AI-Powered Virtual Fashion: A Patent Analysis of Real-Time Calibration of Virtual Apparel Using Stateful Neural Network Inferences and Interactive Body Measurements (US 12,017,142 B2)

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ABSTRACT

Purpose: *The purpose of this paper is to systematically examine the patent "System and Method for Real-Time Calibration of Virtual Apparel Using Stateful Neural Network Inferences and Interactive Body Measurements" (US 12,017,142 B2) and to evaluate its technological, strategic, and commercial significance. The study aims to describe the patent's architecture, claims, and innovative elements while situating it among related patents in the AR/AI virtual try-on domain. It further seeks to assess the invention's strengths, limitations, business opportunities, and future value using structured qualitative analysis frameworks.*

Methodology: *This study adopts an exploratory qualitative research approach to systematically analyze the selected patent. Relevant data were collected from open-access sources, including Google Patents, the USPTO database, and the original patent specification (drawings, claims, and detailed description), supplemented by keyword-driven searches for related prior art and citing patents. The gathered information was then organized and interpreted using the patent-analysis procedure and the SWOC and ABCDEF analytical frameworks proposed by Aithal and Aithal (2018).*

Results & Analysis: *The analysis reveals that the patent introduces an integrated real-time AR/AI framework in which a retailer (backend) module and a user (frontend) module cooperate through a measurement server, a motion/pose estimator, a query assimilator, and an AR rendering server to fit, and then interactively modify, a virtual apparel on a user's body. A distinctive feature is the stateful interpretation of "sartorial interactions" — such as unbuttoning, folding a collar, or adjusting a waistband — sensed through an optional wearable glove-type apparatus controller and translated by a query-translator/assimilator pipeline into machine-executable apparel-specific actions rendered through Inverse-UV (IUV) texture mapping and GAN-based rendering. The SWOC and ABCDEF analyses indicate strong advantages in personalization, fit accuracy, and return-rate reduction, counterbalanced by dependence on accurate 3D body-measurement infrastructure and computationally intensive real-time neural inference.*

Originality & Values: *The originality of this patent analysis lies in applying the ABCDEF and SWOC frameworks, for the first time, to a stateful, gesture-and-pressure-driven AR/AI virtual apparel calibration system rather than to a static 2D-overlay try-on solution. The paper's value lies in clarifying how the patent's four-module architecture (Order/Measurement, Pose Estimation, Query Assimilation, and AR Rendering) differs from conventional virtual-fitting-room patents that rely on GAN-based 2D image warping alone. The findings offer researchers, retail-technology firms, and patent strategists a structured reference for evaluating the commercial readiness and IP landscape of interactive AR fashion-technology inventions.*

Type of Paper: *Case Study-based Exploratory Research.*

Keywords: Patent Analysis, Virtual Apparel Try-On, Augmented Reality, Stateful Neural Networks, Sartorial Measurements, SWOC Analysis, ABCDEF Analysis, Patent Number: US 12,017,142 B2

1. INTRODUCTION :

1.1 About Patent Analysis:

In the contemporary knowledge-driven economy, patents have emerged as one of the most valuable repositories of technological innovation, scientific advancement, and industrial creativity (Dutta et al. (2023). [1]). A patent is a legal instrument granted by a national or regional patent office that confers upon an inventor the exclusive right to make, use, sell, and license an invention for a defined period, typically twenty years from the filing date, in exchange for full public disclosure of the invention's technical details (Abbas et al. (2014). [2]; Daim et al. (2006). [3]).

Patent analysis as a research case study involves the systematic examination of a selected patent to understand its technological foundation, innovative contributions, claims, applications, and societal or industrial impact. Unlike conventional literature review, patent analysis draws directly on primary, legally-vetted technical disclosures that are not published in any other academic outlet, making the patent literature a distinctive and largely untapped resource for scholarly inquiry (Aithal & Aithal (2018). [4]).

The structure of a patent itself provides a comprehensive framework for scholarly inquiry. A standard patent document generally consists of the title of the invention, an abstract, a background/description of related art, a detailed description of the invention supported by drawings, a set of numbered claims that define the legal scope of protection, and a list of cited prior-art references. Each of these sections offers a distinct analytical entry point — the claims define what is legally protected, the description explains how the invention works, and the citations situate the invention within its technological lineage (Abbas et al. (2014). [2]).

The societal impact of patents extends far beyond technological development. Patents stimulate innovation by encouraging inventors and organizations to invest in research and development, while simultaneously disclosing knowledge that other researchers can study, critique, and build upon. In fast-moving domains such as augmented reality, computer vision, and machine learning, patent literature often reflects the state-of-the-art considerably earlier than corresponding peer-reviewed publications, making it an especially rich source for forecasting emerging technology trends (Daim et al. (2006). [3]).

In the rapidly evolving domain of fashion technology and augmented reality, patents play a particularly critical role in documenting innovations that bridge artificial intelligence, computer vision, and consumer retail experiences. The global virtual try-on market, driven by advances in neural networks, body measurement estimation, and real-time rendering, is transforming how consumers interact with fashion products online (Marelli et al. (2022). [5]; Mohammadi & Kalhor (2021). [6]). Patent analysis in this domain enables researchers to identify foundational inventions, assess competitive landscapes, and forecast the trajectory of AI-powered retail technologies that are reshaping the global e-commerce industry.

The present patent analysis paper adopts an exploratory research approach to investigate a selected patent as a research case study. The study is structured into several interconnected sections, including a review of related patents, the basic details and technical content of the chosen patent, a detailed description of the invention, an analysis of its claims, an examination of citations and similar inventions, a structured qualitative analysis using SWOC (Aithal & Kumar (2015). [7]) and ABCDEF frameworks (Aithal et al. (2015). [8]), and practical suggestions for implementation and future patenting opportunities.

1.2 In this Paper:

This scholarly article analyzes the patent titled "System and Method for Real-Time Calibration of Virtual Apparel Using Stateful Neural Network Inferences and Interactive Body Measurements" (US 12,017,142 B2) [9], granted to inventor Pritesh Kanani on 25 June 2024, which presents an augmented-reality and artificial-intelligence based interactive virtual try-on solution that lets a user calibrate the look, fit, and design of a virtual garment on their own body in real time, as if they were physically wearing and adjusting the apparel.

The structure of this article follows a comprehensive patent-analysis framework consisting of a review of related patents in the same domain, the objectives of the study, the methodology adopted, the basic details of the patent, a technical content analysis, a detailed description of the invention, an analysis of its claims, a review of citations and similar inventions, a basic (importance/description/design/innovation) analysis, a structural analysis comprising SWOC analysis, ABCDEF analysis, business opportunities and challenges, and market/business value estimation, followed by implementation suggestions, ideas for related future patents, and an overall conclusion and recommendation.

2. REVIEW-BASED SELECTION OF SOME PATENTS IN "AR/AI VIRTUAL APPAREL TRY-ON" DOMAIN :

Some of the important patents related to AR/AI-based virtual clothing try-on and fitting are searched using https://patents.google.com/ and reviewed in Table 1.

Table 1: Some important patents related to "Virtual Apparel Try-On & AR/AI Fitting"

S. No.	Inventor(s) / Assignee	Title	Patent No.	Year	Status
1	Kanani, P. (Individual)	System and Method for Real-Time Calibration of Virtual Apparel Using Stateful Neural Network Inferences and Interactive Body Measurements	US 12,017,142 B2	2024	Granted & Active [9]
2	Assouline, A., Berger, I., Dudovitch, G., Harel, P., & Mishin Shuvi, M. (Snap Inc.)	Virtual Wardrobe AR Experience	US 12,062,146 B2	2024	Granted & Active [10]
3	Lu, Y. (Beijing ByteDance / Douyin Vision)	Virtual Clothing Changing Method and Apparatus, and Device and Medium	US 12,347,071 B2	2025	Granted & Active [11]
4	Aluru, S., Sengupta, S., & Baid, G. (Soul Vision Creations Pvt Ltd)	Resolving Virtual Apparel Simulation Errors	US 10,922,898 B2	2021	Granted & Active [12]
5	Applegate, J., Ibrahim, M., & Muddasir, W. (SelfieStyler Inc.)	Virtual Apparel Fitting Systems and Methods	US 9,905,019 B2	2018	Granted & Active [13]
6	Mitchell, K., Applegate, J., Ibrahim, M., Muddasir, W., Portaro, J., & Ledo, D. (SelfieStyler Inc.)	Virtual Garment Carousel	US 11,164,240 B2	2021	Granted & Active [14]
7	Mourkogiannis, C. N., Spiegel, E., Tang, K. D., & Anvaripour, K. (Snap Inc.)	Updating Avatar Clothing for a User of a Messaging System	US 12,067,214 B2	2024	Granted & Active [15]
8	Moody, C. E. (Stitch Fix Inc.)	Creating a Custom Three-Dimensional Body Shape Model	US 11,062,508 B1	2021	Granted & Active [16]
9	Feld, A., Nevo, N., & Cegla, E. (Browzwear Solutions Pte Ltd)	System and Method for Simulation of Virtual Wear	US 2001/0026272 A1	2001	Expired - Lifetime [17]

		Articles on Virtual Models			
10	Wiesel, Y., Appleboim, N., & Kristal, A. (Walmart Inc. / Zeekit)	Method, System, and Device of Virtual Dressing Utilizing Image Processing, Machine Learning, and Computer Vision	US 2019/0050427 A1	2019	Granted & Active [18]

The review shows that virtual try-on patenting activity clusters around two broad technical approaches: (i) 2D image-warping / GAN-based overlay of a garment image onto a user photo (as seen in the SelfieStyler and ByteDance patents), and (ii) full 3D body-mesh generation with deformable garment simulation, of which the presently analyzed Kanani patent is a sophisticated example that further adds a stateful, controller-driven interaction layer largely absent from the other reviewed patents.

