

O que é neurociência computacional?

COLMEA 2023

Colóquio Interinstitucional Modelos Estocásticos e Aplicações

Sobre mim



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Instituto de Computação IC - UFF

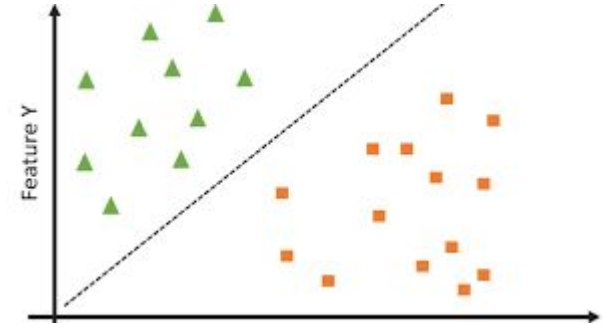
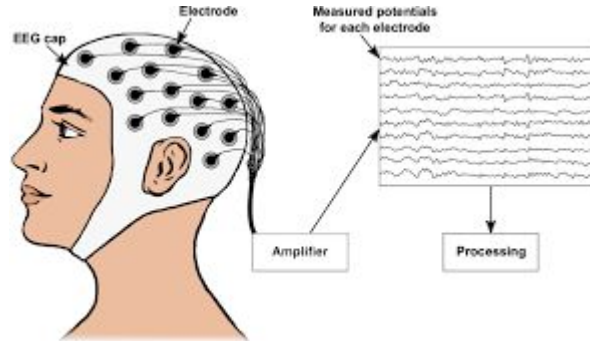
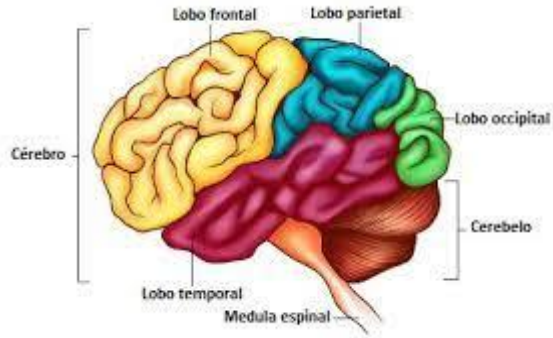
Métodos de IA e Machine Learning

Análise de dados de cérebros e saúde

(fMRI, EEG, smartwatch)

