Integrating Artificial Intelligence to Automate Pattern Making for Personalized Garment Design

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***Abstract*—This paper introduces an innovative AI-assisted pattern construction tool that leverages machine learning models to revolutionize pattern generation in garment design. The proposed system automatically generates patterns from 3D body scans, which are converted into 3D shell meshes and subsequently flattened into 2D patterns using advanced data augmentation techniques and CAD flattening algorithms. This approach eliminates the need for expertise in traditional pattern-making, enabling seamless transformation of 3D models into realistic garment patterns. The tool accommodates various garment styles, including fitted, standard fit, and relaxed fit, while also enabling high levels of personalization by adapting patterns to individual body dimensions. Through its AI-driven automation and user-friendly interface, this plug-in enhances accessibility, allowing individuals without conventional design skills to create customized apparel efficiently.**

***Keywords*—Machine learning models; pattern generation; AI-assisted pattern construction; data augmentation techniques; CAD flattening**

I. Introduction

CAD computer technologies have become an integral part of modern garment technology and the associated process of pattern making. CAD technologies have revolutionized manufacturing processes in the apparel industry, enhancing precision, efficiency, and innovation. CAD applications provide unprecedented accuracy in designing patterns through sophisticated software and precise digital measurement, whereby patterns of garments closely correspond to human body measurements and are extremely reliable [1]. Moreover, CAD software facilitates collaborative working processes across the apparel and textile supply chain. Designers, pattern makers, and manufacturers can work on digital models simultaneously, improving communication and reducing time-to-market [1]. Additionally, CAD technologies assist in green practices by minimizing the use of physical prototypes because virtual simulations allow organizations to reduce material waste and optimize production processes, thereby assisting in environmentally sustainable garment manufacturing [2].

Despite such advances, there are still some limitations to CAD-based pattern creation. Traditional CAD packages require very specialist expertise, making them inaccessible to others without professional pattern-making training. Present-day computerized tools still require manual adjustment and expert knowledge input in order to design optimized garment patterns. The majority of CAD packages also lack AI-enabled automation, limiting their ability to generate adaptive and highly personalized designs based on individual body shapes [3]. In addition, computer-aided design software is usually expensive and requires significant computational capabilities, making it difficult for individual designers and small industries to use them [3].

To alleviate these difficulties, we introduce an AI-aided pattern-making tool that does not require designers to be experts in traditional pattern-making techniques. This is a revolutionary system where users can input digital models or 3D body scans, which are then processed through an AI-driven pipeline to generate customized garment patterns [4]. The software employs machine learning models, data augmentation techniques, and CAD flattening algorithms to convert 3D shell meshes into 2D patterns automatically. Compared with traditional CAD-pattern generation methods with possible human interventions, our scheme ensures total automation, high degree of personalization, and speedy garment pattern creation [4].

Our AI pattern generator is a giant leap towards the democratization of fashion design technology, bridging the divide between traditional craftsmanship and cutting-edge AI-driven automation. By eliminating technical barriers, this platform provides greater opportunities to more people—the independent designers, fashion enthusiasts, and players in the industry—to explore new design frontiers and contribute to the direction of innovation in garment manufacturing [4].

Our approach is not flawless, however. Even though the AI model considerably reduces the need for hand-based pattern fine-tuning, drastic customizations or complex clothing designs may possibly still require professional adjustment for optimization and fine-tuning. Further, the pattern generation process depends not only on the quality but also on the accuracy of 3D body scans, therefore, low-quality or inconsistent scanning data can also influence the quality of the end patterns [4]. Upgrades in the future will center on AI adaptability enhancement, increased model precision, and widening pattern customization functionalities to better polish the system's potential.

The remainder of this paper is structured as follows: Section II presents a literature review, discussing existing CAD-based pattern generation methods, AI-assisted design tools, and their limitations. Section III outlines the methodology, detailing the proposed AI-driven approach, including data processing, machine learning models, and pattern generation techniques. Section IV covers experimentation and discussion, presenting the implementation details, evaluation metrics, and comparative analysis of results. Finally, Section V concludes the paper by summarizing key findings, highlighting contributions, and suggesting future research directions.

