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EMG Analysis Accompanied by Tactile Apparent Movement

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Abstract: Tactile apparent movement recognition is normally considered as a subjective sense of human. Applying the tactile apparent movement to an engineering system, a quantitative evaluation study becomes necessary. In previous studies, finding the body-sway caused by the tactile apparent movement in a fixed experimental condition became possible. However, characteristic of the body-sway was not thoroughly investigated. In this study, investigating the body-sway caused by tactile apparent movement in a fixed experimental condition was aimed. Therefore, we focused on biological information, the body-sway and the comparison between the apparent movement recognized trials and the non-recognized trials. The findings of this research will be conducive to optimize the performance of the systems that are using the tactile apparent movement.

Keywords: Tactile Apparent Movement, EMG (Electromyography), Discrete Wavelet Packet Transforms

I) INTRODUCTION

Tactile sense as one of the five senses of human body has always been considered as an efficient substitution for the other senses of body such as sight and hearing. For example, a tactile interface system is able to transfer the required information by using the tactile sense instead of visual sense. Today we can see the various applications of this substitution in different interface and display systems that are helping people specially the physically challenged persons to perform many tasks despite of a loss in one of their sensory organs. [1]

In this study, the term *apparent movement* (AM) refers to the illusory perception of a movement on skin that is created by the discrete stimulations of a number of points on skin of a part of body that are appropriately separated in space and time. [2]

In previous studies the evaluation of the apparent movement recognition was particularly based on the statistical techniques instead of the quantitative evaluations. As a result of our previous studies, the sway of the subjects' arm during a tactile apparent movement experiment under a specified experimental condition was reported. [3] It has been expected that the quantitative evaluation of the body-sway that in our study refers to the sway of the testing arm, will make the tactile apparent movement evaluation possible.

The characteristics of the body-sway were analyzed by studying the EMG (electromyography) waveforms recorded during the apparent movement recognition time. The analysis was performed by using the various frequency analysis methods and tools such as the Wavelet packet transform. [4]

II) MEASURMENT AND EXPERIMENT

The experiments of our study take place on two different days. Figure 1 shows the experiment system of the first day. By using a PC different stimulations can be applied to the 4 skin stimulators (vibrators) randomly through a D/A convertor and an Op-amp amplifier.

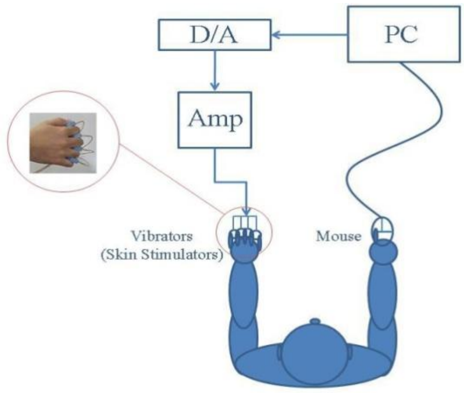

Figure 1: AM recognition experiment system.

During the measurement, the subject (in this report, three 23 years old male student) sits on a chair while the arm (which the vibrators are between its fingers) is open and making a 90 degree angle with upper body. The eyes will be closed and ears will be covered by a voice proof cover. The mouse clicks will be recorded as the subjects' reaction when recognizing the apparent movement.

Figure 2 shows the experiment system that has been used on the second day's experiment. There are two PCs in the experiment system that the first one (PC1) is responsible for applying the stimulations to the stimulators and also recording the real-time tracing data (CCD camera). The second PC (PC2), after amplification and A/D conversion, records the EMG data and the signals from a three-axis acceleration sensor attached to the wrist of the subject`s testing arm. In this experiment, EMG waveforms will be recorded by means of 12 electrodes and 18 channels resulting from the electrode combination.

