

## Abstract

This study reports results regarding the efficiency of using Electromyography (EMG) signals as a biometric modality for user authentication. A pre-recorded data base containing EMG read from the biceps brachii of 10 healthy patients is studied. Motor Unit Action Potential (MUAP) timing information is extracted from the database by our python module and as main feature the Inter Spike Distance (ISD) will be used for user classification.

*Index Terms*—Electromyography (EMG) signals, Motor Unit Action Potential (MUAP), Motor Unit (MU), Inter Spike Distance (ISD), K-Nearest Neighbor (KNN)

## Introduction

Current Authentication Techniques (Figure 1):

- Single Sign On (SSO)
- Multifactor Authentication (MFA)
- Biometrics

Systems using traditional biometrics have showed vulnerability before hacking techniques that spoof user's biometric features stored in their servers to gain access [1]. This study intends to investigate the potential of Electromyography (EMG) signals as a biometric modality for user authentication.

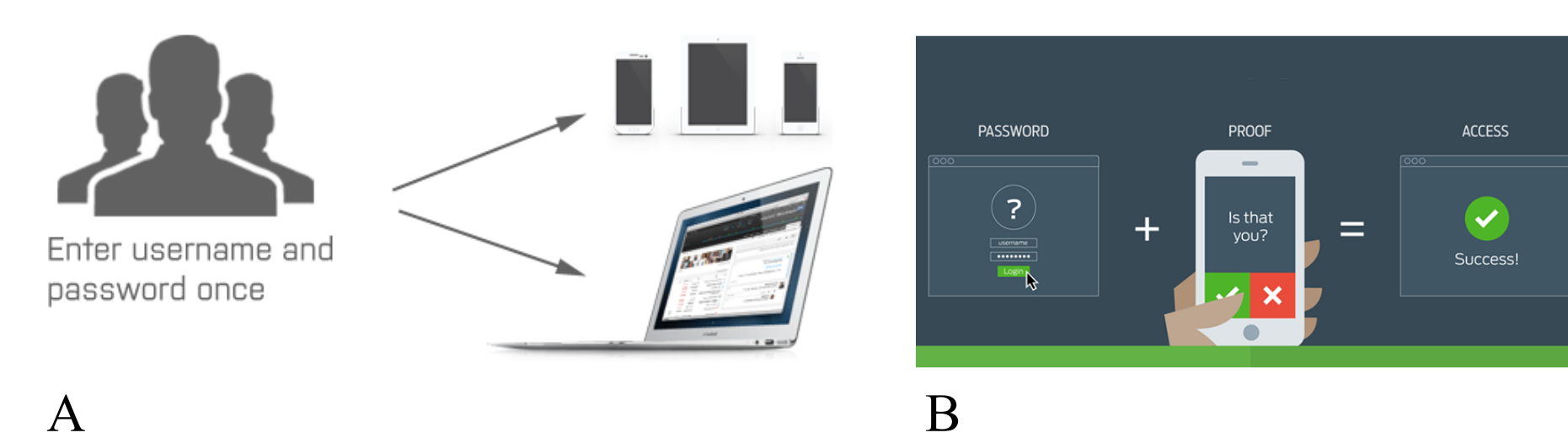


Figure 1. A. Single Sign ON (SSO). B. Multifactor Authentication (MFA)

## Background

- Electromyography (EMG) refers to the sounds, graphs or numerical values resulting from the translation of the electrical activity produced in the muscles [2].
- EMG signals are composed by a train of Motor Unit Action Potentials (MUAPs) plus noise (Figure 2) [3].

