PROJET CORO-IMARO

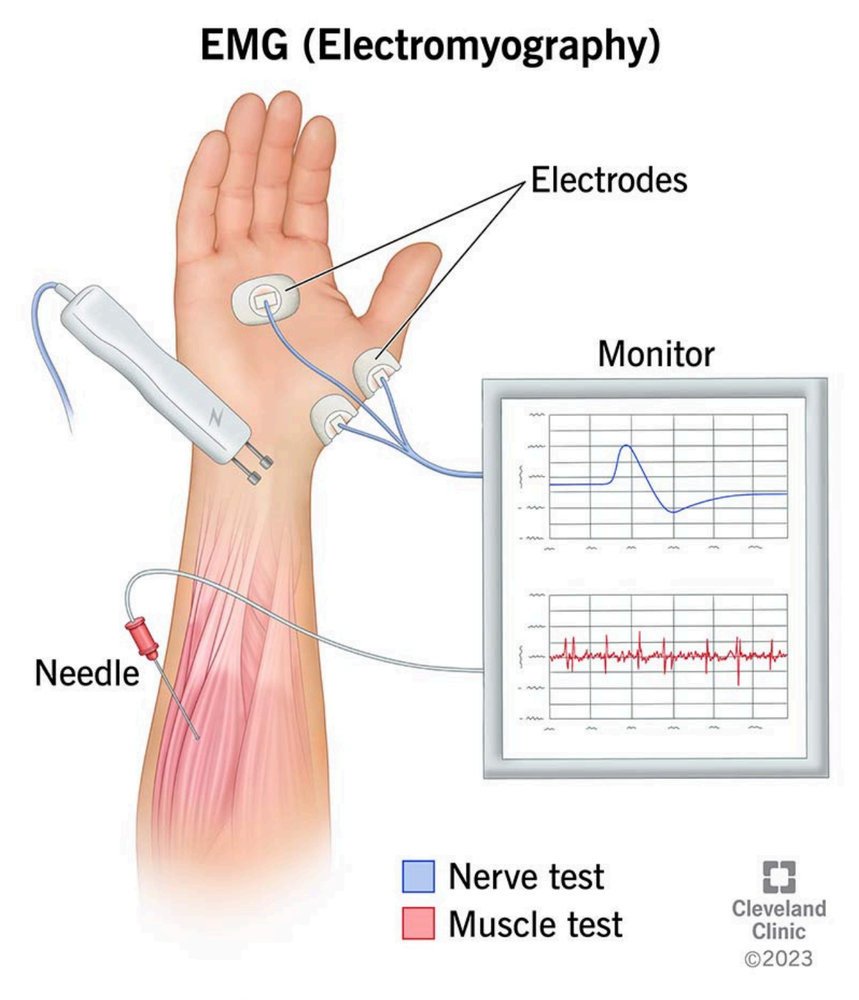
Analyse des signaux électromyographiques

Xu Zhang, Gaëtan Macaire
Professeurs : Yann Péréon, Eric Le Carpentier, Yannick Aoustin

Nantes Université

Bourse de stage FAME - CORO-IMARO - Gaëtan MACAIRE & Xu ZHANG - Mastériales 2024

ANALYSE DES SIGNAUX EMG



https://my.clevelandclinic.org/health/diagnostics/4825-emg-electromyography

PLAN

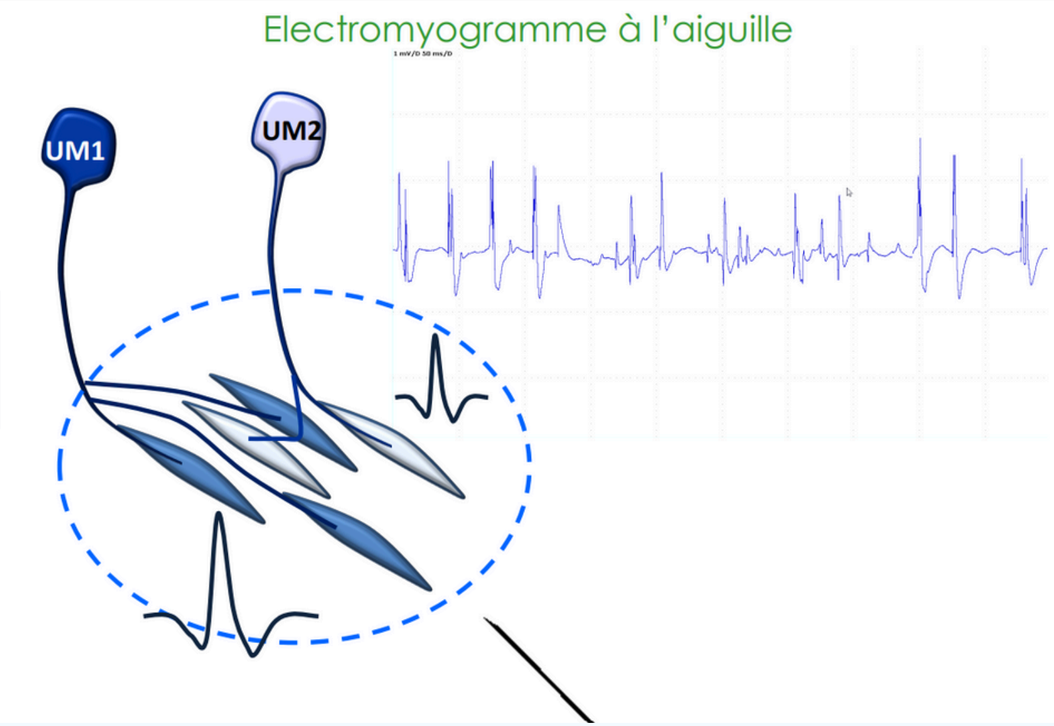
I - Partie clinique

1. Qu'est-ce qu'un signal EMG ?
2. Physiologie d'une unité motrice
3. Les différents types de signaux
4. Exemple de tracés
5. Pourquoi analyser les tracés EMG ?

II - Partie de traitement des données

1. L'analyse des signaux EMG
2. La création d'une base de données
3. Le traitement des signaux
4. L'apprentissage automatique

QU'EST-CE QU'UN SIGNAL EMG ?