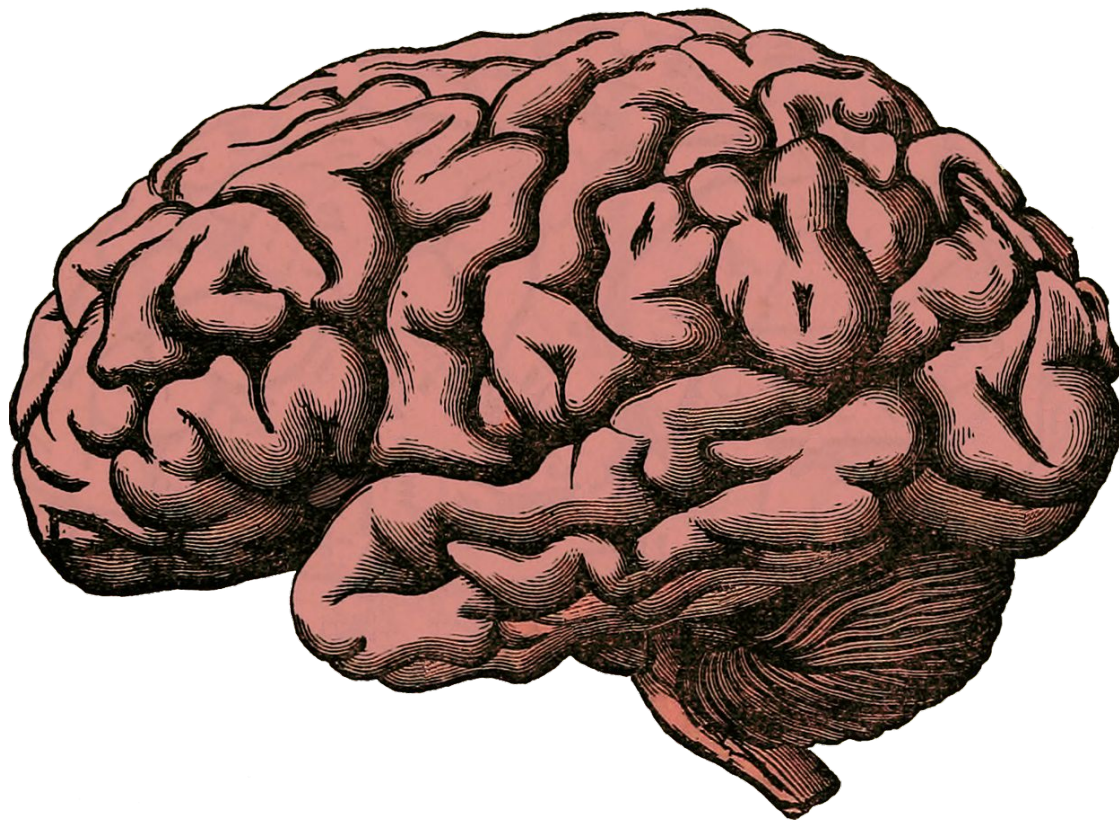


Neuroscience starter pack

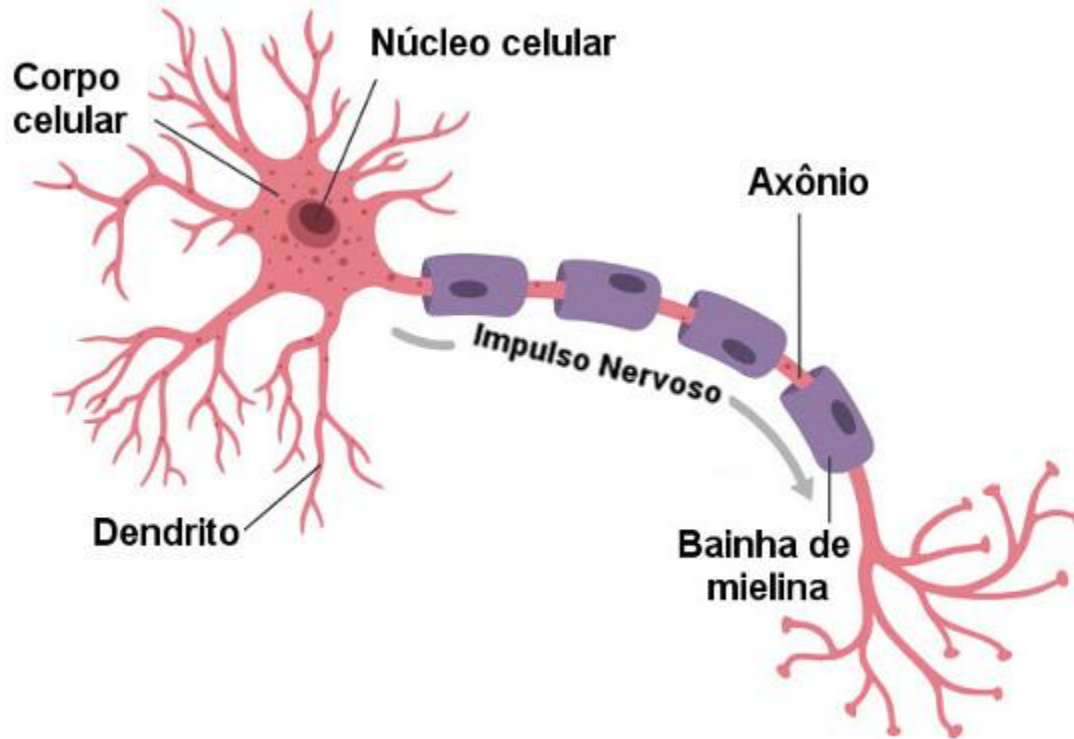


Conceitos fundamentais da neurociência

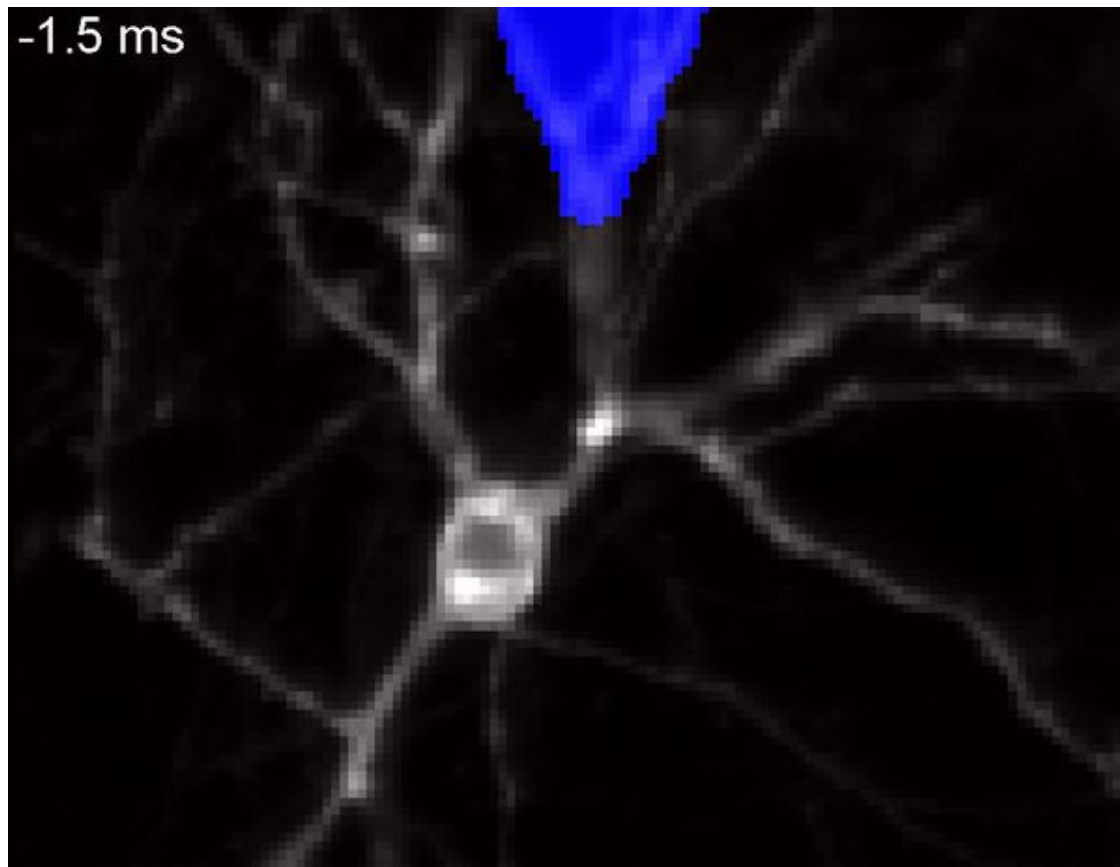
O cérebro



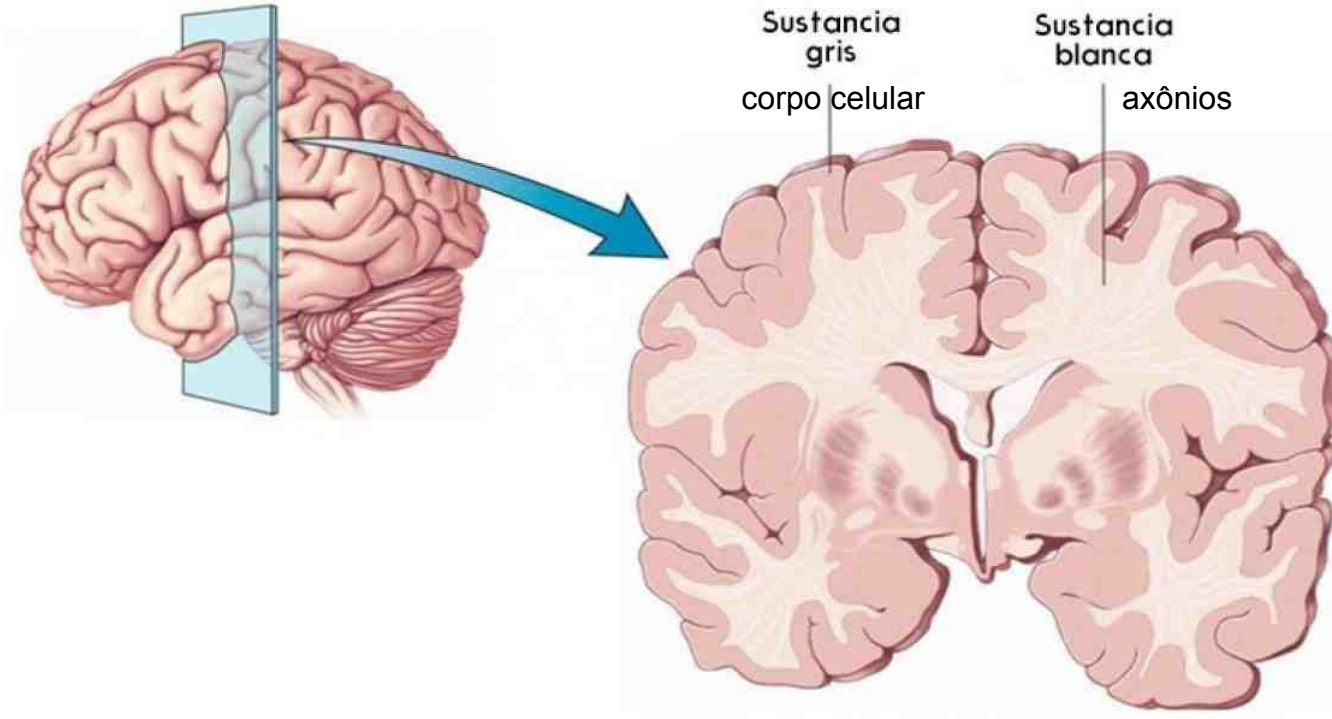
O neurônio



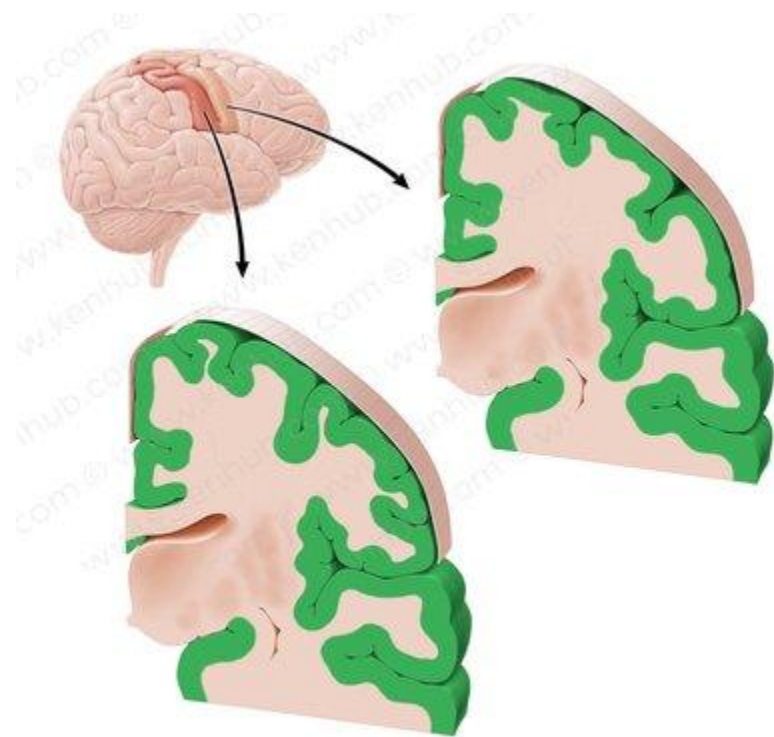
O disparo



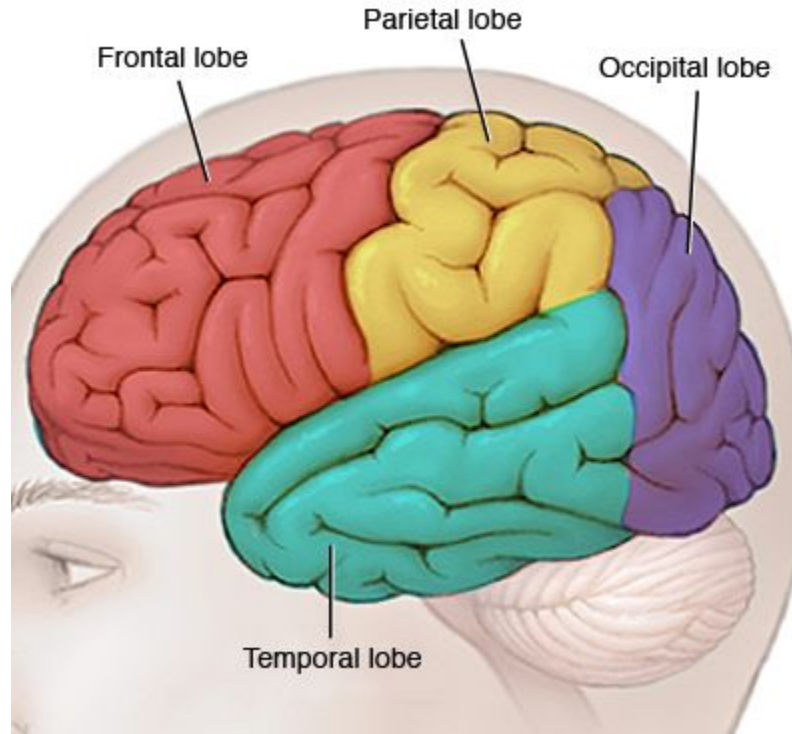
Substância branca e cinzenta



Córtex

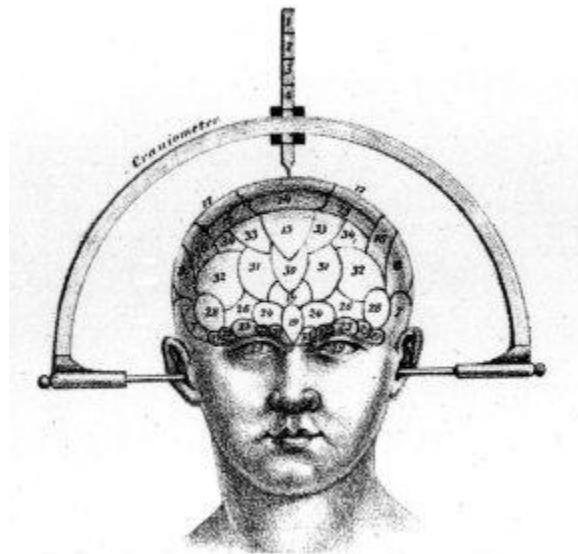


Lobos cerebrais

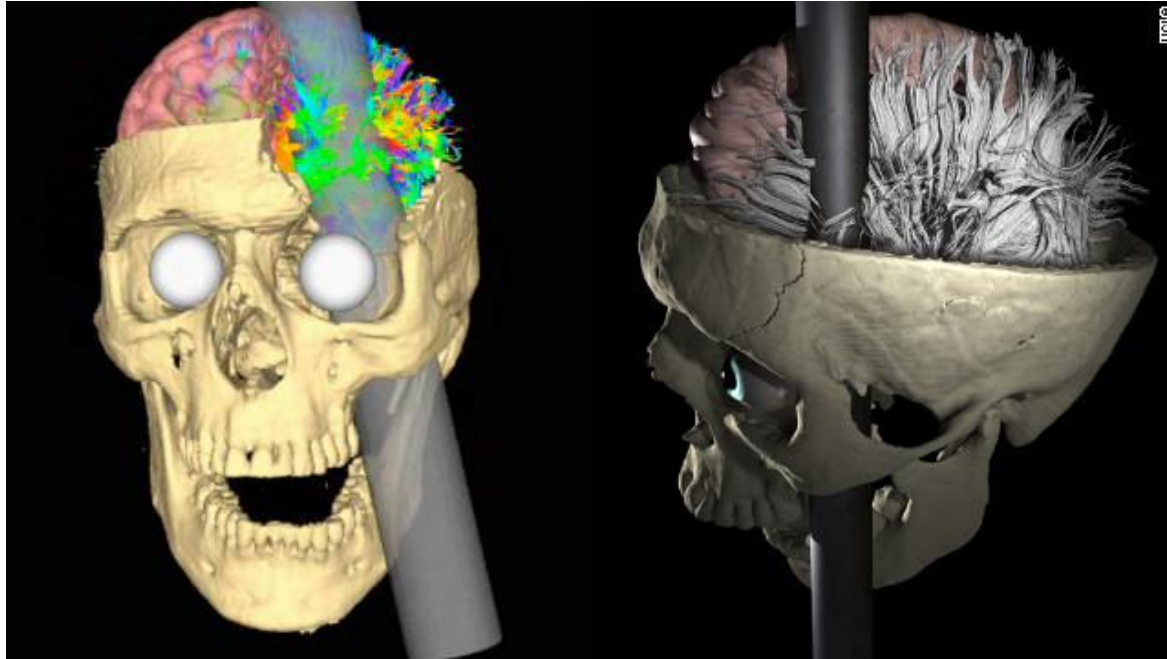


Os primórdios da neurociência

Frenologia (1796) - Pseudociência

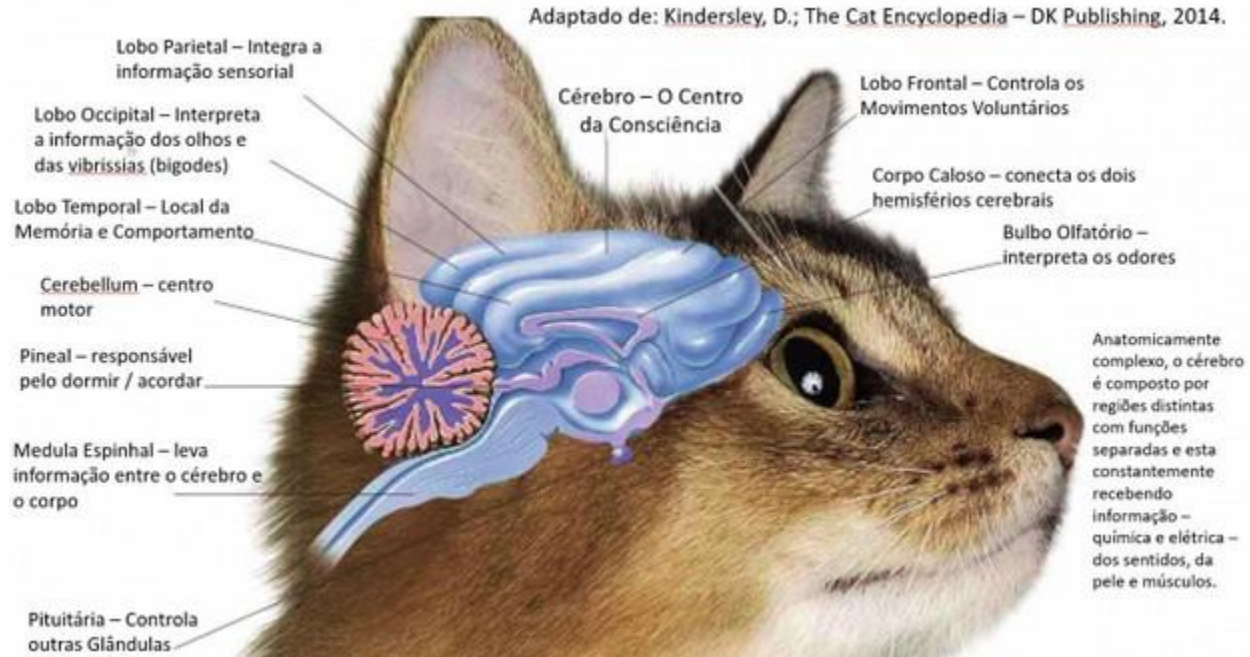


Estudo de lesões e sequelas - Caso Phineas Gage (1848)



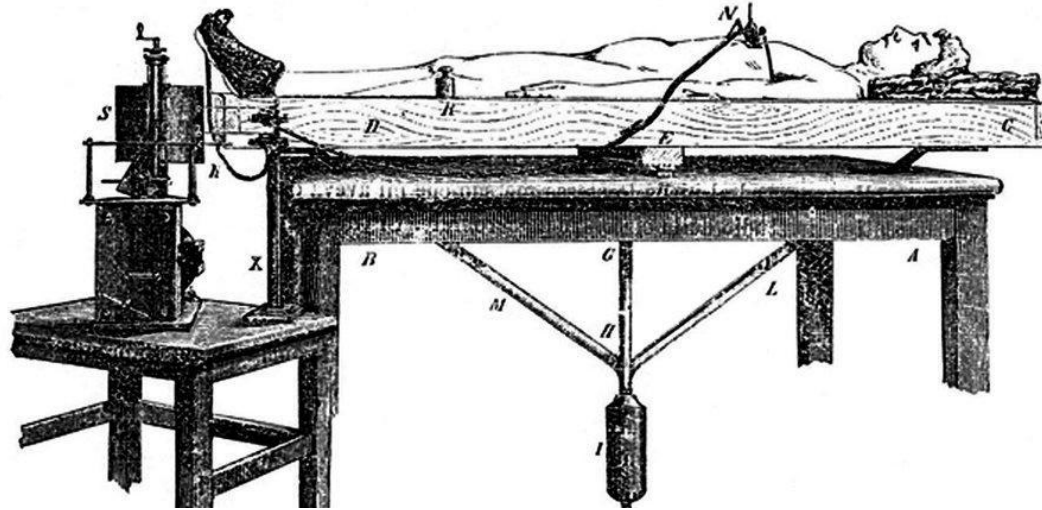
Originally from the collection of Jack and Beverly Wilgus; now in the Warren Anatomical Museum, Harvard Medical School

Uso de modelo animal



Surgimento de técnicas para estudo do cérebro vivo

- 1882 Angelo Mosso



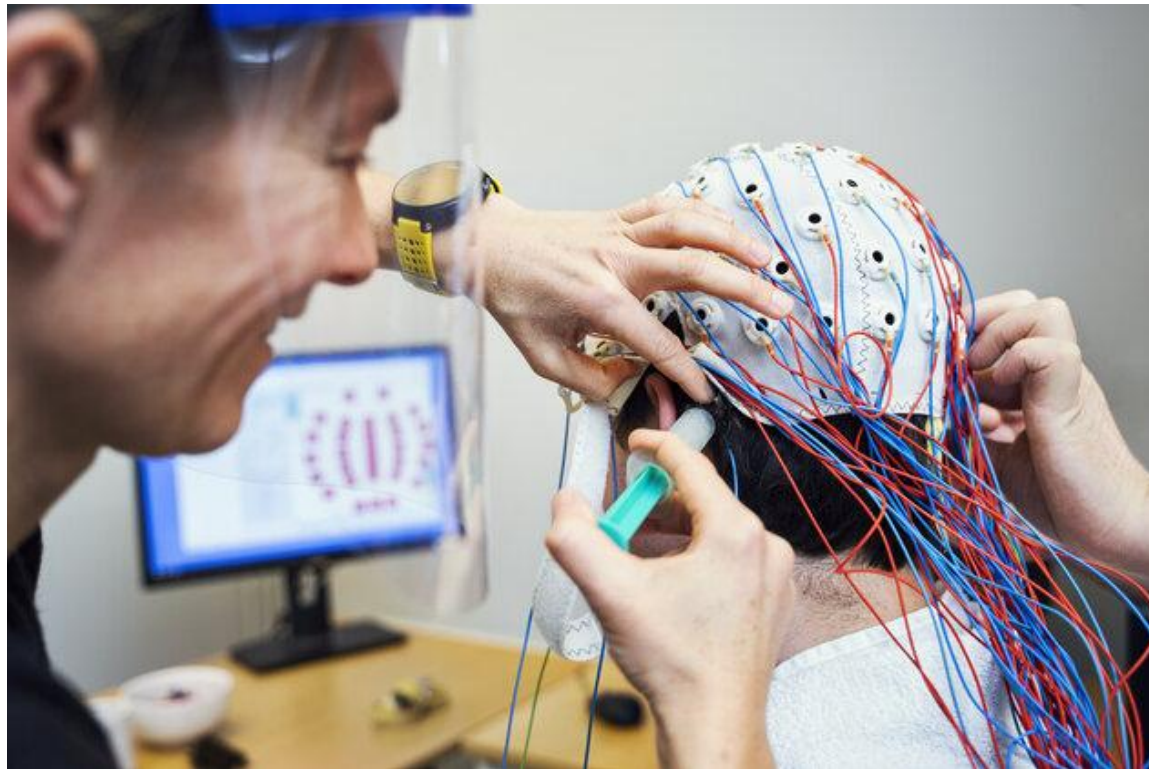
Fonte: Original de Mosso 1884, retirado de Sandrone e colegas 2012

