Optimizing 3D Fashion CAD Software for Physically Disabled Populations

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Abstract

This research paper discusses avatar development and fitting of virtual garments in 3D fashion CAD software and its utilization for individuals with atypical morphologies and physical disabilities. Underdeveloped aspects of the software are discussed. Future research steps are proposed regarding how apparel software may be improved through interdisciplinary research.

Introduction

The increased use of 3D fashion CAD software due to COVID-19 and sustainability efforts necessitate consistent research on innovation possibilities. Further, companies desire to use this software because of its accuracy in product information, faster lead times, lower cost due to reduced physical sampling, and speed in the design and decision-making process (Barrie, 2015). 3D fashion CAD software has been utilized for ready-to-wear by brands such as Adidas and Levi's (BOF Team 2020), but also for digital couture like by The Fabricant (2021). Implementation of the software is limited because of the high cost and training investment. However, investment within this resource may lead to a competitive edge for brands. With 86% of garment manufacturing businesses seeing a drop in orders due to COVID-19 (Barrie, 2021), brands must pay attention to fit consistency to facilitate loyalty. Societal demand for inclusion of underrepresented groups also continues to grow which has also fostered growth in the adaptive apparel market. Adaptive apparel in the market today such as Tommy Hilfiger, Target's Cat & Jack line, and IZ Adaptive predominantly cater to individuals with a physical disability. According to the World Health Organization, about 15% of the global population has a disability. This market is expected to be worth $400 billion by 2026 (Gaffney, 2019).

There has been documented use of 3D fashion CAD software to design for individuals with a disability and atypical morphology in academia, but not in the industry. Due to the evidence above, investing in 3D fashion CAD software optimization for physical disability is an important task best pursued in an interdisciplinary manner. Below is a discussion of current platforms, virtual avatar formation, fitting issues, and virtual garment prototyping for physically disabled individuals.

Analysis and Synthesis of Relevant Facts, Data, and Literature

Current systems for 3D prototyping and fitting on virtual avatars include *3D Suite* (Optitex), *Modaris 3D Fit* (Lectra), *Vstitcher* (Browzwear), *Tuka3D* (Tukatech), *Accumark 3D* (Gerber), and *Clo3D* (Gill, 2015; Lee & Park, 2017). These systems are focused for apparel product development and go beyond general cloth simulation and animation. In each software, capabilities include drafting patterns, sewing and visualizing the garment, viewing garment pressure/tension maps, and integrating human body scans as the virtual avatar. Consistently across platforms, virtual avatar formation and fit have limitations and limited research conducted. This is influential on 3D development of apparel for individuals with disability.

Custom Virtual Avatar Formation

Each software above can create virtual avatars from body scans. The use of body scans often requires extra expertise as scans must be cleaned, holes filled, and slit areas redefined as scan information is missing. (Ballester et al., 2014). Preloaded avatars with changeable measurements are also available. There is no data available regarding the exact number of measurements that can be manually changed in each software. Alvanon, a global leader in body technologies for apparel, offers its dress forms as 3D avatars compatible with Browzwear, Clo3D, Lectra, Optitex, Gerber, Shima Seikei, Scanatic DC Suite, Toray, and Vidya (Alvanon, 2019). The Alvanon Body Platform contains over 6000 virtual bodies based off body scans of Alvanon's client fit models (Alvanon, 2019). In 2019, Tukatech also made 750 virtual fit models based on body scans available (Tukatech, 2019). Currently, there is no data on whether the representation of disabled bodies is present in either platform.

Kinematic skeleton development has allowed for adaptive 3D models of humans (Kozar et al., 2014), which has allowed for changes in body posture (Jevsnik et al., 2017). More specific animation has become a possibility, although the extent of the animation capabilities of avatars originating from body scans in different platforms is undetermined. Adobe Mixamo, an Adobe Creative Suite platform offering avatar creation, animations, and an automatic rigging service, can be used in conjunction with Clo3D. However, it is mainly oriented toward more game/movie design projects, with genres like combat, adventure, sport, dance, fantasy, and superhero. One wheelchair simulation was found on this service by the primary investigator. While the genres can support commercial, creative marketing endeavors for 3D simulations of apparel, the lack of data behind the motion subtracts support for functional accuracy. Daz 3D, a digital marketplace and 3D content space, has also been used for avatar design and animation purposes for apparel but is mainly utilized by digital artists and not for data-based modeling.

Fit

Often, research in the 3D apparel realm have focused on improving the simulation of fabric drape, but details of the avatar form such as body firmness, body fat distribution and fat pockets also have an influence on the final fit and simulation (Balach et al., 2020). Current avatars inaccurately represent these details which affects the final fit for consumers (Balach et al., 2020). Current 3D CAD software also does not allow for the creation of asymmetrical body shapes within the software-- a 3D body scan must be used to generate an accurate model (Balach et al., 2020; Bruniaux et al., 2016). This creates complications for the creation of avatars from disabled populations with asymmetric body types, such as individuals with scoliosis. Further, research shows that there are issues translating fit between virtual and physical environments possibly due to a range of factors, like "garment complexity, fabric visualization data, and type of virtual mannequin used" (Porterfield & Lamar, 2017, p. 321). In Zangue et al.'s study (2020), one design was simulated in three different 3D simulation programs. Virtually, sufficient ease was given, but in a physical environment the garment was too tight (Zangue et al., 2020). Further work must be conducted to accurately simulate body firmness, body fat distribution, fat pockets, and asymmetry to improve fit simulation. While limitations are present when it comes to 3D simulation, innovative outcomes are additionally evident.

