Università degli Studi di Milano Bicocca
Scuola di Scienze
Dipartimento di Informatica, Sistemistica e Comunicazione
Corso di laurea in Informatica

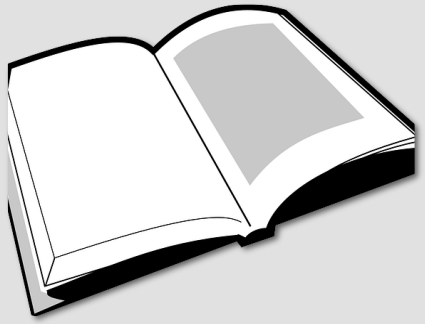
ANALISI DI SEGNALI EEG TRAMITE CONVOLUZIONE WAVELET

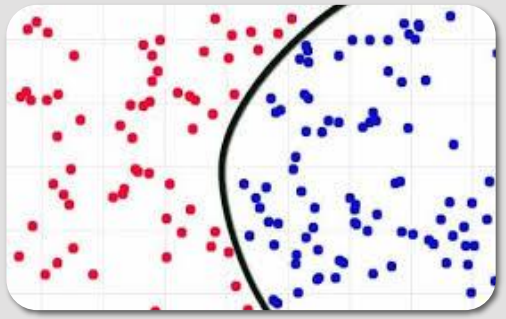
Relatore: Prof. Francesca Gasparini
Co-relatore: Dott.ssa Silvia Elena Corchs

Relazione della prova finale di:
Lorenzo Sasso
Matricola 809055

Anno Accademico 2017-2018

GLI OBIETTIVI DEL PROGETTO



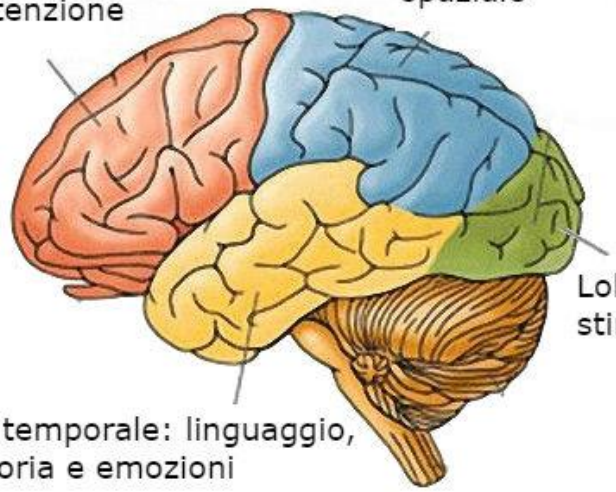


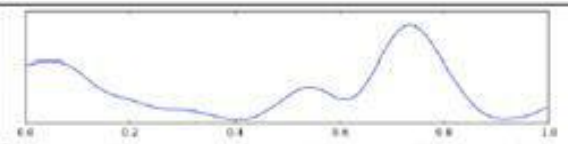
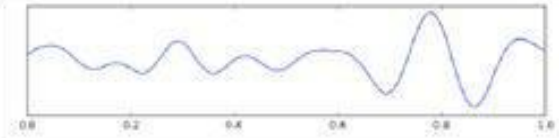
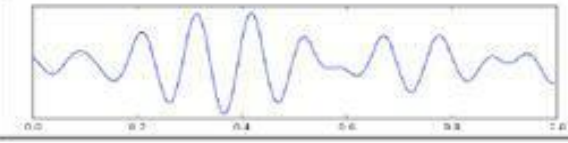
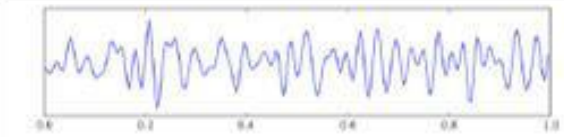
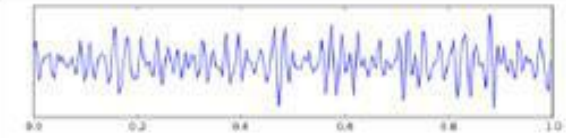
Analisi dello stato dell’arte sullo studio dei segnali EEG

Effettuare un’analisi tempo–frequenza di un segnale EEG

Utilizzare tecniche di analisi dei dati per confrontare il movimento reale da uno immaginato

Anatomia del cervello e i ritmi EEG

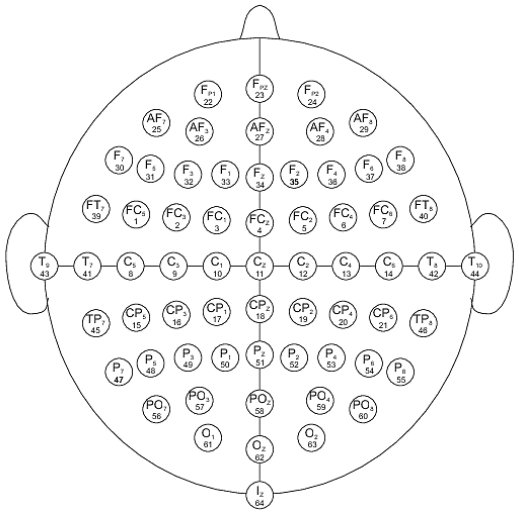


Type	Frequency range (Hz)	Signal Shape
Delta (Δ)	1-3	
Theta (Θ)	4 - 7	
Alpha (α)	8 - 15	
Beta (β)	12 - 30	
Gamma (γ)	> 30	