Técnicas de captura de dados cerebrais

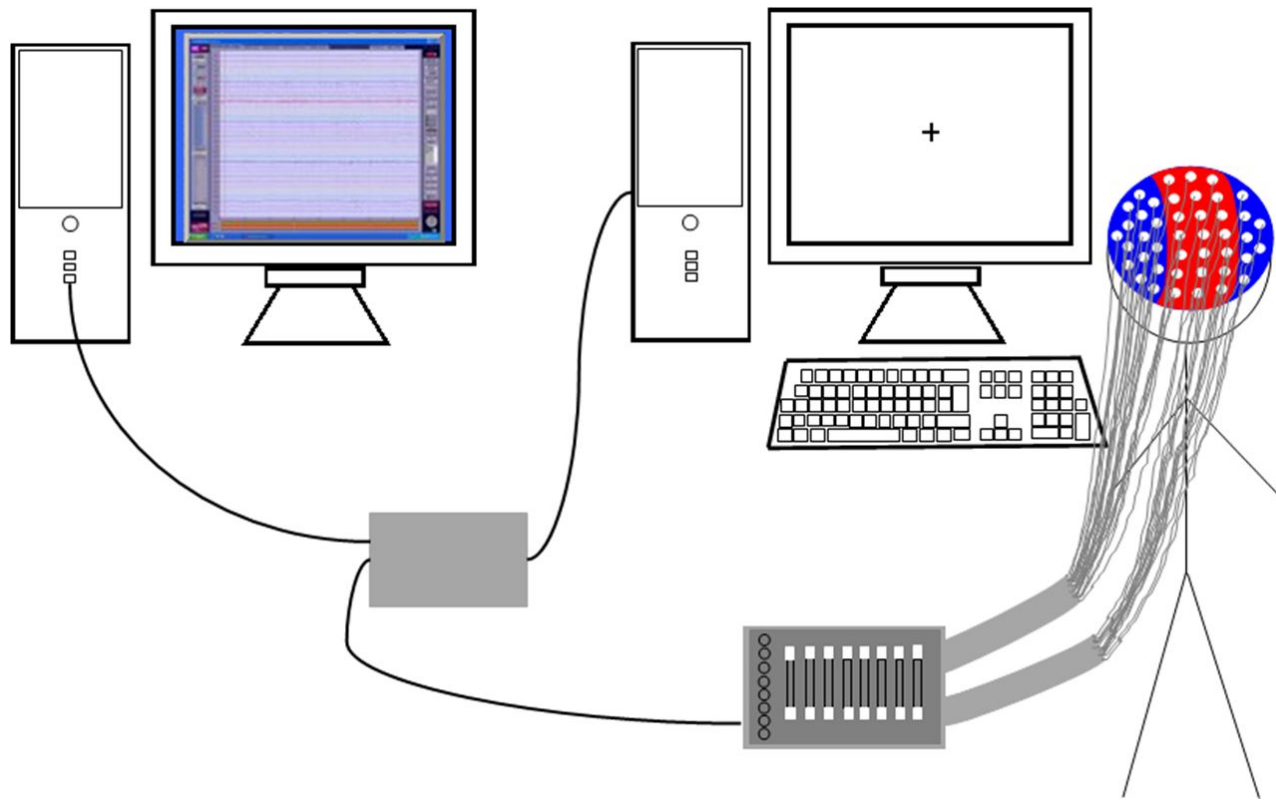
Técnicas de captura de dados cerebrais

- EEG
- ECoG
- sMRI
- fMRI

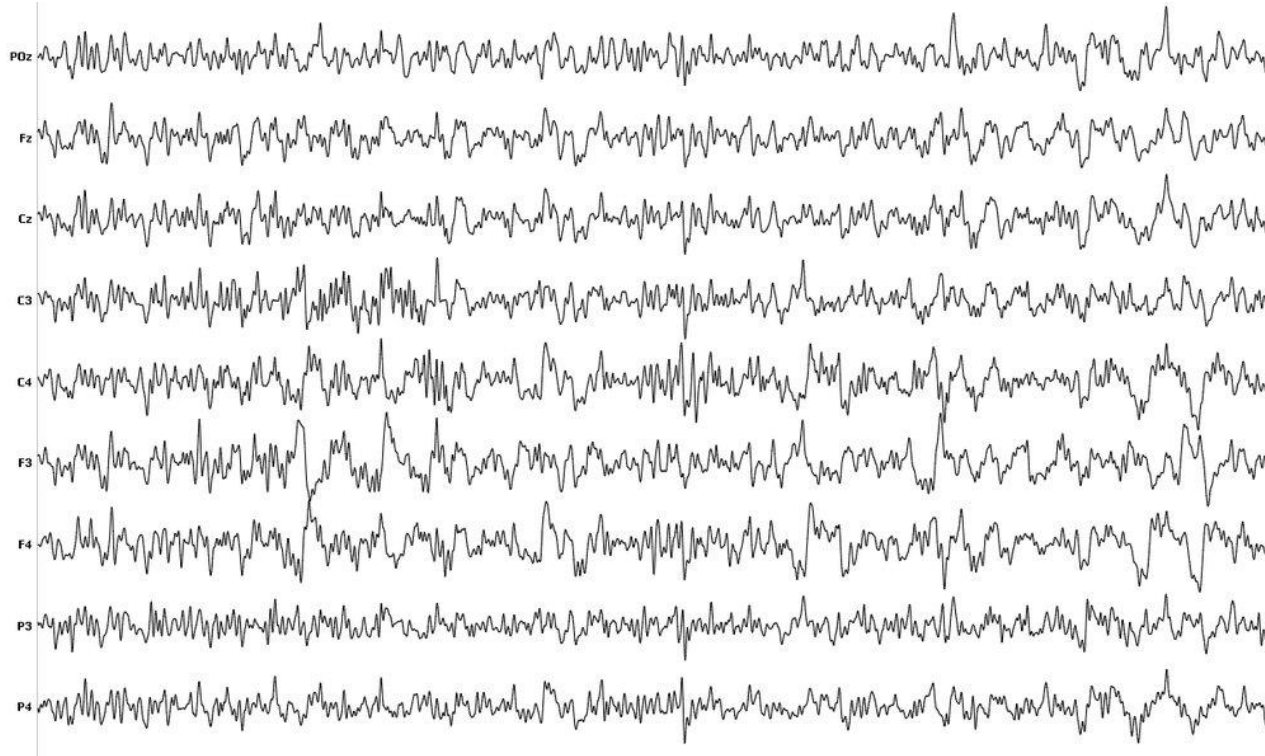
EEG - eletroencefalografia



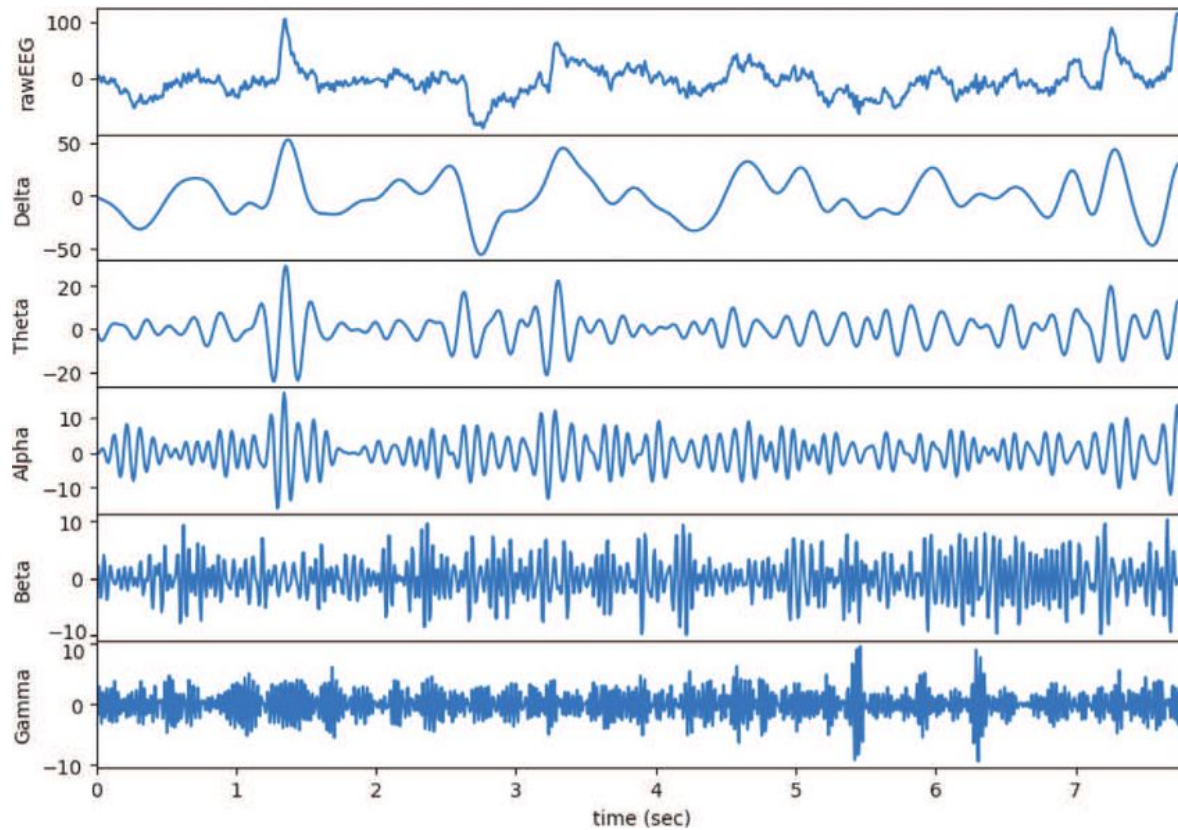
EEG - eletroencefalografia



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EEG - eletroencefalografia

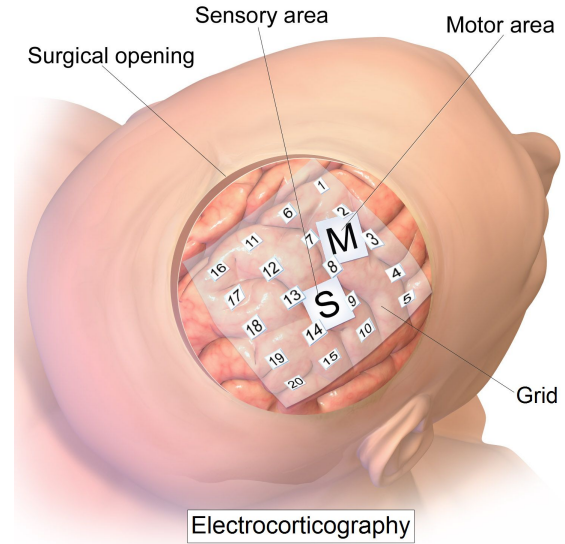
Vantagens:

- Mais barato do que outras técnicas
- Resolução temporal (bom para tarefas)

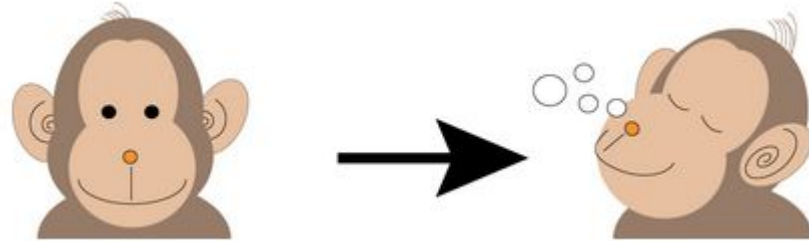
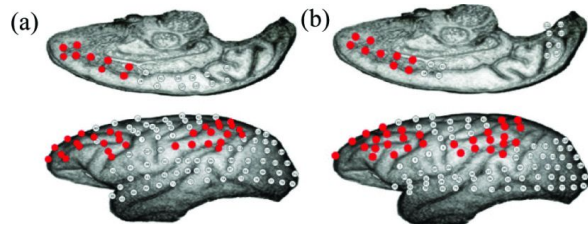
Desvantagens:

- Resolução espacial (fica afastado do cérebro)

ECoG - eletrocorticografia



ECoG - Modelo animal



ECoG - Pacientes que passarão por cirurgia de epilepsia



ECoG

Vantagens:

- Resolução temporal do EEG
- Resolução espacial melhor que o EEG

Desvantagens:

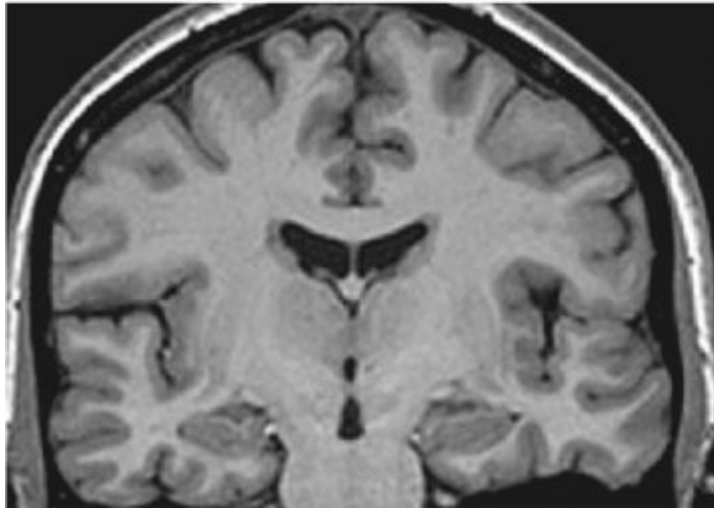
- Procedimento invasivo
- Captura uma pequena região do córtex

sMRI - Ressonância magnética estrutural

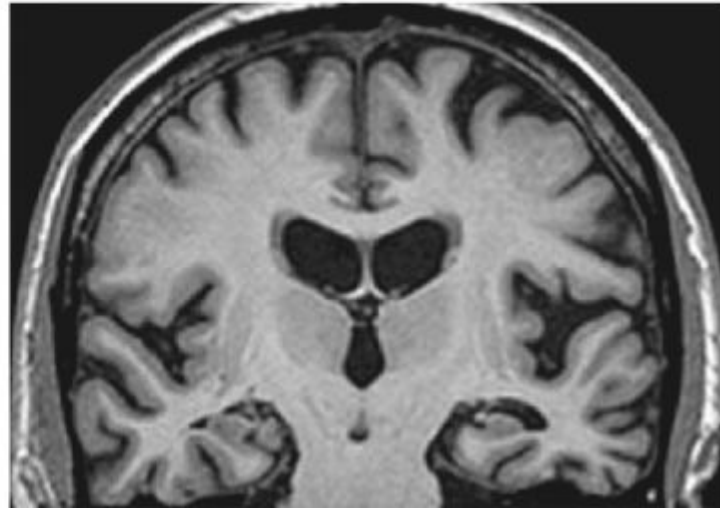


sMRI - Ressonância magnética estrutural

Healthy Control



Alzheimer's Disease



sMRI - Ressonância magnética estrutural

Vantagens:

- Alta resolução espacial (cobre o cérebro todo)
- Bom para diagnóstico de doenças degenerativas ou alterações estruturais

