

# Signal Processing of Muscular Systems to Control Electromechanical Devices

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# Outline Presentation

- Introduction
- Methodology to Design Biomechatronic Systems
- Processing of Biomedical Signals
- Pattern Recognition Systems
- Results
- Conclusions

# Introduction

Electromechanics controlled by human body



Prosthesis



Therapeutic



Enhance human capabilities.

**Bio-mechatronics** is related with the research and design of devices which integrates biology disciplines with mechanics, electronics and control technology with purposes of assistive, diagnostic, therapeutic or even to augment or to enhance human capabilities.

# Introduction

Electro mechanics controlled by human body



Prosthesis



Therapeutic

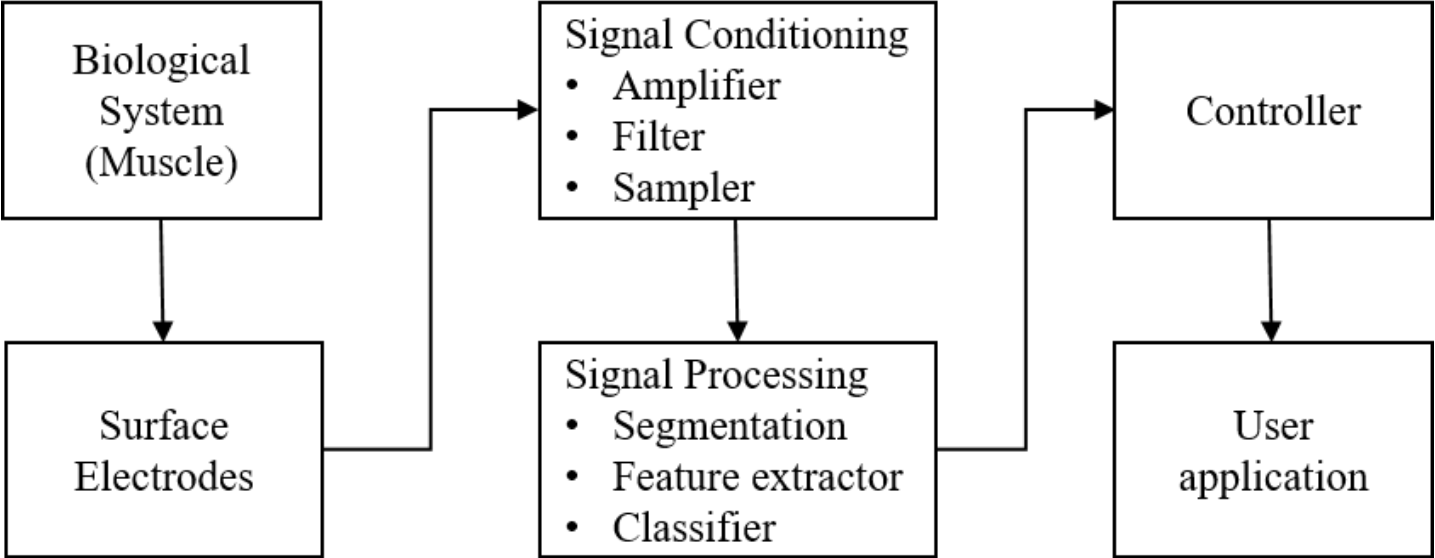
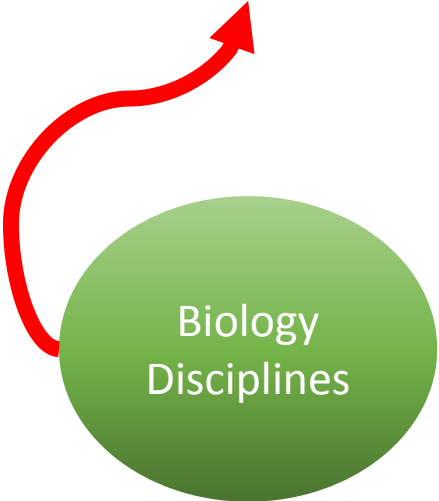
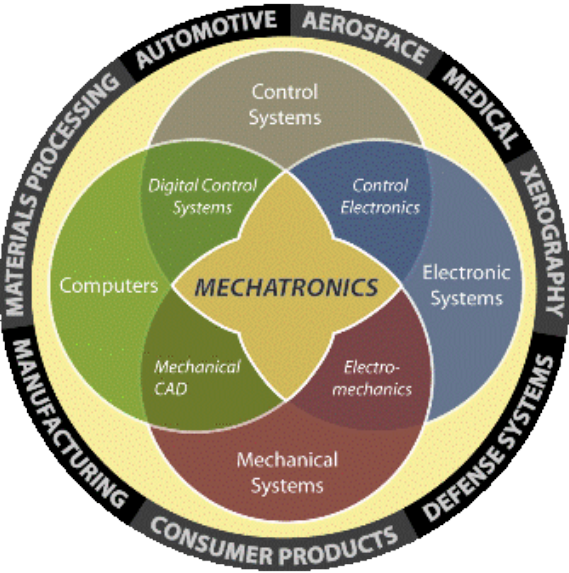


Enhance human capabilities.

All of these technologies share a similar requirement to work properly: **Signal Processing & Pattern Recognition**

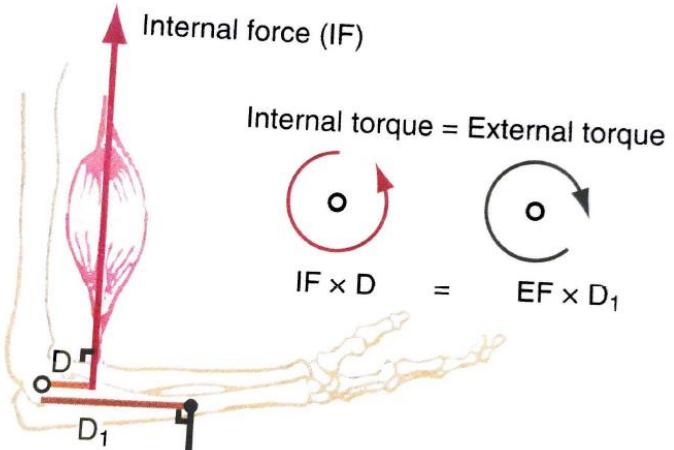
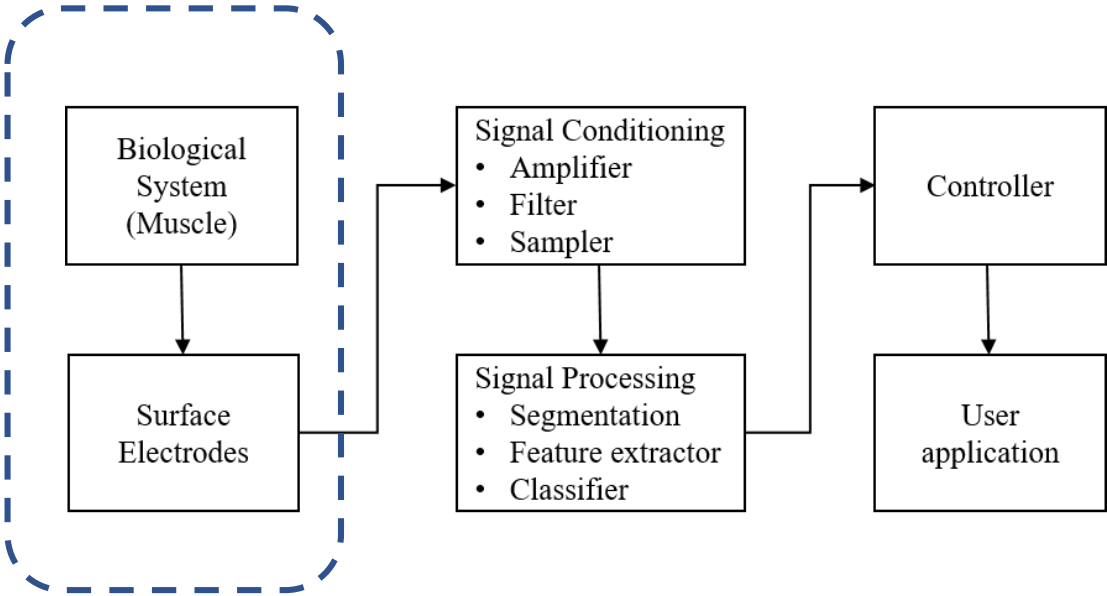
# Introduction

