

## 4D Golf Apparel Wear Simulation for Improved Online Shopping Experience

Doyeon Kong and Heeju Terry Park

Cornell University

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**Introduction** Fit and sizing issues are challenging in online clothing shopping, but more information may help customers purchase items with fit and size confidence (Kaushik et al., 2020; Hajar et al., 2021). This qualitative study was designed to investigate a new way of visualizing apparel items using garment simulation where online customers can see human body-garment interactions and choose the right fit and size. Garment simulation has not been thoroughly scrutinized in fashion retail nor accessible to customers in the market yet. Therefore, this study aimed to examine how online customers react to garment simulation in finding the right fit and size in an attempt to reduce online returns, focusing on golf apparel where human body-garment interactions are essential.

**Method** This study adopted semi-structured interviews and surveying methods. The sample population was 13 female participants with ages ranging from 24 – 55 (age:  $41.6 \pm 9.8$  years), and ethical approval was obtained by the Institutional Review Board (IRB) before the study was conducted. In this study, three demo websites about a sample garment were used as stimuli: Demo A (static product images), Demo B (AI-driven model-generated garment simulation), and Demo C (fashion design software-based garment simulation). The AI-driven model-generated garment simulation featured a clothed avatar in numerous body motions. The fashion design software-based garment simulation displayed a clothed avatar in a golf stance-specific pose and rendered the animated avatar that reflected on the participants' body measurements. The order of demonstrations was controlled and statistically balanced (Suresh, 2011). The participants were asked to choose their size based on the information obtained from the demo websites and complete survey questions to measure the perceived usefulness of golf apparel wear simulation. Thematic analysis was utilized to identify repeated patterns of meaning from qualitative data, and each theme elicited from qualitative interview data was named 'Interactivity', 'Motion', 'Realism', and 'Fabric'.

**Results and Discussion** The findings of the study showed that ten participants (76.9%) favored the interfaces where simulations were available, and only three (23.1%) preferred the interface with static images. The most preferred interface was the one with fashion program-based simulations of the clothed avatar in a golf swing pose, followed by the one with AI-driven model-generated simulations with various body motions, and the typical fashion e-commerce interface with static product images. Online fashion retailers may refer to the following key considerations for the adoption of apparel wear simulation as an effective product display tool in the online shopping environment.

*Interactivity:* The main reason for the higher perceived usefulness of the golf stance-related simulation was interactivity. The participants provided positive feedback relating to this interactive interface where clothed avatars helped them judge how the garment will be fitted to the body based on their real sizes and choose their size more objectively. Adding the value of interactivity can also provide a hedonic

experience to online consumers, driving more traffic to the websites of online retailers (Kim & Niehm, 2009).

*Motions:* As golf involves dynamic upper body movements, the participants expected more room in the sleeve area and in the shirt hem for better mobility. The simulation interfaces displayed how the sample garment would behave according to natural body movements related to golf activities, so the participants found this information useful in judging the overall fit and size of the garment. The findings suggest that apparel wear simulation needs to be presented with one or two poses that are directly related to the end use of the apparel products with moderate speed to effectively display the mobility and fit of apparel items by body area.

*Realism:* The simulations appeared to smooth out the surface of the sample garment and ideally present the fabric features and structures, so the fabric was not simulated realistically. In addition, the lack of realistic simulation of the properties of garments, such as color, texture, and drape, seemed to make customers feel that product simulations on the screen were not reliable. Therefore, the physical properties of the garment fabrics need to be carefully investigated for a more realistic visualization of apparel items.

*Fabric:* Fabric was the most critical aspect that affected the participants' perceived realism in simulation, including colors and textures. Therefore, the physical properties of garment fabrics need to be carefully investigated for realistic visualization of garments. Additionally, a large database of information on the physical properties of fabrics available in the sportswear market needs to be developed and imported to fabric libraries in 4D garment wear simulation systems in the future, which will help improve the quality of fabric simulation in terms of texture, drape, and color.

**Conclusion** This study investigated the potential for the adoption of golf apparel wear simulation that can help online customers choose their fit and size with more confidence and ultimately reduce online returns. As the golf apparel wear simulation hasn't been thoroughly studied in academia nor applied to industry, the results of this study may serve as preliminary data to understand how online customers perceive golf apparel wear simulation in choosing their size. In addition, this study explored two different approaches to identify the pros and cons of golf apparel wear simulation: the data-driven model-generated simulation and the fashion design software-created simulation. The first approach featured various body motions trained on motion capture datasets, such as walking and bending. Thus, it is possible for fashion retailers to build on such a data-driven system and create clothed avatars based on countless body motions depending on their business needs. It may cost initial development, but it has benefits in terms of easy deployment and cost efficiency in the longer term. The second simulation was created using a fashion design software program. If apparel wear simulation can be further developed with various fashion design software programs, the simulation with detailed avatar and cloth features would help customers better assess the fit and size of apparel items in the online shopping environment. In addition, this study provided a blueprint for online retail businesses to optimize the current product displays and consequently improve returns management. The findings of this study suggest that retailers may refer to the key considerations for the increased adoption of golf apparel wear simulation as an effective sportswear product display tool, such as interactive interfaces, relevant motions, and realistic fabric simulation. Future research on apparel wear simulation for other sportswear, such as swimwear and compression garments, may also add a new perspective on wear simulation and potential applications.

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