Surface-EMG Processing & Classification for Muscle Interfaces

University of Southeren Denmark

Supervisors:
Poramate Manoonpong (poma@mmmi.sdu.dk)
Xiaofeng Xiong (xizi@mmmi.sdu.dk)

Date:

1 Abstract

Hello, this is my abstract...

2 Acknowlegdements

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Glossary

abduction/adduction Movement away/towards the midline of the hand. 11, 12

Congential A disease or physical abnormality present from birth. 6

flexion/extension The bending movement of the finger. 11

phalange Bone in the finger. 11

sEMG surface-electromyography. 8

traumatic A disease or physical abnormality due to trauma. 6

Contents

3 Introduction

The human hand is one of the most important factors of the human identity. The hand allows a person to perform complex muscolatory combinations to interact with the surrounding world, express complex emotions during speech, and aid in defining a person's individuality and personalty [?]. The hands are controlled by a complex combination on precise muscles designed to perform gentle, precise control of the fingers. This allows a person to grasp objects in many different ways, perform complex tasks such as writing, playing musical instruments, or even constructing a house. The hand also acts like a sensory device allowing us to perform precise observations through feeling and touch. This allows a person to understand the environment without seeing it, the hand is able to sensor heat/cold, create complex understanding of geometries and texture through touch and manipulation.

Missing limbs, either Congential or traumatic amputation severely reduces a person's ability to interact with- / understand the world, express themselves and perform simple day-to-day tasks. In order to alleviate some of the drawbacks of missing a limb, amputees are often able to aquire a prosthetic replacement of their lost limb. The aquired prosthetic tries to imitate the movements of the lost limb, through muscle-activated interfaces, that is then used to control the movements of the prosthetic. In the case of hand prosthetics, the prosthetic allows the user to perform simple, day-to-day tasks, and is able to alleviate some of the stress caused to the non-amputated hand through overusage.

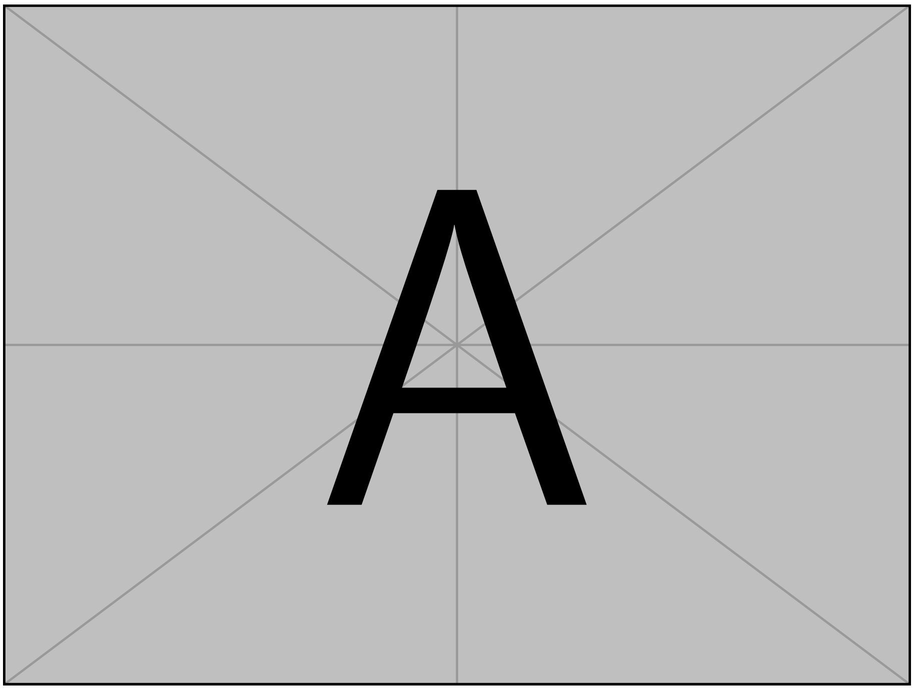

Figure 1: Example figure text

This thesis aims to summarize, and elaborate on current state-of-the-art research and products in the field of prostetics devices, and products the control of prosthetics and the existing limitations of these state-of-the-art products.

