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Engineering and Brain Imaging Use Cases

DIRAC – EGI Meeting

Use Cases

- Two user communities
  - *Turbulence Fluid Dynamics* – Lead by the CMT (Combustion Engines Centre) in the UPV .
  - *Brain Tumour segmentation* – Lead by IBIME-ITACA (UPV).
- Previous experience in distributed computing infrastructures.
- Special software requirements that have reduced adoption
  - OpenFOAM, Matlab (or clones).
  - However shared by multiple user communities.

Turbulence analysis in Engineering

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- Computational Fluid dynamics in thermomachines.
  - Users of OpenFOAM
    - http://www.openfoam.com/
    - Widely used open source CFD software package.
      - Non-trivial installation, supports MPI, OpenMP.
  - Multiparametric studies to optimize configuration.
- Analysis of simulated data
  - High-resolution turbulence simulation by different methods such as Direct Numerical Simulations (DNS), Boundary layers or Large Eddy Simulation (LES) of turbulent flows create massive datasets that lead to serious new challenges.
  - These dataset reach orders of magnitude of several terabytes, and the fine-grain results obtained are of interest for the research community, who post-process them to address new questions on dynamics.

Examples

- CAVIGRID
  - Fluid dynamics of the injection of turbo diesel engines.
    - http://www.e-ciencia.es/wiki/index.php/Cavigrid
  - >500 CPU days per experiment.
  - Multiparametric studies of the geometry of the orifices of the cavity.
  - **Impact**: Reduction of fuel consumption by tackling wider simulation configurations.
- Anayslis of simulated data
  - Several repositories do exist (e.g. http://torroja.dmt.upm.es/turbdata/, http://www.cfd-online.com) even providing simple processing services.
  - Three main sources:
    - DNS Turbulent Channel Data, http://torroja.dmt.upm.es/channels/data, http://turbulence.ices.utexas.edu/.
    - DNS Blayers, http://torroja.dmt.upm.es/turbdata/blayers/.
    - AGARD (Test Cases for the Validation of Large-Eddy Simulations of Turbulent Flows), http://torroja.dmt.upm.es/turbdata/agard/
  - **Impact**: The ability to process in-situ such large databases through more complex and customisable interfaces can lead to a major reutilization of simulation results. According to CFD-Online (http://www.cfd-online.com/About/), more than 1.250.000 unique users yearly visit such web site.

Tumor segmentation based on perfusion multiparametric MRI

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Goal

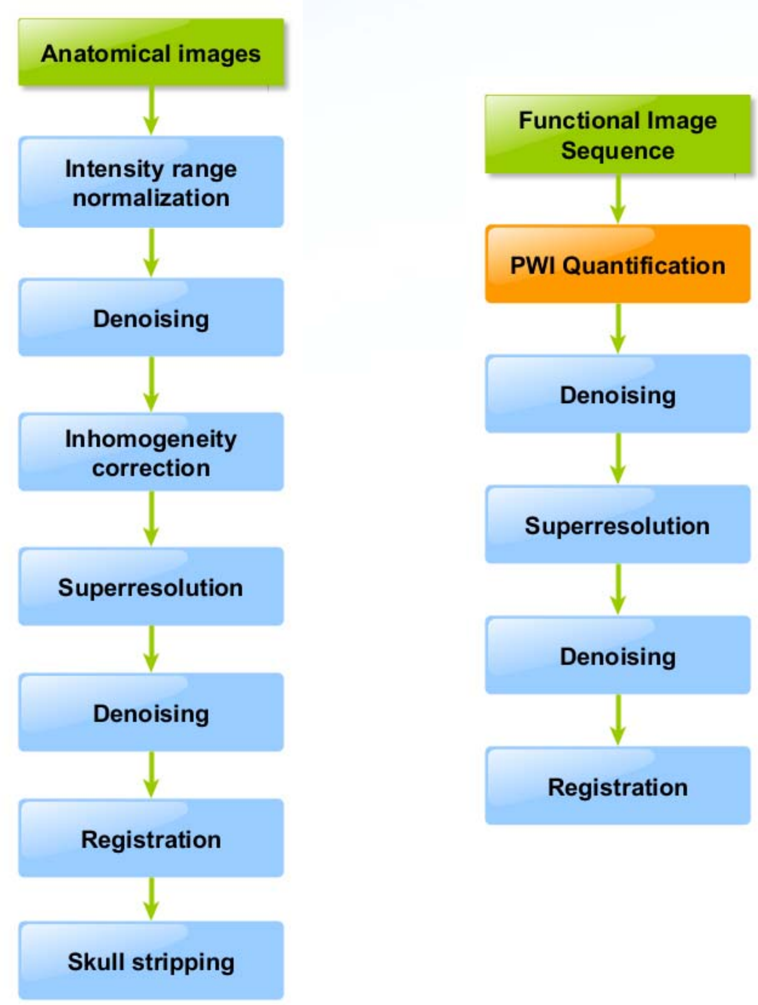
- Calculation of nosological images from the combination of multiparametric medical images to emphasize the tumoral grow at voxel level