- EMG = électromyogramme.
- Détecte l'activité électrique musculaire : les potentiels d'action d'unité motrice
- Unité motrice = motoneurone + fibres musculaire qu'il innerve
- Tracé EMG -> activité électrique d'un ensemble d'unités motrices

Physiologie des unités motrices

PHYSIOLOGIE DES UNITÉS MOTRICES

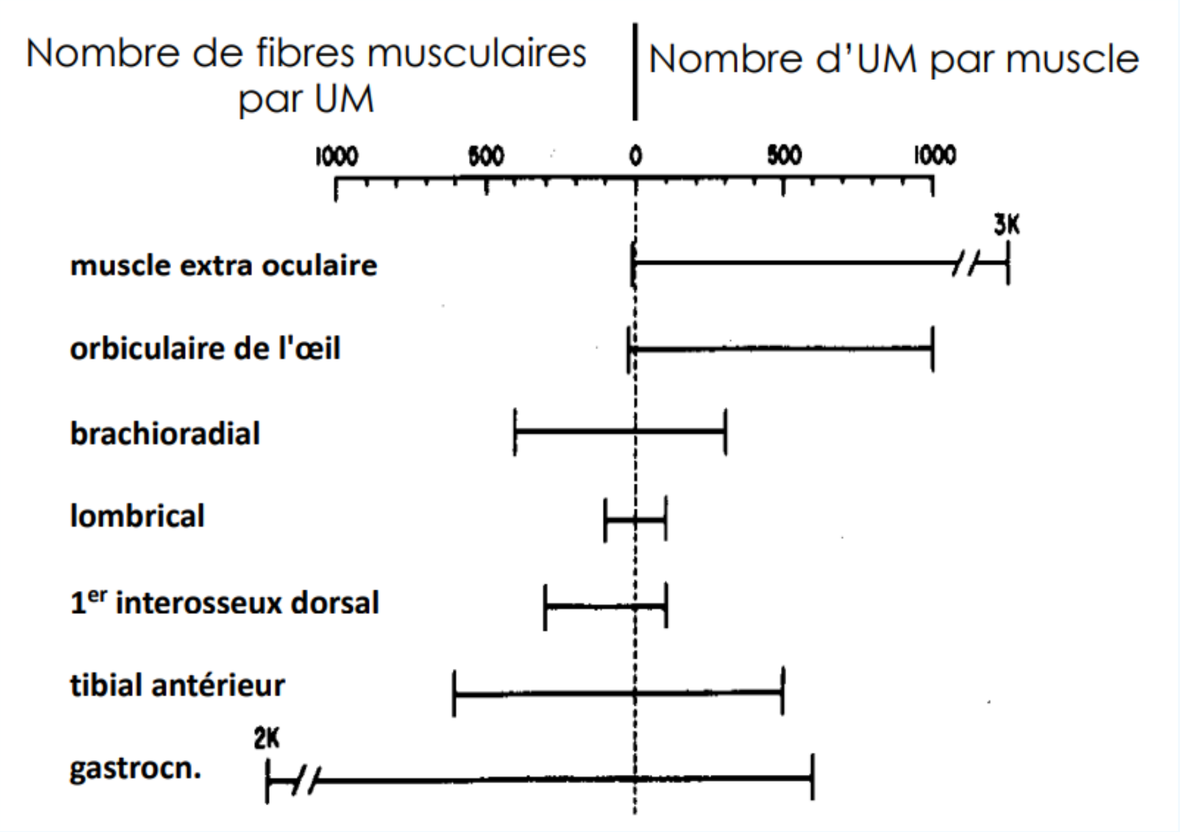
Unité de base du **contrôle moteur**

Adaptation de l'activité des unités motrices **selon la force exercée**

- Recrutement spatial
- Recrutement temporel

= *Dépendant du seuil d'excitation*

Variation du nombre et de la taille des unités motrices **selon le muscle**



Les différents types de signaux EMG

SAIN

Pas d'atteinte nerveuse ni musculaire.
Tracé EMG non altéré.

MYOGÈNE

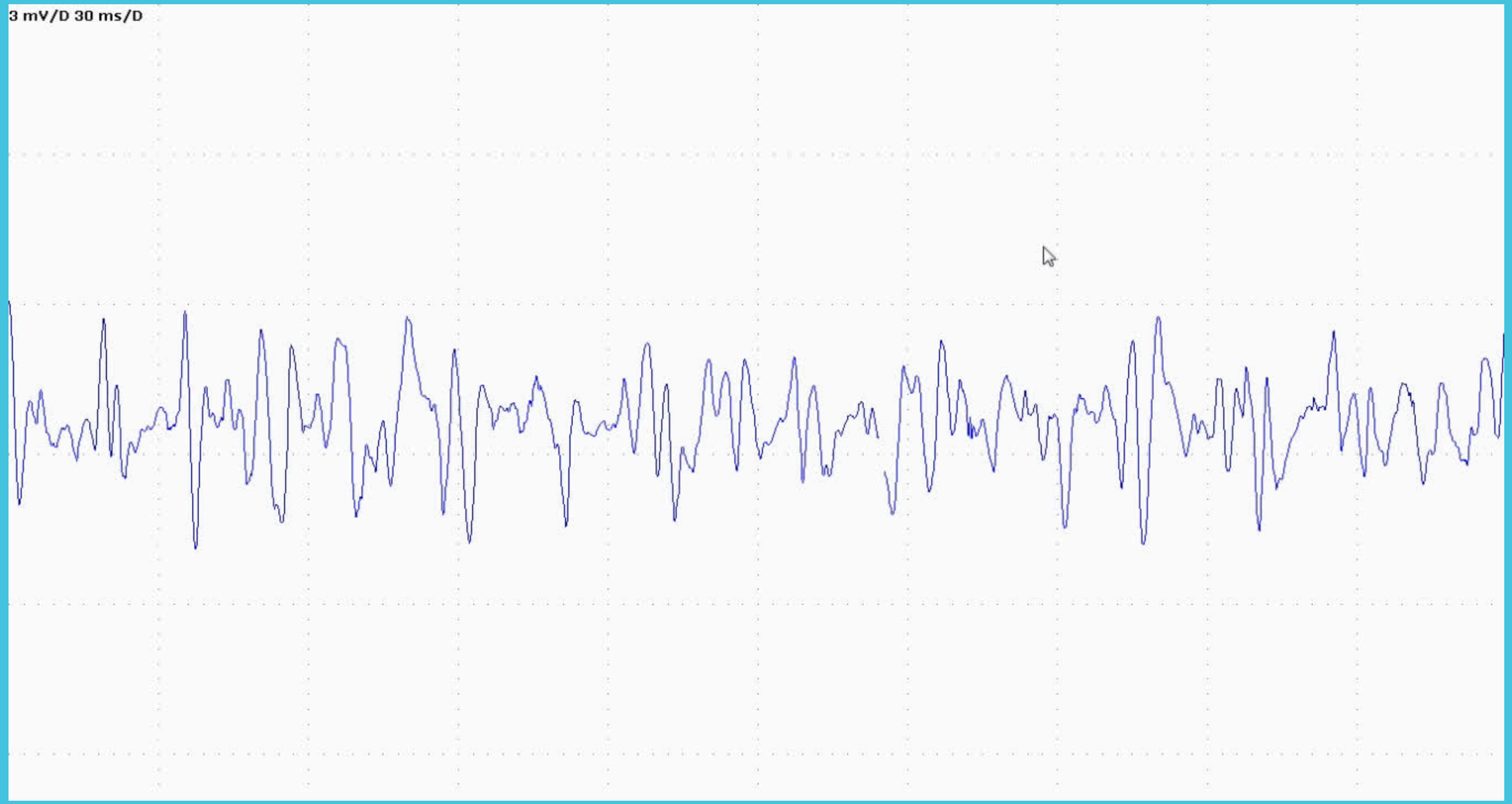
Atteinte musculaire : myosite, myopathie génétique, ...
Tracé EMG riche en unités motrices mais avec une amplitude faible.

