

Research on the Construction and Application of a Full-Path Optimization System for Independent Designer Brands based on CLO3D

Xu Kong, Yan Wu

School of Digital Technology & Innovation Design, JNU, Wuxi Jiangsu, 214122, China

Abstract: As the digitalization process accelerates the change of apparel industry, independent designer brands are facing the development bottlenecks of long design cycle, high sample cost and lagging market verification. Based on CLO3D technology, this study builds a full-path optimization system covering “creative design-virtual prototype-marketing innovation-production collaboration”, aiming to solve the problems of inefficiency and resource waste of traditional processes through technological integration. The system realizes rapid iteration on the design side, precise cost reduction on the production side, and user interaction and innovation on the marketing side through the CLO3D full-path optimization solution. Case studies show that after applying the system, the design cycle of an independent brand has been shortened by 53%, sample iteration has been reduced by 76%, and fabric waste has been reduced by 15-20%; virtual pre-sale and NFT-based operation have reduced marketing costs by 73%. At the same time, the system strengthens consumers' recognition of the concept of sustainability through “carbon footprint visualization” and reduces capacity waste by 48%. The study proposes for the first time a CLO3D full-link integration framework, provides replicable digital transformation solutions for independent brands, and explores the commercial value of virtual clothing in the meta-universe economy, which is of practical significance for promoting the sustainable development of the fashion industry.

Keywords: CLO3D; Independent Designer Brands; Full Path Optimization System; Apparel Digital Technology.

1. Introduction

Under the wave of digital transformation of the global fashion industry, independent designer brands are facing existential challenges such as homogenisation of design, high supply chain costs, and fewer channels for product distribution, and they need to break through the limitations of the traditional design process through technological means to optimise the whole path from creativity to production. In this context, CLO3D, as a professional software integrating 3D modelling, physical simulation and real-time rendering, has become the core tool connecting virtual and real apparel design by virtue of its highly realistic fabric dynamic simulation engine and modular design functions. The traditional apparel design process relies on the production of physical samples, repeated fitting and pattern adjustment, resulting in high time costs and serious waste of resources. According to industry statistics, about 30% of the development cycle of a single garment is spent on sample modification. Through digital twin technology, CLO3D can simulate the draping, folding effect and human body fit of garments in real time, significantly reducing the number of physical samples, and providing independent designers with the innovative possibility of “zero-cost trial and error”. This provides independent designers with the innovative possibility of “zero-cost trial and error”. This enables the designers to flexibly adjust their designs on the design side, reduce costs on the production side to realise their design visions, and provide the possibility of digital zero-cost pre-sale on the marketing side.

2. Clo3d and Independent Designer Brands

(1) Clo3d

Clo3d, as a 3D virtual apparel design system developed by CLO Virtual Fashion in Korea, is deeply coupled with the digital transformation needs of the fashion industry. The software is based on a digital design platform constructed by an advanced physics engine, which realises the virtual reconstruction of the whole process of garment design by integrating material mechanics simulation, 3D spatial topology modelling and dynamic fluid simulation technology. Its core function is to simulate the fabric characteristics, cutting process and dynamic effects of clothing through the physical engine, to achieve the virtualisation of the whole process from design to display, which has now become one of the important tools for global clothing designers. It can realise the whole process of virtual apparel design, including fabric production, apparel pattern making, virtual sewing and product rendering.

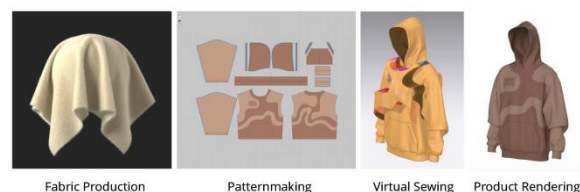


Fig 1. CLO3D virtual clothing production process

(2) Independent designer brands

As an important component of the fashion industry's innovation ecosystem, the concept of independent designer brands has been defined with diversified characteristics. Independent designer brands are brands created by

individuals or groups with personality, originality and design creativity, providing consumers with design products or services with unique styles and building their own brand image through their own design innovation ability, design concepts and personal taste. Compared with traditional commercial brands, these brands take designers' personal aesthetics as their core competitiveness and build their brand value system through cultural narratives. Recent studies have shown three main dimensions: first, the operation mode of independent designer brands presents the production characteristics of "small batch - high value-added", and most of them adopt the pre-sale system and on-demand production strategy in order to control the risk of inventory; second, in terms of the innovation path, independent designer brands emphasise on the value transfer through non-traditional channels such as cross-border co-operation and community operation; third, in the context of the proposition of sustainable fashion, independent designer brands have become more and more important in the market. Thirdly, under the proposition of sustainable fashion, independent brands are willing to embed the concept of environmental protection into the whole life cycle of their products.