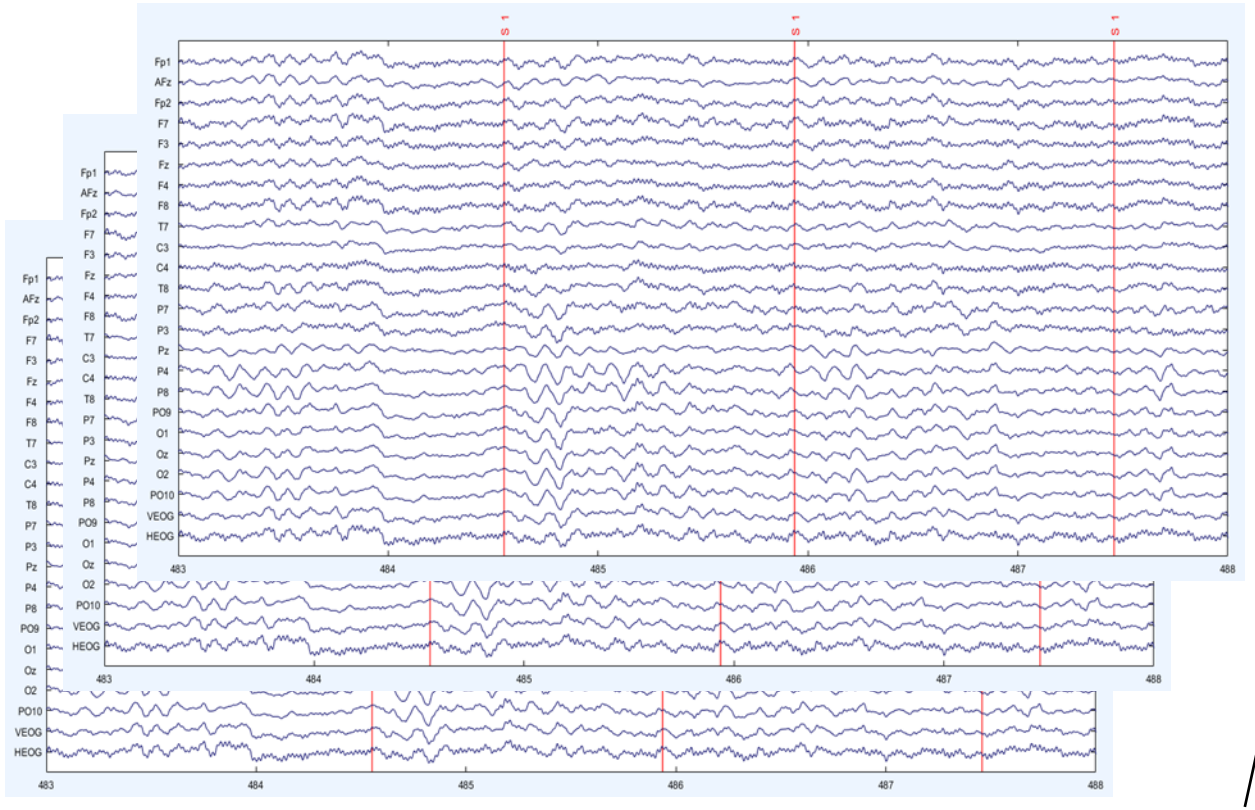
Analisi di segnali EEG

I dati EEG sono:

- Tempo – varianti
- Segnali multidimensionali
  - ✓ N elettrodi
  - ✓ M soggetti



N elettrodi



tempo

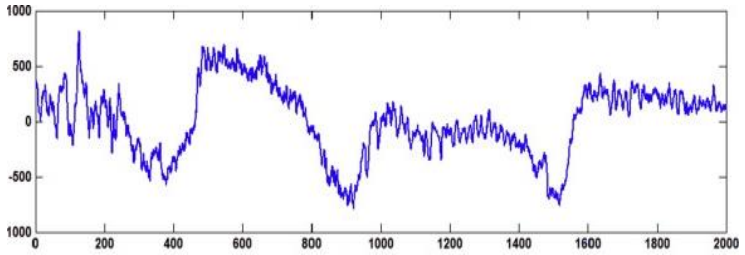
M soggetti

Analisi di segnali EEG

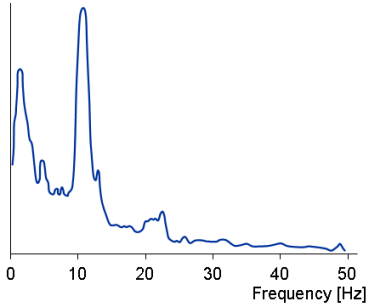
In base alla dimensione, al dominio e ai metodi utilizzati possono essere effettuate diverse tipi di analisi :

DOMINIO

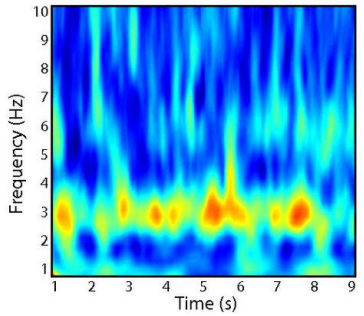
Tempo



Frequenza

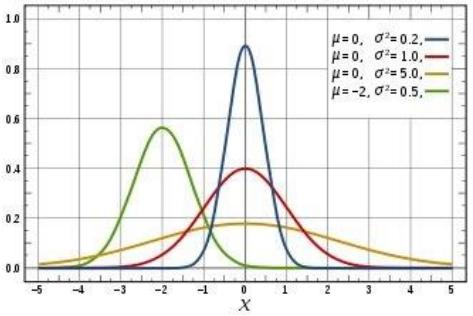


Tempo - frequenza

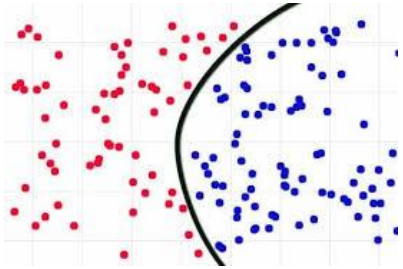


METODI

Statistica inferenziale



Machine learning (classificatori)