NEUROGÈNE

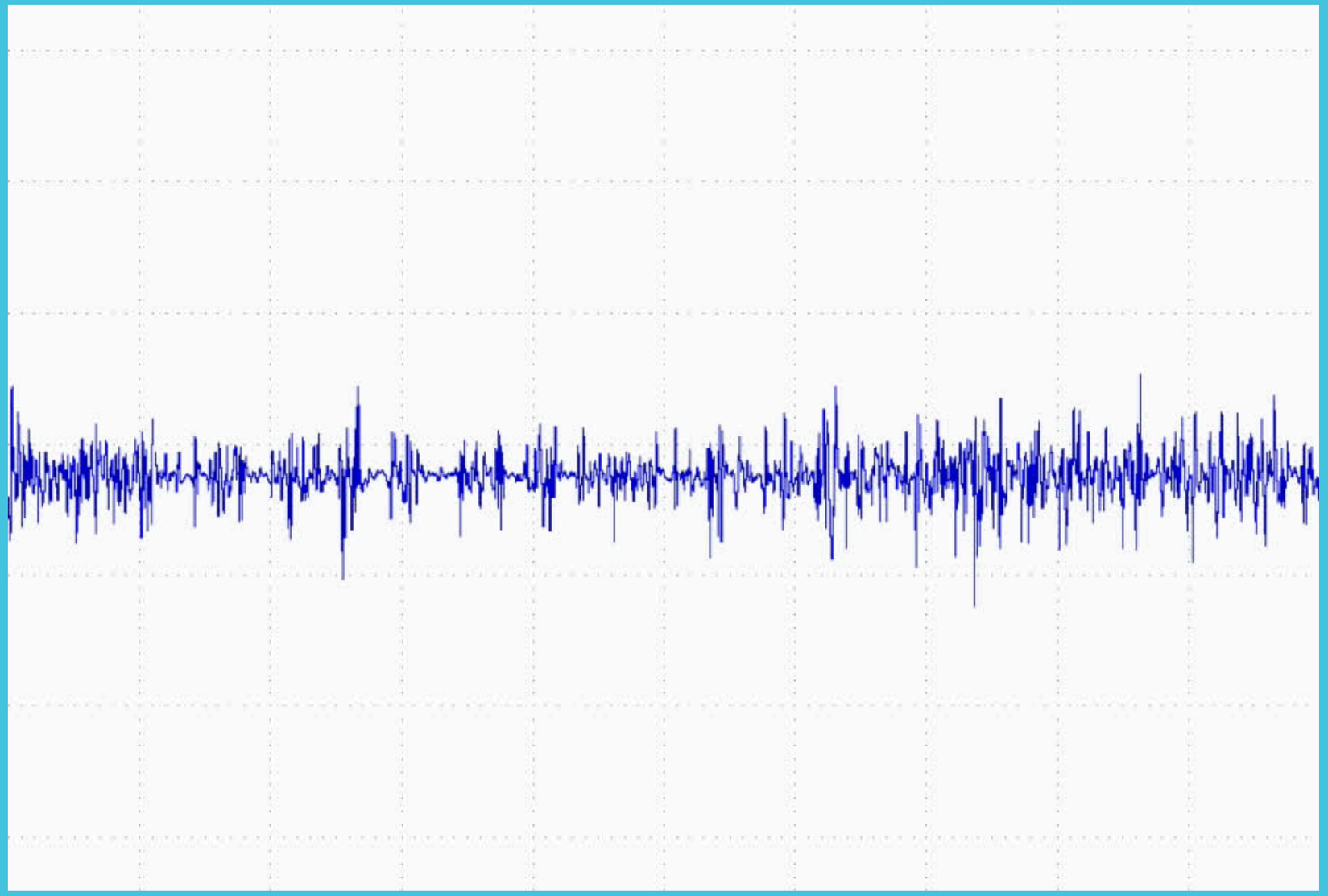
Atteinte neuronale : neuropathies, syndromes canalaires, atteinte plexique, ...
Tracé EMG pauvre en unités motrices mais avec une amplitude haute.