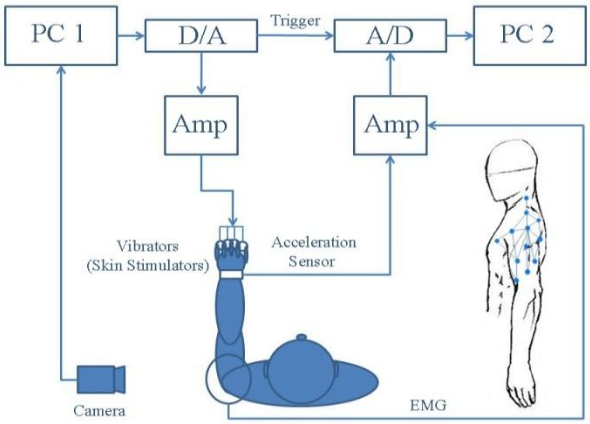

Figure 2: EMG measurement system and electrode combination.

The stimuli are controlled by the two parameters of T and τ that will be applied to the stimulators randomly in 10 cycles (repetitions). The period of applying the stimulation is represented by T and τ is for the interval between the starting (trigger) points of the stimulation in the 4 vibrators (see Figure 3).

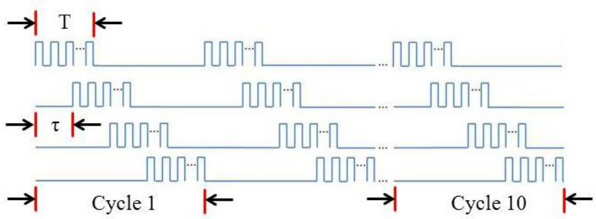

Figure 3: T and τ.

Table 1 shows the of T and τ values which will be selected randomly to make the different types of stimulations.

Table 1: Values of T and τ.

Parameter	[ms.]					
T	300	500	700	900	1100	1300
τ	100	200	300	400	500	600

III) DATA ANALYSIS AND RESULTS

Figure 4 shows the result of the first day`s experiment on one of the subjects. The area with higher values shows the AM recognition area, where the subject has reacted to the stimuli by a mouse click. The center of gravity of the recognition area is named as the (TM, τM) point. In this stage, the experiment will be repeated with the constant value of the T=TM in order to see the precise values (thresholds) of τ at the recognition area which the lower threshold will be represented by τL and the higher threshold will be represented by τH (see Figure 5).

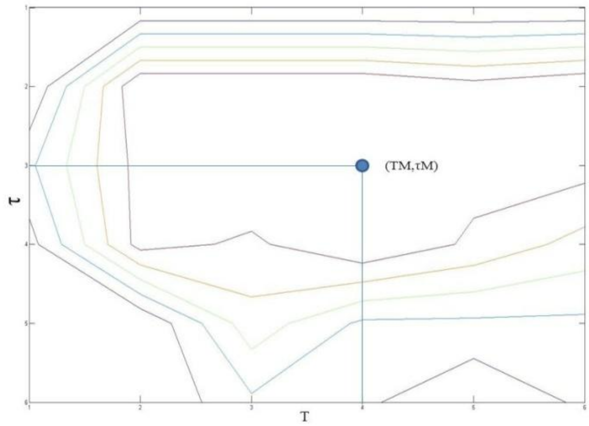

Figure 4: Results of the AM recognition experiment

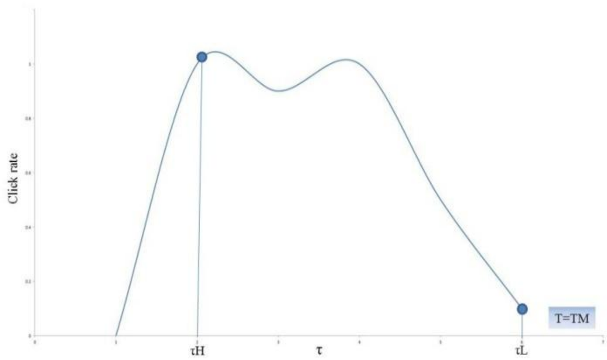

Figure 5: Results of the AM recognition experiment with the constant value of T=TM.

The obtain values of TM, τ0 (the lowest τ value in the first experiment's result), τL, τM, τH will be used as the variables of the second day's (EMG) experiment.

