Machine-Learning for Neuroimaging

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State of the art

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Introduction

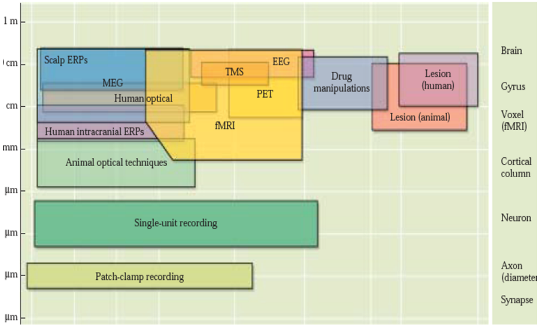
Neuroimaging 101

NMR Techniques

- MRI
  - GMD
- fMRI
  - BOLD

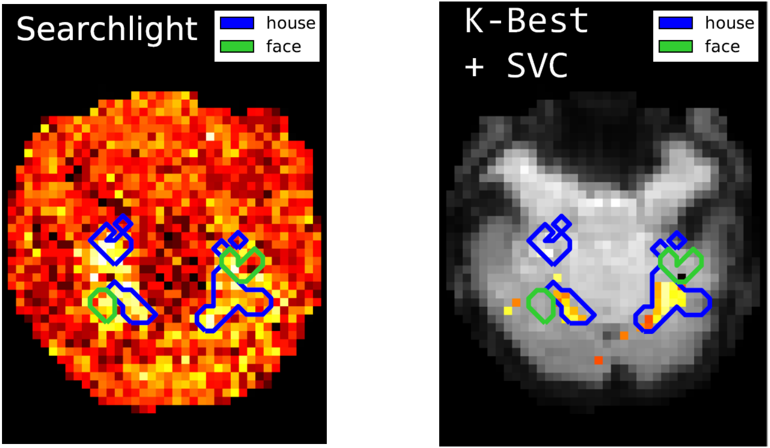
Other techniques

- PET
- MEG/EEG
- NIRS/SPIR
- ...



Techniques

Selecting part of interest



1. Abraham, Alexandre et al. "Machine Learning for Neuroimaging with Scikit-Learn." Frontiers in Neuroinformatics 8 (2014) : 14. PMC. Web. 28 Oct. 2017.

Regression and Classification

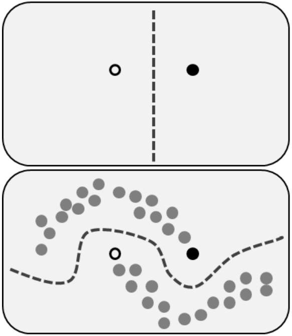
- Support Vector Machine
  - Find an hyperplane that maximizes the distance of the closest points.
  - Focus on the max margin size.
- Logistic Regression
  - Find an hyperplane that maximize the probability ($P(Y = y|X)$) for points to be on the good side.
  - Uses a likelihood function.

Table 1 | Five fold cross validation accuracy scores obtained for different values of parameter *C* (± *SD*), best scores are shown in bold.

C value	0.0005	0.001	0.005	0.01	0.05	0.1
ℓ_1 Logistic regression	0.50 ± 0.02	0.50 ± 0.02	0.57 ± 0.13	0.63 ± 0.11	**0.70** ± 0.12	0.70 ± 0.12
ℓ_2 Logistic regression	0.60 ± 0.11	0.61 ± 0.12	0.63 ± 0.13	0.63 ± 0.13	**0.64** ± 0.13	0.64 ± 0.13
ℓ_1 SVM classifier (SVC)	0.50 ± 0.06	0.55 ± 0.12	0.69 ± 0.11	**0.71** ± 0.12	0.69 ± 0.12	0.68 ± 0.12
ℓ_2 SVM classifier (SVC)	0.67 ± 0.12	**0.67** ± 0.12	0.67 ± 0.12	0.66 ± 0.12	0.65 ± 0.12	0.65 ± 0.12

Semi-supervised learning

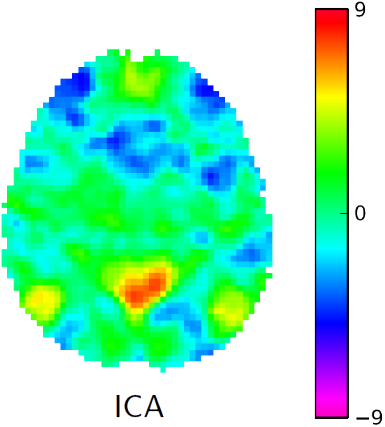
- Inputs : Labeled and non-labeled data
- Clustering for classification
  LDS : Low-density separation
  TSVM : Transductive SVM