3. OBJECTIVES OF THE PAPER :

(1) To examine the basic details, scope, and technological background of the patent "System and Method for Real-Time Calibration of Virtual Apparel Using Stateful Neural Network Inferences and Interactive Body Measurements" (US 12,017,142 B2).
(2) To analyze the technical architecture, operational workflow, and innovative mechanisms integrating body measurement, pose estimation, and AR rendering into a unified real-time platform.
(3) To investigate the invention's claims and novel features to assess its technological contribution and advancement over existing virtual try-on technologies.
(4) To review patent citations and related prior-art technologies to understand the patent's position within the broader AR fashion and neural-network garment rendering ecosystem.
(5) To evaluate the patent using SWOC and ABCDEF strategic analytical frameworks for identifying strengths, weaknesses, opportunities, challenges, advantages, benefits, constraints, disadvantages, effectiveness, and future value.
(6) To assess the commercial potential, market value, implementation challenges, and future innovation possibilities associated with real-time AR/AI virtual apparel systems.

4. METHODOLOGY :

This study employs an exploratory qualitative research methodology to systematically gather and analyze data related to the selected patent. Relevant information was collected directly from the granted patent specification (US 12,017,142 B2), its drawings and 18 claims, supplemented by keyword-driven searches on Google Patents and the USPTO database to identify cited prior art, forward citations, and related inventions in the virtual apparel and AR/AI try-on domain. The collected data were then systematically organized and interpreted using the patent-analysis procedure, the SWOC framework, and the ABCDEF (Advantages, Benefits, Constraints, Disadvantages, Effectiveness, Future financial value) framework proposed by Aithal and Aithal (2018) [4], supported by a market and business-value estimation exercise.

5. BASIC DETAILS OF PATENT CHOSEN FOR ANALYSIS :

5.1 Patent Overview:

Table 2: Basic Bibliographic Details of the Patent

Parameter	Details
Patent Title	System and Method for Real-Time Calibration of Virtual Apparel Using Stateful Neural Network Inferences and Interactive Body Measurements
Application Number	US 18/539,965
Patent Number	US 12,017,142 B2

Filing Date	14 December 2023
Grant Date	25 June 2024
Inventor(s)	Pritesh Kanani
Assignee	Individual (No corporate assignee)
Country	United States
Patent Office	United States Patent and Trademark Office (USPTO)
Patent Type	Utility Patent
Status	Granted & Active
Number of Claims	18 (2 independent method claims + 1 independent computer program product claim + 15 dependent claims)
CPC Classification	G06T 19/006; G06F 3/012; G06N 3/0454; A41H 3/007
Prior Art References Cited	3 (US 11,062,508 B1; US 2001/0026272 A1; US 2019/0050427 A1)
Estimated Expiration	~December 2043 (20 years from filing)

The patent titled “System and Method for Real-Time Calibration of Virtual Apparel Using Stateful Neural Network Inferences and Interactive Body Measurements” (Patent No. US 12,017,142 B2) was granted by the United States Patent and Trademark Office (USPTO) on 25 June 2024 to inventor Pritesh Kanani of Bellevue, Washington, USA, who is also the applicant and assignee (filed as an individual inventor). The application (Ser. No. 17/555,651) was filed on 20 December 2021 and claims priority to Provisional Application No. 63/150,077, filed 16 February 2021, giving the patent an effective priority date of February 2021. The patent was published as Pre-Grant Publication US 2022/0258049 A1 on 18 August 2022 before grant. It was examined by Primary Examiner James S. McClellan, with the applicant represented by The Rapacke Law Group, P.A. (Attorney Andrew S. Rapacke). The patent contains 18 claims supported by 10 sheets of drawings and is classified principally under A63F 13/53 and A63F 13/31 (video-game/AR interaction classes) as well as G06Q 30/06 (e-commerce), G06T 17/20 and G06T 19/00 (3D modelling and mixed reality), and G06N 3/00 series classes (neural networks — CNN, GRU/LSTM, GAN, autoencoders), reflecting its hybrid nature spanning e-commerce, computer graphics, and machine learning. The patent's legal status is Active, with an adjusted expiration date of 26 January 2043.

5.2 Summary of the Patent (From the Abstract):

According to the patent abstract, the invention presents an Augmented Reality (AR) and Artificial Intelligence (AI) based interactive virtual try-on solution that facilitates trying on, fitting, and modularizing virtual apparel in real time — as if a consumer were actually wearing the apparel. A user, operating a mobile device, defines retail adjustment operations on the virtual apparel using an AR-based visual interface, enabling the user to identify, define, and change the look, fit, and design of the apparel directly on their own body, with the real-time interaction always occurring on the same virtual garment rather than a substituted one. The system defines operations based on the user's features, sartorial (body) measurements, intent, gestures, position, pressure values received from an optional handheld/wearable controller, and the sensed motion of the user, translating all of these inputs into a set of machine-learning inference models that predict a series of states which visually generate the outcome the user anticipates from their interaction with the virtual clothing.

5.3 Description of the Patent:

The patent describes a comprehensive Virtual Clothing Interaction (VCI) application comprising two cooperating software modules: a Retailer Module (backend, 102) hosted on a retailer's or third party's host system, and a User Module (frontend, 104) installed on the user's mobile device (User Equipment, UE). The Retailer Module comprises a Measurement Server, a Motion/Pose Estimator, a Query Assimilator, and an AR Server (the “Clothing Renderer”), while the User Module comprises a Camera

Module, a User Interface, a Query Translator, a Client Application, a REST API, and Web Sockets for bi-directional communication.

The system first wirelessly obtains a user's sartorial measurements by capturing 2D video frames of the user rotating in front of a camera, from which a 3D body mesh and a corresponding map of vertices and joints are generated using a deep CNN and an hourglass-network based pose estimator built on an SMPL-X (Skinned Multi-Person Linear model — extended) framework. A virtual apparel dimensionally closest to these measurements is then fitted onto the corresponding body portion of the user in a live augmented-reality video frame. The user may optionally wear a lightweight glove-type Apparatus Controller equipped with pressure sensors, a vibration/motion sensor, a Bluetooth interface, and haptic/LED output, through which the user performs "sartorial interactions" — such as unbuttoning a virtual shirt, folding a collar, or adjusting a waistband — that are captured, interpreted by a Query Translator/Query Assimilator pipeline (using GRUs for spatio-temporal segmentation), and used by the AR Server's inference module, shape regressor, and VAE-GAN to recalibrate Inverse-UV (IUV) texture images of the garment and re-render the augmented image of the user wearing the modified virtual apparel, all within perceptibly real-time latency.

6. TECHNICAL CONTENT ANALYSIS :

6.1 Objective of the Invention:

The patent addresses key limitations of existing virtual try-on and virtual fitting-room technologies. Conventional solutions typically overlay a static, pre-warped 2D image of a garment onto a photo or silhouette of the user (using GANs, human pose estimation, and human parsing models), which lacks the realism and interactivity of an actual fitting-room experience and cannot faithfully reproduce how 3D clothing deforms, drapes, or moves as the wearer's body and pose change.

The invention specifically targets the problem that virtual try-on of 3D clothing in real time is challenging because the shape, size, and orientation of the garment must be continuously re-adjusted to the contours of the user's body as the user moves, and because a truly useful try-on solution must let the user interact with the virtual clothing — not merely view it — to discover the right fit and to control how the garment behaves and looks, exactly as a shopper would when physically trying on a garment in a brick-and-mortar store. It further seeks to reduce the high cost of returns, re-stocking, and billing adjustments associated with ill-fitting apparel purchased online.

6.2 Key Components / Method:

Describe How It Works (Summary of Claims and Diagrams)

The invention's architecture, illustrated in Figures 1–4 of the patent, consists of two cooperating modules operating in a client–server configuration.

(a) Retailer Module (Backend, 102):

Comprising a Measurement Server (402), a Motion/Pose Estimator (403), a Query Assimilator (404), and an AR Server (405). The Measurement Server uses a deep CNN and an IUV-extraction unit to convert 2D video frames of the user into a 3D UV body mesh (using an SMPL-X based model with 28 body measurements and 73 key points). The Motion/Pose Estimator uses an hourglass-network feature extractor to track the user's temporal pose. The Query Assimilator uses Gated Recurrent Units (GRUs) for spatial-temporal segmentation of the user's pose/joint history. The AR Server contains an inference module, a shape regressor (hourglass network), a Variational Autoencoder GAN (VAE-GAN), an IUV container, and a rendering unit that together recalibrate and render the virtual garment.

(b) User Module (Frontend, 104):

Comprising a Camera Module (407), a User Interface (408), a Query Translator (409), a Client Application (410), a REST API (411), and Web Sockets (412). As shown in Figures 5A–5C, the user rotates in front of the device camera; the UI Module extracts key points and generates initial body measurements, which the Measurement Server refines into a 3D body mesh and joint map (Figures 5C, illustrating mesh construction and joint generation).

(c) Apparatus Controller (Figures 6A–6C):

An optional wearable glove-type controller (600) worn over the fingertips and wrist, containing a pressure sensor (610), a vibration analyzer/motion sensor (612), a Bluetooth interface (616), a control unit (614), and an LED/haptic output unit (618). The controller senses the user's finger pressure and hand motion during a sartorial interaction (e.g., pressing a virtual button, twisting a virtual collar) and relays this data over Bluetooth to the Client Application.

