

Multi-day analysis of surface and intramuscular EMG for prosthetic control

by

Muhammad Asim Waris

Myoelectric control of upper limb prostheses has been an active area of research for many years. To date, surface electromyography (sEMG) is the main control signal used in commercial systems. However, it has been suggested that signals obtained from implantable electrodes, such as intramuscular EMG, may be a better source to provide independent sources for control. From the control schemes point of view, pattern recognition (PR) has been extensively researched as means to enable a more robust, intuitive, effective and simultaneous control of a large number of degrees-of-freedom (DoF) as offered by current advanced prosthetic limbs. However, how to achieve robustness over time with different PR schemes has received less attention in the literature. In the current thesis, the main aim was therefore to examine the behaviour of EMG based PR myoelectric control over time. Three specific research questions (SRQ) were formulated to address this aim: 1) To what extent threshold values affect the time domain features and their combinations in surface and intramuscular recordings? This question was addressed in the study I, where the threshold for each feature was computed as a factor ($R = 0:0.02:6$) times the average root mean square of the baseline. For each threshold value, classification error was quantified using two classifiers first for each individual feature and then combined. Results have demonstrated that using appropriate threshold value is very important to assure acceptable performance. 2) What is the correlation between the performance of PR based myoelectric control schemes and time? This question was addressed in study II and III using surface and intramuscular EMG concurrently recorded from 10 able-bodied subjects and six trans-radial amputees for seven consecutive days. A standard linear regression analysis was performed in study II on each EMG type for the identification of time effect (days) on classification accuracies. Study II showed that performance is significantly dependent on the time elapsed between training and test. In study III, Artificial neural network outperformed all other tested classifiers in terms of mitigating the effect of time on classification. 3) How do PR training strategies influence real-time performance over time? This question was addressed in Study IV, an experimental protocol was designed to determine the effect of training strategies on real-time PR control over time using a Fitts' law approach. Results suggest that increasing the size of training set over time (by concatenation) can be beneficial to assure robust performance of the system over time. Moreover, classification error can be mitigated as the time lag between training and testing increase.

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Ph.D. lecture

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Wednesday 26 June 2019



DEPARTMENT OF HEALTH SCIENCE AND TECHNOLOGY
AALBORG UNIVERSITY

This thesis is based on Muhammad Asim Waris's research work at:



SMI
Department of Health Science and Technology
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To fulfill the requirements for the Ph.D. degree, Muhammad Asim Waris has submitted the thesis: Multi-day analysis of surface and intramuscular EMG for prosthetic control, to the Faculty Council of Medicine at Aalborg University.

The Faculty Council has appointed the following adjudication committee to evaluate the thesis and the associated lecture:

Associate Professor Levi Hargrove
Northwestern University
US

Associate Professor Max Ortiz Catalan
Chalmers University of Technology
Sweden

Chairman:
Associate Professor Samuel Schmidt
Aalborg University
Denmark

Moderator:
Professor Winnie Jensen
Aalborg University
Denmark

The Ph.D. lecture is public and will take place on:

Wednesday 26 June 2019 at 13:00
Aalborg University – Room D2-106
Fredrik Bajers Vej 7 D2
9220 Aalborg East

Program for Ph.D. lecture on

Wednesday 26 June 2019

by

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Chairman: Associate Professor Samuel Schmidt

Moderator: Professor Winnie Jensen

13.00 Opening by the Moderator

13.05 Ph.D. lecture by Muhammad Asim Waris

13.50 Break

14.00 Questions and comments from the Committee
Questions and comments from the audience at the
Moderator's discretion

16.00 (No later than)
Conclusion of the session by the Moderator

After the session a reception will be arranged