

OntoNeuroBase: a Multi-Layered Application Ontology in Neuroimaging

Lynda TEMAL^a, Pascal LANDO^b, Bernard GIBAUD^a, Michel
DOJAT^c, Gilles KASSEL^b, and Anne LAPUJADE^b

^aUnit/Project VisAGeS U746, INSERM/INRIA/CNRS/University of Rennes 1, Rennes,
France

^bLaRIA, CNRS (FRE 2733) and Jules Verne University of Picardie, Amiens, France

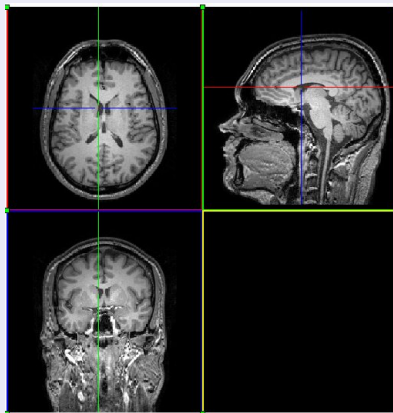
^cINSERM UM594, Grenoble, France

14 december 2006

Context

Examples of Neuroimaging data

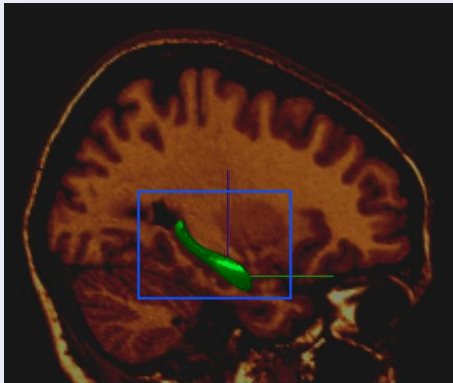
Morphological Imaging



MRI

Examples of Neuroimaging data

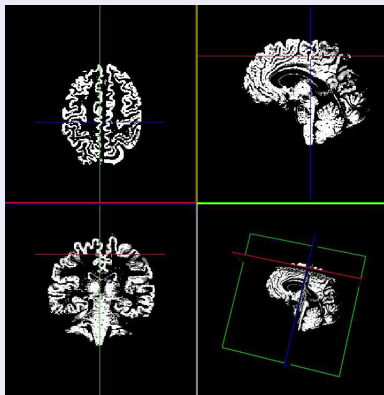
Morphological Imaging



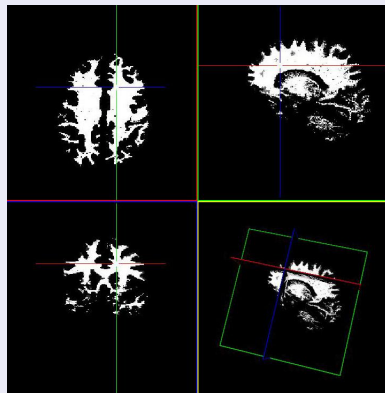
Hippocampus segmentation in MRI image

Examples of Neuroimaging data

Morphological Imaging



Grey Matter



White Matter

Examples of Neuroimaging data

Morphological Imaging



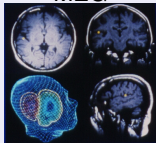
Fibers tracking with Diffusion Tensor Imaging

Examples of Neuroimaging data

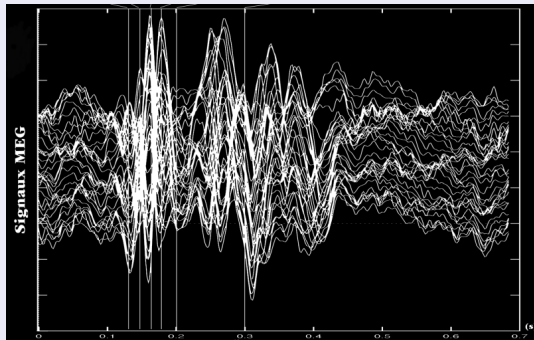
Functional Imaging



MEG



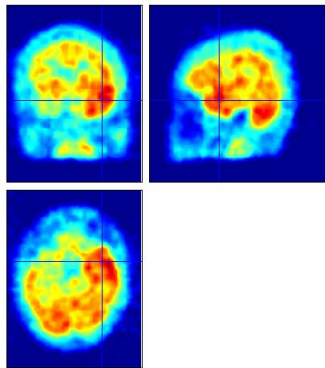
Reconstructed
Image



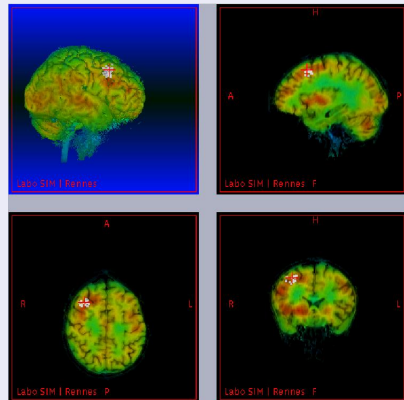
Non-Reconstructed Data

Examples of Neuroimaging data

Functional Imaging



SPECT image



fusion MRI and SPECT

General Motivation

- Optimise collaborative work in neuroimaging, through **the sharing of data and image processing tools**
- in order to :
 - carry out **large scale** experiments
 - **reuse** existing image processing tools
 - **validate** new image processing tools
 - Access to validation data sets
 - Comparison to existing processing tools

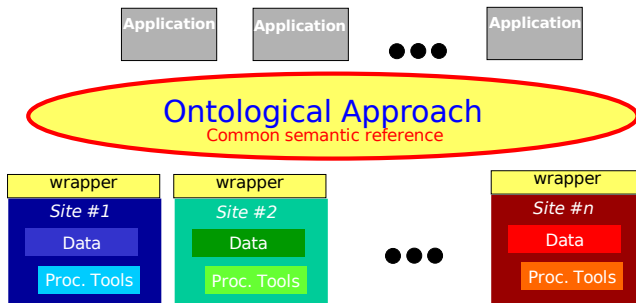
Specific Motivations

- Integration of **heterogeneous** data
 - Image data
 - Processed data
 - Interpretation of image content
 - Associated clinical information
- **Interoperability** of processing tools
 - Input data : images and parameters
 - Output data : images, registration data, etc.
 - Semantics of data processing

Specific Motivations

- Integration of **heterogeneous** data
 - Image data
 - Processed data
 - Interpretation of image content
 - Associated clinical information
- **Interoperability** of processing tools
 - Input data : images and parameters
 - Output data : images, registration data, etc.
 - Semantics of data processing

Federated Distributed System



Ontological Objectives

OntoNeuroBase aims to :

- Integrating conceptualizations from different fields
- Ensuring compatibility with other ontologies
- Designing a reference ontology
- Designing an easily extensible ontology

Ontological Objectives

OntoNeuroBase aims to :

- Integrating conceptualizations from different fields
- Ensuring compatibility with other ontologies
- Designing a reference ontology
- Designing an easily extensible ontology

Ontological Objectives

OntoNeuroBase aims to :

- Integrating conceptualizations from different fields
- Ensuring compatibility with other ontologies
- Designing a reference ontology
- Designing an easily extensible ontology

