Development of 3D Textile Sensor using Conductive Embroidery on Pre-Stretched Fabric

Smart textiles are gaining great interest over the last few decades with intensified competition in the smart device market. To implement various functions on textile products, traditional manufacturing technologies of the fashion industry such as weaving, knitting, embroidery, and printing are being widely utilized. In the meantime, the method of forming 3D shape by 3D printing the pattern on the pre-stretched textile substrate has been widely studied recently (Schemelzeisen et al., 2018, Stapleton et al., 2019, Berdos et al., 2020.) Such a method can realize 3D shape more economically by utilizing the residual stresses of fabric to curve the stiff material. However, the process of stretching and fixing the fabric, the key step of this method, is performed manually so the strain couldn't be quantitatively controlled and reproducible.

In this study, a device that can stretch and fix the fabric quantitatively is developed. Instead of 3D printing, embroidery has been used to realize the structure of 3D shapes. When an embroidery pattern is made using the conductive thread on the pre-stretched elastic fabric, embroidered part is fastened by the thread. Once the strain is removed, the rest of the fabric returns to its original state and a 3D curved shape is formed. Using this method, a 3D textile capacitive sensor was made. Embroidery is easy to design, and the result has more flexible and warm properties, which is beneficial to be integrated into wearable electronics. By applying conductive embroidery, the flexible 3D textile sensor has been developed and the property of the prototype is evaluated connecting to circuit consists of Lilypad Arduino and LED.

Highly elastic single jersey fabric made of 100% polyester was used as the substrate of the sensor. Silver-plated 200D polyamide yarn was used to realize capacitive sensing through conductive embroidery. The resistance of the conductive thread was 230-300Ω per meter and the allowable current was 0.23A. A special device for stretching and clamping the fabric was prepared using FDM type 3D printer as shown in Figure.1 to introduce a uniform strain on the fabric. Using this device, the energy to be stored in the stretched fabric could be controlled quantitatively as well as reproducibly, which determined the final 3D shape of the textile structure.

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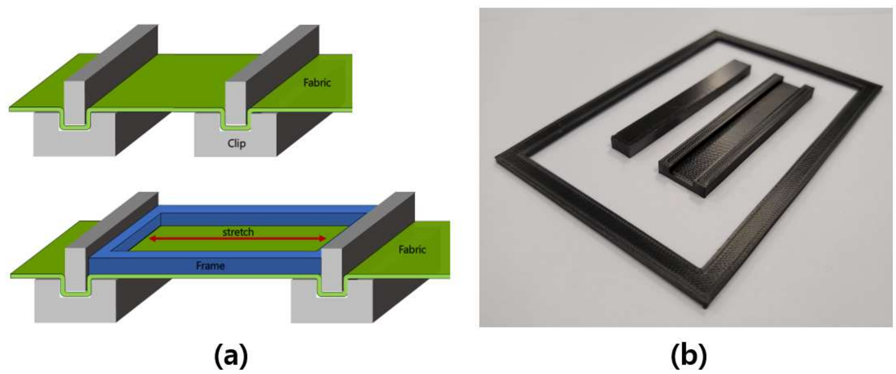

Figure 1. Schematic Diagram of Fabric Stretching
(a) Process Design
(b) 3D Printed Device

As a result, a 3D textile sensor that feels warm, soft, and light as conventional textile was produced as shown in Figure.2 and it has been successfully integrated into the form of garment. In addition, the conductive part of the sensor induced a gradual contact between the skin and the sensor.

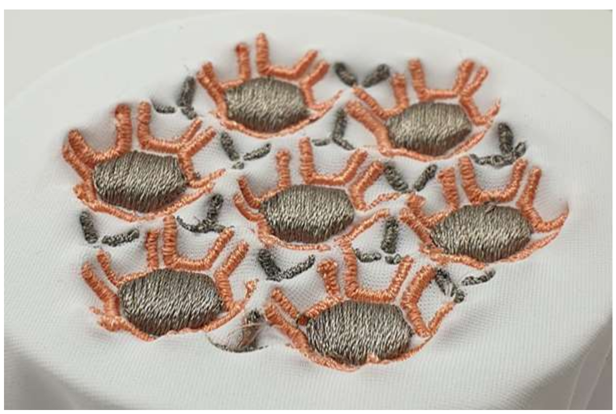

Figure 2. 3D Textile Sensor

This study presents a new method to make a 3D textile sensor by utilizing the energy stored in the pre-stretched elastic fabric through conductive embroidery technique. The proposed method can realize the 3D textile structure effectively as well as economically. Our future work will be focused on exploring the parameters which can affect the shape and performance of 3D textile sensors.

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