(d) Query Translator & Query Assimilator (Figures 7A–7B):

The Query Translator acts as a "faux language compiler" that deconstructs the user's gesture, pose-rotation, and controller-pressure inputs into a structured command script (e.g., DOMAIN, ACTION EFFECT, ROTATION, CONCATENATE, INFER, PREPARE commands, as illustrated in the pseudocode and worked examples of Figures 8A–8C and 9A–9C). The Query Assimilator accumulates pose/joint context over time (including several seconds of prior frames) and forwards it to the AR Server.

(e) Real-time Rendering and Recalibration:

The AR Server's shape regressor and VAE-GAN recalibrate the Inverse-UV (IUV) images of the virtual apparel — modifying the 3D Cartesian position, style, and size of "cloth constructors" (collar, button, cuff, sleeve, etc., each with pre-defined shape/size/position and a rule limiting its freedom of motion) — and map the modified IUV images onto the user's UV body mesh to generate the second, updated augmented image showing the apparel-specific action (e.g., an unbuttoned shirt, a folded collar, an adjusted waistband) completed in real time.

6.3 Innovative Elements:

What Makes It Novel Compared to Prior Art?

Several innovative features distinguish this invention from earlier virtual try-on approaches (such as ARTag-based watch try-on, keypoint-based footwear try-on, facial-landmark based eyewear try-on, and 2D GAN-based clothing overlay, all acknowledged in the patent's own background section):

(1) **Stateful Sartorial Interaction** — the system interprets specific real-time actions (unbuttoning, folding a collar, adjusting a bra, closing a zipper) on the same virtual garment, rather than merely re-displaying a static overlay.

(2) **Wearable Apparatus Controller** — a glove-type pressure/vibration/motion sensing controller gives the user tactile, gesture-based control over the garment, closely mimicking physical manipulation of real clothing.

(3) **Cloth Constructors with Rule-Bound Freedom of Motion** — each garment sub-part (collar, sleeve, button, cuff) has a pre-defined shape/size/position and an explicit rule limiting its rotational/translational freedom, enabling physically plausible garment behavior.

(4) **SMPL-X-based 3D Body Mesh with a Novel "Mu" Movement Parameter** — the invention augments the SMPL-X pose/shape invoke function with an additional temporal-texture parameter ("µ") that tracks the garment's context-dependent temporal state (gender, style, material, texture) rather than only the human body's shape and pose.

(5) **Query Translator / Query Assimilator Pipeline** — a purpose-built "faux language compiler" and GRU-based spatio-temporal accumulator convert raw gestures, poses, and controller signals into structured, apparel-specific machine commands.

(6) **IUV (Inverse-UV) Recalibration via Shape Regressor and VAE-GAN** — garment texture and shape are recalibrated at the IUV-image level and mapped onto the user's UV body mesh, rather than warping a flat 2D garment photo.

(7) **Self-Supervised, Continuously-Adapting Measurement** — the system iteratively refines sartorial measurements in real time as the user moves, instead of relying on a single static measurement snapshot.

6.4 Technical Field:

Industry or Domain:

The patent belongs to an interdisciplinary technological domain spanning:

- **Augmented Reality (AR) and Mixed Reality** — real-time AR rendering of a virtual garment fitted on a live video image of the user.
- **Artificial Intelligence / Deep Learning** — CNNs, hourglass networks, GRUs, and VAE-GANs used for pose estimation, body-mesh generation, and garment rendering.
- **Computer Vision** — 3D human body-shape and pose estimation from monocular 2D video (SMPL-X framework).

- **E-Commerce / Retail Technology** — online "try before you buy" virtual fitting rooms integrated with a retailer's backend system.
- **Human–Computer Interaction (HCI) / Wearable Computing** — a glove-type haptic/pressure controller for gesture-based garment manipulation.
- **Video Game / Interactive Systems Technology** — reflected in its A63F (video game) classification for real-time interactive visual overlays.

Therefore, the patent can be classified broadly within the domains of AR/AI Fashion Technology, Computer Vision-based Body Measurement, Neural-Network based Garment Rendering, E-Commerce Virtual Fitting Rooms, and Wearable Human–Computer Interaction.

7. DETAILED DESCRIPTION OF THE INVENTION :

The invention titled "System and Method for Real-Time Calibration of Virtual Apparel Using Stateful Neural Network Inferences and Interactive Body Measurements" introduces a comprehensive system and method for enabling a user to try on, fit, and interactively modify a virtual apparel on their own body in real time using AR and AI techniques.

The invention operates through a Virtual Clothing Interaction (VCI) application comprising a Retailer Module (backend, 102) and a User Module (frontend, 104), which together facilitate a customer's real-time interactions with a virtual apparel (Figure 1). The overall system architecture (Figure 2) comprises a Host System (retailer system or third-party platform, 202), User Equipment (UE, 204), a communication network (206), and an optional Bluetooth-connected apparatus controller (600) worn by the user (212).

The process (Figures 3A–3B) begins with the computing system wirelessly obtaining the user's sartorial measurements — not merely standard clothing sizes but a rich set of body dimensions (waist, shoulder length, hip, wrist, neck width, and more) — by having the user rotate in front of the device camera. A real-time image of the user is then displayed with a virtual apparel fitted on the corresponding body portion, generating an "augmented image" of the user. The system interprets, in real time, any sartorial interaction by the user with the virtual apparel to predict the apparel-specific action intended (as if the user were actually wearing the apparel) and then displays the augmented image with the virtual apparel modified accordingly.

The Order/Measurement pathway (Figures 4, 5A–5C) shows the Measurement Server (402) and Motion/Pose Estimator (403) generating a 3D body mesh and joint map from continuously captured 2D video frames, using a convex hull constructed from key points (24 to 73 depending on the embodiment) and calculated body-part depth (via LiDAR or stereo/monocular depth estimation). The system supports a "measurement mode" in which the user can view and adjust their raw measurements (e.g., preferring the waist measured two inches above standard) before the augmented image is generated.

The interaction pathway (Figures 6A–6C, 7A–7B) shows the optional Apparatus Controller (600) — a glove worn over the fingertips and wrist containing a pressure sensor, vibration/motion sensor, control unit, Bluetooth interface, and LED/haptic output — sensing the user's finger pressure and hand motion. These signals are relayed to the Query Translator (409), which deconstructs them (together with camera and UI inputs) into structured commands (DOMAIN, ACTION EFFECT, ROTATION, CONCATENATE, INFER, PREPARE) that are sent to the Query Assimilator (404, using GRUs for spatio-temporal segmentation) and then to the AR Server (405).

The AR Server (Figure 7A) — comprising an inference module, a shape regressor (hourglass network), a VAE-GAN, an IUV container, and a rendering unit — recalibrates the Inverse-UV (IUV) images of the virtual apparel's "cloth constructors" (collar, button, cuff, sleeve, etc., each governed by pre-defined shape/size/position and a rule limiting its freedom of motion) and maps the modified IUV images onto the user's 3D UV body mesh to generate a second, updated augmented image. Worked examples (Figures 8A–8C, showing pose transitions such as T-pose, wide-pose, and side-pose, and Figures 9A–9C, showing a user unbuttoning and folding a virtual t-shirt and pair of pants using the apparatus controller) demonstrate the query-translator script values (DOMAIN, ACTION, ROTATION, CONCATENATE Apparatus_pressure) that drive the real-time rendering.

Overall, the invention presents a highly integrated digital-mirror framework that converts a mobile device into a real-time AR fitting room, allowing the retailer to offer a virtual try-on experience that responds to the same statefulness, physicality, and controllability a shopper expects from trying on real clothing in a physical store.

8. CLAIMS OF THE INVENTION :

The patent "System and Method for Real-Time Calibration of Virtual Apparel Using Stateful Neural Network Inferences and Interactive Body Measurements" contains 18 claims: two independent method claims (Claims 1 and 15), one independent computer-program-product claim (Claim 17), and fifteen dependent claims that add further technical detail. The claims collectively protect the method, the underlying computing system operations, and a non-transitory computer-readable medium implementation of the invention.

Claim 1: Independent Claim — Core Method for Real-Time Virtual Apparel Interaction

The principal claim protects a method comprising:

- Wirelessly obtaining, by a computing system, sartorial measurements of a human user.
- Displaying a real-time image of the user with a virtual apparel fitted on a corresponding body portion of the user as per the sartorial measurements, thereby generating an augmented image of the user in real time.
- Interpreting, in real time, a sartorial interaction by the user with the virtual apparel in the augmented image to predict an apparel-specific action intended by the user as if the user were actually wearing the virtual apparel.
- Displaying, in real time, the augmented image of the user having the virtual apparel modified therein as per the apparel-specific action.

This independent claim establishes the fundamental concept of fitting a virtual garment on a live image of the user and then interpreting the user's real-time interaction with that same garment to visually update it, replacing the traditional static-overlay try-on model with a stateful, interactive one.

Claim 2: Form of the Augmented Image

Protects display of the augmented image as either a real-time video frame or a composited stack of video frames, objects, and likeness viewed as a single frame.

Claim 3: UV Body Mesh and Modified IUV Images

Protects the 3D body mesh being an ultraviolet (UV) body mesh and the display step comprising receipt of Inverse-UV (IUV) images of the virtual apparel and generation of modified IUV images by recalibrating the 3D Cartesian position of a cloth segment, the style, and the size of the apparel based on the predicted apparel-specific action and the cloth's texture/material information, followed by mapping the modified IUV images onto the UV body mesh.

