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Virtual Evaluation of CLO 3D Auto-Grading Tool in Attaining the Fit of Women's Clothing with Complex Patterns

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Abstract

Grading is a crucial task for pattern makers, involving increasing or decreasing the original pattern according to body measurements to produce different sizes for clothing production. Computer grading systems have advanced significantly; CLO 3D is one such system that provides distinctive grading features, including auto-grading and edit grading, which improve industrial efficiency and productivity. The auto-grading technique creates new patterns in different sizes based on existing patterns, reducing errors and eliminating the necessity for manual grading. This study employs the auto-grading features of CLO 3D in grading complex patterns. Besides, it ensures that the various graded sizes fit and conform to the body. Furthermore, evaluate the fit of the graded patterns for each style on the 3D parametric virtual mannequin using the fit maps supplied by the CLO 3D program.

The basic bodice block pattern was drafted and graded with the CLO 3D auto-grading tool, then the fit of the graded pattern was evaluated with fit maps on a 3D parametric virtual mannequin. Therefore, two complex women's styles were selected and drafted using the CLO 3D program with size XS. The auto-grading technique was applied to the style's patterns with the sizes (S-M-L). The graded pattern fit was then evaluated with fit maps on a 3D parametric virtual mannequin. The results indicate that the auto-grading tool within the CLO 3D program has proven highly effective in grading complex styles, considering virtual Evaluation using the fit maps method. This tool facilitates the automatic grading of such complex styles, achieving accurate and well-fitted outcomes.

Keywords: CLO 3D Program, Auto-Grading, Women's Clothing, Fit, Virtual Fitting, Women's Pattern.

1- Introduction

Pattern making acts a crucial role in fashion design and garment manufacturing, as it transforms a basic sketch into garments [1]. The process of pattern making involves transforming three-dimensional designs into two-dimensional components using a mathematical foundation [2]. The process of building patterns for the purpose of designing and producing clothes is a complex and varied process [3]. Therefore, pattern making is affected by a set of factors, the most important of which are the skill that helps the pattern designer in making accurate patterns, experience, as pattern making requires years of experience, and knowledge of clothing styles and bodies, which requires familiarity with the various methods of preparing patterns [4]. The traditional methods used by ready-made clothing factories to design patterns vary. Some of them depend on shaping the fabric directly on the artificial or human body to obtain the required pattern, which is called draping. Some of them depend on drawing the pattern in a geometric way on paper according to specific measurements, which is known as drafting. Some of them adjust the basic pattern with all its parts (the bodice block pattern in front and back, the skirt block pattern in front and back, and the sleeve block pattern) to fit a standard body, whether industrial or human, called Flat-pattern or Sloper, which is used as a basis for producing patterns for all required clothing designs, including the reverse copying method, called Knockoff, which is done by taking measurements of the garment to be copied and transferring them to paper or by disassembling the garment and transferring its parts [5]. There are three basic techniques for building the shape of the pattern,

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including firstly, flattening the pattern by dart manipulation, which is done in two ways: the Cut and Slashing method and the Pivot Method [6]. Secondly, the contouring technique involves adding darts, cuts, pleats, or ruffles so that the garment matches the body lines. Thirdly, the fullness-adding technique involves making slits in the pattern from the bottom and inserting the expansions according to the required design (Fairhurst, [7]. All these techniques of making manual patterns require a large amount of time and a specialized skill in various areas such as grading, marker planning, and fabric utilization [1], so most apparel manufacturers in the drafting and grading of clothing patterns try to utilize apparel CAD systems, especially with the complex areas of work [8].

Grading is one of the tasks performed by the pattern maker; it is defined as “the process of increasing or decreasing the original pattern according to a set of body measurements by specific proportions to obtain a set of different sizes that help in producing clothing” [9]. To grade a pattern, increases (or decreases) are applied at specific points of the original pattern to make the new pattern larger (or smaller). Therefore, the process of grading patterns ensures that the same garment design is produced in a variety of sizes while maintaining fitting [9]. Grading systems are divided into two main systems, namely the simplified 2D grading system, which depends on increasing the pattern in the length and width directions on the edges of the garment only, and the more complex 3D grading system, which does not depend on applying the increase on the edges of the pattern only but also distributes the increase in the areas of (darts, pleats, or ruffles) according to their presence in the garment design. Hence, the 3D grading system is necessary to obtain better fitting for garments with complex designs [9]. There are three main types of grading techniques: shifting, edge changes, and proportional grading. All techniques require a basic fitted pattern. Shifting uses the incremental movements of the whole pattern. Edge changes use grade rules with horizontal and vertical changes at cardinal points on the pattern. Proportional grading uses the total horizontal and vertical change to the biggest (or smallest) size, it utilizes the base size pattern and the biggest size pattern (obtained by grading up from the base size directly to the biggest size using the total horizontal and vertical increases). The two patterns are lined up by matching the zero points. A diagonal line is created between each cardinal point of the base size and the corresponding cardinal point of the biggest size. A divisional tool is used to divide the line into a variety of sizes [9]. There are two fundamental concepts that should be followed for successful grading: all the sectional increases must add up to the whole girth or length increments, and all increments must match the adjoining seams and notches [10]. When grading patterns, it’s critical to maintain the garment’s design integrity; this means making sure that features like darts and seams are properly fitted each size [11]. Accordingly, with the more complex garment styles, it becomes increasingly difficult to obtain accurate fitted sizes to the body using traditional grading methods [12].

Computer grading systems have evolved rapidly in response to new technology. It essentially uses the same grading techniques and converts them into a digital format [11]. Current computer grading systems rely on edge-change grading [9]. CLO 3D is a 3D tool for designing and visualizing apparel developed by CLO Virtual Fashion Inc. CLO 3D provides designers with various tools and capabilities to develop and render realistic 3D clothing since the program employs complex algorithms and physics-based models to simulate the textile behavior and interaction with the body. It involves an important tool for pattern makers, fashion designers, and apparel manufacturers that contributes to transforming their designs into the physical product in a virtual environment [1]. Besides, it has effective tools for reducing the time and the cost with higher efficiency and accuracy. It also enables pattern modification through quicker simulations of the fit [13] [14]. Pattern grading can begin once the basic size pattern has been completed, which includes the procedures of drafting, fitting, finalization, and any necessary modifications to suit design requirements. This includes adjusting the basic size pattern to make patterns for other sizes. The CLO 3D program offers a range of unique grading capabilities, involving automatic grading and edit grading, that enhance industrial efficiency and productivity. Through the CLO 3D program, the auto-grading technique can generate innovative patterns of varied dimensions from pre-existing patterns. This functionality can be useful for designers and pattern makers, as it reduces errors and avoids the need for manual grading [1].

The fit of clothing on the 3D body contours is the key factor influencing comfort and appearance [15]. Fitting a garment to body contours is one of the most important properties, in addition to design and fabric quality. Because a garment is made up of several materials, the ultimate fit is determined by how these parts interact, as well as maintaining the body silhouette, pattern construction, and fashion trends [16]. The conformity of clothing is a critical factor in product quality and end-user satisfaction [17]. Fit testing plays a crucial role in the development and production of clothing. Traditional fit evaluation primarily relies on visual analysis, where an expert or a group of experts evaluates the fit of a garment by visually inspecting it on a model or dress form. This conventional method is typically employed only after the manufacture of a garment prototype or garment batch during the bulk production. In contrast, the virtual fit analysis technique allows for the

Evaluation and prediction of clothing fit prior to manufacturing. This method combines both subjective and objective evaluations of fit by integrating a visual inspection of the simulated fit displayed on a computer screen with numerical Evaluations of fabric stress against the body and ease mapping from virtual clothing [18].