Ontological Objectives

OntoNeuroBase aims to :

- Integrating conceptualizations from different fields
- Ensuring compatibility with other ontologies
- Designing a reference ontology
- Designing an easily extensible ontology

Methods

- Basic principles
 - Modularity
 - Re-use of **existing** components
 - Foundational ontology
 - Core Domain ontologies
 - Use **formal** ontologies
- Methodology
 - ONTOSPEC
 - Ontology Engineering
 - Ontology Evaluation

Methods

- Basic principles
 - Modularity
 - Re-use of **existing** components
 - Foundational ontology
 - Core Domain ontologies
 - Use **formal** ontologies
- Methodology
 - ONTOSPEC
 - Semi-formal approach
 - Easy translation in OWL

Excerpt from an ONTOSPEC document

//Concept

Agent

Meta-properties

AGENT is ANTI-RIGID (**~R**). AGENT is NOT CARRYING AN IDENTITY CRITERION (**-I**). AGENT is NOT CARRYING A COMMON UNITY CRITERION (**-U**). AGENT is EXTERNALLY-DEPENDENT (**+D**).

Properties

[EP/SLD] An AGENT is a DETERMINANT which *is agent of* an EVENT or a PROCESS *at* a TIME INTERVAL. [EP/SL] Every AGENT is an AGENTIVE.

Excerpt from an ONTOSPEC document

//Concept

Agent

Meta-properties

AGENT is ANTI-RIGID (**~R**) AGENT is NOT CARRYING AN IDENTITY CRITERION (**-I**). AGENT is NOT CARRYING A COMMON UNITY CRITERION (**-U**). AGENT is EXTERNALLY-DEPENDENT (**+D**).

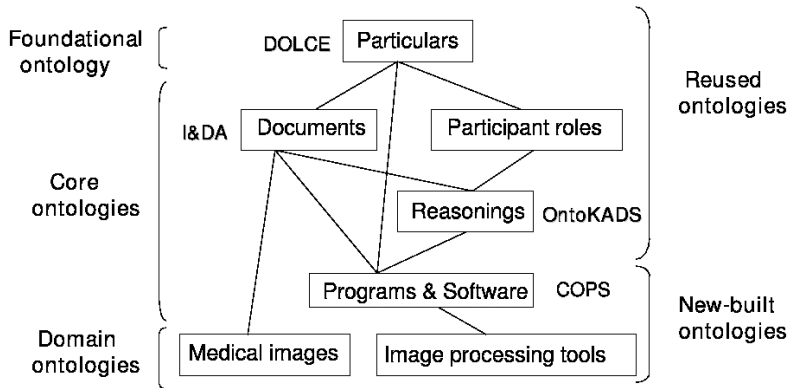
Properties

[EP/SLD] An AGENT is a DETERMINANT which is *agent of* an EVENT or a PROCESS *at* a TIME INTERVAL. [EP/SL] Every AGENT is an AGENTIVE.

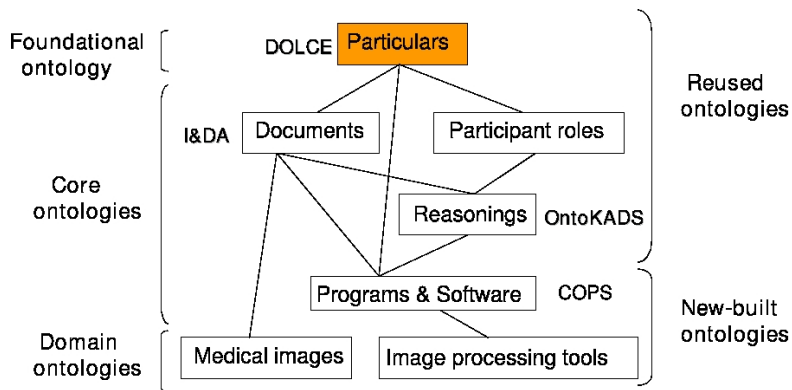
Meta-Properties

Essential Properties

Overview



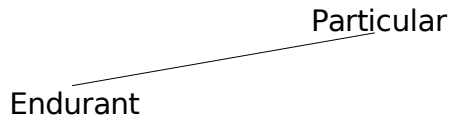
The Ontological Reference Framework



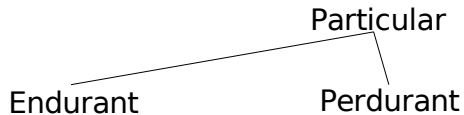
Ontology of Particulars (DOLCE)

Particular

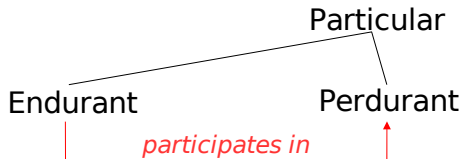
Ontology of Particulars (DOLCE)



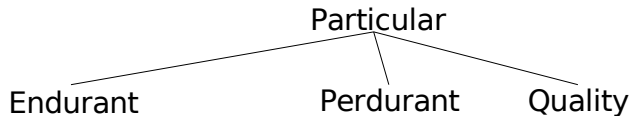
Ontology of Particulars (DOLCE)



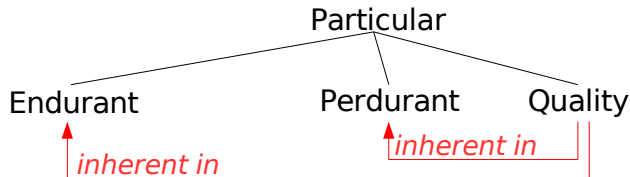
Ontology of Particulars (DOLCE)



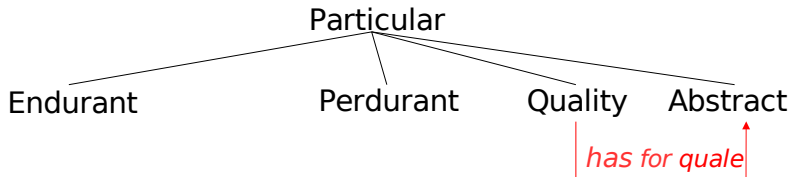
Ontology of Particulars (DOLCE)



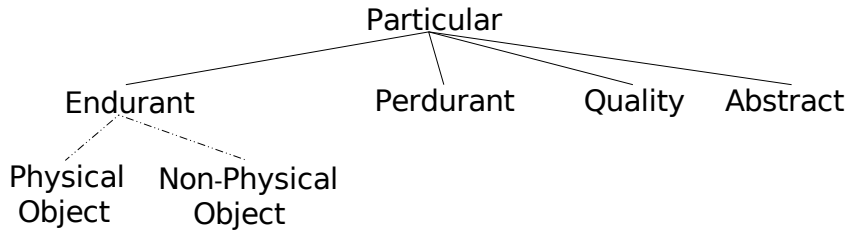
Ontology of Particulars (DOLCE)