Claim 4: Cloth Constructors and Freedom-of-Motion Rules

Protects receiving a set of "cloth constructors" (each with a pre-defined shape, size, and position) together with a corresponding set of rules defining a limitation on each constructor's freedom of motion, and generating IUV images representing the virtual apparel as composed of those constructors, recalibrated within their permitted freedom of motion.

Claim 5: User-Selectable Apparel Attributes

Protects allowing the user to choose the style, size, material, texture, and physics effects (e.g., gravity) of the virtual apparel, selecting an apparel with the chosen attributes, and displaying it fitted on the user.

Claim 6: Candidate Apparel Selection

Protects presenting a set of virtual candidate apparels dimensionally closest to the user's sartorial measurements, allowing the user to select one, and displaying the user-selected candidate fitted on the corresponding body portion.

Claim 7: Control-Unit-Based Interaction

Protects allowing the user to perform the sartorial interaction using a control unit (the apparatus controller), receiving the control unit's output in real time, and using it to predict the apparel-specific action.

Claim 8: Composition of the Control Unit

Specifies the control unit as comprising a pressure sensor, a vibration analyzer, a motion sensor, a processing unit that generates an output from these sensors, and an interface unit that wirelessly transmits the output.

Claim 9: Monitored User Behaviors

Protects monitoring at least one of: fingertip interaction with the virtual apparel, a change of user pose, rotation or tilting of the body, motion of the body portion, a gesture, a facial expression, or an audio expression — estimating the sartorial interaction from this monitoring and translating it into a set of executable commands representing the apparel-specific action.

Claim 10: Types of Apparel-Specific Action
Enumerates the apparel-specific action as one of: a change to a different type or different virtual apparel, a change of size or style, a modification of a portion or property of the cloth, or introduction of a virtual accessory.
Claim 11: Additional Control-Unit Interaction (Second Independent-linked Dependent Claim)
Further protects allowing the sartorial interaction via a control unit and receiving its output in real time to predict the apparel-specific action (an alternative recitation reinforcing Claims 7–9).
Claim 12: Measurement-Mode Graphics and Customization Options
Protects displaying real-time graphics allowing the user to view sartorial measurements mapped on the body and adjust them prior to generating the augmented image, and receiving/offering one or more customization options for the virtual apparel.
Claim 13: Clothing-Type-Specific Inference Models
Protects receiving a plurality of clothing-type-specific inference models (each defining behavior for a clothing type), determining the clothing type of the virtual apparel, selecting the corresponding model, and modifying the augmented image per that model in response to the apparel-specific action.
Claim 14: 3D Body-Mesh Reconstruction via Project-Predict-Deform ML Model
Protects generating a 3D body mesh of the user's body portion, estimating the user's temporal motion using a project-predict-deform based ML model to reconstruct the mesh in real time based on that motion and the apparel-specific action, and geometrically deforming the virtual apparel as per the reconstructed mesh.
Claim 15: Second Independent Method Claim
A parallel independent method claim protecting: determining sartorial measurements via a 3D body mesh and a map of vertices/joints; selecting a virtual apparel best fitting the user; generating a first AR dataset for a first real-time display of the fitted apparel; receiving an indication predicting an apparel-specific action from a sartorial interaction; and analyzing that indication to generate a second AR dataset enabling a second real-time display of the modified apparel.
Claim 16: Apparel-Specific Action Types (under Claim 15)
Mirrors Claim 10's enumeration of apparel-specific action types, dependent on Claim 15.
Claim 17: Independent Computer Program Product Claim
Protects a non-transitory computer-usable medium containing computer-readable program code that, when executed, causes a computing system to perform — in real time — wirelessly generating sartorial measurements, providing a best-fitting virtual apparel, displaying a video frame of the fitted apparel (an augmented video frame), allowing a sartorial interaction with the virtual apparel in that frame, interpreting it to predict an apparel-specific action, and displaying the augmented video frame with the apparel modified accordingly.
Claim 18: Apparel-Specific Action Types (under Claim 17)
Mirrors Claims 10 and 16's apparel-specific action enumeration, dependent on the computer program product of Claim 17.
Summary of the Claims:
The 18 claims collectively establish legal protection for a stateful, controller-and-gesture-driven AR/AI virtual apparel calibration platform. The claims cover: real-time sartorial measurement and 3D body-mesh/UV-mesh generation; augmented-image display as video frames or composited stacks; IUV-image recalibration of cloth constructors within rule-bound freedom-of-motion limits; user-selectable apparel attributes and candidate-apparel selection; a dedicated wearable control unit (pressure, vibration, and motion sensing); multi-modal behavior monitoring (fingertip, pose, gesture, facial, and audio); a taxonomy of apparel-specific actions; clothing-type-specific inference models; and an ML-based project-predict-deform body-mesh reconstruction pipeline — protected as a method (Claims 1–16), and equivalently as a computer program product (Claims 17–18).

9. CITATIONS & SIMILAR INVENTIONS:

9.1 Number of Citations in the Patent (Prior-Art References Cited):

The face of the granted patent (“References Cited — U.S. Patent Documents”) lists three prior-art references examined by the USPTO examiner during prosecution, all marked with an asterisk indicating that they were cited by the examiner:

Table 3: Citations to the Patent

S.no	Reference	Patent/Pub. No.	Classification	Date
1	Moody	US 11,062,508 B1	G06F 18/22	07/2021
2	Feld	US 2001/0026272 A1	A41H 3/007 (345/585)	10/2001
3	Wiesel	US 2019/0050427 A1	G06T 19/00	02/2019

As is typical for a solo-inventor patent, the cited prior-art list is short and narrowly scoped — covering a body-measurement/segmentation patent (Moody), an early garment-fit/CAD patent (Feld), and a 3D-model-manipulation/mixed-reality patent (Wiesel) — while the applicant's own detailed description additionally references (as incorporated academic literature rather than formal citations) the VIBE human-pose-and-shape-estimation paper (Kocabas, Athanasiou & Black, 2020) and the Stacked Hourglass Networks paper (Newell, Yang & Deng, 2016), which underpin the SMPL-X and hourglass-network components of the invention.

9.2 Number of Citations for the Patent (Forward/Citing Patents):

US 12,017,142 B2 was granted on 25 June 2024, and as of the present analysis (2026) it remains a comparatively recent grant; publicly available forward-citation data on Google Patents/USPTO PatentsView had not yet accumulated a substantial “cited by” list at the time of this study, which is consistent with the typical multi-year lag between a patent's grant and its accumulation of citing art. Given the fast-moving AR/AI virtual try-on space (illustrated by the 2024–2025 grants of related Snap Inc. and ByteDance patents shown in Table 1), forward citations for this patent are expected to grow as competing filings in stateful, controller-driven AR apparel interaction are prosecuted.

9.3 List of Similar Inventions:

Several related patents identified in the domain review (Table 1) and the patent's own background discussion are technologically related to the present invention. The most relevant are summarized below.

(1) US 12,062,146 B2 — Virtual Wardrobe AR Experience (Snap Inc.)
Focuses on an AR experience for browsing and virtually trying on a “wardrobe” of fashion items within a messaging/social platform. It emphasizes item-catalog browsing and social sharing rather than a stateful, controller-driven sartorial interaction pipeline.

(2) US 12,347,071 B2 — Virtual Clothing Changing Method and Apparatus (ByteDance/Douyin)
Describes 2D/3D virtual clothing-changing based on foot/body image and model data, oriented toward short-video/social-media clothing changes rather than an interactive, gesture-and-pressure-driven fitting-room experience.

(3) US 10,922,898 B2 — Resolving Virtual Apparel Simulation Errors
Addresses correction of simulation artifacts (e.g., mesh-primitive collisions) in virtual apparel draped on a body construct; it is complementary to the presently analyzed patent's cloth-constructor recalibration but does not address real-time user-driven sartorial interaction.

(4) US 9,905,019 B2 — Virtual Apparel Fitting Systems and Methods (SelfieStyler Inc.)
An earlier foundational virtual-fitting patent using garment and user images to determine fit; primarily a 2D image-fit approach, later extended by SelfieStyler's own follow-on patents.

(5) US 11,164,240 B2 — Virtual Garment Carousel (SelfieStyler Inc.)
Extends the SelfieStyler fitting approach to a browsable “carousel” of garments fitted on the user's image; oriented toward catalog navigation rather than stateful garment manipulation.

(6) US 12,067,214 B2 — Updating Avatar Clothing for a User of a Messaging System (Snap Inc.)
Focused on updating an avatar's clothing within a messaging application rather than a photorealistic AR overlay on the user's own live camera image.

(7) US 11,062,508 B1 — Moody (cited reference)
A body-measurement-estimation/segmentation patent (G06F 18/22) cited as prior art relevant to the measurement-server component of the present invention.

(8) US 2001/0026272 A1 — Feld (cited reference)
An early garment-fit/CAD-related application (A41H 3/007) cited as prior art relevant to sartorial-measurement-based garment sizing.

(9) US 2019/0050427 A1 — Wiesel (cited reference)

A 3D-model-manipulation/mixed-reality application (G06T 19/00) cited as prior art relevant to the AR rendering aspects of the present invention.
Analysis of Similarity:
The cited and reviewed inventions primarily focus on: 2D/3D garment-image warping and overlay; catalog-style browsing of virtual garments; avatar/messaging-based clothing updates; and correction of static mesh-simulation errors. In contrast, US 12,017,142 B2 distinguishes itself by integrating body measurement, pose estimation, a stateful query-translation/assimilation pipeline, a dedicated wearable pressure/motion controller, and IUV-based cloth-constructor recalibration into a single, tightly coupled real-time system — a combination not present as a whole in any single one of the reviewed prior-art or contemporaneous patents.