Therefore, this study aims to utilize the features of the auto-grading technique in CLO 3D, a three-dimensional (3D) virtual clothing program, in grading complex patterns. besides attaining fit and conformity to the body for the different graded sizes. Additionally, evaluate the fit of the graded patterns for each style on the 3D parametric virtual mannequin using the fit maps provided by the CLO 3D program.

2- Methodology (Practical Framework)

2.1 The empirical study procedures:

This study employed CLO 3D program (CLO standalone version 7.1) to perform the empirical study necessary to fulfill the study objectives. This was done according to the following procedures:

2.1.1 Adjusting the CLO 3D women mannequin to the standard sizes (XS-S-M-L) according to the standard body measurements of Aldrich [19], then saving these new-sized mannequins in the program library.

2.1.2 Drafting the basic bodice block pattern based on the pattern design method of Bunka-style Sloper for adult women with size XS [20]. The Bunka-style Sloper pattern-making system is known for its accuracy and fit [21]. According to [22] study, the Bunka-style Sloper pattern-making system can be used for drafting bodice block pattern since it was found that the pattern of Bunka is the best of all pattern-drafting methods under study about total fitting and the front and back side silhouette.

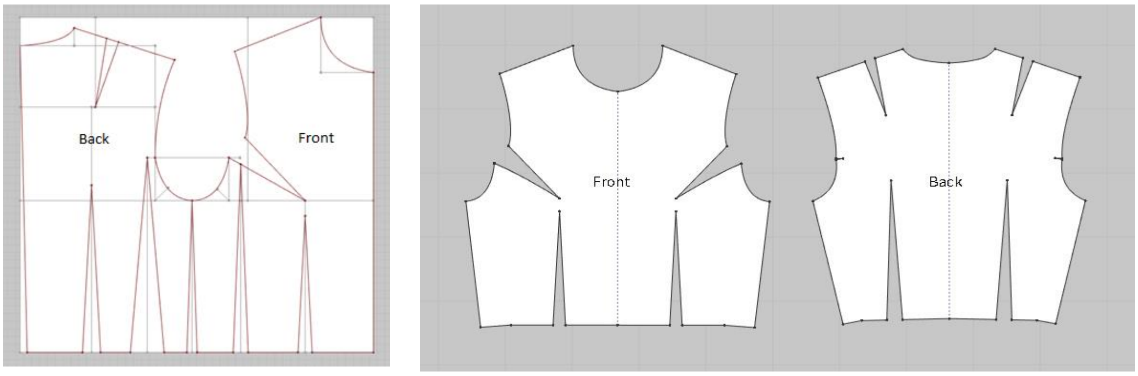


Fig. 1. Drafting the woman basic bodice block pattern (Bunka-style Sloper)

2.1.3 Importing the pre-sized prepared mannequins from the program library and applying auto-grading to the basic bodice block pattern for the three sizes using the auto-grading tool in the CLO 3D program.

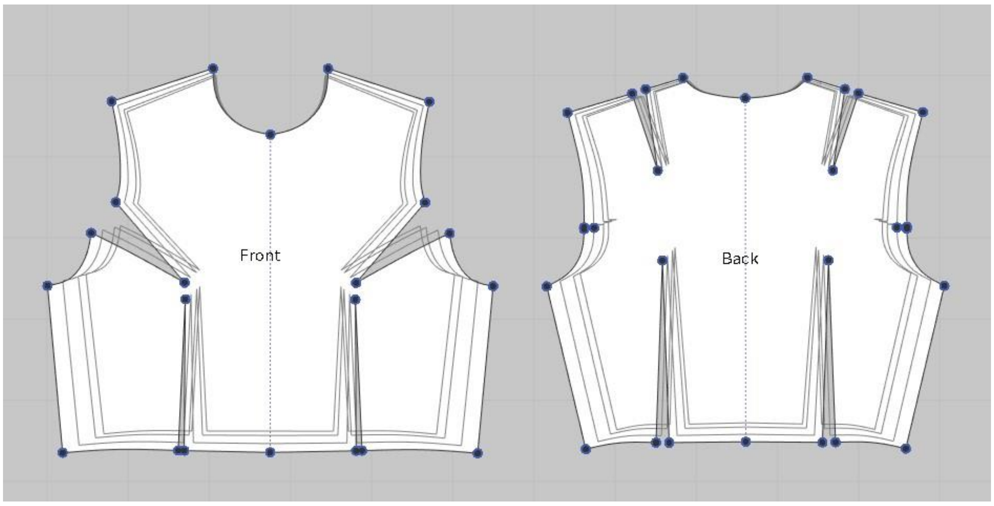
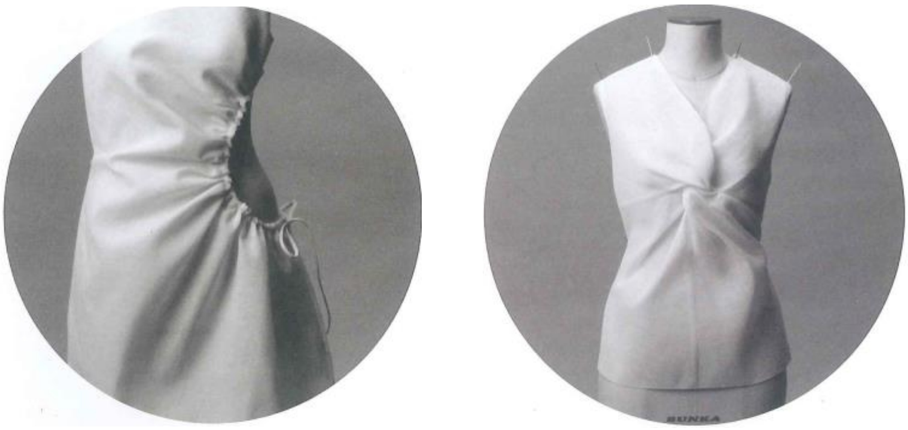


Fig. 2. grading the woman basic bodice block pattern with the auto-grading tool.

2.1.4 Evaluating the graded patterns fit on the 3D parametric virtual mannequin using the fit maps of the CLO 3D program.

2.1.5 Selecting two women styles (from the Pattern Magic book); styles that require complex steps in preparing their patterns. These styles are (Dress with gathered hole, page 30) and (Simple draped design, pages 62, 63).