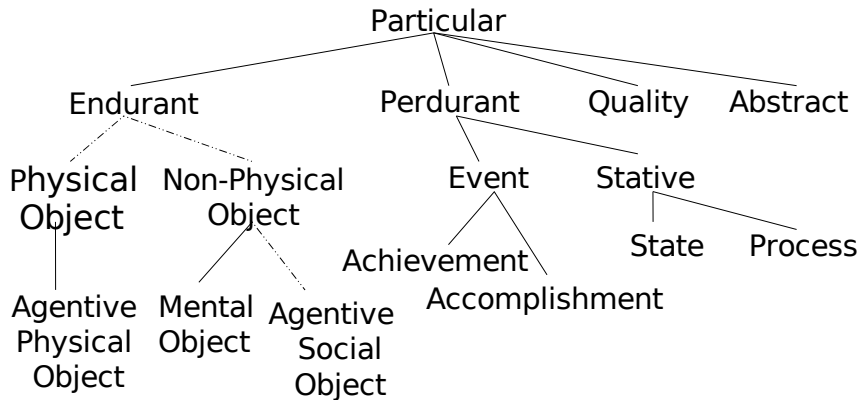
Ontology of Particulars (DOLCE)

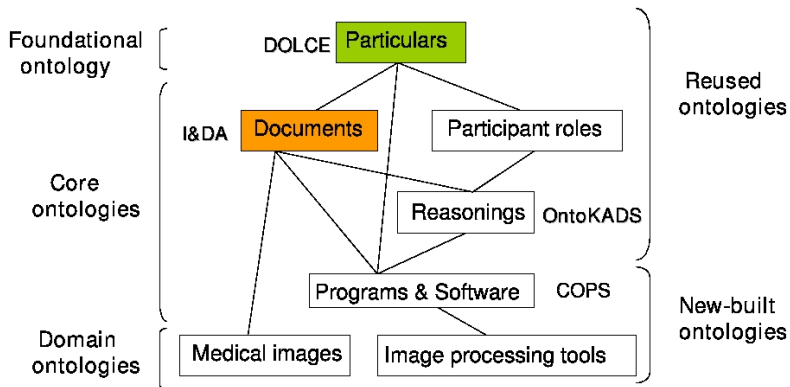


Ontology of Particulars (DOLCE)

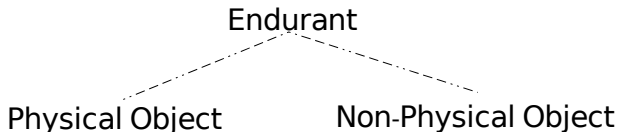


Ontology of Particulars (DOLCE)

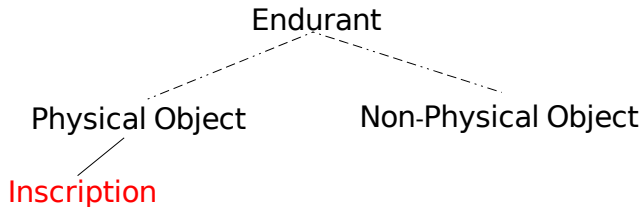




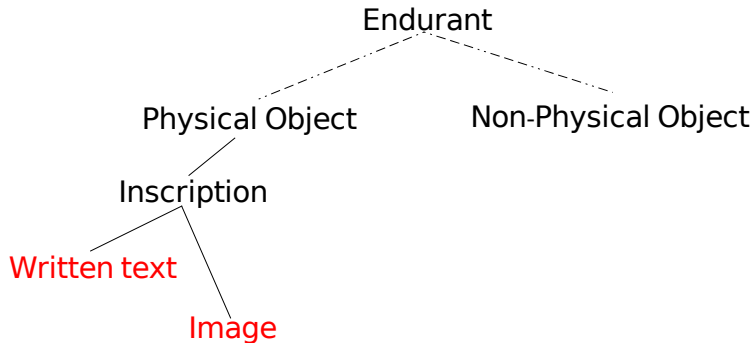
Ontology of documents (I&DA)



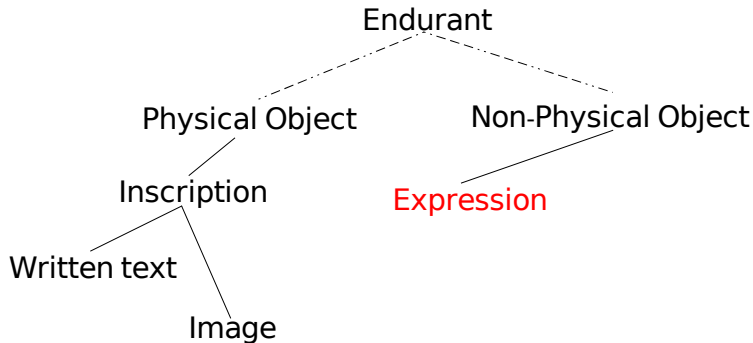
Ontology of documents (I&DA)



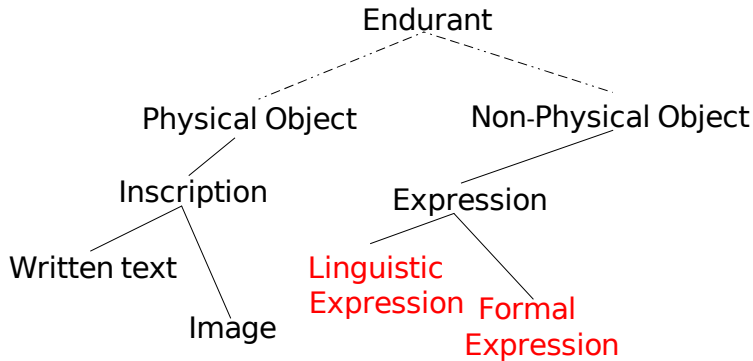
Ontology of documents (I&DA)



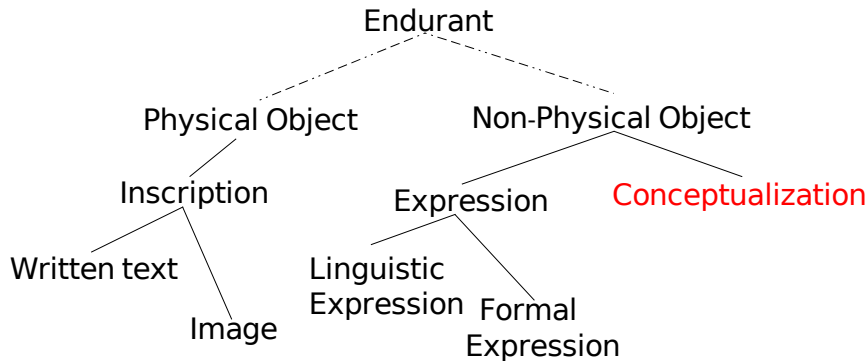
Ontology of documents (I&DA)



