

LEVERAGING BODY SCANNERS AND AI SOFTWARE FOR ADAPTIVE CLOTHING DESIGN FOR FEMALES WITH HAND-LIMB DISABILITIES

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Abstract

This research explores integrating body scanning technology, such as Nettelo, with AI-driven design software like CLO3D to develop adaptive clothing for females with physical disabilities affecting their hand limbs. By utilizing advanced digital tools, designers can create customized, functional, and stylish garments that address the unique needs of this demographic. This paper examines the feasibility, advantages, and potential challenges of implementing these technologies in the adaptive fashion industry.

This study explores using digital tools to improve garment customization for women with hand-limb disabilities, aiming for better fit, functionality, and style. Traditional tailoring often doesn't meet their unique needs, highlighting the need for innovative approaches like AI and 3D body scanning. The research analyses fit, mobility, and aesthetics in a virtual environment by utilizing the Nettelo app to capture 3D body images and importing them into CLO3D for digital clothing simulations. Results indicate that digital prototyping reduces fabric waste, enhances garment precision, and allows for rapid modifications based on user needs. The study concludes by discussing the feasibility, advantages, and potential challenges of implementing these technologies in the adaptive fashion industry.

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Keywords: Adaptive clothing, 3D body scanning, AI-driven fashion, digital prototyping, CLO3D, Nettelo, inclusive design.

Introduction

Adaptive clothing plays a crucial role in enhancing the independence and confidence of individuals with disabilities. Traditional design methods often fail to fully accommodate the unique body structures and mobility limitations of women with hand-limb disabilities. With the advent of technology, body scanners and AI-driven software offer new opportunities for personalized, inclusive clothing design. As a guiding principle, this research embraces the philosophy that *everyone deserves to dress well*.

Aims and Objectives

The primary aim of this research is to explore the integration of AI-driven software and body scanning technologies in designing adaptive clothing for women with hand-limb disabilities. The specific objectives include:

- Evaluating the effectiveness of Nettelo and CLO3D in adaptive fashion design.
- Enhancing garment fit, comfort, and accessibility through digital prototyping.
- Reducing material waste by leveraging virtual testing and design iterations.
- Assessing the feasibility of implementing these technologies in the Indian adaptive fashion market.

Research Hypothesis

This study is based on the following hypotheses:

1. **Enhanced Fit and Comfort:** The use of 3D body scanning (Nettelo) and AI-driven garment design software (CLO3D) provides a better fit and improved comfort for females with hand-limb disabilities compared to traditional tailoring methods.
2. **Improved Accessibility and Functionality:** Adaptive clothing designed using digital tools offers increased ease of dressing, enhanced mobility, and better accessibility for individuals with physical disabilities.
3. **Sustainability and Waste Reduction:** Virtual prototyping through CLO3D reduces fabric waste and minimizes the need for multiple physical samples, making the design process more sustainable.

4. **Cost and Time Efficiency:** Digital prototyping and AI-driven simulations lower production costs and reduce design iterations, making adaptive fashion more economically viable.
5. **Feasibility in the Indian Market:** The adoption of AI-driven adaptive fashion solutions can be successfully implemented in the Indian market, despite initial technological and financial barriers.

According to the World Health Organization, **1.3 billion people live with significant disabilities, which represents 16% of the world's population or 1 in 6 individuals.** (World Health Organization, 2023). This highlights the pressing need for inclusive solutions, including adaptive clothing, to support individuals with disabilities.



Global population of persons with disabilities. Infographic from UN Disability-Inclusive Communications Guidelines (IASC Guidelines, 2019, Inclusion of Persons with Disabilities in Humanitarian Action) (The United Nations Convention on the Rights of Persons with Disabilities (CRPD) , 2019)

Adaptive clothing means: **“Clothes designed for those with physical limitations, the elderly, and people with limited mobility who may have trouble in dressing themselves is known as adaptive clothing.”** (Sharina Mahajan, 2024).