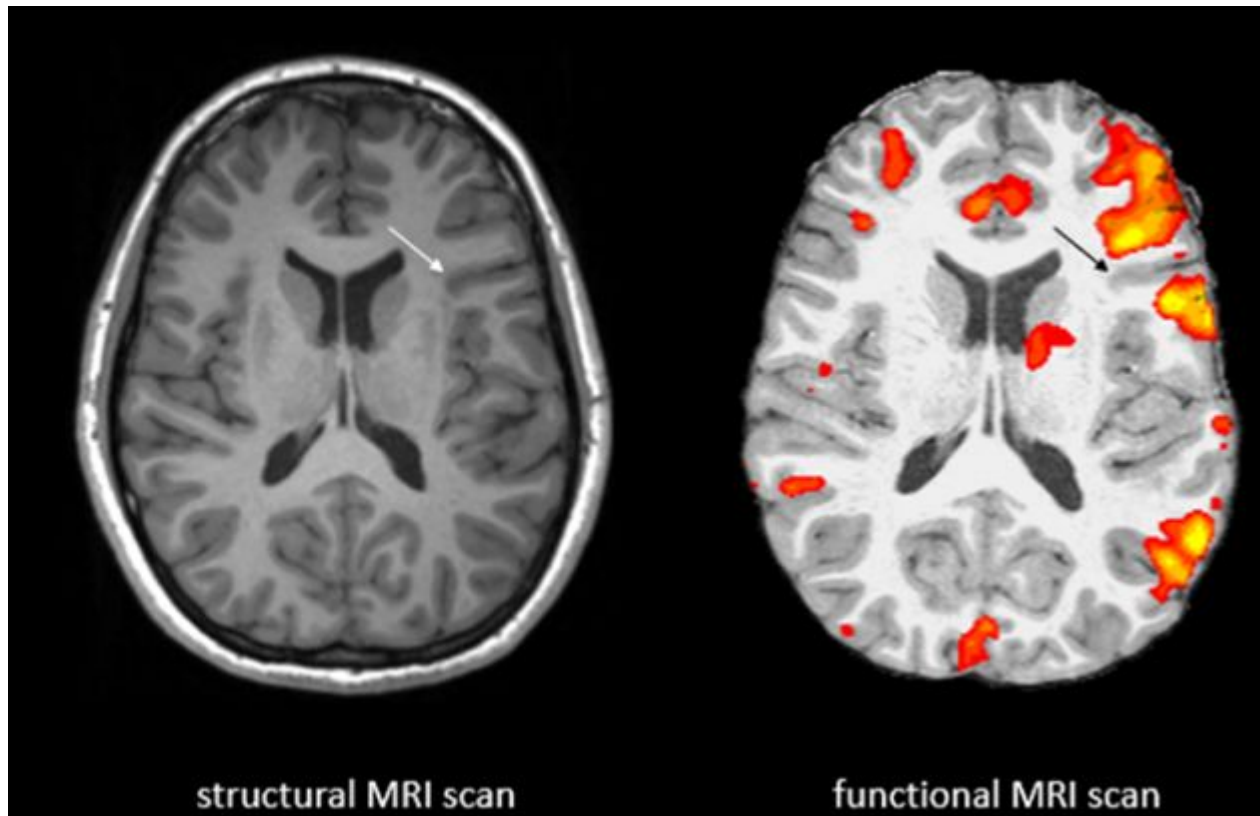
Desvantagens:

- Não registra dados de funcionamento
- Custa caro

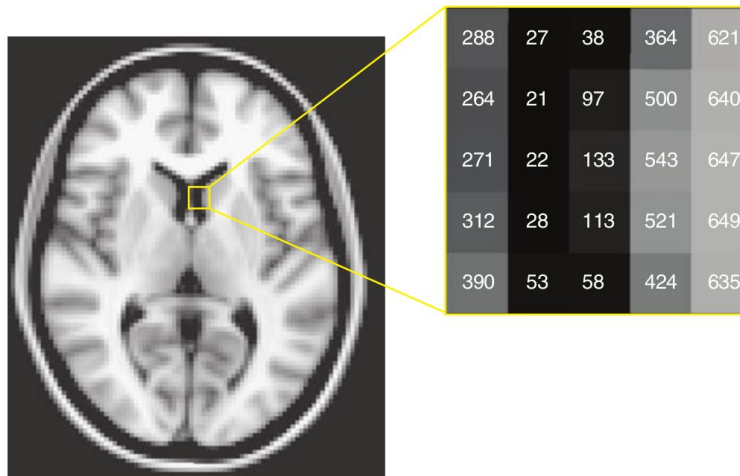
fMRI - Ressonância magnética funcional



fMRI - Ressonância magnética funcional

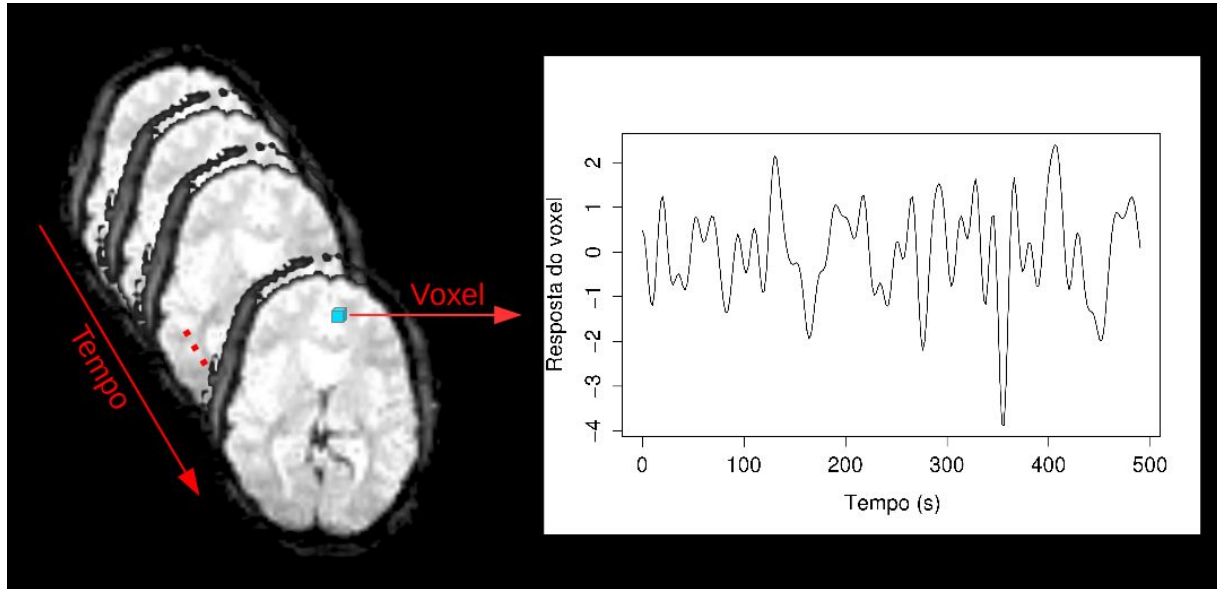


fMRI - Voxels



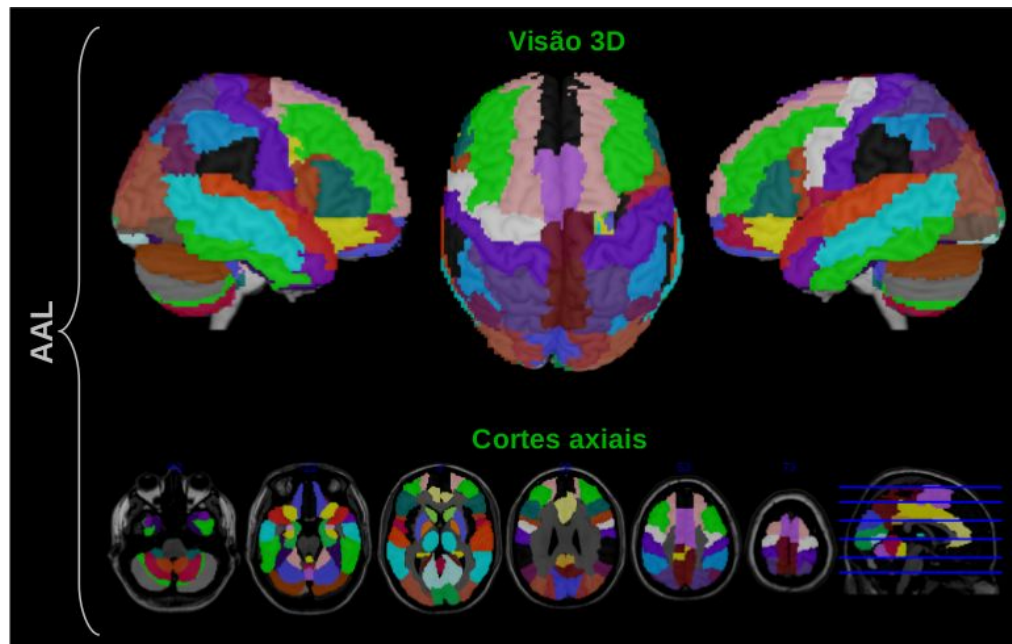
fMRI - Voxels

- Uma medida de sinal BOLD por instante de tempo



Fonte: Vidal, 2014

fMRI - ROIs e Atlas



Fonte: Vidal, 2014

fMRI

Vantagens:

- Resolução espacial
- Possibilita estudar o cérebro em funcionamento

Desvantagens:

- Resolução temporal (lento)
- Custa caro

Pré-processamento

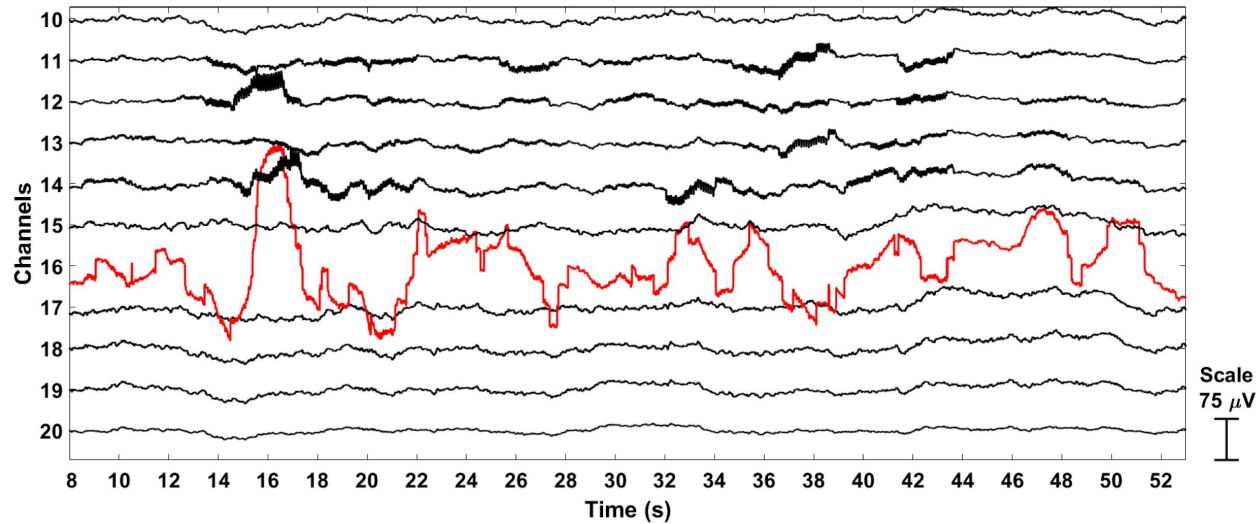
Problemas:

- Ruídos
- Diferenças entre os pacientes

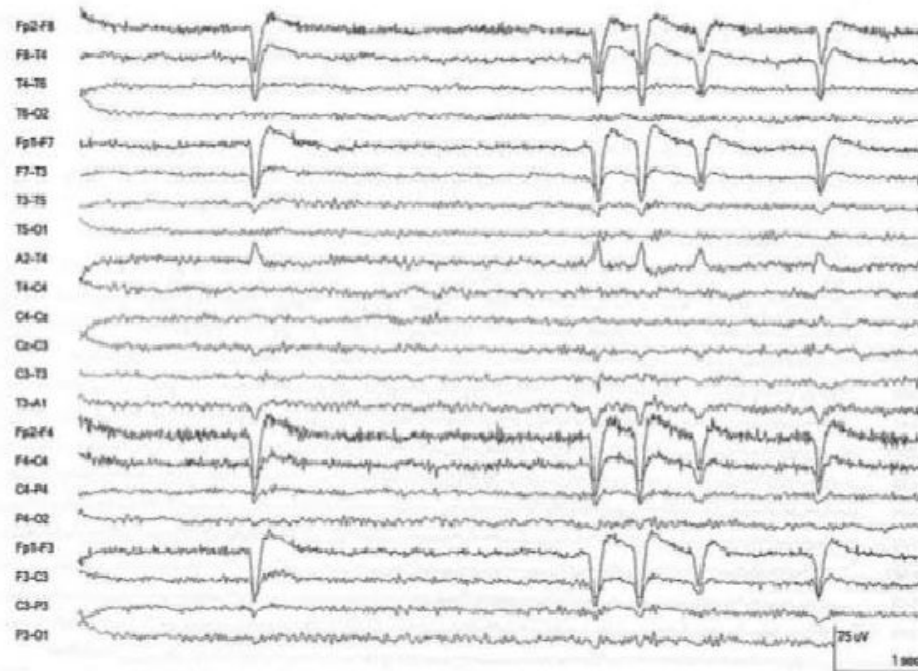
Objetivos:

- “Limpar” o dado
- Tornar os dados comparáveis

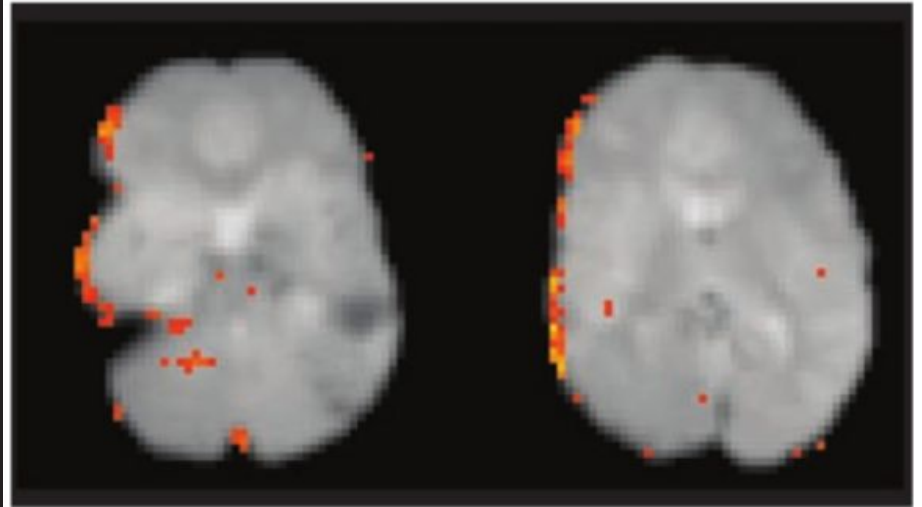
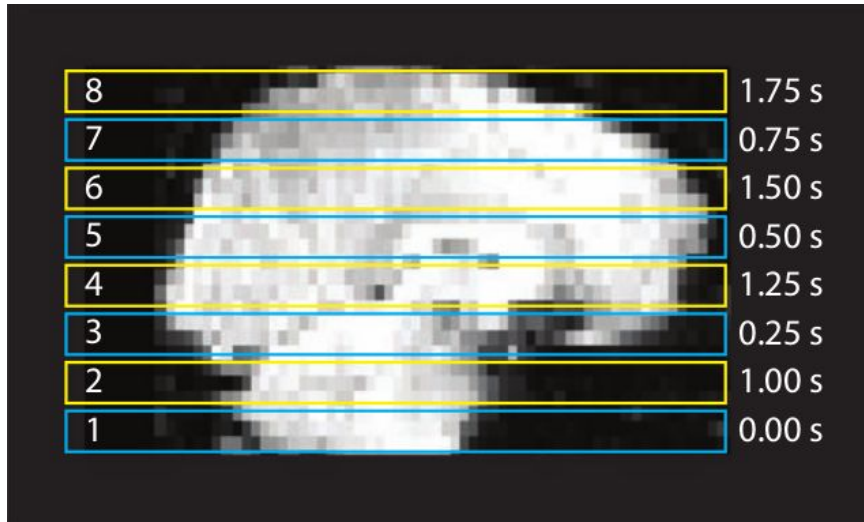
Pré-processamento EEG - Canal ruim



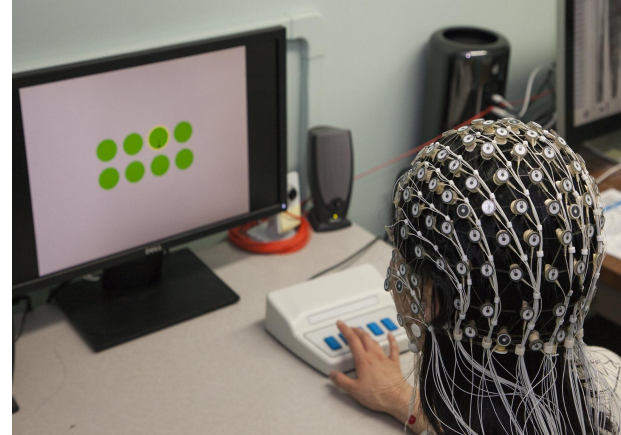
Pré-processamento EEG - Artefato de piscada



Pré-processamento fMRI

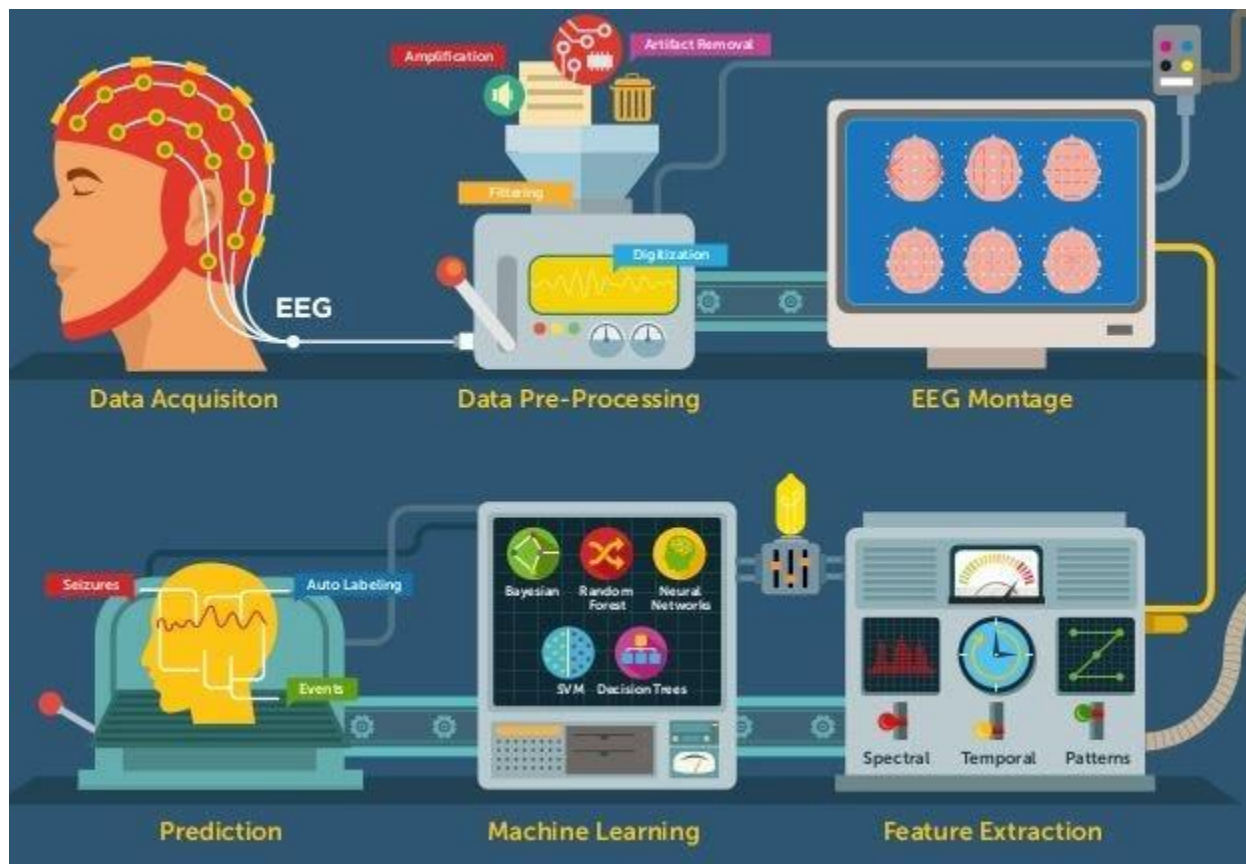


Tipos de captura - Resting state vs task based



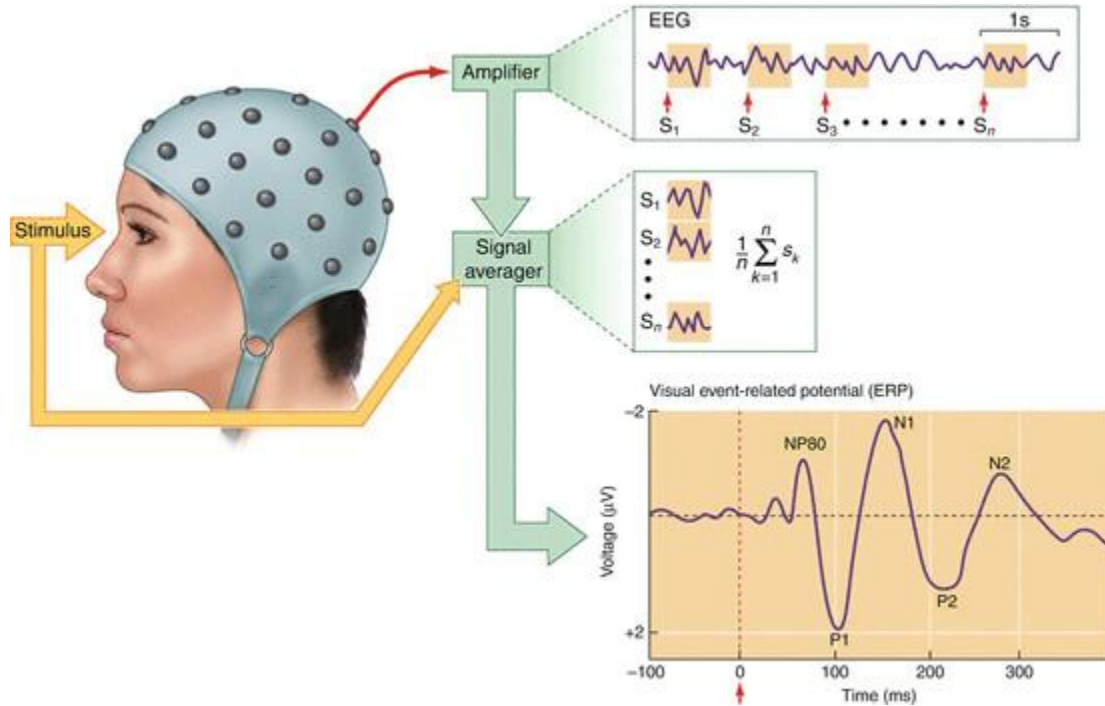
Técnicas computacionais

Usando dados de neuroimagem para predições

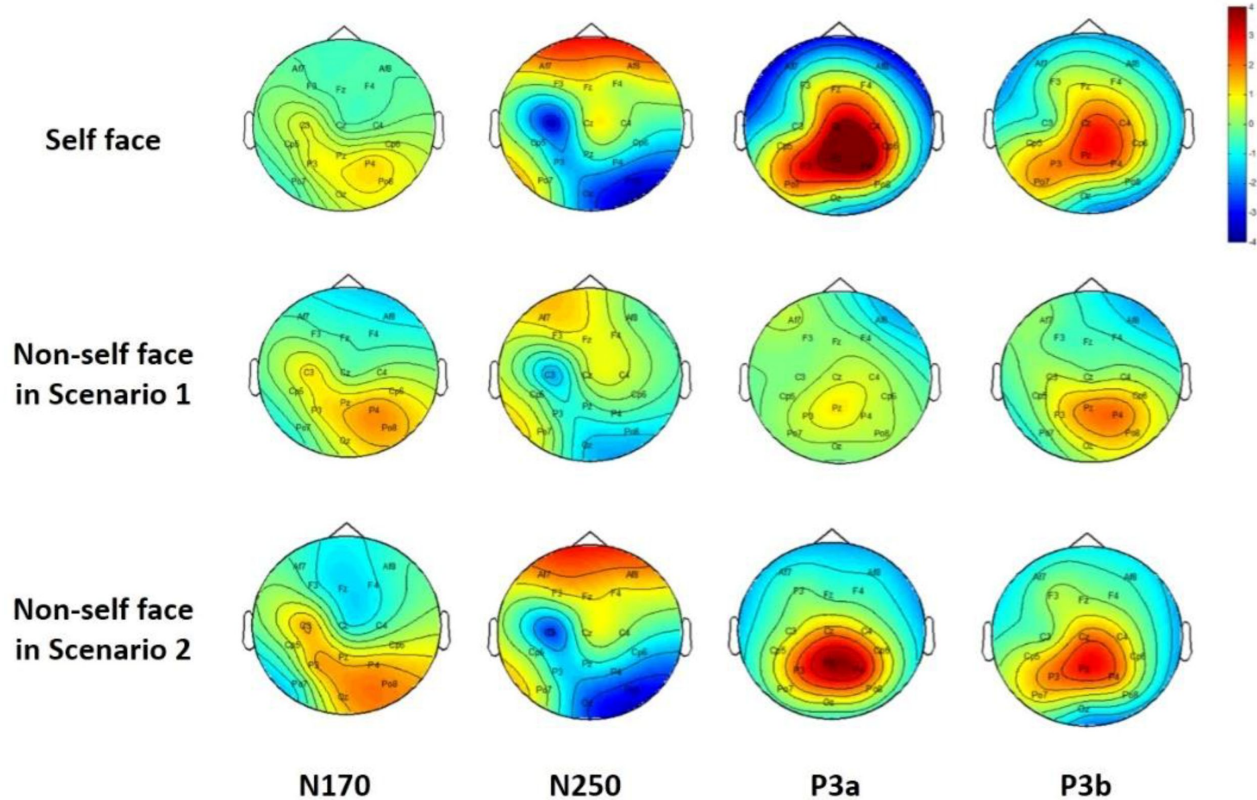


Features

EEG - ERP (Event Related Potential)



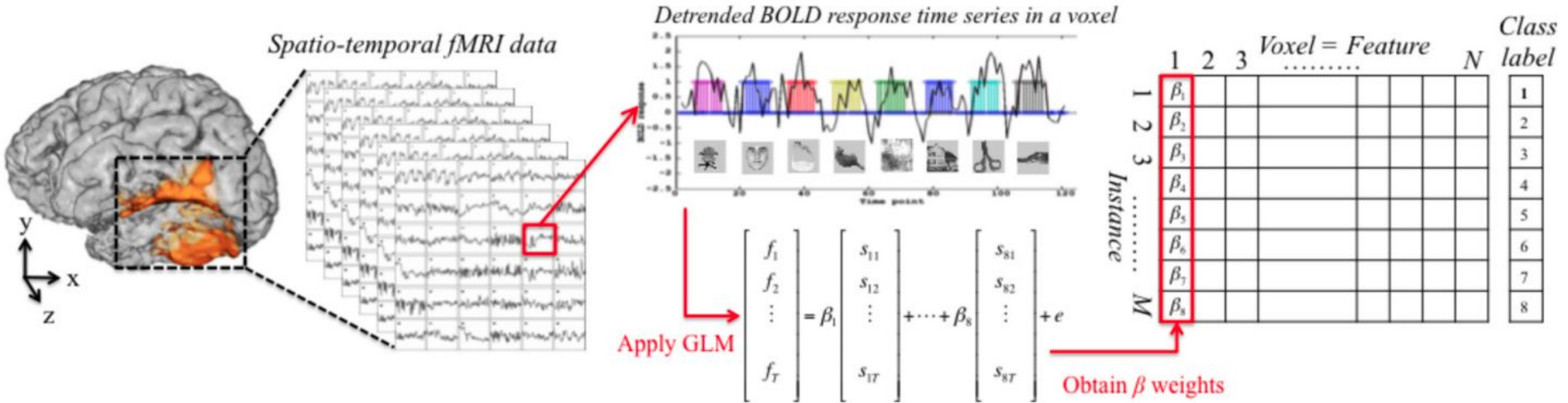
EEG - Mapas topográficos / Microestados



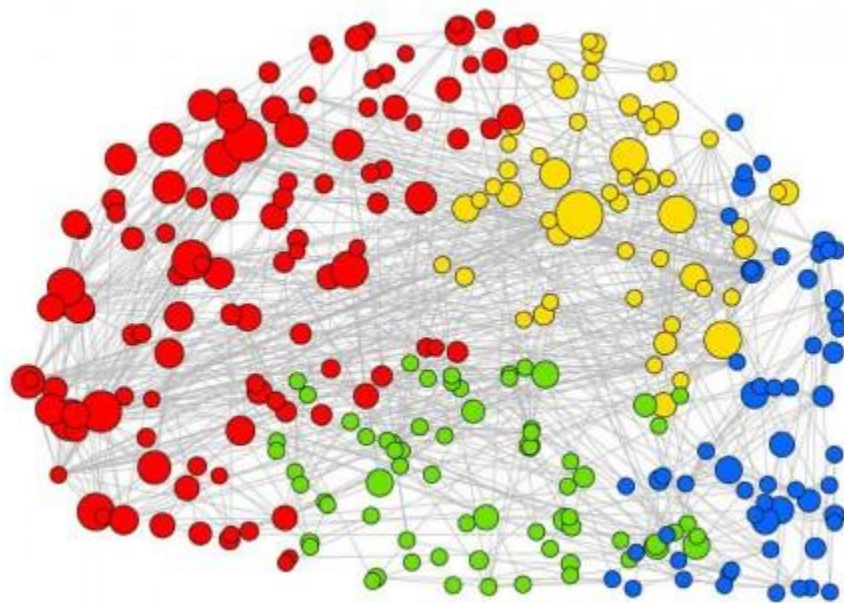
Séries temporais - Medidas não-lineares

- Detrended Fluctuation Analysis (DFA)
- Sample Entropy (SampE)
- Hurst Exponent (HurstE)
- Lyapunov Exponent (LyapE)
- Permutation Entropy (PermE)
- Spectral Entropy (SpecE)
- Singular Value Decomposition Entropy (SVDE)
- Approximate Entropy (AppE)
- Higuchi Fractal Dimension (HFD)
- Katz Fractal Dimension (KFD)