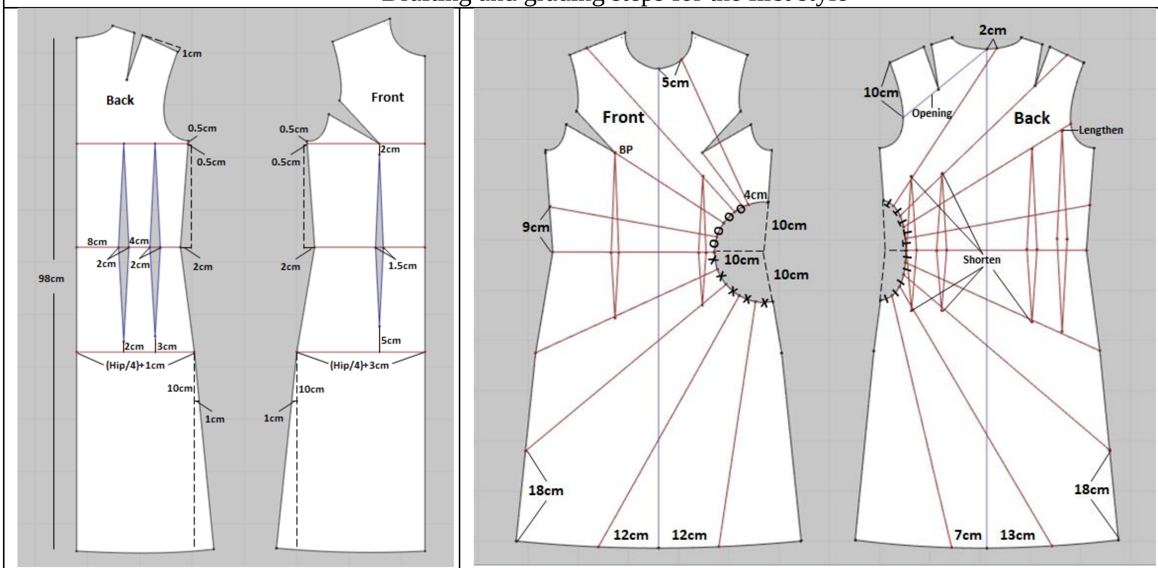
The first style: Dress with gathered hole. The second style: Simple draped design.

Fig. 3. the selected women's styles

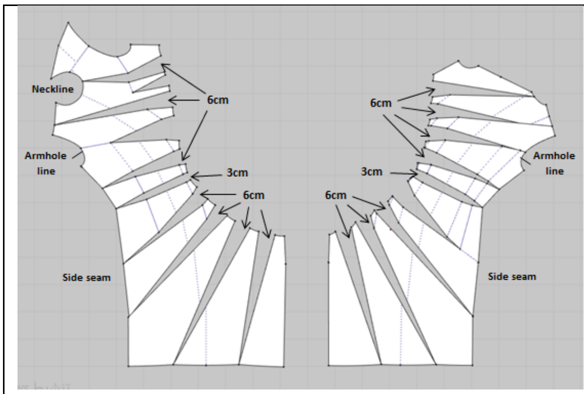
2.1.6 Drafting the two selected styles using the CLO 3D program.

2.1.7 Importing the pre-sized prepared mannequins from the program library and applying auto-grading to the two selected styles.

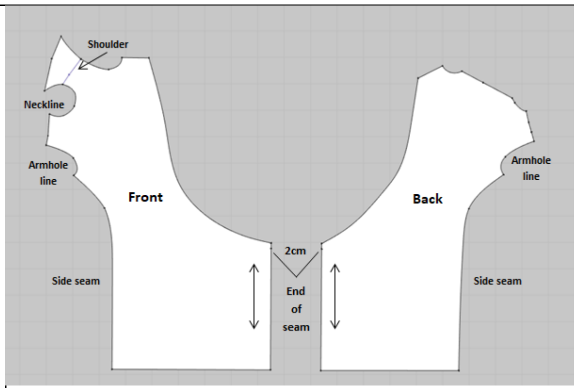
Drafting and grading steps for the first style



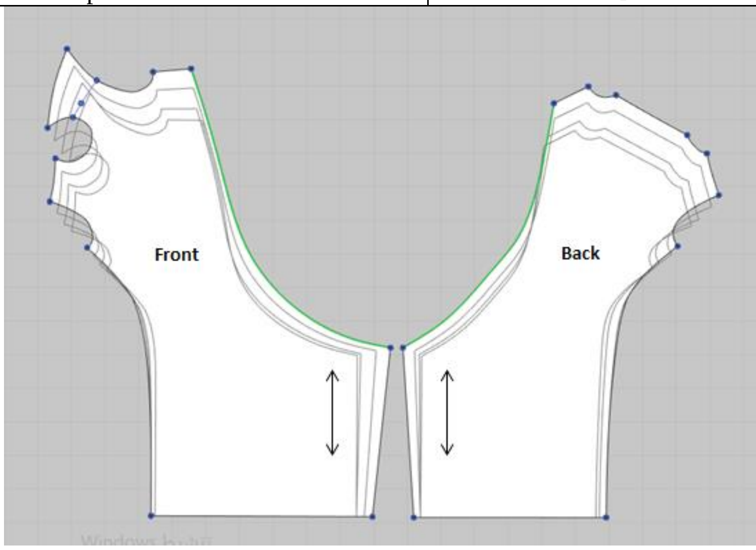
Step 1 Step 2



Step 3



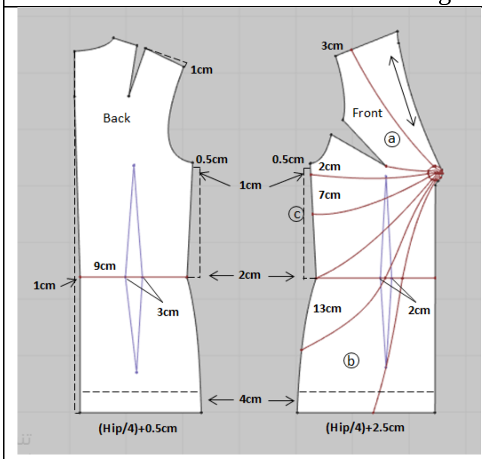
The drafted pattern (the first style)



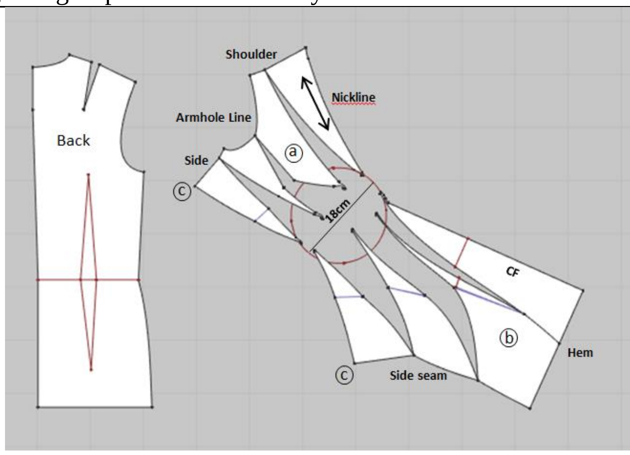
The graded pattern (the first style)

