful for pattern cutters and designers. The Clo3D "Trace as a Pattern" tool allows designers to swiftly trace over an existing shape or garment to produce a new pattern piece, saving them time. It can also be used to test many design iterations, assisting designers in improving their concepts and ultimately producing better-fitting, higher-quality clothing. In Figure 10, the Clo3D trace tool programmer is displayed.

6.2. Cut & Sew Pattern

Designers can see a garment's fit and drape in three dimensions prior to producing it. The Cut & Sew template function of Clo3D provides this chance. With the use of this technology, designers may find fit problems and make design changes before garment production. A useful method for product development is the Clo3D cut and sew template, which enables the construction of intricate 3D simulations for presentations and lifelike representations for advertising. Figure 11 shows the application of the cut-and-sew design.

6.3. Merge Pattern

The "Merge Pattern" function in Clo3D allows pattern makers and designers to choose different pattern elements and combine them into a single pattern. This

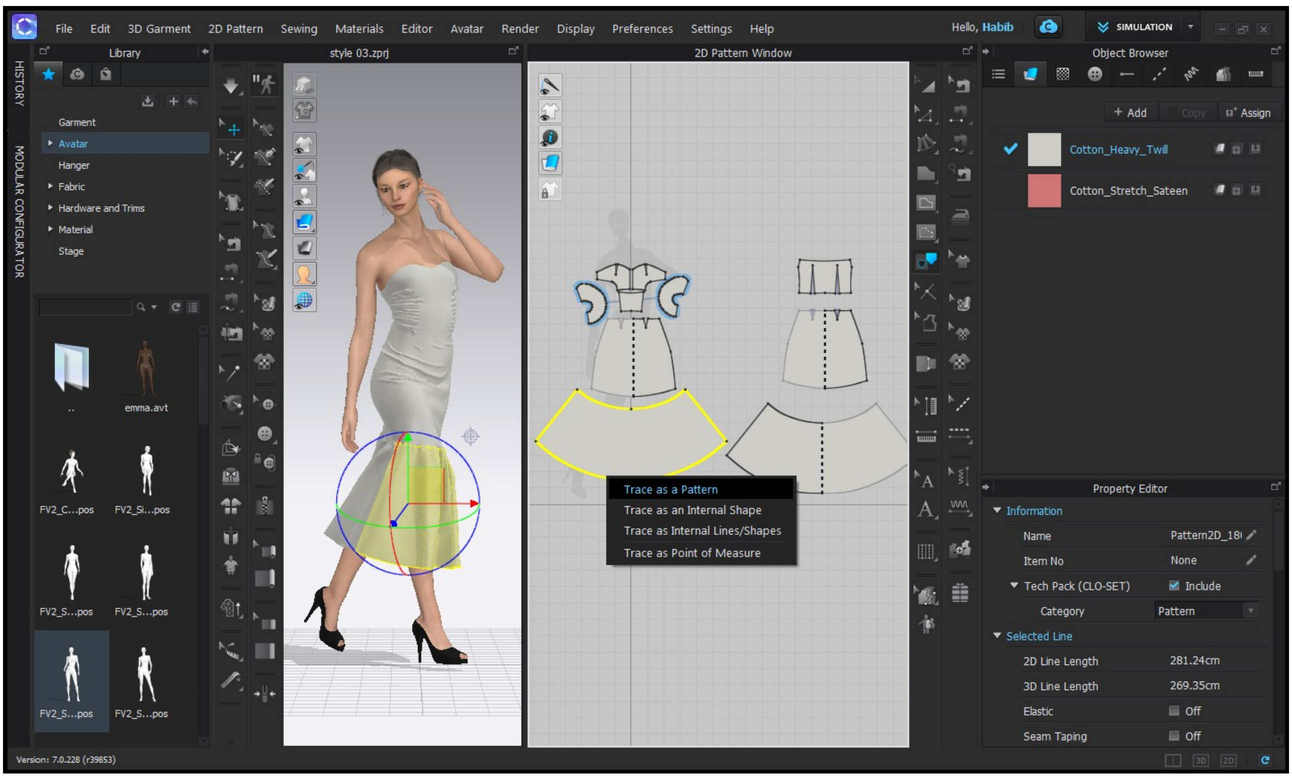

Figure 10. Trace Tool application in Clo3D.

capability can be used by designers to combine multiple patterns into a single, complex pattern, or to speed up the pattern making process in general. The Clo3D "Merge Pattern" feature can be useful to save designers time. The Clo3D Merge Pattern application window appears in Figure 12.