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II. Literature Review

A. Traditional Methods in Pattern Construction

Traditional pattern construction in garment engineering is highly craft-based, requiring a great deal of expertise and special techniques. Normally, it is based on a basic pattern that serves as a blueprint for the different types of garments to be constructed [5]. It first involves taking the precise body measurements from which the derivations of the construction parameters for drafting the pattern are obtained. These measurements are interpreted and put onto a two-dimensional pattern that then is adapted to meet the three-dimensional contours of the human body. The first pattern is altered and perfected on a model or mannequin for a correct fit and desired design effect [6]. More often than not, such refinement entails several rounds of alterations and changes until an ideal result is achieved. Traditional pattern-making techniques require great craftsmanship, experience, and technical precision to produce patterns that are to the standard of accuracy and fit required. The process is effective yet very time-consuming and heavily reliant on the skill of the individual [7].

B. Overview of Pattern Systems in Garment Construction

Over the years, a number of pattern systems have been designed, and each of them has its unique methods on garment construction. The demand of the fashion world is maximal flexibility of the selected pattern system. The selection, therefore, depends on the specific criteria, individual tastes, and available means. The best known today is the M. Müller & Sohn pattern system of Michael Müller, founded in Munich in the 19th century [8]. This system, which has gained universal international acceptance, has undergone continued development or reworking to meet present-day industry standards. It includes pattern making for women, men, and children, using a precise series of measurements taken from anatomical measurements and garment-making techniques. Similarly, the Hohenstein pattern system emphasizes the work of basic and model-specific patterns, but it focuses on final pure optical appearances, for example, garment shapes, while still using measurement series.

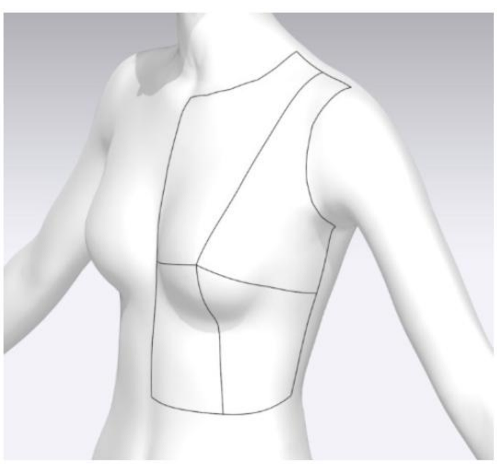


Fig. 1. Segmentation of the upper torso into regions for flattening, highlighting reference points such as the chest point, waistline, and center back and front [1].

One of the more relevant systems is the Optikon, [9] designed as part of a research project undertaken by the Niederrhein University of Applied Sciences. This is a closed-loop system and is versatile because it allows for the development of outer garments for males and females. Essential measurements of the body - chest, waist, hips, height, and type – are related and used to calculate secondary measurements by using formulae based upon the relationships identified in conventional measurement tables. These measures are used to create coordinate systems for construction where human body measures are related to other points around the flat pattern. Considering human measures, along with the unique garment requirements, these systems ensure careful and accurate garment construction with respect to the unique body measurements [10].

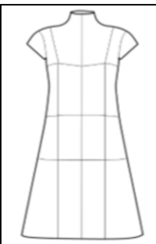
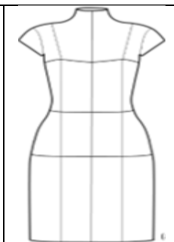
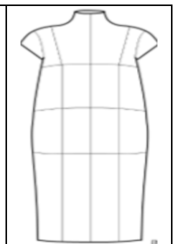
C. Flattening