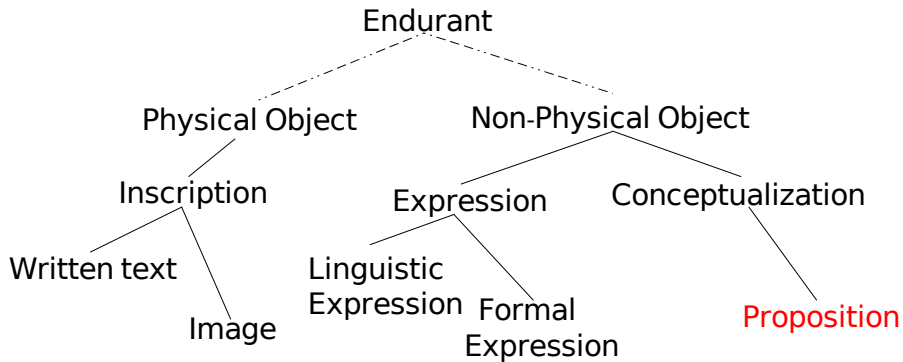
Ontology of documents (I&DA)



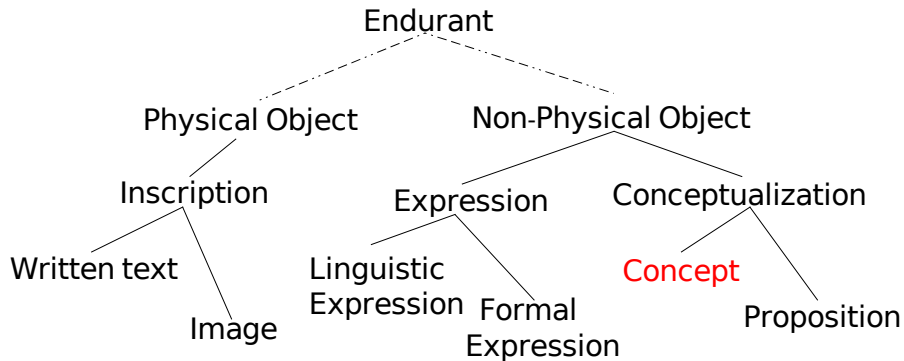
Ontology of documents (I&DA)



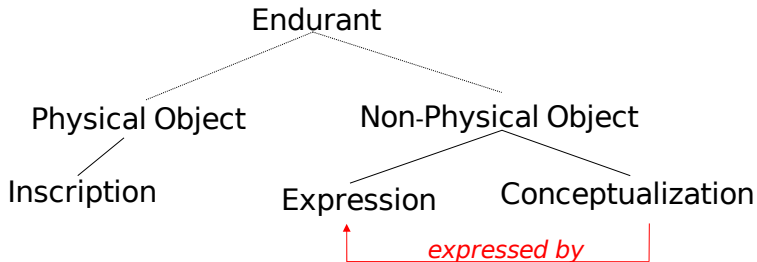
Ontology of documents (I&DA)



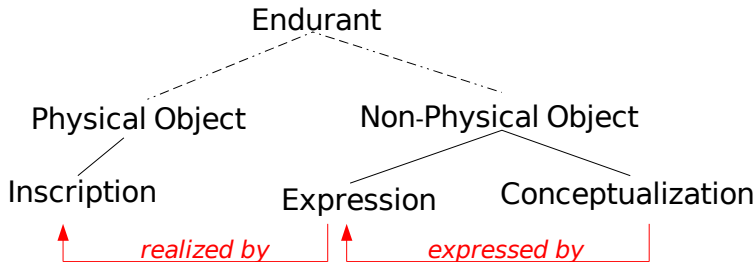
Ontology of documents (I&DA)



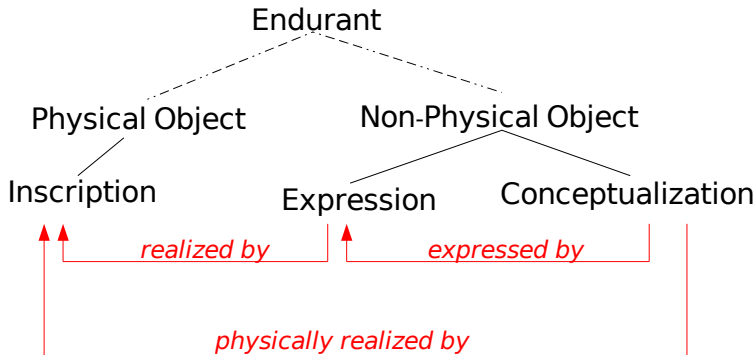
Ontology of documents (I&DA)



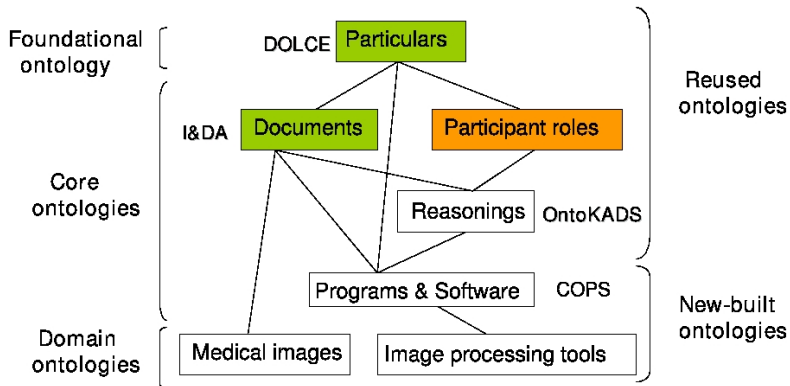
Ontology of documents (I&DA)



Ontology of documents (I&DA)



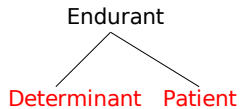
The Ontological Framework Reference



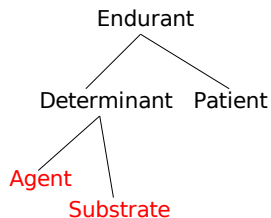
Roles Modelling

Endurant

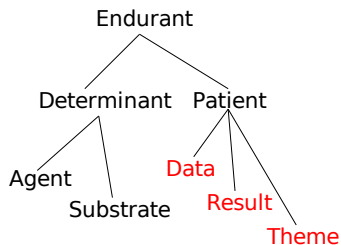
Roles Modelling



Roles Modelling



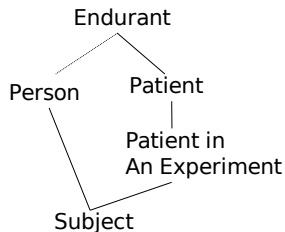
Roles Modelling



Roles Modelling

Role Characteristics

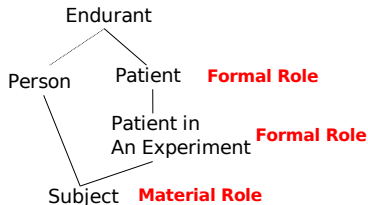
- *Anti-rigid* (Person/Subject)
- Relationally dependent (Subject/Experiment)