In India, the adaptive clothing sector is comparatively new. Till date, no big retail brands have entered this segment. In the year 2014, two well-known designer labels, namely Shivan and Naresh and Nidhi Munim, came up with intimate wear for women who had undergone mastectomy. However, no recent listings of these products were available. Another brand that

was mentioned in a few articles is ‘Cocoon’ by the ‘Old is Gold Store.’ However, apparels are no longer available in their store. Ekansh Trust, a Pune-based organization, launched a competition in 2019 for designing adaptive clothing. Their aim was to create a product catalog to promote adaptive clothing in India’s mainstream clothing industry, catering to senior citizens, PwDs, and individuals facing clothing challenges after surgery. Today, there are a couple of homegrown brands that are making adaptive clothing. ‘Moveability Clothing’ from Kottayam, ‘Cur8ability’ from Mumbai, and ‘Zyenika’ from Kolkata are some of the brands (Choudhury, 2024).

2. The Role of Body Scanners in Adaptive Fashion Body scanning technology, such as Nettel, captures precise 3D body measurements, which are critical for designing well-fitted adaptive clothing. The key benefits include:

- Accurate measurement of body proportions
- Identification of asymmetries and unique postures
- Customization based on real-time data
- Improved comfort and mobility

The development of the 3D whole-body scanner has made non-contact body measurement become a reality due to its capacity to capture a vast amount of information. (Mohamed Najib Salleh, Jan 29, 2018). A 3D body scanner is advantageous in that it obtains body measurements quickly and provides data on cross-sectional shapes and changes in lengths on the body surface resulting from body movement. (Cynthia L Istook Cynthia L Istook, Dec 1, 2011). These features make 3D scanning an invaluable tool in designing adaptive clothing that ensures better fit and comfort for individuals with disabilities.

CLO3D: AI-Driven Clothing Simulation and Design

CLO3D is an AI-powered software that allows designers to create and visualize garments in a 3D virtual environment. The application of CLO3D in adaptive fashion includes:

- Virtual fitting and modification
- Simulation of fabric drape and movement
- Real-time adjustments based on scanned body data

- Iterative prototyping with minimal material waste

Integration of Nettelo and CLO3D for Adaptive Clothing Design

Combining Nettelo body scanning with CLO3D can revolutionize the design process in the following ways:

- **Personalized Fit:** 3D scans ensure garments are tailored to individual body shapes.
- **Ease of Dressing:** Design features like magnetic closures, larger openings, and adjustable fasteners can be tested virtually.
- **Functional Aesthetics:** AI-driven simulations help balance style and practicality.
- **Sustainability:** Reducing physical prototyping leads to eco-friendly production.

Nettelo's Role in Generating 3D Body Images for CLO3D

Nettelo scans the body using a mobile device or a 3D scanner and converts the data into an OBJ file format. This OBJ file contains precise body measurements and surface details, making it suitable for import into CLO3D. Once in CLO3D, the scanned body model can be used as a virtual mannequin, enabling designers to:

- Fit garments to exact body proportions.
- Test different fabric behaviors on the scanned model.
- Modify patterns in real-time for better accessibility and ease of wear.
- Ensure adaptive clothing aligns with the unique physical needs of the user.

3D CAD in Adaptive Fashion Design

Another perspective method used in adaptive design is digital 3D Computer-Aided Design (CAD). In this virtual case study, digital 3D CAD was employed to create adaptive clothing prototypes with high precision. The primary advantage of this approach is its ability to generate digital models that minimize fabric waste and optimize the design process. This technique ensures that garments can be tested for fit, comfort, and accessibility before actual production, leading to a more sustainable and efficient adaptive fashion industry. (Bukhantsova, 2024)

Research Methodology

This study follows a mixed-method research approach, integrating qualitative and quantitative analysis to assess the feasibility and effectiveness of AI-driven adaptive clothing design for females with hand-limb disabilities.

1. Research Design

A virtual case study methodology was employed to design, develop, and analyze adaptive clothing using Nettelo and CLO3D. The study involves:

- **3D Body Scanning:** Using the Nettelo app to capture body measurements and create digital models.
- **Digital Clothing Design:** Utilizing CLO3D to develop and simulate adaptive garment prototypes.
- **Comparative Analysis:** Evaluating adaptive designs against traditional clothing models in terms of fit, comfort, and accessibility.

2. Data Collection Methods

- **Primary Data:**
 - Virtual prototypes developed using 3D body scanning and CLO3D.
 - Feedback from users (females with hand-limb disabilities) through virtual trials and surveys.
 - Expert opinions from designers specializing in adaptive clothing.
- **Secondary Data:**
 - Literature review of previous research on adaptive fashion.
 - Case studies of AI-driven fashion technology in accessibility design.

