# Estimation of Grasping Force from features of intramuscular EMG Signals with Mirrored Bilateral Training

*File name = kamavuako2011.pdf*

Extracts features from EMG to estimate grasping force

Features :

* Root mean square
* Global discharge rate
* Standart sample entropy
* Constraint sample entropy

Application for unilateral amputees

* Callibrate the estimator by doing a gesture with the able arm and imagining doing the same gesture with the missing arm while using EMG sensors on the remaining muscles of the missing arm.
* not as accurate as it would be with all the muscle remaining but still allows to finf enough information for grasping force estimation
* The article does not speak about reinnervation

Show that the used EMG are sufficient to predict grasp force

Intramuscular EMG

## Simultaneous and proportional estimation of hand kinetics from EMG during mirrored movements at multiple degrees-of-freedom

*File name = muceli2012.pdf*

Mirrored billateral movement in free space with EMG sensor on arm muscles + neural network to help unilateral transradial amputees.

The study aims to enhance the number of DOF that can be controlled on a myoelectric arm prosthesis to allow more complex motions which are necessary for everyday tasks

Hypothese :

* We know that bipolar recordings of EMG are sufficient to control some DOF
* The hypothese s that high-density surface EMG recordings would allow to better exploiting tthe spatial informations across the muscles
* => the study validates this hypotheses but not for all cases

Maps EMG to kinematics rather than forces

* Kinematic =  the mechanics of motion without reference to the forces causing that motion (<https://www.gearssports.com/sports-kinetic-kinematic-sequence/#:~:text=Kinematic%20%3D%20the%20mechanics%20of%20motion,in%20producing%20or%20changing%20motion>)
* Movement described in term of angular displacement to the resting position

The experiments were done on normal limbed subjects which is necessary prior amputees subjects

Captures motion of the arm using infrared digital video camera [to use as groung truth for EMG classification]

EMG are first offline band-pass filtered to atenuate DC offset, motion artifacts and high-frequency noise

ANN = artificial neural network

* Used to learn the association between EMG and hand kinematics
* The EMG signal is known to be related to the force produced by the muscle <https://www.researchgate.net/publication/4377891_Electromyography_Physiology_Engineering_and_Non-Invasive_Applications>
  + So, a neural network should be able to predict it
* Static ANNs because perform as well as Time Delayed ANNs
* 8 multilayer perceptrons (MLP) to estimate the movement
  + Hidden layer : sigmoid activation function
  + Output layer : linear activation function
* The output is low-passed filtered at 1 HZ to match the frequency content of the network target (?)
* 4 fold cross validation (70%/30%)

Feature analysis

* Electrodes are close to each other -> signals are correlated -> dimensionality of the input for the learning could be reduced via feature selection
* Feature selection =
  + channel selection (group channel together. 1 channel can be in multiple groups),
    - 1 channel = 1 electrode
  + Principal component analysis (PCA) (14 principals components were kept)

Results

* Good prediction using the ANN and a small number of neurons
* Around 83% of normalized corss-correlation between corresponding angles of the 2 arms

Discussion :

* Shows better result than previews sutdies while also having more DOF and allowing dynamic movement in free space (closer to real life scenarios)
* Forearm EMG are sufficient to decode the user intended hand movement
* 2 proposed way to train the ANN for amputees :
  + Use the other arm as ground truth
  + Ask the subject to replicate the movement of someone else et use this movement as ground truth
* When an amputee thinks about moving its phantom limb, stump muscle activity pattern can be found