Fig. 4. drafting and grading steps for the first style

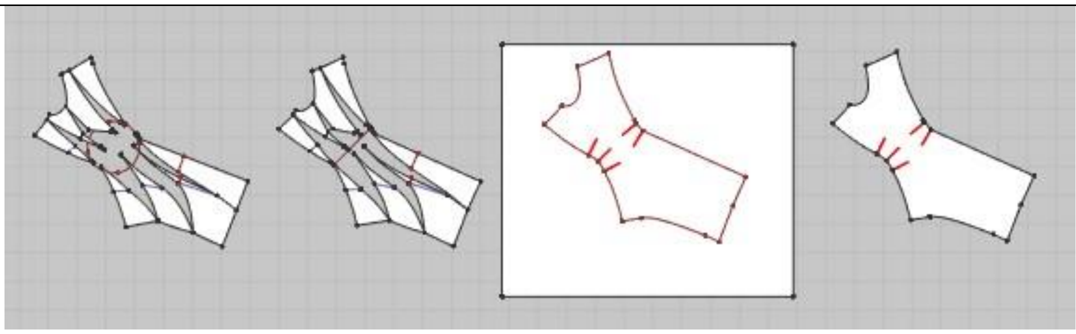
Drafting and grading steps for the second style



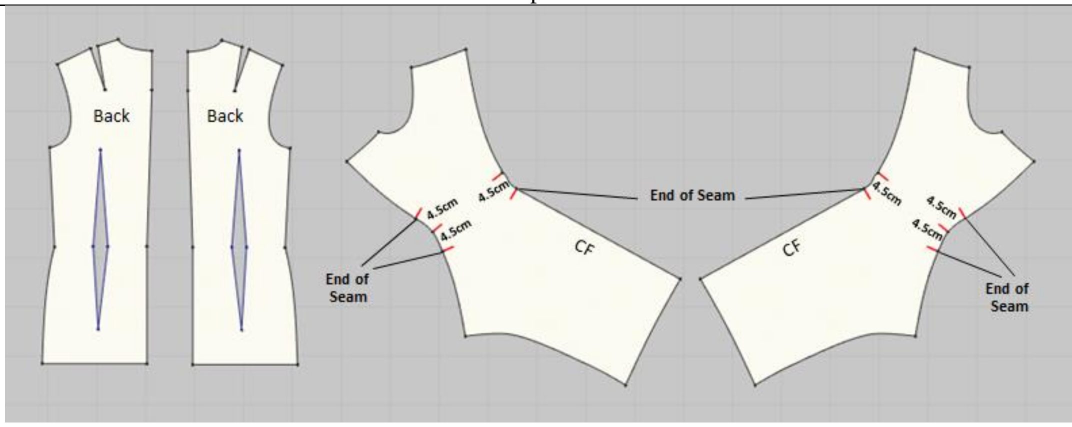
Step 1



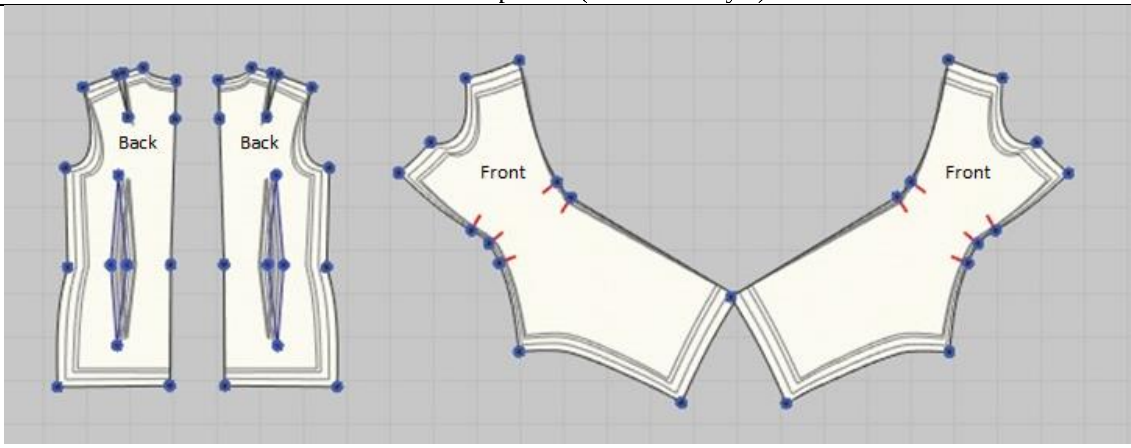
Step 2



Step 3



The drafted pattern (the second style)



The graded pattern (the second style)

Fig. 5. drafting and grading steps for the second style

2.1.8 Evaluating the graded patterns fit for every style on the 3D parametric virtual mannequin using the fit maps of the CLO 3D program. The simulation was performed using silk fabric (Silk Duchess Satin with 0.17 mm thickness).

2.2 The virtual fit Evaluation with CLO3D:

By using CLO3D we can have a judgment on the finished clothes through fit maps:

2.2.1 The stress map:

The clothing itself applies pressure (stress). The pressure distribution can indicate the stress levels of the clothing when worn on the model. The Stress Map measures it as a force per unit area in Pascal (Pa) / Kilopascal (kPa). It indicates the maximum stress a material can endure is represented as a pressure unit when the fabric begins to tear when stretched; consequently, any area exceeding the permissible stress ultimately ruptures. The Stress Map is displayed in eight colors. Blue indicates zero stress (0.00 kPa), while red denotes the highest stress level (100 kPa). Intermediate values are illustrated through a gradient of colors. Simply, the stress map reveals the pressure levels on the fabric for each section caused by a close-fitting garment [23] [24].

2.2.2 Strain map

The external stress leads to the distortion of a garment, resulting in its stretching. The strain map measures this stretching to its capacity. While the strain map and pressure map may appear similar at first glance, they serve different purposes; the pressure map illustrates the garment's pressure on the virtual model, whereas the strain map reveals the level of tension caused by that pressure. The strain map appears in eight colors. Blue signifies a 100% distortion rate (indicating no distortion), and red represents a 120% distortion rate, indicating that the clothing pressure on the human body is more than the human body can bear. Intermediate values are represented through a gradient of colors. In essence, the strain map illustrates the degree to which a garment is stretched when worn [23] [24].

2.2.3 The fit map:

The fit map evaluates the suitability of the virtual model for wearing the dress. Each fabric has a defined maximum distortion, which is influenced by its stretch, shear, and stiffness properties. The Fit Map value represents the percentage of fabric stretch in relation to this maximum distortion: 100% indicates the fabric has reached its maximum stretch, while 0% signifies no stretch. A red indicator (Cannot Wear) signifies a stretch exceeding 100%, yellow (Tight) indicates a stretch above 80%, and white denotes a stretch below 80% of the maximum distortion ratio. In the yellow zone, adjustments can be made based on the desired fit of the garment. However, adjustments are necessary in the red zone of the actual clothing; otherwise, it cannot be worn normally [23] [24].

3-Results and Discussion

3.1 Analysis of the women's basic bodice block grading results:

It is noted from the stress distribution maps in Figures (6) and (7) that when grading the women's basic bodice block from size XS to the three sizes (S, M, and L), the stress levels on the fabric in some areas, such as the neck, shoulder, chest, and armscye, appear in blue color. This is an acceptable stress level, not exceeding 14.29 kilopascals, which does not cause any distortion or tearing for the fabric.

The strain maps in Figures (6) and (7) show that the blue color is distributed in the neck, shoulder, chest, and armscye areas for the four sizes; the blue color appears in the side area in size L. The blue color indicates that the stretching of the fabric due to body pressure is such that it does not distort the shape of the garment. The yellow color appears very slightly around the neck in sizes XS and S, then increases slightly in size in M. Then, the yellow color appears, with a slight orange color in size L. This indicates that as the graded size increases, slight stretching occurs in the fabric around the neck area, which may require widening the neck hole as the graded size up.

