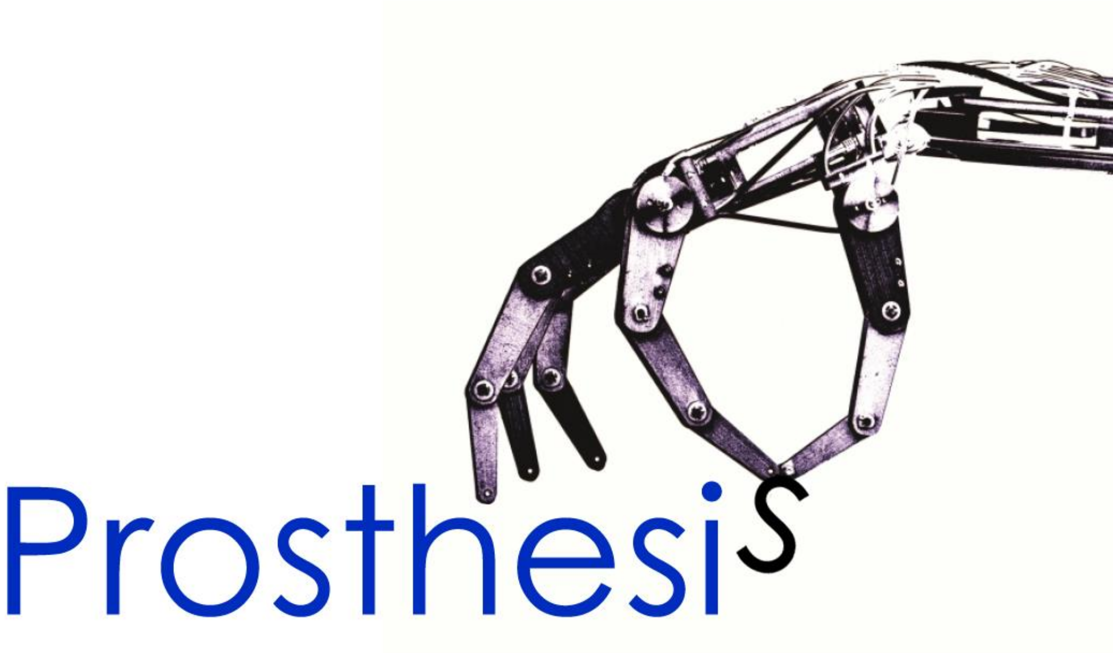


EMG-based

Prosthetic Hand

Contents

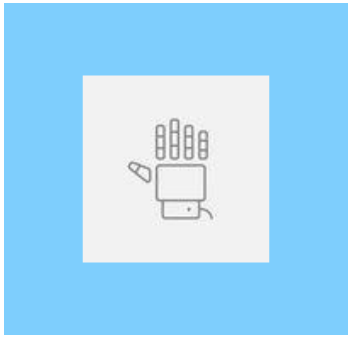
ProsthesiS

1.
Motivation

Why is Prosthesis important?

Motivation

- Ability to compensate the missing limb
- An impact of the participating in society
- A global demand for prosthetic devices and biomedical technologies



2.Objectives

“

The main objective of this project is to design and implement a EMG-based prosthetic hand using advanced signal processing techniques.

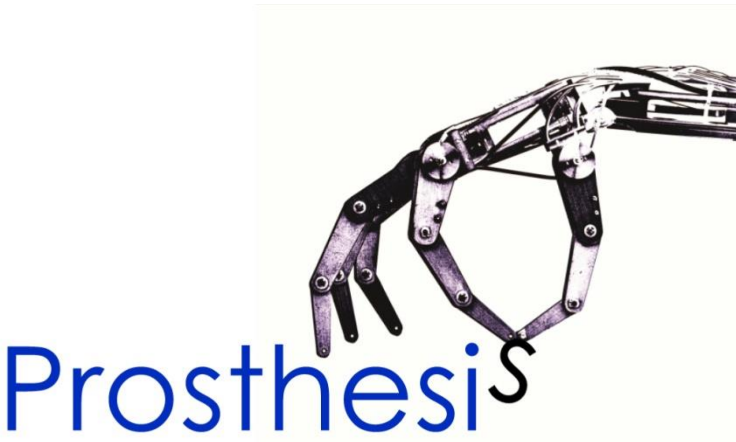
“

***Objectives*:**

▷ To understand and implement advanced signal processing techniques .i.e. Wavelet Analysis and statistical signal processing.

▷ To learn the machine learning concepts and apply pattern recognition techniques.

▷ To create and implement algorithms on a microcontroller hardware.



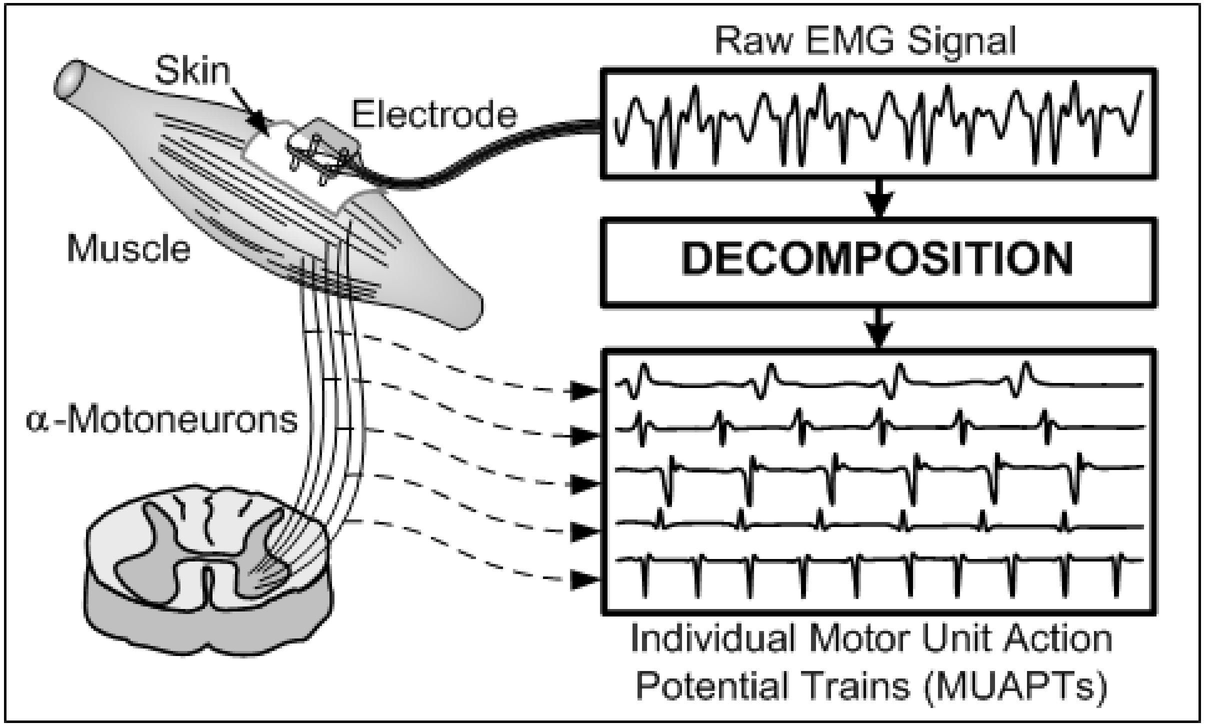
3. Introduction and background

Prosthesis is an artificial body part that replaces a missing body part in shape and functionality.

