Introduction

Multiple Sclerosis Brain MRI Segmentation Workflow deployment on the EGEE grid

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Introduction

NeuroLOG *http://neurolog.polytech.unice.fr*

- A three years ANR scientific project (2007-2009)
- Goal: Federate medical data and algorithms, and sharing computing resources on grid infrastructure.
- On three different pathologies:
  - Multiple Sclerosis
  - Brain Stroke
  - Tumours
- Partners from different disciplines:
  - Software technologies
  - Databases and knowledge
  - Medical imaging

Introduction

Goals:

- Feasibility study: to deploy a “real” medical image processing solution on the grid
- Application: parameter sweeping

Plan:

- Brain MRI segmentation pipeline
- Workflow deployment on the EGEE grid
- Time performance
- Study of a method’s parameter influence
- Conclusion and future work.

The pipeline

Multiple Sclerosis brain MRI segmentation

- Segmentation of lesions on brain MRI is required for diagnosis or follow-up purpose in MS.

- First step: Segmentation of brain healthy tissues.

- Use multi-spectral MRI sequences: T1, T2 and DP.
- MRI have to be normalized (spatially and in intensity).
- A brain mask is also needed.
- Segmentation of the healthy compartments classes (WM, GM and CSF) is realized.

- Lesions are then segmented on T2-FLAIR sequence, using the brain healthy compartments classes.

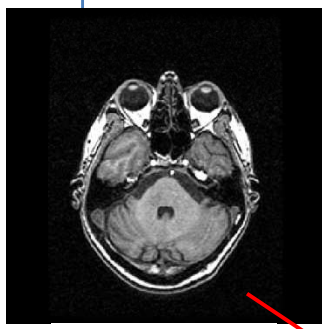
Improved EM-based tissue segmentation and partial volume effect quantification in multi-sequence brain MRI.
G. Dugas-Phocion, M. Angel G. Ballester, G. Malandain, C. Lebrun, and N. Ayache. MICCAI'04.

The pipeline

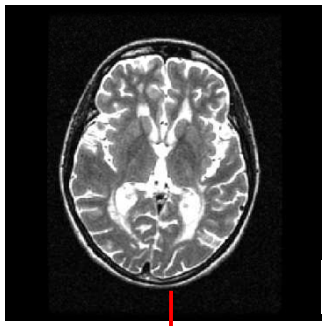
Brain MRI segmentation pipeline : Five main steps

Spatial normalization

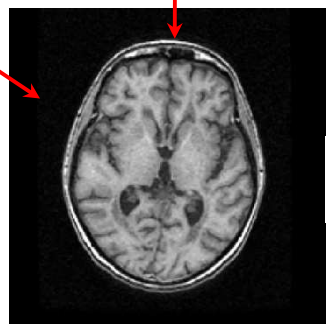
A rigid registration of the T1 on the T2 sequence is performed.



T1 sequence



T2 sequence



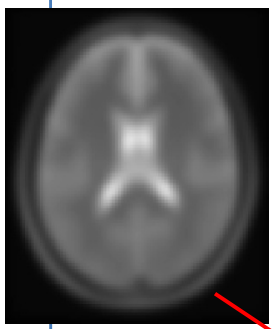
T1 sequence registered

Block matching: A general framework to improve robustness of rigid registration of medical images.
S. Ourselin, A. Roche, S. Prima, and N. Ayache. MICCAI'00

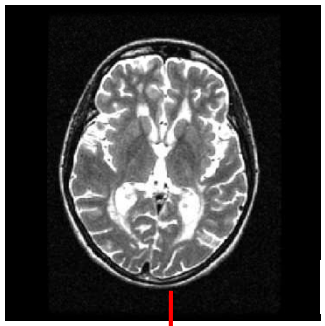
The pipeline

Brain MRI segmentation pipeline : Five main steps

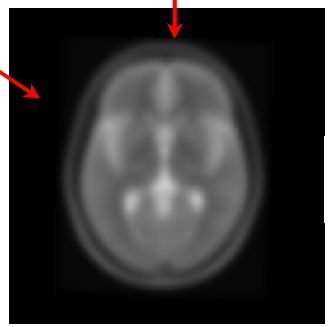
A rigid registration of the atlas images on the T2 sequence is performed.



