A Comparison of Supervised Learning Algorithms for Telerobotic Control Using Electromyography Signals

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PROBLEM

Human Computer Interaction (HCI) is central for many applications

- Hazardous environment inspection
- Reconnaissance
- Telemedicine

Can supervised learning produce effective user interfaces?

REQUIREMENTS

Utilize the human body as input controller for HCI

- Response time <= 50 ms
- Accuracy >= 90 %
- Algorithm training < 1 s

PRIOR WORK

Entirely in simulation or tested a single machine learning algorithm

- Neural networks or dimensionality reduction

Position sensors used for calculating position and direction of movement

APPROACH

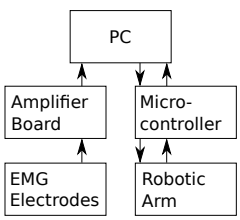
Acquire EMG data for training set from three arm positions

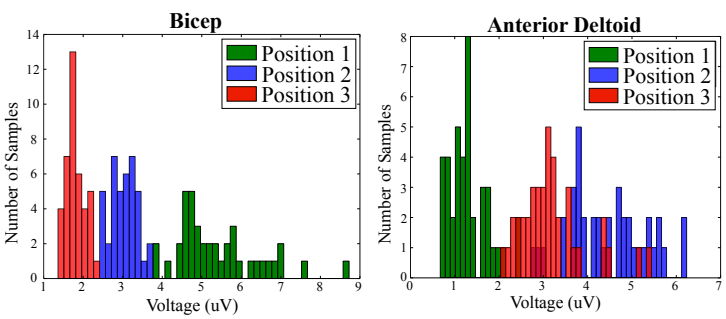
Preprocess signals

- 50-140 Hz bandpass filter
- Mean average value

Compare performance of supervised learning algorithms by 10-fold cross validation in Weka v3.6

Control robotic arm with electromyography (EMG) signals from operator's arm





SUPERVISED LEARNING RESULTS

With a small data set (450 samples) and data showing separability we determined supervised learning algorithms would be a good starting point

- Naïve Bayes (NB)
- Support Vector Machine (SVM)
  - Radial basis function kernel
- Logistic Regression (LR)
- k-Nearest Neighbors (kNN)
  - L2 distance, 1/D weighting
- J48 Decision Trees (J48)
- Random Forests (RF)

	NB	SVM	LR	kNN	J48	RF
Accuracy* (%)	90.00	95.70	90.10	97.80	95.10	97.30
Training (ms)	0.00	20.00	0.00	30.00	20.00	120.00
Testing (ms)	0.02	0.15	0.03	0.08	0.02	0.02

*10-fold cross validation

DISCUSSION

Response time for all algorithms were fast enough for the real-time control

kNN was selected and a single operator was successfully able to control the robotic arm using static arm positions

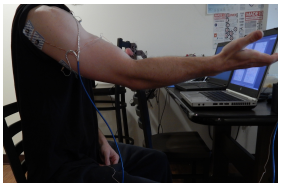
FUTURE WORK

Evaluate whether the system design generalizes to multiple subjects

Additional static positions, with the eventual goal of continuous motion

Static position measurements can be used in to help determine the direction of dynamic movements

Connect an Oculus Rift to the system to take control of a three axis gimbal making it more immersive



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