3.Background:

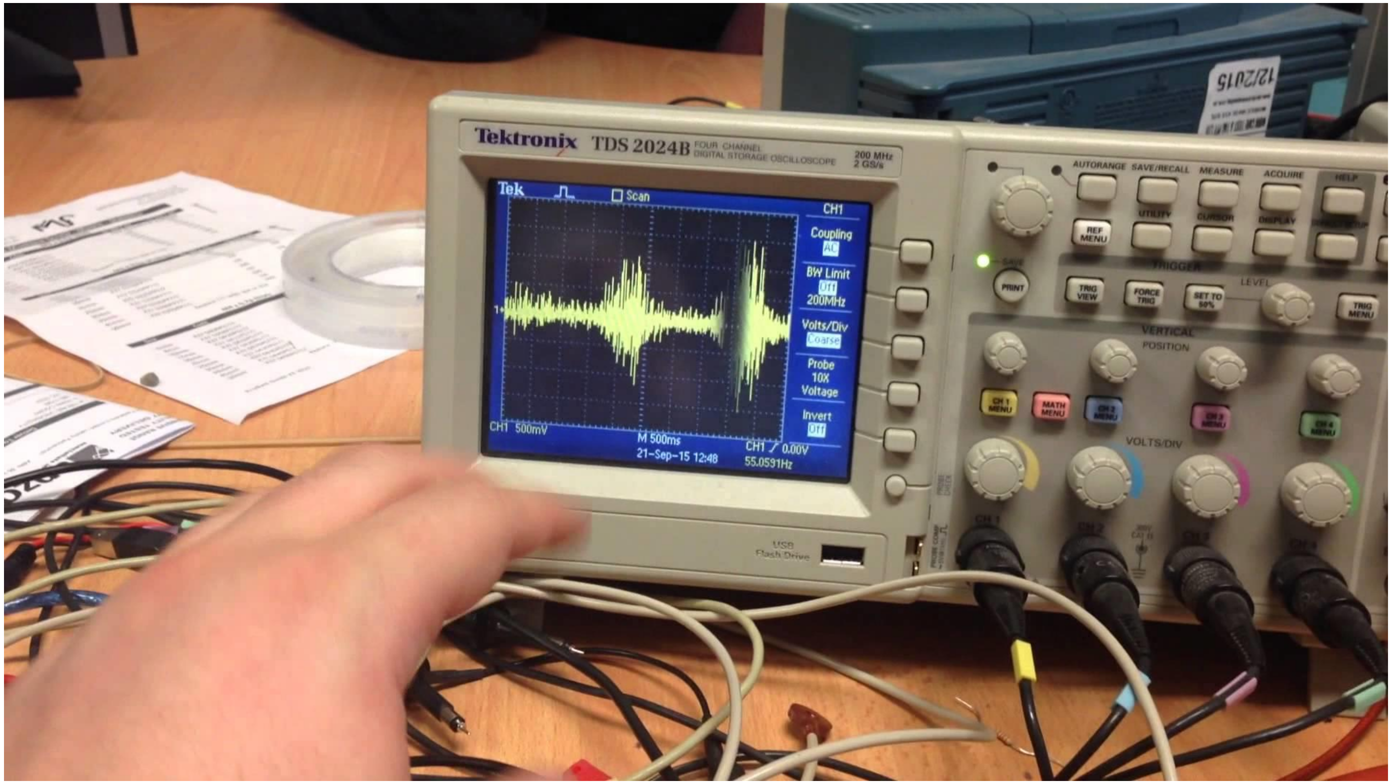
The medicine concept

The nerves system and generating electrical pules from the brain



The Engineering task

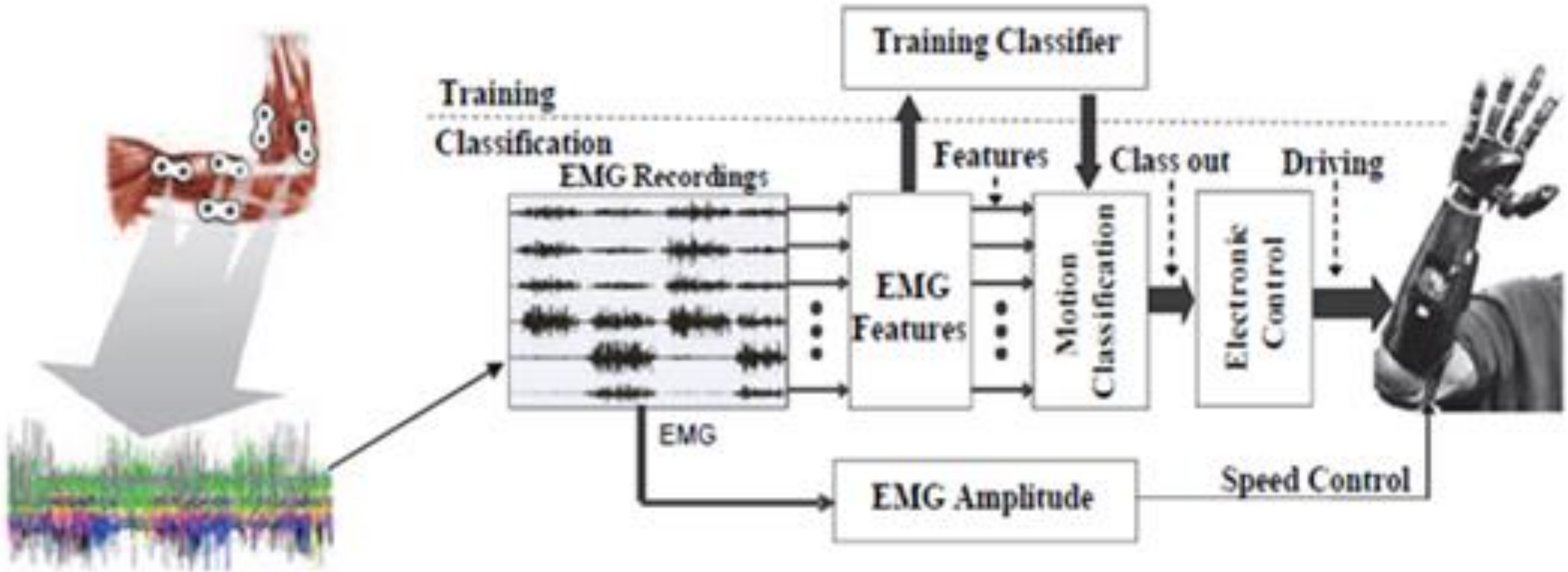
Making EMG signals proper to be converting into a mechanical motion



4.
Design Stages

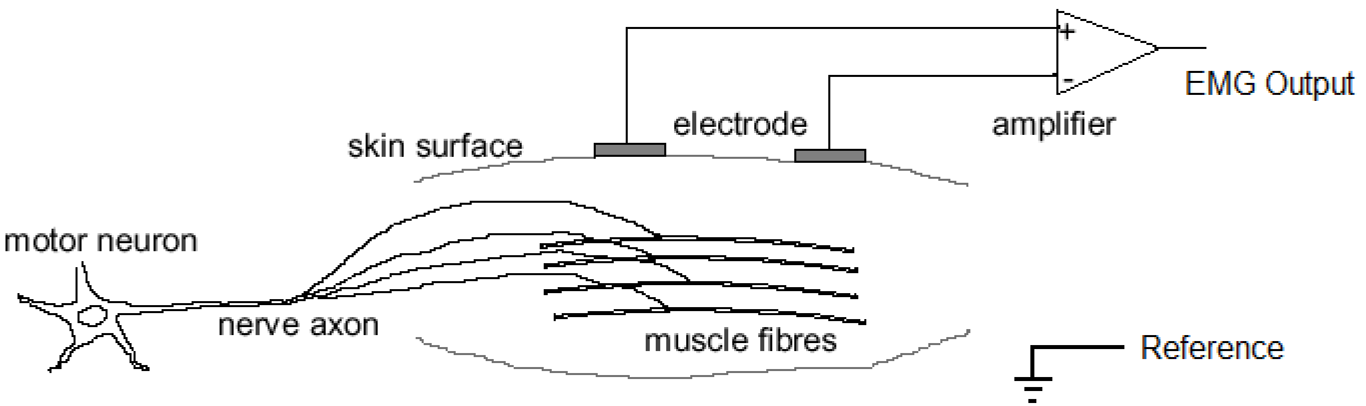
Design Stages:

EMG Acquisition → Pre-Processing → Feature Extraction → Classification



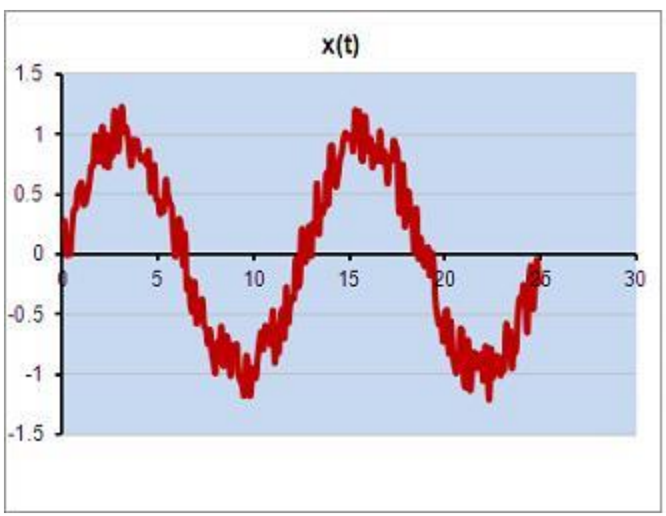
Design Stages:

EMG Acquisition → Pre-Processing → Feature Extraction → Classification

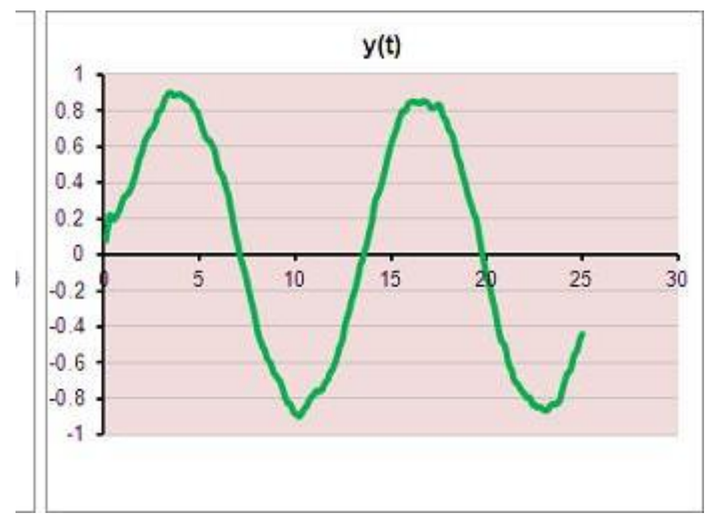


Design Stages:

EMG Acquisition → Pre-Processing → Feature Extraction → Classification



Filtering



Design Stages:

EMG Acquisition → Pre-Processing → Feature Extraction → Classification

Bonekta

El-safi

How to Distinguish one from the other?

Bonekta

El-safi

Feature to be extracted?

- Skin color   White/Black
- Weight   80 gm <=
- Height   180 cm <=
- Gender?

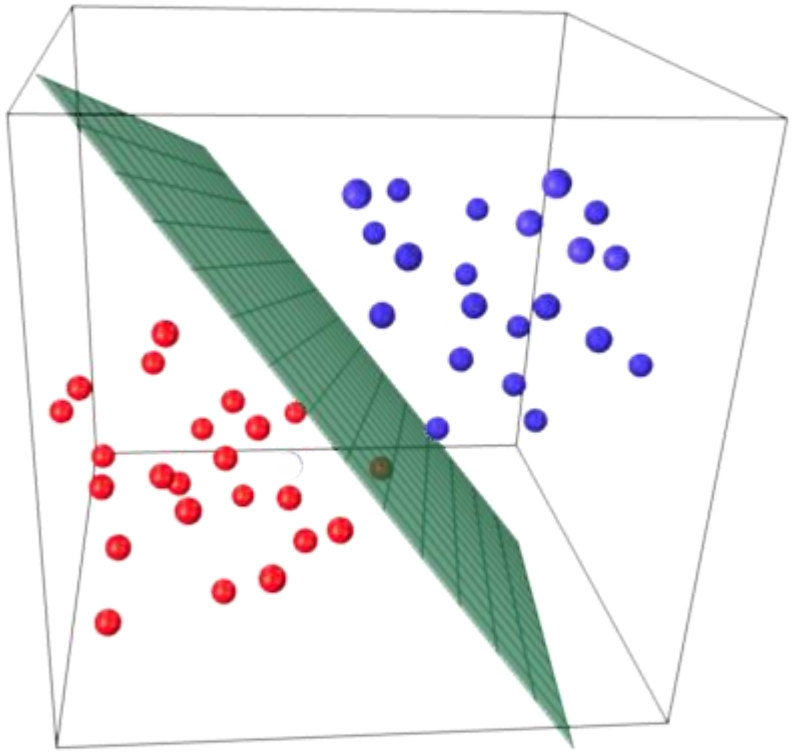
Signals ?