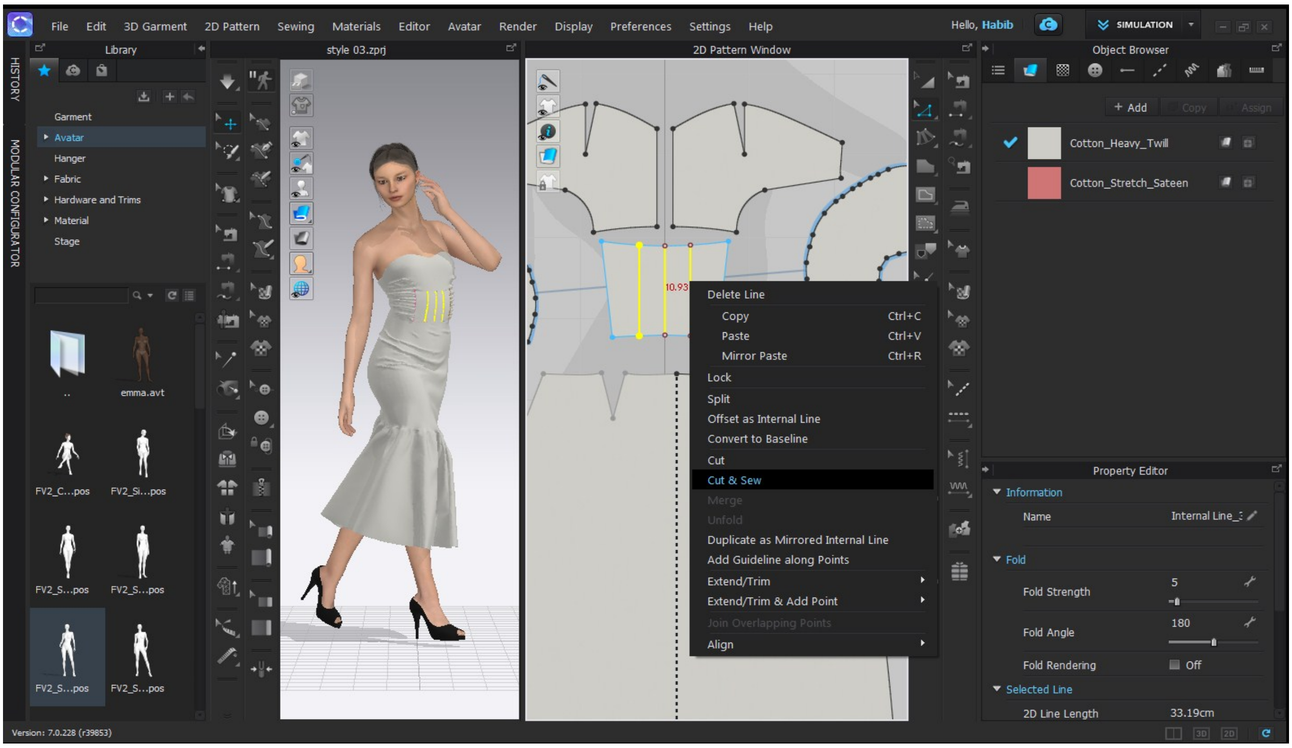

Figure 11. Cut & Sew Pattern in Clo3D.

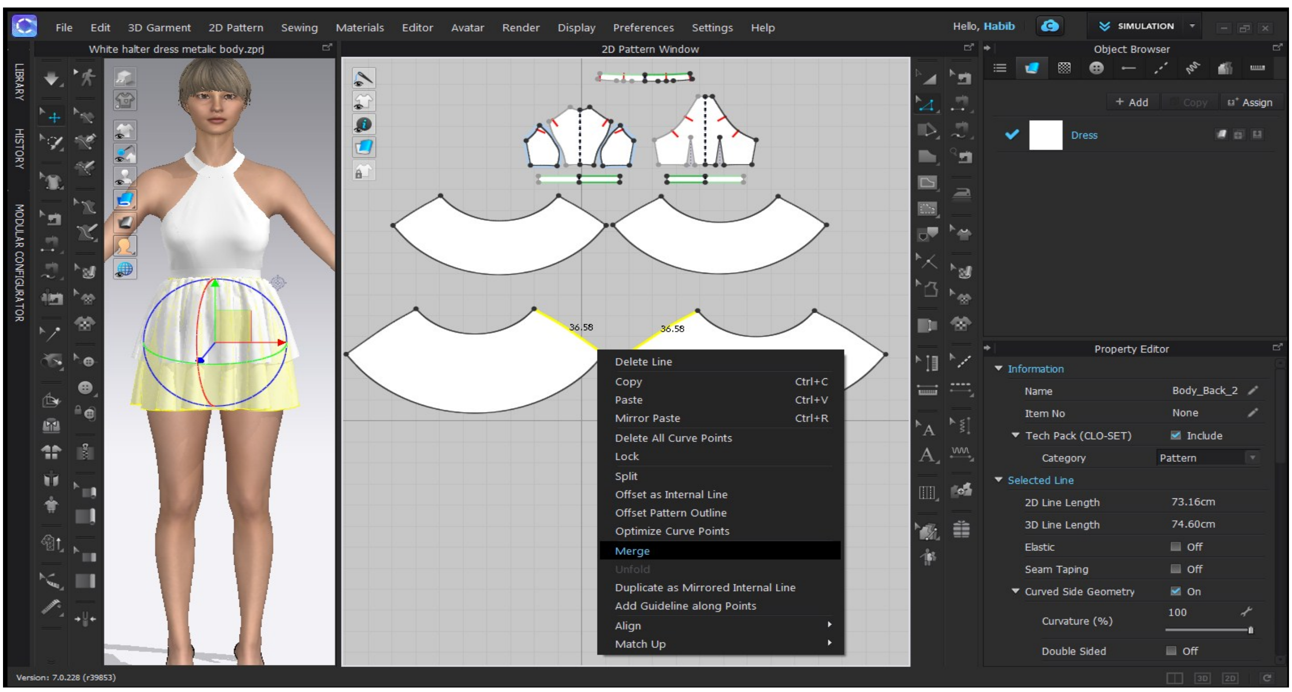

Figure 12. Merge Pattern in Clo3D.

6.4. Add Fullness and Darting, Pleats, and Other Fullness

Finishing touches are frequently necessary when developing a new style or design for a garment. Where fullness is necessary, the pattern frame's length or width must be increased by slicing and spreading [36]. Give a textile pattern additional volume by using the "Add Fullness" function in Clo3D. It is frequently used to give a skirt, pair of trousers or other articles of apparel a looser, more comfortable fit or to add flair. For a tighter fit, the "Add Fullness" option works by adding more fabric to specific pattern sections. This extra fabric can be used evenly throughout the pattern or just in certain areas. A variety of darts, pleats and other finishes can be added to garment patterns using Clo3D. Using the capabilities of Clo3D, additional fillings can be created, including gathers and tucks, which are helpful in adding volume and form to garments. These tools allow placement of fill where it is needed and changes in its size and spacing. This extra fabric can be used uniformly throughout the pattern or selectively in certain places. Using Clo3D, various darts, pleats, and other finishes can be applied to garment patterns. Clo3D's capabilities can be used to create additional fillings, including gathers and tucks, and are useful for adding volume and shape to fabrics. Using these tools, the fill can be positioned where needed and its size and spacing can be changed.