Materials

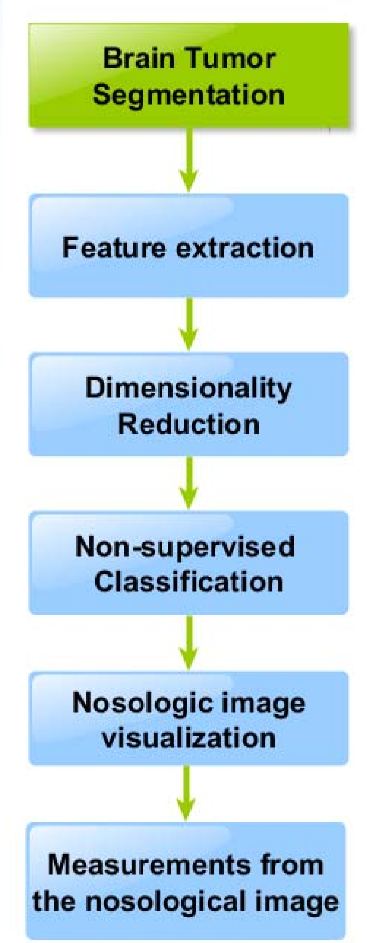
- Pre- and Post gadolinium Transversal 3D-IR-FSPGR-T1 (TR 8.9 ms, TE 2.5 ms; FoV 24 × 24 cm^2; TI 400 ms; flip angle 158º, slice thickness 1.5 mm, 256×256 matrix)
- Transversal FSE-T2 (TR 4250ms, TE 93ms, slice thickness, 5 mm; intersection gap, 2 mm; matrix, 256 × 256; FOV, 21.9 × 21.9 cm)
- Coronal TSE-FLAIR (TR/TE, 9,000/165 ms; TI, 2,200 ms; number of signals acquired, 1; slice thickness, 5 mm; intersection gap, 2 mm; matrix, 256 × 192; FOV, 22.0 × 22.0 cm)
- Transversal DSC TSE-T2* (TR/TE 2000/20 ms, flip angle 40°, slice thickness 7 mm, 128x128 matrix (in-plane resolution of 1.8 x 1.8 mm), 14 cm full coverage cranio-caudal (20 slides), 40 sequential temporally equidistant volumes each one with an acquisition time of 2.4 seconds. Bolus injection of 0.1 mmol/kg contrast agent will be administered at 5 ml/s using a power injector)
  - T2* weighted gradient-echo dynamic perfusion study (DSC).

Methods

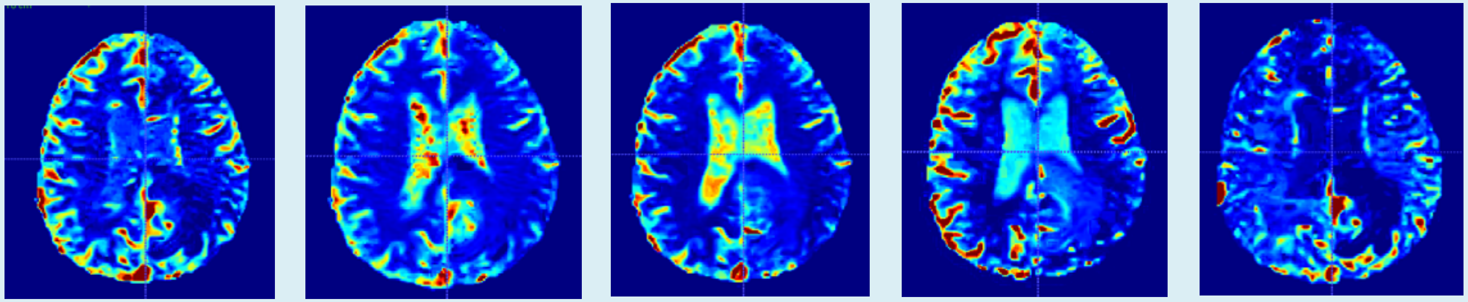
(Preprocess and Quantification

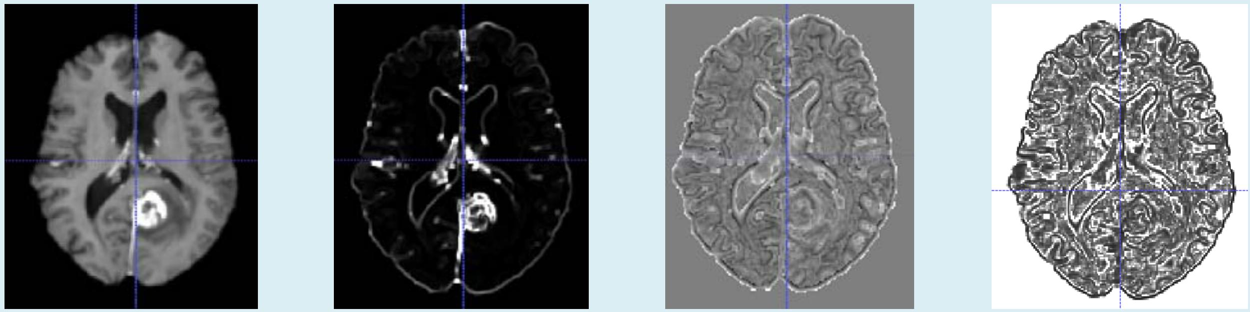


Methods
(Brain Tumor Segmentation)