How **Bio-mechatronics** works

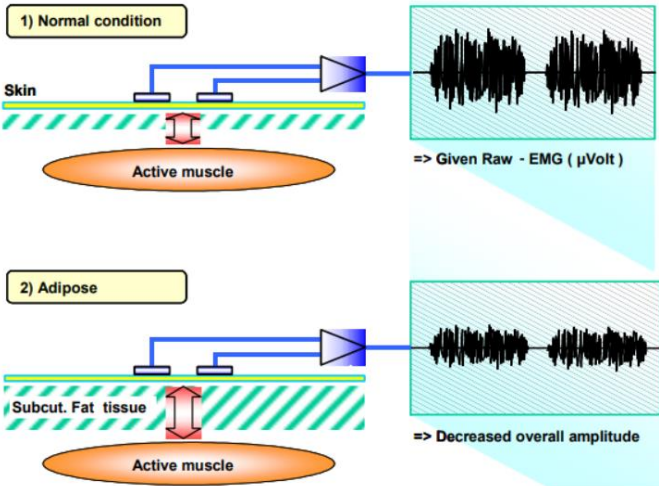


# Introduction

## How Bio-mechatronics works

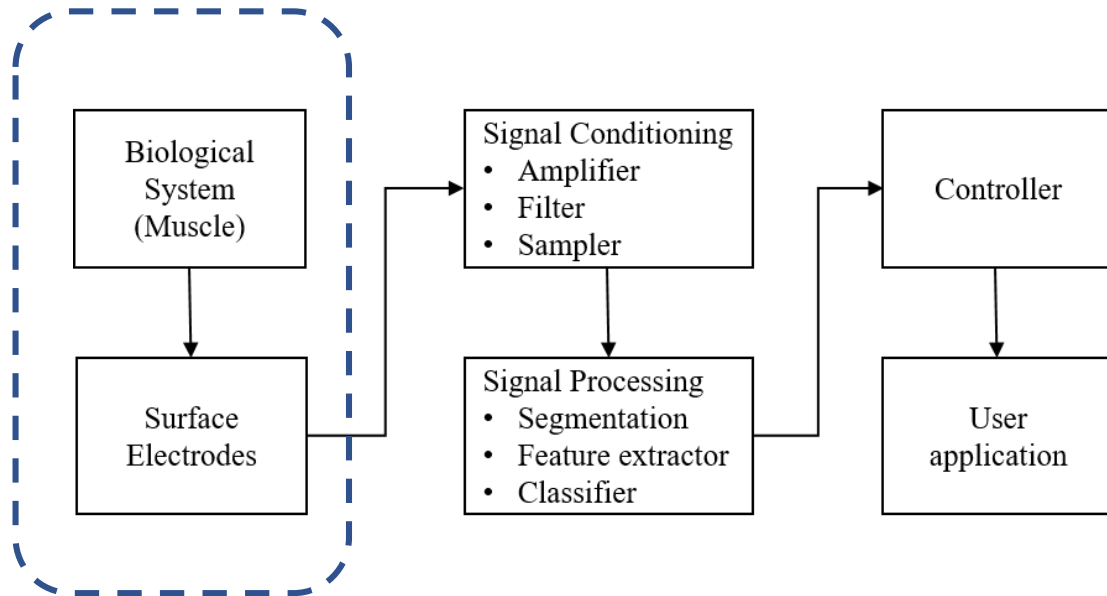


External force (EF)



# Introduction

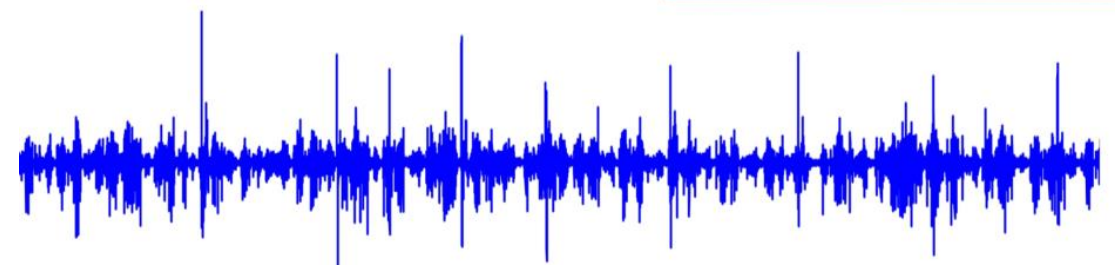
How **Bio-mechatronics** works



“Do you know where your surface EMG (sEMG) signal comes from?”



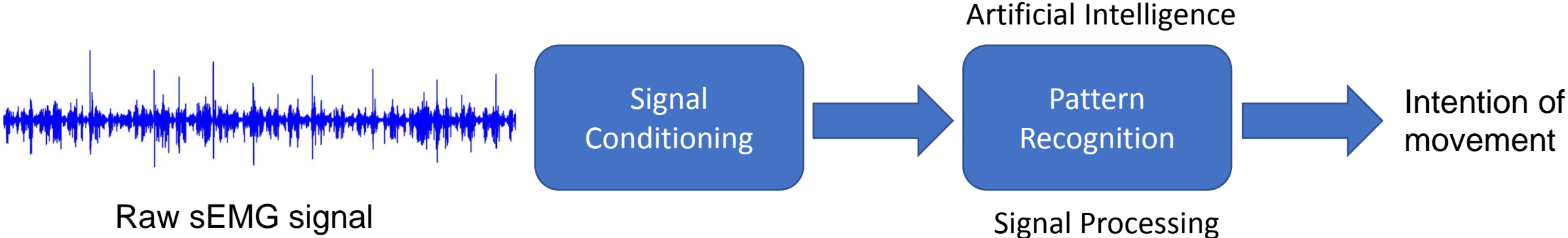
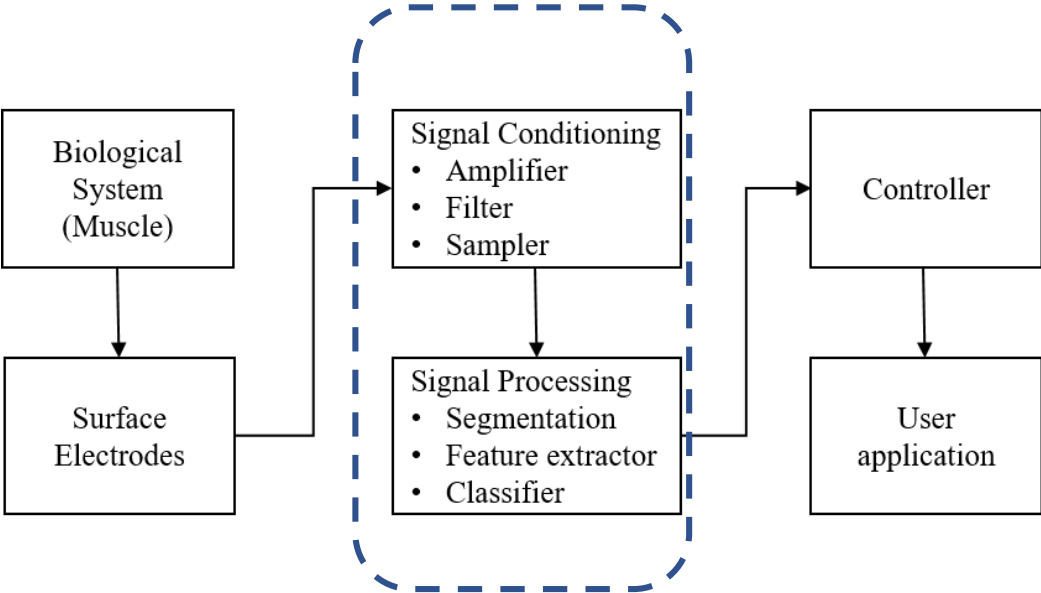
sEMG signal