(3) Progress of Clo3d technology application in fashion design field

As a representative tool of 3D virtual apparel design technology, CLO3D has evolved from a single visualisation tool to a full-process collaborative innovation platform in the fashion design field in recent years. Its technological evolution can be divided into three stages: basic function application, process reconstruction application and system integration application, and the related research covers multiple dimensions such as technology validation, design method innovation and industrial value assessment.

Basic Functional Application: Technology Iteration for Virtual Sample Development

The simulation accuracy of CLO3D's physics-based engine continues to improve. In the official CLO database, there are a large number of fabric materials, model materials, accessory materials, and scene materials for designers to use. Its fabric physical attribute library has supported more than 200 preset material parameters, and users can customise the adjustment of key metrics such as stretch, bend and shear stiffness. Designers can flexibly adjust the model figure data, 1:1 modelling of the customer's figure, virtual garment customization can be achieved, which greatly reduces the time and effort required for traditional garment customization, and more efficiently outputs customer-satisfied garments.

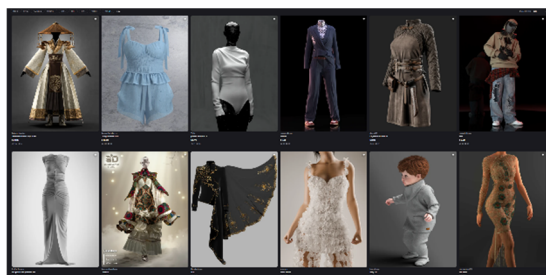


Fig 2. CLO3D database

Process Re-engineering Application: Digital Integration of Design-Production Chain

CLO3D works with Gerber AccuMark and other pattern making software through API interface, which significantly improves the efficiency of data flow. Tommy Hilfinger confirmed in its public case study in 2021 that it has reduced

the production of physical samples by 76% and shortened the development cycle of a single season by 40% through the CLO3D virtual sample system. In terms of sustainable practices, Stella McCartney's Autumn/Winter 2023 collection used CLO3D to complete 83% of sample development and reduce fabric waste by 1.2 tonnes.

System Integration Application: Cross-discipline Technology Integration and Innovation

Industry practices show that CLO3D is deeply integrating with emerging technologies. For example, in the field of meta-universe, digital fashion house The Fabricant generates NFT fashion assets through CLO3D, and the transaction value of a single virtual garment reaches \$9,500; in the field of AI, the AI layout generation system developed by the Korea Institute of Science and Technology (KIST) is based on the training model of the CLO3D database, and realises silhouette in the field of 3D printing, Iris van Herpen Studio has directly imported CLO3D files into the 3D printing system to achieve digital moulding of high-fashion garments.



Fig 3. NFT art

Technical limitations and research trends

The current technological bottlenecks are concentrated in the lack of dynamic simulation accuracy of some special fabrics, the gap in the digital restoration of complex decorative processes, the complexity of the digital twin production of complex fabrics, and the high error rate of the simulation of the pressure distribution of garments for oversized models.

3. Design of a Full Path Optimisation System based on CLO3D

In the field of fashion design, independent designer brands are facing multiple challenges such as complicated design process, serious waste of resources and low efficiency. The traditional design mode relies on physical sample production, which is not only time-consuming and consumable, but also difficult to achieve accurate design verification and real-time communication and collaboration. CLO3D, an advanced 3D virtual apparel design software, provides a full-process digital solution from design to presentation, but independent designer brands often fail to make full use of its potentials in practical applications.

This chapter aims to build a full-path optimisation system based on CLO3D, which solves the pain point problems of independent designer brands in design, production, display and collaboration by integrating the core functions of CLO3D with various key aspects of the design process, so as to achieve efficiency improvement, resource saving and innovation empowerment in the whole design process.

