PerfectFit: Custom-Fit Garment Design in Augmented Reality

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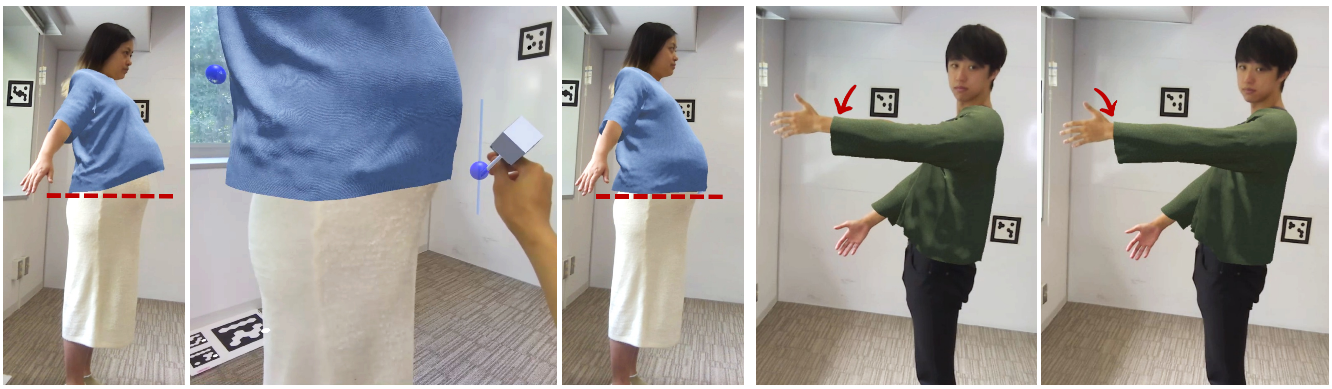

(a) (b) (c) (d) (e)

Figure 1: PerfectFit is an interactive AR garment design system for fitting garments based on individual body shapes. Two examples of custom-fit garment design using PerfectFit: the designer views the virtual garment on the clients in different poses from various viewpoints (a, d) to identify fitting issues. The designer adjusts garment size by a slider (b), extending the front panel for full coverage of the belly (c) and extending the sleeve to cover the wrist (e).

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1 INTRODUCTION

The mass production of garments under a standard size in the garment industry does not consider individual body shape differences, resulting in poorly-fitted garments and severe overproduction. Unfortunately, the traditional tailor-fitting process is time-consuming, labour-intensive and expensive. We present PerfectFit, an interactive Augmented Reality (AR) garment design system for fitting garments based on individual body shapes. Our system simulates the virtual garment reacting realistically to the client's body shape and motion, and displays stereoscopic images to the designer via the AR headset. This enables the designer to identify the garment fitting via the client's real-time motion from any viewpoint. Additionally, our system provides an editing interface to the designer which allows him/her to interactively explore the design space of the garment and adjust the fitting in situ. Our system then reflects the changes on the client's body.

Though existing computer-aided garment design methods [Brouet et al. 2012; Montes et al. 2020; Wang et al. 2005; Wolff et al. 2023] and professional software can support the designer to adjust the garment fits on a virtual predefined avatar via their PCs, this neglects the fact that estimating the garment fits or looks requires a situated experience on the real human body. Instead, leveraging the design in situ advantage of AR, our system allows the designer to interactively customize the fit garment on the client's real body and view the fitting of the new design immediately. Compared with existing projection [Saakes et al. 2016] or screen-based [Chong et al. 2021] mirror try-on systems, our system provides the designer stereoscopy scene stimulating the way humans perceive depth,which is essential for garment fitting evaluation. Additionally, our system uniquely enables the designer to change the shape of the virtual garment by simple interaction technique and we will bring a demonstration for visitors to Siggraph Asia 2023.

Visitor Experience For the exhibit, visitors will play the role of the *Designer* and interact with a person who plays the role of the *Client*. The visitor (*Designer role*) wears the AR headset and can view the garment fitting issue on the *Client*'s body. The visitor

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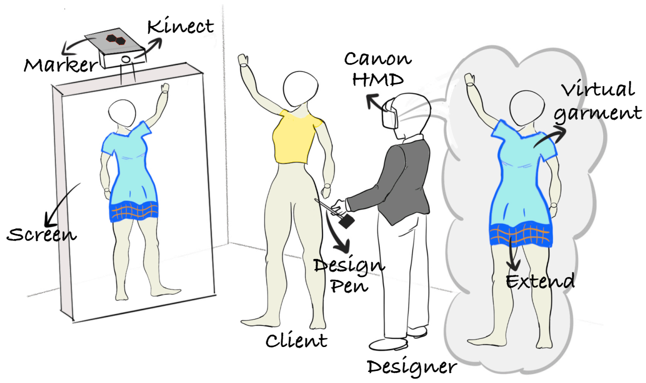


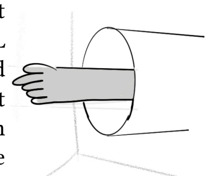
Figure 2: System overview. The designer extends the hem of the blue virtual dress for better coverage on client's body. The extended part is highlighted in dark blue with yellow stripes for illustration only.

can explore the garment design space freely, and the author will provide slight guidance to the visitor on where and how to edit the garment to achieve better fits when needed. Our system will give the visitor an immersive experience of customizing the garment like a tailor.