3. Data Analysis Techniques

- **Fit and Functionality Assessment:** Comparing adaptive designs with standard clothing models based on digital simulations and user feedback.

- **Cost-Benefit Analysis:** Evaluating the economic viability of integrating AI and body scanning technology in adaptive fashion.
- **Sustainability Analysis:** Measuring fabric waste reduction through virtual prototyping.

4. Ethical Considerations

- **Informed Consent:** Participants providing feedback on adaptive clothing designs were informed about the purpose of the study.
- **Privacy Protection:** All digital body scans were anonymized and used solely for research purposes.

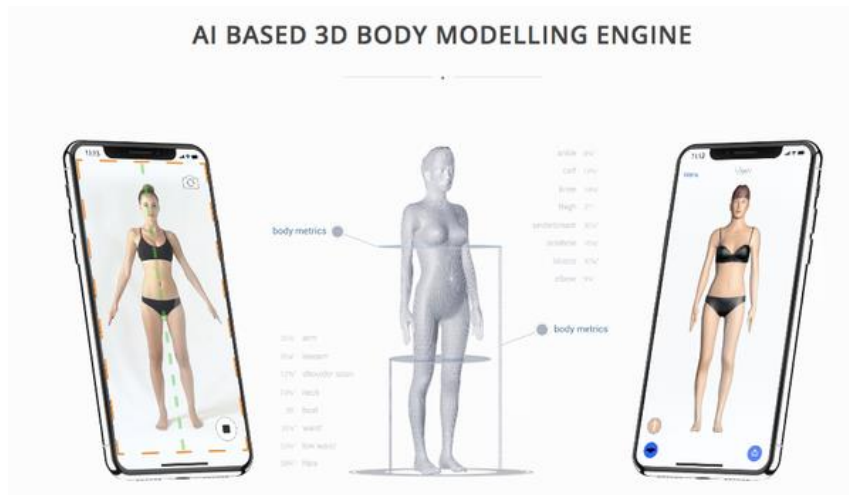
5. Limitations of the Study

- The study is limited to digital prototyping and does not include large-scale manufacturing.
- The sample size for user feedback is relatively small, requiring further studies for broader validation.

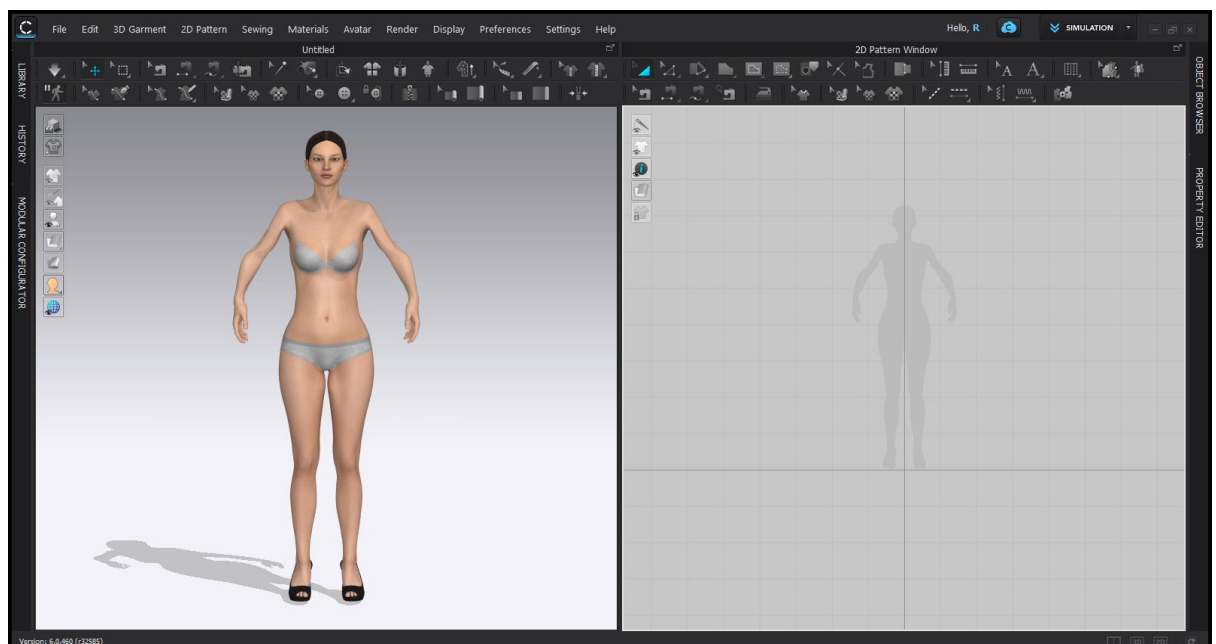
Case Study: Designing an Adaptive Dress and Comparison with a Normal Female Body