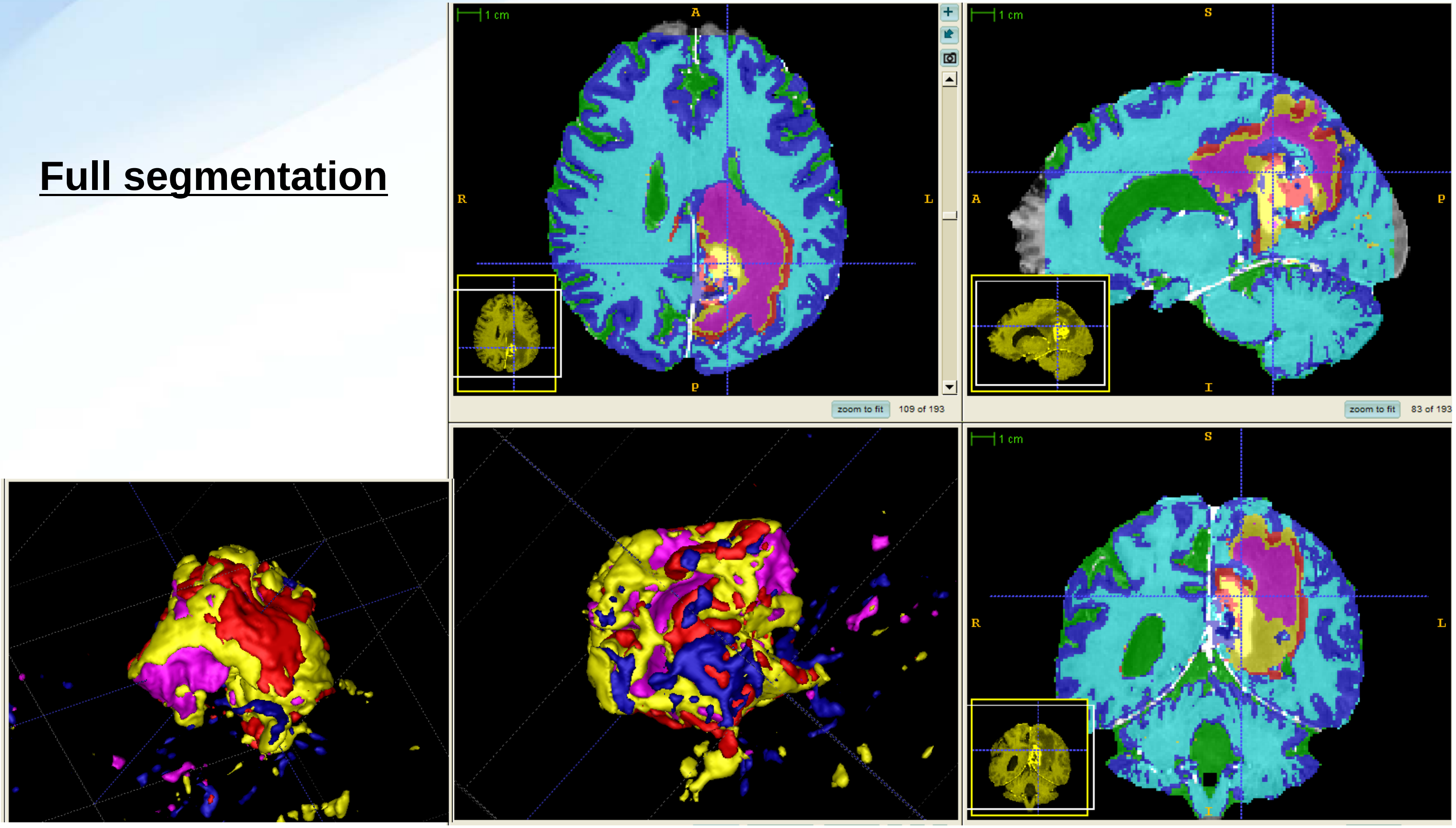
Methods





Unsupervised brain tumor segmentation

Full segmentation



Conclusions: Input

- A typical input of our study will be a 5-dimensional structure por each patient, composed by the parameter values of each parametric image in a position of a 3D space for each moment of a time series
- Given a resolution of 160 x 216 x 176, 25 parameters and a series of 3 instances, the case is represented by 456 millions of values, connected by a spatio/temporal structure from which a nosological image of similar resolution is generated
- Studies requires a set of patients to develop interpatient models

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Conclusions: Computation

- Several pre-processing steps
- Quantification based on physical models
- Segmentation based on classification algorithms.
- The calculation of a single nosological image takes several hours in a workstation
- It is desired to reduce the computation time to less than 10 minutes