Atlas T2 sequence



T2 sequence



Atlas T2 sequence registered

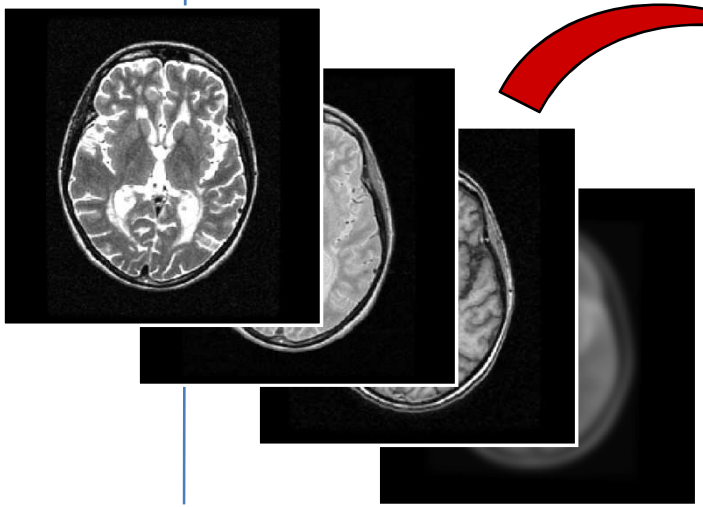
Spatial normalization

MNI atlas registration

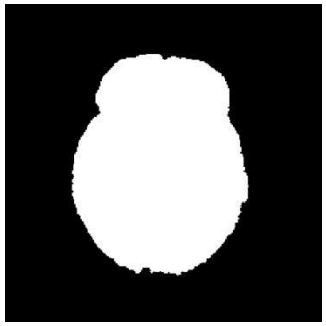
The pipeline

Brain MRI segmentation pipeline : Five main steps

A skull-stripping method is used
to isolate the brain healthy compartments



Patient and Atlas sequences



Brain mask

- Skull-stripping
- MNI atlas registration
- Spatial normalization

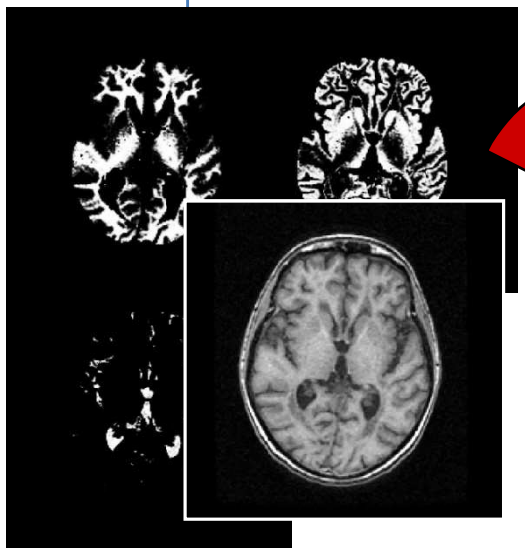
Hierarchical segmentation of multiple sclerosis lesions in multi-sequence MRI. G. Dugas-Phocion, M. Angel G. Ballester, C. Lebrun, S. Chanalet, C. Bensa, G. Malandain, and N. Ayache. ISBI'04.

The pipeline

Brain MRI segmentation pipeline : Five main steps

A first classification of the brain into WM, GM and CSF classes is realized.

Parameters of bias field are then computed from these segmentations.



T1 sequence and brain compartements

T1 sequence unbiased

- Spatial normalization
- MNI atlas registration
- Skull-stripping
- Intensity normalization

Maximum likelihood estimation of the bias field in MR brain images: Investigating different modelings of the imaging process.
S. Prima, N. Ayache, T. Barrick, and N. Roberts. MICCAI'01

The pipeline

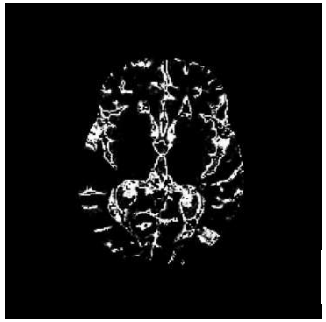
Brain MRI segmentation pipeline : Five main steps

The Expectation Maximization method is used once again to classify brain MRI voxels from unbiased images.

