Dynamic body models and garments for apparel product development: A conceptual model

Fatma Baytar, Cornell University, USA
Arzu Vuruşkan, Izmir University of Economics, Turkey
Keywords: dynamic models, 3D/4D, apparel product development

Introduction In apparel product development, it is very important to understand body-garment relationships thoroughly to design a garment that provides both comfort and function to the wearer. During pattern development ease allowances are added to two-dimensional patterns to provide distance between garments and the stationary body (Lage & Ancutiene, 2017; Thomassey & Bruniaux, 2013). However, these pre-determined distances generate different results on individual body sizes and shapes, particularly when wearers move. Understanding dynamic body-garment interactions would transform apparel product development, because patterns designed with dynamic ease allowances in mind can increase the quality of garments and help better accommodate a wide range of motions (Ashdown, 2011). Digital product development and three-dimensional (3D) digital design technologies are gaining an accelerated importance in the apparel industry particularly during the COVID-19 pandemic. 3D body scanning has been widely used to capture one frame of a movement at a time to analyze body-garment interactions and inform patternmaking to improve garment sizing and fit (Song & Ashdown, 2010). Recently, four-dimensional (4D) technologies, which combine 3D body models with movements to represent time, have been gaining traction in the apparel industry as an innovative tool for product development (Klepser & Morlock, 2020).

4D technologies can allow users to analyze how body changes during movement and the ways clothing restricts body to perform tasks. At present, there are two approaches to generate 4D body models. The first approach is using cutting-edge 4D body scanners such as the ones developed by 3dMD (3dMD, 2021) and IBV **(**Alemany Mut et al., 2020**),** These scanners are currently not widely available and very expensive, therefore presenting a similar case to the early stages of 3D body scanners in 2000s. The second approach, which presents a much cheaper alternative to the first one, is rigging 3D body scans or parametric models by using a skeleton hierarchy and appropriate skinning weights to generate animations that would mimic certain range of motions (Feng, Rosenberg, & Shapiro, 2017). Virtual body pose, virtual motion, and virtual flesh could be included as optional compositions for simulated human bodies in 3D CAD systems (Kim et al., 2019). Unfortunately, the drawbacks in using these technologies include the lack of realism in body changes, as well as the ongoing challenges in simulating fabric and garment drape (Ancutiené, & Sinkevičiūtė, 2011; Hernández, Mattila, & Berglin, 2019). To improve these shortcomings of the simulated bodies and garments, current efforts include learning from 4D scan data to predict body-garment relationships that would ultimately allow merging movements on different body models (Pons-Moll et al., 2017). These studies would be not only useful for technical apparel designers, but also for online shoppers for virtual try-on.

Practical benefits of these 4D systems to apparel product development as well as their potential other uses still need clarification, which will depend on further improvements in computer graphics and hardware systems. Nonetheless, 3D/4D technologies hold great potential

for the future of apparel product creation, as well as presentation and retail. Therefore, within the Technological Components and Adoption (TCA) Framework, which postulates that the technology adoption success depends on how technological components interact with the adoption contexts/ environment where people are involved in the process (Leon, 1995), we propose a conceptual model (Figure 1) to categorize the use of dynamic models and garments in apparel product development, and offer suggestions for future research and teaching needs that would integrate innovative methods and technologies.

Conceptual Model In the proposed conceptual model, we summarize the uses and highlight the needs for the existing commercial software tools for animating avatars and garments not only for visualization purposes, but also to represent real fit, for the ultimate purpose of integrating such tools in apparel supply chain. However, there are gaps from the user perspective and a broad field exists for improvement. Our conceptual model examines the current use of dynamic avatars and garments in three categories: Creative design, fit evaluation & production and presentation and retail. Digital tools provide an integral approach for 2D/3D apparel design, where 3D/4D virtual tools create opportunities for understanding the garment-body interaction. The effective use of these tools enhances design, production, and presentation phases not only for active wear, protective, and functional clothing, but also for daily wear. Fit evaluations and, consequently, production chain would benefit from the realistic garment simulations in motion. This would partly replace real prototypes and result in quicker and more sustainable phases in apparel supply chain, thus reducing the costs. One of the categories in this model is the presentation of apparel to the customers in the supply chain and to end-users. For end users/customers, visual representations would carry more importance than the realization of garments in a virtual space. In this case, we envision that adaptation of these digital tools, which are originated from visualization rather than realizing garments, could be even a quicker process.

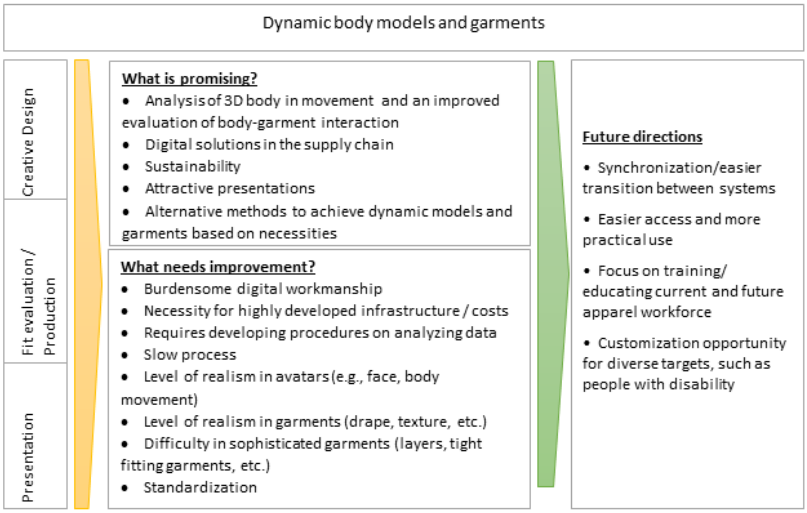

Figure 1. Conceptual framework for the use of animated models in apparel and the needs

Discussion and Implications The use of dynamic garments and avatars expands its borders not only in academia, but also in the apparel industry. With the recent necessities already happening during the pandemic, the use of digital tools in apparel industry is accelerating more than ever before. Adapting dynamic avatars in apparel product development will be one of the transformative steps toward designing for the active body. The proposed conceptual model draws a framework for the use of animated avatars for apparel product development and production phases and provides a foundation for future research and theory development. This framework would be useful to researchers in identifying the current advantages and the needs for further improvement of the animated avatars in 3D/4D CAD systems.

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