The Clo3D dart manipulation tool allows designers to quickly and accurately create complex dart combinations, creating highly realistic and detailed virtual garments and reducing the need for physical prototypes. Figure 13 and Figure 14

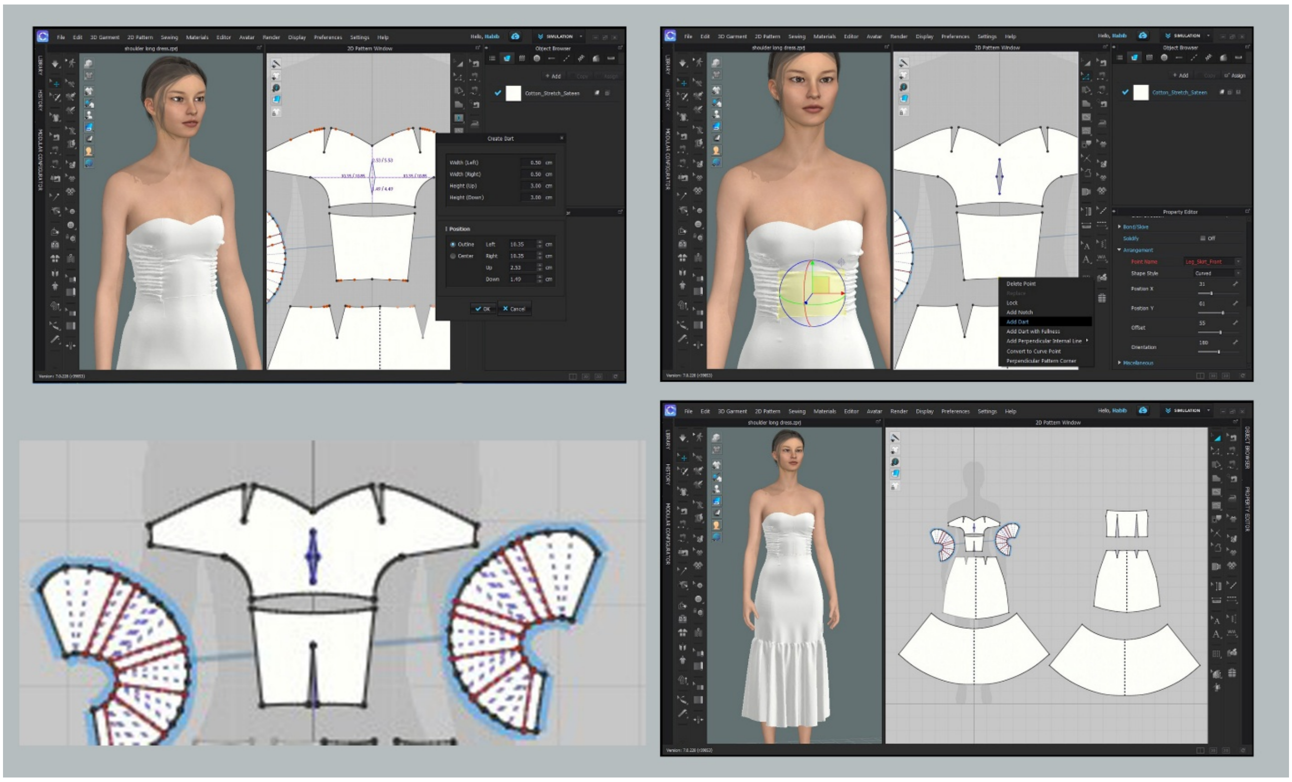

Figure 13. Dart Application windows in Clo3D.

show the Clo3D Dirt application window and Add Completion application window, respectively.

6.5. Style Lines

Designers can create unique and attractive style lines for their clothing designs with Clo3D's line and curve line tools. Design selection is easier when designers can see the garment in 3D and understand how the style lines will affect the finished product. The procedures for creating a style line in Clo3D are shown in Figure 15. The garment is shown in step 1 with no style lines, step 2 with style lines added, and step 3 with all style lines added.