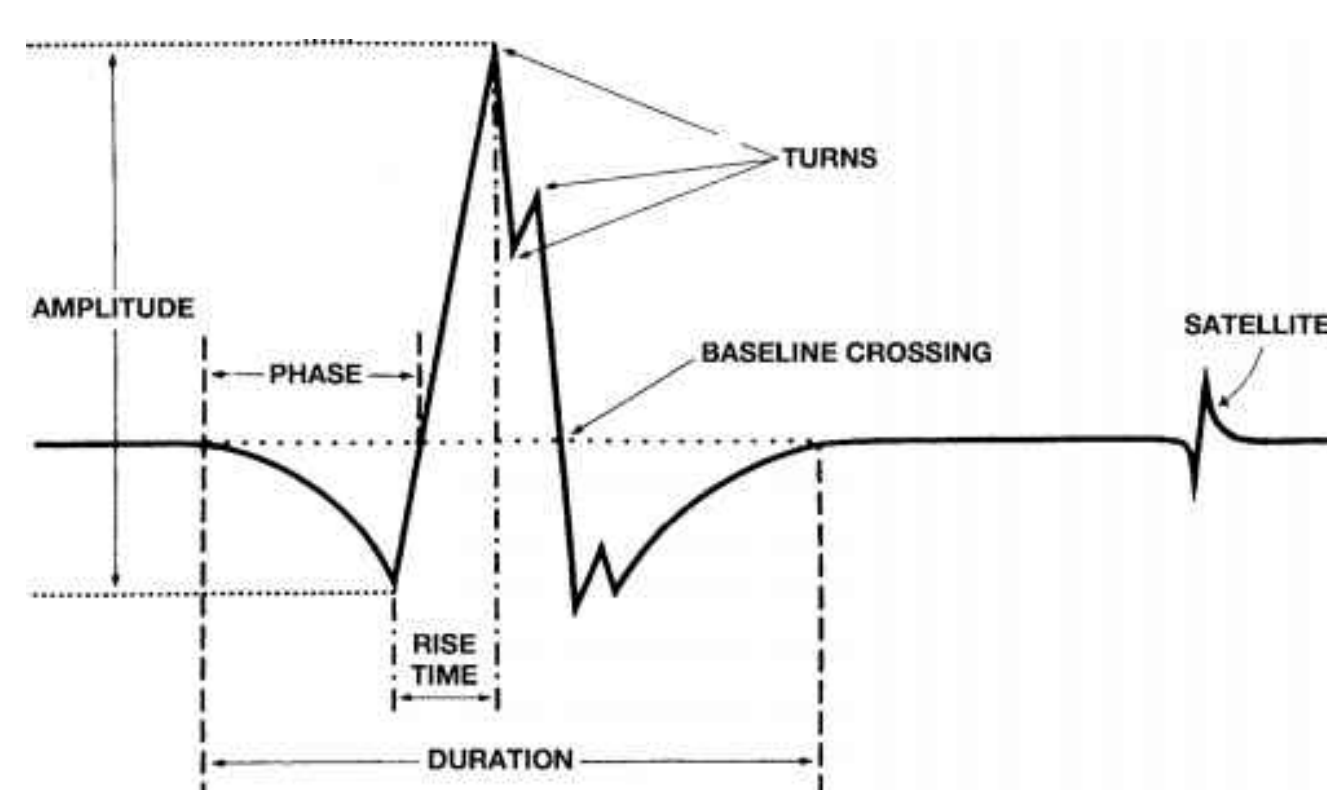


Figure 2. MUAP Characteristics

## Methods

Signal Decomposition:

- A database of clinical signals containing 10 healthy subjects aged 21-37 years' old, recorded by Nikolic M. [4] under normal clinical conditions at low, constant isometric contraction will serve as raw data input to the study.
- Florestal et al. have developed a novel method for decomposing the EMG signal. The decomposition uses an extraction module to determine the EMG constituent MUAP waveforms, and a classification module to match each MUAP to its corresponding Motor Unit (MU) or firing train [5].

