Sensing Wear for Multi-channel sEMG Acquisition

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Abstract— The paper proposes a sensing wear to measure surface electromyography (sEMG) signals from the human upper body. The sensing wear has several benefits such as it does not have any side-effects for skin, it has a merit of wearability, and it is lightweight. The developed sensing wear consists of two parts such as a conductive area using silver-coated yarn including electrodes and conductive paths, and a non-conductive area using synthetic yarn for the body part. Thus, users are easily able to wear the sensing wear, unlike wet and dry type electrodes. In order to verify the performance of the sensing wear, we conduct measurement experiments for sEMG signals acquisition. Experimental results showed significant differences in 16 channel sEMG signals (p<.001) according to three kinds of motions.

I. INTRODUCTION

Conductive textile industry becomes growing and expected to reach USD 2.11 Billion by 2021 with a compound annual growth rate of 16.4% [1]. The conductive textile is a smart fabric which has functions of sensor and communication with traditional advantages coming from the fabric itself such as lightweight, inexpensive and flexible. Especially, a human-robot interaction (HRI) area requires soft sensors because humans and robots collaborate closely [2]. In addition, the textile sensor is drawing attention amid growing biotechnology for smart healthcare interest. Textile electrodes are easier to acquire a variety of biomedical signals such as EMG, ECG (electrocardiography) and EEG (electroencephalogram) than conventional electrodes such as wet silver/silver-chloride electrodes and dry electrodes [3]. To attach wet electrodes to the skin, especially, electrolytic gels are required. Also, dry electrodes should be embedded in hard materials and require to strong pressure. The fabric electrodes have been constantly studied as an interesting topic. Previous studies [2,4] usually focused on materials, size, and shape of the fabric electrode regardless of commercialization.

Sensing wear having sixty-two electrodes included two ground electrodes is suggested in the paper. For the wearability and stretchability, the knit technology is applied to the sensing clothing. To verify applicability of the sensing wear, sEMG signals acquisition performance is confirmed using the repeated measures analysis of variance (RM-ANOVA) regarding experimental data. The fabrication processes of the sensing wear are presented in section 2. The method and experimental results to verify its performance are described in section 3. The conclusion is given in section 4.

II. FABRICATION OF THE SENSING WEAR

The sensing wear using the conductive textile electrodes is fabricated to acquire the sEMG signals. The major materials for the sensing wear are conductive and non-conductive yarns. The conductive yarn as textile electrodes is 99% pure silver-plated nylon yarn which has the electrical resistance of 3Ω/cm. The non-conductive yarn except the conductive area is composed of polyester 30% and rayon 70%. In order to increase stretchability, spandex yarn is used as well.

Using a knitting machine, it is possible to become much stretchable and to integrate electrodes directly into fabrics. Thus, it can be used in clothing for measuring sEMG signals. The conductive part can be classified into electrodes and conductive paths. As shown in Fig. 1, the conductive paths are used to transfer the signals to an electric connector using their large area. The distance between centers of textile electrodes is maintained with 20mm known as the SENIAM (surface EMG for the noninvasive assessment of muscles) [5] and previous studies [6].

The number of the textile electrodes inside the sensing wear is sixty-two, among them, sixty for sEMG signals acquisition and two as the ground electrodes. The sensing wear is designed to operate various pattern recognition. The multi-channel textile electrodes are used to acquire sEMG signals from the human upper body. The electrode placements can be classified into three great areas such as arm, chest, and back. In addition, Ribbing pattern (or rib stitch) is used in the wrist and waist for elasticity, and plain stitch is as a whole used in the sensing wear as shown in Fig. 2.

![Figure 1. Side view of the textile electrode](image-url)
III. METHODS AND RESULTS

This study was approved by the Institutional Review Board (IRB) on Human Subjects Research and Ethics Committee at Hanyang University Hospital, Seoul, Korea (2018 July, HYI-16-055-3). The measured sEMG signals were assessed in terms of root mean squared (RMS) operation by using MATLAB R2018a (Mathworks, Natick, MA, USA). The statistical analysis was performed using IBM® SPSS Statistics® (Chicago, IL, USA).

To begin with, the one-channel sEMG signal measured through the sensing wear and its RMS value is shown in Fig. 3. Here, we can know that the RMS provides clearer information regarding the muscle forces than the raw sEMG signals. To verify the applicability of the sensing wear, the experiment was conducted for three motions. Fig. 4 illustrates three target motions such as right-limb abduction (R/A), left-limb abduction (L/A), and shoulder extension (S/E). After obtaining the data, differences among the three target motions were evaluated using RM-ANOVA. In the Fig. 4, three target motions and their RMS values while performing the corresponding motions were depicted, and we can easily confirm the differences between each motion from the RMS values. As a result, it is verified that there are significant differences in statistics between the RMS values of sEMG signals corresponding to the R/A, L/A, and S/E motions (p<.001). According to the time progress, the RMS values pattern variations during 3000 samples were shown in Fig. 5. It is expected that three target motions can be easily classified using the pattern recognition method in the near future.

IV. CONCLUSIONS

The sensing wear having sixty-two textile electrodes was developed for motion classification. The conductive and non-conductive yarns were integrated into the same surface using the knitting technology. It has several advantages such as high usability, flexibility, repetitive wash-ability, and no skin side-effect. Through the experiments according to upper-body motions, we showed the practicability of the sensing wear. In the near future, it is expected that sEMG acquisition could be extended to ECG and EEG measurements.

REFERENCES