Raw sEMG signal

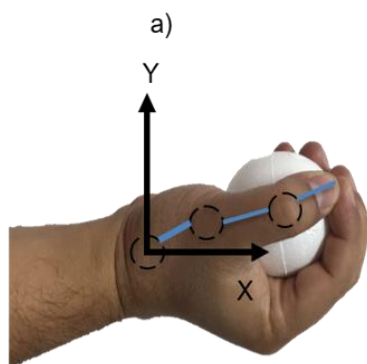
# Introduction

## How Bio-mechatronics works

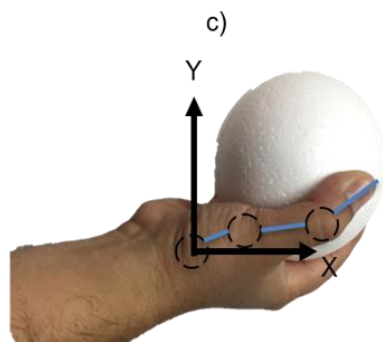




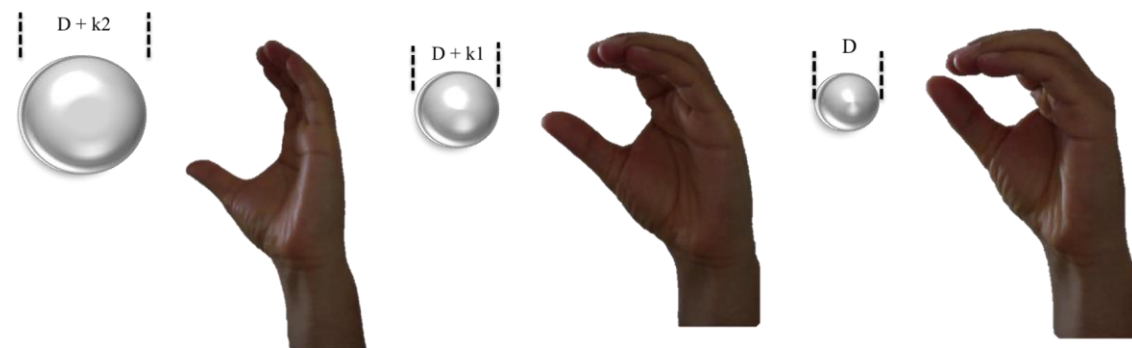
**In this presentation, I will show you how Decision Trees, which are a particular AI technique, are used to design a motion control system that is able to track the finger positions of human hand.**



b)

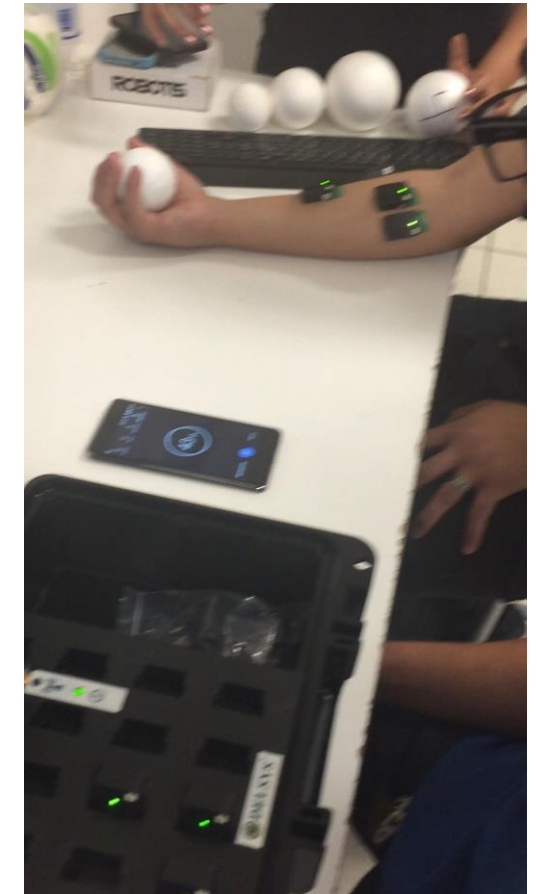
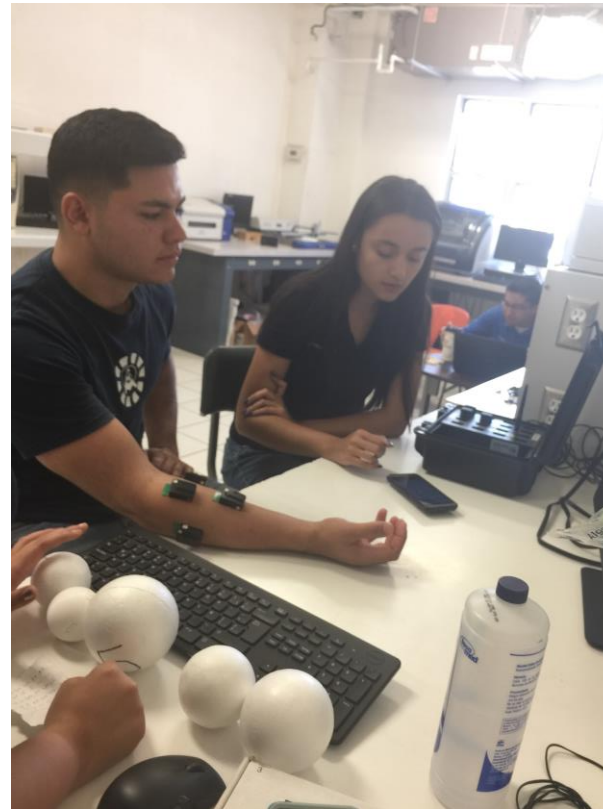
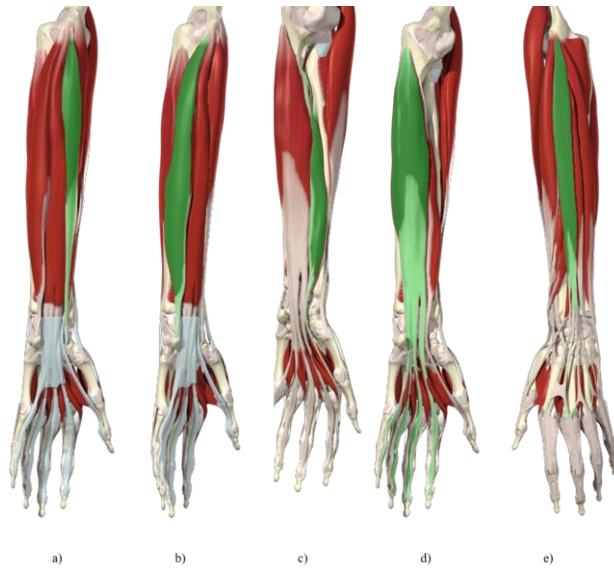


d)