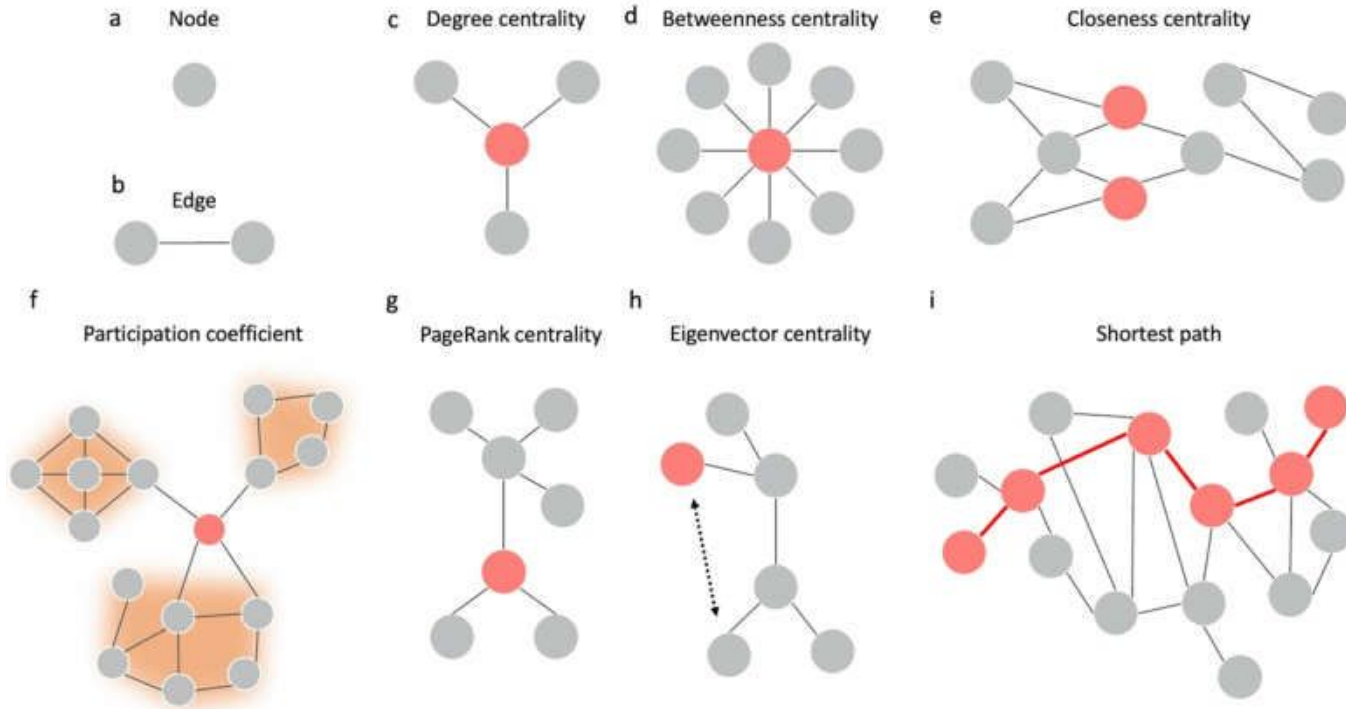
fMRI - Intensidade do sinal BOLD



Redes funcionais cerebrais (FBNs)



Medidas de centralidade de grafos



Densidade espectral do grafo

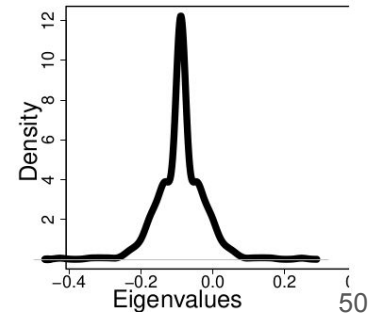
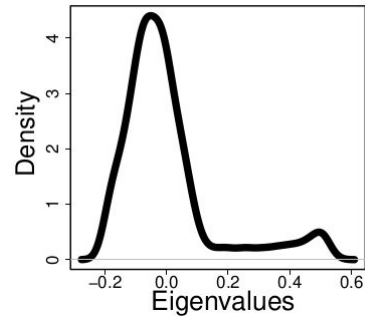
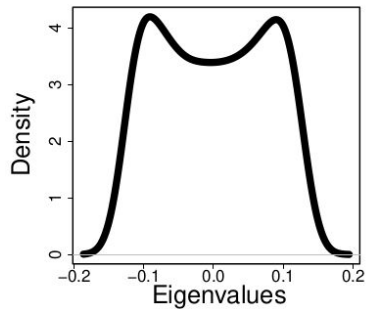
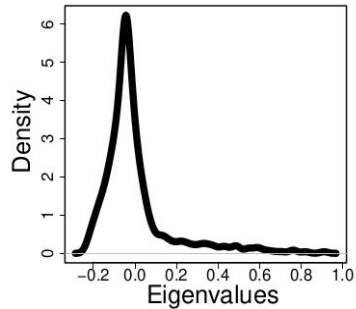
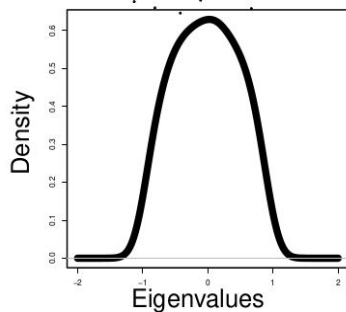
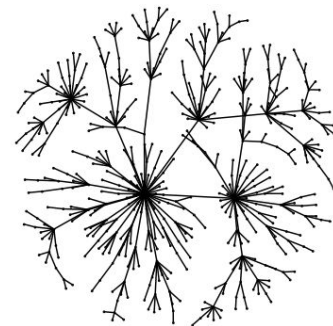
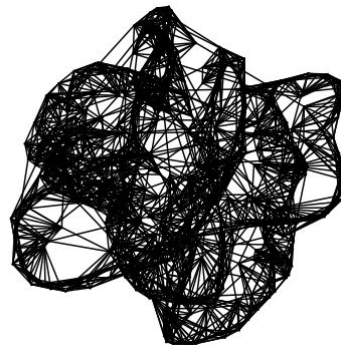
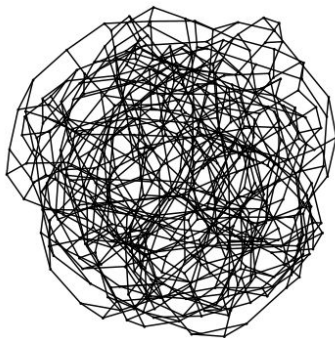
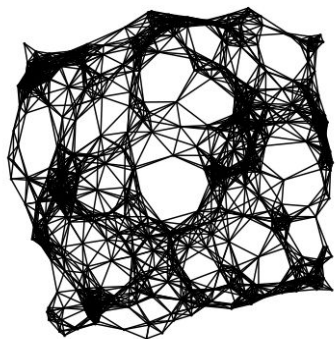
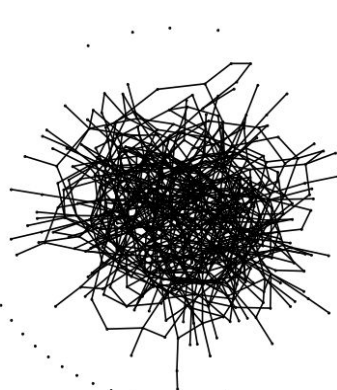
Erdős-Renyi

Geométrico

K-Regular

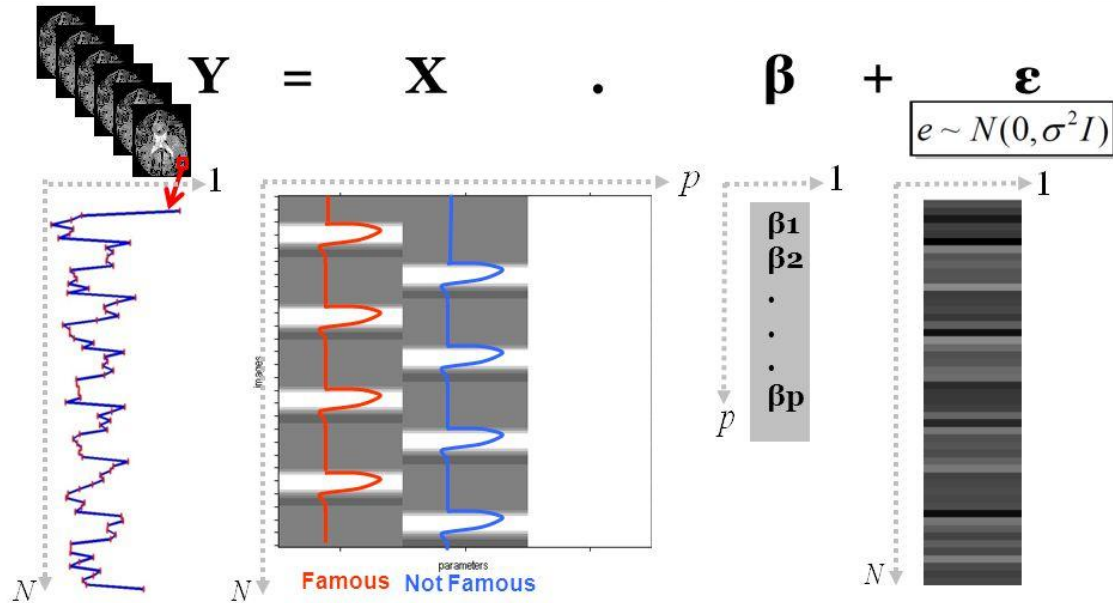
Watts-Strogatz

Ligação preferencial



Métodos de análise

Regressão linear (GLM)



Observed data

Y is the BOLD signal at various time points at a single voxel

Design matrix

Several components which explain the observed BOLD time series for the voxel. Timing info: onset vectors, and duration vectors, HRF. Other regressors, e.g. realignment parameters

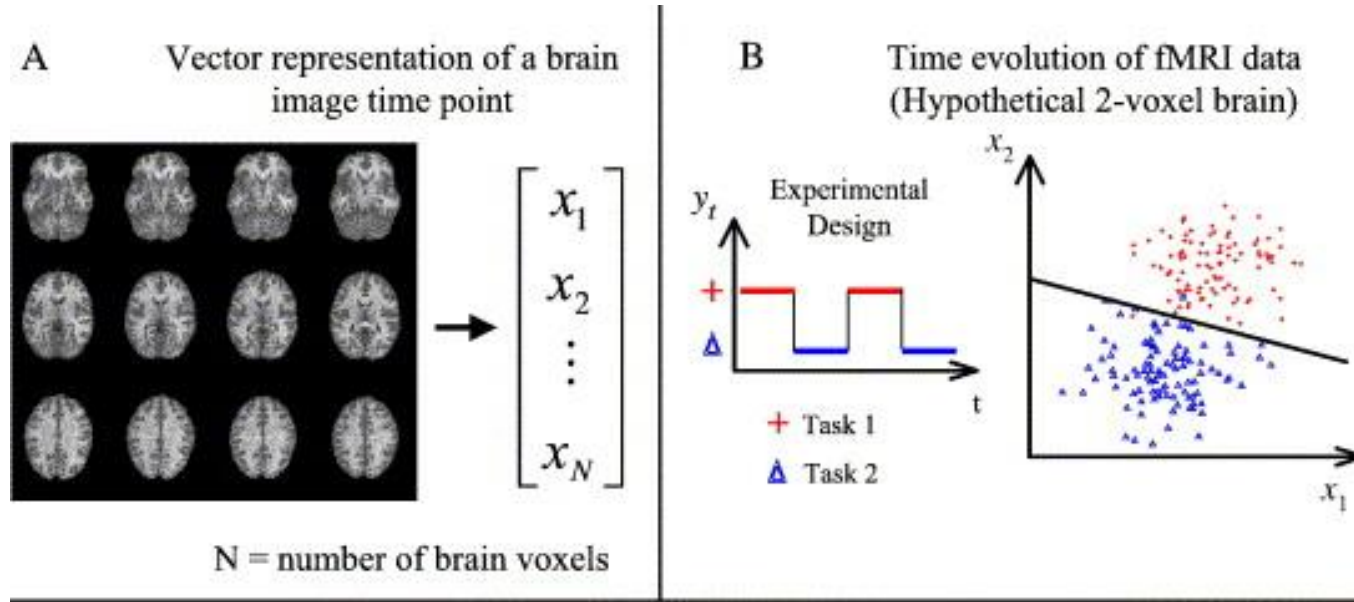
Parameters

Define the contribution of each component of the design matrix to the value of Y

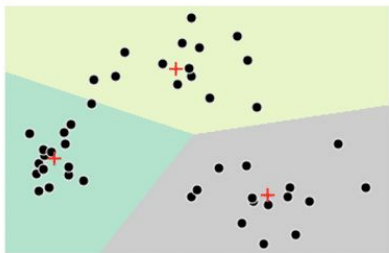
Error/residual

Difference between the observed data, Y, and that predicted by the model, $X\beta$.