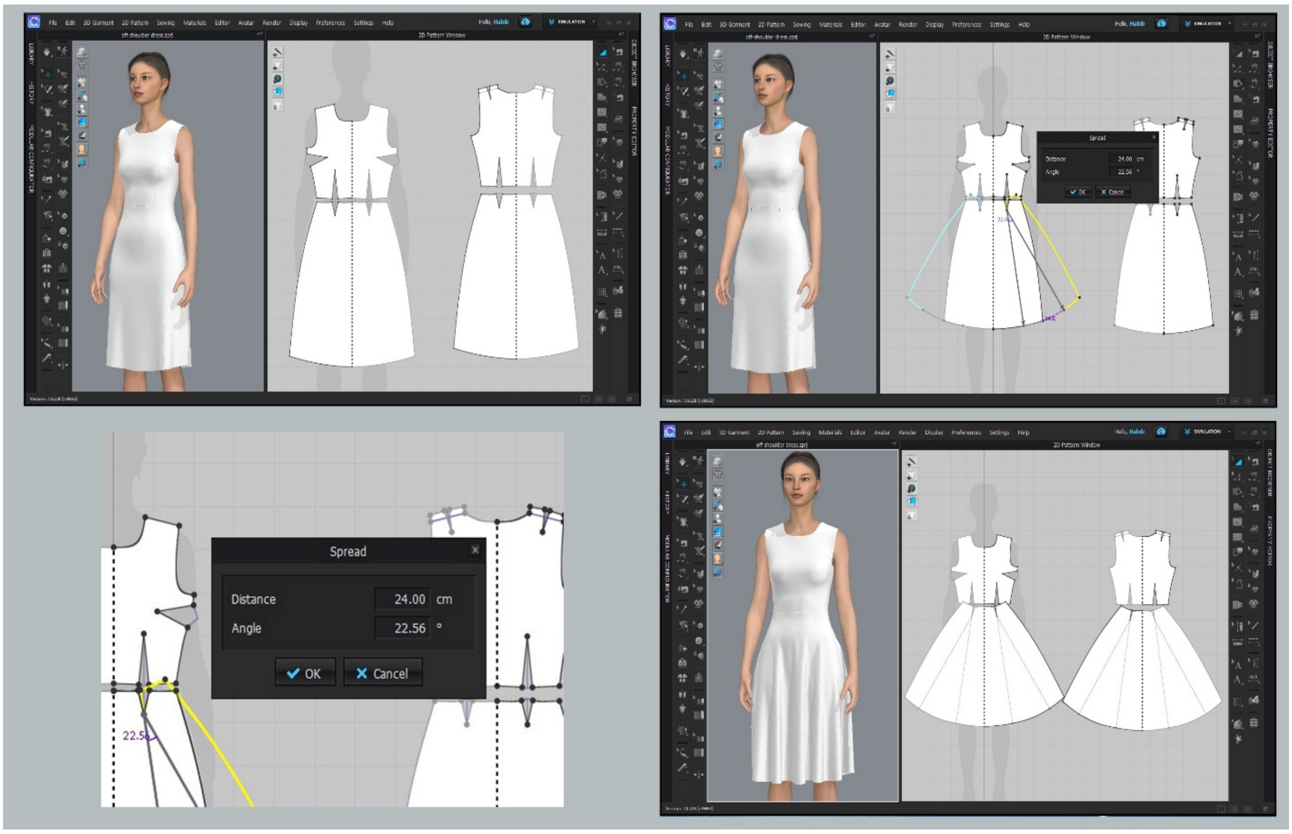

Figure 14. Add fullness Application windows in Clo3D.

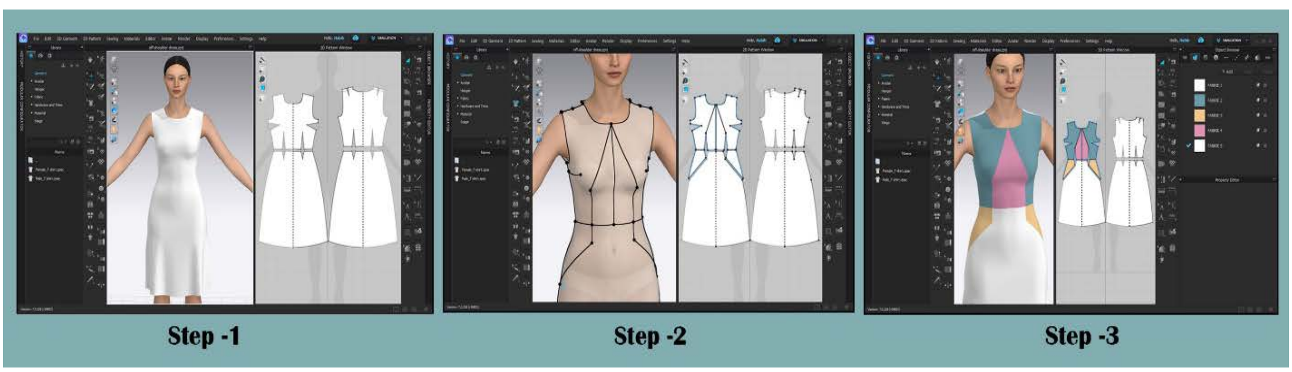

Figure 15. Style Lines creation in Clo3D.

7. 3D Pen Tool

The Clo3d 3D pen tool is essential for producing garment patterns since it has sophisticated capabilities with quick pattern creation in a three-dimensional image or avatar. It aids in idea generating, experimentation, and the exploration of design possibilities. Additionally, it aids in imagining how a garment will seem prior to manufacture and helps spot any potential fit or design flaws. The 3D pen tool fosters teamwork among pattern makers, designers, and other creatives, resulting in compositions that are more dynamic and interesting. By permitting quick testing and exploration of a wide range of design possibilities as well as helping pattern makers and designers to picture how their works would look when worn, it can help in the concept generating process. Figure 16 shows the steps of application 3D Pen tool windows in Clo3D.

Modular Configurator

Fashion designers and pattern creators may mix and modify pre-designed modules, such as garment patterns, using the Clo3D Modular Configurator tool to create modular designs. In the fashion sector, where many clothing products have replaceable parts or components, this is extremely useful. It has a wide range of tools that may be used to create and alter garments. Designers may create and modify garment designs, provide the option to re-save in the modular configurator, utilize a variety of materials and textures, simulate garment drape and movement, and do virtual fittings to obtain the right fit and aesthetics. The