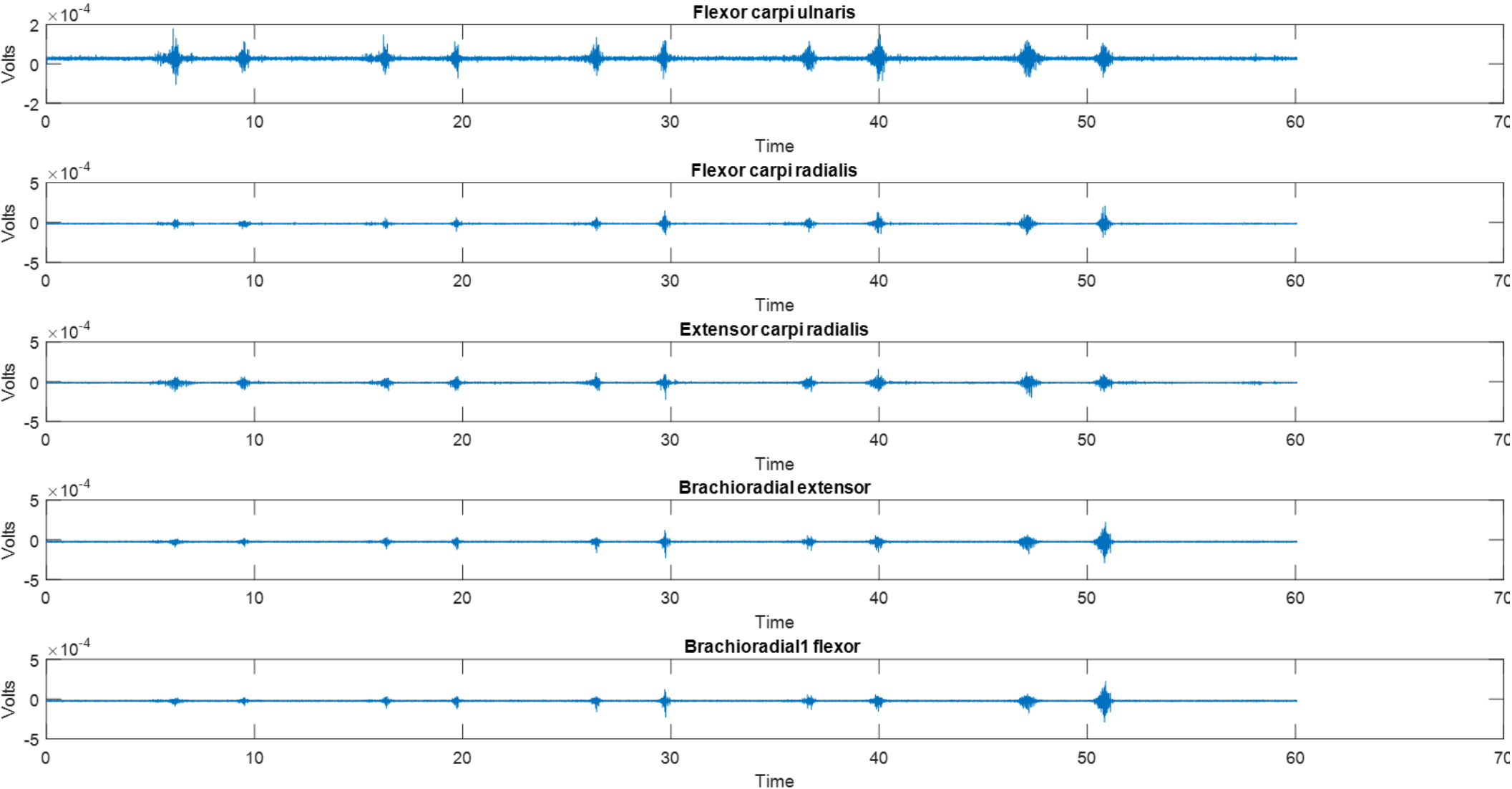


# Acquisition of EMG signals

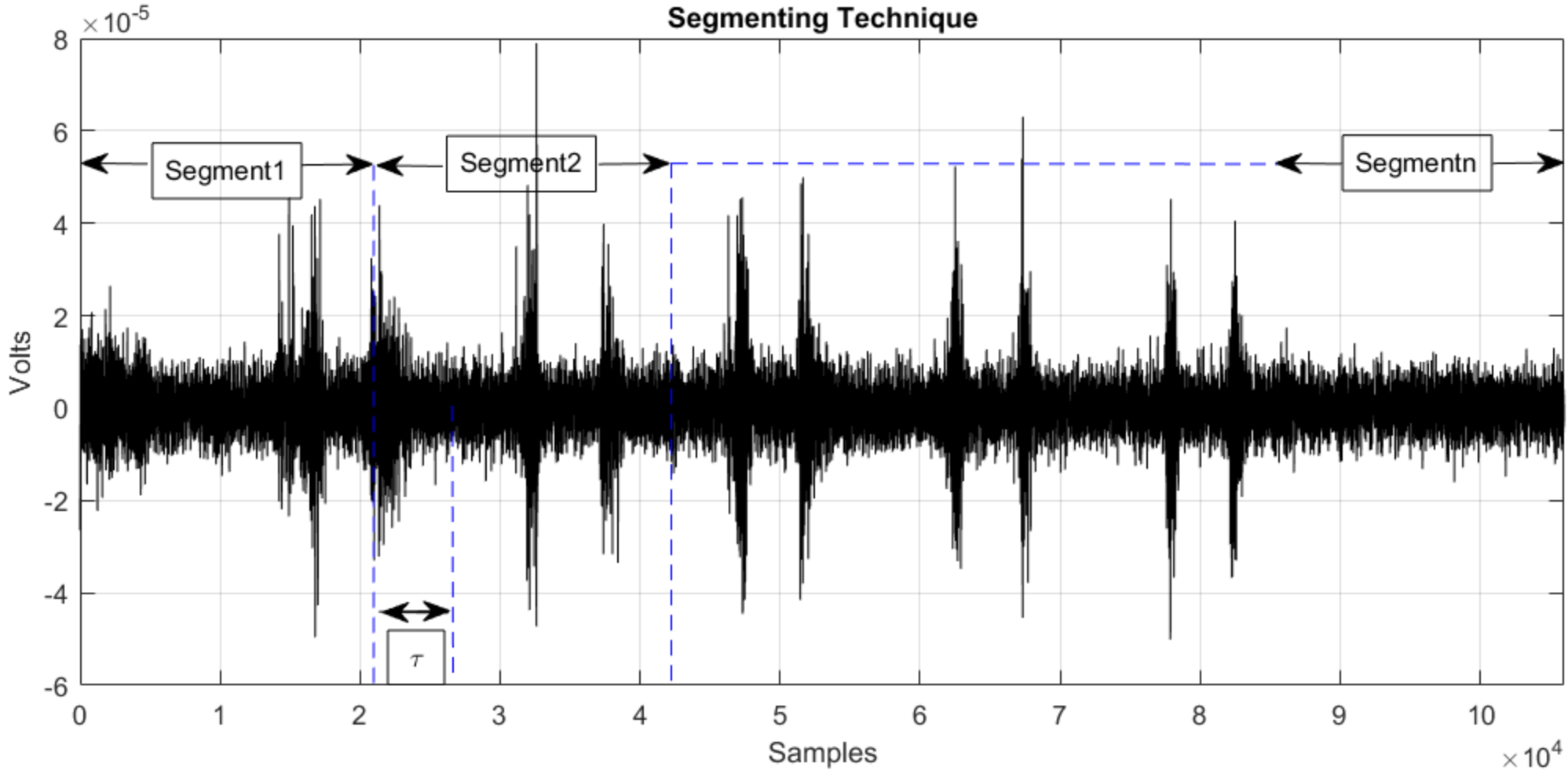
Subjects are instructed to grasp five spheres randomly. The spheres are made of expanded polystyrene with different diameters. Volunteers are seated comfortably and performs the requested fastening of a sphere. Electrodes are located on five muscles: flexor carpi radialis, flexor carpi ulnaris, flexor pollicis longus, flexor digitorum profundus, and extensor digitorum.