Flattening is one of the important processes in the developing cycle of a garment pattern, which changes a three-dimensional garment shape to a two-dimensional pattern. This technique serves as the base of how design concepts eventually get transferred into a pattern ready for production, allowing the designer and pattern maker to create scaled and accurate designs. This uses mathematics and geometric calculation to project complex 3D shape and curved objects onto flat surfaces with minimum distortion, ensuring accuracy in garment fit and construction [11]. A very effective way to achieve flattening is dividing the upper torso into eight separate regions; the lower part is divided into two additional regions for a total of 12 regions, which can also be doubled to account for both right and left sides of the torso addition resulting in 24 regions. These regions are based on different reference points such as the chest point, waistline, and the front and back centers around which they are oriented as shown in Fig. 1. For instance, such segmentation permits the unfolding of 3D body shapes without distortion as darts will be used in the 2D pattern modeling for reshaping the garment for the human body. The procedure starts with picking critical points such as the bust, the side seams, the waist and hip heights that act as the directives in the division of the torso [12]. This technique has been found to have phenomenal accuracy in developing patterns given the difference in individual body measurements.

Flattening of surfaces is much better than traditional methods, particularly in custom or tailored pattern production. Traditional approaches often require many modification loops and highly rely on the skill and ability of the pattern maker. Inefficiency in flattening is quite the opposite, as it offers a possibly regular and predictable way of arriving at an ideal fit. Nonetheless, issues remain, including the exclusion of necessary allowances when directly employing scanned body data in the creation of patterns [13]. This exclusion restricts application to close-fit clothing with highly elastic material, as it both decreases comfort and affects garment aesthetics.

To optimize 3D models for flattening and get the best in class results in the form of garment patterns, one has to consider: the garment's silhouette — be it X, O, or A; its position or layering—for example, undergarments or outerwear; and the wanted fit or fitting—close, regular, or loose. For example, a garment with an O-silhouette will need more space at the middle than an X-silhouette garment. In a similar fashion, the garment layers determine the required ease, where undergarments require minimal easing while outer garments, illustrated by coats, need much larger adjustments (Table I). These can all be achieved through traditional pattern making methods [14]. The key body shapes used to flatten the pattern were of slim-fit X-silhouettes, used as primary, secondary, and tertiary garment layers, without taking into account structural modules. It is also very important to ensure that the displace values along the vertical axis are exactly zero, because even the slightest variation will tend to shift important measurements such as the chest, waist, and hips, resulting in poor fitting for garments. Therefore, vertical axis displace values should be set to zero. The actual body measurements and the respective ideal making measurements of the original forms used are summarized in Table II [15].

TABLE I OFFSET CLASSIFICATIONS FOR DIFFERENT GARMENT SILHOUETTES (X, O, AND A) TO DETERMINE INITIAL SPACING IN PATTERN DEVELOPMENT

			
Silhouette	A-silhouette	X-silhouette	O-silhouette
Offset knee	High	Medium	Low
Offset hip	High	Medium	Medium
Offset waist	Medium	Low	High
Offset bust	Low	Low	Medium

D. *Overview of Digital Solutions in Garment Design*

Digital garment design tools have contributed to improved capabilities and features, which have optimized the full process from conceptual designs to manufacturing. This means that such software has enhanced the efficiency, accuracy, and even creativity in the field [16]. Main digital solutions include versatile Optitex software, which can offer functions ranging from pattern making all the way to 3D visualization, sizing, and virtual fit. Designers can build 3D models of garments, so-called virtual prototypes, in a realistic manner using Optitex—a further great solution. One more remarkable solution is the combination of 2D and 3D presented by Assyst in Style3D. Assyst does precise 2D pattern drafting, and it allows for diverse design and size support, with grading [17]. On the other hand, Style3D allows designers to simulate garments in a 3D virtual environment, allowing try-ons along with material simulation and rendering. This brings out seamless coordination between the 2D and 3D processes, therefore more efficiency and accuracy.

Gerber Technology, also amongst the few, dominates the apparel industry using pattern making tools, sizing, marker creation, and production management. With its subsidiary, the Lectra Modaris features design and pattern development, refined production planning, and automated cutting, which brings streamlined manufacturing processes. Browzwear also develops software, offering their key software, VStitcher, which designs realistic 3D models for fitting and design down to the last details. Software includes GRAFIS—one of the best 2D parametric pattern software. Some other great tools in the market are CLO for 2D and 3D garment design with realistic 3D modeling, virtual try-ons, pattern making, sizing, and textile simulation, to fit the entire cycle of production [18].

