Integration of High density sEMG and advanced biomechanical model for the study of muscle finger force

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Abstract— ***We propose the introduction of high density surface EMG data into a new finger biomechanical model for the study of muscle force.***

Keywords—Biomechanical model; HD-sEMG; finger extensor mechanism; muscle; blind source separation

INTRODUCTION

The understanding of muscle coordination in human finger is essential for many application fields, such as muscle computer interface, movement simulation and surgeries. Biomechanical modeling is widely used to characterize the force sharing across the muscles. However, the models result in ill-posed problems since the number of muscles crossing the joints exceeds the number of degrees of freedom of these joints. To solve this problem, one advanced method [1] includes the intra muscular electromyographical (EMG) signal as additional inequality constraints into the optimization procedure. This method is attractive, but it presents some limitations mainly due to the great spatial selectivity of the recordings. Finally, since it is invasive, this technique is not suitable for daily life and sport applications. We propose a new finger biomechanical model and the introduction of high density surface EMG (HD-sEMG) into the optimization procedure.

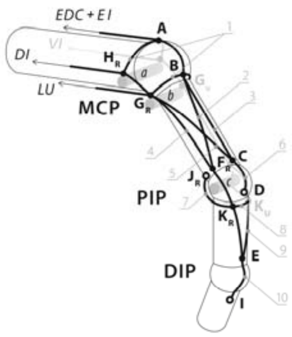

Figure 1: Biomechanical description of Index finger extensor mechanism model.

We focused on the extension movement of the index and little finger because of their high level of biomechanical independence. A complex tendinous structure of the extensor mechanism was developed as elastic elements (Fig. 1). To simulate the deformation of the mechanism, the potential energy of the system was minimized using the Quasi-Newton method.

The HD-sEMG signals were recorded in a monopolar configuration using a 64-channel electrode grid (8x8 electrodes, 10 mm inter-electrode-distance, LISiN, Italy) placed on the dominant arm (Fig. 2) The electrode configuration allowed acquiring signals from the Extensor Indicis and Digiti Minimi muscle. Ten subjects were asked to perform cyclic isometric extensions of index, little, and index+little at different force levels (30%, 50% and 70% of the maximum voluntary force). Blind source separation of mixtures of signals of active muscles was performed in order to separate contributions from different muscles.

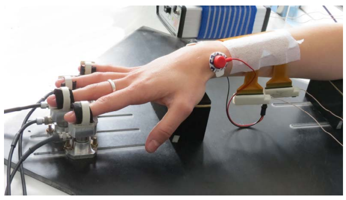

Figure 2: Experimental setup. 3D force sensors were used to measure the extension forces. A 64-channel electrode grid was used to record HD-sEMG.

Figure 3 shows the muscle activity distribution detected with the HD-sEMG system. It is possible to identify distinct areas of activity for index and little finger, and one merged activity area in the case of simultaneous extensions of the two fingers.

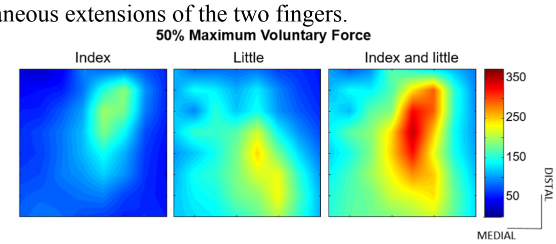

Figure 3: HD-sEMG Root Mean Square (RMS) maps calculated over a 500-ms data window. The RMS maps were interpolated with a factor of 10.

The preliminary results show that the proposed methodology is promising to overcome the limits of classical approaches, and open new perspective in the understanding of biomechanics and motor control of hand movement.

REFERENCES

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