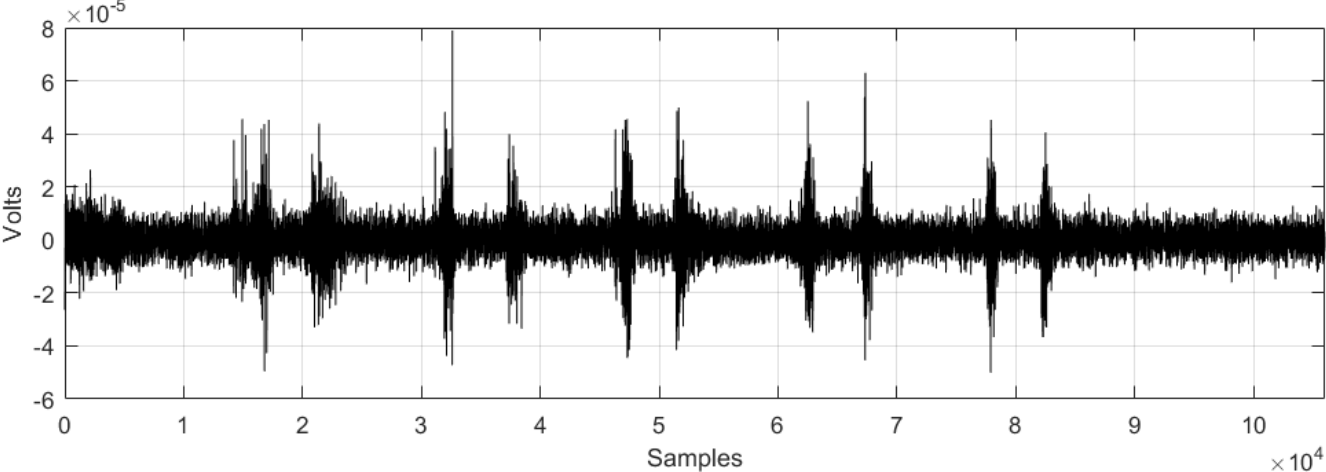
# Raw EMG Signal



# Processing EMG Signal: Segmentation

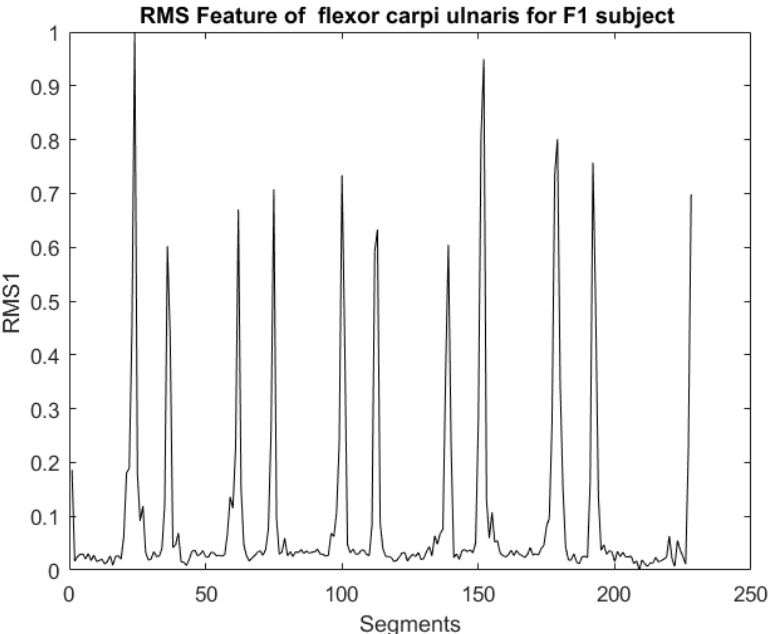


# Processing EMG Signal: Normalization & Feature Extraction

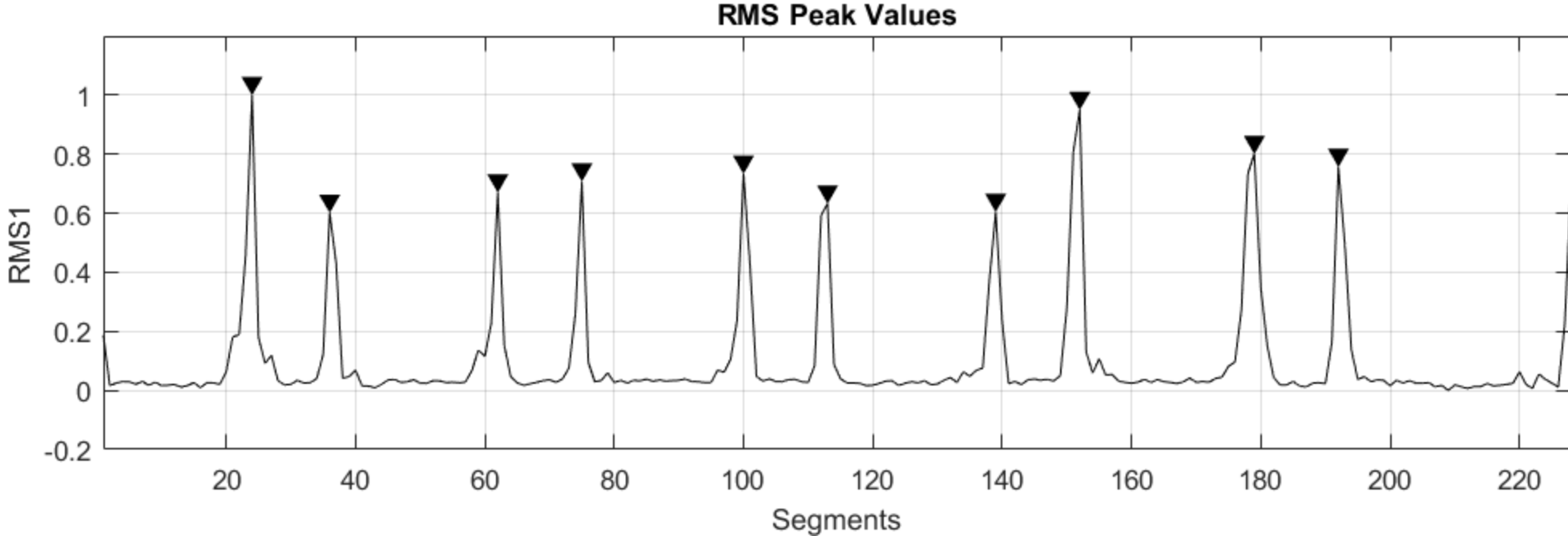


$$X_{RMS} = \sqrt{\frac{1}{N} \sum_{k=1}^N |x_k|^2}$$

