Developing a Wearable Technology Compression Shirt Prototype: Interdisciplinary Collaboration between Apparel Design and Mechanical Engineering

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Introduction

The development of garments with integrated wearable technology holds specific challenges related to the functionality and wearability of the clothing created, based largely on the disconnect between wearer comfort, movement, and stretch, and the restrictions imposed by wearable technology components. However, there are some garment design and construction techniques that can help to develop this garment-tech integration more effectively. This project describes the design research process for the creation of a fitted compression shirt designed to utilize flexible wearable sensors that detect location and force based on fiber optics. This interdisciplinary project was conducted between the mechanical engineering and apparel design departments at a large university in the spring of 2019. The goal of the collaboration was for the apparel designer to produce a wearable garment for use in testing the technology developed by the mechanical engineering team, with a secondary goal of aesthetics and function for display at industry events. The research questions addressed through this project include: How can wearable technology be integrated into a compression shirt? What apparel design techniques can be used in the development of the garment, in conjunction with the functional needs of the engineering team? Through iterative design development, technique samples, the use of 3D body scanning and printing, and experiential knowledge of apparel production methods, a series of garments were developed and refined to create the end garment.

Process

Kettley et al.'s (2010) collaborative work utilized apparel design techniques with integrating a flexible sensor into wearable garments. In their process, they utilized methods such as design exploration and iterative garment development to create their artefacts. Similarly, the present research project began with a tactile exploration of the fiber optic sensor: how could it be integrated into a wearable garment? Early explorations included weaving the sensor into mesh fabric, knitting with other yarns, hand sewing to a fabric surface, and trials with heat bonding into a casing. For utility and time, sensors were zigzagged onto stretch mesh "patches" in predefined lengths and configurations for use in technological tests by the Engineering team.

To develop end garments, one of the researchers was selected as the fit model and anthropometric body measurements were taken with a measuring tape for use in preliminary shirt iterations. However, due to the need to create a close-fitting compression shirt with exacting measurements, the fit model was later 3D body scanned using a Human Solutions Vitus XL scanner. The right arm was chosen as the main body zone for testing the technology, thus a 3D print was created of the model's arm for fitting and testing purposes. This arm was invaluable in the shirt pattern refinement process, indicating the benefit of 3D body scanning and printing in the development of wearable technology garments. Documentation for the project included photographs, notes, video, and written materials, and physical artefacts included seven shirt iterations, with the final two developed into full prototypes.

Findings

Body placement for the sensors began at the center back between the shoulder blades and continued across to the shoulder then down the arm to the wrist. To help with "anchoring" the sensors in place, the sleeve pattern was modified to include a thumb hole. Further, as the sensors needed to be close to the body, it was decided to eliminate as many seams as possible which resulted in the development of a raglan-sleeved compression shirt with a yoked back. In this way, the battery and printed circuit board pack were situated in a pocket at the center back between the shoulder blades, with pack removable for launderability. The sensors were then able to extend down the length of the arm without crossing seams. Heavyweight compression fabric was used and seams were serged. In the 6th prototype, heat bonded tape was also used. In the 7th and final prototype, the sensors were stitched to the surface of the compression fabric with a zigzag stitch, enabling movement and stretch.

Challenges in the process included modularity of the technology, garment seam placement, and materials. A major finding of the process was the need for deeper knowledge of material interaction. Specifically, a heat bonded tape was utilized in the final stages of garment creation that ultimately leached light away from the fiber optic cord, rendering the shirt unusable for the originally intended purposes. To compensate for this, a new prototype was created with an alternate application method involved that eliminated the heat bonded tape. Further materials testing is recommended, along with different application techniques.

Conclusions

While the process of integrating wearable technology seamlessly with apparel such as compression shirts is ongoing, this preliminary research into the phenomenon provides a base of knowledge from which future researchers can benefit. The interdisciplinary nature of the work was a valuable experience in developing relationships between departments and served as a way to bring a multi-faceted approach to the design problem. Researchers with differing skill sets and backgrounds are able to work together to create design research garments through close collaboration and a working vocabulary that enables open communication of ideas and needs. Technology such as 3D body scanners and printers can aid in the development of garments for fitting purposes, which can yield better results in fit tests and technology trials. Material interactions are an important factor, and the development of further technique explorations is recommended.

Reference

Kettley, S., Downes, T., Harrigan, K., & Glazzard, M. (2010). Fit for purpose? Pattern cutting and seams in wearables development. *Digital Creativity, 21*(4), 247-256. https://doi.org/10.1080/14626268.2010.548870