Mathematical operation …
ex

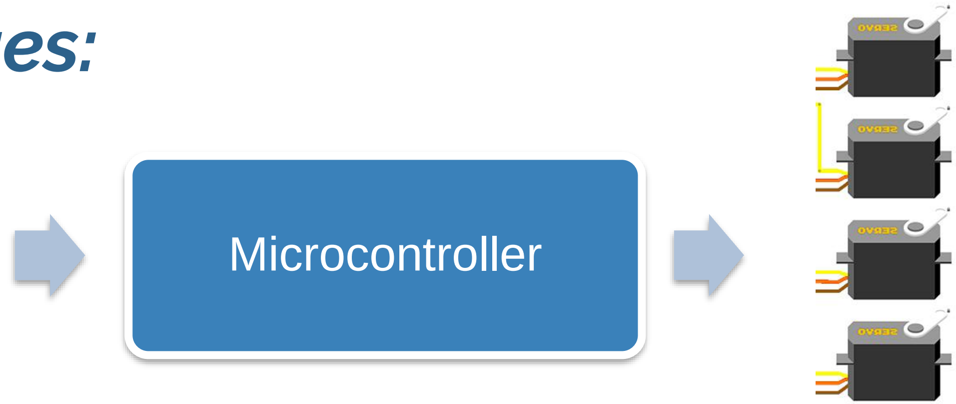
- Mean
- Zero Crossing
- Integration

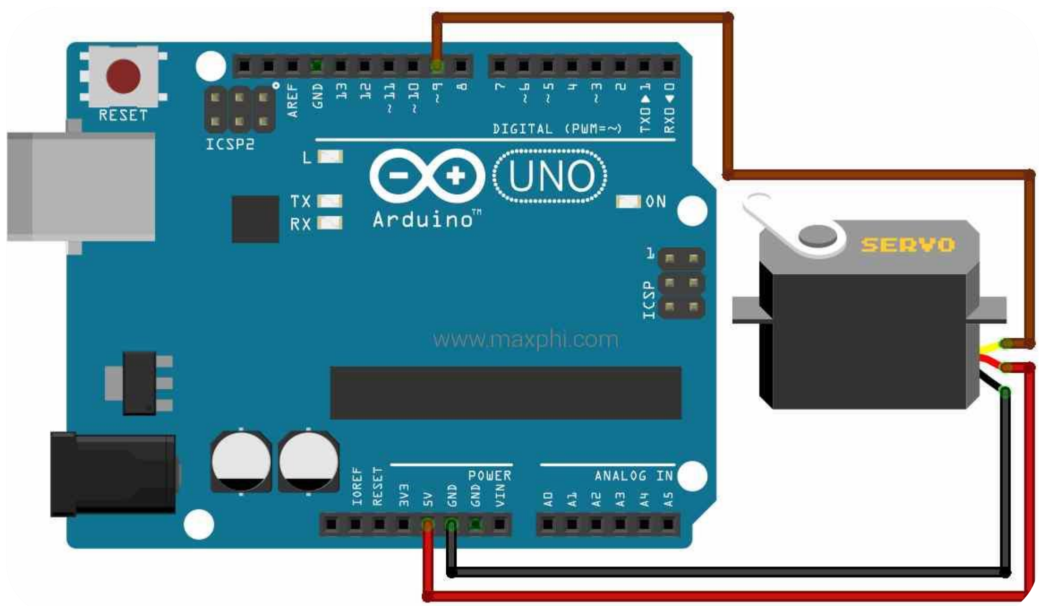
Design Stages:

EMG Acquisition → Pre-Processing → Feature Extraction → **Classification**



Design Stages:





5.
Procedures

Task1:
Six basic hand movements

The goal is to design and classify a dataset of six movements acquired by KIC laboratory research group

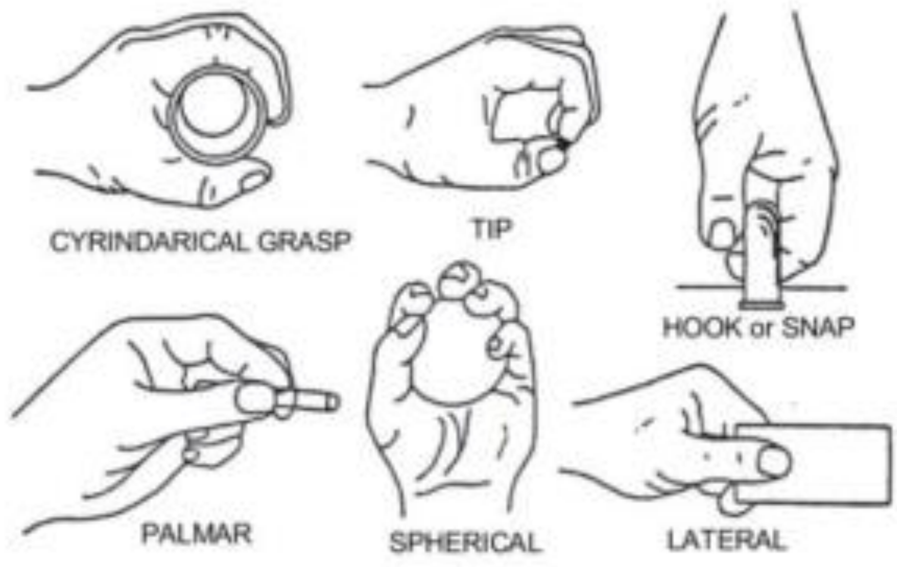
Six basic hand movements

1- Data set information

- Information about the data:
  5 subject, 6 movements, 30 trails for each movements

- The pre-processing: filtering (15Hz – 500Hz).

- Two channel Electrodes.



a) **Spherical:** for holding spherical tools

b) **Tip**: for holding small tools

c) **Palmar**: for grasping with palm facing the object

d) **Lateral**: for holding thin, flat objects

e) **Cylindrical**: for holding cylindrical tools

f) **Hook**: for supporting a heavy load

2- Feature Extraction

1- Root Mean Square (RMS)

2- Willison Amplitude (WAMP)

3- Waveform length (WL)

4- Simple Square Integral (SSI)

5- Integrated EMG (IEMG)

6- Variance (VAR)

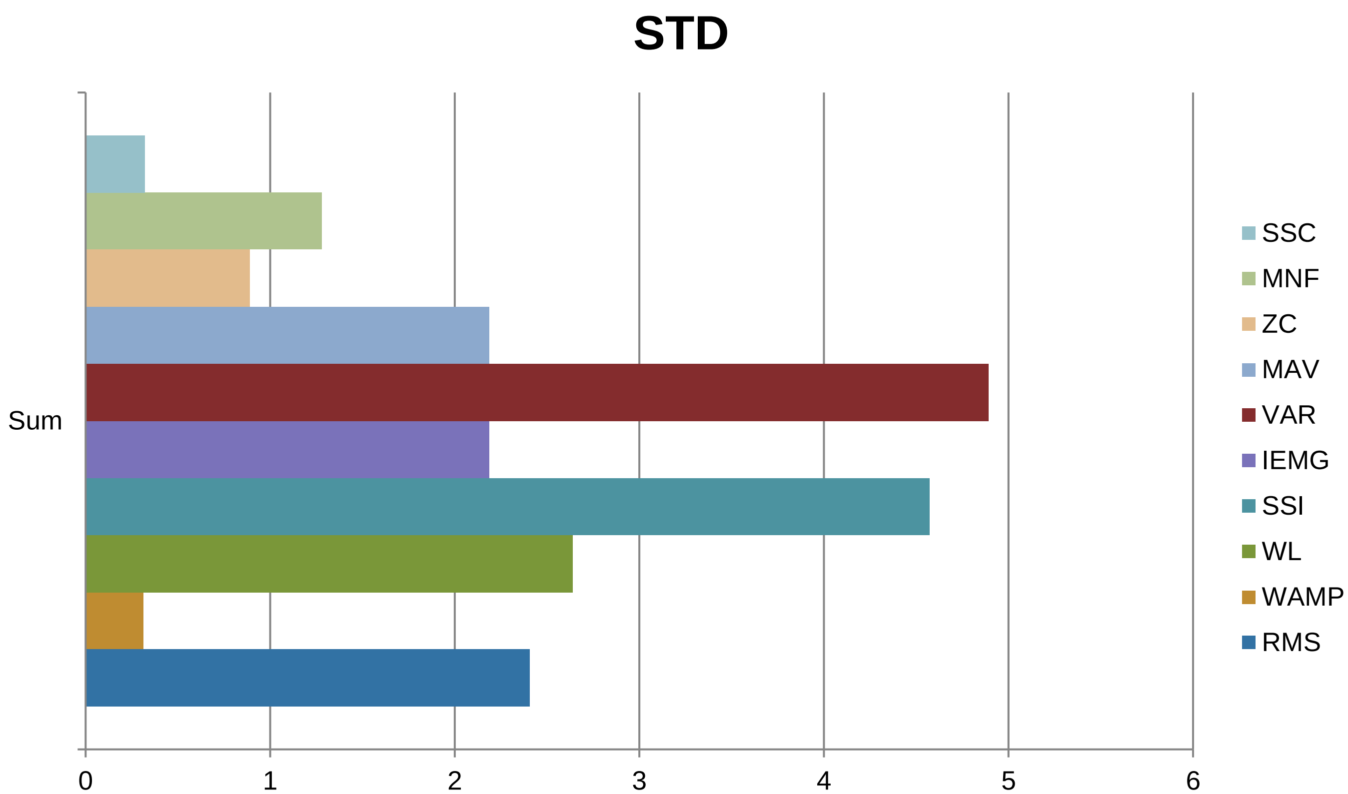
7- Mean Absolute Value (MAV)

8- Zero crossing (ZC)