This thesis aims to contribute to the world of prosthetics control, by researching effective methods of collecting sensory data from the lower-/upper-arm, and by doing so, creating an state-of-the-art Artificial Intelligence (AI) based controller, that is able to imitate the intent and movements or a real hand. And by doing so, by improving sEMG controller design to increase functionality and the controllable DoF of the prosthetic, to provide a more true-to-life experience to the prosthetics user, and thus reduce the amount of patients that disregard prosthetics.

This thesis also aims to explore efficient methods of designing a network to identify lower-/upper-arm muscolatory intent, with the purpose of controlling a simulated prosthetics device, and by doing so, increase the controllable Degree-of-Freedom for the prostetics user.

4 Problem Specification

There is a large need for new technology that improves the effectiveness and ergonomics of human hand prosthetics.

Current state-of-the-art products on the market exhibits a severe reduction of controllable Degree of Freedom (Dof) compared to their biological counterparts. These products often rely on simple, grasp control based on 2 or more surface-electromyography (sEMG) interfaces, to classify "open/close" signals for the control scheme. The prosthetics user is then manually required to change grip control-scheme, creating very crude control dynamics that is very different from biological hand-control. A in-debth explanation of "open/close" control can be seen in section **??** This is a great pitfall in the field of Research and Creation of prosthetics, as unsatisfactory function of prosthetics lead to amputees, that exhibit a great deal of stress douring the rehabilitation process.

This can cause the patient to repel the rehabilitation process and the prosthetic all-together. The repelling of the prostetic increase in the cases of the most severe cases of amputation, where the largest amount of control muscles are lost. These amputations are often located further up the limbs, where the loss of mobility and controllability are greatest. The amount of muscles leftover from amputation also dicates the type of prosthetic a patient is able to recieve. Patients of lower-arm amputation has less control over their prosthetic than patients of hand amputation, due to the loss of the muscles in the lower-arm. The loss of control increases as the amputation severity increases, and this is a problem in prosthetics design because it is impossible to create a standardized controller that suits most patient's needs.

State-of-the-art commercial prosthetics further decrease the controllable DoF in order to increase robustness of the control experience, this is further elaborated upon in **??**.

4.1 Motivation

The main goal of this thesis is to provide a meaningful contribution to the world of prosthetics design and control. In order to confine the workload done in this thesis, a set of development goals has been made:

1. Create a software-based, biology-inspired, anatomically realistic simulation of a humanoid lower-arm/hand that is able to imitate the movements of the humanoid limb.
2. Make the prosthetics simulation controllable from a widely-used robotics-software.
3. Design a sEMG muscle pre-prossesing pipeline for a prosthetics controller.
4. Design a state-of-the-art prosthetics controller based on AI, to control a simulated prosthetics device.
5. Create a custom dataset to train AI based controllers for prosthetics.

6. Test and Validate the created prosthetics controller against state-of-the-art methods.

5 Literature Rewiew

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6 Methodology

6.1 Design

In order to design a state-of-the-art simulated prosthetic hand, a number of anatomical design choises needs to be considered. This thesis tries to create the most anatomically-correct hand simulation available, this will hopefully have a number of positive effects on prosthetics research. By having access to an advanced simulation, it would in turn be able to test and visualize more advanced movement controllers that can facilitate more DoF than current commercial prosthetics. By creating an anatomically correct prosthetic hand simulation, it is hoped that prosthetics users can have more advanced rehabilitation, and learn to have more natual control of their prosthetics. This would create a more natual usage experience, and decrease the percentage of users that reject the usage of their prosthetic alltogether.

A set of requirements The simulated anatomically correct hand should be determined in order to create a state-of-the-art prosthetics simulation.

The simulated prosthetic should:

1. Facilitate the same DoF as an anatomically correct hand.
2. Have porpotions that closely resemble that of an anatomically correct hand.
3. Be simulated and be controllable in a commonly used robotics software to increase accesability for researchers.

6.1.1 Brief of used Software

6.1.2 Anatomy

The hand is an anatomically-complex appendage designed to facilitate a large amount of control in different usage scenarios. The hand consists of 27 bones, 14 of these are called phalnages, and make up the 4 fingers and the thumb. These bones, alongside a complex set of ??? muscles facilitates 24 DoF (Not counting Translation of the entire hand).