Virtual Garment Prototyping for Disability Design

A few researchers have used body scanning and 3D simulation to create apparel for individuals with mobility impairments and atypical morphologies. Jevsnik et al. and Rudolf et al. investigated the suitability of body scanning and 3D CAD systems in developing ergonomic garments for wheelchair users (2017; 2017). A laser body scanner as well as two optical scanners were utilized at different angles and heights to create the final form. Additionally, they created a special chair for scanning that was vertically adjustable and had handles for the legs, arms, and head to support the balance of a hypothetical paraplegic when sitting. Jevsnik et al.'s kinematic skeleton supported visualization of different postures and designs for wheelchair athletes (2017).

Fig. 1. Virtual 3D simulation of garment and real prototype (Jevsnik et al, 2017; Rudolf et al, 2017).

Designs for scoliosis have also been created through body scanning and 3D CAD systems (Hong et al., 2017). An individual with scoliosis was body scanned, the 3D mesh was cleaned, Design Concept software was used to locate fit and fashion points, and a 3D garment wireframe was simulated which 2D patterns were based on (Hong et al., 2017).

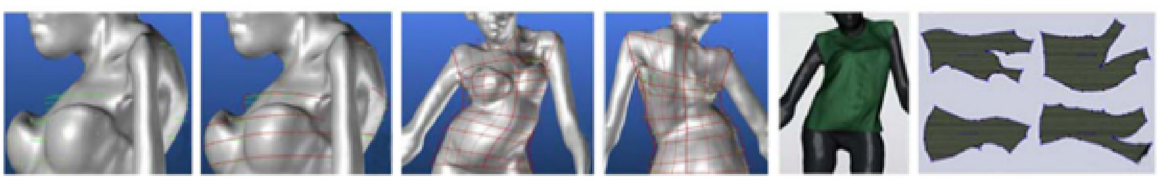

Fig. 2. Generation of 3D virtual garment (Hong et al., 2017).

In the studies above, accurate forms were created through body scans, reconstruction in 3D modelling software, and integration into a 3D CAD system. Jevsnik et al. demonstrated ability to visualize different postures, but no live animation capability was demonstrated. The studies were limited to the physical conditions of paraplegia and scoliosis. As can be noticed from these studies, the process of integrating disabled bodies into 3D simulation is time, resource, and skill intensive—body scanners, licenses for 3D software, custom chairs, skill with 3D modelling, and expertise in patternmaking are requirements for successful outcomes. Current animation resources come from computer graphics artists' resources which support visualization but are not founded on true human motion data. To further support designing adaptive clothing in 3D CAD systems for apparel, experts in apparel design, fit, computer graphics, human ergonomics, and more should come together. Recommendations are given below regarding interdisciplinary interaction.

Proposal for Future Action: Intersectional Potential

Expertise across many disciplines will make 3D fashion CAD systems for adaptive apparel accessible for designers and brands. As pointed out, there is a lack of motion simulations that accurately depict disabled individuals' body movements and posture. Future research should seek to integrate profiles of users requiring adaptive clothing into 3D fashion CAD systems. Ergonomics researchers have previously integrated individuals' profiles through a multivariate database that considers 3D anthropometry and the functional abilities of many people to facilitate inclusive design (Porter et al., 2004). Profiles had varying ages, abilities, shapes, sizes, and analysis of participants' ways of handling different tasks (Porter et al., 2004). These profiles included data from video recorded tasks regarding participant posture, coping behavior such as learning or kneeling, and reach range and were accessible for future ergonomics design (Porter et al., 2004).

For 3D fashion CAD systems, a similar system could be possible. Computer graphics artists, materials modeling specialists, and Alvanon could create different aged and sized users with body firmness relative to age and fat distribution and fat pockets based on body scans' average location. Researchers could further integrate motion and position profiles of disabled users in everyday tasks and postures influenced by disability. For example, these profiles may include walking with forearm crutches, gait affected by amputation, back curvature due to kyphosis, fine motion coordination with buttons, and arm range of motion after mastectomy. Further, if designers have individualized body scans, this data could be integrated with these pre-created avatars for more accurate simulation in future designs. After developing the aforestated profiles, interface designers may facilitate the creation of a customer co-design interface. This interface will have less technical detail available to the user and communicate fit and fashion ease with which the customer may provide feedback.

This paper has described the importance of innovating 3D fashion CAD systems for purposes of adaptive apparel design. Creating custom avatars, current fit issues, and cases of disability design in 3D fashion CAD systems are described. Recommendations include creating custom anthropometric-physiological-motion profiles for different ages, sizes, and abilities to facilitate inclusive design in 3D fashion CAD systems. If created, the research developments will make adaptive apparel more accessible for designers to create and accessible for individuals experiencing a disability to wear.

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