While the integrated use of these digital tools has greatly enhanced garment design and craft, specialized knowledge, and required skill in pattern making, they are also restricting access for those without educational qualifications. Recognizing it all, they undoubtedly become essential in shaping accuracy, innovation, and productivity in the fashion sector.

E. *Gap Analysis in Digital Garment Technology and Pattern Development*

Digital garment technology has upfront accelerated the process of generating patterns from 3D scans and contributed to traditional ways of depending on created physical prototypes for fit analysIs. Traditional methods of pattern construction often require high expertise, while AI and automation technologies have greatly facilitated creating a particular type of pattern. AI-enabled tools can help users, even without professional experience, generate basic patterns in a short period of time. Although AI cannot fully replicate the nuanced expertise of experienced pattern makers—particularly for accommodating diverse body shapes and textile materials—it allows non-professionals to bypass complex processes and achieve satisfactory results [19].

Accessibility is another key consideration when evaluating current technologies. Traditional methods often depend on costly, specialized equipment, and most modern digital solutions require expensive licenses and high-performance PCs. On the other hand, an open-source patterning software, for example, Blender, makes broad use more accessible because it is free and compatible with commonly used hardware. Especially, Blender allows for the automation of developing custom patterns based on 3D scans [20]. The pattern design has complex tasks that can be automated with the use of algorithms and artificial intelligence, making time expenditure less and efficiency increased. Thus, users can design accurate and individual patterns, without time-consuming manual work. Hence, the key elements of this workflow are measurement programs, 2D pattern systems, and 3D simulation and visualization software. This integration makes it possible for even users with a limited level of expertise and experience to quickly and easily develop customized basic patterns for further design development [21]. The flattening operation is viewed via UV Editor within Blender; this editor contains a heatmap shader that graphically and through color demonstrates UV stretching from the blue to yellow color, marking the amount of distortion happened on the UV faces. Although this shader helps to detect stretching, still in some particularly difficult cases, that may be hard to recognize if working with 3D model editing. This is handy because the UV Editor also allows the selection of overlapping UV faces, which are visible in both the Editor and the 3D View. Blender also has the ability to preview surface normals on the model by actually coloring individual model faces appropriately, but this feature is not available for

UV normals. The texture visualization process within Blender requires users to create a new material, assign the texture to this material, and then add the material to the model. This is a key set of a procedure for the exact display of textures in the 3D viewport and final rendering. Procedures such as these demonstrate the flexibility and practicality of Blender in pattern creation and visualization, offering a comprehensive and user-friendly instrument for garment design workflows.

TABLE II OFFSET VALUES FOR BUST, WAIST, AND HIP CIRCUMFERENCES ACROSS DIFFERENT GARMENT LAYERS [15]

Measurement in cm	Body height	Chest circumference	Waist circumference	Hip circumference	Shoulder width
Size 38	168	88	72	97	12.7
Offset	0	4	4	4	0
1st layer	168	92	76	101	12.7
Offset_2	0	5	5	5	1.5
2nd layer	168	97	81	106	14.2
Offset_3	0	5	5	5	0.5
3rd layer	168	102	86	111	14.7

F. *Artificial Intelligence and Resources for Advanced Garment Design*

Artificial Intelligence has transformed the face of fashion design—from forecasting upcoming trends and providing stylistic solutions to making virtual models, devised by AI, the guiding light that carries forward the vision of a novel world of fashion. Artificial intelligence, through machine learning, is transforming the fashion industry by analyzing huge datasets comprising historical fashion trends, consumer behavior, and market patterns to predict future preferences and upcoming styles. Capability for trend prediction provides designers with important information, making it easier to adapt their products to consumer needs. AI-driven virtual prototyping tools further streamline the design process by enabling fast visualization and iteration of garments digitally even before physical production begins [22]. Additionally, styling platforms driven by artificial intelligence tools can be able to make suggestions considering personal preferences and body types.