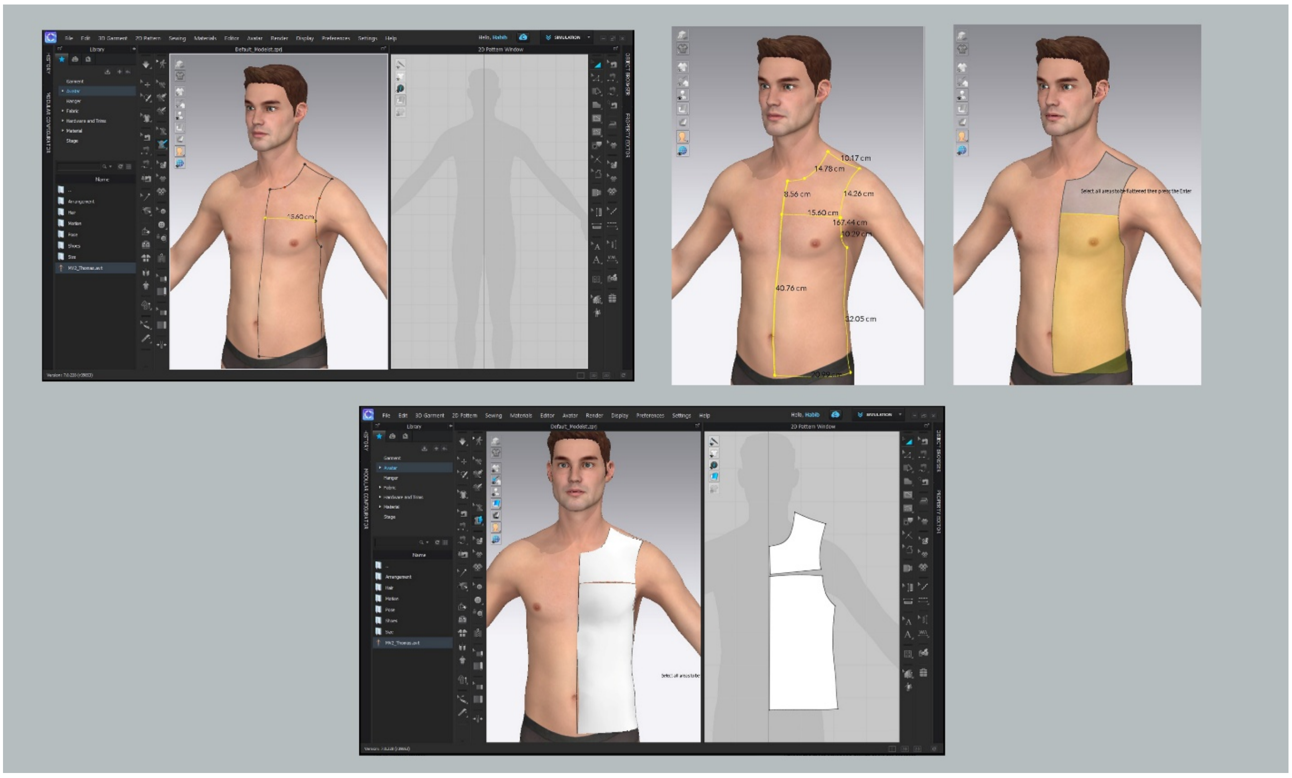

Figure 16. 3D Pen tool windows in Clo3D.

Modular Configurator window in Clo3D is seen in Figure 17.

8. Simulation

The Clo3d simulation function gives pattern writers and designers the opportunity to test and evaluate their work in a virtual setting, helping them better understand the look and behavior of their garments. It improves fit and drape while streamlining the process and reducing the cost of physical prototypes. It also lowers the cost of physical prototyping while improving accuracy, efficiency, uniqueness and innovation. The Clo3D simulation window appears in Figure 18.

9. Render

The act of converting a virtual model into a 2D or 3D image or animation of a garment design is known as rendering in Clo3D. Pattern designers and producers can use this programme to produce a precise image of their work that includes lighting, shading, and texture. The created visual is useful for marketing, stakeholder communication, and design assessment. Rendering is crucial for pattern makers, designers, and product developers in the fashion industry because it provides an exact and realistic perspective of the garment that enables them to identify and fix fit and drape problems. Figure 19 depicts the Render Process pane in Clo3D.

10. Result and Discussion

Using Clo3d for pattern making gives us much more options and benefits for

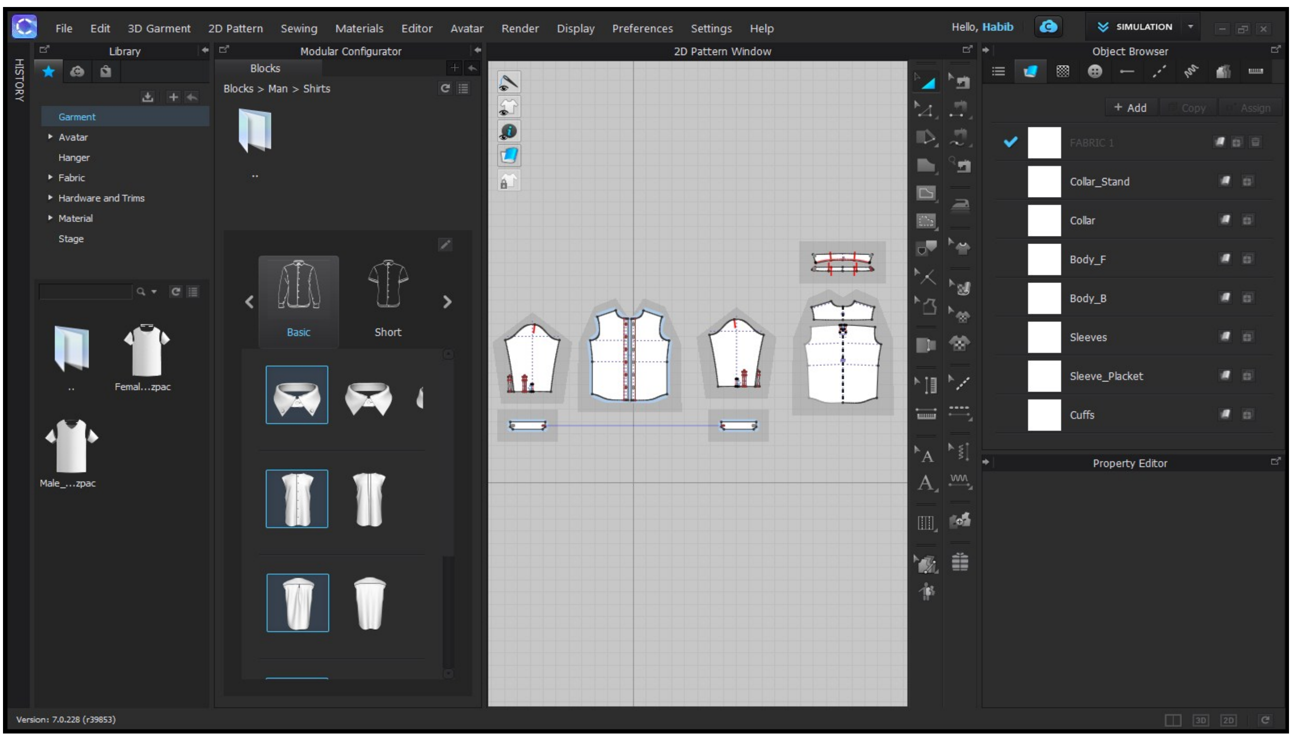

Figure 17. Modular Configurator window in Clo3D.

