DISCRIMINATING 6 GRASPS USING FORCE MYOGRAPHY OF THE FOREARM

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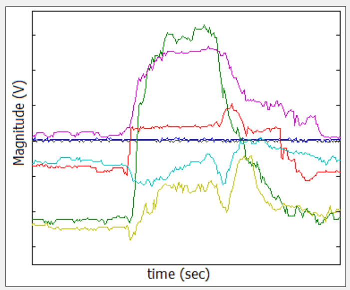
Abstract

The neuromuscular volition of gross motor control of the hand is encoded in the muscles of the forearm. A major challenge for prostheses and rehabilitative schema is to accurately extract that volition. Force Myography (FMG) uses an array of force-sensitive resistors to measure pressure changes on the skin caused by this muscular activity. Using FMG, it is possible to discriminate with high accuracy between 6 different grasps in healthy control subjects. This suggests the feasibility of identifying the volition of impaired subjects using FMG, as well as the potential for FMG signal discriminability to provide a metric for assessing motor control.

Force Myography

- Alternative to Myoelectric control
- Sensorized sleeve records radial pressure changes during forearm muscle contraction
- Permanent mounting configuration
- Naturally low-pass signals
- Grasp characterization decoupled from sensor location

Haptic



One Trial, FMG Signal Magnitude vs time

- Subjects grasp unique objects
- 6 Grasp Types, 10 Trials each
- Feature Extraction:
  - Mean
  - Variance
  - Mean-Crossings
  - Onset slope
- Nearest Neighbor classification
  - 1,2,3 point holdout
  - Increasingly pessimistic
- 10 subjects, 28.7 ± 11.3 yrs
- 5 male, 5 female

Holdout	Accuracy (%)
1	**95.0 ± 5.6**
2	**94.9 ± 5.7**
3	**94.8 ± 5.7**

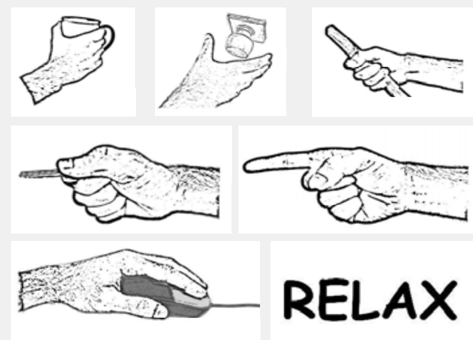
Results from Haptic protocol, Mean ± stdev, N=10 subjects

Postural

- Continuous data collection, repeated for 4 sets

7-state system

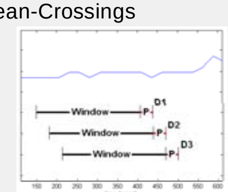
- 6 grasps, 1 rest



Features extracted from data windows

- Mean, Variance, Mean-Crossings

- Windows incremented by length of processing delay, resulting in **maximal density** of data stream



Half of repetitions are unlabeled, used to test classification algorithm → **50% Holdout**

	Accuracy (%)
Raw	46 ± 6.9
MajVote	52 ± 8.5

System Accuracy Estimates, 50% Holdout, ***with & without Majority Vote*** *smoothing Mean(%) ± stdev (N=7 subj)*

	Accuracy (%)
Mean	52 ± 8.7
StDev	33 ± 6.1
Mean-Xings	35 ± 9.7

System Accuracy Estimates, 50% Holdout, ***comparing Mean, StDev, and Mean-Crossings*** *Mean (%) ± stdev (N=7 subj)*

Note: Coin-Flip for a 7-state system is only 14.3%

Discussion

- Both Haptic and Postural protocols produce highly **accurate Grasp Classification** using Nearest Neighbor
- ***Haptic*** produces sparser data-stream, enables **tactile feedback** for greater accuracy
- ***Postural*** allows more data points, yields a more pessimistic Accuracy Estimate, reduces influence of tactile feedback as in **Prosthesis Control**
- **Mean Amplitudes** are most accurate in Postural
- Minimal Processing
- Orientation-Insensitive
- Representative Surface Map
- Comfortable and Convenient

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References

Phillips, S, et al. "Residual Kinetic Imaging". *Robotica* **23,** 277-282, 2005.

Zecca, M, et al. "Control of Multifunctional Prosthetic Hands by Processing the Electromyographic Signal". *Crit Rev. in Biomed Eng.* **30**, 459-485, 2002.

Englehart, K, et al. "Continuous Multifunction Myoelectric Control using Pattern Recognition". *Tech and Disab.* **15**, 95-103, 2003.