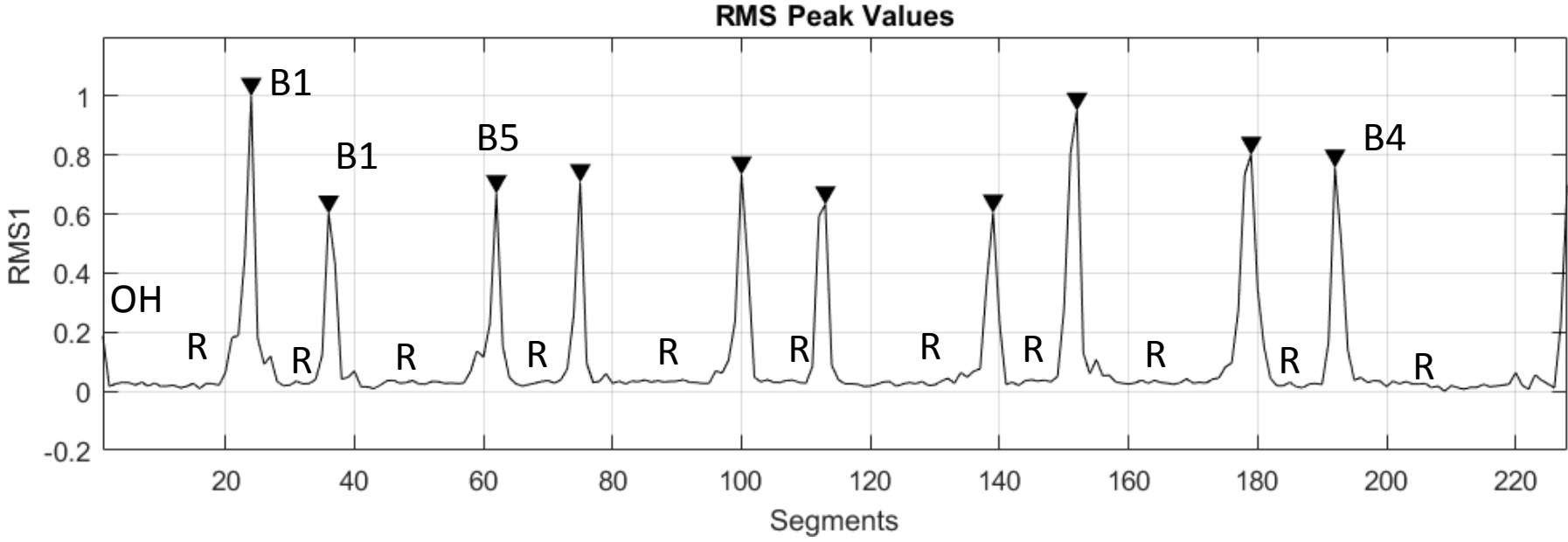
$$\bar{x} = \frac{x - \min x}{\max x - \min x}$$



# Processing EMG Signal: Peak Detector



# Features Extractor



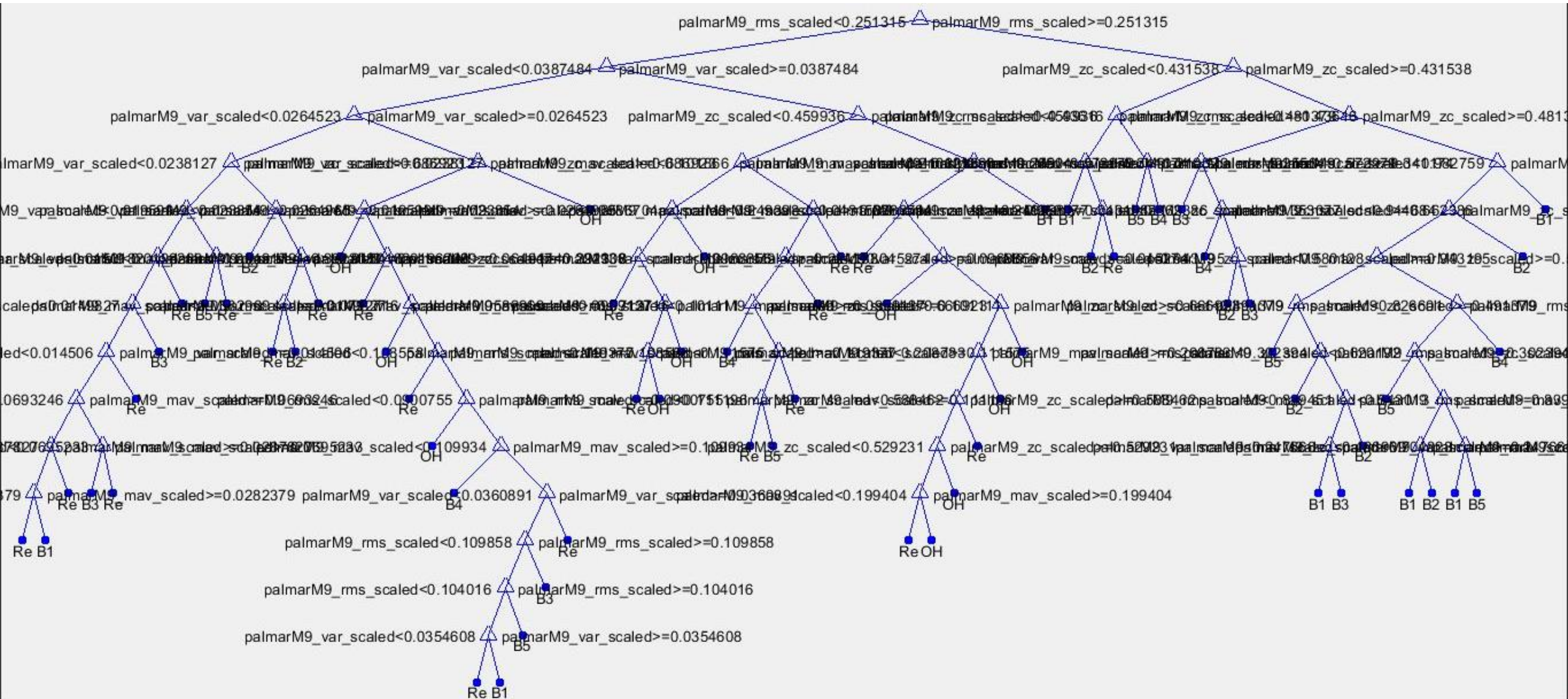
Labels Associations: [OH, R, B1, B5, B3, B2 B4]