2 SYSTEM OVERVIEW

Hardware Setup We illustrate our system setup in Figure 2. The designer wears a Canon MREAL X1 [1] HMD which displays the rendered virtual garment on the client's body. And interact with the system using a 3D-printed plastic stick attached with a cube covered by five registration markers (termed as *design pen*). We use a Kinect v2 depth sensor to capture the pose of the client. On the top of the Kinect, we attach a registration marker used for inferring the Kinect's position in AR space. In addition, we use a screen to display the virtual garment on the client's body, which allows the client and audiences to see the current fit and provide feedback to the designer. We run our system on a desktop with Intel(R) Core(TM) i7-8700K 3.7GHz CPU and NVidia RTX 3080 Ti GPU.

Design and Implementation To simulate the virtual garment on a moving client, we adopt a strategy that creates a 3D avatar sharing the same body shape as that of the client and then simulates virtual clothing on it. In detail, we first calibrate the Kinect to precisely track the client's skeletal position and transfer it into the AR space. Combining the skeletal position with the client's height and weight, the SMPL model [Loper et al. 2015] is reconstructed to present the client's body shape. We simulate the garment that reacts to the user's body shape and motion by position-based dynamics method [Kahler 2021; Müller et al. 2007]. To correctly render the occlusion between the virtual garment and real human body represented by SMPL model (see inset), we render the real-world scene, SMPL model, and the virtual garment in this order whilst writing only the depth component of the frame buffer regarding the SMPL model.



[1] https://www.canon-its.co.jp/files/user/solution/mr/lp/

The garment editing, as the key function of our system, is designed as follows (see Figure. 1 (b)): the designer brings the design pen into the field of view to initiate the editing mode. Our system then shows a blue sphere around each garment semantic part (e.g., front panel, sleeve). The designer selects the desired sphere with the design pen to activate the editing functions. We use a one-dimension range slider for each editing parameter (e.g., length, width), which users can freely adjust to explore the design space in 3D and customize the design. Our editing interaction design mimics directly manipulating the virtual garment by hand akin to the traditional tailor-fitting process, but can reduce the body contact with the client. Technically, we utilize the blendshape method [Lewis et al. 2014] to parametrize the 3D garment shape with the range slider. We developed our system on the Unity platform.

3 CONCLUSION AND FUTURE WORK

This work presents an AR garment design system that supports the designer to realistically view the fitting of the garment for the client from any viewpoint by stereoscopic images, and the designer can interactively customize the fitting garment and view the changes. Our system showcases the advantages of AR in the fashion towards smart manufacturing.

In our current design, we focused on augmenting the designer and the client with visual effects. In the future, we plan to also augment them with haptic feedback via pressure sensing and interactive textiles technique. It will allow them to feel the fabric texture and the tightness of the garment. Additionally, we will investigate more system design considerations and functions together with professional fashion designers to support the creative garment design process for designers and the co-design process for both the designer and the client in the AR environment.

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REFERENCES

Remi Brouet, Alla Sheffer, Laurence Boissieux, and Marie-Paule Cani. 2012. Design preserving garment transfer. *ACM Transactions on Graphics* 31, 4 (2012), Article–No.

Toby Chong, I-Chao Shen, Nobuyuki Umetani, and Takeo Igarashi. 2021. Per Garment Capture and Synthesis for Real-time Virtual Try-on. In *The 34th Annual ACM Symposium on User Interface Software and Technology*. 457–469.

Christian Kahler. 2021. Cloth Dynamics. https://assetstore.unity.com/packages/tools/physics/cloth-dynamics-194408.

John P Lewis, Ken Anjyo, Taehyun Rhee, Mengjie Zhang, Frederic H Pighin, and Zhigang Deng. 2014. Practice and theory of blendshape facial models. *Eurographics (State of the Art Reports)* 1, 8 (2014), 2.

Matthew Loper, Naureen Mahmood, Javier Romero, Gerard Pons-Moll, and Michael J. Black. 2015. SMPL: A Skinned Multi-Person Linear Model. *ACM Trans. Graphics (Proc. SIGGRAPH Asia)* 34, 6 (Oct. 2015), 248:1–248:16.

Juan Montes, Bernhard Thomaszewski, Sudhir Mudur, and Tiberiu Popa. 2020. Computational design of skintight clothing. *ACM Transactions on Graphics (TOG)* 39, 4 (2020), 105–1.

Matthias Müller, Bruno Heidelberger, Marcus Hennix, and John Ratcliff. 2007. Position based dynamics. *Journal of Visual Communication and Image Representation* 18, 2 (2007), 109–118.

Daniel Saakes, Hui-Shyong Yeo, Seung-Tak Noh, Gyeol Han, and Woontack Woo. 2016. Mirror mirror: An on-body t-shirt design system. In *Proceedings of the 2016 CHI conference on human factors in computing systems*. 6058–6063.

Charlie CL Wang, Yu Wang, and Matthew MF Yuen. 2005. Design automation for customized apparel products. *Computer-aided design* 37, 7 (2005), 675–691.

Katja Wolff, Philipp Herholz, Verena Ziegler, Frauke Link, Nico Brügel, and Olga Sorkine-Hornung. 2023. Designing Personalized Garments with Body Movement. In *Computer Graphics Forum*, Vol. 42. Wiley Online Library, 180–194.