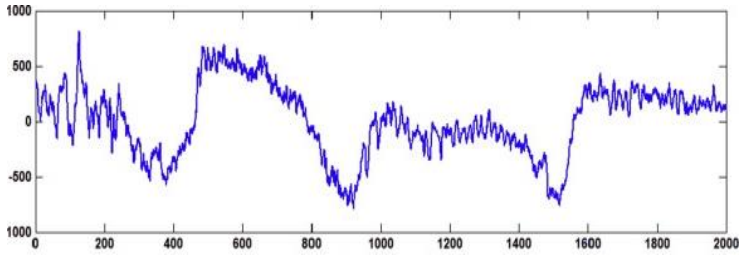


Analisi di segnali EEG

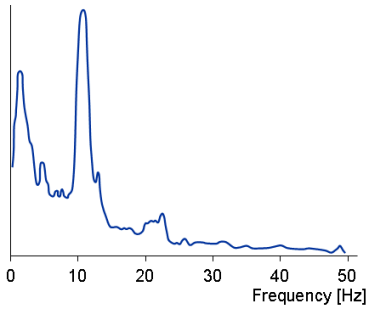
In base alla dimensione, al dominio e ai metodi utilizzati possono essere effettuate diverse tipi di analisi :

DOMINIO

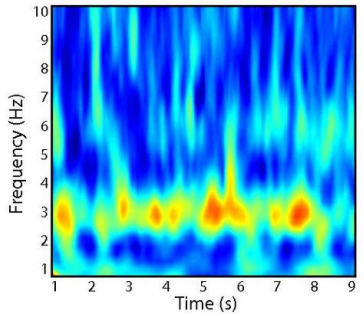
Tempo



Frequenza

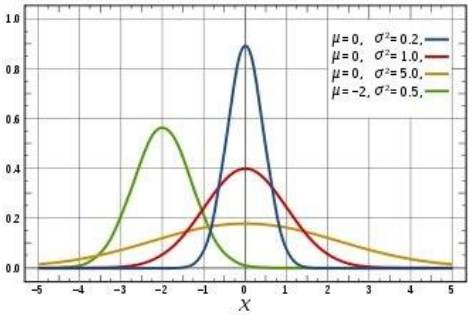


Tempo - frequenza



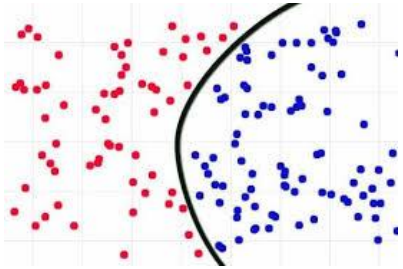
METODI

Statistica inferenziale



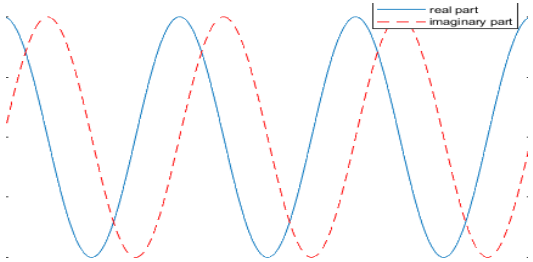
ANOVA

Machine learning (classificatori)



«CLASSIFICATION LEARNER»