The fit maps in Figures (6) and (7) for the original size and the three graded sizes also show the garment's fit to the virtual body. Neither yellow nor red appears in any of the sizes for both the front and back, and all appear white, confirming the garment's fit to the body.

Thus, it is clear from the above that the auto-grading tool in the CLO 3D program exhibited a perfect fit for the women's basic bodice block for all sizes.

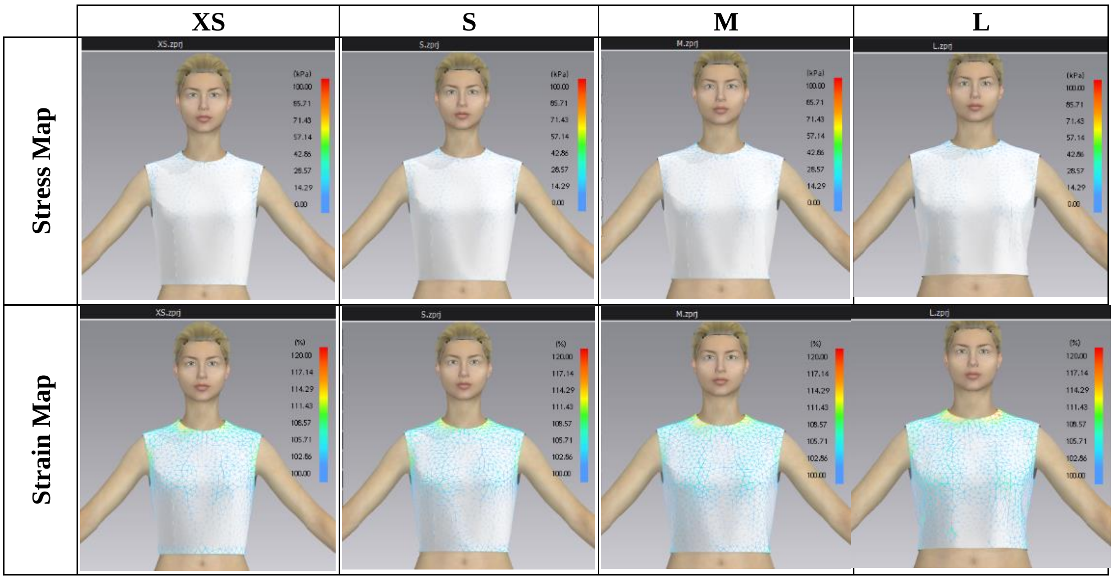


Fig. 6. the front view of the graded patterns for women's bodice block pattern

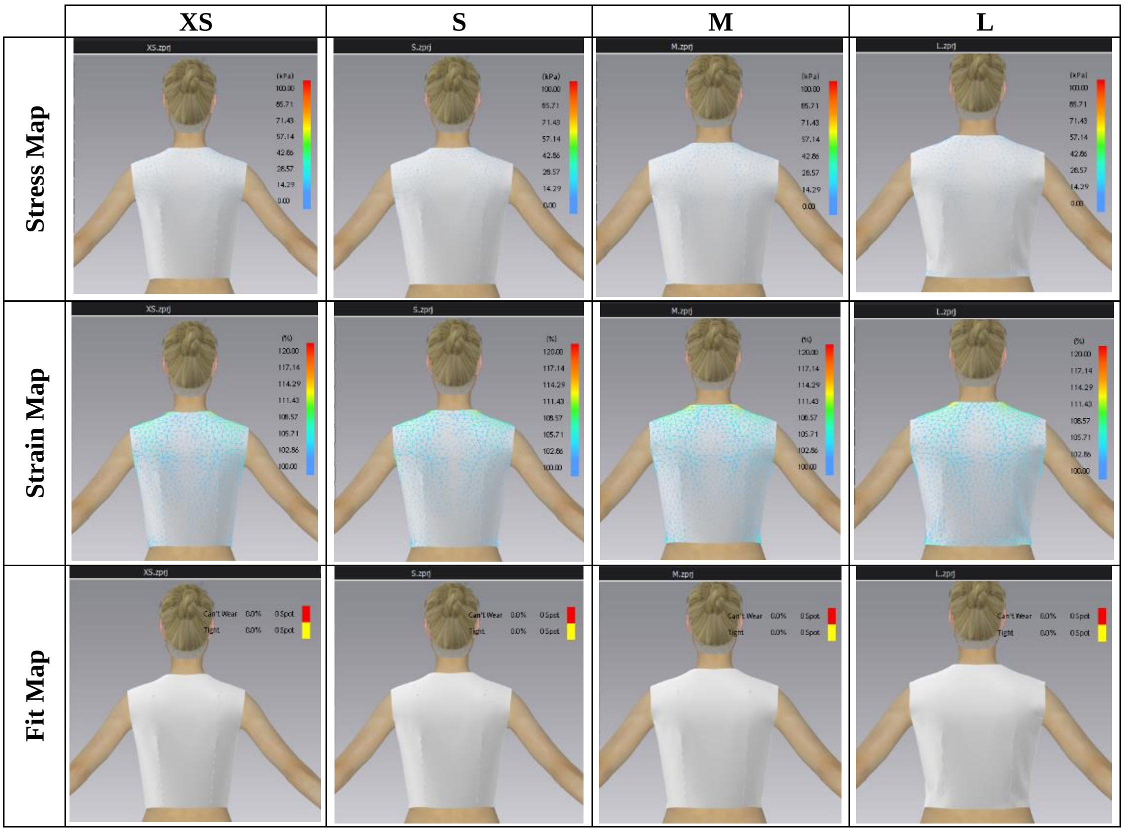


Fig. 7. the back view of the graded patterns for women's bodice block pattern

3.2 Analysis of the first style grading results:

The stress distribution maps in Figures (8) and (9) indicate that when grading the first style from size XS to the three sizes (S, M, and L), the stress levels on the fabric in some areas, such as the neck, shoulder, chest, armscye, and around the hole, appear blue. This is an acceptable stress level, not exceeding 14.29 kPa, which does not cause any distortion or tearing to the fabric.

The strain maps in Figures (8) and (9) demonstrate that blue is predominantly present in most areas of the garment for all four sizes, both front and back. The blue color indicates that the percentage of expansion in the fabric due to body pressure does not cause distortion in the garment's shape. A small amount of yellow and red is present on the edges of the neck, armscye, and the hole area, as well as in the surrounding gathers on both the front and back. The yellow color indicates slight expansion of the fabric, especially in the hole area, due to the presence of gathers around it. However, this expansion does not cause distortion because it is minimal. Similarly, the red color indicates an increased degree of distortion in the fabric. The presence of red is minimal and does not result in any adverse effects. The appearance of red in the hole area may be attributed to the gathers that tighten the garment in this region. The amount of yellow and red also increases slightly with size up. They also increase in the front compared to the back. This may be due to the presence of natural protrusions in the body at the front, such as the protruding chest and abdomen.