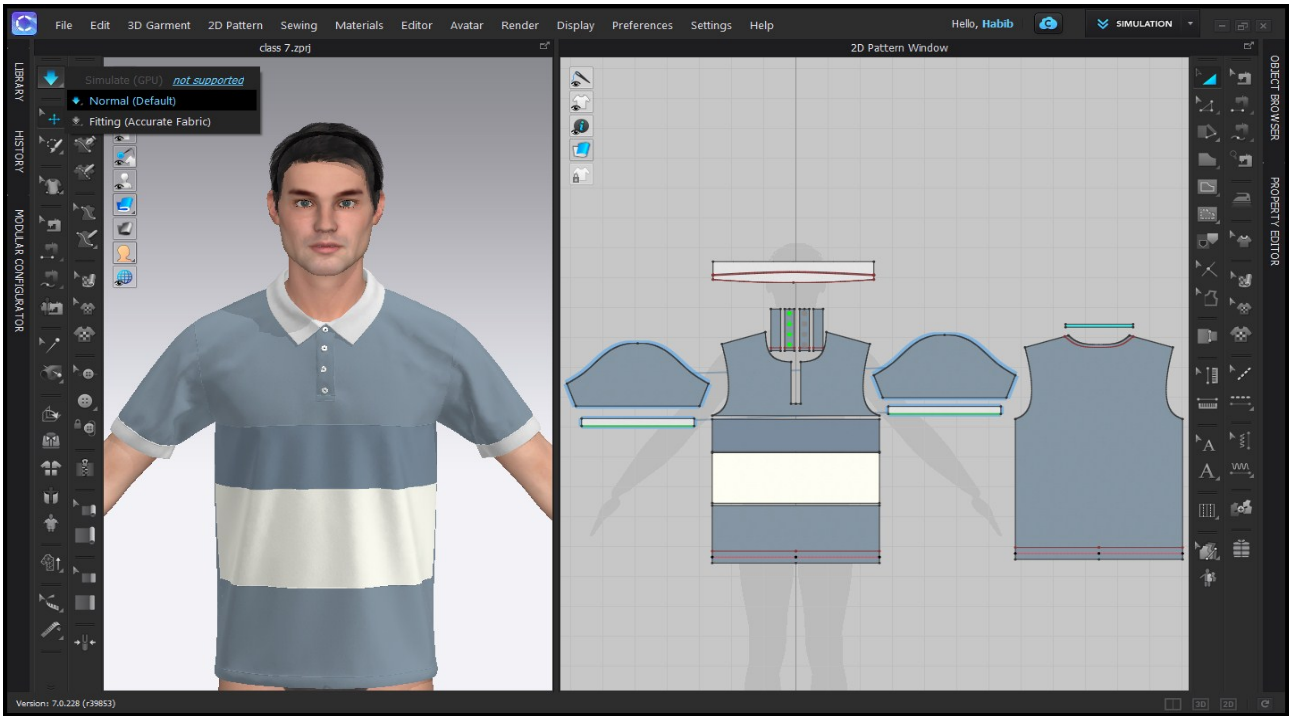

Figure 18. Simulation window in Clo3D.

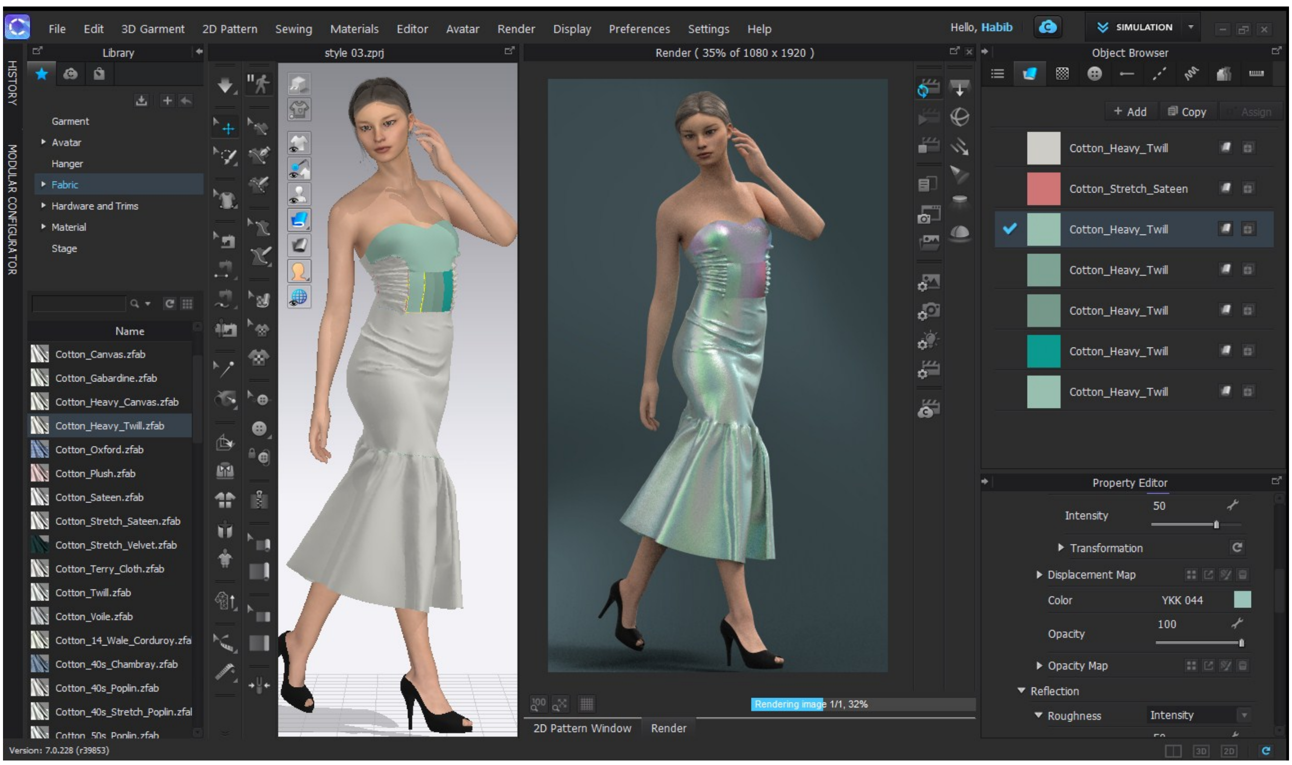

Figure 19. Render window in Clo3D.

pattern making and fashion designing than manual pattern making, which is evident from the aforementioned quick evaluation of results. The results are discussed below.