(1) System Architecture Design

The design architecture of the full-path optimisation system adopts a modular design approach, dividing the design process into four core modules: creative design, virtual prototyping, marketing innovation, and production collaboration. The overall architecture is shown in the figure below:

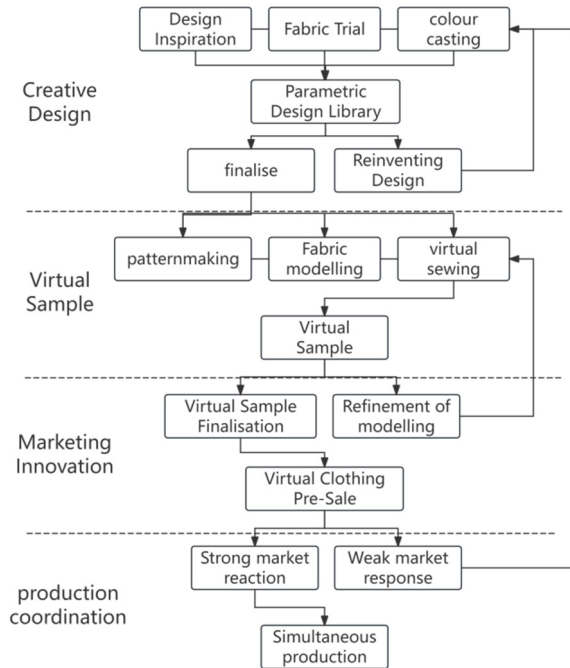


Fig 4. Design of a full path optimisation system based on CLO3D

(2) Four core modules of the full path optimisation system Creative Design Module: Digitally Driven Inspiration Transformation System

Design Inspiration Capture and Parametric Reconstruction, Through CLO3D's "Parametric Garment Library" (e.g. pre-set patterns, dynamic pleat parameters), we can quickly generate diversified design variants, rapidly transform hand-drawn sketches into editable 3D models, and visualise inspiration.

Using CLO3D's physical engine to simulate the drape and gloss of different fabrics, and the "colour pull" function to adjust the material colour matching in real time, we can generate high-precision virtual samples (e.g. silk, knit, and other complex material effects), which can be used in place of the traditional physical samples, and achieve a more efficient selection of fabrics and colour matching.

Interdisciplinary collaboration and data deposition. Designers and pattern makers collaborate online through CLO3D, and historical modification data is automatically archived to the cloud, forming a brand-specific "design knowledge base" to support subsequent series development. Virtual Sample Module: Highly Accurate Simulation and Dynamic Verification

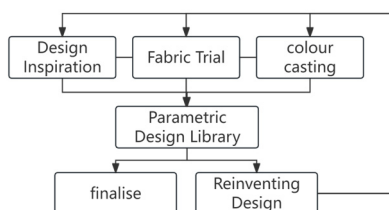


Fig 5. Creative Design Module Refinement Process

Fabric Modelling and Virtual Sewing

CLO3D physics engine simulates the drape, stretch and light effects of different fabrics (e.g. the fluidity of silk, the stiffness of denim), and adjusts the colour scheme in real time with the "Colour Collar Trial" function. The virtual sewing technology automatically detects the seam logic (e.g. seam overlap, stitch density) and generates 3D garments that can be dynamically displayed. Through virtual model fitting (supporting multi-body type data), analyse static fit and dynamic movement (e.g. trouser crease pattern when knees are bent), and output correction suggestions (e.g. pattern scaling).

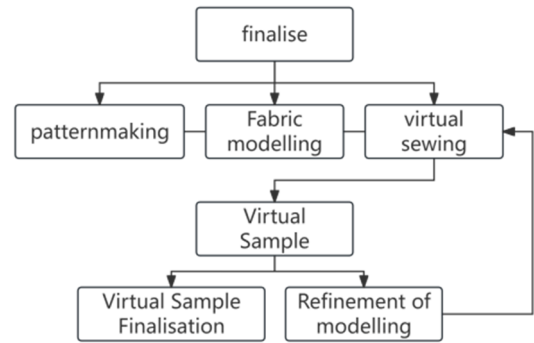


Fig 6. Virtual Sample Module Refinement Process

Marketing Innovation Module: User Interaction Ecology in the Age of Digital Fashion

Virtual Garment Pre-sale and Market Validation, Embed the CLO3D-generated virtual garments into social media try-on filters (e.g. Instagram AR) or gaming platforms (e.g. Roblox), and collect behavioural data such as users' clicks, shares, and length of virtual try-on time, to reverse-guide the design iteration.

NFT-enabled digital asset operation, Using CLO3D's GLTF/USDZ format export function, we can transform virtual garments into cross-platform compatible 3D assets, and through blockchain technology, we can realise the issuance of limited edition digital collections, so as to establish a brand IP value system that "integrates the virtual and the real".

Sustainable Narrative and Consumer Education, CLO3D's simulated "carbon footprint comparison chart" (traditional process vs. digital process) is displayed on the e-commerce page, which strengthens consumers' awareness of the brand's environmental protection concept and enhances the price premium.