Grey matter

White matter

CSF



PVE

- Spatial normalization
- MNI atlas registration
- Skull-stripping
- Intensity normalization
- Classification

Gridification

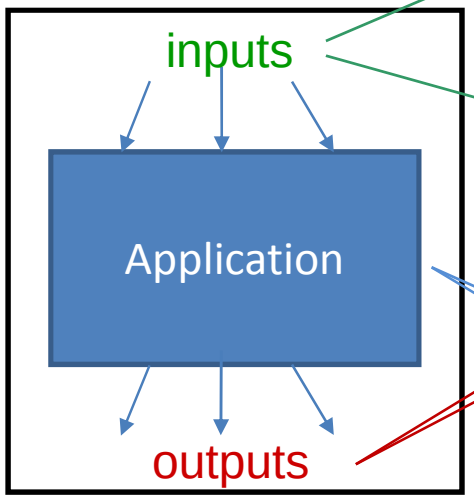
Problematic: How to deploy and parallelize an algorithm on a grid?

- Needed transformations of the pipeline ?
- How to create a workflow ?
- How to execute a workflow ?
- Performances ?

Workflow creation

Services creation

- Splitting the pipeline in black b
- Description of each black box

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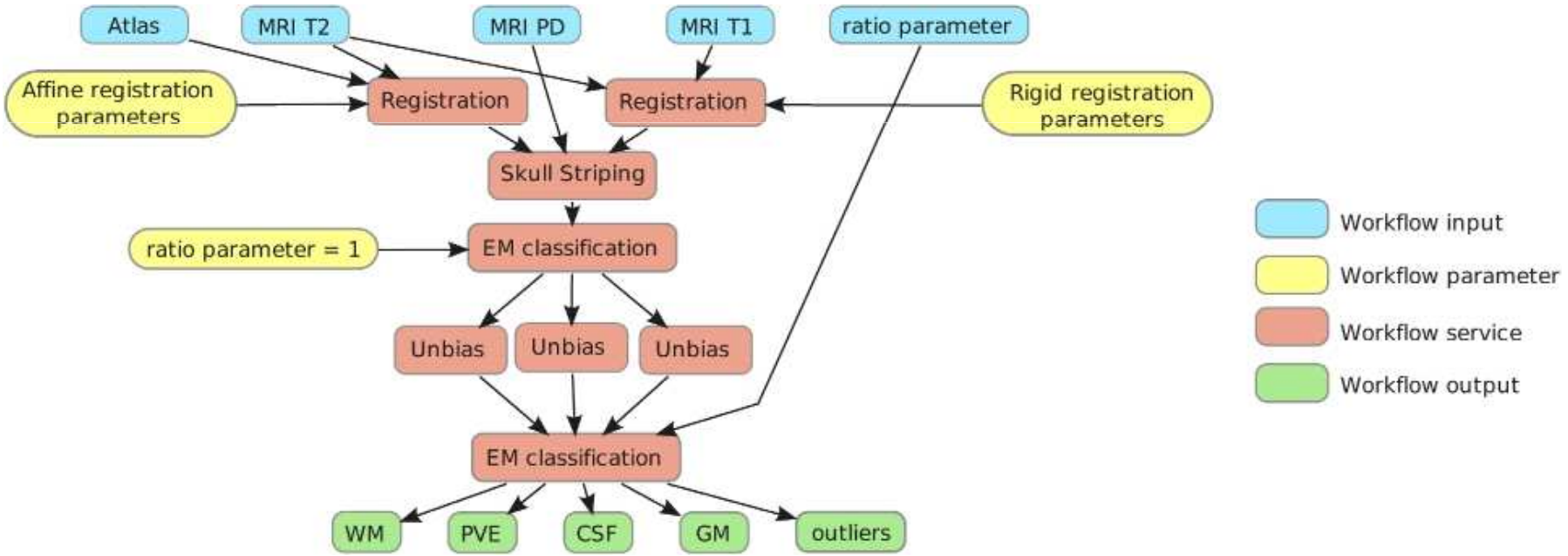
- Use of GASW (Generic Applicatio