Morlet wavelet



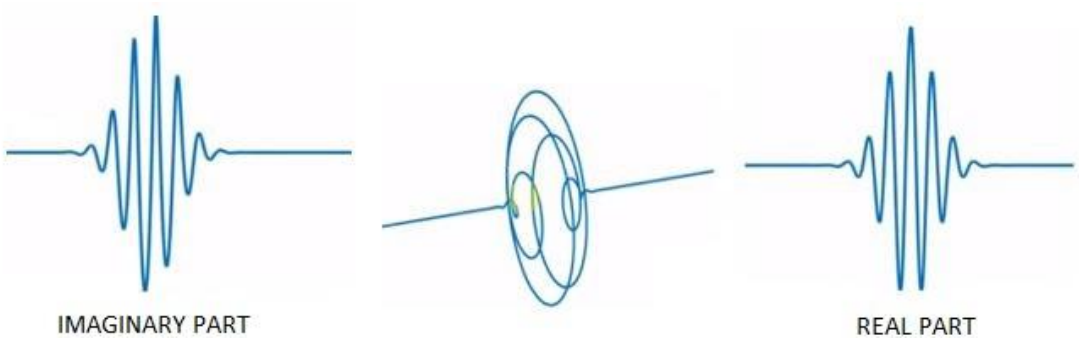
Onda seno complessa

*

Gaussiana

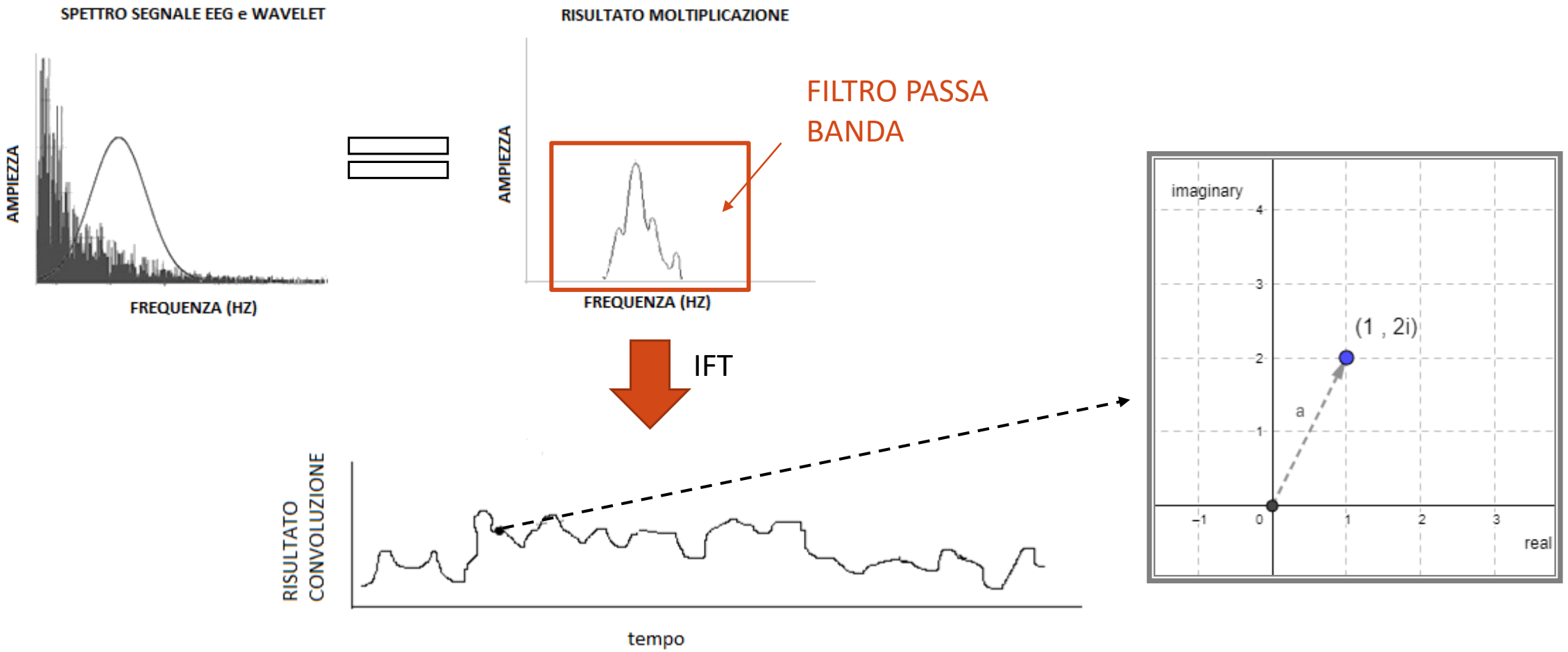
Morlet wavelet

Dominio temporale

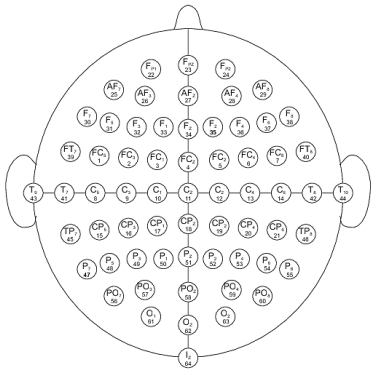


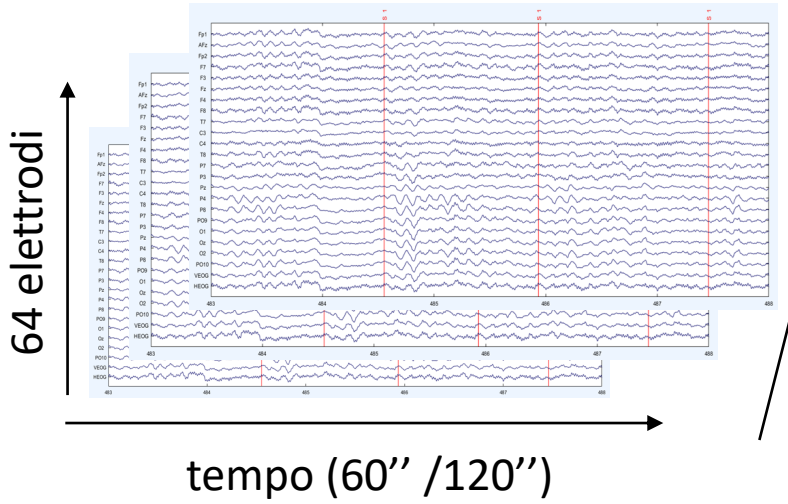
Dominio frequenziale

Convoluzione: significato e informazioni estraibili dal risultato



Esperimenti: il dataset (www.physionet.org/pn4/eegmmidb)