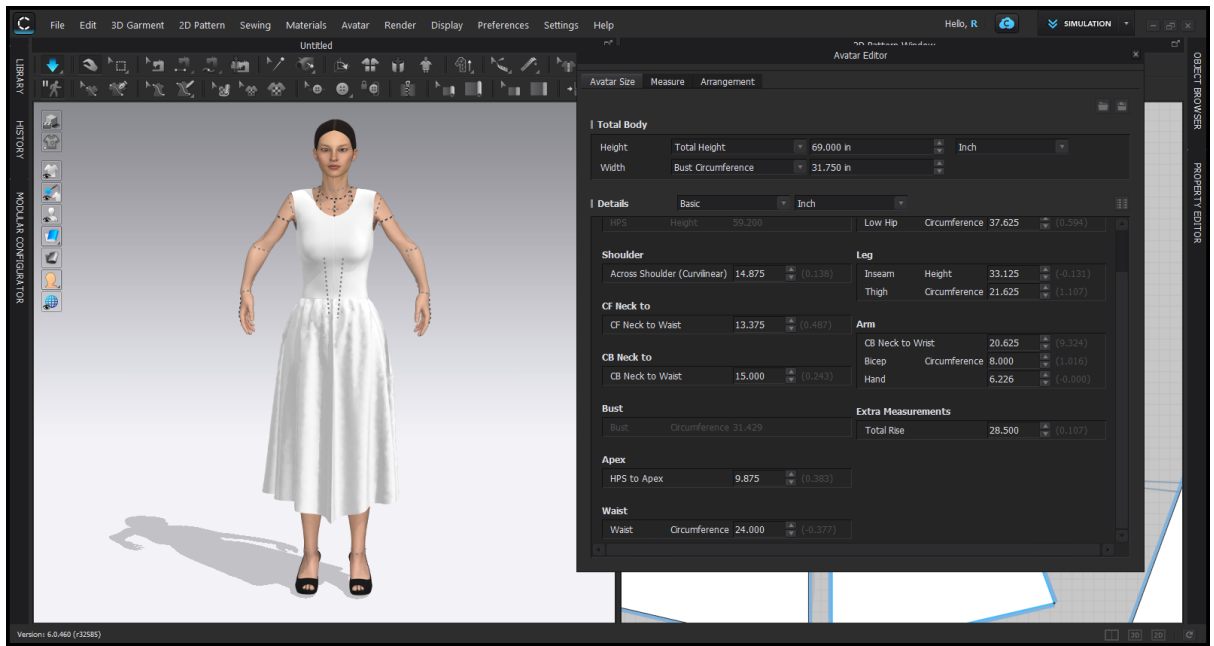
Materials and Methods: This virtual case study employed Nettelo and CLO3D to design an adaptive dress for females with hand-limb disabilities. The methodology included several key steps:

- **3D Body Scanning:** The Nettelo app was used to capture precise 3D body images, ensuring accurate representation of body dimensions and asymmetries.