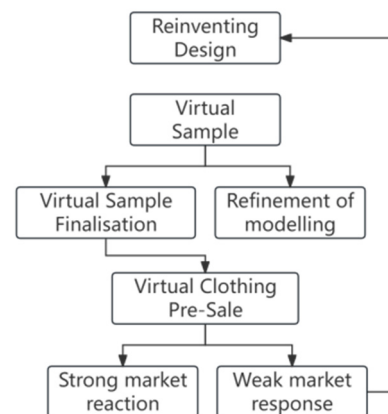


Fig 7. Marketing Innovation Module Refinement Process

Production Collaboration Module: An Agile Manufacturing Network with Virtual and Real Connections

Digital pattern output, The pattern file (DXF/AAMA format) generated by CLO3D is directly connected to the intelligent cutting machine, and combined with the AI scheduling algorithm of the "Service Pattern Making" module, it can maximise the utilisation rate of fabrics (experimental data: saving 15-20% fabric loss), and support the automatic scaling function of "one version, multiple sizes" for small batch orders. It supports "one version of multi-size" auto-scaling function for small-lot orders, and adapts to the flexible production needs of independent brands.

Distributed Production Collaboration, Synchronise design data to the MES system of partner factories via API interface, update process requirements (e.g. stitch type, decoration details) in real time, ensuring "zero information gap" between sampling and mass production.

Fabric Trial Selection Optimisation, Based on the physical parameters (grammage, modulus of elasticity) of CLO3D fabric library, we can recommend the most cost-effective combination of suppliers and simulate the cutting effect to reduce the risk of purchasing decision.

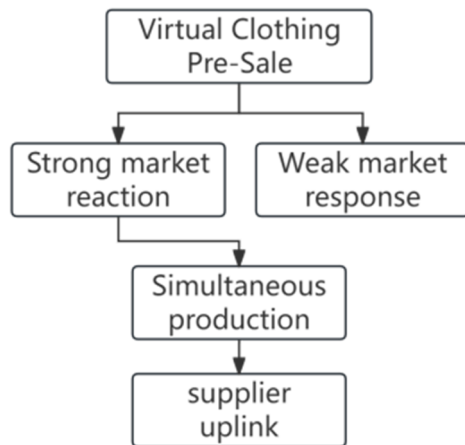


Fig 8. Production Collaboration Module Refinement Process

(3) Core benefits of the Total Path Optimisation system

Based on CLO3D, the full path optimisation system meets the operational needs of independent designer brands to "run fast in small steps". Through CLO3D technology, the design, production and marketing links are deeply coupled to form a sustainable digital closed loop.

All-chain digitalisation: CLO3D technology runs through design, verification, production and marketing, forming a seamless closed loop.

Dynamic response to the market: real-time data feedback enables rapid iteration of "design-production-marketing" (cycle time shortened by more than 40%).

Reduce cost and increase efficiency: Reduce the production of physical samples, reduce the waste of fabrics, expand the virtual economic benefits, and reduce the comprehensive cost by 25%-30%.

4. System Applications and Case Studies

(1) Application Targets and Implementation Methods Application Object

Independent designer brand alpha (anonymous, hereinafter referred to as Brand A) is an independent designer clothing brand inspired by the cultural trends of Generation Z. It has been five years since the brand was founded, and its current problems include long design cycles, poor productiveness, high production costs, and few marketing channels.

Implementation Steps

Aiming at the core problems faced by Brand A nowadays, we propose the design of a full-path optimization system based on CLO3D. For example, we establish a brand design material library on the design side, and enter the brand's historical design results into the library, so as to facilitate the designers to retrieve the materials before the development of the series of styles; we use CLO3D to model the samples on the sample production side, and we try to use different fabrics and accessories, and colour combinations for the designers to choose, and on the basis of the sample modeling, we use CLO3D for the samples. On the marketing side, it is suggested that the brand should improve the modelling standard after the sample modelling is confirmed, output high-quality 3D virtual samples and put them into the brand's website for promotion, so that consumers can view the new products in 360°, and combine with the virtual AR technology, so that the consumers can easily complete the virtual try-on at home and accumulate the product feedback. Feedback. On the production side, according to the number of pre-orders in the process of virtual product placement, reasonable arrangements for production, reduce the storage cycle, achieve light warehouse operation, and reduce capital pressure for the brand to rationally arrange production capacity.