# Features Extractor

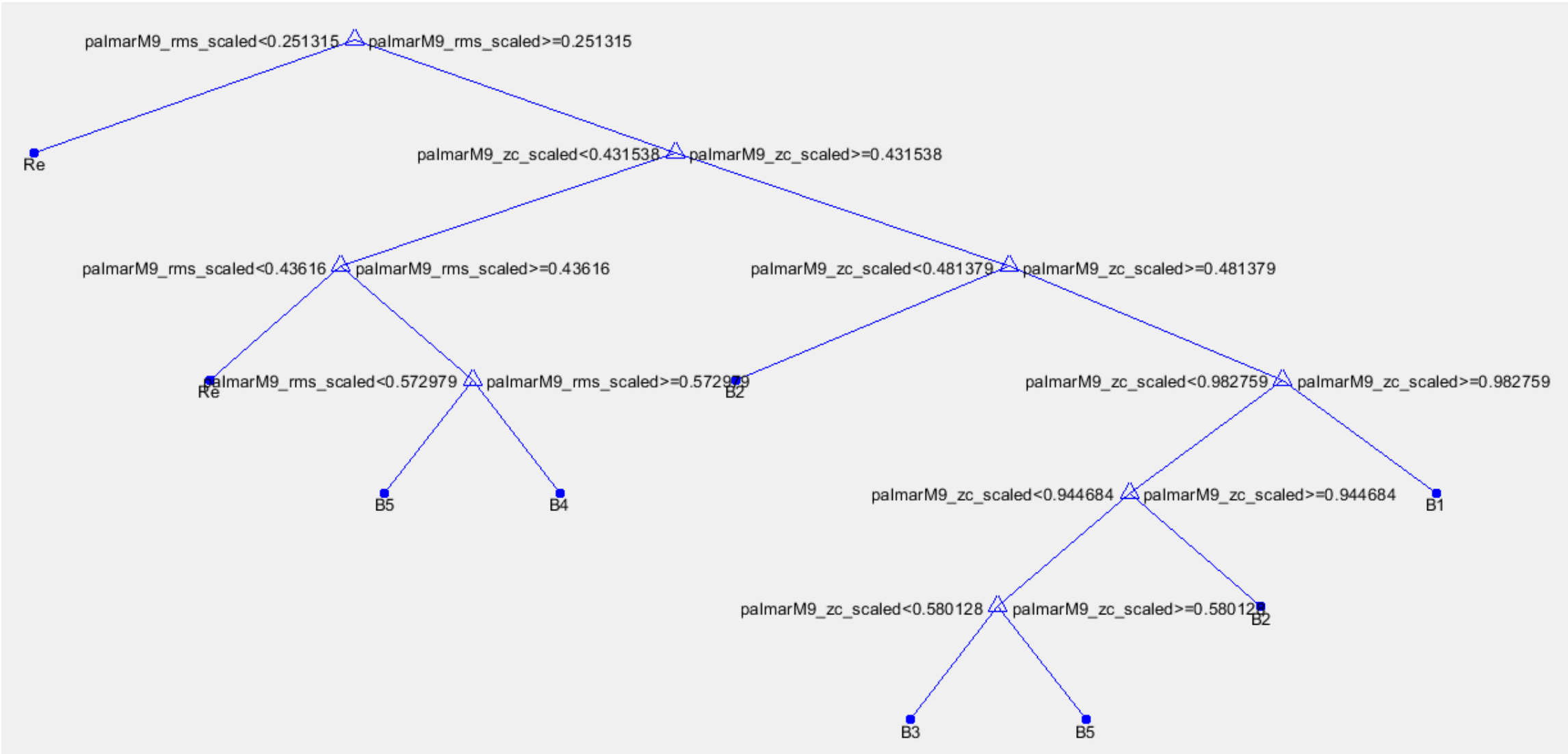
Muscle1 RMS	Muscle1 ZC	Muscle1 VAR	Muscle1 MAV	Label1
0,222813827534454	0,634146341463415	0,181701758612809	0,138656765954966	OH
0,118500900893269	0,682926829268293	0,0774190313422794	0,0948816764221528	OH
0,136119017990988	0,609756097560976	0,0926545543940160	0,109171277008999	OH
0,148147514847144	0,609756097560976	0,104720392679538	0,104798539830816	OH
0,186604343743100	0,560975609756098	0,143710624925430	0,145451118245285	OH
0,0879999471238838	0,634146341463415	0,0528194236285383	0,0740149440744405	OH
0,108078972515700	0,902439024390244	0,0685626412225701	0,0774288319950347	Re
0,0904727192360143	0,585365853658537	0,0546648394563087	0,0744265551267099	Re
0,135375146939432	0,707317073170732	0,0926844184159457	0,107922162336624	Re
0,101150258198694	0,585365853658537	0,0626860558609309	0,0770724768810951	Re
0,0338564098311238	0,804878048780488	0,0170447820447381	0,0258851330921095	Re
0,0608159036030160	0,414634146341463	0,0335811541517727	0,0571018742566299	Re
0,0668126634061916	0,341463414634146	0,0372248208882618	0,0588312392185029	Re
0,0410130519752808	0,658536585365854	0,0213352126678872	0,0356314750153499	Re
0,0244786577957005	0,560975609756098	0,0120300396020574	0,0193557962901734	Re
0,0232350814284462	0,707317073170732	0,0110231058402412	0,0178451058583870	Re
0,0363304802208788	0,634146341463415	0,0184271810125900	0,0281555645906553	Re
0,0698890245028744	0,487804878048781	0,0398230206098786	0,0651984547652076	Re
0,0374499225774968	0,560975609756098	0,0188211797247213	0,0291970742320500	Re
0,0969559042911468	0,487804878048781	0,0598690353953196	0,0764255913291337	Re
0,0966981858724220	0,390243902439024	0,0594184468270019	0,0828468182609333	Re
0,0214035037485283	0,731707317073171	0,0103915012930328	0,0164448333099130	Re
0,0495618725825029	0,731707317073171	0,0265230018029267	0,0367104578121451	Re
0,0716903278380077	0,439024390243902	0,0401102424202633	0,0620555779400526	Re
0,0710196096549631	0,634146341463415	0,0402476977594113	0,0548051243400373	Re
0,0687472353179857	0,463414634146342	0,0389897675440649	0,0575531441300241	Re
0,0384240009019625	0,609756097560976	0,0193894941798337	0,0293302204803379	Re
0,158700551562777	0,390243902439024	0,115101363774637	0,112324890985018	Re
0,143974890972617	0,682926829268293	0,100713659220901	0,107474607102908	Re
0,245994008278178	0,585365853658537	0,213349311990453	0,153881172008723	Re
0,0904533071814466	0,634146341463415	0,0546534817951480	0,0708456242446324	Re
0,223100977478350	0,634146341463415	0,185560515423854	0,175770388523364	B5
0,415092852655251	0,780487804878049	0,485925943935945	0,283794905339661	B5



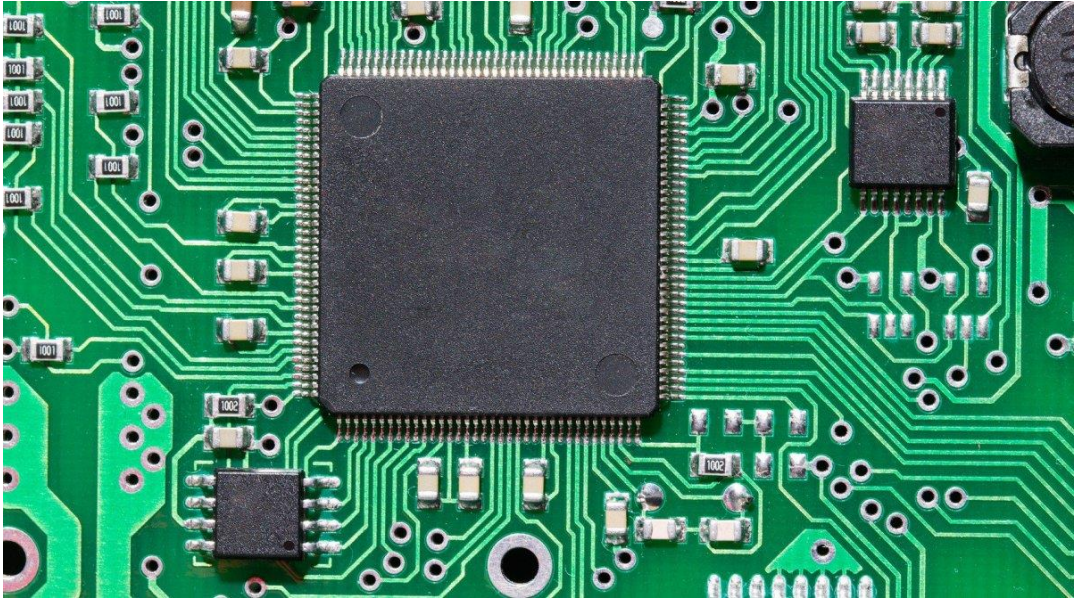
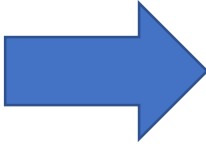
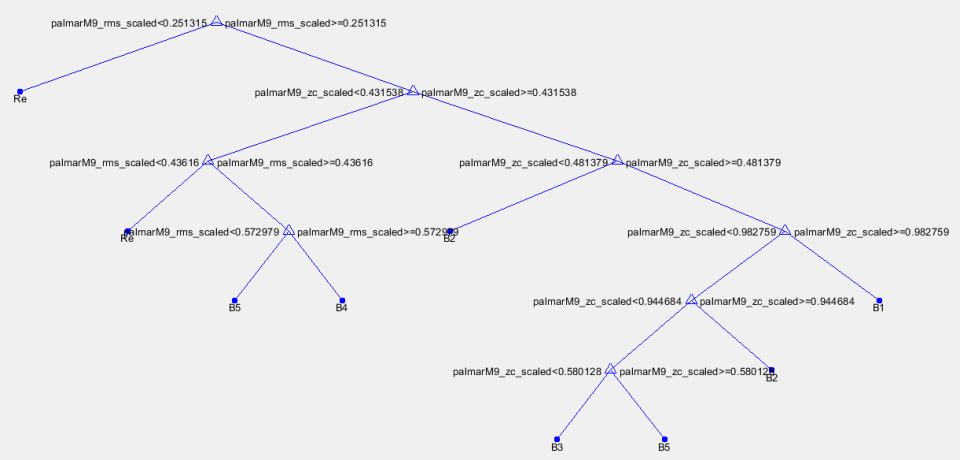
# Training a Decision Tree (DT)