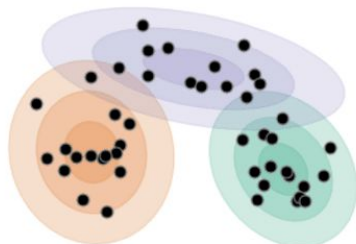
Machine Learning - SVM



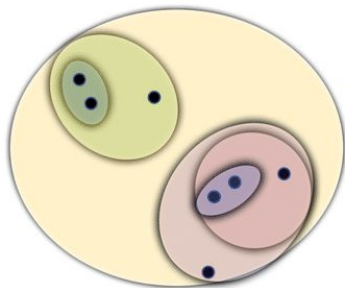
Clusterização



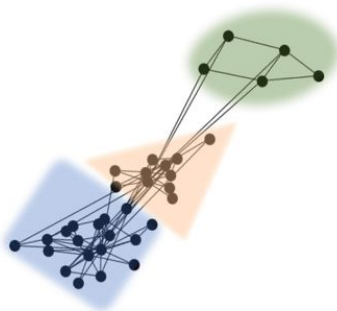
K-means clustering



Mixture model (Gaussian)

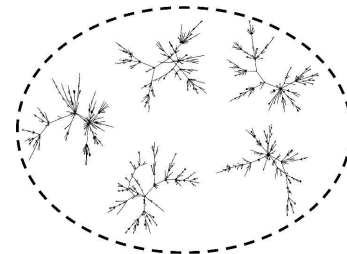
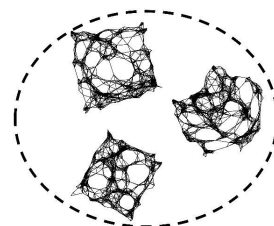
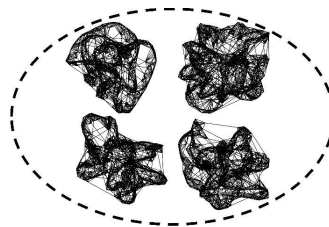


Hierarchical clustering

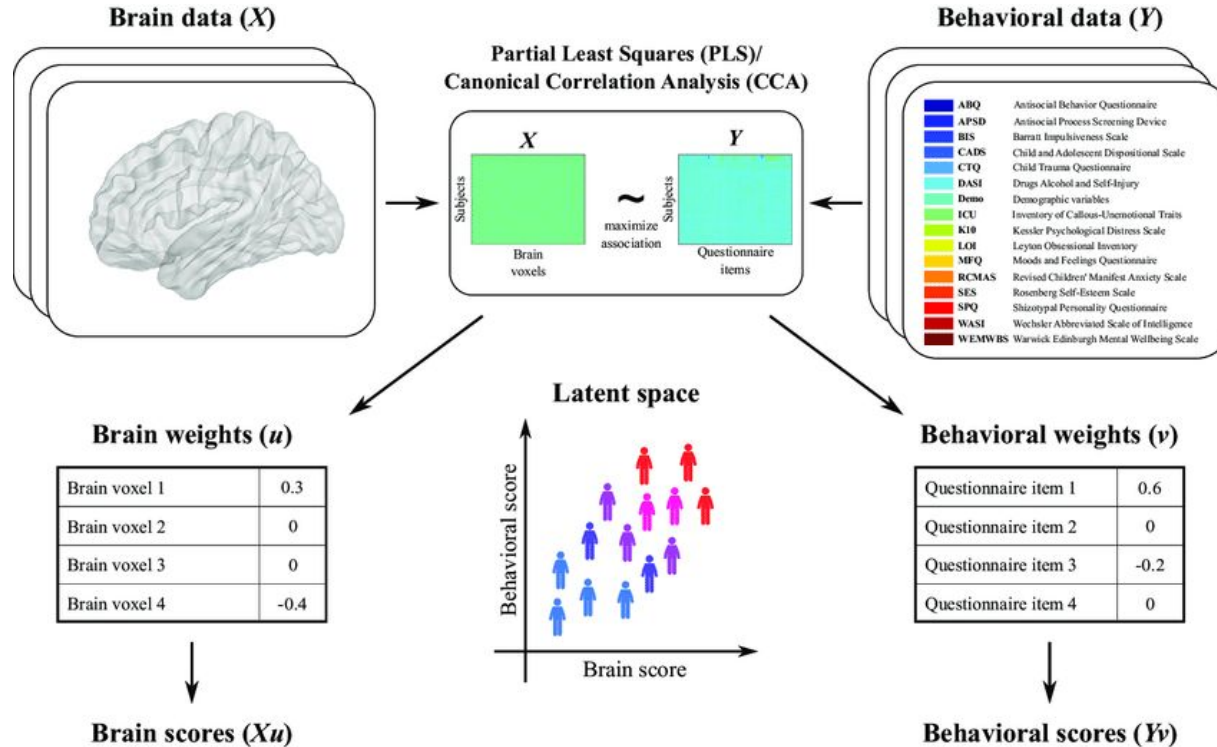


Graph based clustering

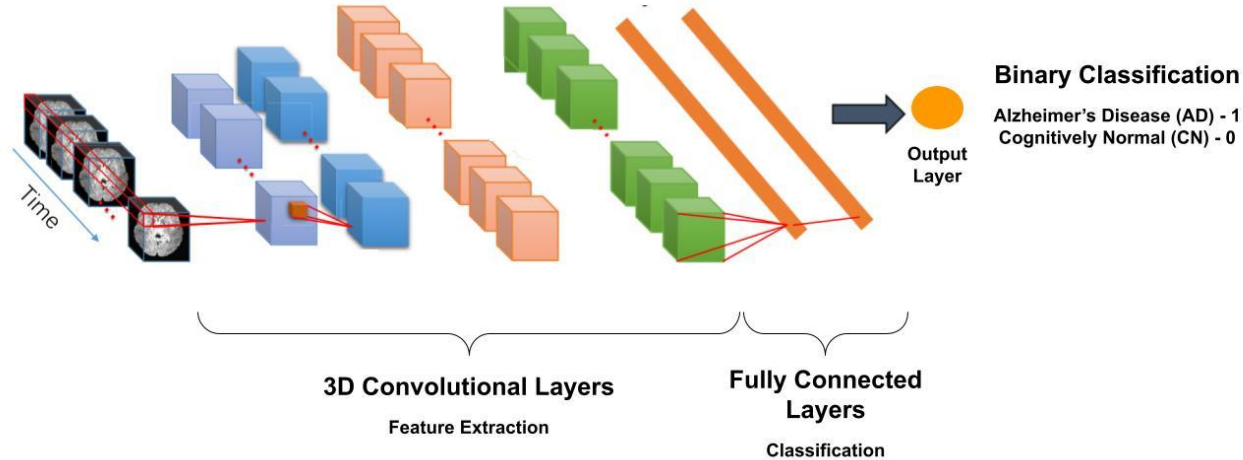
(A)



Métodos multivariados - PLS e CCA

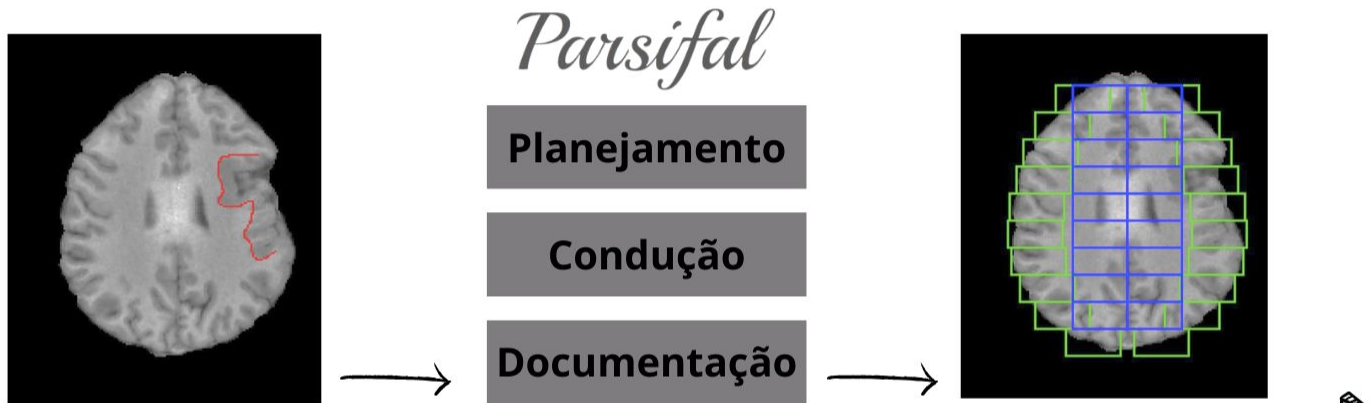


Deep Learning - CNN



Algumas pesquisas do meu grupo

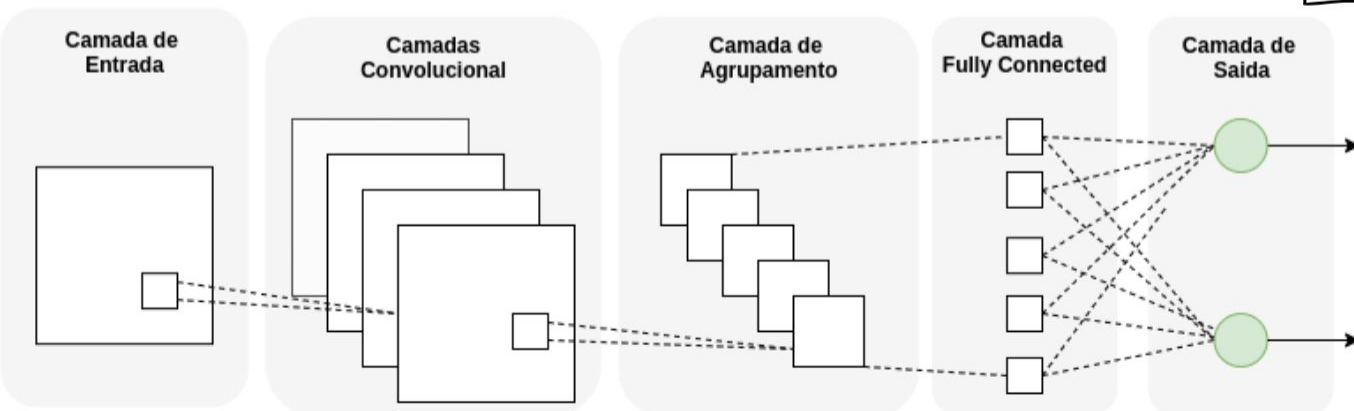
Displasia - Análise de sMRI utilizando CNN



Luana Luna



Carla Caetano



Tamanho da amostra

Sem displasia: **386**
Com Displasia: **386**

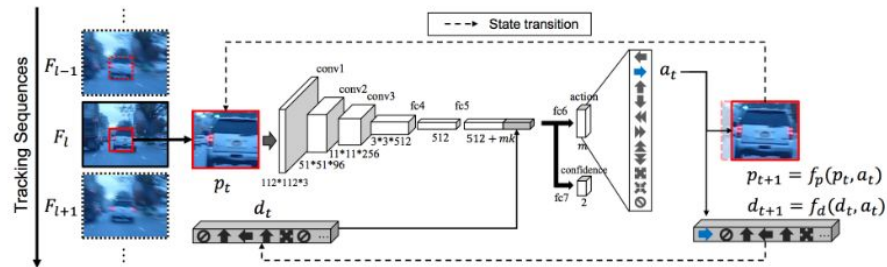
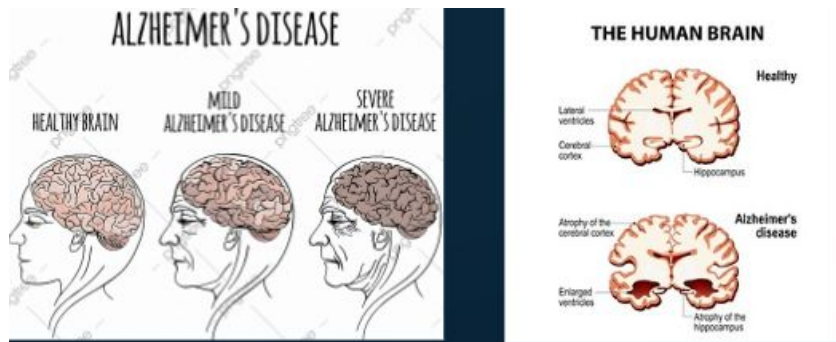
Resultados

Acurácia : **96.37%**
Sensibilidade : **93.45%**
Especificidade: **99.72 %**

Detecção de Alzheimer - Ressonância Magnética

3D-CNN

Action-Decision Network



Action-Decision Network (ADNet): For each frame (F_i) in a video, a sequence of actions is predicted (in a markov decision process manner). Each action a_t is predicted using a convolutional neural network that takes two inputs: a patch p_t (i.e. target image slightly shifted or scaled) and an action dynamics vector d_t (a history of previously predicted actions). Once a "stop" action is predicted, ADNet accepts the last bounding box as the target's location and moves to the next frame F_{i+1} [25].

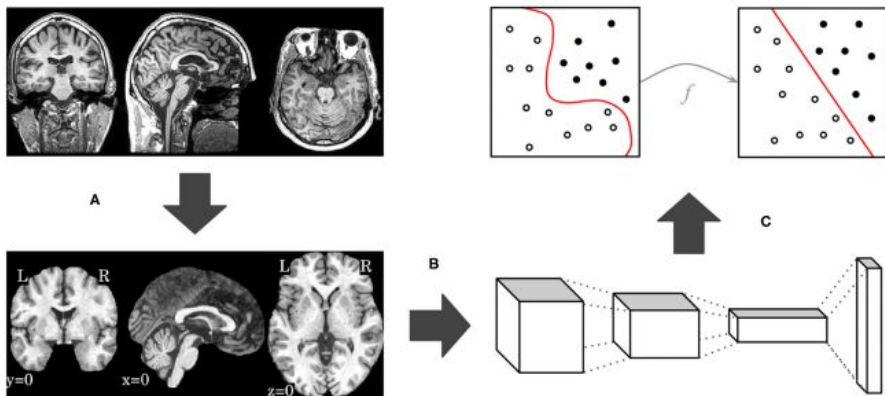


FIGURE 1 | Overview of our proposed pipeline, with brain extraction and normalization (A), 3D CNN processing (B), and domain adaptation (C) steps, in this order.