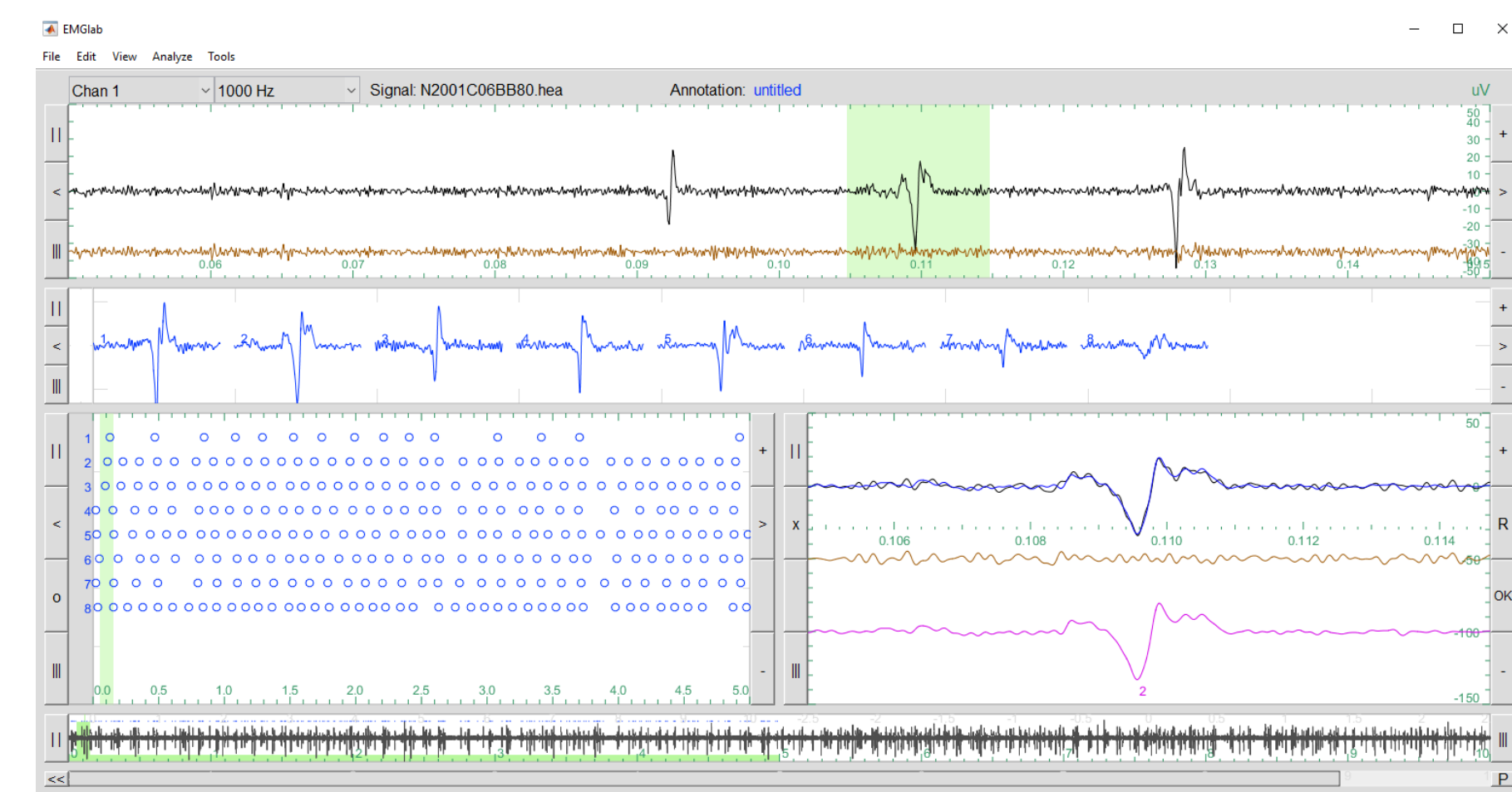


Figure 3. EMGLab GUI. MatLab Module where the MUAP templates and spike times are extracted.

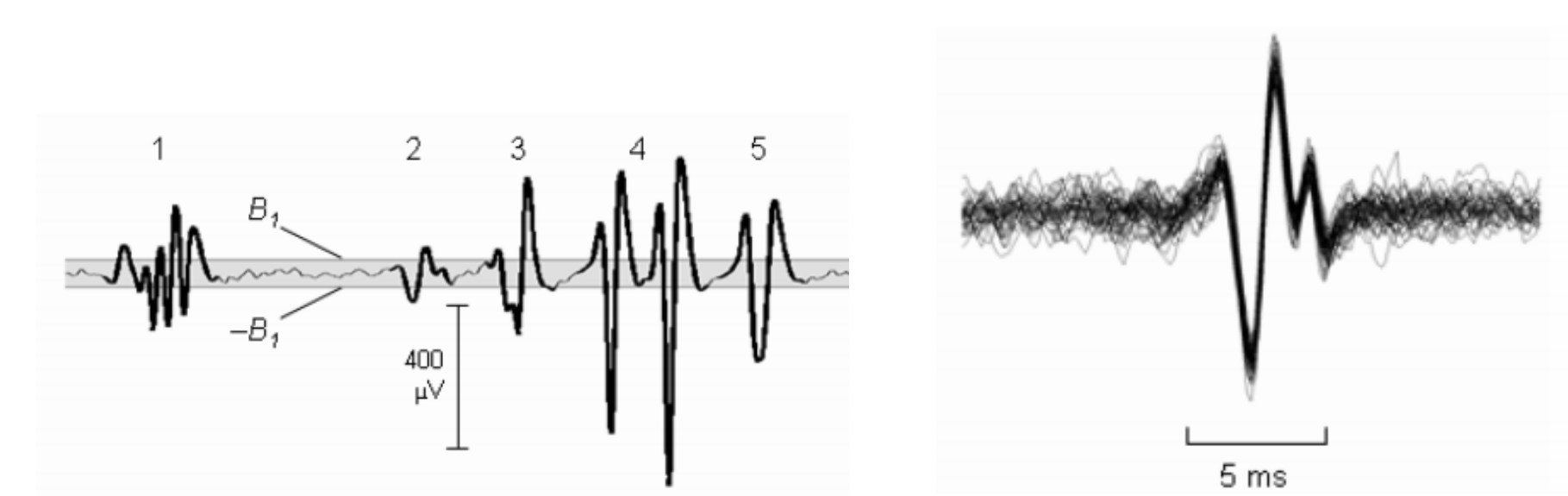


Figure 4. A. Identified MUAP Candidates

Figure 4. B. MUAP Cluster Obtained



Figure 4. C. Averaged MUAP Template

MUAP Spike Times and MUAP Extraction:

- After filtering and decomposing the EMG data annotation files containing MUAP spike times and MUAP shapes may be exported from the MatLab environment.

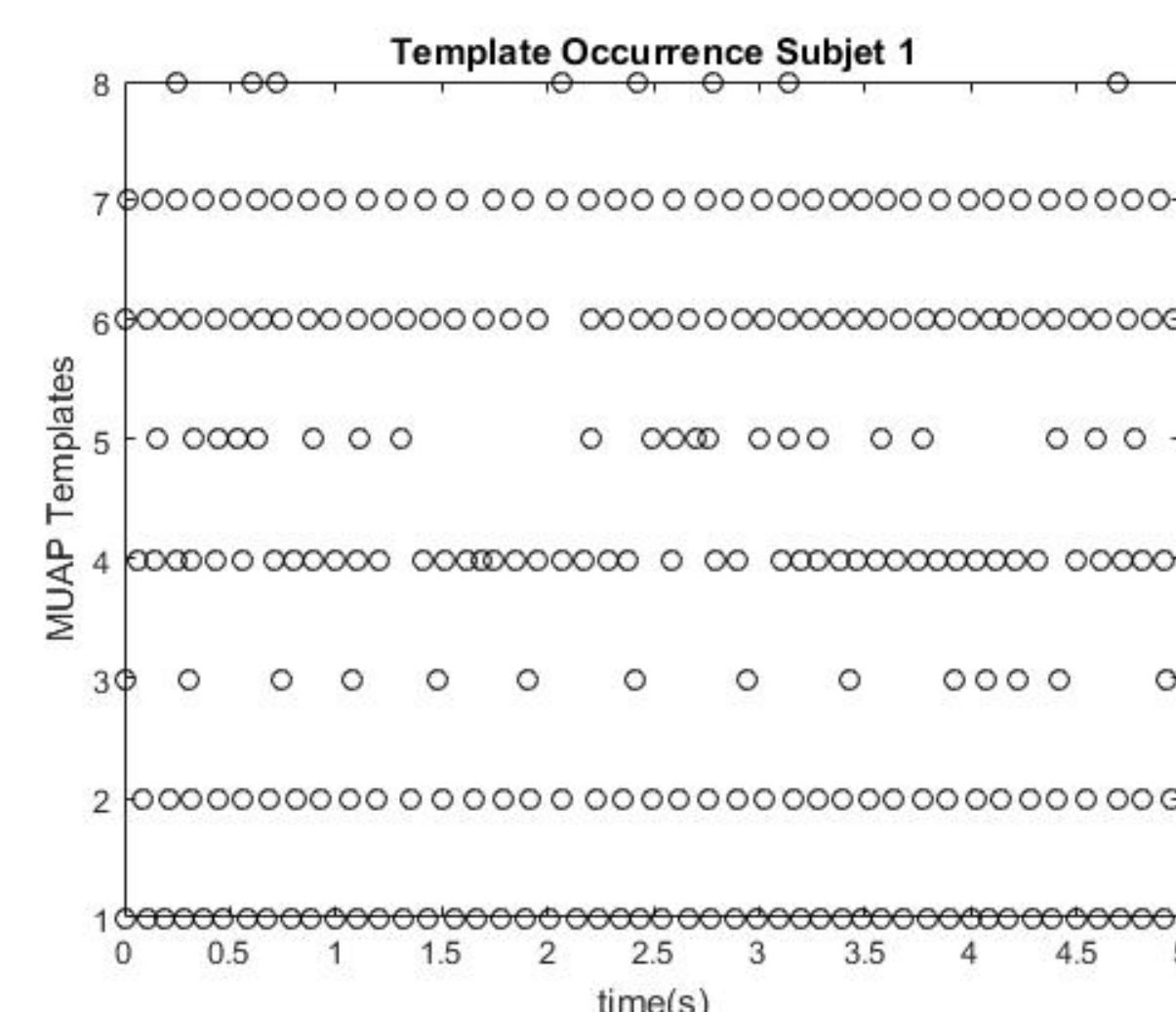


Figure 5. Extracted MUAP Templates for the first 5 seconds of the signal

## Feature Extraction

Inter Spike Distance/Interval:

- Inter Spike Distance (ISD) is the measured time interval between two spikes from the same Motor Unit (MU).
- ISD alongside other EMG signal features are used in medicine on the diagnosis of some neuromuscular diseases [6].
- A python module processes the annotation files containing the MUs spike times to calculate and export to CSV (comma separated value) files, the ISD corresponding to each trial and each subject.