EXEMPLE DE TRACÉ EMG

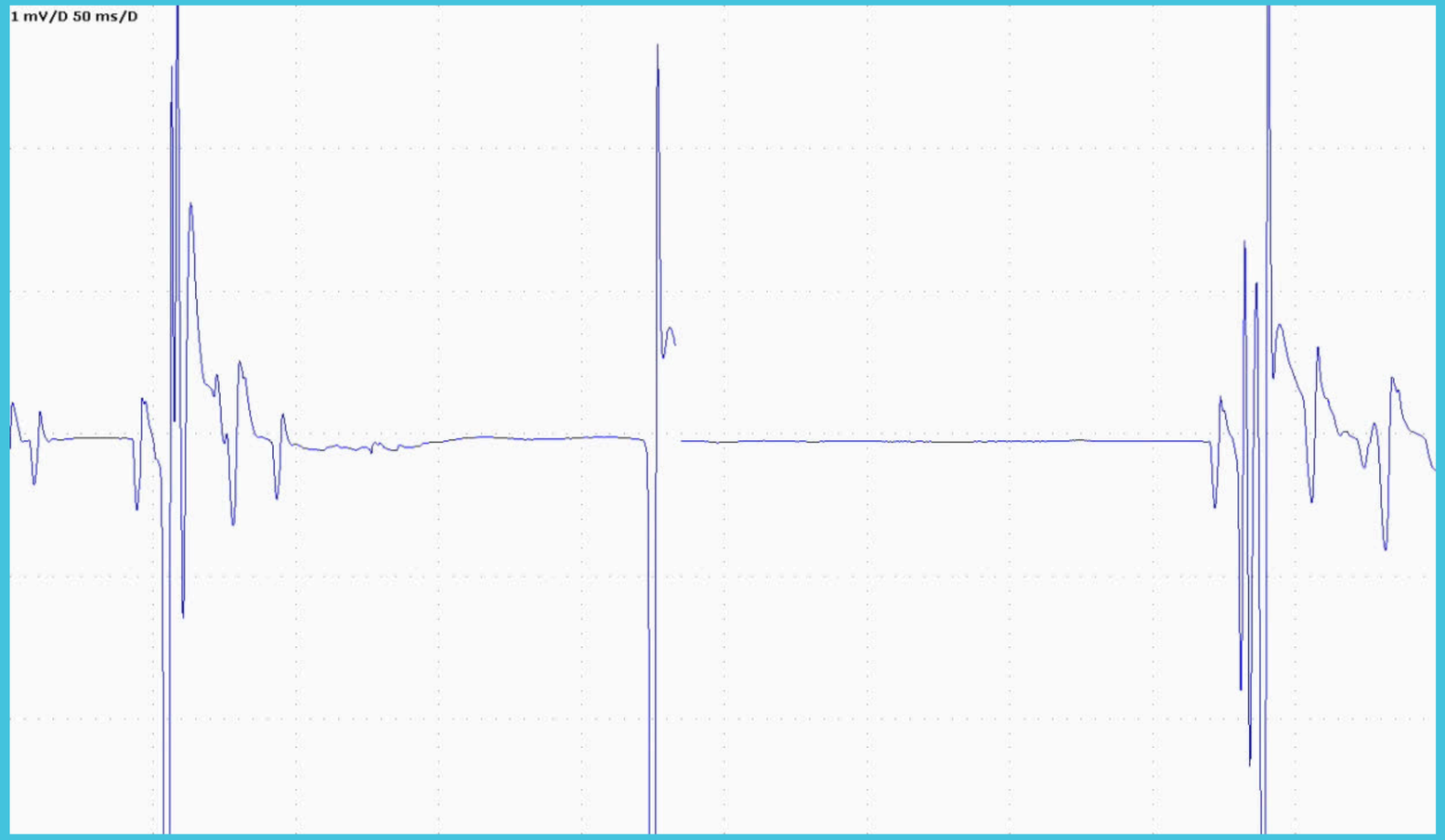
Sain



Myogène



Neurogène



POURQUOI ANALYSER LES TRACÉS EMG ?

Problème

L'interprétation des résultats EMG est clinicien dépendant
Variabilité des tracés en fonction des muscles
Tracés où l'interprétation diagnostique peut s'avérer compliquée

Objectif

Créer une banque de signaux EMG pour différents muscles -> identifier des caractéristiques uniques à chaque muscle
Créer un système d'analyse automatique de signaux EMG pour diagnostiquer les maladies neuromusculaires

Intérêt clinique

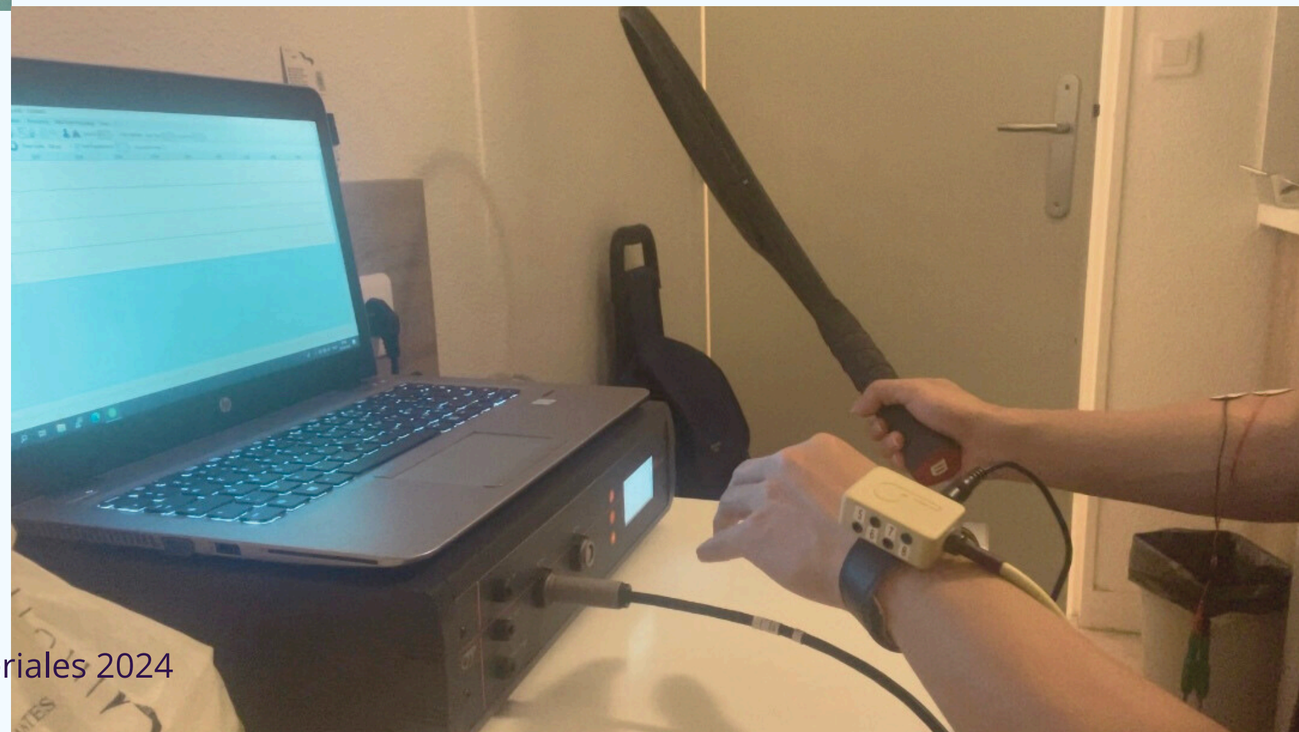
Améliorer la prise en charge des patients
Augmenter la fiabilité de l'examen
Aider le clinicien à poser la diagnostic
Limiter l'erreur humaine