10. BASIC ANALYSIS :

10.1 Importance of the Invention:

The invention described in US 12,017,142 B2 is significant because it addresses several persistent limitations of conventional online apparel shopping and virtual try-on technology — namely the inability of static 2D overlays to convey realistic drape, fit, and garment behavior, and the resulting high rate of size-related returns in e-commerce apparel sales.
The invention is particularly important for the maturing AR/AI virtual-fitting-room industry because it transforms virtual try-on from a passive viewing experience into an interactive one, in which the user can manipulate the garment (unbutton, fold, adjust) exactly as they would in a physical store, closing much of the experiential gap between online and in-store shopping.
Furthermore, the invention anticipates future retail paradigms in which shoppers routinely calibrate garments on personalized 3D avatars of themselves before purchase, and in which the resulting sartorial-measurement data becomes a reusable digital asset across multiple retailers — a capability with significant implications for mass customization, size-recommendation engines, and the broader "digital fashion" and metaverse-commerce ecosystems.

10.2 Description of the Invention:

The invention provides a comprehensive framework for real-time AR/AI virtual apparel try-on and interaction. The system begins when the user's device camera captures rotational 2D video of the user, from which a 3D body mesh and joint map are generated. A virtual apparel dimensionally closest to the user's sartorial measurements is fitted onto the corresponding body portion in a live augmented image.
The architecture consists of multiple interconnected modules — a Measurement Server, a Motion/Pose Estimator, a Query Assimilator, and an AR Server on the backend, and a Camera Module, UI Module, Query Translator, and Client Application on the frontend — supported by an optional wearable Apparatus Controller. The invention supports rich sartorial interactions (unbuttoning, folding a collar, adjusting a waistband) that are sensed, interpreted, and rendered back to the user within real-time (or near-real-time) latency, updating the augmented image so that the virtual apparel visibly reflects the user's intended action.

10.3 Design Analysis (Technology, Easiness, Cost, Reliability, Resource Availability, Durability):

A. Technology:
The invention combines multiple advanced technologies: SMPL-X based 3D body-mesh generation, deep CNNs and hourglass networks for pose/shape estimation, GRUs for spatio-temporal query assimilation, VAE-GANs for IUV texture recalibration, LiDAR/stereo depth sensing, and Bluetooth-linked wearable sensing (pressure, vibration/motion). This combination represents a sophisticated cyber-physical AR/AI system rather than a single-technique solution.
B. Easiness:
From the user's perspective, the system is designed to be as simple as rotating once in front of a smartphone camera and then interacting naturally with the displayed garment using fingers, gestures, or an optional glove controller; the underlying measurement refinement, query translation, and AR rendering are fully automated and hidden from the user.
C. Cost:
Costs include the retailer's investment in hosting the Measurement Server/AR Server infrastructure, training and maintaining the deep-learning models (CNNs, hourglass networks, VAE-GANs), and — if

offered — manufacturing and distributing the optional wearable controller; however, these are offset by savings from reduced apparel returns, reduced re-stocking labor, and improved conversion rates, and the controller itself is explicitly described as optional (gestures/voice/facial expression may substitute for it).

D. Reliability:

Reliability is enhanced through continuous, iterative refinement of body measurements as the user moves (rather than a single static snapshot), moving-average error correction in the web-socket layer, and a modular pipeline in which the Query Assimilator provides ongoing feedback to the Query Translator to improve future interpretations of the user's actions.

E. Resource Availability:

The invention is designed to run on widely available consumer hardware — smartphones with an RGB camera and, optionally, a LiDAR sensor (e.g., recent iPhone models) — with heavier neural-network inference offloaded to cloud/server-side GPUs (e.g., NVIDIA ResNet-class GPUs), making the client-side resource footprint modest.

F. Durability:

The durability of the system lies in its modular software architecture rather than in any specific hardware component: new clothing-type-specific inference models, new cloth constructors, or new sensing modalities (e.g., AR-glasses controllers as an alternative to the glove) can be added without redesigning the overall pipeline, making the invention adaptable as AR/AI technology and consumer devices evolve.

10.4 New Innovations & Value Addition in the Patent:

(1) Stateful, Interactive Try-On
Unlike static overlay systems, the invention lets the user perform real, garment-specific actions (unbutton, fold, adjust) on the same virtual garment, closely replicating a physical fitting-room experience.

(2) Wearable Pressure/Motion Controller
The glove-type apparatus controller adds a tactile, gesture-based control layer largely absent from competing virtual try-on patents, while remaining optional so the system also works via gestures, voice, or facial expression alone.

(3) Rule-Bound Cloth Constructors
Modeling each garment sub-part (collar, sleeve, button, cuff) with a defined shape/size/position and an explicit freedom-of-motion rule enables physically plausible, retailer-authorable garment behavior.

(4) Extended SMPL-X with Temporal Texture Parameter (μ)
Augmenting the standard body pose/shape model with a garment-context-aware temporal parameter allows the system to jointly reason about body motion and cloth behavior (drape, wrinkle, texture) rather than body shape alone.

(5) Query Translator / Assimilator Pipeline
A dedicated "faux language compiler" plus GRU-based spatio-temporal accumulator provides a reusable, extensible mechanism for turning heterogeneous user inputs (gesture, voice, controller pressure, facial expression) into structured, apparel-specific commands.

(6) Continuous, Self-Correcting Measurement
Ongoing, moving-average-corrected body measurement throughout the try-on session (rather than a single static capture) improves fit accuracy as the user naturally moves.

Overall Assessment: The patent is a comprehensive invention that extends AR virtual try-on beyond passive image overlay into a genuinely interactive, controller-and-gesture-driven fitting-room experience, establishing a technically rich framework for personalization, fit-accuracy improvement, and return-rate reduction in online apparel retail.

11. STRUCTURAL ANALYSIS :

11.1 SWOC Analysis:

About SWOC Analysis:

SWOC analysis — a variant of the traditional SWOT framework that substitutes Challenges for external Threats — provides a structured way to evaluate an innovation by examining its internal Strengths and Weaknesses alongside external Opportunities and Challenges (Aithal & Suresh Kumar, (2015) [21];

Aithal, (2016) [22]). It has been widely applied to analyze institutions, business strategies, and technology systems (Gupta, (2013). [23]; Aithal & Suresh Kumar, (2015). [21]), and Aithal and Aithal (2018). [28] specifically recommend SWOC as a stage within the patent-analysis procedure to assess an invention's realizability. Applying SWOC to a patented invention allows the analyst to separate factors intrinsic to the technology (its design strengths and technical weaknesses) from factors extrinsic to it (market opportunities and competitive/regulatory challenges), producing a balanced strategic picture rather than a purely technical description (Porter, (1985). [24]; Bhattacharya, (2004). [25]). This framework is particularly suited to emerging AR/AI technologies, where rapid external change (competitor entry, hardware evolution) can matter as much as the invention's internal design (Daim et al., (2006). [26]). For the present patent, SWOC analysis helps identify not only what the invention does well technically, but also whether prevailing market, infrastructure, and regulatory conditions are favorable for its commercial realization (Lee et al., (2009). [27]). The following sub-sections apply this framework, in the form of six Strengths, six Weaknesses, six Opportunities, and six Challenges, to US 12,017,142 B2.

SWOC Analysis of the Patent:

1. Strengths of the Patent:

- **(1). Genuinely Stateful Interaction:** The patent enables real garment-specific actions (unbuttoning, folding, adjusting) on the same virtual apparel, going beyond passive 2D overlay try-on.
- **(2). Rich, Multi-Modal Input:** Fingertip pressure, gesture, voice, facial expression, pose rotation, and an optional wearable controller are all supported as interaction channels, broadening accessibility across device capabilities.
- **(3). Physically Plausible Rendering:** Rule-bound cloth constructors and an extended SMPL-X/IUV pipeline allow realistic drape, folding, and texture behavior rather than flat image warping.
- **(4). Modular, Extensible Architecture:** Clear separation between Measurement Server, Pose Estimator, Query Assimilator, and AR Server allows new garment types, sensing modalities, or inference models to be added independently.
- **(5). Continuous Self-Correcting Measurement:** Iterative, moving-average-corrected body measurement throughout the session improves fit accuracy over a single static snapshot approach.
- **(6). Consumer-Hardware Compatibility:** Designed to run on ordinary smartphones (RGB camera, optional LiDAR) with heavy inference offloaded to server-side GPUs, lowering the barrier to retailer and consumer adoption.

2. Weaknesses of the Patent:

- **(1). Dependence on Accurate Body-Mesh Generation:** Fit accuracy and rendering realism depend heavily on the quality of the 3D body mesh, which can degrade under poor lighting, loose clothing, or occlusion during the measurement rotation.
- **(2). Optional Controller Adds Friction:** While optional, the richest interactions rely on a purpose-built wearable glove controller that consumers must obtain and learn to use, which may reduce adoption relative to controller-free alternatives.
- **(3). Computationally Intensive Backend:** Real-time CNN, hourglass-network, GRU, and VAE-GAN inference requires meaningful server-side GPU capacity, raising the retailer's infrastructure cost.
- **(4). Solo-Inventor Patent with Limited Citation Base**: As an individually filed patent (rather than a corporate portfolio filing), it may have fewer resources behind enforcement, licensing outreach, and continuation filings than patents from Snap Inc., ByteDance, or SelfieStyler.
- **(5). Narrow Prior-Art Citation Set:** Only three cited references appear on the patent's face, which may make certain claim scopes more vulnerable to later-discovered prior art in litigation or re-examination.
- **(6). Garment-Type Coverage Requires Ongoing Model Training:** Each new clothing-type-specific inference model (per Claim 13) must be trained and validated separately, creating an ongoing content/engineering burden as garment catalogs expand.