Débora
Barbosa

TEPT - Predição de Sintomas por fMRI



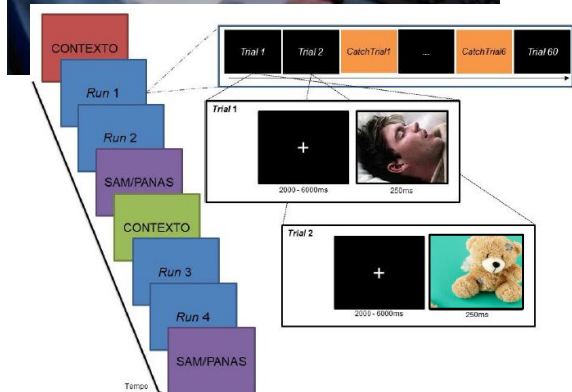
Matheus Francis



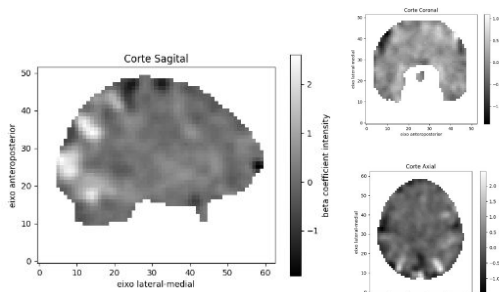
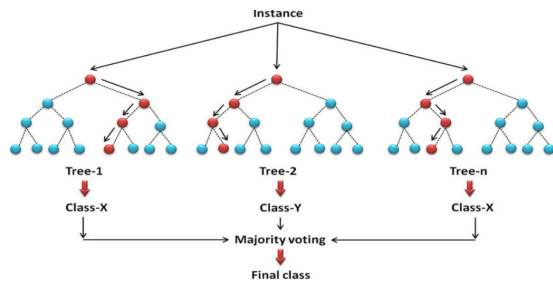
Rodrigo Junger



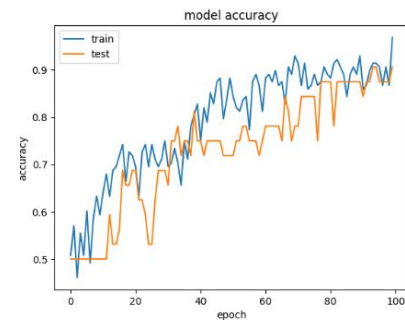
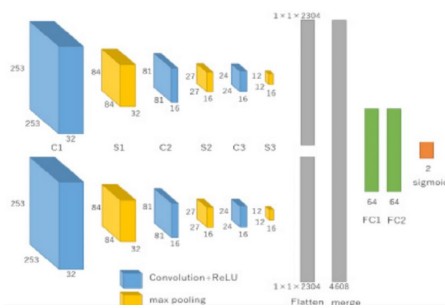
Roberto Lourenço



Abordagem 1



Abordagem 2



Stratified k-fold (K=5)

avg test accuracy: 85%

Apoio ao diagnóstico de Alzheimer utilizando Smartwatches



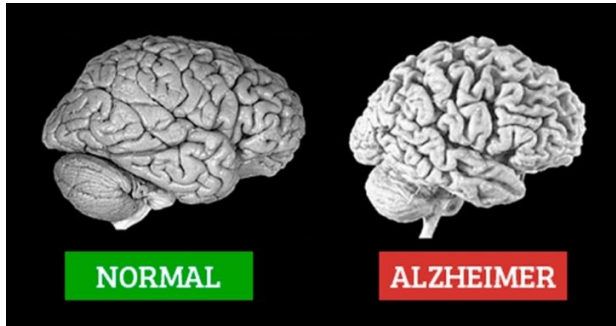
Adriyel Rodrigues



Raphael Mendes



Amanda Zírpolo

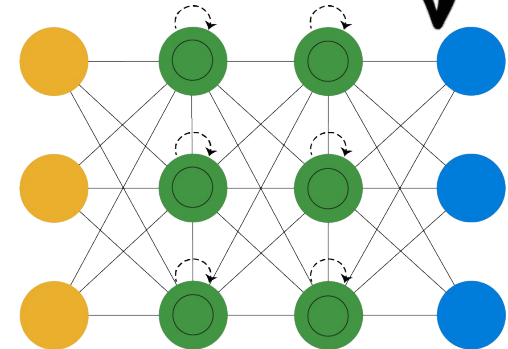


Coleta de dados via Smartwatch

Influência do Alzheimer no sono



Aplicação dos dados no algoritmo de Machine Learning



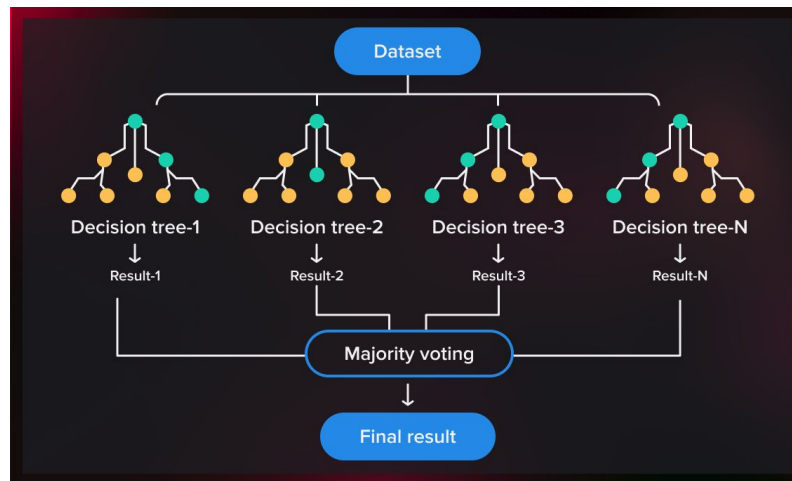
Reconhecimento de Atividades com Smartwatch e smartphone



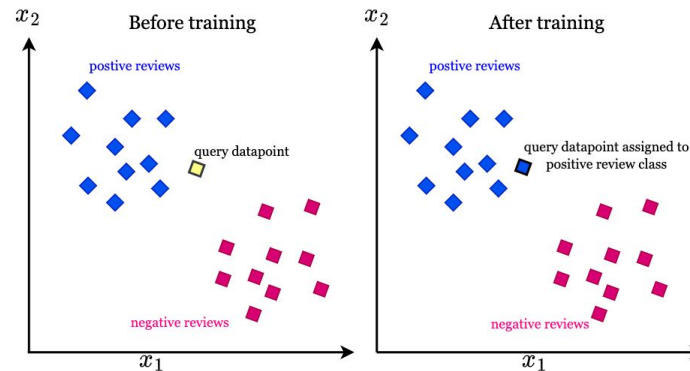
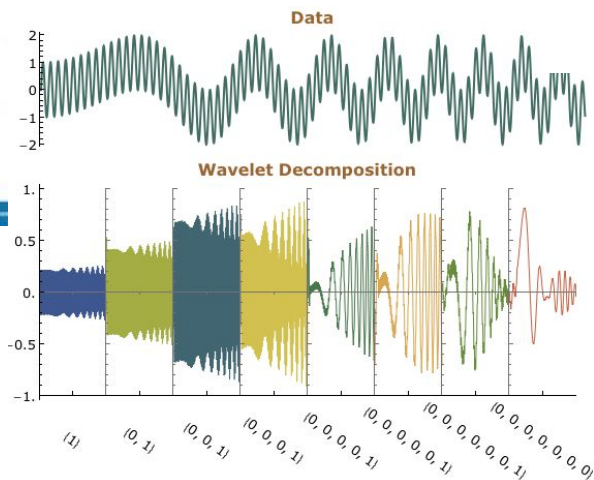
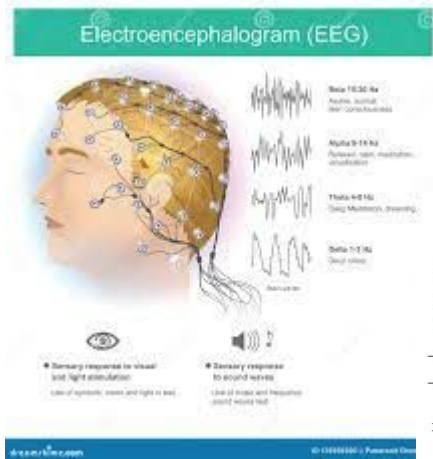
Pedro Cotrim



Acelerômetro+Giroscópio



Predição do desenvolvimento motor usando medidas não-lineares do EEG

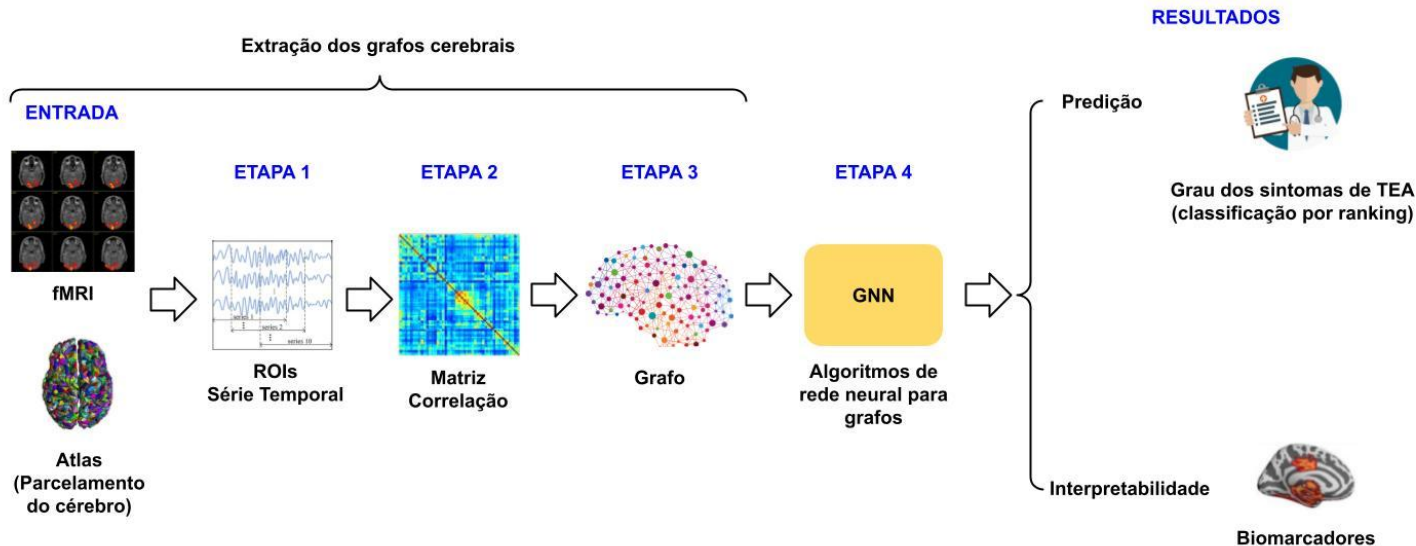


Raíssa Torres Barreira

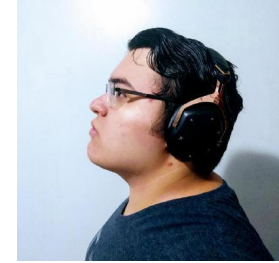
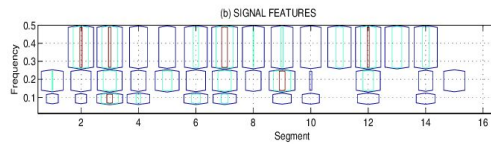
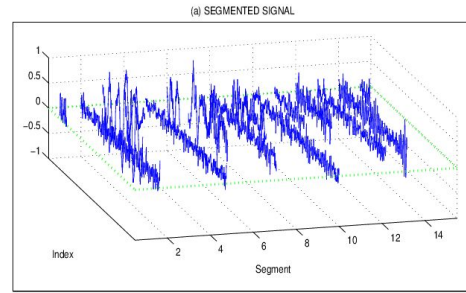
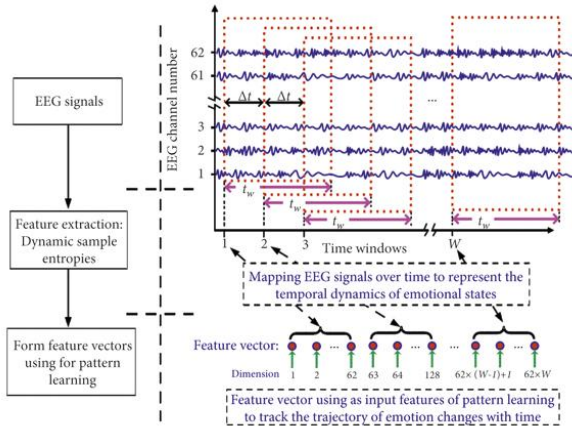
Redes Neurais para Grafos aplicadas a classificação de sintomas de autismo em dados de fMRI



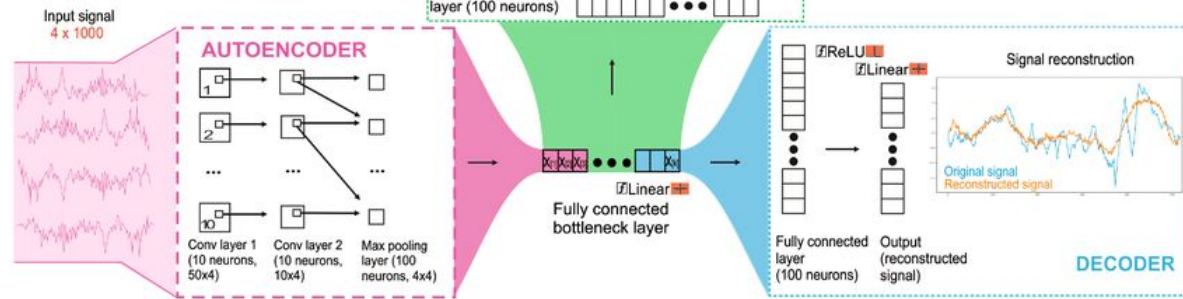
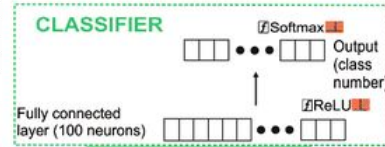
Ana Letícia
Garcez Vicente



Otimização de métodos de extração de características de EEG utilizando Deep Convolutional Autoencoders



Pedro Augusto Alves



Segurança da Informação - Projeto Secflow



Felipe Salles

OBJETIVO

Detecção de ataques em Redes de Computadores

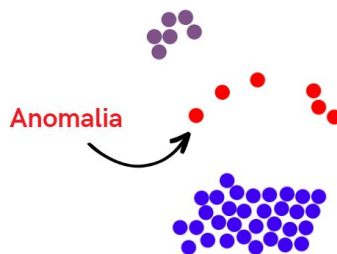


Primeira Abordagem

index	conjunto de fluxos	label Dataset	label DBSCAN
990	fluxo 991	1	-1
...	...	0	2
999	fluxo 1000	1	3

1

Clustering: Aprendizado não supervisionado.

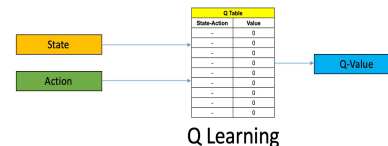


DBSCAN

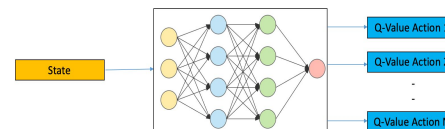
Abordagem Futura

Aplicação de técnicas de **Deep Learning** para melhorias na detecção de ataques.

2



Q Learning



Deep Q Learning

Deep Reinforcement Learning

Perguntas?