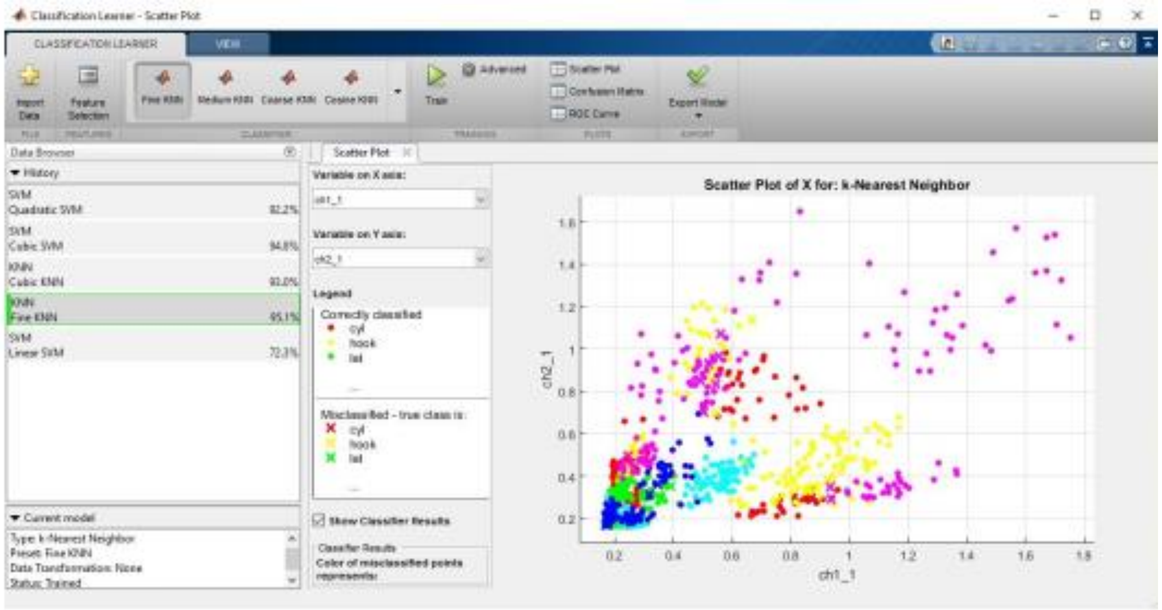
9- Slope Sign Change (SSC)

10- Mean Frequency (MNF)

2- Feature Extraction



3- Classification



- Quadratic support vector machine.
- Cubic support vector machine.
- Cubic K-Nearest Neighbor.
- Fine K-Nearest Neighbor

3- Classification

Classifier	Accuracy
Fine KNN	95.1%
Cubic SVM	94.8%
Cubic KNN	93.0%
Quadratic SVM	92.2%

Task2: Implementation of our six movements acquired data

The goal is to acquire six hand movements using EPET electrodes and use our built algorithm to implement the model

1- Data set Information

- The data was acquired using the Electrodes of the Electronic Prosthesis Engineering Team (EPET)

1- Data set Information

- 6 different hand movements of one subject
- 30 trails each movements (The measured time is 1.8 sec)

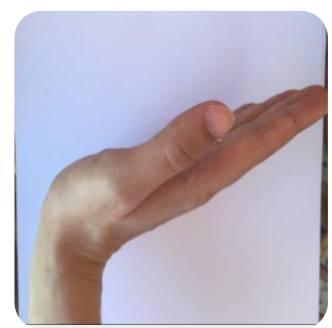
Close

Open

Rotate inside

Rotate outside

Left



Right

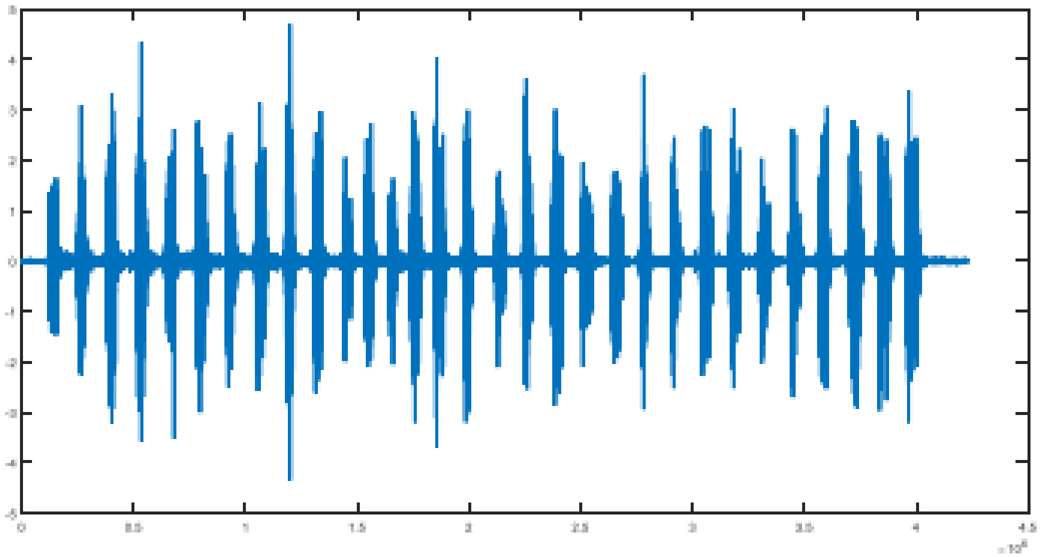
2- Data Acquisition

- Audacity open source software is used to acquire the data.

- Sampling rate : 44100 Hz
- About: 1:30 minutes record each movements (1.8 sec each trail)
- Each trail: 80’000 samples.