es in

Workflow creation

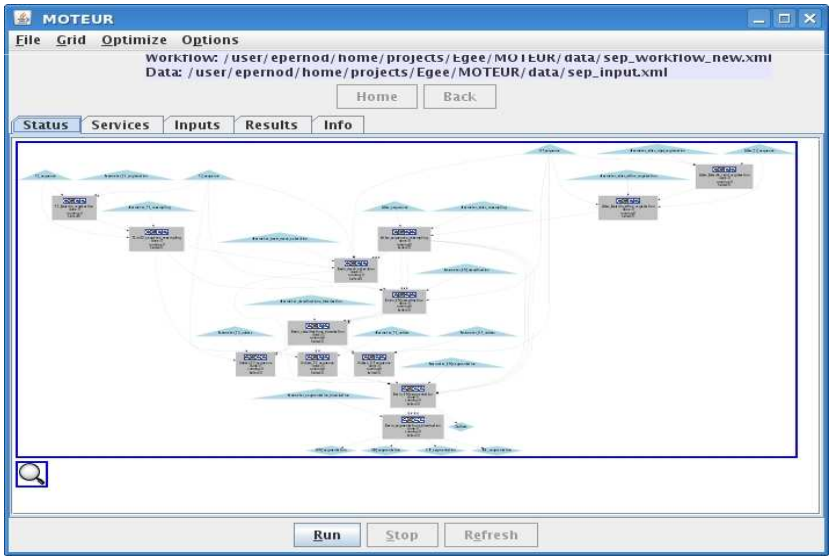
Use of the software Taverna to build the structure of the workflow



Workflow creation

Workflow execution

- Need a account on one computer of the grid
- Execution of the workflow (XML file) using MOTEUR