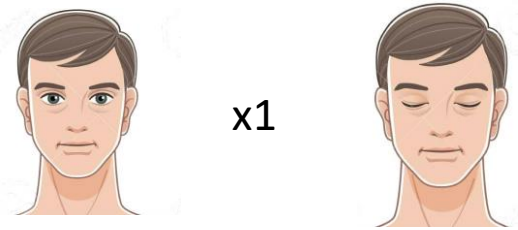
BASELINE 60 s

TASK 4.2s 4.1s 4.2s 4.1s ⟷ 4.2s 4.1s 120 s

Registrazioni per soggetto

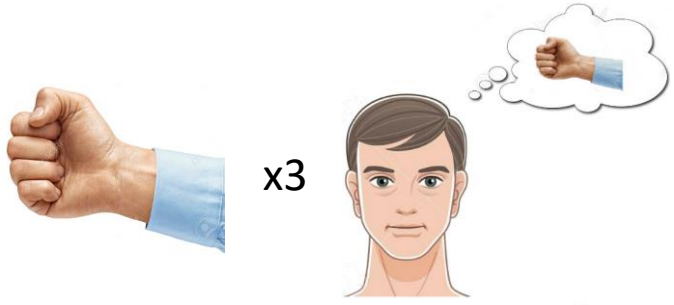
BASELINE

- x1 x1

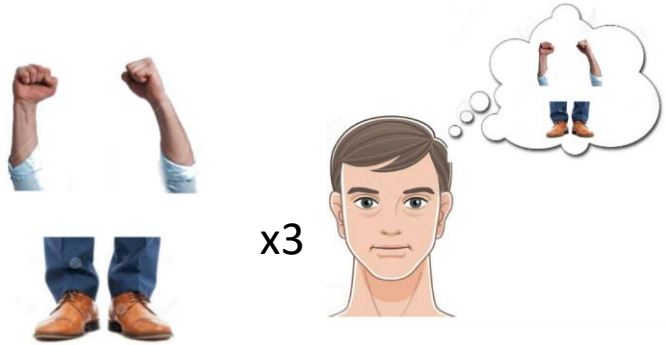


TASK

- x3 x3



- x3 x3



Esperimenti: le prove

Population-based

- Esperimento 1

x 109 vs x 109

Population-based

- Esperimento 2

x 103 vs x 103

Subject-based

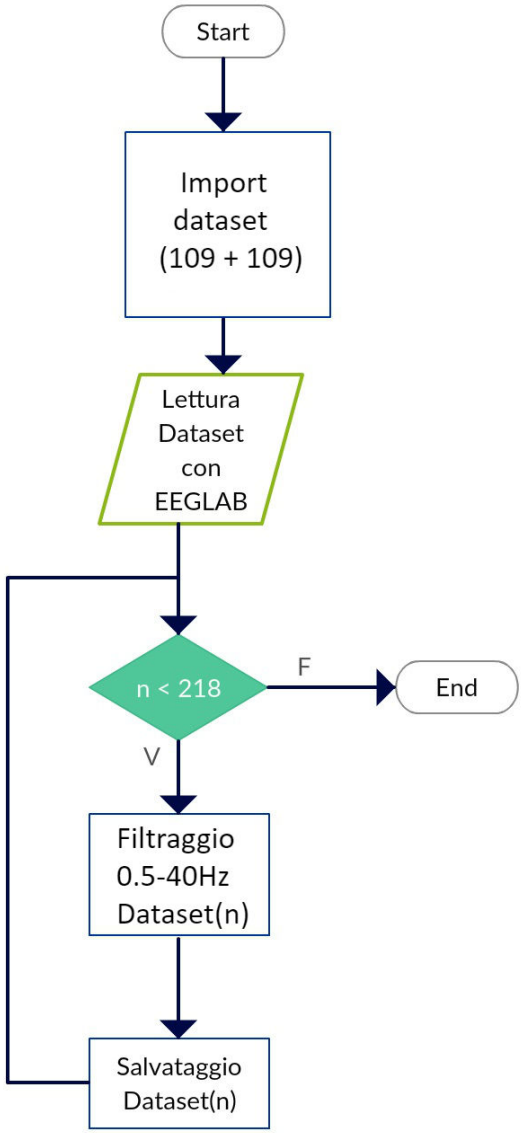
- Esperimento 3

x 1 vs x 1

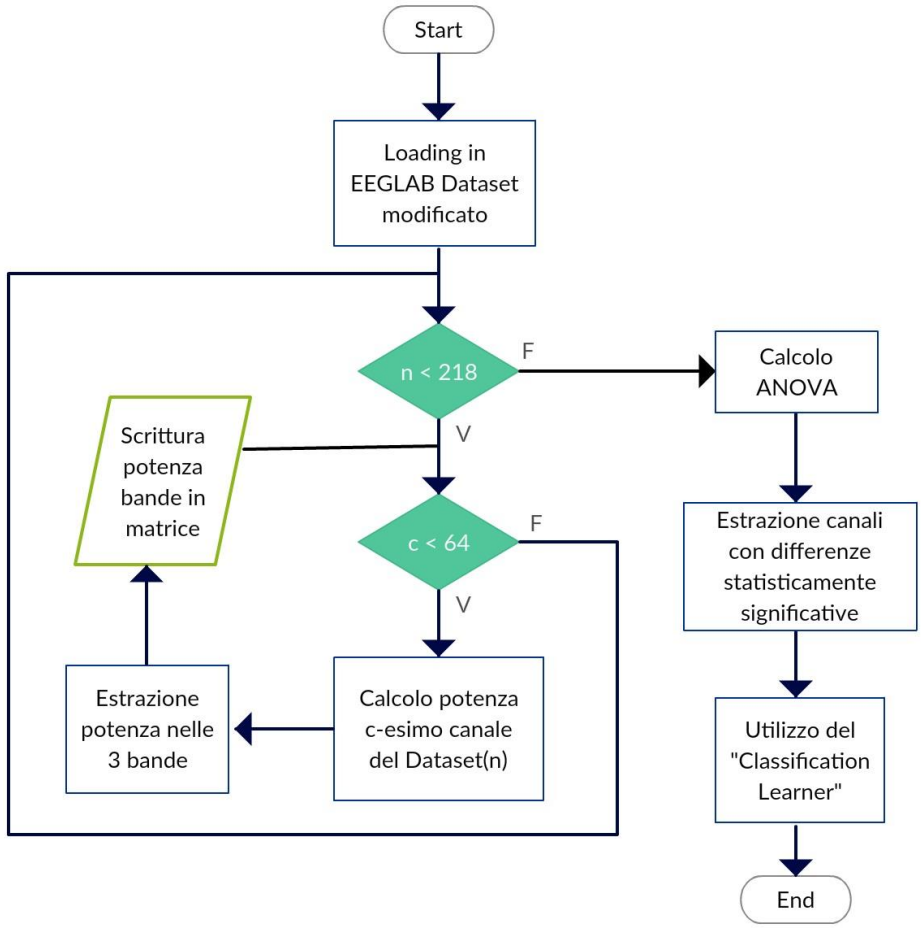
Population-based

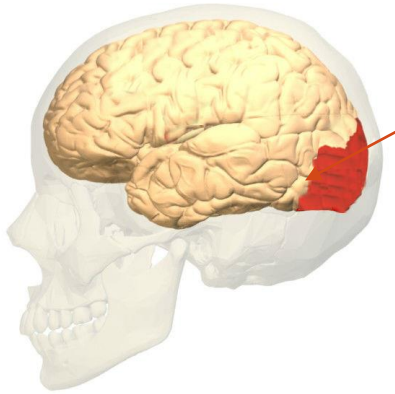
- Esperimento 4

x 309 vs x 309

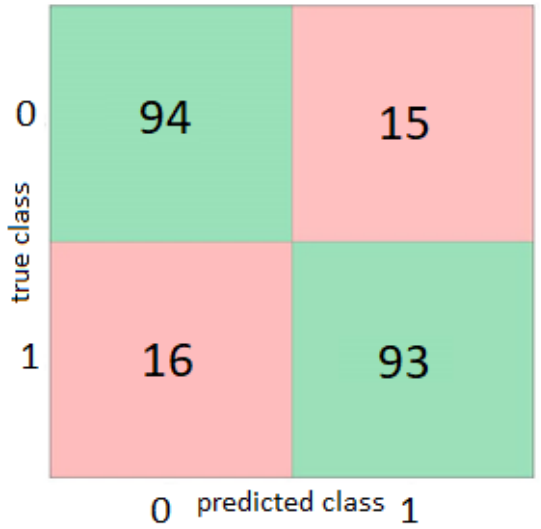


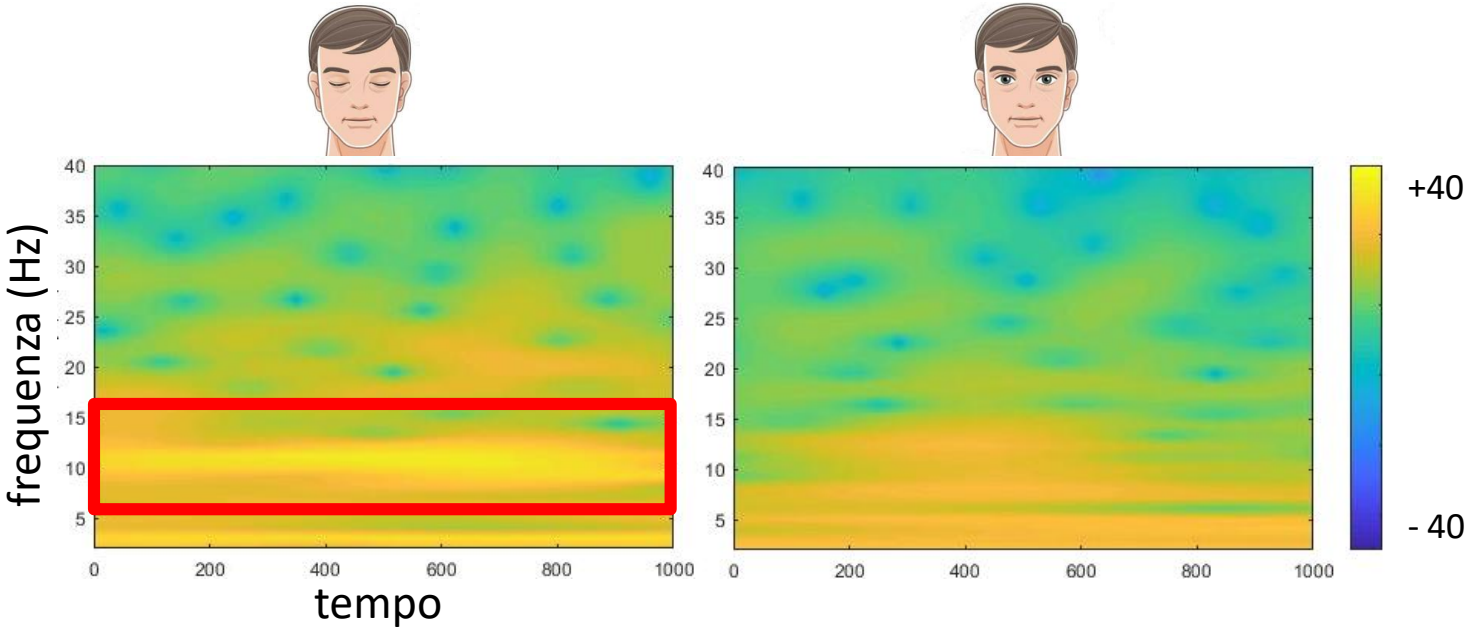
Esperimento 1



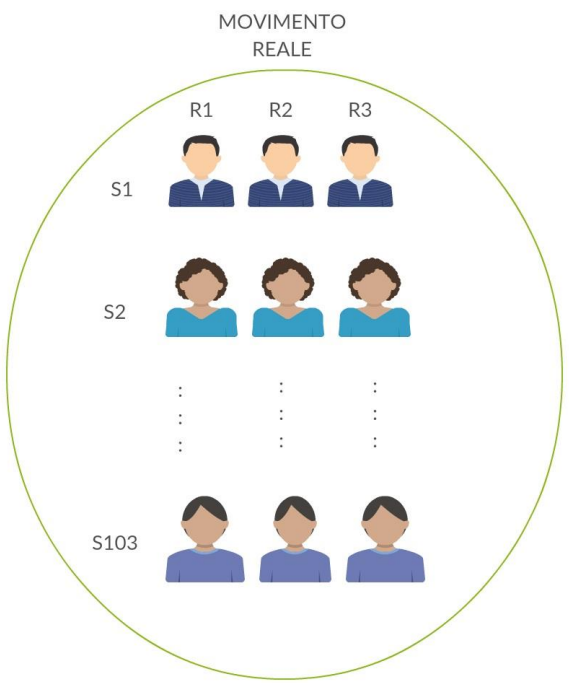


P << 0.01

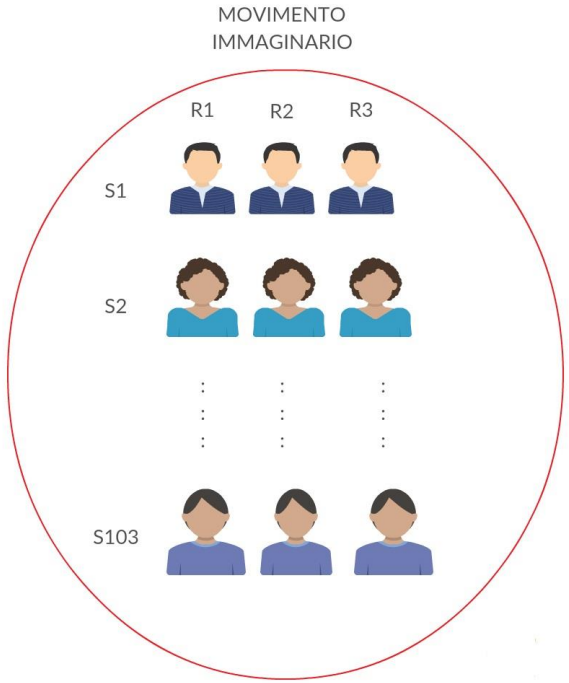


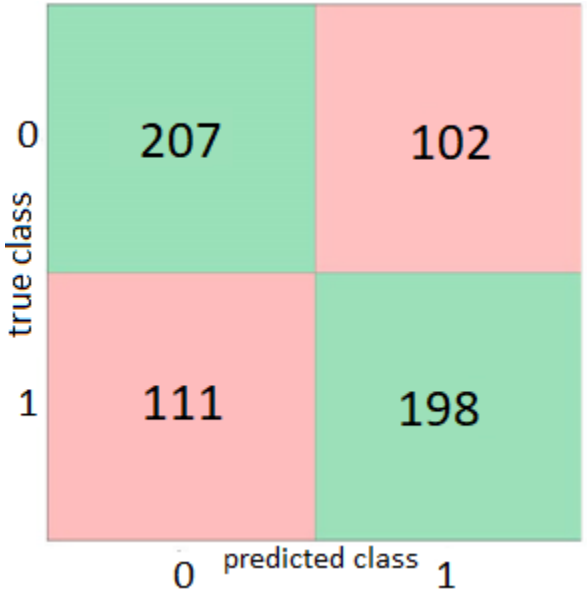