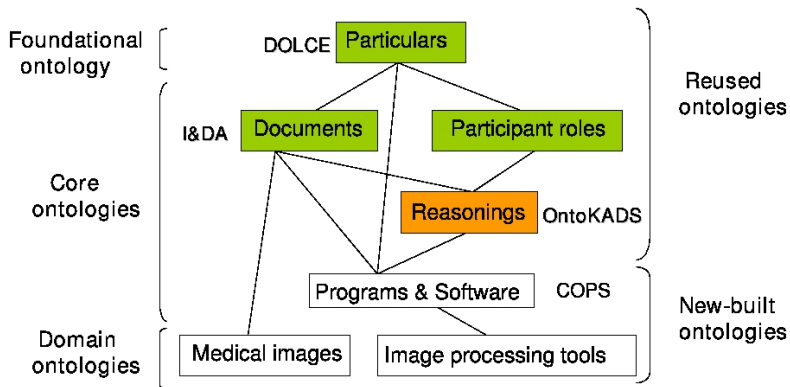


Roles Modelling

Meta-Properties

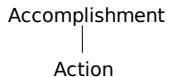
- *Role*
- *Formal Roles* : *Roles* not carrying any identity criterion (include participant roles)
- *Material Roles* : *Roles* carrying an identity criterion (include *Formal Roles* + type of instance)



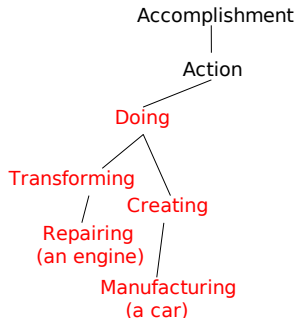


Reasoning and "Knowledge Roles" (OntoKADS)

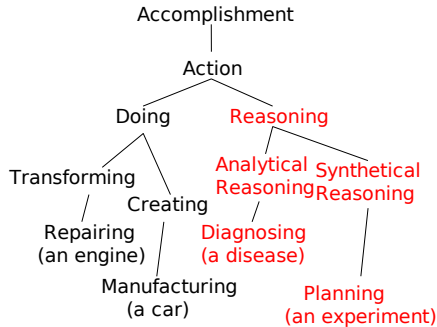
Reasoning and "Knowledge Roles" (OntoKADS)



Reasoning and "Knowledge Roles" (OntoKADS)



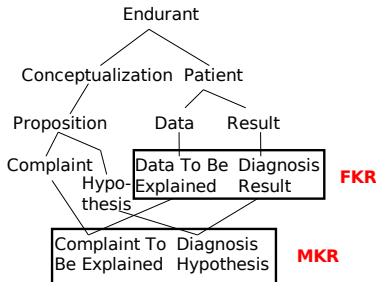
Reasoning and "Knowledge Roles" (OntoKADS)



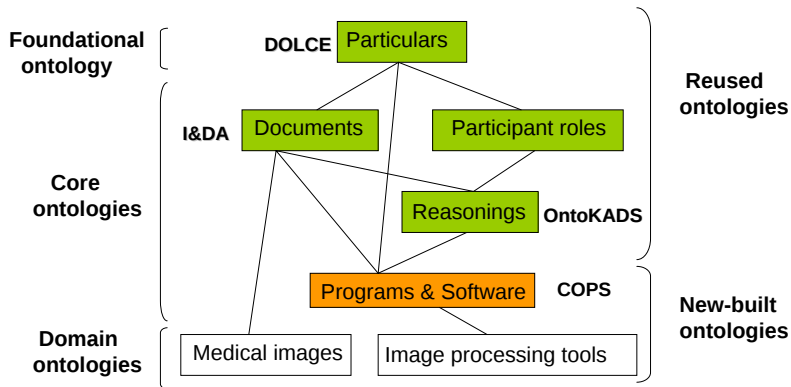
Reasoning and "Knowledge Roles" (OntoKADS)

Knowledge Roles

- *Formal Roles* classified into "Formal Knowledge Roles" which cite a particular *Reasoning*
- *Formal Knowledge Roles* allow to define "Material Knowledge Roles" including the "type" of their instances



New-built Ontologies

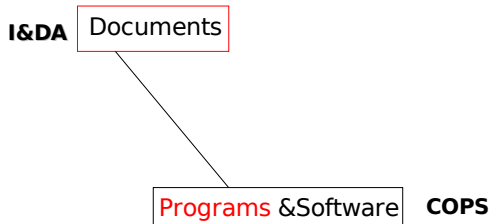


Core Ontology of Programs and Software (COPS)

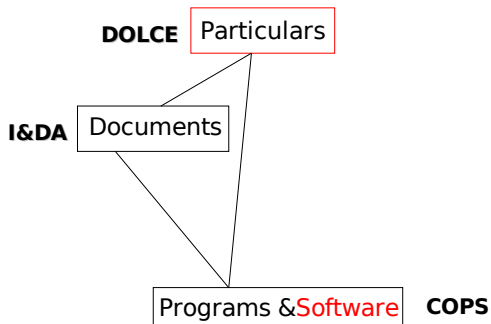
Programs &Software

COPS

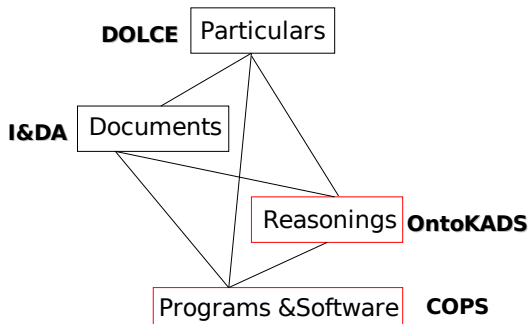
Core Ontology of Programs and Software (COPS)



Core Ontology of Programs and Software (COPS)



Core Ontology of Programs and Software (COPS)

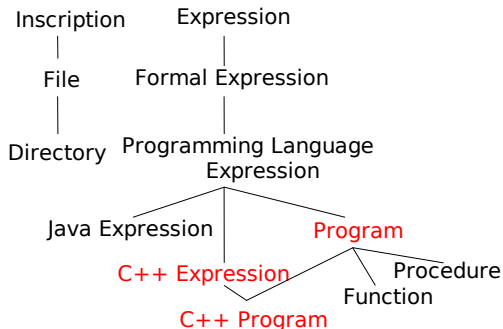


Programs as Endurants

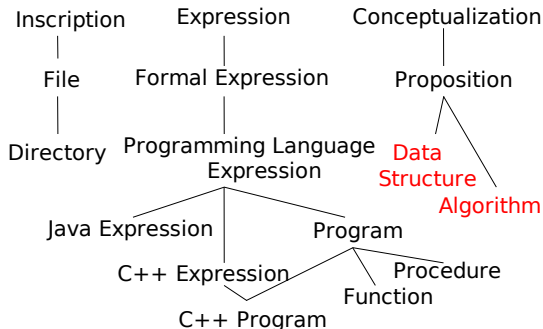
Programs as Endurants



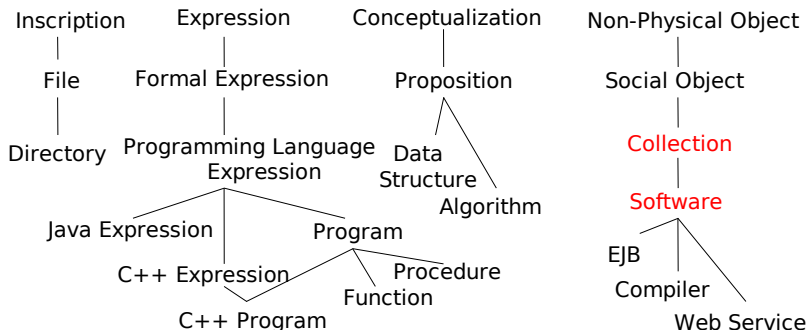
Programs as Endurants



Programs as Endurants



Programs as Endurants



Programs & Perdurants

- *Programs* are involved in *Perdurants*
- *Programs* are linked to *Actions (Reasonings)* with the relationship *AllowsToCarryOut*
- *Conceptualizations* or *Expressions* participate in *Reasoning* as *Data* or *Result*