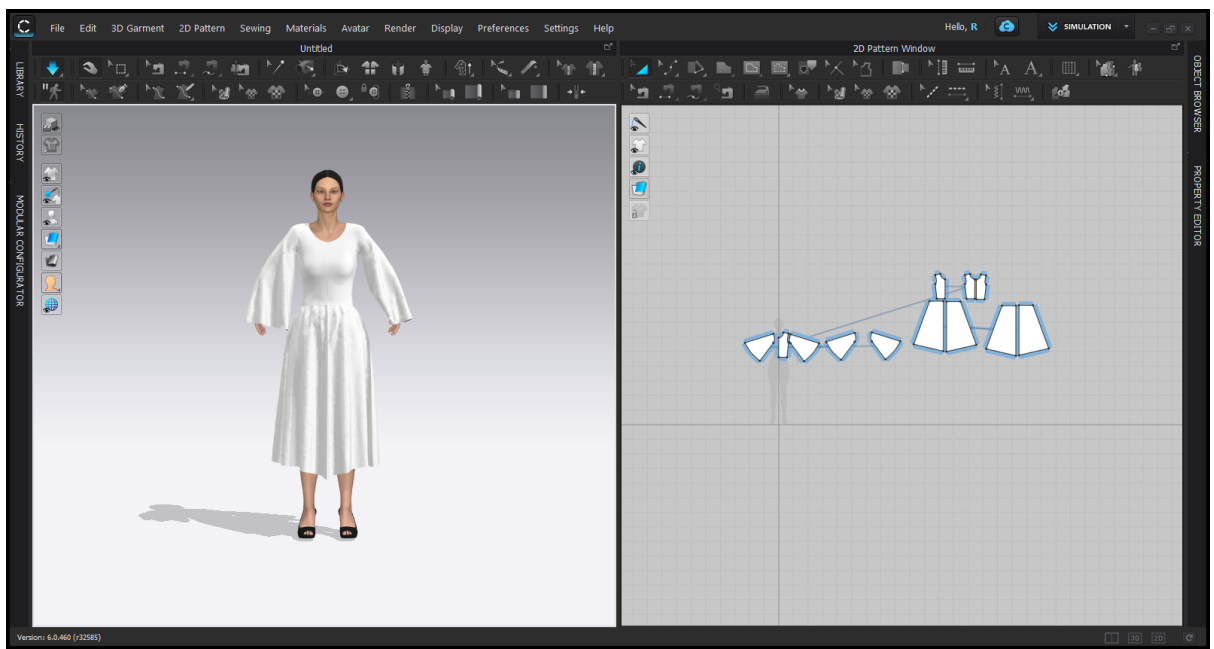


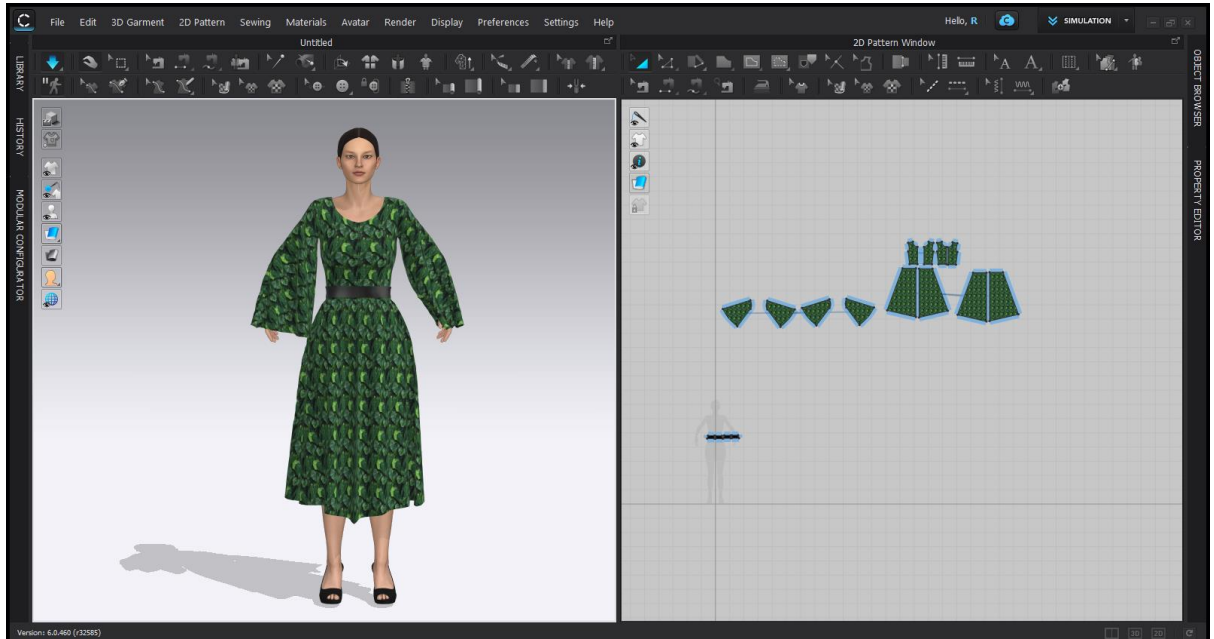
- **Digital Design and Simulation:** The scanned body model was imported into CLO3D, where an adaptive dress was designed. Special features such as magnetic closures and adjustable fasteners were incorporated to enhance ease of dressing.