The sustainability of the fashion industry has increasingly been emphasized through the integration of artificial intelligence. These AI-powered systems improve sustainability in the fashion industry by refining supply chain processes and improving demand forecasting while reducing material waste. Such technologies enable the use of ecologically friendly techniques and materials for the good of the environment. Artificial intelligence thus not only enhances operations and fosters creativity but also leads to sustainability by advancing the processes of design and production. The geometric models of clothes come from a collection of the UC Berkeley Computer Graphics Research Group known as the Berkeley Garment Library. Exactly such garment models fitted for simulating cloth behavior are very important training data for our system. Either. We further enriched this dataset with the SewFactory one, comprising approximately one million annotated images and sewing patterns, and with the “Dataset of 3D Garments with Sewing Patterns” that comprises 23,500 three-dimensional models split into 12 various garment categories. These were a significant contribution to the training and model validation. A garment creation common add-on used in this study is the Garment Tool 2.0 developed inside Blender to speed up the process in garment creation. This led to enabling the realism in the simulation of textiles, designs, and sewing technologies available within Blender by attracting the physics engines for fine-quality cloth dynamics. The various UV-mapping tools and texture visualization possibilities for clothing design within Blender supported the creation and evaluation in a virtual environment. In combination, such tools and resources allowed for an effective and precise garment model, moving further to enable future development in fashion design.

III. METHODOLOGY

A. *Conceptual Framework and Objectives of the Custom Blender Tool*

One of the core parts of this technological setup of the project is a specially designed Blender tool through which theoretical methodologies are linked to practical applications in the construction of garments. The tool's functionality basically is observed in Blender's support of 3D-scanned avatars and the prospect of making automated, smooth processes in the transformation of raw scan data into useful forms. The tool interface provides user-friendly options for the selection of various garment types, the setting of fit preferences between loose-regular-tight, and the customization of additional parameters. These settings are seamlessly transferred to the level of the 3D body model, so that users can appropriately customize garment designs without the need for intensive technical background.

The process starts from choosing the type of garment, for which the tool insults a gratuitous pre-stored database of template garments. Each template includes traditional structural components: seamlines, cutlines, and construction specifications of each individual garment type chosen. For each specific garment type selected, the fit preferences are set. Loose, regular, or tight adjustments are controlled through artificial intelligence algorithms which make proper changes to the templates [23]. For instance, the closer the fit, the more number of darts needed for the kind of shaping in the garment silhouette; a looser fit would lessen the number of darts and gathers in order to create a causal silhouette. The script can also aid in the planning of specific pattern details suitable for the 3D body model. Seamlines are drafted from garment templates and are manipulated based on body measurements and fit for equilibrium between structural integrity and aesthetic properties. Darts are placed in strategic areas where shaping is required, such as bust darts in any garment drafted with the need for shaping around the chest. Gathers are added in areas where added volume is required, such as the waist in some kinds of skirts. Tailored features are added according to the end user's desire and placed according to traditional methods of garment construction. The incorporation of body surface analysis in this tool makes it easier for one to create an Ideal Construction Body (ICB), or a three-dimensional body model that is meant to achieve a better fit. The tool makes it easier to perform the complex procedures of 3D scanning and garment fitting using advanced algorithms in Blender's powerful modeling environment. This helps improve the efficiency and accuracy of garment design, through digital means, while still enabling a user to explore creative opportunities without requiring further knowledge in constructing real garments.

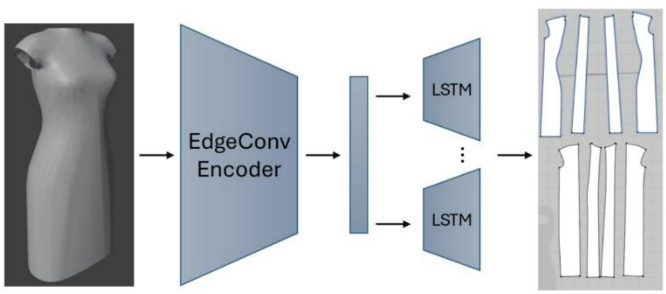


Fig. 2. AI-driven garment generation network: from 3D model and clothing type parameters to flattened sewing patterns using EdgeConv-encoder and LSTM-decoders.