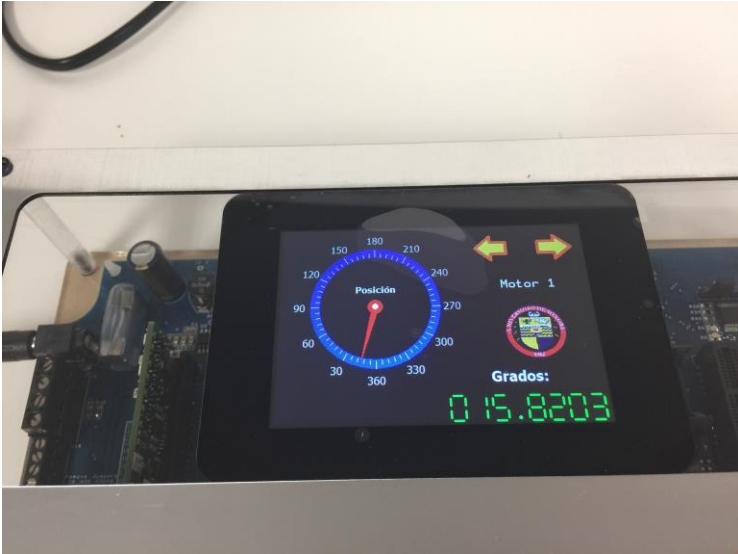
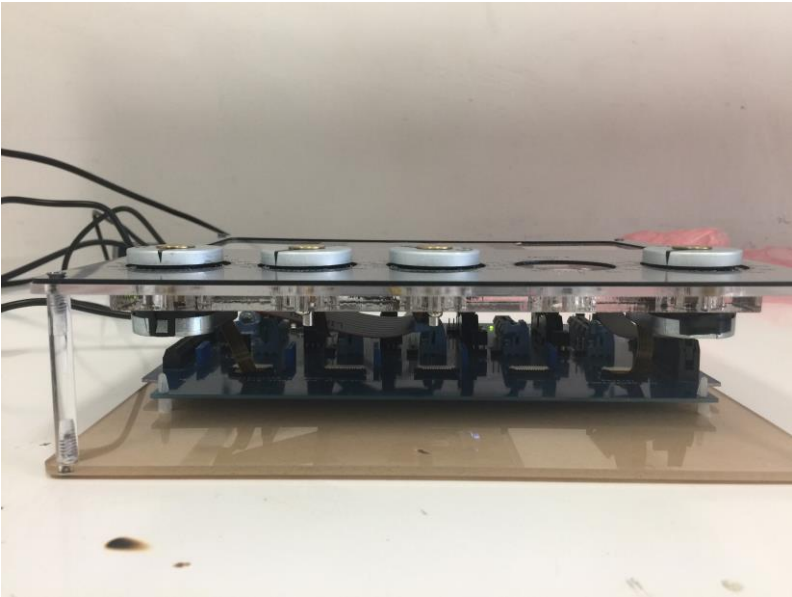
# Pruning the DT



# Embedded System Deployment

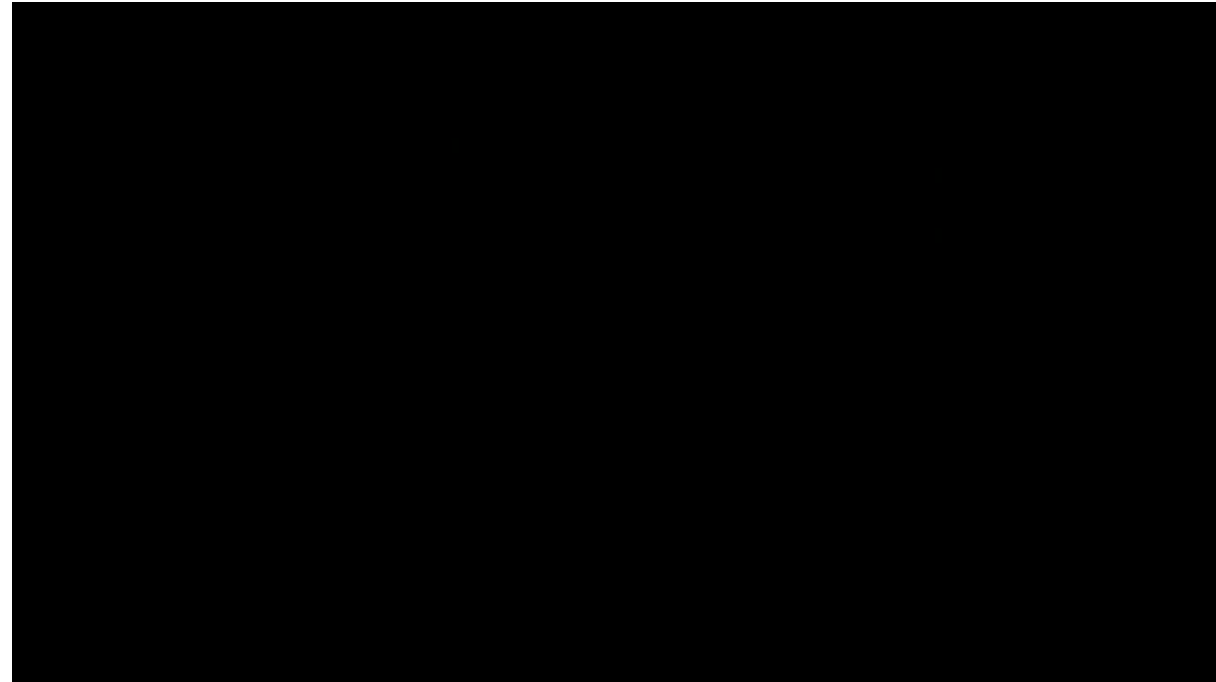


# Embedded System Deployment



# Conclusions

- An experimental is designed to capture motion intention of fingers
- Mechanical position of fingers are studied via EMG signal
- Features are extracted from EMG data and used to train a DT learning system (AI system)
- DT information is deployed into a microcontroller
- DT can be used to design biomechatronics systems
- This methodology is attractive to develop biomechatronic systems with the following characteristics:  
Computationally simple and easy to implement



# References

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