Point	Problems faced	Optimisation programme
Creative design phase	Long design cycle	CLO3D online brand design material library fabrics, colours for online trial selection
	Cumbersome design process	
Virtual Sample Stage	High number of sample returns	CLO3D sample modelling, online communication of sample details, flexible adjustments
	Inefficient designer-layout artist communication	
Marketing Innovation Stage	High marketing costs	Virtual ready-to-wear goes live earlier, pre-sales to get pre-order numbers, while developing product NFTs to give away to consumers to increase user viscosity
	Poor marketing effectiveness	
Production synergy phase	Inflexibility of production capacity	Flexible arrangement of production capacity for the number of pre-sale orders, data sharing between upstream and downstream of the supply chain, flexible digestion of production capacity
	High cost of goods suppression	

Fig 9. Brand A Full Path Optimisation Programme

(2) Evaluation of the effectiveness of the full path optimisation programme

After 6 months of full-path optimisation, Brand A has achieved different degrees of optimisation on the design side, production side and marketing side.

The designers have established the brand product material library and completed the 3D modelling of historical products, fabrics and accessories, and cooperated with other fabrics and accessories companies to build a fabrics and accessories database based on the CLO ecology, so that the designers can call the materials in the database to complete the design very quickly, and the time for completing the final draft of a series of product designs has been statistically improved by 53%, from the past 30 days to 14 days to finalise the design.

the design in 14 days instead of 30 days in the past.

The workflow optimised by Full Path has eliminated the need for designers and pattern makers to constantly modify samples in traditional work. In Brand A's traditional apparel design and production process, it takes an average of 3-4 processes in the sample production stage to confirm the final big-shipment pattern, but under the Full Path optimisation system, designers and pattern makers only need to constantly modify the style design in CLO3D, which greatly reduces the number of sample production times, and the work efficiency has been reduced. The number of sample production has been greatly reduced, and the work efficiency has increased by 64%, shortening the sample production cycle from 14 days in the past to 5 days.

In the traditional marketing mode of Brand A, it is often necessary for the series of products to produce big goods before starting marketing. However, under the reform of the full path optimisation system, when the virtual sample clothes produced by CLO3D pass the audit of designers and pattern makers, they can be directly handed over to the marketing side to be put on the shelves and open the product preview, so that consumers can achieve a 360 ° view of the new products and complete the virtual try-on at home by combining with the AR technology. At the same time, the product NFT was launched, allowing consumers to have the same products during the pre-order period. Under the reform of the whole-path optimisation system A brand marketing costs were reduced by a cumulative 73%.

On the production side, under the traditional business model, a series of products often require a starting quantity for production ordering, but under the optimisation of the full path optimisation system, the brand accurately controls the production capacity based on marketing data to achieve the production of the ordered products, reducing the pressure of brand hoarding and realising the production mode of light warehousing. Under the reform of the whole-path optimisation system, the brand reduced unnecessary capacity waste by 48% in six months.

5. Conclusion

Based on CLO3D technology, this study constructs a full-path optimisation system of "creative design-virtual

prototyping-marketing innovation-production collaboration" for independent designer brands, which solves the core problems of inefficiency, high cost, and lagging market response in the traditional apparel development through technological integration and process reconstruction. The full-path optimisation solution has shortened the design cycle of the case brand by 53%, reduced sample iterations by 76%, and reduced fabric waste by 15-20%; the virtual pre-sale and NFT operation has reduced marketing costs by 73%, and compressed the order delivery cycle to 5 days. At the same time, through the "carbon footprint visualisation", consumers' recognition of the concept of environmental protection is strengthened. We also proposed the first CLO3D full-link integration framework to fill the gap of digital research for small and medium-sized brands. It also explores the business model of virtual-reality integration and provides a practical path for the fashion economy of the universe.

References

- [1] Ruohan Ren,Fangchao Yang,Jie Sun.The Development and Logic of Digital Fashion from a Design Perspective[J].Apparel Journal,2024,9(02):127-136.
- [2] Xuewei Wang,Xiaokun Yu.Meta-universe virtual space in the field of fashion application of the current situation and developmenttrend[J].TextileJournal,2024,45(04):238-245. DOI: 10. 13475/j.fzxb.20230300202.
- [3] Shufang Deng.A study of the impact of the operating ecology of digital fashion platforms on the purchase intention of virtual apparel consumers under the perspective of information ecology [D]. Donghua University,2024.
- [4] Junli Zhao, Jiachen Qi.Digital Empowerment, Technological Transformation and Green Transformation of Textile and Garment Enterprises[J].silks,2025,62(01):11-19.
- [5] Ziye Chen.A Study of the Interaction between Virtual and Physical Clothing Consumption[D].Donghua University,2024. DOI: 10.27012/d.cnki.gdhuu.2024.001303.
- [6] Chenxin Feng.Digital Design of Sportswear Brands Based on Virtual Clothing Technology[D].Jiangnan University,2023. DOI: 10.27169/d.cnki.gwqgu.2023.001195.