Esperimento 4

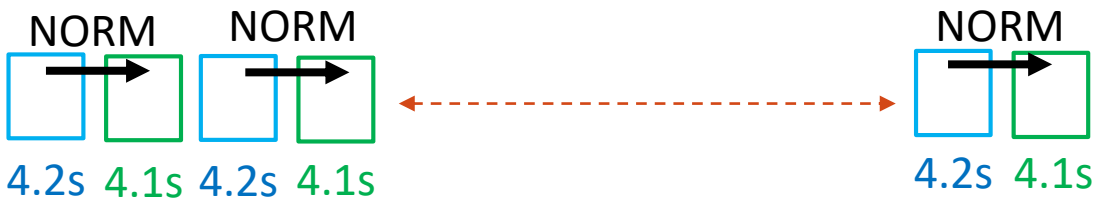


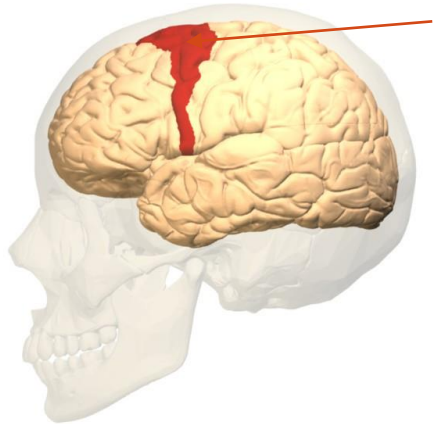
VS





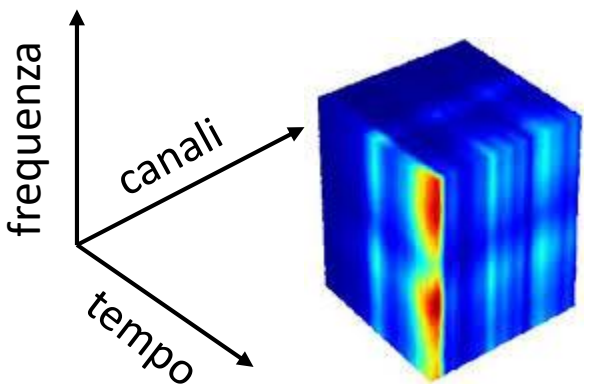
TASK

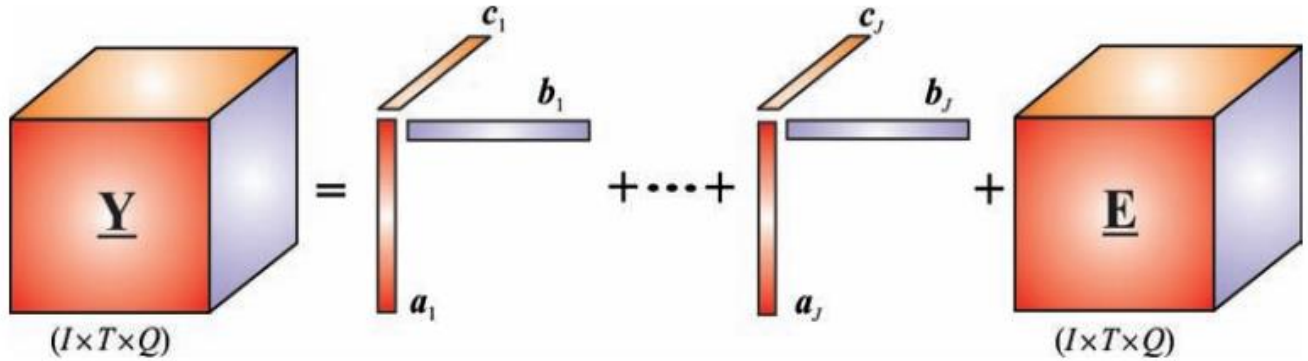




P << 0.01

Future works . . .





COMPETENZE ACQUISITE

- Utilizzo del toolbox EEGLAB di Matlab per la gestione dei dati elettroencefalografici
- Effettuare l'analisi tempo-frequenza di un segnale EEG tramite convoluzione con Morlet wavelet
- Utilizzo di metodi di statistica inferenziale e machine learning per estrarre dei risultati
- Funzionamento della decomposizione PARAFAC di un tensore

Grazie per l’attenzione . . .

ESPERIMENTO 2

	Prova 1	Prova 2	Prova 3	Prova 4
Accuracy	63.6%	61.2%	64.1%	62.6%
F-score	0.647	0.594	0.62	0.619

ESPERIMENTO 3

Canale	Theta	Alpha	Beta
1	0.0032	0.0914	0.2174