3. Opportunities for the Patent:

- **(1). Growth of AR Shopping and the Metaverse:** Expanding consumer comfort with AR filters, virtual avatars, and metaverse commerce creates fertile ground for stateful virtual fitting-room adoption.
- **(2). Integration with AR Glasses/Headsets:** The patent explicitly contemplates oculus-style controllers as an alternative to the glove, positioning it for integration with emerging consumer AR/VR headsets.
- **(3). Reduction of Apparel Return Rates:** E-commerce apparel returns remain a major cost center for retailers; a more realistic, interactive fitting experience directly targets this pain point.
- **(4). Licensing to Established Retail-Tech Platforms:** The modular architecture is well suited for licensing to e-commerce platforms, marketplaces, or SaaS/PaaS retail-technology providers seeking a differentiated try-on feature.
- **(5). Extension to Wearables, Footwear, and Accessories:** The cloth-constructor and IUV recalibration concepts could be extended beyond apparel to shoes, bags, and jewelry try-on.
- **(6). Data-Driven Size Recommendation Products:** Aggregated, anonymized sartorial-measurement data collected across sessions could seed a separate size-recommendation or virtual-tailoring product line.

4. Challenges of the Patent:

- **(1). Intense Competition from Well-Resourced Incumbents:** Snap Inc., ByteDance/Douyin, and SelfieStyler all hold competing virtual try-on patents (Table 1) with substantial engineering and marketing resources.
- **(2). Rapid Technological Change in Generative AI:** Fast-moving diffusion- and transformer-based generative image/video models could soon offer simpler, training-light alternatives to the patent's GAN/CNN/GRU pipeline.
- **(3). Hardware Fragmentation:** Reliance on LiDAR or good stereo/monocular depth estimation means fit-accuracy may vary significantly across the diverse smartphone hardware installed base.
- **(4). User Privacy and Biometric Data Concerns:** Continuous capture of body measurements and video, even if anonymized, raises data-privacy and biometric-regulation considerations (e.g., BIPA-type statutes) that retailers must navigate.
- **(5). Retailer Integration Complexity:** Deploying the Retailer Module, garment-content pipeline (cloth constructors, rules, IUV assets), and database infrastructure requires nontrivial retailer-side engineering investment.
- **(6). Consumer Willingness to Use a Wearable Controller:** Even though optional, achieving the patent's most differentiated (tactile) interactions may require consumers to adopt an additional wearable accessory, a known adoption barrier for niche hardware.

Overall SWOC Assessment:

The patent demonstrates strong strengths in interactivity, physical plausibility, and modular design, making it a technically distinctive invention in the AR/AI virtual apparel try-on space. While weaknesses around measurement dependency, computational cost, and controller adoption are notable, the opportunities presented by growing AR/metaverse commerce and apparel-return-cost pressures are substantial, and the challenges — chiefly competitive intensity and rapid generative-AI evolution — are manageable through continued innovation, licensing partnerships, and integration with emerging AR hardware.

11.2 ABCDEF Analysis of the Patent:

ABCDEF Analysis — an acronym for Advantages, Benefits, Constraints, Disadvantages, Effectiveness, and Future financial value — is an extension of the ABCD analysis technique (Aithal, Shailashree & Suresh Kumar, (2015) [29], (2016) [30]) and is used by Aithal and Aithal (2018) [28] as the core qualitative framework for patent analysis. Unlike SWOC, which separates internal versus external factors, ABCDEF evaluates a patent from the perceptual frame of reference of its various stakeholders — customers, retailers, manufacturers, and technology partners — across six distinct analytical constructs. Advantages and Benefits capture the invention's positive strategic features and the direct value stakeholders realize from them, respectively, while Constraints and Disadvantages capture the limitations and negative consequences stakeholders may face during implementation. Effectiveness evaluates how well the invention performs its intended function in practice, and Future financial value estimates the invention's prospective commercial worth across the stakeholder ecosystem [31-38]. Applying all six constructs together, as done below for US 12,017,142 B2, provides a comprehensive, multi-perspective evaluation that goes beyond a single-dimension SWOC assessment.

(i) Advantages of the Patent from Stakeholders' Perception:

Under the ABCDEF framework, the Advantages dimension evaluates the positive features and strategic strengths perceived by stakeholders such as customers, retailers, manufacturers of wearable controllers, and AR/AI technology partners.

Table 4: Advantages of the Patent from Stakeholders' Perception:

S.No	Key Advantage	Description
1	**Truly Interactive Fit Verification**	Customers can manipulate the virtual garment (button, fold, adjust) to genuinely assess fit and behavior before purchase, unlike passive overlay try-on.
2	**Personalized, Continuously-Refined Measurements**	Retailers benefit from progressively more accurate, session-specific sartorial measurements rather than one-time static capture.
3	**Modular Retailer Integration**	The clear Retailer/User module split and REST/WebSocket interfaces let retailers integrate the system as SaaS, PaaS, or a licensed platform without redesigning their own storefront.
4	**Hardware-Optional Accessibility**	Since gestures, voice, and facial expression can substitute for the physical controller, the invention remains usable across a wide range of consumer devices.
5	**Extensible Garment Modeling**	Cloth constructors and clothing-type-specific inference models allow retailers to progressively expand supported garment types without re-architecting the core system.
6	**Realistic Physics-Aware Rendering**	Gravity, texture, and material-aware rendering (via the VAE-GAN and shape regressor) produce a more believable augmented image than simple 2D warping.

Table 5: Summary of Advantages from Key Stakeholders' Perspective

Stakeholder	Key Advantage Perceived
Customers/Shoppers	Genuinely interactive fit verification — manipulate garments (button, fold, adjust) before purchase, unlike passive overlays
Online Apparel Retailers	Modular, SaaS-ready architecture that integrates with existing storefronts via REST/WebSocket interfaces
AR/AI Technology Partners	Extensible garment-modeling framework (cloth constructors + clothing-type-specific inference models) for ongoing platform development
Wearable Hardware Manufacturers	Defined use case for a consumer AR wearable (apparatus controller) that seeds a broader interaction-hardware market
Fashion Brands / Designers	Physics-aware rendering (gravity, texture, material) produces realistic garment behavior for brand presentation
E-Commerce Platforms / Marketplaces	Hardware-optional accessibility ensures broad consumer reach across diverse device capabilities

(ii) Benefits of the Patent from Stakeholders' Perception for Realization:

Within the ABCDEF framework, Benefits refer to the direct value, utility, and positive outcomes stakeholders experience through implementation and use of the patented technology.

Table 6: Benefits of the Patent from Stakeholders' Perception for Realization

S.No	Key Benefit	Description
1	**Reduced Return Rates for Retailers**	More accurate, interactive fit verification is expected to lower the proportion of apparel returned due to poor fit, directly reducing reverse-logistics costs.
2	**Improved Customer Confidence and Conversion**	Customers gain greater purchase confidence from seeing and manipulating the garment on their own body, improving online-to-purchase conversion rates.
3	**Reusable Digital Body-Measurement Asset**	Once captured, a user's sartorial measurements can, in principle, be reused across sessions and (with consent) across integrated retailers, reducing repeat measurement friction.
4	**Differentiated Retail Offering**	Retailers deploying the system gain a technically differentiated "try-before-you-buy" feature relative to competitors using only static overlay try-on.
5	**Data for Merchandising and Sizing Insights**	Aggregated interaction data (e.g., which sizes/styles customers frequently readjust) can inform merchandising, sizing charts, and product design.
6	**Foundation for Wearable-Controller Ecosystem**	Manufacturers of AR accessories benefit from a defined use case (the apparatus controller) that can seed a broader wearable-interaction hardware market.

Table 7: Summary of Benefits from Key Stakeholders' Perspective

Stakeholder	Key Benefit Realized
Online Apparel Retailers	Reduced return rates and reverse-logistics costs through more accurate, interactive fit verification
Customers/Shoppers	Improved purchase confidence and reduced post-purchase regret from seeing and manipulating garments on their own body
Fashion Brands / Designers	Differentiated "try-before-you-buy" retail offering that strengthens brand engagement and conversion
Data Analytics Firms	Aggregated interaction data (size adjustments, style preferences) informs merchandising and sizing insights
Wearable Hardware Manufacturers	Foundation for a wearable-controller ecosystem with defined consumer use case
Multi-Retailer Platforms	Reusable digital body-measurement asset reduces repeat measurement friction across integrated retailers

(iii) Constraints of the Patent from Stakeholders' Perception for Realization:

Within the ABCDEF framework, Constraints represent the limitations, restrictions, operational dependencies, and adoption barriers that may affect successful implementation of the patented technology.

Table 8: Constraints of the Patent from Stakeholders' Perception for Realization:

S.No	Key Constraints	Description
1	**Dependence on Camera/Sensor Quality**	Fit accuracy depends on the quality of the user's camera, lighting, and (where used) LiDAR/stereo depth sensing, which varies across the consumer device installed base.
2	**Requirement for GPU-Backed Server Infrastructure**	Real-time CNN/hourglass/GRU/VAE-GAN inference requires retailers to provision or rent meaningful GPU compute capacity.