The fit maps in Figures (8) and (9) for the original size and the three graded sizes also show the garment's fit to the virtual body. Neither yellow nor red appeared in any of the graded sizes for both the front and back. All appeared white, confirming that the garment fits the body and requires no alterations.

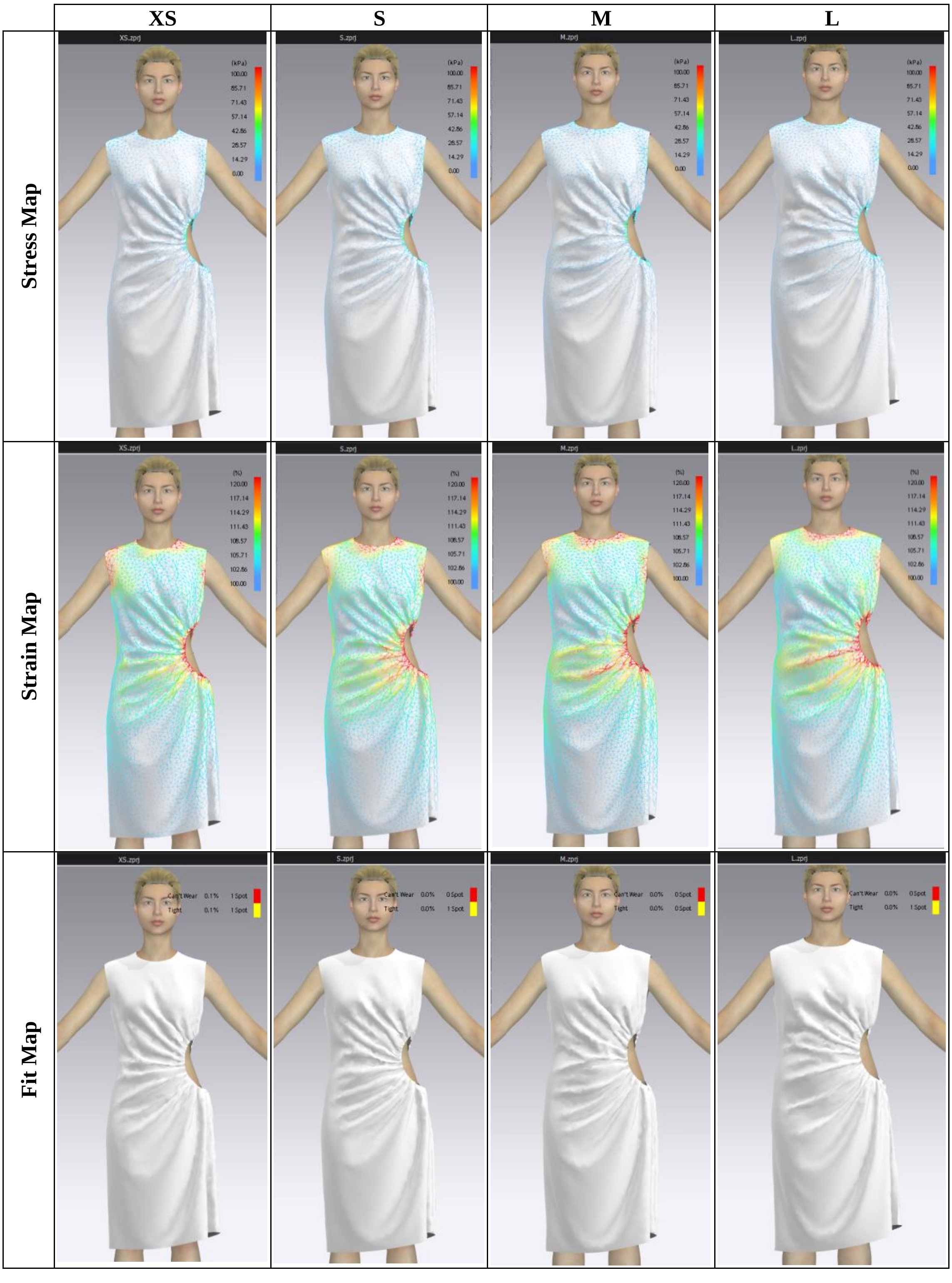


Fig. 8. the front view of the graded patterns for the first style pattern

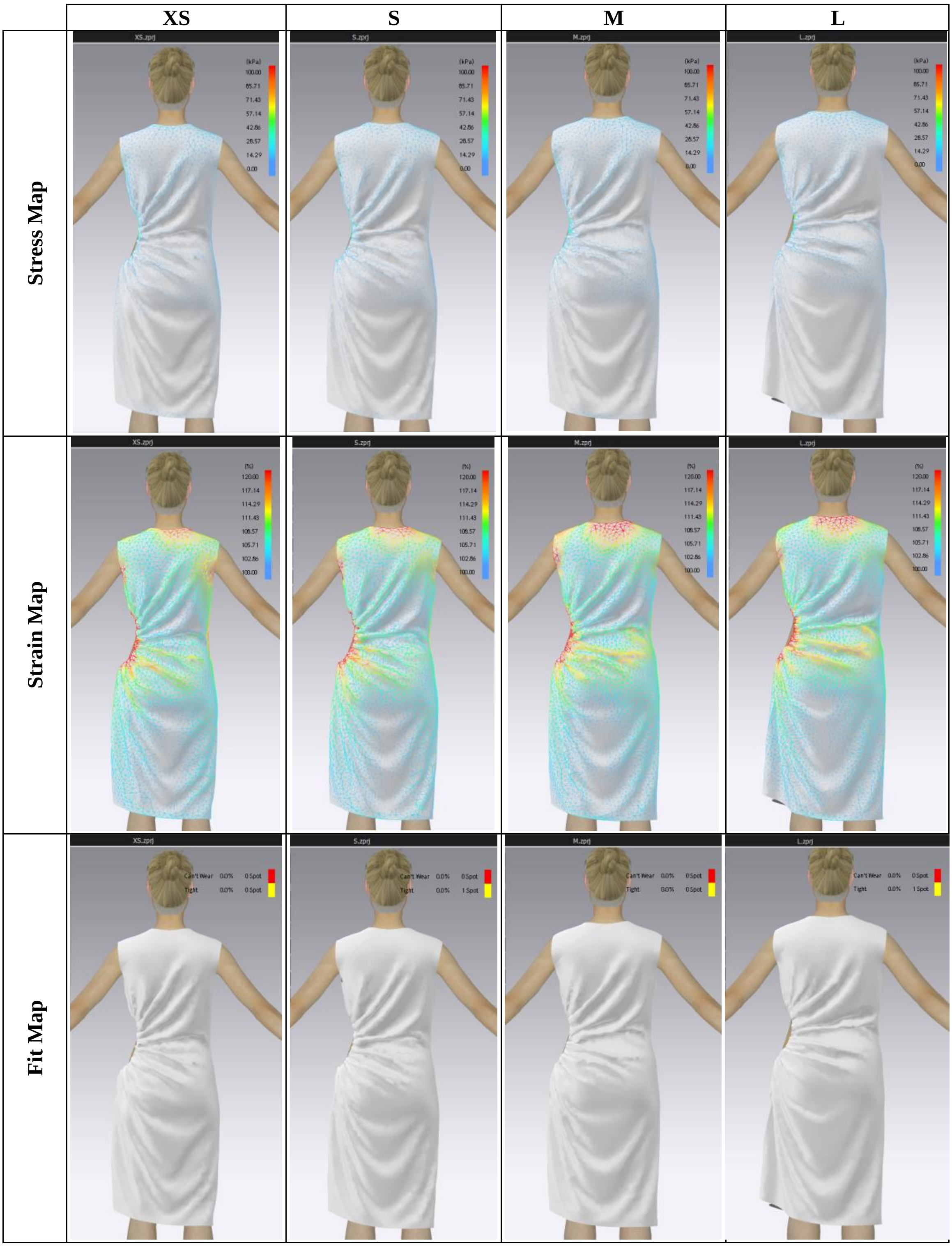


Fig. 9. the back view of the graded patterns for the first style pattern

3.3 Analysis of the second style grading results:

The stress distribution maps in Figures (10) and (11) indicate that when grading the second style from size XS to the three sizes (S, M, and L), blue stress levels are observed on the fabric in specific regions, including the neck, shoulder, armscye, and knot area. This is an acceptable stress level, not exceeding 14.29 kPa, which does not cause any distortion or tearing to the fabric.

The strain maps in Figures (10) and (11) indicate that the blue color is prevalent across the majority of the garment for all four sizes, on both the front and back. The blue color indicates that the percentage of stretching in the fabric due to body pressure does not cause distortion in the garment's shape. A small amount of yellow and red is visible in the neck hole, under the armscye, and around the knot. The presence of yellow suggests slight stretching of the fabric, particularly in the knot area, which is surrounded by drapes. However, this stretching does not cause distortion because it is minimal. Similarly, the appearance of red indicates an increase in the percentage of distortion in the fabric. However, it is noticeable that its presence in the garment is very small, not causing any adverse effects. The appearance of red in the knot area may be due to the existence of drapes in this area, which causes tension in the garment.

The fit maps in Figures (10) and (11) for the original size and the three graded sizes also show the garment's fit to the virtual body. Neither yellow nor red appeared in any of the graded sizes for both the front and back. All appeared white, confirming the garment's fit to the body and requiring no alterations.