B. AI-Driven Framework for Automated Garment Pattern Generation

One of the primary objectives of the project is the inclusion of a custom Blender script combined with a pre-trained neural network dedicated to the generation of garment patterns. The combination allows for the direct generation and alteration of garment patterns directly in the Blender environment, hence streamlining the design-to-pattern process (Fig. 2). The neural network is based on NeuralTailor [13], which is adapted to transform the ideal 3D body surface model into precise, ready-to-sew sewing patterns. The AI-based garment generation network operates as follows: It starts with input processing, wherein the network is given 3D body scans and offset values are applied to build an Ideal Construction Body (ICB) model. ICB is a precise model of the subject's body topography, which forms the basis for creating personalized apparel. The backbone of the network is an EdgeConv-based encoder, which leverages convolutional neural networks designed to learn geometric structures well. The encoder accepts the 3D model and obtains the main features that are essential for fitting garments. A skip connection is established from the input to the deepest EdgeConv layer to retain fine-grained information by conveying information through deeper layers of the network.

After feature extraction, a Long Short-Term Memory (LSTM) network transforms the garment's latent code. The LSTM is well suited to handle sequential data and stores the temporal dependencies among garment panels in the latent vectors. The process ensures that the final garment design is structurally sound and coherent when formed. The LSTM's latent vectors are individual garment panels. The final step involves a Panel Decoder to restore the complex form and stitching details for every garment panel. The decoder translates the abstract latent codes into practical sewing patterns, which determine panel sizes, layouts, and stitching recommendations. The task is highly significant to ensure the created patterns are correct and feasible to sew. This computer-based system allows for smooth transition from 3D body scanning to precise sewing patterns, a revolution in automated, made-to-measure clothing manufacturing [24].

C. Features and Functionality

The tool developed converts the raw 3D scans to ICBs and creates 2D garment patterns with least distortion automatically. The first step of the process is to convert 3D scans into 3D ICBs, which are specific to the measurement of an individual and may vary in shape and proportion. Advanced AI algorithms ensure these ICBs are correct representations of anatomical details, while offset values referenced from Table II have been applied at critical points such as the bust, waist, and hips to account for different layers of garments. This step ensures that the constructions are both precise and anatomically correct for a wide range of garment designs. The unwrapping automatically produces a 2D pattern of the 3D mesh once the ICB is produced. It minimizes distortions to yield flat, ready-to-use patterns that can be used as the basis of garment assembly. The complex workflow is simple in this tool through the user-friendly interface, enabling users to easily customize their garment styles and sizes. Modifications to fit preferences, such as close-fitting, regular, or loose-fitting designs, become so easy for users according to their needs and liking. Because it is highly customizable, the tool actually enables users to create garments that reflect their vision. The tool works out the most advanced technologies, streamlining the pattern-making process while giving users increased creative freedom. From 3D scan processing to very detailed 2D pattern creation and enabling customizable style variations, this innovative tool offers a perfect combination of precision, efficiency, and accessibility in garment construction.

D. Workflow for Enhanced Garment Fitting Using 3D Scanning and AI

It describes in detail a systematic workflow that attempts to enhance fitting garments with developments in 3D scanning and machine learning algorithms. The heart of the matter in this method lies in the question of how design in clothes may be adjusted regarding singular contours of the human body to make comfort complement elegance. It involves steps ranging from person-scanning to virtually assessing comprehensive fit. It begins with a very precise 3D scan of the person using a 3D scanner. This initial scan gives the basic data necessary to fit the garment to the person's unique body shape. After the scan, the user selects the type of garment they would like to create, and the program allows variable parameters such as the layer of fit preferred, from loose through regular to tight. This enables the garment to be tailored specifically to the wearer's preference and his or her anatomy. After configuration, the next step involves analysis of the 3D body scan to look at important areas of the surface and body measurements. These will be useful for finding the peculiar contours and measures necessary in garment design. Further from this extracted data during the workflow, a model of ICB or Ideal Construction Body will be generated. Serving as a virtual mannequin, this offers a framework adapted to ensure the intended fit's achievement.