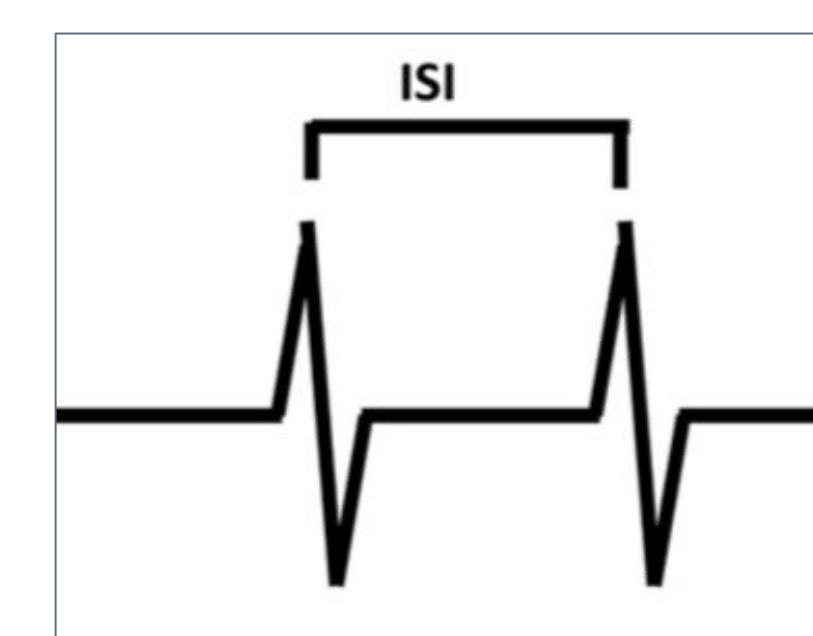


Figure 6. Inter Spike Interval/Distance (ISD)

	A	B	C	D
1	subject	trial	motor-unit	inter-spike-distance
2	1	1	1	0.1009
3	1	1	1	0.0916
4	1	1	1	0.0825
5	1	1	1	0.0962
6	1	1	1	0.0955
7	1	1	1	0.1101
8	1	1	1	0.1001
9	1	1	1	0.1074
10	1	1	1	0.0897
11	1	1	1	0.1161
12	1	1	1	0.1059
13	1	1	1	0.108
14	1	1	1	0.1177
15	1	1	1	0.1052
16	1	1	1	0.1296

Figure 7. Sample Output File

## Classification | Training

Inter Spike Distance (ISD) as Feature for classification:

- From figure 7 it can be observed the output file contains along rows a vector with the following format: (subject number, trial number, MU number, ISD).
- These two feature vector (MU-ISD) is used in the classification phase for user classification.
- To train the model 50% of the data is used and the other 50% is classified after.

Training Performance Comparison:

Classifier	Accuracy	Features
1 ☆ KNN	Accuracy: 21.6%	2/2 features
2 ☆ Tree	Accuracy: 27.9%	2/2 features
3 ☆ KNN	Accuracy: 25.5%	2/2 features
4 ☆ Tree	Accuracy: 24.9%	2/2 features

Figure 8. Comparison of different classifiers training the data set

## Classification | Predicting

Classifier	Accuracy Percentage
Fine KNN	17.2 %
Complex Tree	19.3 %
Simple Tree	17.4 %
Medium KNN	18.3 %

Table 1. Comparison of different classifiers predicting the user from the data set.

## Discussion

The observed results from table 1 and figure 8 show that using the Inter Spike Distance (ISD) and its corresponding Motor Unit (MU) as features for user classification are not efficient, resulting in a very low classification accuracy. The most accurate classifier was Complex Tree with a 19.3 % accuracy.

Also the data set is small and the percentage used for training should contain a larger percent of the total data set.

## Further Research

The following steps in the research will be to extract more EMG features from the data set. These new features should be independent but correlated to the Inter Spike Distance e.g. the amplitude of the signal at its corresponding spike time and duration of the MUAP.

Collecting a new data base will also increase the rate of success since there will be control over how the data is collected, sample rate and more subjects.

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## References

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