2	0.0027	0.0240	6.8432e-06
3	0.0252	0.0145	1.4179e-06
4	0.0335	0.0201	2.5284e-06
5	0.0270	0.0062	3.4288e-06
6	0.0261	7.4366e-04	1.3682e-05
7	0.0918	0.0927	0.1487
8	0.0127	0.1529	0.5631
9	0.0045	0.4000	6.3762e-05
10	0.0214	0.2203	2.0070e-05
11	0.1073	0.1085	0.0160
12	0.0556	0.0086	0.0042
13	0.0521	0.0029	0.0038
14	0.1898	0.0117	0.2162
15	0.0119	0.0343	0.0411
16	0.0091	0.0627	3.1286e-04
17	0.0307	0.0295	0.0053
18	0.0908	0.0261	0.0541
19	0.1325	0.0041	0.2032
20	0.0497	1.2345e-04	0.3815
21	0.1114	0.0086	0.6480
22	0.0020	0.1482	0.1886
23	0.0039	2.3953e-04	0.0220
24	0.0078	0.3382	0.4521
25	0.0667	0.3081	0.0640
26	0.0024	0.1472	0.0534
27	0.0041	0.0173	1.2457e-05
28	0.0037	0.4404	0.0941
29	0.0339	0.4893	0.2155
30	0.0044	0.8854	0.1997
31	3.5190e-04	0.2701	0.6467
32	0.0038	0.0058	0.0085

Canale	Theta	Alpha	Beta
33	0.0149	0.0048	9.6854e-06