New-built Ontologies

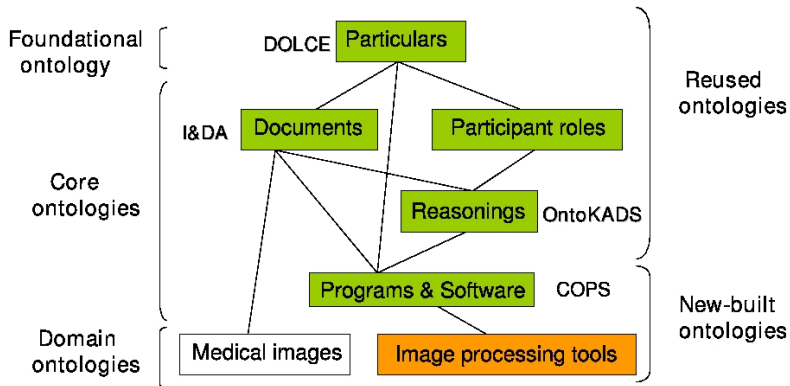


Image Processing Tools Ontology (IPTO)

- *IPTO* (Image Processing Tools Ontology) organizes tools according to the kind of processing
- *Image Processing Tools* are *Programs*
- *Image Processing Tools* are part of *Software* (eg : VTK, SPM)
- *Image Processing Tools* specify input constraints modelled by the *acceptsAsData* relationship
- *Image Processing Tools* specify output constraints modelled by the *providesAsResult* relationship

Image Processing Tools Sub-ontology

Program
|
Image
Processing
Tool

Image Processing Tools Sub-ontology

Program
|
Image
Processing
Tool

Synthetical
Reasoning
|
Data
Processing

Image Processing Tools Sub-ontology

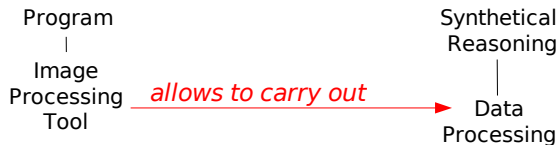


Image Processing Tools Sub-ontology

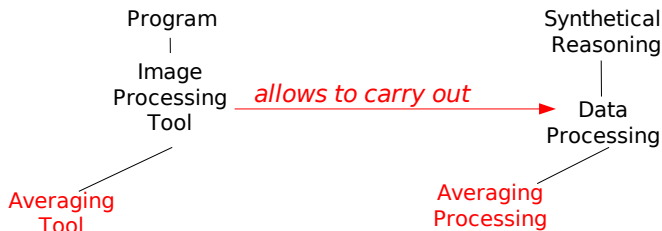


Image Processing Tools Sub-ontology

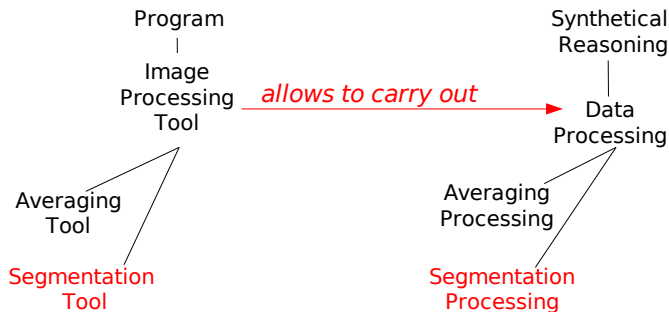


Image Processing Tools Sub-ontology

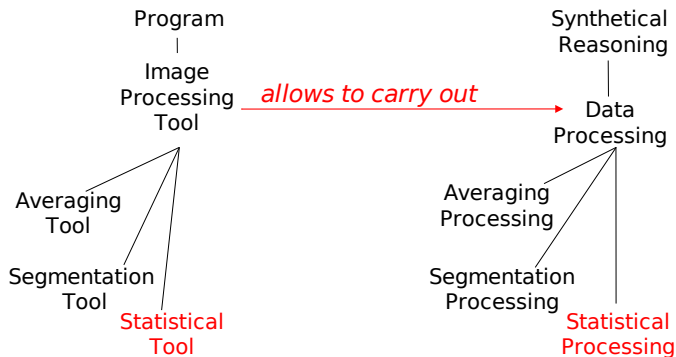


Image Processing Tools Sub-ontology

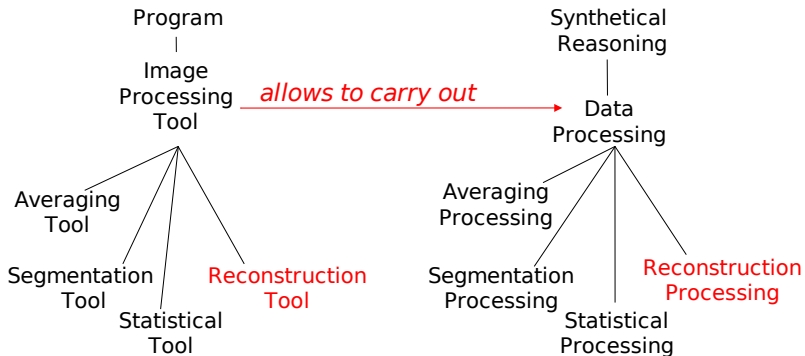
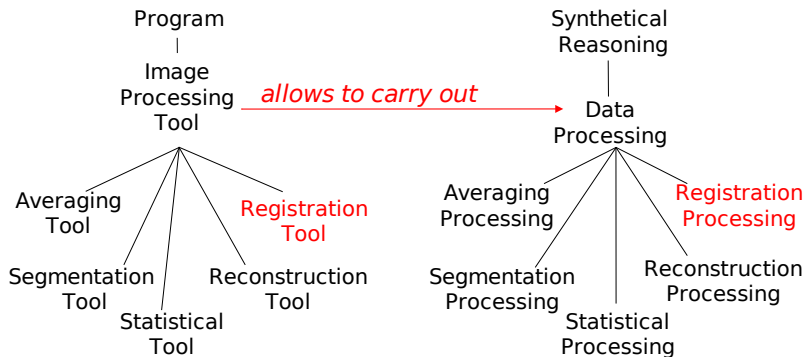
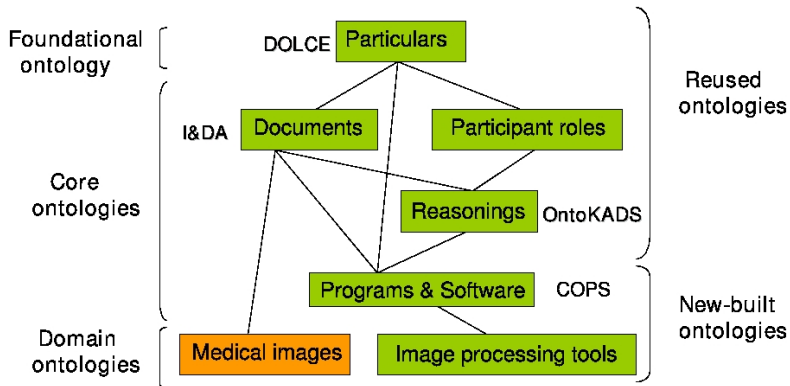