The individual finger consists of 3 bones called phalange, arranged linearly from the palm of the hand. The 3 finger bones are called the proximal phalange, middle phalange and distal phalange. The joints between the phalanges are able to do flexion/extension movement, while the base of the finger is further able to do abduction/adduction movement.

6.1.3 Simulated Hand Articulation design

In order to translate the biology and anatomy of a real hand into an robotics simulation, we start by denoting the relative lengths of the wrist bones and phalnages by refrence, as can be seen in figure 2.

The porpotions of the refrence is used to denote the bone lengths for the model. The model is implemented in Coppeliasim **??**, The model is created in a hierachy, the

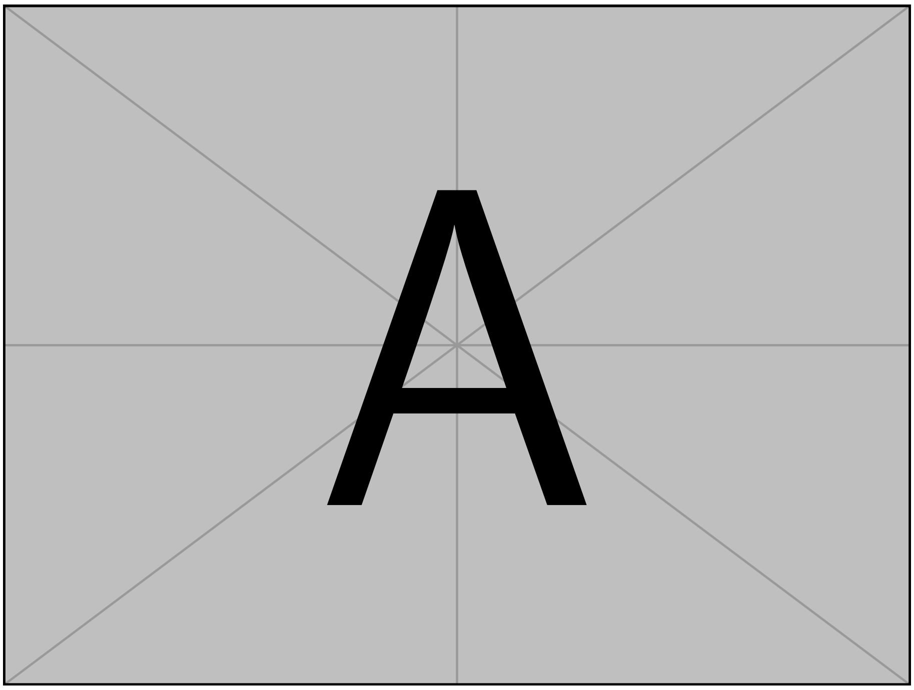

Figure 2: Example figure text

bones are created with cylinders and the joints are created using 1 DoF Revolute joints. As specified in section 6.1.2, some joints of the human hand facilitates 2 DoF of rotation. This is needed in order for the wrist and finger base joints to be able to do abduction/adduction. To simulate this, two 1 DoF revolute joints were placed in series, thus allowing 2 DoF.

6.2 Dataset Creation

In order to train a simulated hand prosthetic, a sofisticated dataset containing the measured relation between muscle activity and the finger placements is needed. The recording of the dataset is done using the software explained in section 6.1.1, namely XXXX & YYYY.

6.2.1 Motion Capture Glove

In order to get precise recordings of the motion of the hand and fingers, using the software XXXX, flourecent 3D markers were placed on a glove. The pattern of the marker positions were carefully closen in order to calculate the angles of the individual finger bones. The precise positions of the 3D markers on the recorder glove can be seen in figure 3.

6.2.2 Sensor Locations etc.

The muscle recording sensors are located along the muscles of the forearm, the exact positions can be seen in figure 4.