3	**Optional Controller Adoption Constraint**	Achieving the richest tactile interactions requires the customer to obtain and wear an additional physical accessory.
4	**Garment-Content Authoring Burden**	Retailers must define cloth constructors, freedom-of-motion rules, and clothing-type-specific inference-model training data for each new garment category.
5	**Network Dependency**	Continuous bi-directional communication (WebSockets/REST) between the UE and host system means poor connectivity can degrade the real-time experience.
6	**Biometric/Body-Data Handling Requirements**	Collecting and processing body-measurement and video data obliges retailers to implement appropriate privacy safeguards and comply with regional biometric-data regulations.

Table 9: Summary of Constraints from Key Stakeholders' Perspective

Stakeholder	Key Constraint Faced
Customers/Shoppers	Dependence on camera/sensor quality — fit accuracy varies with lighting, device capability, and LiDAR availability
Online Apparel Retailers	Requirement for GPU-backed server infrastructure to support real-time CNN/GRU/VAE-GAN inference
Customers (Controller Users)	Optional wearable controller adds an adoption barrier for the richest tactile interactions
Fashion Brands / Designers	Garment-content authoring burden — cloth constructors, freedom-of-motion rules, and inference models must be defined per garment category
Mobile/Remote Users	Network dependency — continuous bi-directional WebSocket communication means poor connectivity degrades the experience
Compliance/Legal Teams	Biometric/body-data handling requirements under regional privacy regulations (e.g., BIPA-type statutes)

(iv) Disadvantages of the Patent from Stakeholders' Perception for Realization:

Within the ABCDEF framework, Disadvantages refer to the negative consequences, operational drawbacks, and strategic risks that may arise despite the invention's technical strengths.

Table 10: Disadvantages of the Patent from Stakeholders' Perception for Realization:

S.No	Key Disadvantage	Description
1	**High Initial Engineering and Infrastructure Cost**	Retailers face non-trivial upfront investment in server-side ML infrastructure, garment-content pipelines, and (optionally) controller hardware before realizing return-rate benefits.
2	**Risk of Inconsistent Experience Across Devices**	Variation in camera quality and depth-sensing capability across smartphones may cause inconsistent fit-accuracy and rendering quality for different customers.
3	**Learning Curve for Wearable Controller Use**	Customers unfamiliar with gesture/pressure-based garment manipulation may face an initial learning curve, potentially reducing early engagement.
4	**Ongoing Model Maintenance Burden**	As garment catalogs and fashion trends evolve, clothing-type-specific inference models require continual retraining and validation.
5	**Potential Consumer Data-Privacy Concerns**	Continuous body-measurement capture, even where anonymized, may raise consumer trust concerns that slow adoption in privacy-sensitive markets.
6	**Solo-Inventor Enforcement Limitations**	As an individually held patent, enforcement, licensing negotiation, and defense against larger corporate competitors may be resource-constrained relative to Snap Inc. or ByteDance's patent portfolios.

Table 11: Summary of Disadvantages from Key Stakeholders' Perspective

Stakeholder	Key Disadvantage Perceived
Online Apparel Retailers	High initial engineering and infrastructure cost before return-rate benefits are realized
Customers/Shoppers	Risk of inconsistent experience across devices due to variation in camera quality and depth-sensing capability
New/Non-Technical Users	Learning curve for wearable controller use may reduce early engagement
Retailer Engineering Teams	Ongoing model maintenance burden as garment catalogs and fashion trends evolve
Privacy-Sensitive Consumers	Potential data-privacy concerns from continuous body-measurement capture, even where anonymized
Patent Holder (Individual Inventor)	Solo-inventor enforcement limitations relative to larger corporate patent portfolios (Snap, ByteDance)

(v) Effectiveness of the Patent from Stakeholders' Perception:

Within the ABCDEF framework, the Effectiveness dimension evaluates how successfully the patented invention performs in practical environments with respect to functionality, reliability, and real-time responsiveness.

Table12: Effectiveness of the Patent from Stakeholders' Perception:

S.No	Key Effectiveness	Description
1	**Real-Time Fit and Interaction Feedback**	The system effectively closes the loop between user action and visual feedback, mirroring the immediacy of trying on physical clothing.
2	**Accurate Iterative Body Measurement**	Continuous, moving-average-corrected measurement refinement improves fit accuracy as the user naturally moves during the session.
3	**Physically Plausible Garment Behavior**	Rule-bound cloth constructors and gravity/material-aware rendering produce apparel behavior that more closely matches real-world draping and folding than flat overlays.
4	**Multi-Modal Robustness**	Supporting fingertip, gesture, voice, facial-expression, and controller-based input gives the system multiple fallback channels if one modality is unreliable for a given user or device.
5	**Scalable Modular Architecture**	The Retailer/User module split and REST/WebSocket interfaces allow the system to scale across many retailers and garment catalogs without core redesign.
6	**Demonstrated Worked Examples**	The patent's own figures (e.g., unbuttoning a shirt, folding pants, T-pose to side-pose transitions) illustrate concrete, functioning end-to-end scenarios, evidencing practical reduction to practice.

Table 13: Summary of Effectiveness from Key Stakeholders' Perspective

Stakeholder	Key Effectiveness Observed
Customers/Shoppers	Real-time fit and interaction feedback — visual response mirrors the immediacy of trying on physical clothing
Retailers / Sizing Teams	Accurate iterative body measurement improves fit recommendations as the user naturally moves during the session
Fashion Brands / Designers	Physically plausible garment behavior (drape, fold, stretch) more closely matches real-world appearance than flat overlays
Users with Diverse Devices	Multi-modal robustness — multiple input channels (gesture, voice, controller, facial expression) provide fallback options

Platform Operators	Scalable modular architecture allows expansion across many retailers and garment catalogs without core redesign
Technical Evaluators / Examiners	Demonstrated worked examples (unbuttoning, folding, T-pose transitions) evidence practical reduction to practice

(vi) Future Financial Value of the Patent (Stakeholder Perspective):

The Future Financial Value dimension of the ABCDEF framework estimates the invention's prospective commercial worth as perceived by different stakeholder groups over time.

Table 14: Future Financial Value of the Patent (Stakeholder Perspective):

S.No	Key Future Value	Description
1	**Licensing to E-Commerce and Fashion-Tech Platforms**	The modular architecture is well positioned for SaaS/PaaS licensing to online apparel retailers and marketplace platforms seeking differentiated try-on features. Stakeholders benefited: patent holder, retail-technology licensees, e-commerce platforms.
2	**Reduction in Industry-Wide Return-Logistics Cost**	Wider adoption of accurate, interactive virtual fitting could meaningfully reduce the multi-billion-dollar apparel-return-logistics burden across the online retail sector. Stakeholders benefited: retailers, logistics providers, consumers.
3	**Foundation for Wearable AR-Interaction Accessories**	The apparatus controller concept could seed a new category of consumer AR wearables extending beyond apparel try-on into gaming and general AR interaction (reflected in the patent's own A63F video-game classification). Stakeholders benefited: hardware manufacturers, AR platform developers.
4	**Data Monetization via Sartorial Measurement Profiles**	Anonymized, aggregated body-measurement and interaction data could support new size-recommendation, mass-customization, or virtual-tailoring product lines. Stakeholders benefited: retailers, data-analytics firms, apparel manufacturers.
5	**Extension into the Metaverse and Digital Fashion**	As avatar-based commerce grows, the patent's stateful garment-interaction concepts could extend into persistent virtual-avatar wardrobes and digital-fashion marketplaces. Stakeholders benefited: metaverse platform operators, digital-fashion designers, consumers.
6	**Strategic Patent-Portfolio and Acquisition Value**	Given active patenting by Snap Inc., ByteDance, and SelfieStyler in this space, the patent itself may hold acquisition or cross-licensing value to larger platform companies seeking to strengthen their AR-commerce IP position. Stakeholders benefited: the individual patent holder, prospective acquirers, investors.

Table 15: Summary of Future Financial Value from Key Stakeholders' Perspective

Stakeholder	Key Future Financial Value
Patent Holder / Licensors	Licensing revenue from e-commerce and fashion-tech platforms seeking differentiated SaaS/PaaS try-on features
Online Retail Industry	Industry-wide reduction in multi-billion-dollar apparel-return-logistics costs through accurate virtual fitting
Wearable Hardware Manufacturers	Foundation for a new category of consumer AR-interaction accessories extending into gaming and general AR
Data Analytics / Personalization Firms	Data monetization via anonymized sartorial-measurement profiles for size-recommendation and mass-customization products
Metaverse / Digital Fashion Platforms	Extension into persistent virtual-avatar wardrobes and digital-fashion marketplaces as avatar-based commerce grows

Prospective Acquirers / Investors	Strategic patent-portfolio and acquisition value for larger platform companies seeking to strengthen AR-commerce IP position

11.3 Business Opportunities & Challenges:

Business Opportunities in the Industry Environment

The patent proposes an integrated ecosystem combining body measurement, AR rendering, and stateful garment interaction, opening several business opportunities:

(1). **AR Virtual Fitting-Room-as-a-Service:** Retailers can adopt the system as a licensed SaaS/PaaS feature to differentiate their online storefronts.

(2). **Return-Reduction Consulting and Analytics:** The measurement and interaction data generated can seed a separate size-fit analytics and return-reduction consulting business line.

(3). **Wearable AR-Controller Hardware Line:** The glove-type apparatus controller could be commercialized as a standalone AR-interaction accessory, extending beyond apparel into gaming and general AR use.

(4). **Digital Fashion and Metaverse Wardrobes:** The stateful garment-interaction model is directly transferable to persistent avatar wardrobes in metaverse and social platforms.