INTRAMUSCULAR EMG

Injection-based detection of iEMG signals is hindered by the complexity of the procedure, making it difficult to obtain a large amount of data for model training. As a result, it can only be used to detect whether the subject has potential muscle diseases.

SURFACE EMG

Based on bipolar electrodes, sEMG signals are much easier to be acquired. Such as the brachioradialis of the right arm, we can easily obtain sEMG generated by gripping and swinging.

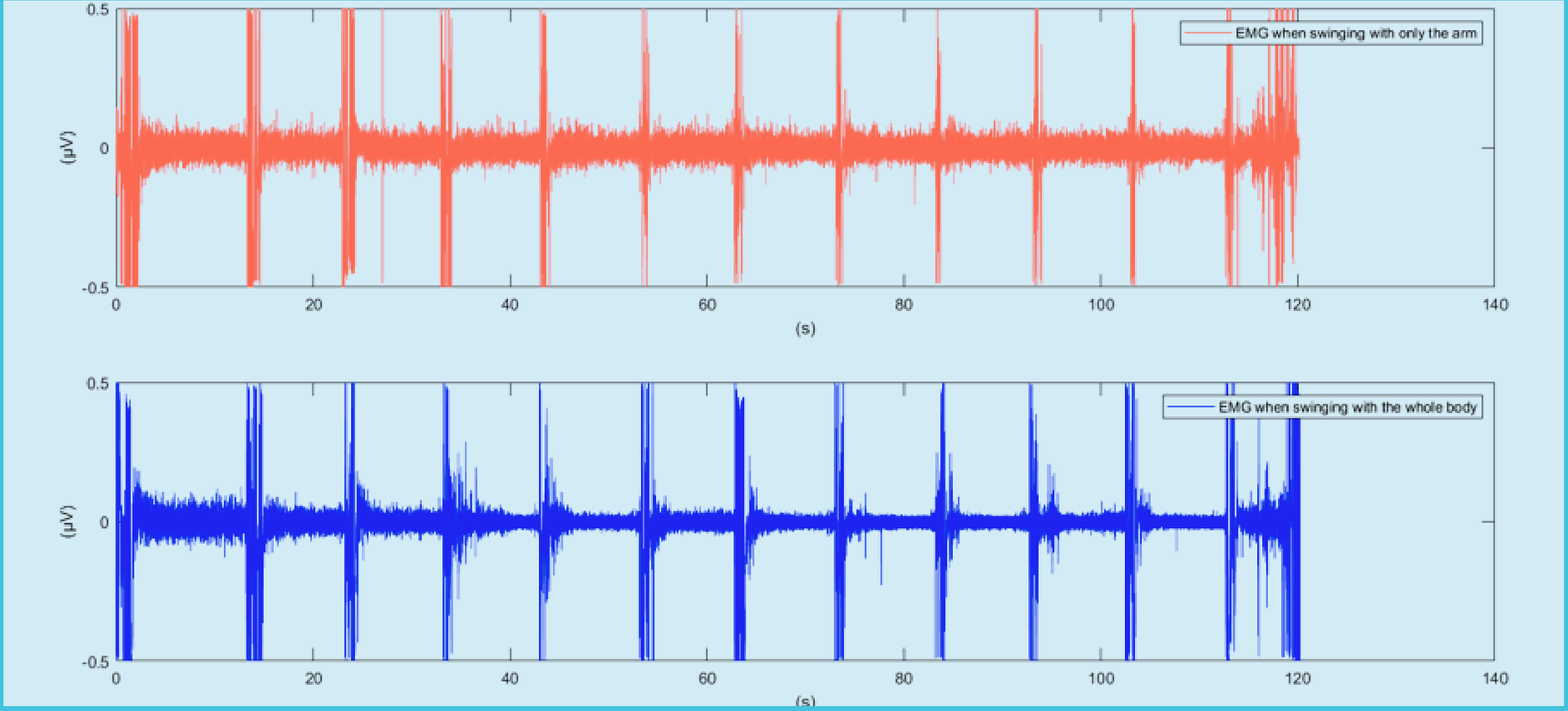


MY WORK

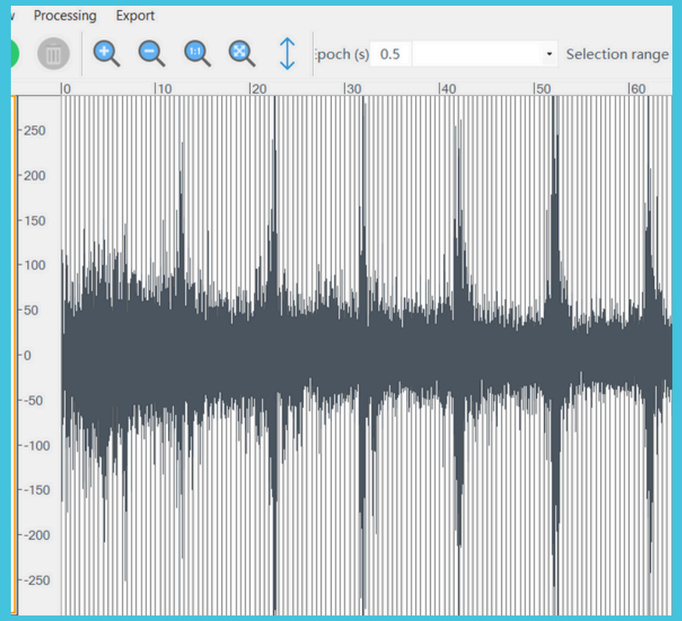
1.DATABASE BUILDING
2.SIGNAL PROCESSING
3.MACHINE LEARNING

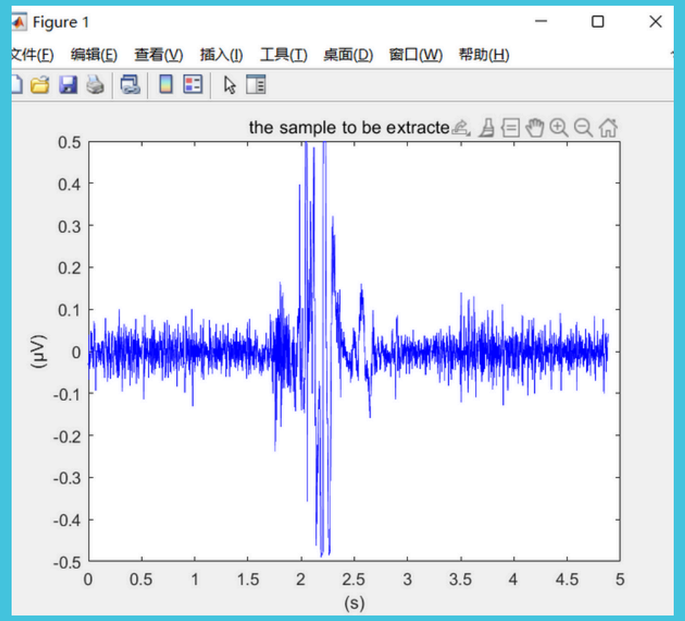
The aims is to investigate the pathology of tennis elbow by acquiring EMG signals from the brachioradialis muscle, processing, classifying, and predicting,

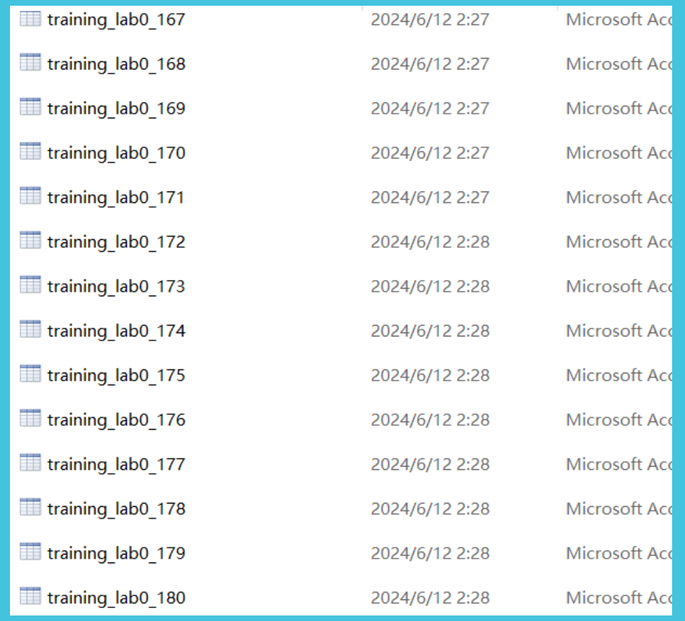
COMPARISION OF TWO TYPES(aim to determine)