This includes the gathering of sewing information, such as seam placement and allowances, among other necessary data for precision in pattern construction. Then the pre-trained neural network, from that data, predicts an estimate of count, form, and configuration of garment pattern pieces. By doing so, this cutting-edge machine-learning technique will thus yield an accurate construction of distortion-free patterns best fitted on the 3D model of the individual human body. The last step is 3D simulation, which checks the fitting of the garment. The integration of newly generated patterns with the scanned 3D body model enables a virtual try-on experience through simulation. This allows the detection and correction of any fit issues, ensuring that the final garment perfectly matches the specified design and comfort requirements. This smooth workflow seamlessly integrates state-of-the-art technologies to enhance efficiency and accuracy in garment creation while providing a highly personalized outcome.

IV. Experimentation and Discussion

In order to validate the performance of the developed tool, a structured approach was followed to establish its efficacy in converting 3D scans into Ideal Construction Bodies and subsequently creating custom garment patterns. The objective of this test was primarily to determine how accurate the AI-generated patterns were compared to manually created patterns. A specific program was developed for performing this test based on three key parameters: perimeter, area, and HU moments. Higher-order moments of the pixel intensity distribution yielded HU moments, statistical measures of shape and structure in digital images. The resultant metrics are capable of presenting quantitative insights into two important features of a pattern: symmetry and general congruence. The comparison of AI-generated patterns with the ground truth during the evaluation process was done by tools implemented in Python. The formula used for finding the discrepancy between the two patterns involves the differences in HU moments, as expressed in the given equation. This summarizes the differences for all seven HU moments of each pattern piece, normalizing them with respect to the ground truth. The tool will automatically assign an identifier to every pattern piece and assess it independently from any transformation, like rotation or scaling, against the others.

The process is illustrated in Fig. 3, which compares the calculated HU moments of each pattern piece. These differences are summed and normalized to provide a quantitative measure of how well the AI-generated patterns match their ground truth counterparts. Area, perimeter, and HU moments for each section of the pattern are further analyzed in the program, with detailed results presented in Table III. This indeed constitutes a very detailed analysis that brings out the consistency and precision of the generated patterns. The test proves that this tool can generate patterns that are quite accurate with a few errors when compared to manually unwrapped patterns. Moments of HU mean the perfect fitting when the value of the distance is 0.0 and a larger deviation would indicate regions which might need refinement. Results proved that wider garment layers are usually capable of giving more accuracy, hence pointing out the strength of this tool to adapt with different design needs, thus generally increasing the efficiency in garment productions.

TABLE III EVALUATION METRICS FOR BASIC PATTERNS ACROSS FIRST, SECOND, AND THIRD LAYERS

	Perimeter in %	Accuracy Area in %	Distance HU moments	Perimeter in %	Accuracy Area in %	Distance HU moments	Perimeter in %	Accuracy Area in %	Distance HU moments
1	98.9	79.1	0.6	97.2	74.5	1.03	95.1	77.7	3.21
2	99.6	119.4	67.61	96.1	74.3	1.05	99.2	88.9	1.25
3	100	113	24.27	98.8	86.5	2.66	93.4	79.6	0.4
4	98.7	86	0.57	96.9	91.2	1.16	99.9	98	0.65
5	94.5	75	0.59	91.8	80.2	0.66	97.8	97.9	0.46
6	93.7	74.8	0.59	94.4	68.8	0.55	99.6	98.3	0.68
7	100.9	105.8	1.17	99.3	84	3.15	94.5	76.7	0.8
8	101.4	106.1	1.48	97.4	75.8	5.16	98.5	95.6	0.82
Total	97.9	83.8	88	96.4	77.7	1.9	97.3	89.1	1.03