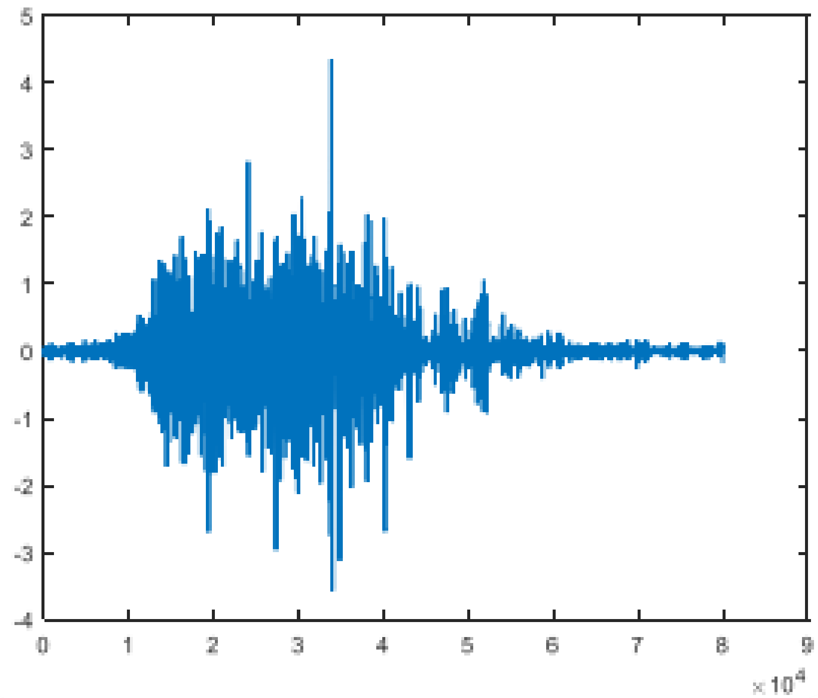
2- Data Acquisition

- The raw signal in MATLAB



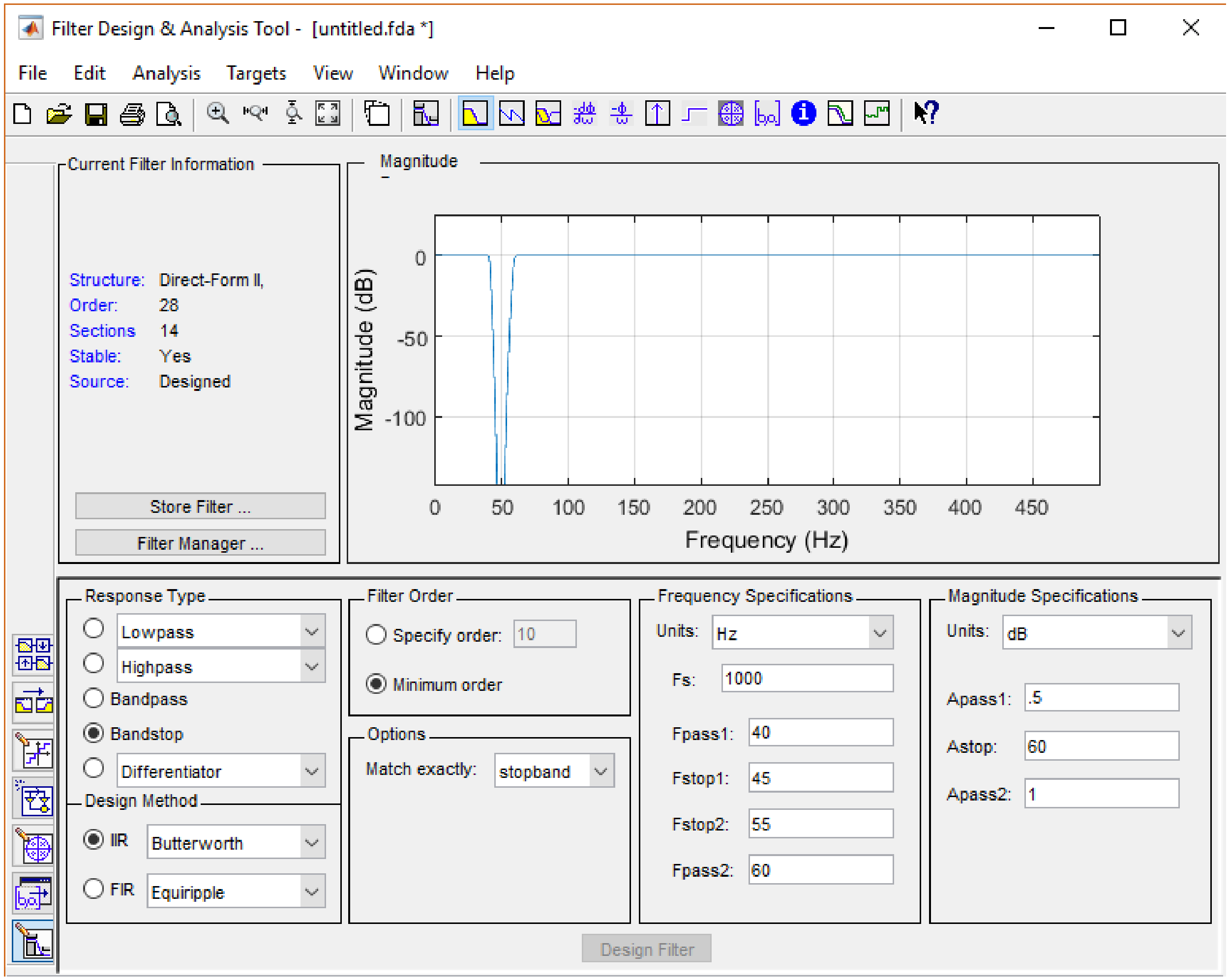
2- Data Acquisition

- The raw signal in MATLAB



2- Data Preprocessing

Design : band-pass (15,500 Hz) filter with notch 50Hz filter.



Our model that built and implemented in the previous task is used here

..

In MATLAB:

```
Tic
clear all;
load('close.mat');
f=[];
for i=1:30
    x=eval(['y' int2str(i)]);
  x1=RMS(x);
    x2=WAMP(x,0.05);
    x3=WL(x);
    x4=SSI(x);
    x5=IEMG(x);
    x6=VAR(x);
    x7=MAV(x);
    x8=ZeroCross(x);
    x9=MNF(x);
    x10=SSC(x);
    f=[f;x1,x2,x3,x4,x5,x6,x7,x8,x9,x10];
end
```

- 10 feature extractions
- Quadratic support vector machine (10% cross validation).

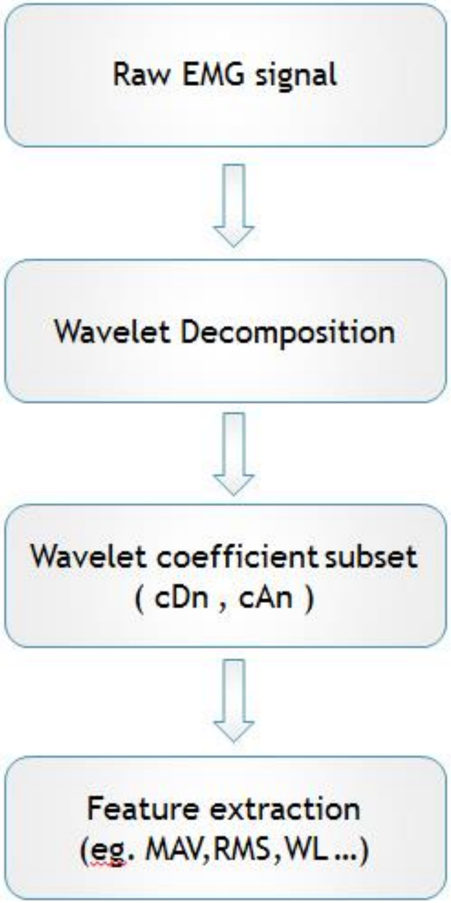
3- The Results

No. of Movements		Accuracy
2	Close/Open	100%
3	Close/Open/Rotate inside	98.9%
4	Close/Open/Rotate inside/Rotate outside	96.7%
5	Close/Open/Rotate inside/Rotate outside/Left	95.3%
6	Close/Open/Rotate inside/Rotate outside/Left/Right	91.1%