1. By Techerin - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=19514958

Extracting brain's network with ICA

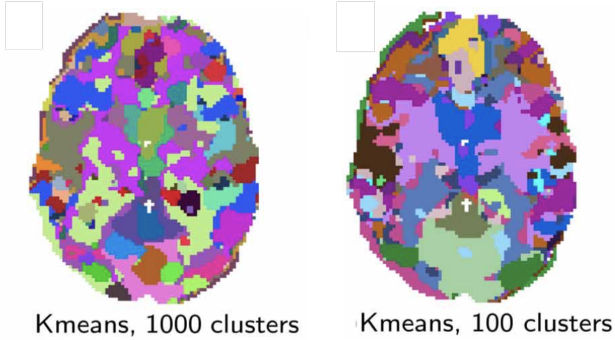
- Limits Neuroimaging
- Need for cognitive ontology (BrainMap Database)
- Improving Reverse Inference



1. Abraham, Alexandre et al. "Machine Learning for Neuroimaging with Scikit-Learn." Frontiers in Neuroinformatics 8 (2014) : 14. PMC. Web. 28 Oct. 2017.

Clustering with K-means approach

- Each voxel is assigned to the nearest center, forming clusters

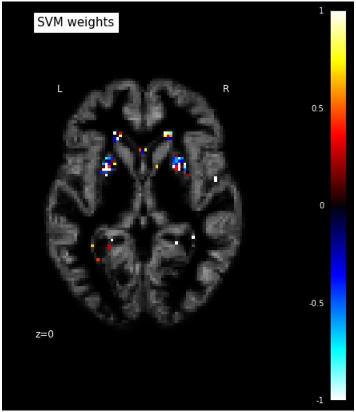


1. Abraham, Alexandre et al. "Machine Learning for Neuroimaging with Scikit-Learn." Frontiers in Neuroinformatics 8 (2014) : 14. PMC. Web. 28 Oct. 2017.

Case studies

Age and dementia prediction

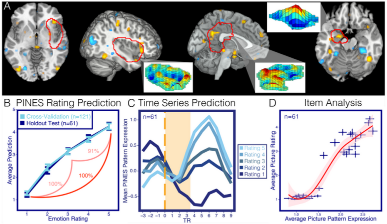
- Record MRI based on GMD.
- Train a dementia classification model and an age regression model.
- Look at the involved parts of the brain.



1. https://github.com/intv0id/ADST2018/blob/master/AgePrediction/AgePrediction.ipynb

Feelings and emotions

- Showing uncomfortable pictures while recording fMRI (BOLD).
- Getting "bad feeling grades" back (1 to 5)
- Train the model and evaluate it using K-Fold cross-validation

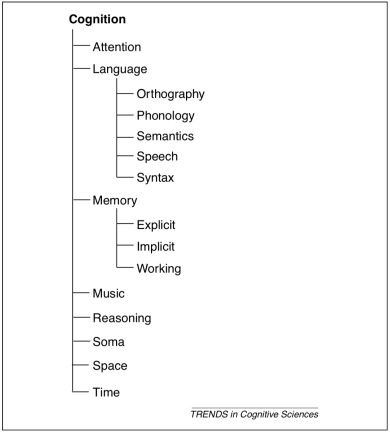


1. Chang LJ, Gianaros PJ, Manuck SB, Krishnan A, Wager TD (2015) A Sensitive and Specific Neural Signature for Picture-Induced Negative Affect. PLoS Biol 13(6) : e1002180. https ://doi.org/10.1371/journal.pbio.1002180
2. https://github.com/intv0id/ADST2018/blob/master/SentimentAnalysis/SentimentAnalysis.ipynb

Conclusion

Reverse inference Limits

- Neuroimaging limits
- Need for cognitive ontology (BrainMap Database)
- Improving Reverse Inference



1. Russell A. Poldrack, Can cognitive processes be inferred from neuroimaging data ?, In Trends in Cognitive Sciences, Volume 10, Issue 2, 2006, Pages 59-63, ISSN 1364-6613, https ://doi.org/10.1016/j.tics.2005.12.004.

The future of machine learning for Neuroimaging

- Be able to detect and understand physical disease such as ADHD
- Be able to detect and understand mental disease such as schizophrenia
- European Brain Project

Questions ?