A SMARTWORKOUT SHIRT PROTOTYPE USING EMBROIDERED PIEZORESISTIVE SENSORS

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INTRODUCTION

Wearable technology is an emerging field in health monitoring and fitness. While the majority of these products nowadays are accessories such as smart watches and smart glasses, there is a push to innovate further and move into smart garments and fully embrace this revolution. The SmartWear Revolution project, led by the University of Alberta, aims to address the needs of roughly 2.4 billion people who live with conditions that could benefit from rehabilitation and assistive technology [1]. The project will deliver clothing that augments posture, arm movement, balance, and walking for people with motor impairment due to age, congenital or acquired conditions. As an initial step, a fitness smart garment called the "SmartWorkout Shirt" is being developed to track resistance training progress. The shirt measures fabric strain (piezoresistive) and temperature. It will allow for the exploration of different techniques to integrate non-fibrous sensing elements into a garment.

MATERIALS

Knit fabrics were selected for the shirt because of their stretch and recovery elasticity, making them ideal for active wear. They are also often more breathable than their woven counterparts. A moisture-wicking fabric like polyester was chosen to help the user stay dry and comfortable during intense workouts.

For muscle stretch data and breathing rate monitoring using piezoresistive stretch, a silver-plated nylon 66 yarn (Shieldex & V Technical Textiles, Newark, NY) is used. It has an electrical resistivity of less than 100 Ω/m [2]. The temperature sensor is a low-power linear active thermistor IC (SparkFun Electronics, Boulder, CO). A LilyPad Arduino board is used to analyze the data from the strain and temperature sensors.

PROTOTYPE & METHODS

The conductive yarn is embroidered onto the shirt in a sinusoidal pattern, which exhibits piezoresistive properties: a change in resistance is produced when the fabric is stretched [3]. This has a wide variety of potential uses during exercise, such as measuring the muscle expansion (pump), the range of motion during a workout activity, and the expansion/contraction of the thoracic cavity for the breathing rate of the user. Figure 1 shows the conductive yarn embroidered using polyester thread onto a rectangular piece of fabric using a domestic sewing machine. These strain gauges are positioned on the sleeve of the shirt to measure the pump of the bicep/triceps and on the chest area to measure the breathing rate through volume changes of the thorax. Preliminary tests with the conductive yarn have been successfully conducted. More testing will be required to assess the effect of repeated wear and exposure to sweat on the measurements. The temperature sensor is also attached to the sleeve to give insights into workout intensity and blood flow. For data acquisition, the LilyPad is connected to the different sensors using an embroidered conductive thread. It is located on the shoulder and is powered by a 3V coin cell battery. Data transmission to a computer is performed via an FTDI board.

As the electronic components of the SmartWorkout Shirt are not washable, they are secured on detachable pieces of fabric attached to the shirt using Velcro. As a next step, strategies involving the encapsulation of the electronic components will be explored to facilitate the laundering of the SmartWorkout Shirt. Future work will also include optimizing sensor placement, validating repeatability of tests, and implementing wireless capabilities/onboard logging for data transmission.

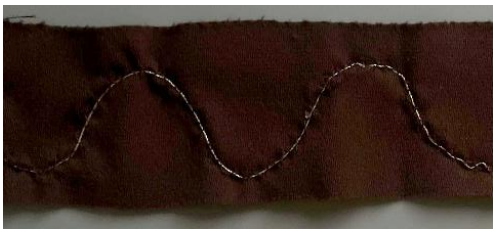

Fig 1 Conductive yarn embroidered onto the fabric to form a piezoresistive strain gauge.

CONCLUSIONS

The SmartWorkout Shirt would demonstrate the viability of the SmartWear Revolution and showcase practical applications of everyday smart wear. This shirt serves as a stepping stone in learning about smart wear and how to properly integrate non-fibrous electronics onto garments, which will prove useful in advancing the ambitious goals of the SmartWear Revolution.

REFERENCES

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