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（博士課程）
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論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	ライフエンジニアリング 系 コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of (philosophy)
学生氏名： Student's Name	STAPORNCHAISIT SORAWIT	指導教員（主）： Academic Supervisor(main)	
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Conventional prosthetic hand control system usually controls finger using pattern recognition from surface ElectroMyoGraphy (sEMG) signal from the forearm, as most of the finger muscles are located in the forearm with small tendon connected to the finger skeletal. However, pattern recognition can provide only limited posture and grip motion which is different from natural musculoskeletal models of hand. Although science understands the relation between muscle activity and finger motion but most prosthetic arms still operate using the conventional method of pattern recognition such as machine learning and artificial neuron network.

The first study provided further research in the field of thumb and index finger angle and force estimation. The experiment was setup to measure the characteristic of thumb and index finger muscles, which will be used in the proposed Musculoskeletal model (MSM).

In the first experiment, the sEMG signals are considered as muscle contractions and motion of all fingers are simplified into flexion and extension motions. The method used to calculate thumb and index finger angle from surface EMG signal is mathematic equation derived from MSM. Stiffness and force command were converted into torque using simple spring theory, then applied to motor. Generally, the statistical analysis showed high correlation between sEMG signal and thumb, index angle estimated by MSM and Linear Regression model (LRM). MSM showed better performance due to 2-order regression. However, MSM was still unable to maintain finger angle during smaller activation after motion due to its lack of damper element. The finger angle result showed highly consistence correlation coefficients (CC) with different around 0.04 ± 0.06 for thumb finger and 0.08 ± 0.06 for index finger which was relatively low in term of CC value. This indicated that MSM and LRM performed very similarly with small improvement. In term of Root Mean Square Error (RMSE), it showed similar improvement in the same trend as CC value.

For the finger force experiment, the results were still consistence for thumb finger but less consistence in index finger. In some subject, the force estimated using LRM showed better performance. The different between MSM and LRM also became much smaller, indicated that finger force might be able to represent using only 1-order linear regression. MSM also showed deep dip before force activation. This happened because subject unconsciously extended their fingers before the experiment which could be reduced by repeating the experiment multiple times on one subject. However due to muscles fatigue, we try to limit the number of repeated experiments to as small as possible for each subject. The results of MSM and LRM in force were not different because the relation between EMG signal and force from finger was linear. Therefore, MSM did not provide any advantage over LRM.

After regression method was confirmed using MSM and conventional sEMG sensor. Many problem was arise and can be call as signal quality. sEMG signals from the forearm used in prosthetic hand and finger control systems require precise anatomy data of finger muscles that are small and located deep within the forearm. The main problem of this method is that the signal quality depends on the placement of sEMG sensor, which can significantly affects the accuracy and precision to estimate joint angles or forces. Moreover, in case of amputees, the location of finger muscles is unknown and needed to be identified manually for sEMG recording. As a result, most modern prosthetic hands utilize limited number of muscles with pattern recognition to control finger according to predefined grip which is unable to mimic natural finger motion. To address such issue, we used array sEMG sensors to obtain sEMG signals from all possible positions on the forearm and applied regression method to produce natural finger motion. The signals were analyzed using independent component analysis (ICA) to find the best-fitted independent component (IC) that matches the anatomical data taken after the experiment. Next, from the IC and ElectroMyoGraphy (EMG) signals, finger angles were estimated using LRM. Each finger was assigned EMG and IC component for flexion and extension muscles, to assess the possibility of controlling each finger angle separately. We compared the joint angles of each finger between calculated from IC and EMG by for all fingers. The average CC values were higher than 0.7, demonstrating the strength of the linear relationship. The different between IC and EMG methods suggests that the IC method can reduce noise and increase the signal to noise ratio. The performance of ICA method showed higher CC value at around 0.2±0.10. In order to confirm the performance of ICA method, we also tested mathematical MSM. The result from this study showed that not only array EMG sensors with ICA significantly improve the quality of signal detected from forearm but also reduce problems of conventional EMG sensors and consequently improve the performance of regression method to imitate natural finger motion.

The advantages of our system over conventional EMG system are:
· Standard protocol for all subjects participate in the experiment (Reduce complexity).
· Reduce time used for select location of EMG sensor due to anatomy variation of each subject.
· Able to detect deep muscle (such as finger muscles) EMG signal using multiple sensors and signal processing.
· Able to compensate for muscle movement under skin that generate disruption of EMG signal caused by adjacent joint movement.
· Higher overall performance using the same regression method.
· Do not limit number of muscles.
And the disadvantages are:
· Require at least 30 minutes before experiment to attach sensors.
· Target area should not move during experiment.