Database building





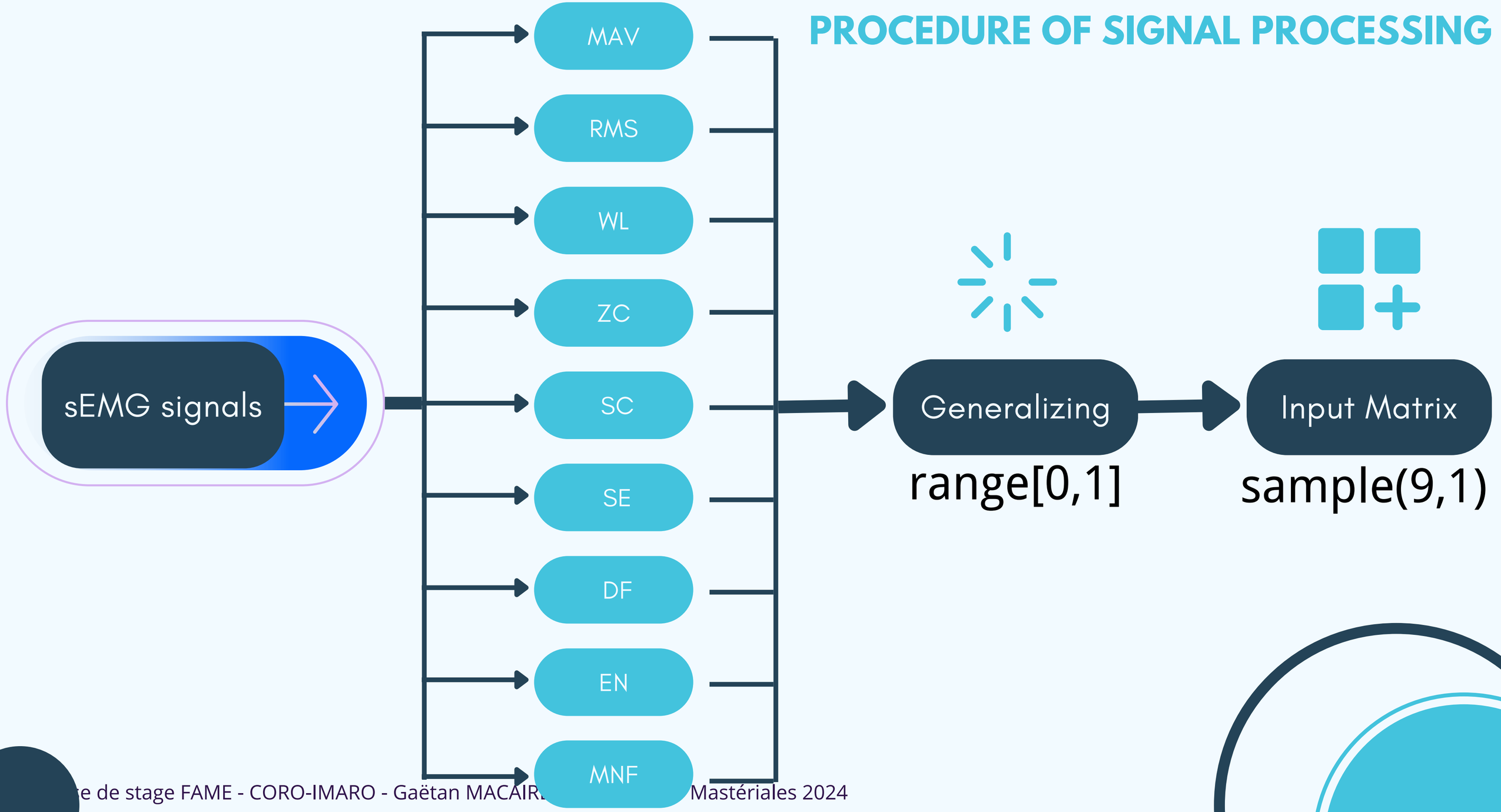


ACQUIRE ORIGINAL SIGNALS

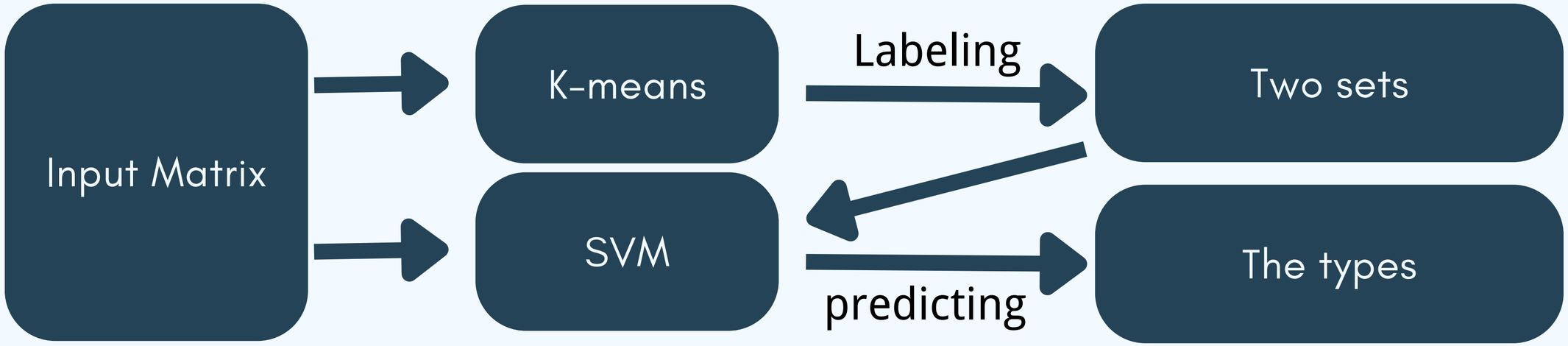
EXTRACT SAMPLES

BUILD A DATABASE

PROCEDURE OF SIGNAL PROCESSING



PROCEDURE OF MACHINE LEARNING

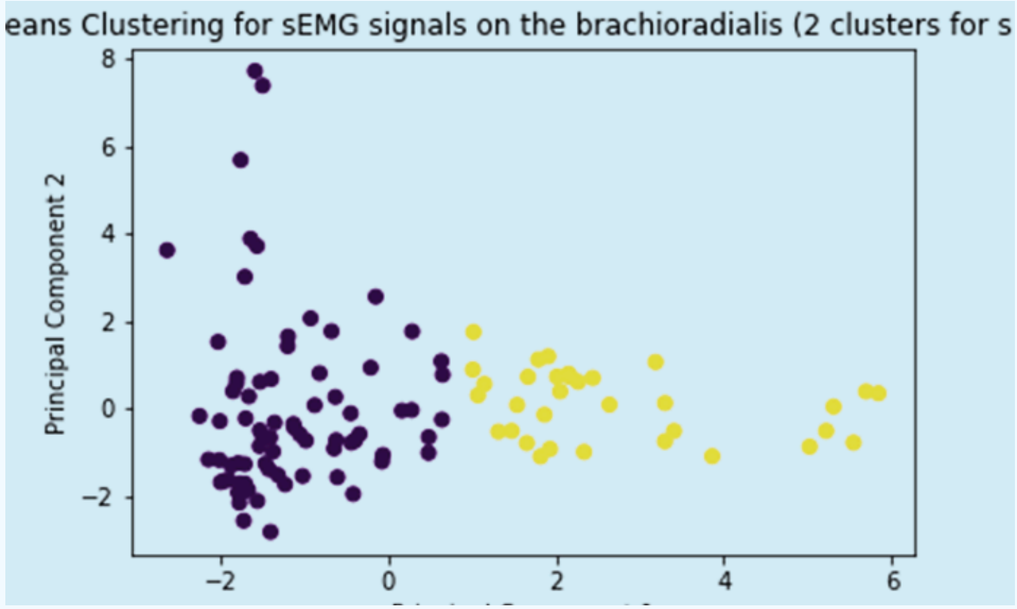


K-MEANS ALGORITHM

CLUSTERING SAMPLES

Applying K-means to the samples, we can find the critical plane between being injured and not being injured. That means we can answer the question that “at what percentage of body usage can we avoid the occurrence of tennis elbow?”

