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SYNERGY OF NANOCOMPOSITE FORCE MYOGRAPHY AND OPTICAL FIBER-BASED WRIST ANGLE SENSING FOR AMBIGUOUS SIGN CLASSIFICATION

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ABSTRACT

This paper aims at understanding the capabilities and limitation of combining Nanocomposite Force myography sensors (FMG) and optical fiber sensors in standalone systems and their synergy influence on the classification of ambiguous hand gestures. A set of 10 highly similar hand signs from the fingerspelling of the American sign language is adopted in this study. Force myography (FMG) signals are collected from one healthy subject performing the selected set of gestures with 40 repetitions for each gesture. The K-Tournament Grasshopper Extreme Learner (KTGEL) classifier has been implemented to perform an automated feature selection and hand sign classification with an efficient network size and a high accuracy.

***Index Terms* –**Force Myography, Optical Fiber Sensors, Nanocomposite Force Myography, K-Tournament Grasshopper Extreme Learner.

1. INTRODUCTION

Force myography (FMG) is an emerging alternative of surface electromyography (sEMG) for gesture recognition wearables [1]. Widely used commercial piezoresistive sensors (FSR 400 series) have a sensitivity in the range of 0.2 N–20 N, and a hysteresis of 10% [2]. However, the recently developed piezoresistive FMG sensor [3] has a sensitivity in the range of 0,01N-50N and a hysteresis of 0.8%, which outperforms the capabilities of commercial and other customized sensors [4]. Based on this sensor, an FMG sensors band is built realizing a higher sensitivity to the muscle contractions. We combine it with optical fiber sensors based on the fiber segment interferometry (FSI) [5] technique for wrist angle measurements to improve gesture recognition accuracy for those gestures involving wrist movements, which can not be detected by the FMG band. For the gesture classification, the Tournament Grasshopper Extreme Learner (KTGEL) classifier proposed in [6] is implemented, as it has been reported to realize a high accuracy with a reduced network size.

2. NANOCOMPOSITE FMG SENSORs BAND AND MEASUREMENT SYSTEM

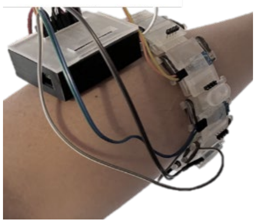

Figure 1:NFMG sensors band

A novel, adjustable and wearable 3D printed band is designed for monitoring the change of external muscle force distribution in general and gesture recognition in particular. The band circumference is adjustable from 20 cm to 30 cm according to the subject hand. Eight nanocomposite CNT/PDMS pressure sensors are completely integrated within the structure including the data acquisition circuit. The eight sensors are equidistance distributed to monitor the forearm muscle contractions.

3. OPTICAL FIBER SENSOR AND MEASUREMENT SYSTEM

Highly sensitive FSI-based [5] optical fiber strain sensors based are used to obtain additional information on wrist movement, where FSI permits spatially integrated strain measurement over defined fiber sections. In the proposed experiment, sensor cables that contain FSI sensors that are mounted upon a lightweight, bendable substrate are used. Here, because the fiber is situated outside of the neutral axis of the cable, any bending of the sensor cable will lead to an observable strain in the fiber. Two of these sensor cables are routed across the subject's wrist, one across the top of the wrist and one at the side. Bending of the wrist will then lead to a strain signal that is proportional to the wrist angle. Unlike, for example, in the use of inertial sensors, the measured signals from FIS are independent of the overall hand movement which makes the technique particularly appealing for gesture recognition. The two wrist angle measurements obtained are then incorporated into the gesture classification model.

4. DATA COLLECTION

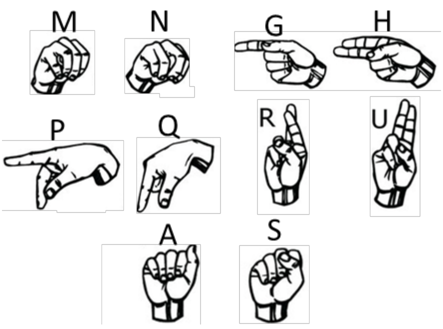

Figure 2: Performed signs

In this work the set of highly similar hand signs from the fingerspelling of the American Sign Language (ASL) shown in Figure 2, is chosen to test the capability of nanocomposite FMG sensors and optical fiber sensor signals for ambiguous gestures classification. For this data collection one healthy subject is asked to perform each sign 2 seconds for 40 repetitions. A resting time of 2 minutes is kept after each 10 records to prevent muscle fatigue. During data collection, the subject is asked to wear both FMG and OFS measurement systems shown in Figure 2.

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