Improved accuracy: By reducing errors in manual patterns, Clo3d pattern making software gives accurate representation, saving time and cutting waste. This results in a more efficient process.

Time saving: Unlike conventional techniques that require precise measurements and fabric placement, software designs save time and work while designing. With a few clicks, you can quickly adjust the design and size.

Savings: Cost of production is reduced due to lower cost of finished garments due to fewer mistakes. Having access to a digital library of patterns also eliminates the need for physical archives, which frees up space in a company's factory or warehouse.

Flexibility: Designers can quickly change concepts without waiting for a prototype to spot flaws or problems, enabling them to create complex and difficult items like corsets or ball dresses. This gives more creative flexibility when developing difficult items.

Versatility: Since Clo3d is designed to work with a variety of textiles, it is perfect for fashion enterprises that want to create seasonal fashion collections without having to use different software programs for each season.

Design Automation: By creating patterns based on parameters, Clo3D automates the design process, reducing effort and shortening it drastically.

It contributes to waste reduction: Clo3D promotes ethical clothing design while reducing waste from pattern production. It enables 3D collection construction and administration of virtual fittings and releases.

It guarantees a good fit: Before sending our garments to production, we can use 3D modeling to ensure that they fit correctly. We can immediately identify and correct problem areas using stress maps.

Clo3D technology offers online collection design, presentation and tailored displays for customers of all sizes. This allows retailers to sell clothes before they are made.

Using a 3D printer, customers can design their own clothing using Clo3D's clothing modeling software to create unique looks. Original clothing and accessories can be produced through 3D printing [37].

11. Conclusions

In the pattern-making industry, there are benefits and drawbacks to both traditional pattern making and virtual pattern building in Clo3D. The use of Clo3D for pattern manufacturing has many advantages for the fashion industry, including rapid prototyping, improved design accuracy, simulation, and rendering, among many other advantages. There are a few drawbacks to this programme that should be considered when using it. Due to early expenditures, learning curves, and dependency on technology, small businesses or lone designers may find it difficult to justify the investment. Another significant drawback is the lack of feedback and inadequate comprehension of conventional pattern construction, because designers solely utilise digital simulations to make design decisions. Last but not least, some people worry that the usage of Clo3D will lessen the creativity and originality of fashion designers, because the designs they produce might be too similar to one another. Despite these shortcomings, Clo3D is still a helpful tool for pattern development in the fashion industry. Designers and producers should carefully weigh the benefits and downsides of the programme to decide if it is the best fit for their requirements. While utilising Clo3D to create patterns for the fashion industry has several benefits over traditional pattern manufacturing, it also has some serious drawbacks. One of the major drawbacks of traditional pattern making is how labour- and time-intensive it is. A design can take a while to develop.

Traditional approaches can develop designs too slowly, which might not be practical for manufacturing projects with short lead times. Traditional pattern-making techniques rely heavily on manual processes, which might result in more mistakes and inconsistencies. Traditional pattern making cannot match the level of accuracy and precision provided by 3D software. There are variables and elements that can influence the outcomes, even for skilled patternmakers who can produce the greatest calibre designs. It is evident that both methods can be utilised to produce classy, sophisticated designs that satisfy the demands of modern customers. They both have an important role in the apparel industry.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Kershaw, G. (2021) Pattern Cutting for Menswear. Hachette UK.

[2] Amos, E.Y. (2013) Developing Digital Techniques for Fashion Illustration. Doctoral Dissertation, Kwame Nkrumah University of Science and Technology, Kumasi.

[3] Jhanji, Y. (2023) Computer-Aided Design—Garment Designing and Patternmaking. In: Nayak, R. and Padhye, R., Eds., *Automation in Garment Manufacturing*, Elsevier, Amsterdam, 253-290. https://doi.org/10.1016/B978-0-08-101211-6.00011-2

[4] Takebira, U.M., Mohibullah, A.T. and Murshed, S.S. (2018) Standardization of Standard Size Chart (Female Size 6 to Size 18) with Secondary Sizes. *Fashion Technology & Textile Engineering*, **6**, 1.

[5] Calderin, J. (2009) Form, Fit, Fashion: All the Details Fashion Designers Need to Know but Can Never Find. Rockport Publishers, Beverly.

[6] Armstrong, H.J. (2014) Patternmaking for Fashion Design. Pearson, London.

[7] Mohibullah, A.T., Takebira, U.M., Islam, S., Robin, M.A., Shipto, M.R., Ahmed, R., Rabby, M.F. and Zaman, L. (2020) Costing Break down of Fully Fashioned Knitwear. *Journal of Textile Science and Technology*, **6**, 153-167. https://doi.org/10.4236/jtst.2020.64013

[8] Shahadat, M.H., Chowdhury, A.H., Nathan, R.J. and Fekete-Farkas, M. (2023) Digital Technologies for Firms' Competitive Advantage and Improved Supply Chain Performance. *Journal of Risk and Financial Management*, **16**, Article No. 94. https://doi.org/10.3390/jrfm16020094

[9] Mohibullah, A.T., Takebira, U.M., Alam, M.S., Hossain, M.Z., Chakraborty, T. and Chowdhury, M.R. (2021) Washing Impacts on Jeans Costing. *International Journal of Advanced Research in Engineering and Technology*, **12**, 33-44.

[10] Takebira, U.M. and Mohibullah, A.T. (2017) Using Critical Path Method for Making Process Layout of a T-Shirt within Earliest Finish Time. *Journal of Textile Science & Engineering*, **7**, Article ID: 1000316.

[11] Bowers, J. (1999) Introduction to Two-Dimensional Design: Understanding Form and Function. John Wiley & Sons, Hoboken.