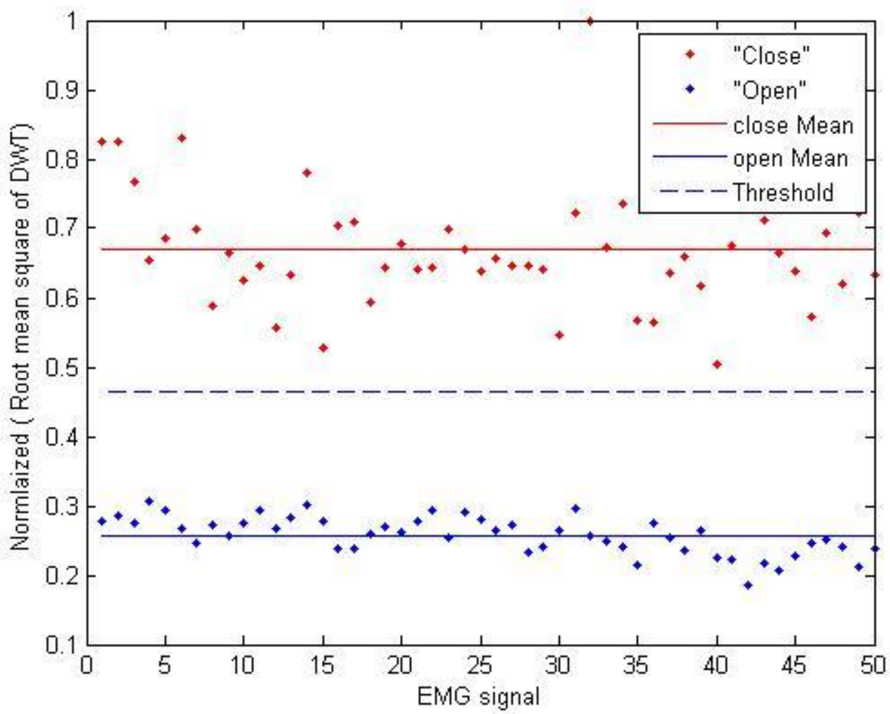
Task3: Wavelet Analysis

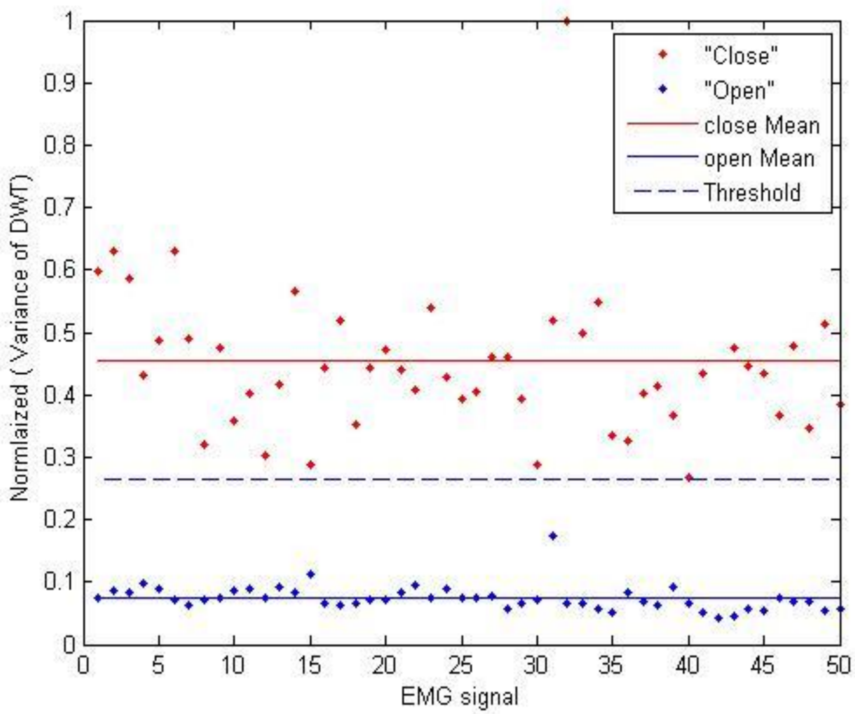
The goal is to use the advantage of wavelet transform to get a better features.

1- The Wavelet



2- Feature results





3- Best Features for Wavelet Transform

Difference	Feature
0.4124	Root Mean Square
0.3886	Simple square Integral
0.3857	Willison Amplitude
0.3799	Variance
0.342	Mean Absolute Value
0.3394	Integrated EMG
0.3332	Waveform length
0.0178	Mean frequency

Task4: Practical Real-Time Hand Movements Model.

The goal is to design a real-time model of hand movements classification.

1- Why LabVIEW?

2- Best Implementation

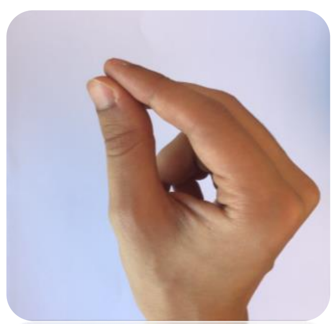
- Accuracy or more movements?
- Features
- Sampling rate