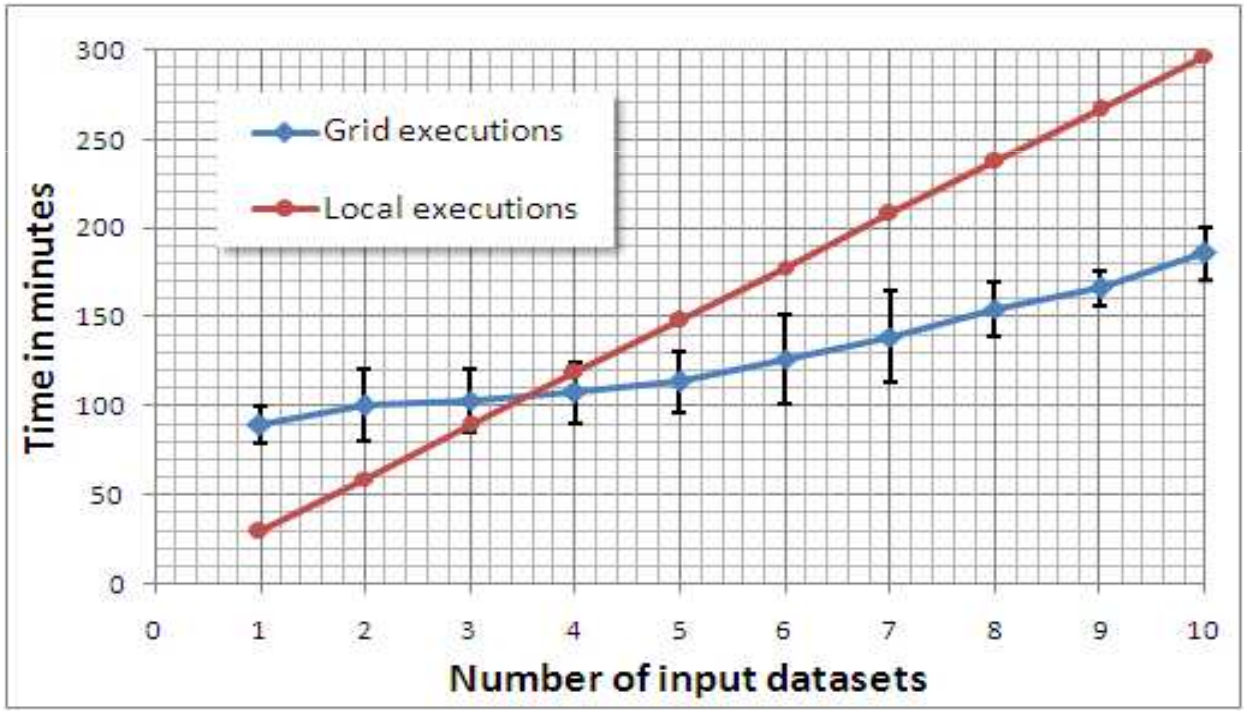


Efficient services composition for grid-enabled data-intensive applications.
T. Glatard, J. Montagnat, and X. Pennec. HPDC'06

- MOTEUR takes in charge all the interactions with the grid

Performances

- Possibility of multiple concurrent executions
- Time performance:



Performances

Potential issues

- The EGEE grid use the gLite middleware. *http://glite.web.cern.ch/glite/*

- In this framework, the Resource Broker is responsible for the matchmaking between job requests and resources.

    - Fastest responding resources are chosen. (after filtration)
    - Not necessarily the most powerful
    - Nor directly available.

- Workload management could becomes a bottleneck.

Performances

Parameter-sweep test

- Validation of the deployment on the grid
  - Comparison with a sequential execution on one single computer: identical results

- The power of the grid allows to perform parameter sweeping in a reasonable amount of time

- Goal: To find a good compromise between accuracy and speed in the EM method. Study of the performance w.r.t. the percentage of points used to estimate distributions.

Performances

- Ratio Parameter of the EM

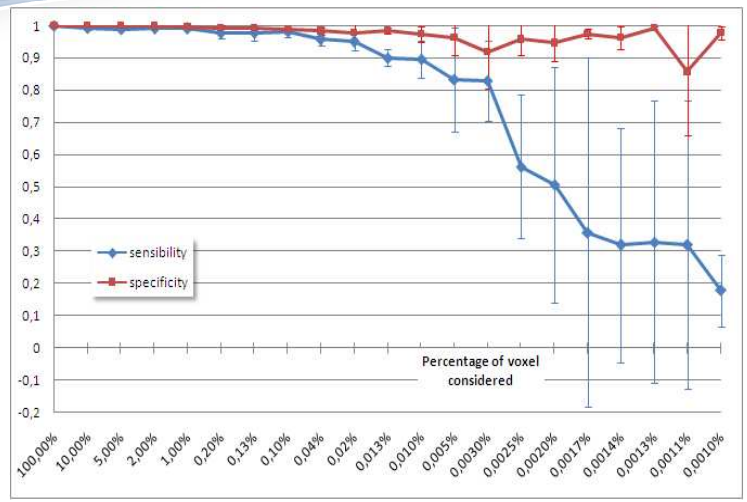
- Generation of WM segmentations obtained using different ratio value in the EM method.

- Comparaison of these segmentation to the segmentation of reference (ratio = 1)