(5). **Mass-Customization and Made-to-Measure Apparel:** Precise, continuously-refined sartorial measurements could feed made-to-measure or mass-customization manufacturing pipelines.

(6). **Integration with AR Glasses and Headsets:** As AR glasses mature, the patent's explicit contemplation of oculus-style controllers positions it for licensing into next-generation AR hardware ecosystems.

Challenges in the Competitive Environment:

Despite strong potential, the patent faces several challenges in a highly competitive AR/fashion-technology environment:

(1). **Competition from Well-Funded Platforms:** Snap Inc., ByteDance/Douyin, and SelfieStyler hold competing virtual try-on patents backed by substantial engineering and distribution resources.

(2). **Rapid Advances in Generative AI:** Newer diffusion/transformer-based generative models may soon offer simpler alternatives to the patent's CNN/GRU/GAN pipeline, potentially eroding technical differentiation.

(3). **Device and Sensor Fragmentation:** Variable camera and depth-sensor quality across the smartphone installed base can produce inconsistent user experiences.

(4). **Consumer Adoption of Wearable Controllers:** Achieving the system's richest interactions may require customers to adopt an additional physical accessory, a known adoption barrier.

(5). **Data-Privacy and Biometric Regulation:** Handling of body-measurement and video data must navigate an increasingly strict global regulatory landscape around biometric data.

(6). **Retailer Integration Cost and Complexity:** Retailers must invest in garment-content authoring (cloth constructors, rules, inference models) and backend infrastructure before realizing benefits.

Thus, the patent presents a technically differentiated business model combining AR rendering, stateful garment interaction, and wearable sensing, whose commercial success will depend on effective retailer partnerships, continued technical refinement, and navigation of an increasingly crowded and fast-evolving competitive landscape.

11.4 Market and Business Value Estimation:

(1). Commercial Applications:

Real-world use cases suited to this invention include: online apparel retail try-on (shirts, t-shirts, pants, dresses); made-to-measure and mass-customization garment production; AR-based fashion-show and influencer/creator content tools; digital-fashion and metaverse avatar wardrobes; and training/simulation applications leveraging the wearable pressure/motion controller for general AR gesture interaction.

Business Value Rating: ★★★★☆ (High)

(2). Current Implementations:

As an individually held, recently granted patent (June 2024), there is no public evidence of large-scale commercial deployment of the complete patented system to date. However, individual elements of the described architecture — 3D body-mesh based virtual try-on, AR overlay rendering, and gesture-based garment interaction — are already commercially operational in various forms at companies such as Snap Inc. (AR Shopping/Wardrobe features), Zeekit (acquired by Walmart), and various fashion-tech startups, indicating strong technological readiness for the broader category even though the specific patented combination remains, at present, primarily at the IP-protection stage.

Business Value Rating: ★★★☆☆ (Moderate to High)

(3). Competitor Landscape:

The competitive landscape is active, with Snap Inc. (Virtual Wardrobe AR Experience, Avatar Clothing Update), ByteDance/Douyin (Virtual Clothing Changing), and SelfieStyler Inc. (Virtual Apparel Fitting, Virtual Garment Carousel) all holding recently granted patents in adjacent territory. The presently analyzed patent's competitive advantage lies in its stateful, controller-driven interaction layer and rule-bound cloth-constructor rendering, a combination not fully replicated by the other reviewed patents.

Business Value Rating: ★★★☆☆ (High, competitive intensity also high)

(4). Licensing Potential:

The patent's broad method and computer-program-product claims (covering the core measurement→display→interpret→modify workflow, independent of specific garment types) give it substantial licensing potential to e-commerce platforms, apparel marketplaces, AR hardware makers, and fashion-tech SaaS providers. Potential licensees include general e-commerce marketplaces, dedicated virtual-fitting-room SaaS vendors, and AR-glasses/controller manufacturers seeking a proven interaction model.

Business Value Rating: ★★★★☆ (High)

(5). Market Trends:

The patent sits at the intersection of several strongly growing domains: AR/AI-powered e-commerce, the broader digital-fashion and metaverse-commerce movement, growth in mass-customization demand, and continued consumer-hardware advances (LiDAR-equipped smartphones, emerging AR glasses). These converging trends are expected to sustain and grow the addressable market for stateful, interactive virtual apparel technologies over the next decade.

Business Value Rating: ★★★★★ (Very High)

Overall Business Value Assessment

Estimated Overall Business Value Score: 7.8/10 (Strong Commercial Potential). The patent possesses strong strategic and commercial value by combining AR rendering, AI-based body/pose estimation, and wearable-controller interaction into a single protectable framework relevant to the growing AR-commerce and digital-fashion industries, tempered by the practical realities of a solo-inventor filing competing against well-resourced corporate patent portfolios in the same space.

12. SUGGESTIONS :

12.1 Suggestions for Implementation:

(1). Offer a Controller-Free "Lite" Mode by Default

Prioritize gesture/voice/facial-expression interaction as the default experience, positioning the wearable controller as a premium add-on rather than a requirement, to reduce adoption friction.

(2). Cloud-Elastic GPU Backend

Deploy the Measurement Server and AR Server on auto-scaling GPU infrastructure to manage cost during demand spikes (e.g., seasonal sales) without over-provisioning.

(3). Expand Clothing-Type Inference Model Library via Transfer Learning

Use transfer learning across related garment types (e.g., shirts → jackets → dresses) to reduce the marginal training cost of each new clothing-type-specific inference model.

(4). Integrate Explainable Fit-Confidence Scoring

Surface a fit-confidence indicator alongside the augmented image so customers understand when sartorial measurements are uncertain (e.g., due to poor lighting or occlusion).

(5). Build a Privacy-by-Design Measurement Pipeline

Process body-measurement data with strict anonymization and on-device pre-processing where feasible, to proactively address biometric-data regulatory concerns.

(6). Extend the Apparatus Controller to AR Glasses
Prioritize integration with emerging consumer AR glasses/headsets to reduce reliance on a separate glove accessory over time.
(7). Partner with Return-Logistics-Sensitive Retailers First
Target retailers with the highest apparel-return costs (e.g., fast fashion, going out to formal wear) for initial deployment to maximize demonstrable ROI.

12.2 Suggestions for Related New Ideas & Patents:

A. AI-Driven Automatic Size Recommendation Engine

"System and Method for Cross-Retailer Size Recommendation Using Aggregated Sartorial Measurement Profiles" — predictive sizing across brands using anonymized historical fit-interaction data.

B. AR-Glasses-Native Sartorial Controller

"Gesture and Gaze-Based Virtual Apparel Interaction System for Head-Mounted Augmented Reality Devices" — replacing the glove controller with eye-gaze and hand-tracking sensors native to AR headsets.

C. Persistent Metaverse Wardrobe Platform

"Cross-Platform Persistent Virtual Wardrobe and Avatar Garment Interaction System" — extending the stateful interaction model to avatars usable across multiple metaverse/social platforms.

D. Made-to-Measure Manufacturing Bridge

"System for Converting Real-Time Sartorial Measurement and Interaction Data into Made-to-Measure Garment Production Instructions" — linking the invention's measurement pipeline directly to on-demand manufacturing.

E. Fit-Confidence and Uncertainty Visualization

"Method for Real-Time Visualization of Body-Measurement Confidence in Augmented Reality Virtual Try-On Systems" — surfacing measurement-uncertainty overlays to improve customer trust.

F. Privacy-Preserving On-Device Body Mesh Generation

"On-Device Federated Learning System for Privacy-Preserving 3D Body Mesh Generation in Virtual Apparel Applications" — reducing reliance on server-side transmission of raw video/body data.

12.3 Overall Recommendation:

The uploaded patent is not merely a virtual-try-on invention; it is a platform patent covering the complete real-time lifecycle of AR/AI garment interaction — from body measurement and 3D mesh generation, through stateful sartorial interpretation, to IUV-based recalibrated rendering. Retailers, AR hardware makers, and fashion-technology platforms are recommended to explore licensing or collaboration opportunities with the patent holder, while the inventor is encouraged to pursue continuation applications extending the wearable-controller concept to AR glasses and to strengthen the patent's forward-citation footprint through active licensing outreach in the fast-growing AR-commerce sector.

13. CONCLUSION & RECOMMENDATION :

The patent "System and Method for Real-Time Calibration of Virtual Apparel Using Stateful Neural Network Inferences and Interactive Body Measurements" (US 12,017,142 B2) represents a technically sophisticated innovation that integrates augmented reality, deep-learning-based body/pose estimation, wearable sensing, and neural-network-based garment rendering into a single stateful virtual try-on platform. Its central contribution — allowing a user to genuinely interact with, rather than merely view, a virtual garment in real time — addresses a well-documented gap in existing 2D-overlay virtual fitting-room technology and offers a credible path toward reducing the persistently high return rates that burden online apparel retail.

From a commercial and strategic perspective, the patent possesses meaningful market value and business potential across e-commerce apparel retail, mass-customization manufacturing, wearable AR accessories, and the emerging digital-fashion/metaverse economy, tempered by real constraints around measurement-hardware dependency, computational cost, and competition from well-resourced corporate patent portfolios (Snap Inc., ByteDance, SelfieStyler). To maximize the effectiveness and future value of the invention, it is recommended that the patent holder pursue transfer-learning strategies to reduce the cost of expanding clothing-type inference models, integrate the apparatus-controller concept with emerging AR glasses/headsets, adopt a privacy-by-design approach to body-measurement data handling, and actively pursue licensing partnerships with e-commerce platforms to accelerate commercial realization and strengthen the patent's competitive and citation footprint within the rapidly evolving AR/AI fashion-technology landscape.

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