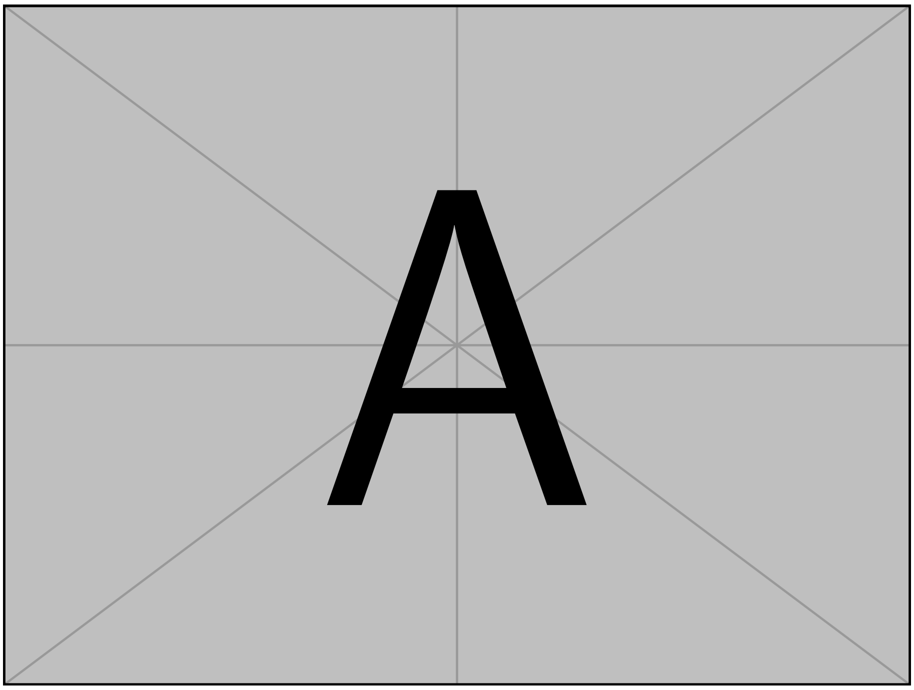

Figure 3: Example figure text

6.2.3 Trial/motion overview

6.3 Implementation

6.3.1 Data Pre-Processing

6.3.2 Network Design

6.3.3 Software Hand Design

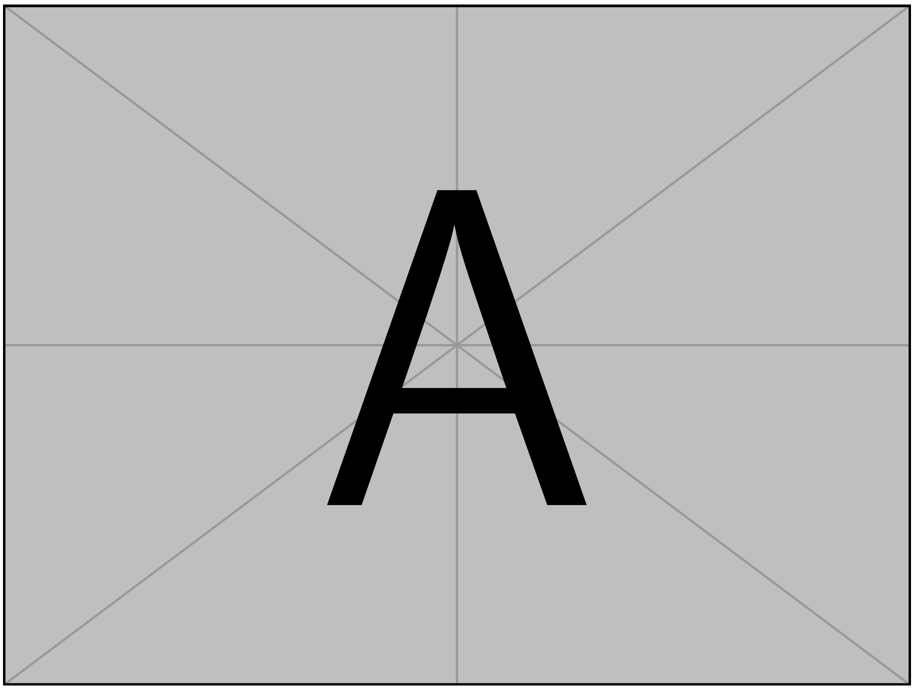

Figure 4: Example figure text

7 Tests & Results

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8 Discussion

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9 Conclusion

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9.1 Perspectivation

List of Figures

List of Tables

10 Refrences