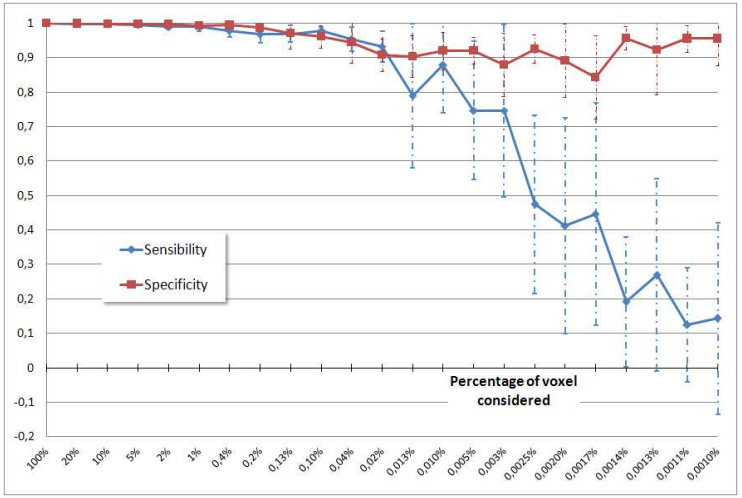
$$\text{Percentage of voxel considered} = 100 \times \frac{1}{\text{ratio parameter}}$$

$$\text{Sensibility} = \frac{\text{true positives}}{\text{true positives} + \text{false negatives}}$$

$$\text{Specificity} = \frac{\text{true negatives}}{\text{true negatives} + \text{false positives}}$$