34	0.0253	0.0161	3.5429e-06
35	0.0122	0.0322	3.3275e-07
36	0.0125	0.0406	6.9406e-06
37	0.0156	0.6157	0.0096
38	0.0598	0.0771	0.9904
39	0.0020	0.2398	0.0165
40	0.0165	0.1069	0.3057
41	0.1992	0.1065	0.5781
42	0.3354	0.3169	0.6504
43	0.3306	0.0658	0.0111
44	0.3760	0.6968	0.9991
45	0.0866	0.0192	0.8569
46	0.2949	5.7039e-04	0.0510
47	0.1485	5.7185e-04	0.2058
48	0.0034	6.6052e-04	0.0300
49	0.0088	5.2285e-04	0.0023
50	0.0322	0.0012	0.0062
51	0.0271	0.0017	0.0395
52	0.0137	2.7903e-05	0.0971
53	0.0084	1.4585e-06	0.1566
54	0.0354	1.1561e-05	0.1148
55	0.0274	2.8618e-04	0.0177
56	0.0062	0.0054	0.2246
57	0.0041	7.2048e-04	0.0631
58	0.0012	2.0578e-04	0.0423
59	0.0014	4.3449e-06	0.3669
60	0.0678	7.1910e-05	0.1603
61	0.0293	0.0058	0.5735
62	0.0185	0.0037	0.7327
63	5.3363e-04	1.8656e-04	0.7746
64	0.1374	0.9249	0.9008