WEARABLE CLOTHING PRESSURE MEASUREMENTS BY DETECTION OF SIGNALS THROUGH THE ALPHA PROTYTYPE

Heejae Jin, Hyojeong Lee, Kongju National University, Republic of Korea

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Introduction

Comfortable wearing is the crucial factor when garments are conducted, especially in the functional design field since the aspect of comfort is closely related to body movement. Additionally, clothing pressure is considered as the essential factor affecting comfort wear when functional clothing is developed. Due to this, it is important that clothing pressure is measured precisely. However, research of measurement of clothing pressure, particularly on the direct measurement, has been limited. For instance, the air-pack type is typically used to directly measure clothing pressure. This type is usually measured in the standard position because of its balloon shape and how it can be damaged by any aggressive movement or from high clothing pressure. However, clothing pressure measured at the standard position and at the dynamic position can be different even with the sensor at the same location on the body (Luo, S. etc., 2016). Furthermore, it is important to measure clothing pressure at the dynamic position for the improvement of wearer's comfort. The air-pack instrument is also difficult to approach due to its expensive price and complex method of measuring. Thus, the purpose of this study is to construct the initial alpha type prototype, which is the wearable measurement system with low cost and easy measurement of clothing pressure. In addition, this study investigated the detection of clothing pressure signals during movement from the Arduino system, which is an open source electronic platform that receives various input signal, including pressure sensors, then outputs diverse variables.

Methodology

For the measurement of pressure system, sensors should be first decided. Pressure sensors have been used in many researches including the pressure ulcers (bedsores) in medicine, as well as force detection in engineering. These pressure sensors have used a force sensitive resistor (FSR), which has price range between 10 ~ 20$. For this study, one of the FSR selected for the wearable pressure measurement, which is FSR RA12P, was small (0.47″ x 0.55″) and without tail. To read FSR pressure sensor, FSR with a fixed resistor (R_{FSR}) is connected to the V_{CC}. Also, the other end of FSR is connected to a pull-down resistor (R_{PDR}). In order to create a voltage divider, ADC input of an Arduino is connected to the point between R_{FSR} and R_{PDR} (Figure 1).

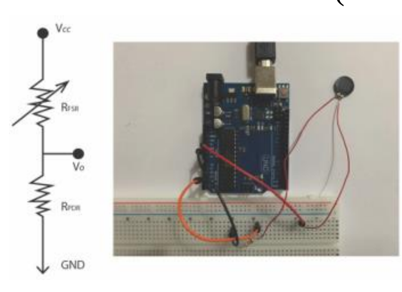

Fig 1. FSR diagram and Arduino system

To fulfill sensor calibration procedure, this study used loads 20g, 50g, 100g, 200g. Each load was measured 10 times and the obtained average was shown as the blue dotted line in figure 2. Since the graph of figure 2 shown was a non-linear curve, the exponential curve fitting algorithm was used for the interpolation of the force value. For the curve fitting model of this study, the equation below was applied.

$$y = a\,e^{bx} \qquad \text{(e: Euler's number)}$$

,where x is analog read and y is a force value. In addition, a and b are calibration parameters. Least square method was used to obtain the optimized a and b parameters. Based on the calculated parameters, the orange line was shown in figure 2.

Arduino Uno hardware size including the bread board is approximately 15cm~ 20cm and has limitations in measuring pressure during movement on the specific surface of the body. For this study, Adafruit, which is light weight and compatible with Arduino, was used and the calibrated sensor FSR above was employed. Pull-down resistor was applied as 10kΩ. In order to easily attach on the body, the alpha prototype suggested the conductive threads instead of wire (Figure 3). Also, this prototype was developed on the felt which can be flexible and suitable for the wearable system as the patch type.

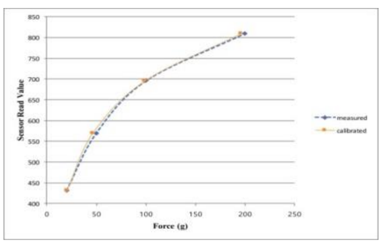

Fig 2. FSR sensor calibration

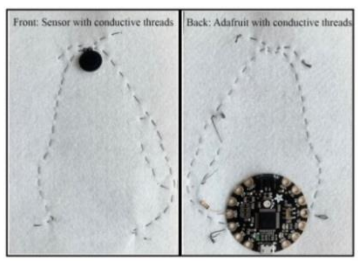

Fig 3. The proposed the alpha prototype

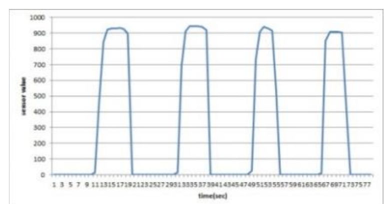

Fig 4 detection sensor value during movements

In order to detect the signal from the alpha prototype during movements, the subject sat down on a chair for 5 seconds then stood up and repeated this movement 4 times. The prototype as seen in figure 3 was attached on the knee during this movement. Significant changes in signals were detected by the sensor every time there was movement (Figure 4).

Conclusion

This study demonstrated the potential wearable system for the measurement of clothing pressure during movements as the proposed alpha prototype. Moreover, clothing pressure can be easily measured even during active movements as seen through the detection of stable signals. In addition, since this alpha system was specifically proposed as a patch type, this prototype can be suggested to standardize measurement of clothing pressure in each movement. For future research, the wearable system should be wireless in order to attach to the body surface more conveniently and without the wires being a disturbance. Also, the study should use more than one sensor to measure the clothing pressure for the specific surface of the body.

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References

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