Image Processing Tools Sub-ontology



New-built Ontologies



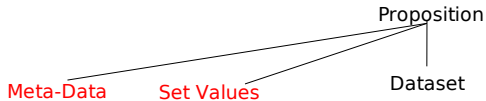
The Dataset Ontology

Proposition

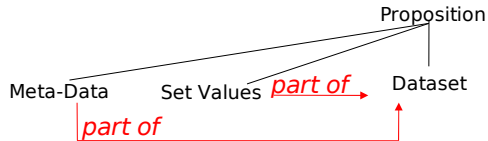


Dataset

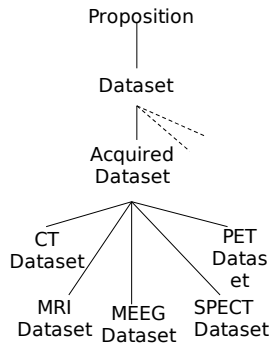
The Dataset Ontology



The Dataset Ontology



The Dataset Ontology



The Dataset Ontology

Expression

Dataset
Expression

Proposition

Dataset

Acquired
Dataset

CT
Dataset

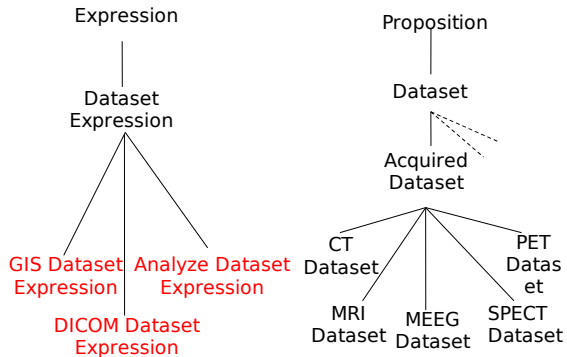
MRI
Dataset

MEEG
Dataset

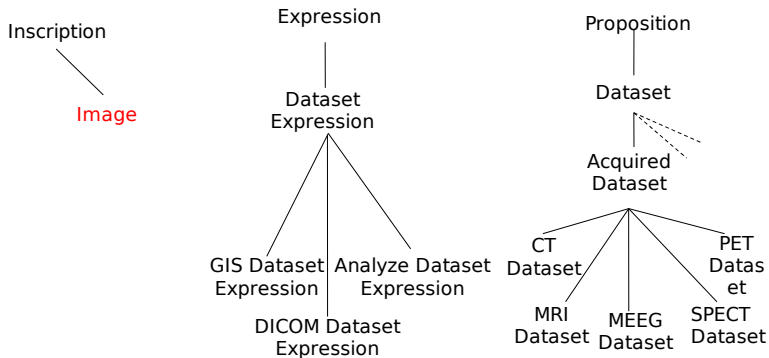
PET
Dataset

SPECT
Dataset

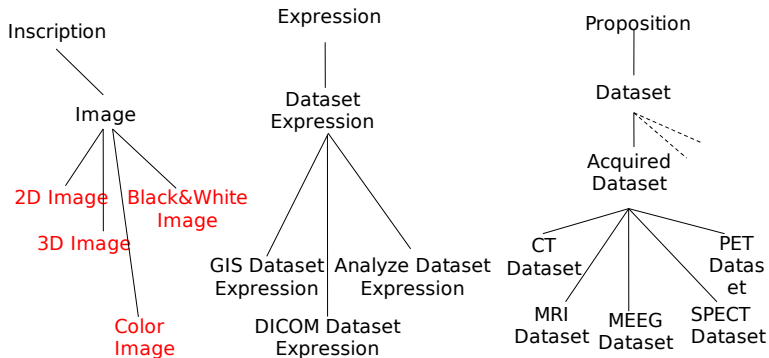
The Dataset Ontology



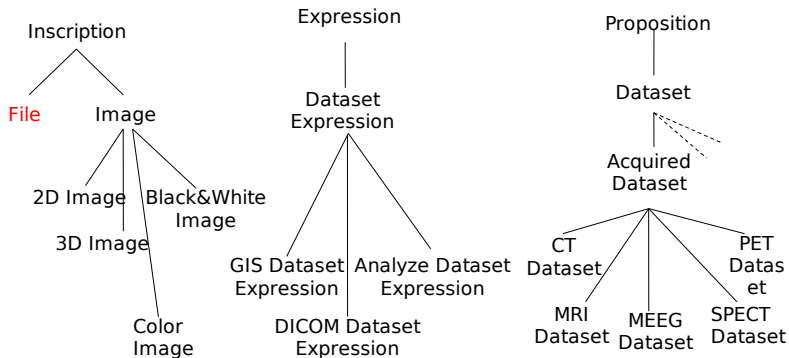
The Dataset Ontology



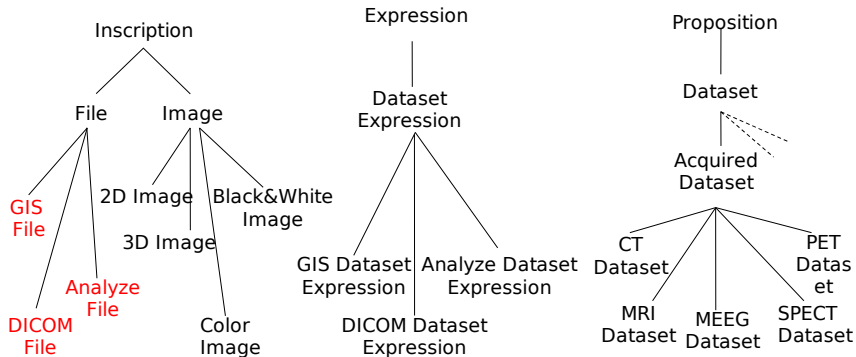
The Dataset Ontology



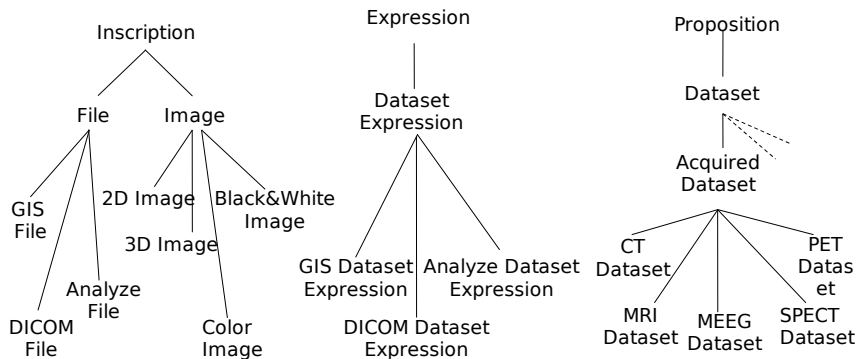
The Dataset Ontology



The Dataset Ontology



The Dataset Ontology



Datasets categories

The First Semantic Axis

- *Datasets* are specialized according to *Reasonings* in which they participate as *Results*
- OntoKADS is used to define *Roles* and *Reasonings* (eg : *Acquiring, Data Processing*)