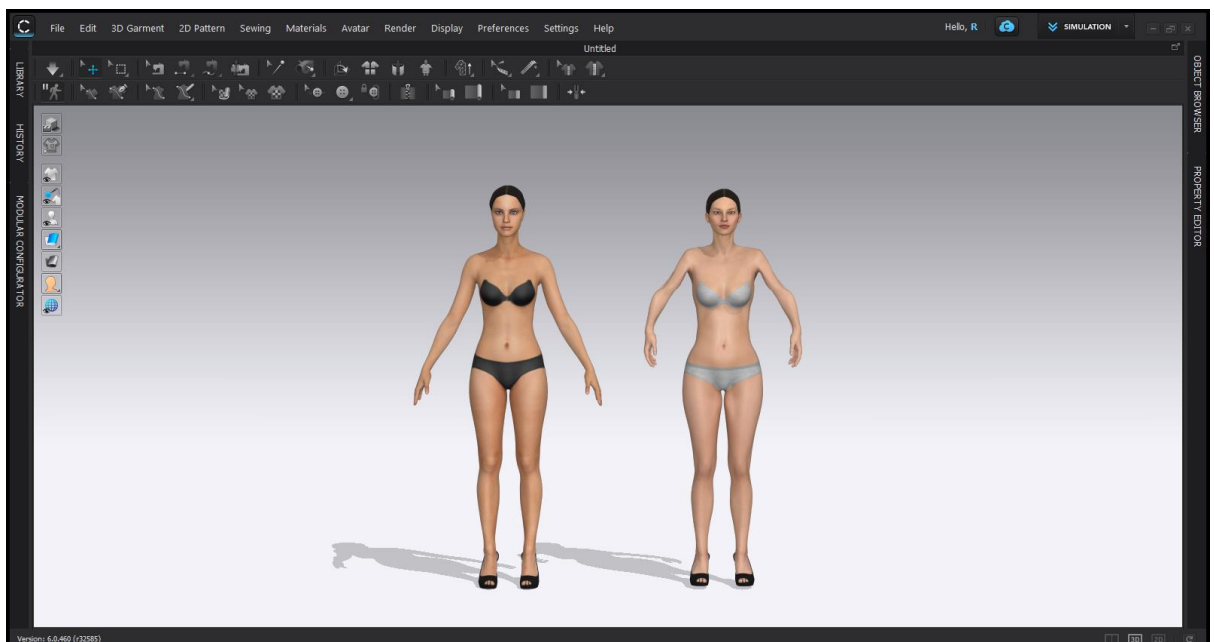


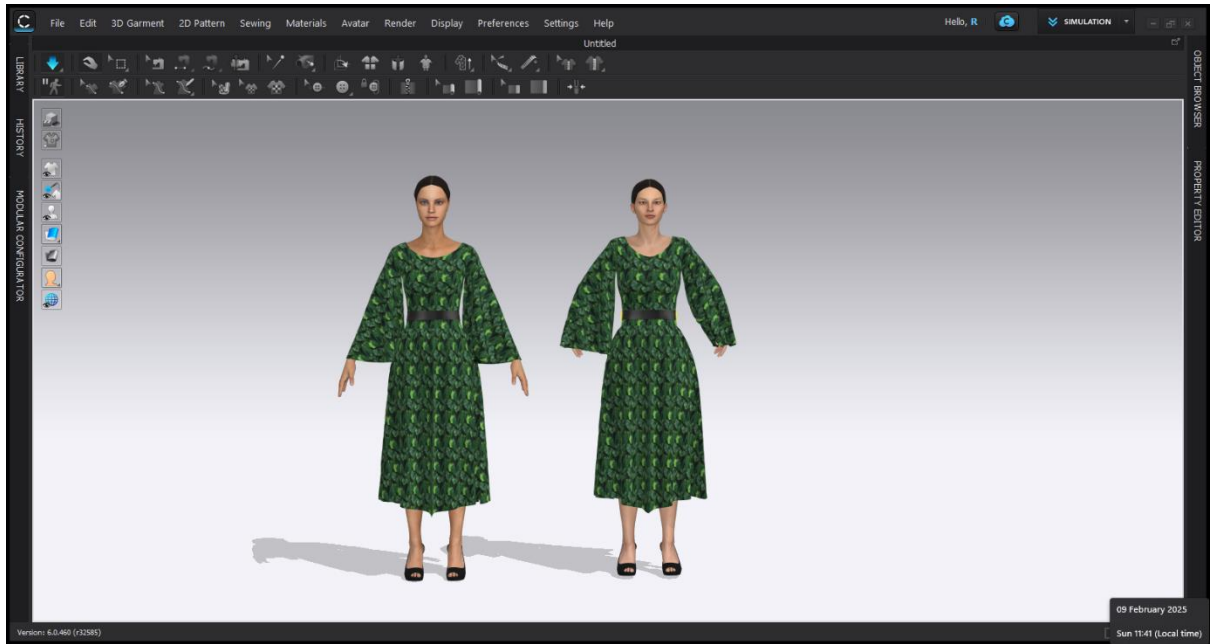
- **Virtual Testing:** The designed dress was tested on a 3D mannequin within CLO3D to evaluate fit, mobility, and comfort.