In our study, two periods of the EMG data are in the center of attention: the period before applying the stimulations (pre-stimulation data) and the period after applying the stimulations (post-stimulation data).

In order to study the frequency characteristics of the EMG data (since it has a vast frequency range from 50Hz to 200Hz) discrete Wavelet packet transform was tried. The Wavelet packet transformation is performed in 8 levels by using the Doubachese-3 mother wavelet. As a result of wavelet packet decomposition in 8 levels, 256 packets appeared. Additionally, in order to compare the data of wavelet packets of different channels and different subjects *Fisher`s ratio* is used. Fisher's ratio (FR) is a measure for (linear) discriminating power of some variable that is defined as below: [5]

$$FR = \frac{\sum_{i=1}^{c} \frac{n_i}{n} \left\| \overline{x}_i - \overline{x} \right\|^2}{\sum_{i=1}^{c} \frac{n_i}{n} \overline{\overline{x}}_i} \tag{2}$$

when:

$$\overline{\overline{x}}_i = \frac{1}{n_i} \sum_{i=1}^{c} \left\| x_i - \overline{x}_i \right\|^2 \tag{3}$$

The EMG results recorded with (TM,τ0) parameters will be considered as class 1 and the EMG results recorded with (TM,τL) or (TM, τM) or (TM,τH) parameters will be considered as class 2. In these equations *i* is the index of wavelet packets, $\overline{x}$ is the average values and $\overline{\overline{x}}$ represents the variance values.

Since the EMG data recorded before applying the stimulations can be considered as the default behavior of the subject, the results of data analysis will be presented as the variance between the post-stimulation data and pre-stimulation EMG data (*V*) as:

V = (Post Stimulation – Pre Stimulation) (4)

The calculated FR of the 12th EMG recording channel of all subjects owns the maximum value of FR among the other 18 channels. Thus, the 12th channel`s results will be presented as the final results for each subject.

After obtaining Fisher`s ratio in the mentioned 3 types of class selection (τ0-τL, τ0-τM andτ0-τH), we tried to find the packets (frequency ranges) which Fisher`s ratio is maximum when the selected 2 classes, regarding to the definition of τM, are τ0 and τM .

Different ranges of Fisher`s ratio were tried and compared. In order to find the range that owns the maximum FR values, variance between the 3 types of FR class selection was calculated. Figures 6 and 7 show the variance between the summations of FR values that have been calculated in 3 different types of class selection. In figure 6 variances between FR summations of two different class selection groups (τ0-τM and τ0-τL) for 3 subjects is depicted. Figure 7 depicts the variances of FR summations in two different class selection groups of τ0-τM and τ0-τH (3 Subjects).

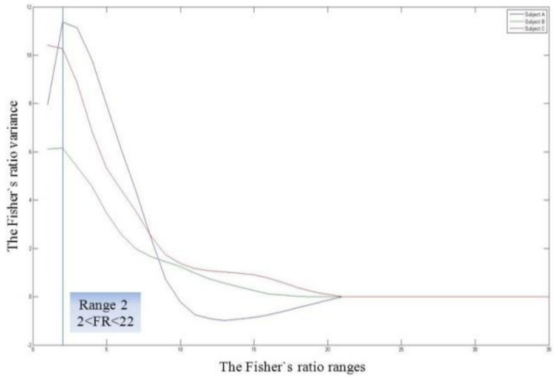

Figure 6: Subject A

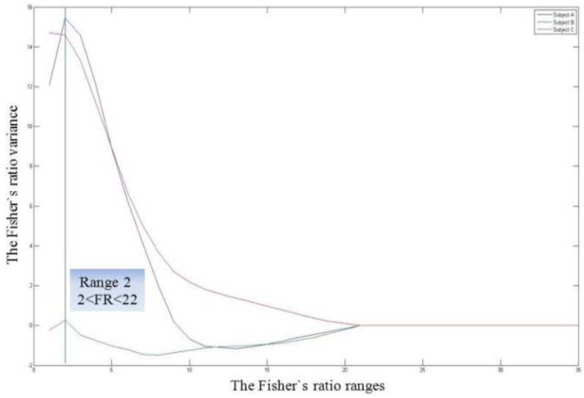

Figure 7: Subject B

Comparing the different FR ranges, we came to this conclusion that Fisher`s ratio is maximum in the 2nd range that belongs to the range between FR=2 and FR=22. Figures 8, 9 and 10 show the Fisher`s ratio values (calculated with the two classes of τ0/τM) in the mentioned range of 2~22 for all the 256 packets of the 8th level of DWPT.

