Flex: hand gesture recognition using muscle flexing sensors

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Flex: Hand Gesture Recognition using Muscle Flexing Sensors

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ABSTRACT

We present *Flex*, a low cost, lightweight, energy-efficient spatial input armband consisting of four flex resistance sensors. The device provides a continuous, 4-dimensional signal of forearm muscles flex. We train a long short-term memory network (LSTM) to enable real-time recognition of motion gestures as read by the sensor.

CCS CONCEPTS

• **Human-centered computing → Empirical studies in interaction design**;

KEYWORDS

spatial input, gesture recognition, freehand interaction, flex sensor

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1 INTRODUCTION

In recent years, low-cost spatial input devices and techniques were proposed using optical tracking (e.g. Leap Motion), electromyography (e.g. Thalmic Myo), and everyday devices such as smartphones and smartwatches [1]. We present a prototype of a spatial input device that uses forearm muscles' flexing as input. We also report on preliminary results of motion gesture recognition using the device.

2 HARDWARE DESIGN

The device consists of four *Flex* Sensors from Spectra-Symbol for angle displacement measurements. As passive elements, these sensors have an electrical resistance rate of 56 mΩ per degree (plane angle). Every sensor is connected to a Wheatstone Bridge and the low voltage output is gained by Instrumentation Amplifiers of INA 128. The sensors' response time is immediate and only restricted by the INA 128 with a Slew Rate of 4V/μs. We use Arduino Uno as an analog-to-digital converter. We apply a linear response delay filter to the raw sensors' output for noise reduction and signal smoothing. In our setup, the sensors are attached to the forearm *flexor carpi* muscle group (Figure 1). This group of muscles is active during finger movements, providing input for hand gesture recognition.

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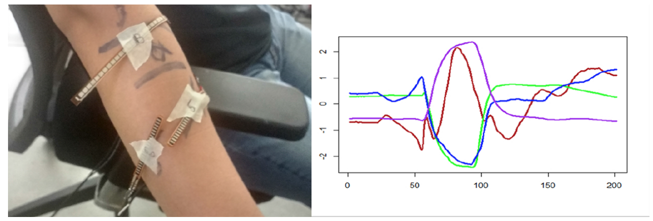

Figure 1: Left: *Flex* sensor components (with fabric sleeve removed). Right: example signal from 4 flex sensors

Gesture	Noiseo	Left	Right	Double Tap	Fist
Noise	99.8%	00.0%	00.1%	00.0%	00.1%
Left	03.2%	95.7%	00.5%	00.5%	00.2%
Right	15.3%	00.2%	84.2%	00.2%	00.2%
Double Tap	04.3%	00.0%	00.2%	95.5%	00.0%
Fist	07.8%	00.0%	00.3%	00.0%	91.8%

Table 1: Confusion Matrix of Gesture Recognition

3 GESTURE RECOGNITION

To evaluate *Flex* input for gesture interaction, we collected 12,000 gesture samples from 3 users. Each user performed 1,000 repetitions of *waving left, waving right, making fist, and double tap* gestures. Additionally, we recorded 18,000 samples of noise: holding a cup, writing, spreading fingers etc. For gesture recognition, we used long short-term memory deep recurrent neural network [2] with 3 hidden layers of size 120, 80% dropout rate, and 15,000 iterations.

The resulting confusion matrix is presented in table 1. We observe that the rate of *false positives* is low ($< 1\%$) for all gestures, which indicates that the *Flex* input provides a distinct signal for each gesture. We believe that the number of false negatives (14.7% for *wave right* vs. 2.8% for *wave left*) may be reduced by re-training the network on more data collected from more users.

4 CONCLUSION

We introduce new spatial input device: *Flex* sensor. The device reads flexing information of a user's forearm muscles. The sensor provides four-dimensional data with a signal-to-noise ratio sufficient for defining and recognizing a gesture set similar to Myo armband.

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