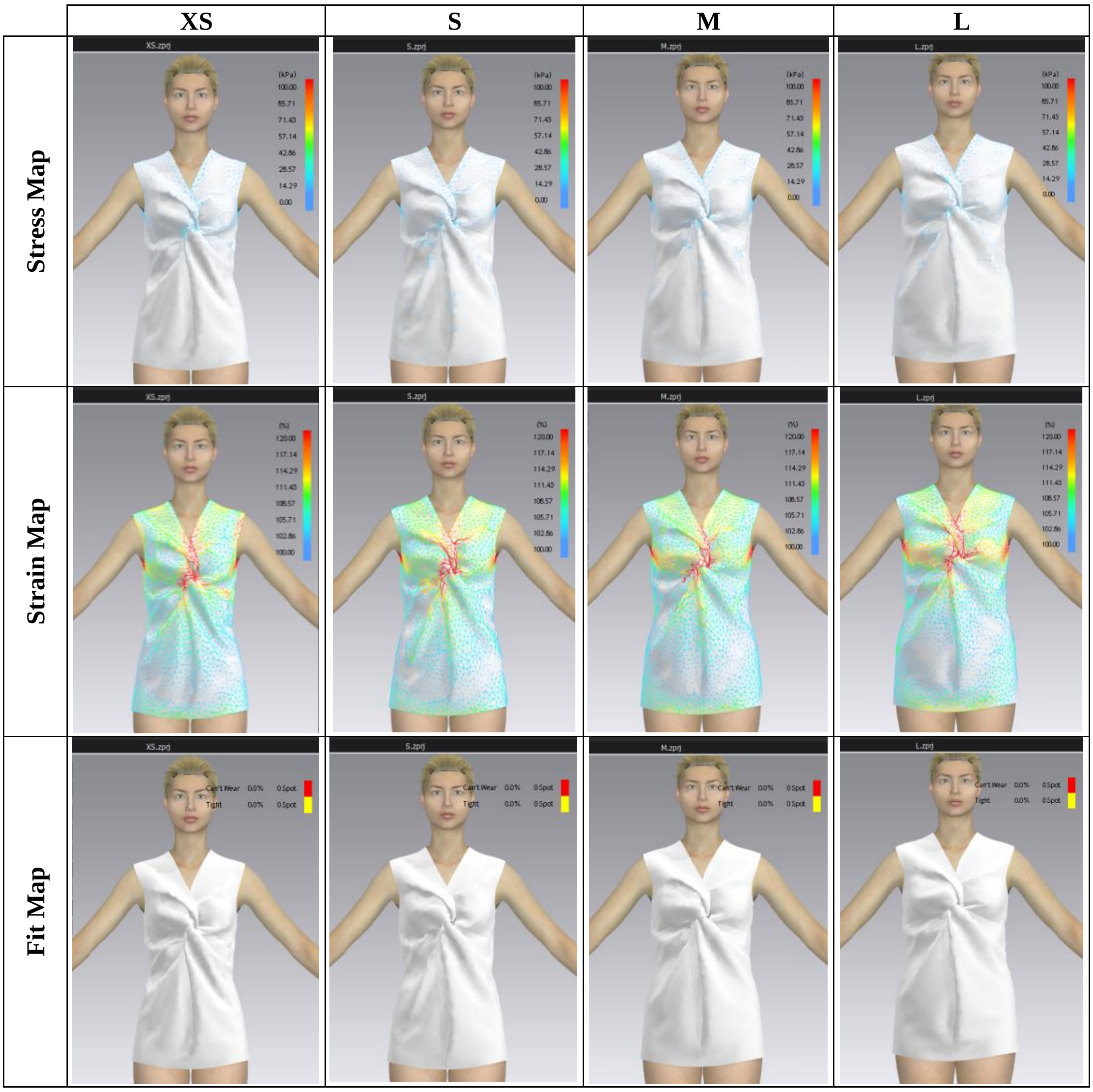


Fig. 10. the front view of the graded patterns for the second style pattern

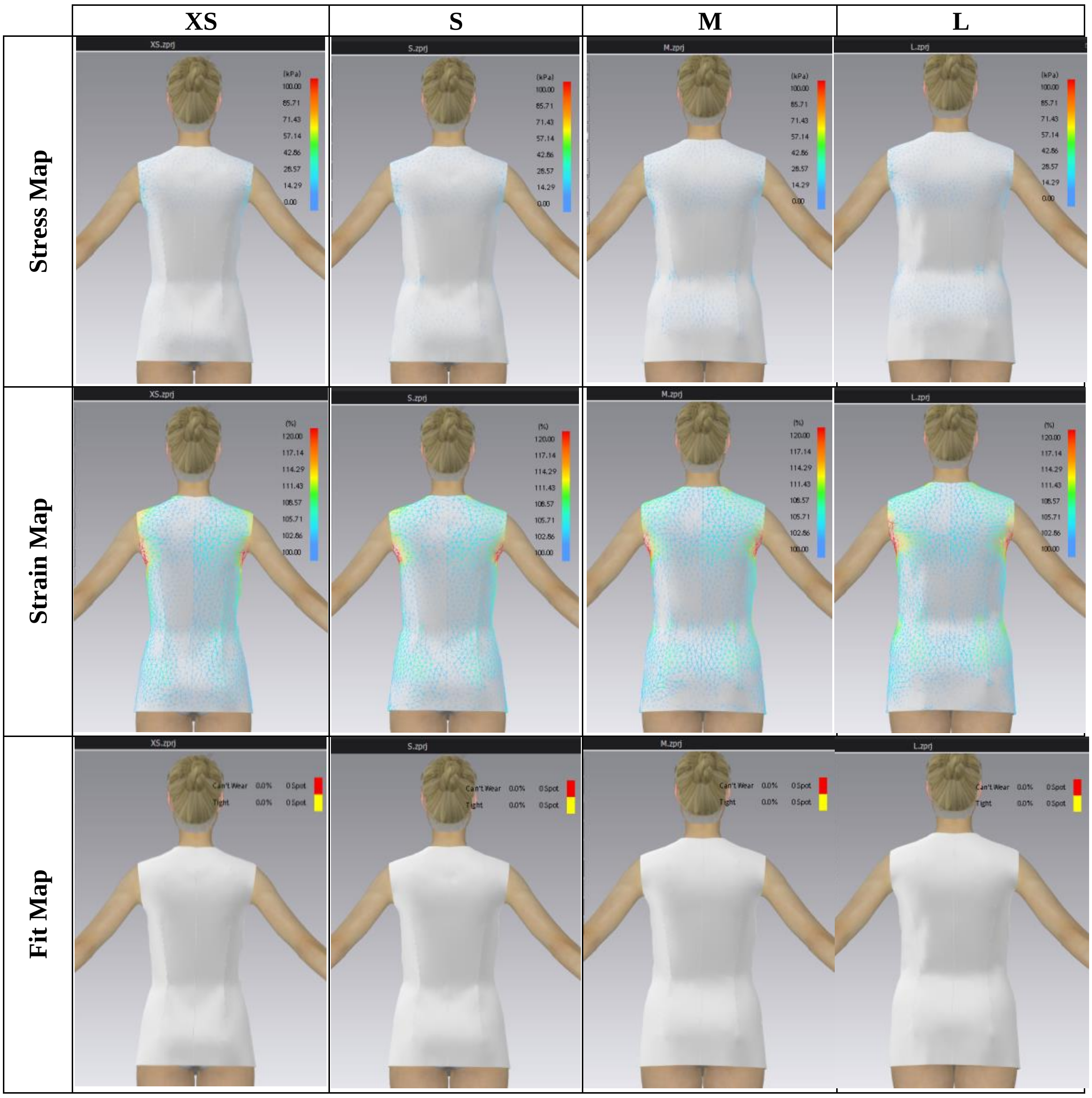


Fig. 11. the back view of the graded patterns for the second style pattern

Accordingly, the previous study demonstrates that the auto-grading tool in the CLO 3D program has proven highly effective in grading complex styles that require careful preparation and grading using traditional methods. It enables these complex styles to be graded automatically in a few simple steps, attaining precise and body-fitted results.

4- Conclusion

Grading is an essential responsibility for pattern makers, which entails adjusting the original pattern based on body measurements to create various sizes for clothing production. The evolution of computer grading systems has been remarkable; CLO 3D exemplifies this with its unique grading capabilities. The auto-grading method produces new patterns in multiple sizes from existing ones.

This study investigates the auto-grading capabilities of CLO 3D in grading complex patterns, ensuring fit and conformity to the body across the different graded sizes. Additionally, it evaluates the fit of the graded patterns for each style on the 3D virtual mannequin, utilizing the fit maps provided by the CLO 3D program. The judgment on the finished graded patterns in the CLO 3D program was through stress maps, strain maps, and fit maps.

The auto-grading technique will provide useful solutions to many pattern grading problems in garment factories, especially for patterns that require significant effort to prepare, allowing designers to focus more on creativity while relying on technology. Furthermore, evaluating garment fit through virtual simulation and fit maps in the CLO 3D program reduces the time and number of prototypes required to create suitable garments. All of this will lead to the advancement and development of the garment industry.

This study reveals that the auto-grading tool integrated into the CLO 3D program has been exceptionally effective in grading complex patterns that demand careful preparation and grading via traditional methods. It allows automatic grading of these complex styles in a few simple steps, resulting in precise and tailored results.

