# SMUAP Decomposition Method Considering Estimated Distance from Surface Electrodes to Motor Unit during Voluntary Isovelocity Elbow Flexion

Jun Akazawa[1] and Ryuhei Okuno[2]

[1]School of Health Sciences and Medical Care, Meiji University of Integrative Medicine, Kyoto, Japan

[2]Department of Electrical and Electronics Engineering, Setsunan University, Osaka, Japan

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Abstract: The purpose of this study was to decompose Surface Motor Unit Acton Potential (SMUAP) clearly even in case that the estimated distance from surface electrodes to motor units changing during voluntary isovelocity elbow flexion. We developed decomposition algorithm focusing on SMUAP Profile, and investigated motor unit (MU) recruitment and firing rate in biceps short head muscle during isovelocity elbow flexion using our developed method. As a result, we concerned that calculated MUs firing rates were almost same as the results in the previous studies, and the estimated MU's territory was changed with elbow flexion. It was shown that the developed algorithm was useful for decomposing SMUAP when the estimated distance from surface electrodes to MU changing during voluntary isovelocity elbow flexion.

## 1 INTRODUCTION

In the field of spots science and rehabilitation, they had been interested in the methode to analyze the motor units (MUs) recruitment and firing rates during voluntary isovelocity elbow flexion (hereinafter referred to as elbow flexion).

During elbow flexion, the distance from surface electrodes to muscle fibres of single MU changes slightly. It was sometimes difficult to decompose Surface Motor Unit Action Potential (SMUAP) clearly. So it was important to estimate the distance between surface electrodes and the muscle fibres. In the previous study, at first we had devised the system to decompose SMUAP for short period with template maching during the elbow flexion, and investigated firing rate of MU in biceps short head muscle (Akazawa, 2013), though, we didn't confirmed that the distance form surface electoredes to motor units changing during the elbow flexion.

In this study, in order to decompose SMAUP clearly even in case that the estimated distance from surface electrodes to motor units changing during the elbow flexion, we developed the decomposition algorithm, in which we used not only template matching method for short period but also we added the algorithm conditions of SMUAP profile (Akazawa, 2005).

## 2 MEATHOS

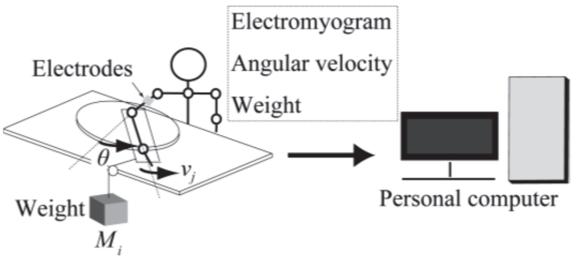


Figure 1: Schematic overview of the experimental setup.

Schematic overview of the experimental setup is shown at Fig. 1. The subject was instructed to flex the elbow joint smoothly to approximately 75 degree at constant angular velocity (5 degree/s) against the weight (2.0 kg). The experiments were performed with one healthy subject who gave informed consent and the investigation was approved by the local Ethics Committee (Meiji University of Integrative Medicine).

The eight-channel surface electrode was used. The SEMG signal was amplified with the gain 80 dB

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and the band pass filter was set at 43 Hz - 2.8k Hz. In the algorithm, firstly the measured SEMG was extracted for 3 seconds by every 1.5 seconds (Akazawa, 2013).

In this study, the developed algorithm condition of SMUAP profile was as follows: The SMUAP channel which outputs the max value won't change for less than two channels during the short period of 3.0 sec. We estimated location and shape of MU (Akazawa 2005). The central coordinate was set at the center between CH4 and CH5 of surface electrodes.

# 3 RESULTS

Fig. 2 shows a typical decomposed result of MUAP Train, and firings of nine motor units, MU1 to MU9 were identified. The results of calculated MU's firing rates are in agreement with the generally accepted behavior of MUs firing rates.