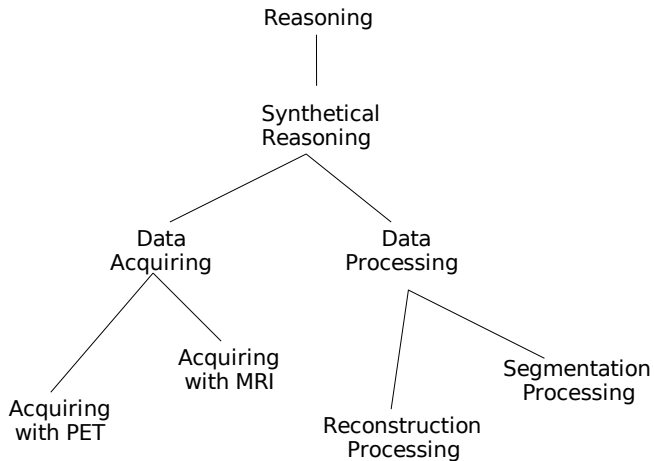
Datasets categories

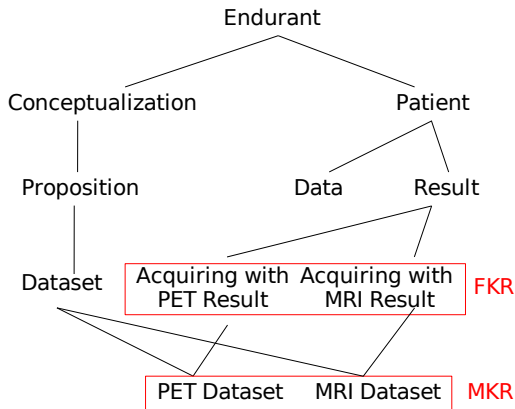
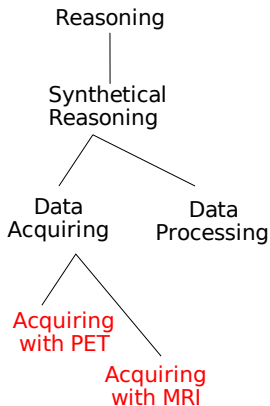
The First Semantic Axis

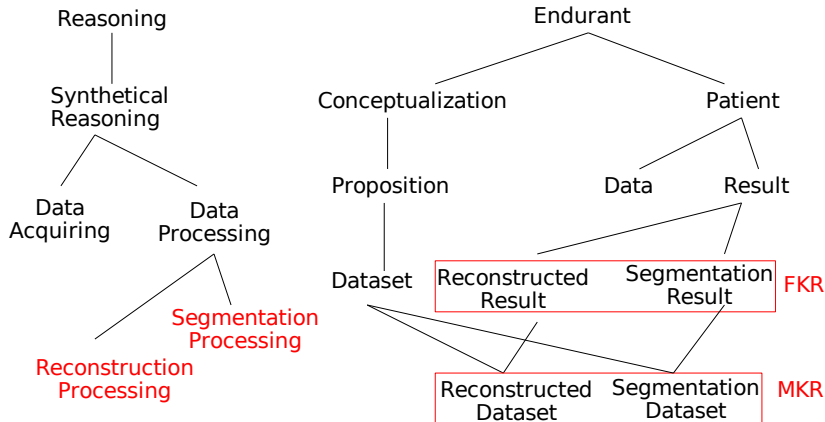
- *Datasets* are specialized according to *Reasoning* in which they participate as *Results*
- OntoKADS is used to define *Roles* and *Reasonings* (eg : *Acquiring, Data Processing*)

The Second Semantic Axis

- *Datasets* are specialized according to structure or function explored



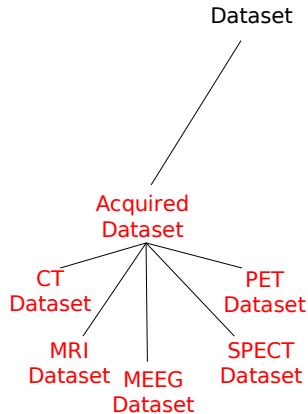




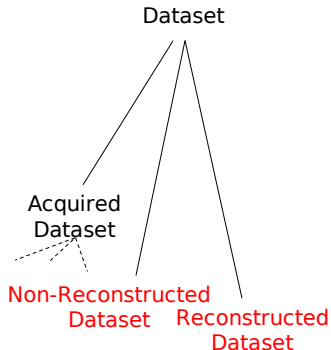
Dataset top-level taxonomy

Dataset

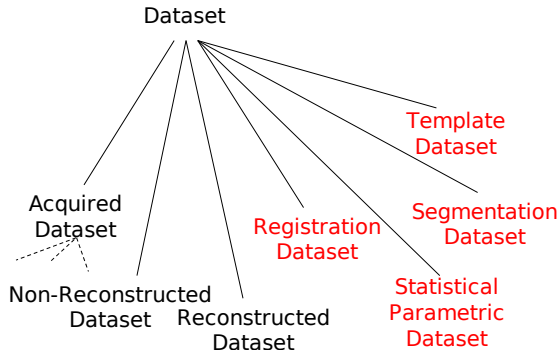
Dataset top-level taxonomy



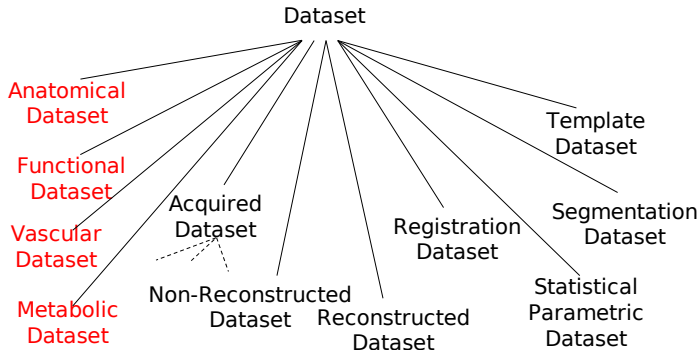
Dataset top-level taxonomy



Dataset top-level taxonomy



Dataset top-level taxonomy



Conclusion & Perspectives

Conclusion

- OntoNeuroBase involves a wide complex domain
- Building framework methodology :
 - OntoNeuroBase based on DOLCE
 - OntoNeuroBase reuses core ontologies
- OntoNeuroBase kernel : IPTO and the Datasets ontology

Conclusion & Perspectives

Perspectives

- Achieving the Dataset ontology in terms of contents description
 - Describing the contents by a mathematical function (eg : MR Signal Intensity, Regional Cerebral Blood Flow)
 - Linking the contents to real world entities (eg : anatomical entities, physiological processes)
- Achieving COPS and IPTO
 - Detailed description of programs functionalities
 - Detailed description of Input/Output constraints

Thank you for your attention !