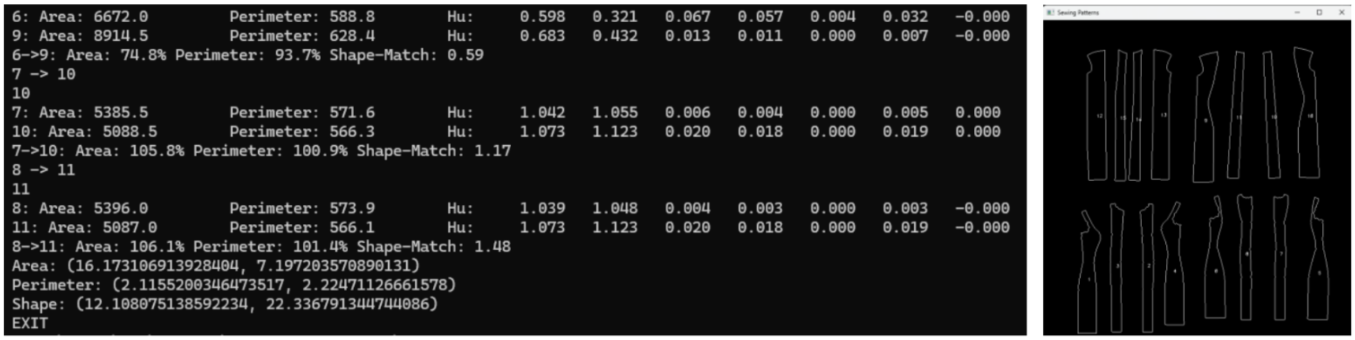


Fig. 3. Comparison of HU moment differences between AI-generated patterns and ground truth shapes.

V. Conclusion

This paper introduces meaningful changes in garment manufacturing and personalization with AI-generated patterns from 3D scans. This is quite a critical approach, as it reduces by a great deal the time spent making simple garments to fit the person's exact measure. By simplifying several steps of the process in fashion design, the tool makes it easy for novice and professional 3D artists to generate well-fitting garments for multiple layers. While AI speeds up the process of creating basic patterns for new designs, their effectiveness depends on user expertise and further physical prototyping to validate the generated patterns. This new tool bridges the gap between design and production by automatically converting 3D body scans into sewing patterns. It revolutionizes the workflow from concept to creation, making personalized basic patterns more accessible and enabling scalable bespoke garment production. However, this tool has its current implementation limitations. The system is limited to generating patterns of garment types included in the pre-trained dataset, which restricts design versatility. Besides, the manual steps of importing 3D scans may reduce the speed of the workflow and make it prone to inaccuracies. These challenges mark points that need improvement in order to further develop the capabilities and usability of the tool. Inclusiveness and accessibility make the democratization of fashion design through the integration of AI in the construction of patterns. Further developments involve increasing the functionality of the tool in constructing patterns on pants, sleeve designs, and the placement of seams according to particular needs; hence, its reach will go outside basic garments.

Another significant digital apparel breakthrough was the AI-powered tool that converts 3D scans into bespoke garment patterns. The conducted experiments demonstrate that the tool can generate patterns with precision and accuracy comparable to manually created designs. The quantitative evaluation of metrics such as perimeter, area, and HU moments substantiates the tool’s reliability and efficiency. These findings provide a solid foundation for optimizing and extending the tool’s capabilities, ensuring greater adaptability and performance in real-world applications. The results provided here are part of the ongoing digitalization of fashion and will support further developments within digital garments. The next steps in this research include the verification of the patterns through physical productions, new possibilities of design like multi-layer garments, and more intricate pattern models. This tool currently utilizes basic patterns, but it's a promising step toward a future of personalized and scalable garment design.

Future work will focus on enhancing the AI model’s adaptability, improving pattern customization for complex garment structures, and integrating real-time feedback mechanisms for better accuracy and user experience.

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