Product Development Process for E-Textile Garments: A Design Guideline for Apparel Manufacturers

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Introduction: Garments with embedded electronic capabilities have the potential to meet the functional needs of a user in an efficient, dynamic manner compared to traditional body worn technologies, and may offer expanded functionality and comfort (Dunne et al., 2015). However, the integration of electronic and computing technologies into garment form is a relatively new technique for apparel manufacturers and designers. While integrating electronics into textiles seems very promising to apparel manufacturers and designers, a gap exists in the provision of designers with a common understanding of embedded technology (Islam Molla et al., 2017). The design and development of electronic textile (e-textile) garments crosses the boundaries between fashion design, apparel manufacturing, electronic engineering, human biology, and so on. Therefore, it is often not pursued by apparel manufacturers due to their lack of understanding on the influencing design variables that lie outside their scope of experience.

A few studies have looked into the design challenges of e-textile garments (Martin et al., 2003; Dunne et al., 2005). However, most of these studies lack an emphasis on consideration of manufacturing variables and design issues that emerge during the product development process. While some studies (Bahadir et al., 2012; McCann et al., 2005) have described a general design guideline for the development of e-textile garments, manufacturing variables involved in spatially distributed e-textiles are often not considered, especially in a cut, make, and trim (CMT) factory setting. This paper addresses the gap in the product development process of e-textile garment manufacturing variables and provides a 5-step design framework emphasizing design issues that arise from the development of e-textile garments in a CMT factory setting.

Step 1 – Electronic Hardware System Development: First, the electronic hardware system for the garment needs to be developed, which helps determine constraints on electronic components and system architecture, and shows the feasibility of translating into an e-textile. It contains all the necessary components (microcontroller, sensors, actuators, battery, etc.) to make the system work. A prototype board may be used to for quick and easy system circuit development. Once the hardware system is developed the system firmware and software should also be developed.

Step 2 – E-textile Swatch Development and Testing: In this stage, the electronic circuit will be converted into an e-textile circuit. Circuit components (connectors, wires, and sensors) need to be integrated onto the textile platform. Functionality of the e-textile circuit needs to be tested in textile form

prior to translating it for product development. Sub-steps involved in the integration of the electronic system into the product are described below.

2.1 – Integration Technique: A suitable method for textile-electronics integration needs to be determined since the manufacturing process will vary largely. Electronics can be integrated directly into fibers, yarns or fabrics; or off-the-shelf electronic components can be attached to the surface of the textile; or the complete electronic system can be attached directly onto the textile. Each of these techniques will bring unique challenges for mass production of e-textiles.

2.2 – Material Selection: Materials (fabric) and electronic system components (sensors, actuators, etc.) are selected based on the aesthetic and functional requirements of the garment and the embedded system. A balance between design and wearability requirements of the garment is necessary when selecting the appropriate components for an e-textile garment. The integration technique selected in the previous stage constrains the available electronic component package types and sizes. In addition to individually-integrated components, other system components must also be selected, taking into account their size and shape as well as functional capabilities. This includes a central processor (such as a microcontroller), any communication or networking hardware (such as multiplexers or wireless capability), and the system power source.

Step 3 – Product (Garment) Soft-goods Design (Pattern and Construction Specifications): The design of soft-good elements are developed in this stage, which include: desired garment design, patterns (including electronics placement), and fabric cutting.

3.1 – Component Placement: Component locations with specific spatial requirements need to be determined. These requirements depend on the system design, base fabric substrate, trace/insulation materials, and the wearability of the garment. Further, component placement may take into account other factors like avoiding high-flex or high-impact body areas.

3.2 – Trace Routing: Traces are necessary to connect electronic components throughout a garment and may have different requirements – trace connection or isolation. Based on the position and alignment of the traces, a method may be needed to ensure effective trace/seam crossing in the garment, such as a satin stitch to go over a trace, a material to insulate a trace (fabric paint, silicone, thermoplastic tape, additional fabric layer), or a more advanced multilayer circuit technique) (Islam Molla, 2018).

Step 4 – Prototype Fabrication: Final prototypes are made in this stage, which involves printed circuit board (PCB) assembly, electronics integration, and garment construction.

Step 5 – Prototype Quality Testing and Troubleshooting: In this stage, the functionality of the finished prototype is tested. Troubleshooting is performed if there are any connection and/or system issues found at any stage of the product development. Necessary rework of the product is also performed to ensure the e-textile system is functional, and fabrication processes are modified if needed to prevent future faults.

Conclusion: Textile based garment-integrated technologies possess soft, flexible structures that can provide improved user support and comfort compared to traditional hard goods based wearable

technologies. However, manufacturing of garment-integrated technologies remains a major challenge for e-textile developers. The inconsistency between electronics manufacturing systems and apparel manufacturing practices make the integrated process a complex task. This paper presents a design framework of a product development process for manufacturable e-textile garments. This framework could be used as a design guide for electronic embedded smart garments developers or novice e-textiles product developers in an apparel factory setting.

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