- **Comparison Metrics:** The adaptive design was assessed against a standard female body model to analyse improvements in functionality, comfort, and accessibility.





- **Scanning Process:** The Nettelo app was used to capture precise body measurements, ensuring an accurate representation of the user's body structure.
- **Digital Design:** CLO3D facilitated the creation and refinement of the adaptive dress, incorporating user-friendly features such as magnetic closures and adjustable fasteners.
- **Virtual Testing:** The dress was evaluated on a 3D-scanned mannequin, comparing fit, mobility, and aesthetics with a standard female body model.
- **Comparison Metrics:** Fit precision, ease of dressing, and comfort were analyzed to assess the effectiveness of adaptive modifications.

Results

- **Enhanced Fit and Comfort:** The adaptive dress demonstrated a significantly improved fit and ease of wear compared to standard designs. The precise 3D body scanning ensured a tailored fit, while AI-driven modifications allowed for better mobility and accessibility.
- **Sustainability:** Virtual prototyping minimized fabric waste and reduced the need for multiple physical samples.
- **Cost Efficiency:** The virtual design process cuts down production costs by streamlining modifications before physical manufacturing.

These findings highlight the potential of AI and 3D scanning in revolutionizing adaptive fashion design.

- **Scanning Process:** Capturing precise body measurements
- **Digital Design:** Creating and refining the dress in CLO3D
- **Comparison:** Evaluating the fit, functionality, and wearability of the adaptive dress on both a female with hand limb disabilities and a typical female body
- **Cost Calculation:**

S.No	Feature	Nettelo (Body Scanning)	Manual Body Measurement	CLO3D (Garment Design)
1	Estimated Monthly Cost	1,500 - 3,000 INR	200 - 500 INR per session	6,000 - 8,000 INR
2	Precision	High (3D scanning)	Lower	High (Digital Design)
3	Efficiency	High (AI-driven)	Lower	High (Reduces iterations)
4	Long-Term Cost Savings	Potentially (depending on usage)	No	Yes (Reduces fabric waste & prototyping)

- Additional costs include marketing and development, which encompass materials, production, and promotional activities.
- **User Feedback:** Assessing comfort, ease of wear, functionality, and overall aesthetic appeal for both cases through user feedback and virtual simulations.

Conclusion and Future Directions

This study highlights the transformative potential of AI-driven design software and body scanning technology in the adaptive clothing sector. By integrating Nettelo and CLO3D, designers can create highly customized garments that cater to the specific needs of individuals with hand-limb disabilities. The virtual testing conducted in this research demonstrates that digital prototyping enhances fit, reduces material waste, and streamlines the overall design process. Furthermore, AI-driven simulations improve accessibility by allowing rapid modifications without the need for multiple physical samples.

Despite these advancements, some challenges remain:

- **Cost and Accessibility:** High initial investment in technology
- **Technical Expertise:** Need for skilled designers trained in AI and 3D modeling
- **User Adaptation:** Ensuring end-users can easily adopt the clothing designs

Future research should focus on integrating AI for automated pattern-making, enhancing fabric simulation for adaptive needs, and expanding accessibility for designers in emerging markets. Additionally, this study has been exclusively conducted using Nettelo for body scanning and CLO3D for 3D garment design. Other scanning technologies and 3D design software have not been explored, nor has a cost comparison been conducted. Future research may consider evaluating alternative tools and their feasibility in adaptive fashion design.

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