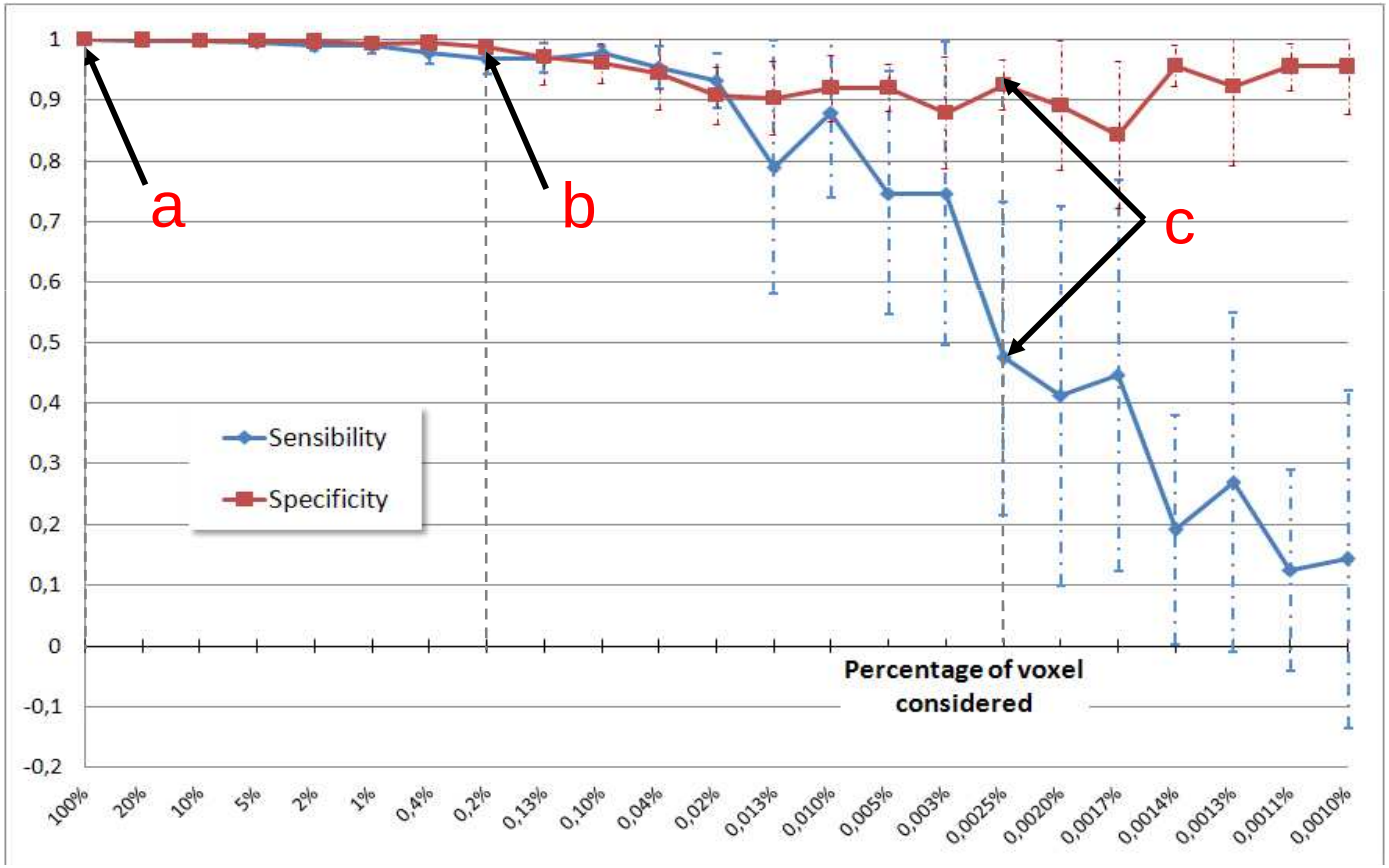
MR image of a control subject

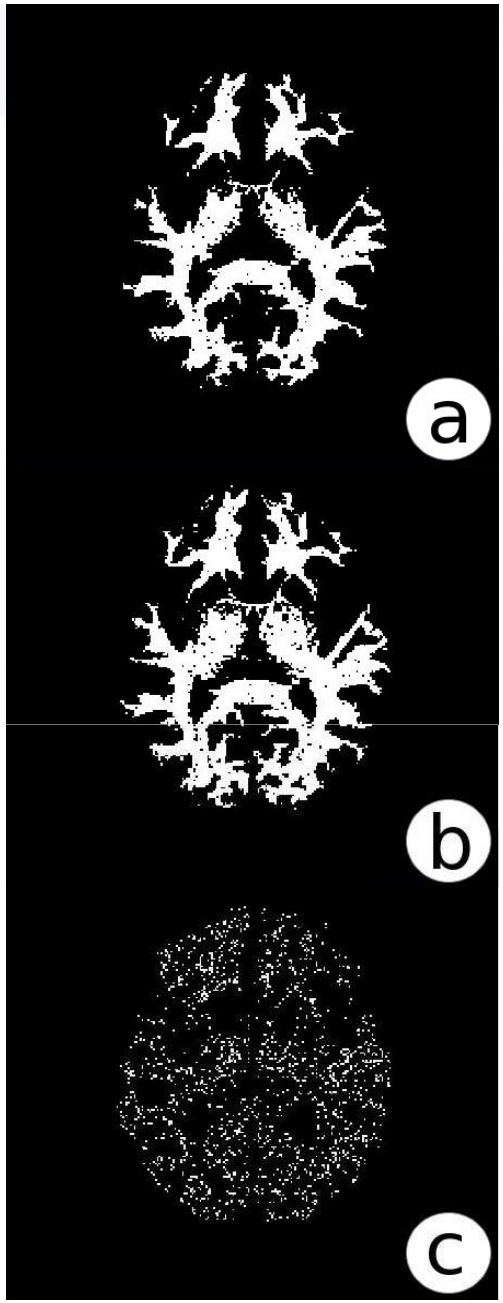


MR image of a MS patient

Performances

- Ratio Parameter of the EM





Performances

- Ratio Parameter of the EM
  - Using only 1% of the image voxels in the EM method:
    - Divides the execution time of the method by ~3
    - Still provides segmentation of sufficient quality
  - Taking less than 1% of the voxels may leads to poor results
  - ~ 210 workflow executions (10 per ratio value) have been computed (per image set).
    - Local execution time (sequential): ~ 100 hours (estimated)
    - Grid execution time: ~ 40 hours (4 hours per bunch of 21 workflow executions)

Conclusion

Conclusion:

- Deployement demonstration of a “real”application on the grid.
- The power of the grid allows multiple concurrent executions and a sizeable gain of time.
- As a consequence, it allows computation costly tests, e.g. parameter sweeping.

Future work:

- Generalization of the services to support more image formats
  - Does not require to modify the workflow nor the web service descriptions
  - Can be done directly at the application level
  - Allows the workflow diffusion to other research groups
- Add new services to the workflow to get the lesions segmentation.