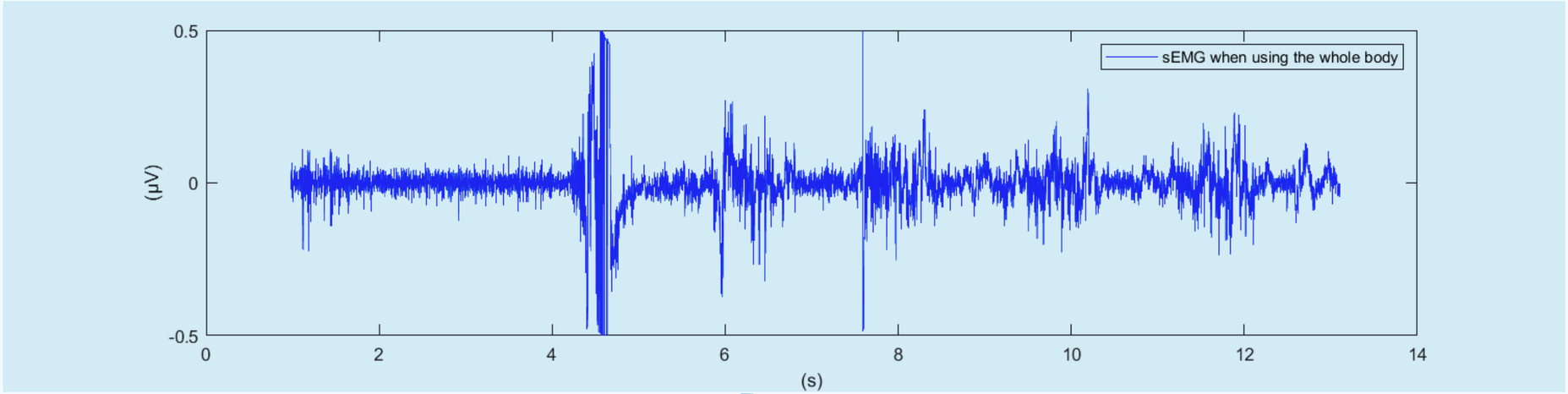
Actually due to the lack of signal decomposition, we are unable to accurately identify the characteristics of each signal. Finally the data is artificially divided into two sets.



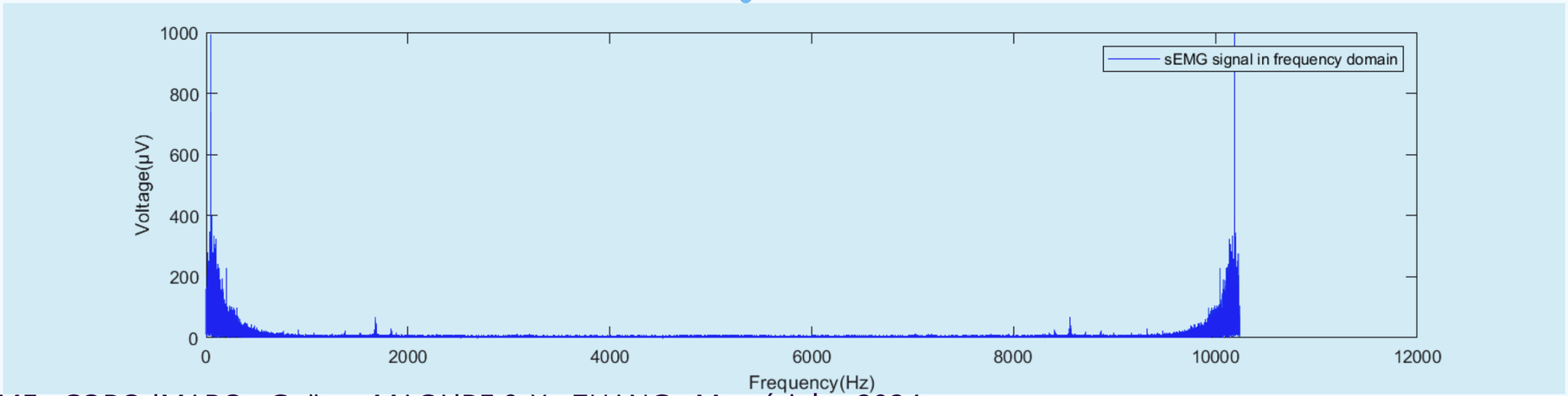

```
Total files in folder: 10
loading file: D:/xu/Datatest_EMG\training_lab0_1.mat
loading file: D:/xu/Datatest_EMG\training_lab1_1.mat
loading file: D:/xu/Datatest_EMG\training_lab0_2.mat
loading file: D:/xu/Datatest_EMG\training_lab1_2.mat
loading file: D:/xu/Datatest_EMG\training_lab0_3.mat
loading file: D:/xu/Datatest_EMG\training_lab1_3.mat
loading file: D:/xu/Datatest_EMG\training_lab0_4.mat
loading file: D:/xu/Datatest_EMG\training_lab1_4.mat
loading file: D:/xu/Datatest_EMG\training_lab0_5.mat
loading file: D:/xu/Datatest_EMG\training_lab1_5.mat
New sample cluster belongs to: [0 1 0 0 0 0 0 0 0 0]
```

TIME-DOMAIN AND FREQUENCY-DOMAIN

ANALYSIS OF SIGNAL COMPOSITION



(FFT)



SVM ALGORITHM

REDUCE ERRORS BY INCREASING THE SAMPLE SIZE.

120 samples

The large proportion of errors leads to low accuracy.

Classification report:

	precision	recall	f1-score
0.0	0.67	0.67	0.67
1.0	0.67	0.67	0.67
accuracy			0.67
macro avg	0.67	0.67	0.67
weighted avg	0.67	0.67	0.67

Accuracy: 0.6666666666666666

240 samples

With samples increasing, the accuracy becomes more satisfying

Classification report:

	precision	recall	f1-score
0.0	0.69	0.78	0.73
1.0	0.73	0.63	0.68
accuracy			0.71
macro avg	0.71	0.71	0.71
weighted avg	0.71	0.71	0.71

Accuracy: 0.7083333333333334

360 samples

Once the sample size reaches a certain point, its impact on accuracy becomes marginal

Classification report:

	precision	recall	f1-score
0.0	0.72	0.65	0.68
1.0	0.71	0.77	0.74
accuracy			0.71
macro avg	0.71	0.71	0.71
weighted avg	0.71	0.71	0.71

Accuracy: 0.7129629629629629

FUTURE WORK

FOCUS ON AUTO-DECOMPOSITION

CURRENT STAGE

The machine learning models are built, but the motor units needs to be added to input matrix

STEP 1(-)

To find or design an appropriate software for decomposition

STEP 2

To decompose signals and analyse their characteristics

STEP3

To optimise the model, increase the accuracy of prediction

MERCI POUR VOTRE ATTENTION

GAËTAN MACAIRE
gaetan.macaire@etu.univ-nantes.fr
XU ZHANG
xu.zhang@eleves.ec-nantes.fr

Page du stage