Generalized multivariate Student distributions : application to tumor characterization with multiparametric MRI

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LJK, INRIA & GIN

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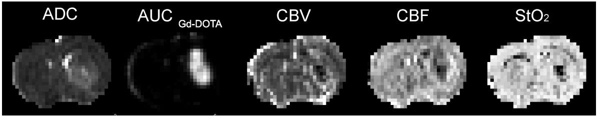
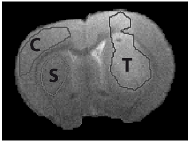
Presentation plan

Goal : improving brain tumor characterization



- 5 physiological parameters
  - **ADC** : apparent diffusion coefficient
  - **CBV** : cerebral blood volume
  - **CBF** : cerebral blood flow
  - **AUC** : vessel permeability
  - **StO_2** : tissue oxygen saturation
- 4 brain tumor models :
  - **C6**, **F98** (N. Coquery)
  - **C6**, **9L** (B. Lemasson)
- 3 regions of interest :
  - **Cortex**, **Striatum**
  - **Tumor**



→ voxels clustering based on a mixture of heavy-tailed distributions (generalized multivariate Student distributions)

Presentation plan

1. Study context
2. Theoretical model
3. Finalized part
4. Current works
5. Future work

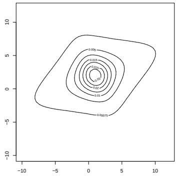
Generalized Multivariate Student Distribution

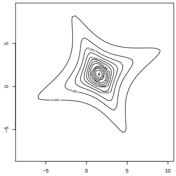
F. Forbes, D. Wraith 2014

Let $\boldsymbol{y} \in \mathrm{R}^{\mathrm{L}}$ a random variable of density :

$$\mathrm{p}\left(\boldsymbol{y}\right) = \int_{\mathrm{R}^{\mathrm{L}}} \mathcal{N}_{\mathrm{L}}\left(\boldsymbol{y} \; ; \; \boldsymbol{\mu}, \boldsymbol{D}\boldsymbol{\Delta}^{-1}\boldsymbol{A}^{-1}\boldsymbol{D}^{\mathrm{t}}\right) \boldsymbol{f}_{\boldsymbol{\Delta}}\left(\boldsymbol{w}\right) \mathrm{d}\boldsymbol{w}$$

where $\mathcal{N}_{\mathrm{L}}\left(\cdot \; ; \; \boldsymbol{\mu}, \boldsymbol{T}^{-1}\right)$ denotes the L-dimensional Gaussian distribution with mean $\boldsymbol{\mu}$ and precision matrix $\boldsymbol{T} = \boldsymbol{D}\boldsymbol{A}\boldsymbol{D}^{\mathrm{t}}$ ($\boldsymbol{D}$ eigenvectors, $\boldsymbol{A} = \mathrm{diag}\left[\boldsymbol{a}_1, \ldots, \boldsymbol{a}_{\mathrm{L}}\right]$ eigenvalues). $\boldsymbol{\Delta} = \mathrm{diag}\left(\boldsymbol{w}_1, \ldots, \boldsymbol{w}_{\mathrm{L}}\right) \in \mathrm{R}^{\mathrm{L}}$ is a diagonal weight matrix with density $\boldsymbol{f}_{\boldsymbol{\Delta}}$.





Presentation plan

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Obtained results

- detection and exclusion of atypical data :
  - choice of the number of classes with the Bayesian Information Criterium
  - unsupervised clustering of tumors
- tumor dictionary :
  - creation of tumor signatures
  - tumor prediction
  - dictionary relevance with a leave-one-out process
- theoretical development of a Variational Bayesian Approximation for the automatic choice of the number of classes within the mixture

Presentation plan

Current works

- improve speed and accuracy of numerical estimation of orthogonal matrices
- obtain an efficient parallelization of the R code
- rewrite the R code into (parallelized) C++ code
- choose priors for the decomposition of covariance matrix inside the Variational Bayesian Approximation

Presentation plan

PhD next steps

- implementation of the Variational Bayesian Approximation
- clustering on whole brain data and raw scanner data
- taking to account spatial dependency with a hidden Markov field
- test of the parameters sensitivity

End

Thanks !