In order to present the most results in the most understandable form, the results of the figures 8, 9 and 10 are depicted after applying a low-pass filtration in frequency domain. In these figures, the higher areas show the bigger values of FRs that has been calculated between the two classes of data recorded with τ0 and τM.

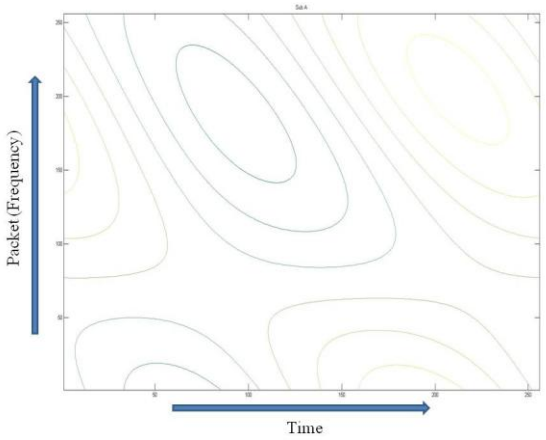

Figure 8: Subject A

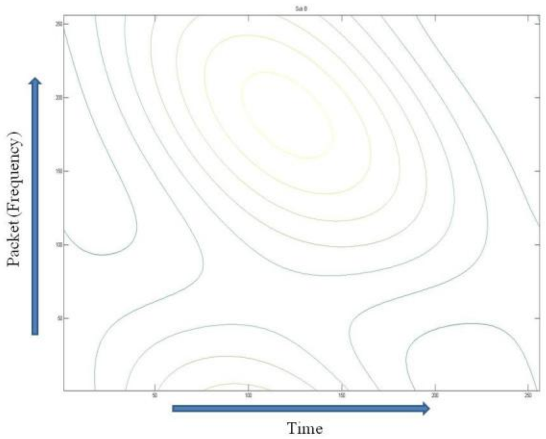

Figure 9: Subject B

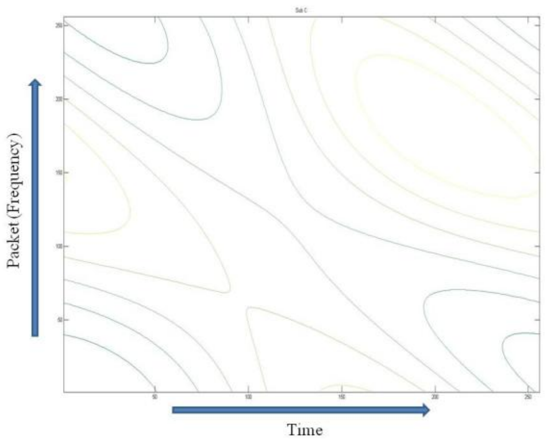

Figure 10: Subject C

Comparing the results of the recorded EMG data analysis for the 3 subjects of A, B and C, basically, two significant areas own the maximum ranges of FR with a similar shape and formation. It can be understood that the results of the subjects A and C are quite similar from the formation of the maximum areas point of view while the result of subject B is still obeying the same form with a down-ward shifting.

IV) CONCLUSION

In this study, the sway of the subjects' arm caused by individual tactile stimulations and tactile apparent movement recognition as its result was investigated. By focusing more on the frequency characteristics of the body-sway, the expected quantitative evaluation of the body-sway became possible. The results of this study show the possibility of the periodic movements of the testing part of the body which occur during the apparent movement recognition.

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