MU1 which was firing for the longest time, so template of MU1 which was made with calculating the arithmetic mean (average) of the MU1 signals.

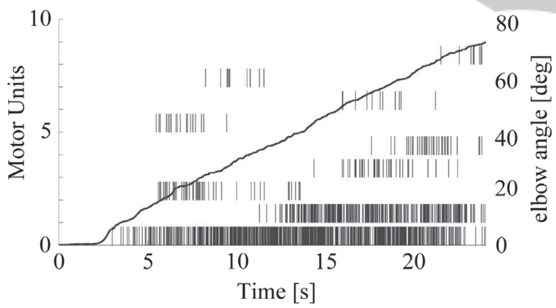


Figure 2: Solid lines: elbow joint angle (average velocity was approximately 5 degree/s). Identified firings of nine MUs are shown. Each bar represents one firing and firings of the same MUs are aligned horizontally. The average frequency of Motor Unit 1(MU1) was 22.52 Hz, and the standard deviation was 11.35 Hz. The average frequency of MU2 was 20.86 Hz, and the standard deviation was 10.90 Hz.

We made four templates of MU1 during time period of 3.0 sec so that we could confirm the shape change of SMUAP with changing the distance from surface electrodes to the motor units. The results are shown at Fig. 3. We can know that the highest voltage value of SMUAP was changing from CH8 to CH5. As increasing the subject's elbow angle, the amplitude of SMUAP was increasing gradually.

As shown at Fig. 3 (d), the channel which output the highest value is CH5. So, the condition that the SMUAP which was made by MU1 is that the channel output the highest value is CH4 to 6.

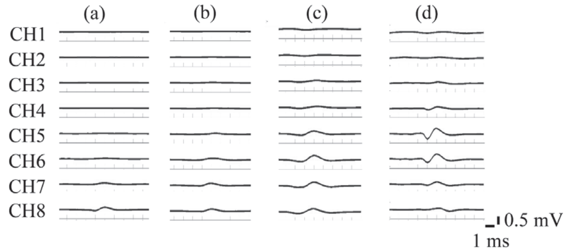


Figure 3: Template of MU1 The short period of Fig, (a) was 3.5 to 6.5 sec, (b) was 8.0 to 11.0 sec, (c) was 14.0 to 17.0 sec, (d) was 21.5 to 24.5 sec. At fig, (a) the estimated territory's radius (R) was 5.0 mm, depth (D) was 2.0 mm, and horizontal shift (Y) from the middle of the electrodes was 10.16 mm, fig, (b) R was 5.0 mm, D was 1.9 mm, and Y was 7.62 mm, fig, (c) R was 5.0 mm, D was 2.20 mm, and Y was 5.08 mm, fig, (d) R was 0.25 mm, D was 2. 0 mm, and Y was 2.54 mm,

# 4 CONCLUSIONS

In this study, in order to decompose SMUAP clearly even in case that the estimated distance from surface electrodes to motor units changing during elbow flexion, we developed the decomposition algorithm, in which we used not only template matching method for short period but also we added the algorithm conditions of SMUAP profile. The results of calculated MU's firing rates are in agreement with the generally accepted behavior of MUs firing rates.

It was shown that the proposed method was useful for decomposing MUAPs during elbow flexion.

# ACKNOWLEDGEMENTS

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# REFERENCES

Akazawa, J., Okuno, R., 2013. A Method for Quantitative SEMG Decomposition and MUAP Classification during Voluntary Isovelocity Elbow Flexion. 35th Annual International Conference of the IEEE EMBS, pp.6776-6779, Osaka, Japan.

Akazawa, J., Sato, T., Minato, K., Yoshida, M., 2005. "Method of estimating location and territory of motor units in human first dorsal interosseous muscle with multi-channel surface electromyograms," JSMBE, vol. 43(4), pp. 595-604 (in Japanese).