5- Conflicts of interest

"There are no conflicts between authors".

6- Formatting of funding sources

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فاعلية أداة التدريج التلقائى ببرنامج CLO 3D فى تحقيق ضبط الملابس النسائية ذات النماذج المعقدة.

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الملخص

يُعد التدريج عملية بالغة الأهمية لصانعى النماذج، إذ يتضمن تكبير أو تصغير النموذج الأصلي وفقًا لقياسات الجسم لإنتاج المقاسات المطلوبة لصناعة الملابس. وقد تطورت أنظمة التدريج الحاسوبية تطورًا ملحوظًا؛ ويُعدّ نظام CLO 3D أحد هذه الأنظمة التي توفر مزايا فريدة للتدريج، تشمل التدريج التلقائى والتدريج بالإدخال الرقمى، مما يُحسّن الكفاءة والإنتاجية الصناعية. تُنتج تقنية التدريج التلقائي نماذج جديدة بمقاسات مختلفة عن النماذج الموجودة فعلياً، مما يُقلل الأخطاء ويُجنّب الحاجة إلى التدريج اليدوى. تُوظّف هذه الدراسة مزايا التدريج التلقائى ببرنامج CLO 3D فى تدريج النماذج المعقدة، بالإضافة إلى تحقيق الضبط والملاءمة للجسم لمختلف المقاسات المُدرجة. علاوةً على ذلك، يتم تقييم ضبط النماذج المُدرجة لكل موديل على المانيكان الافتراضى ثلاثى الأبعاد باستخدام خرائط الضبط التى يوفرها برنامج CLO 3D. تم رسم نموذج الكورساج الحريمى الأساسى وتدريجه باستخدام أداة التدريج التلقائى CLO 3D، كما تم تقييم ضبط النماذج المدرجة منه باستخدام خرائط الضبط ببرنامج CLO 3D على المانيكان الافتراضى ثلاثى الأبعاد. ومن ثم تم اختيار موديلين يتطلبا صعوبة فى إعداد النماذج الخاصة بهما حيث تم رسمهما باستخدام برنامج CLO 3D بمقاس XS، كما تم تطبيق تقنية التدريج التلقائى على نماذج الموديلين بمقاسات (S-M-L). تم إجراء تقييم لضبط هذه النماذج المدرجة باستخدام خرائط الضبط على المانيكان الافتراضى ثلاثى الأبعاد. تشير النتائج إلى أن أداة التدريج التلقائى ببرنامج CLO 3D أثبتت فعاليتها المرتفعة فى تدريج النماذج المعقدة، حيث تُسهّل هذه الأداة عملية التدريج مع تحقيق نتائج دقيقة ومضبوطة على الجسم الافتراضى مما يؤدى إلى تقليل الوقت والجهد اللازم لإنتاج العينات الأولية وبالتالى النهوض بصناعة الملابس.

الكلمات المفتاحية: برنامج CLO 3D، التدريج التلقائى، ضبط ملابس النساء، الضبط الافتراضى، ضبط النماذج.