3- Data set Information

- 4 different hand movements of one subject

Close

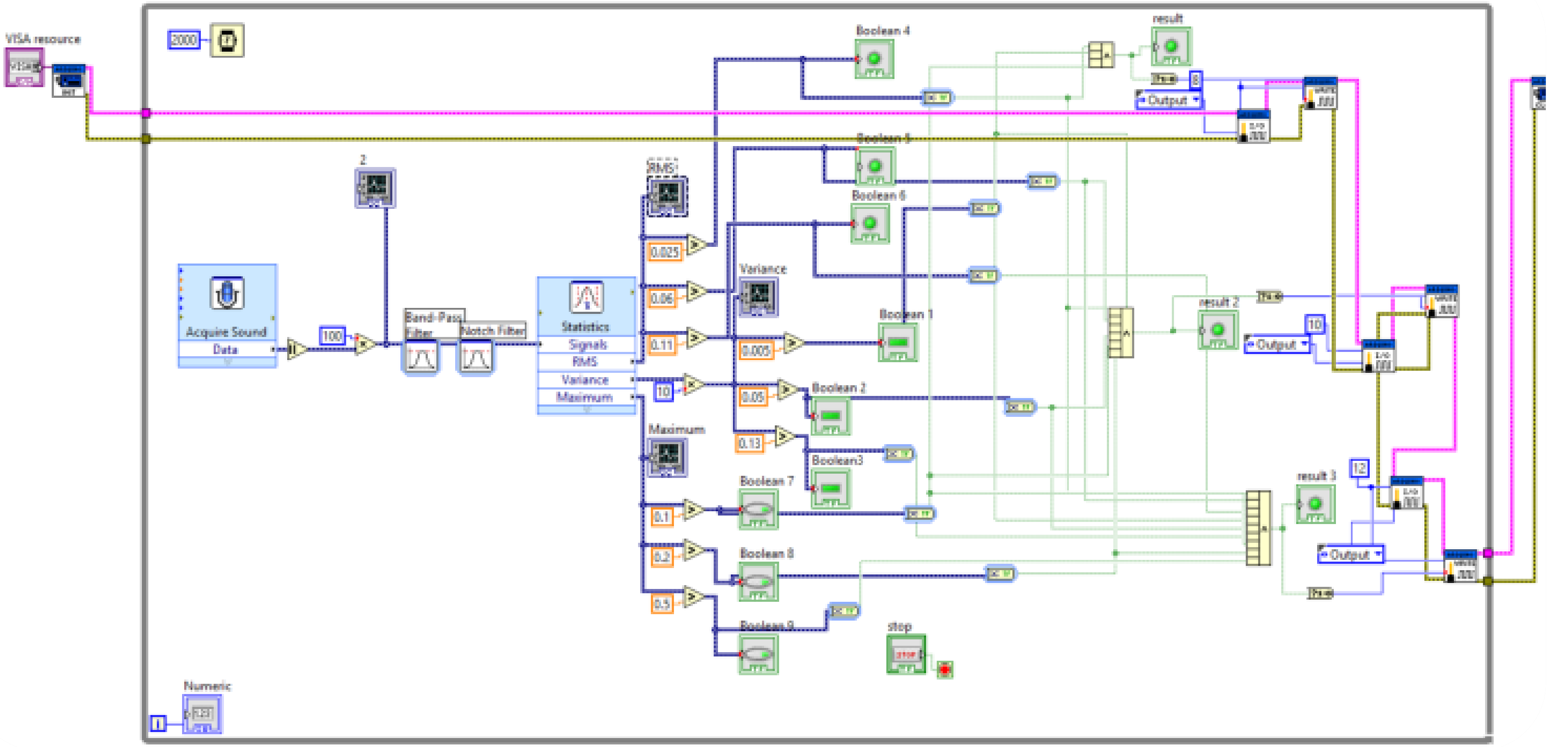
Open



Palmar

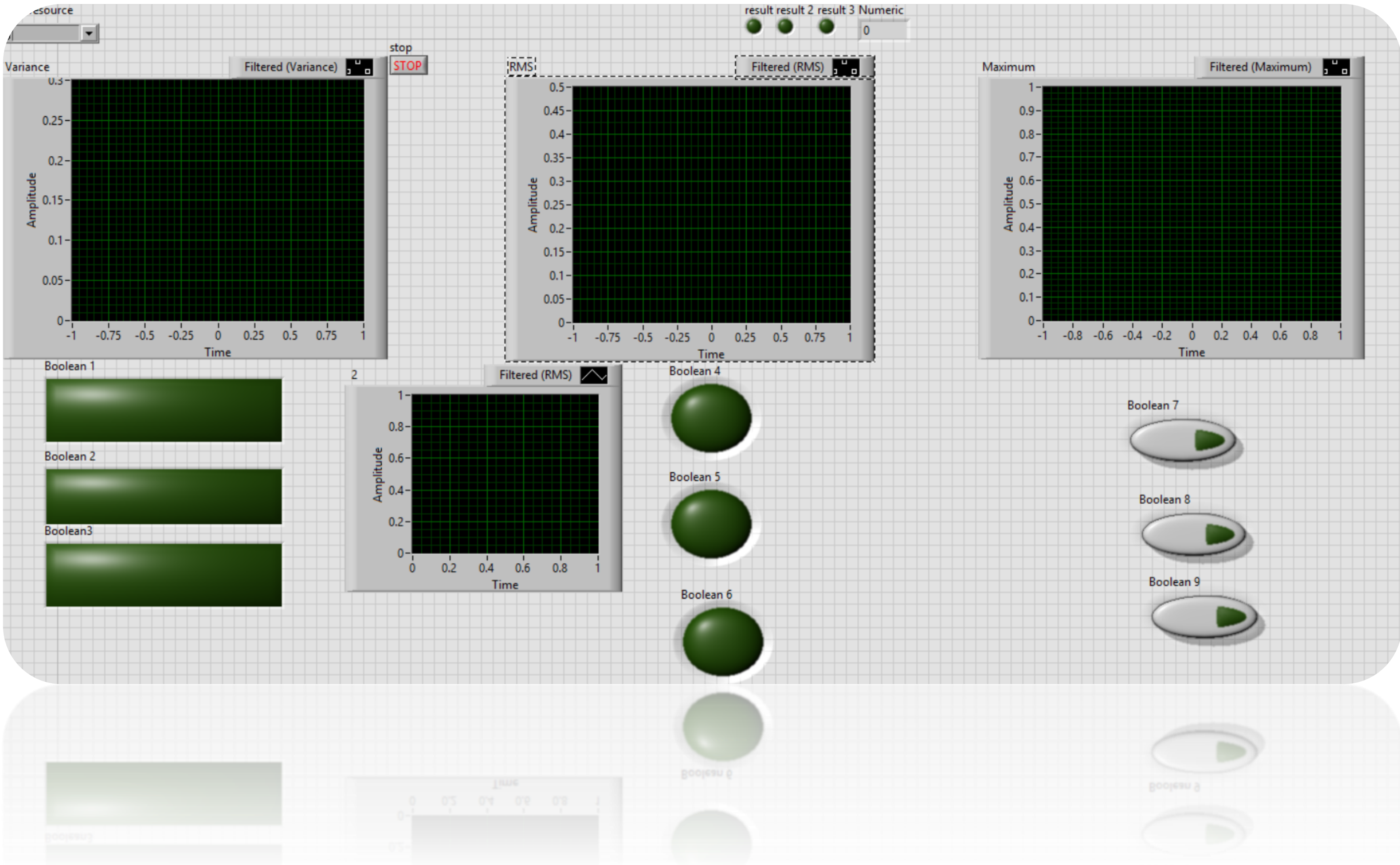
Pointing

3- The model



VISA resource
2000
Boolean 4
result
Output
Boolean 5
2
RMS
Boolean 6
0.025
Variance
0.06
Acquire Sound
Data
100
Band-Pass Filter
Notch Filter
Statistics
Signals
RMS
Variance
Maximum
0.11
0.005
Boolean 1
result 2
10
Output
10
0.05
Boolean 2
0.13
Boolean3
Maximum
Boolean 7
0.1
result 3
12
Output
0.2
Boolean 8
0.5
Boolean 9
stop
Numeric

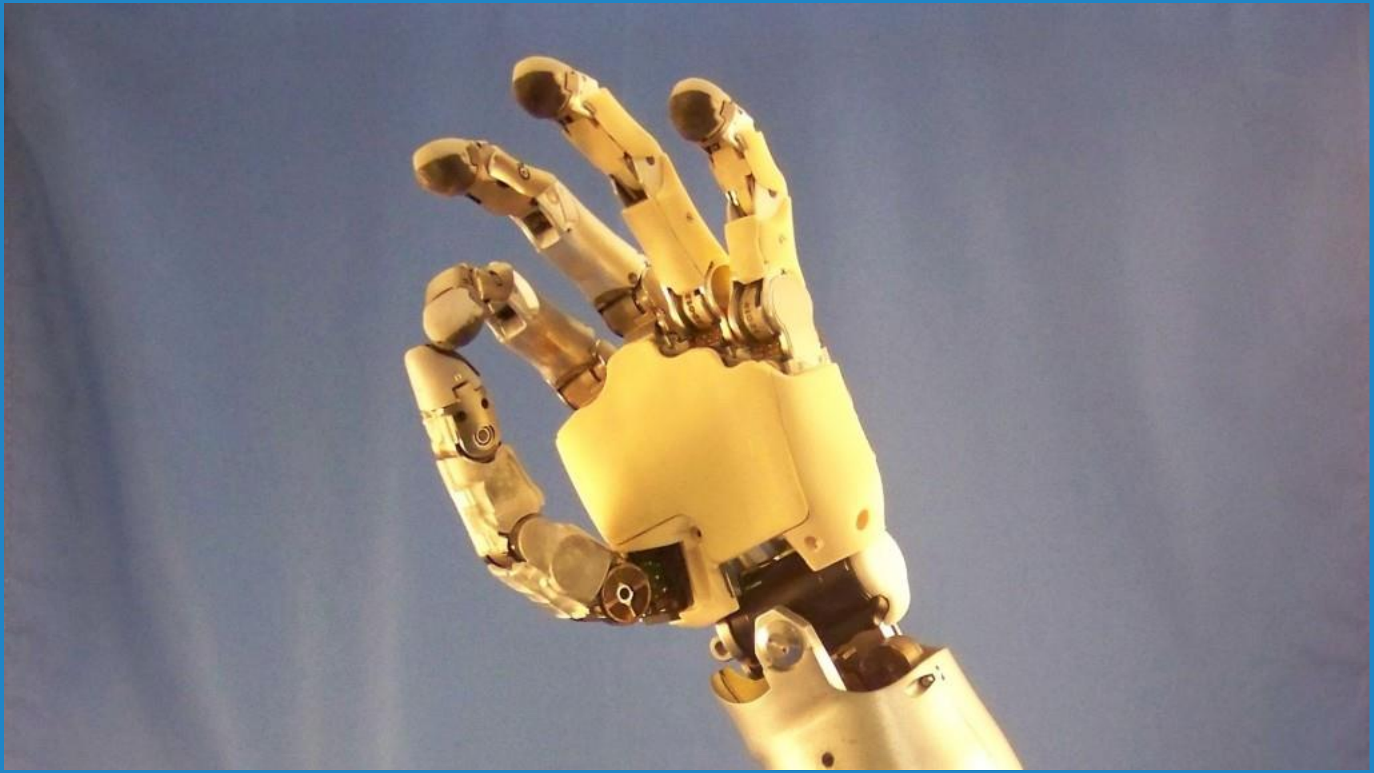
4- The Front Panel



4.Conclusion

“ Knowledge is power. Information is liberating. Education is the premise of progress, in every society, in every family.”

Kofi Anan



Thanks! Any questions?