[12] Huang, H.Q., Mok, P.Y., Kwok, Y.L. and Au, J.S. (2012) Block Pattern Generation: From Parameterizing Human Bodies to Fit Feature-Aligned and Flattenable 3D Garments. *Computers in Industry*, **63**, 680-691. https://doi.org/10.1016/j.compind.2012.04.001

[13] Kwong, M.Y. (2004) Garment Design for Individual Fit. In: Fan, J., Yu, W. and Hunter, L., Eds., *Clothing Appearance and Fit*: *Science and Technology*, Elsevier, Amsterdam, 196-229. https://doi.org/10.1533/9781845690380.196

[14] Rissanen, T.I. (2013) Zero-Waste Fashion Design: A Study at the Intersection of Cloth, Fashion Design and Pattern Cutting. Doctoral Dissertation, University of Technology Sydney, Sydney.

[15] Aldrich, W. (2015) Metric Pattern Cutting for Women's Wear. John Wiley & Sons, Hoboken.

[16] Sedig, K. and Parsons, P. (2013) Interaction Design for Complex Cognitive Activities with Visual Representations: A Pattern-Based Approach. *AIS Transactions on Human-Computer Interaction*, **5**, 84-133. https://doi.org/10.17705/1thci.00055

[17] Workman, J.E., Caldwell, L.F. and Kallal, M.J. (1999) Development of a Test to Measure Spatial Abilities Associated with Apparel Design and Product Development. *Clothing and Textiles Research Journal*, **17**, 128-133. https://doi.org/10.1177/0887302X9901700303

[18] Narang, V.A. (2014) Pattern Development for Menswear Using Block Method. Unpublished Doctoral Thesis, National Institute of Fashion Technology, New Delhi.

[19] Lu, S., Mok, P.Y. and Jin, X. (2017) A New Design Concept: 3D to 2D Textile Pattern Design for Garments. *Computer-Aided Design*, **89**, 35-49. https://doi.org/10.1016/j.cad.2017.03.002

[20] Marquês, C., Ferreira, A.M. and Oliveira, F. (2023) TechnoFashion2Sustainability. Digital Tools, Modular Strategies and Participatory Design Approach to Brand Engagement and Customized Solutions. In: Martins, N., Brandão, D. and Fernandes-Marcos, A., Eds., *Perspectives on Design and Digital Communication IV*: *Research*, *Innovations and Best Practices*, Springer Nature, Cham, 189-206. https://doi.org/10.1007/978-3-031-41770-2_11

[21] Braga, T. (2023) Brand Values in Digital Marketing: What Do They Mean and How Can They Affect Consumers Decisions.

[22] Faerm, S. (2012) Towards a Future Pedagogy: The Evolution of Fashion Design Education. *International Journal of Humanities and Social Science*, **2**, 210-219.

[23] Rissanen, T. (2007) Types of Fashion Design and Patternmaking Practice. https://doi.org/10.21606/nordes.2007.038

[24] Papahristou, E. and Bilalis, N. (2017) 3D Virtual Prototyping Traces New Avenues for Fashion Design and Product Development: A Qualitative Study. *Journal of Textile Science & Engineering*, **7**, 1-6.

[25] Huang, Y., Yi, H., Liu, W., Wang, H., Wu, B., Wang, W., Lin, B., Zhang, D. and Cai, D. (2023) One-Shot Implicit Animatable Avatars with Model-Based Priors. *Proceedings of the IEEE/CVF International Conference on Computer Vision*, 8974-8985.

[26] Mitchell, W.J. and McCullough, M. (1995) Digital Design Media. John Wiley & Sons, Hoboken.

[27] Bolder, J., Oomen, T., Koekebakker, S. and Steinbuch, M. (2014) Using Iterative Learning Control with Basis Functions to Compensate Medium Deformation in a Wide-Format Inkjet Printer. *Mechatronics*, **24**, 944-953. https://doi.org/10.1016/j.mechatronics.2014.07.003

[28] Cao, Y. and Wang, S. (2023) Research on the Application of CLO3D Technology in the Structure Design of National Costume. *Advances in Economics and Management Research*, **6**, 158-163. https://doi.org/10.56028/aemr.6.1.158.2023

[29] Vrljanac, M., Šikman, K., Simić, M., Naumović, T. and Despotović-Zrakić, M. (2023) Application of 3D Modeling in the Fashion Industry. *E-Business Technologies Conference Proceedings*, **3**, 176-184.

[30] Kim, H. and Damhorst, M.L. (2010) The Relationship of Body-Related Self-Discrepancy to Body Dissatisfaction, Apparel Involvement, Concerns with Fit and Size of Garments, and Purchase Intentions in Online Apparel Shopping. *Clothing and Textiles Research Journal*, **28**, 239-254. https://doi.org/10.1177/0887302X10379266

[31] Gill, S. (2015) A Review of Research and Innovation in Garment Sizing, Prototyping and Fitting. *Textile Progress*, **47**, 1-85. https://doi.org/10.1080/00405167.2015.1023512

[32] Bertola, P. and Teunissen, J. (2018) Fashion 4.0. Innovating Fashion Industry through Digital Transformation. *Research Journal of Textile and Apparel*, **22**, 352-369. https://doi.org/10.1108/RJTA-03-2018-0023

[33] Vitali, A. and Rizzi, C. (2018) Acquisition of Customer's Tailor Measurements for 3D Clothing Design Using Virtual Reality Devices. *Virtual and Physical Prototyping*, **13**, 131-145. https://doi.org/10.1080/17452759.2018.1474082

[34] Aluculesei, B., Krzywinski, S., Curteza, A. and Avadanei, M. (2021) Digital Methods in Developing Textile Products for People with Locomotor Disabilities. Materials Research Forum LLC, Millersville.

[35] Luff, P., Heath, C., Norrie, M., Signer, B. and Herdman, P. (2004) Only Touching the Surface: Creating Affinities between Digital Content and Paper. *Proceedings of the* 2004 *ACM Conference on Computer Supported Cooperative Work*, Chicago, 6-10 November 2004, 523-532. https://doi.org/10.1145/1031607.1031695

[36] Wu, Y. (2012) Development of an Intelligent Patternmaking System for Skirt Design.

[37] Kenkare, N.S. (2005) Three Dimensional Modeling of Garment Drape. PhD Thesis, North Carolina State University, Raleigh.