The NeuroFMA: Ontological Framework for Neuroanatomy

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Neuroinformatics

Expectations: Neuroanatomy Ontology should

Index and retrieve neuroscience information by species for mouse, rat, macaque, human;

Define several hierarchical schemes for grouping primary structures to support accessing information in bigger chunks;

Specify the relation of several thousand synonyms to allow the retrieval of information in terms of different nomenclatures;

Provide atlases of segmented coronal brain sections for warping of MRI and PET scans.

Neuroanatomy Ontology Workshop Summary

General Challenges in Biomedical Informatics

- Interoperability
- Representation of biomedical knowledge in machine-processable form
- Integration and correlation of biomedical information and data
- Inadequacy of traditional knowledge sources

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Neuroanatomical Terminologies

Anatomy and library reference: **NeuroAnatomy Textbooks** Terminologia Anatomica **MeSH** Clinical terminologies: **SNOMED** GALEN **BrainML** Basic and clinical neuroscience: **NeuroNames**

 Incorporate neuroanatomical views from various sources in accord with the FMA ontological principles.



Brain

Is it an organ?



Brain

Brain + Spinal cord = Whole an organ part?

Spinal cord



Brain

Brain + Spinal cord = Neuraxis

Spinal cord

Foundational Principles of Anatomy

- 1. Definition principle
- 2. Dominant class principle
- 3. Organizational unit principle
- 4. Content constraint principle

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Role of Definitions

- To specify a unique taxonomy
- To assure semantic and logical consistency within the ontology
- To assure transitive inheritance of properties through type hierarchy (taxonomy)

Michael J, Mejino JLV, Rosse C. The role of definitions in biomedical concept representation. *Procs AMIA Fall Symp* 2001; 463-467.

Foundational Model of Anatomy Ontology

$$FMA = (AT, ASA, ATA, Mk)$$

where:

- AT = Anatomy Taxonomy
- ASA = Anatomical Structural Abstraction
- ATA = Anatomical Transformation Abstraction
- Mk = Metaknowledge

(principles, rules, axioms)

Cornelius Rosse and Jose LV Mejino Jr 2007. The Foundational Model of Anatomy Ontology. in: Burger A, Davidson D, Baldock R. (eds.), Anatomy Ontologies for Bioinformatics: Principles anD Practice, New York: Springer, in press. http://sigpubs.biostr.washington.edu/archive/00000204/

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Anatomy Taxonomy



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Organizational Unit Principle



Organizational units



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Ontology based on structure only

How is the brain represented in the FMA?





Spatial Association Network

Anatomical Structural Abstraction

$$FMA = (At, ASA, ATA, Mk) \quad (1)$$

ASA = (Do, Bn, Pn, SAn) (2)

where:

- Do = Dimensional ontology
- Bn = Boundary network
- Pn = Part-of network
- SAn = Spatial Association network



Anatomical Structural Abstraction

FMA = (At, ASA, ATA, Mk) (1) ASA = (Do, Bn, Pn, SAn) (2) where: = Dimensional ontology Do = Boundary network Bn **Pn** = **Part-of** network = Spatial Association network SAn





Brain							
	Forebrain						
	Telencephalon						
	cerebral cortex cerebral subcortex lateral ventricle	right cerebral hemisphere left cerebral hemisphere	neural tissue of telencephalon ventricular system of telencep. vasculature of telencephalon				

Diencephalon Midbrain Hindbrain

Telencephalon cerebral cortex cerebral subcortex lateral ventricle

Telencephalon cerebral cortex cerebral subcortex lateral ventricle right cerebral cortex left cerebral cortex

right cerebral subcortex left cerebral subcortex

is_a relation NOT part_of relation !

Telencephalon cerebral cortex cerebral subcortex lateral ventricle right cerebral cortex left cerebral cortex

right cerebral subcortex left cerebral subcortex

part_of relation

Telencephalon

right cerebral hemisphere

right cerebral cortex left cerebral cortex

right cerebral subcortex left cerebral subcortex

part_of relation

Telencephalon

right cerebral hemisphere

left cerebral hemisphere

right cerebral cortex left cerebral cortex

right cerebral subcortex left cerebral subcortex

part_of relation

Telencephalon

right cerebral hemisphere right cerebral cortex right cerebral subcortex right lateral ventricle left cerebral hemisphere left cerebral cortex left cerebral subcortex Left lateral ventricle

part_of relation

Telencephalon

right cerebral hemisphere right cerebral cortex right cerebral subcortex right lateral ventricle left cerebral hemisphere left cerebral cortex left cerebral subcortex left lateral ventricle

white matter of RCH set of gray matter of RCS

part_of relation

right subcortical association fiber layer right half of corpus callosum right corona radiata right internal capsule

> white matter of RCH set of gray matter of RCS

part_of relation

right subcortical association fiber layer right half of corpus callosum right corona radiata right internal capsule

white matter of RCHset of gray matter of RCS

basal ganglia of right cerebral hemisphere set of septal nuclei of right cerebral hemisphere



	Contraction of the second se			
🖸 Right cerebral hemispher				_
- C Right cerebral cortex Consti	tutional part has	regional parts	Regional Part	
 C Right cerebral subcontex C Right lateral ventricle Constitutional part hierarchy 	C Cortex of right fronta C Cortex of right tempo C Cortex of right pariets C Cortex of right occipi C Cortex of right insula C Cortex of right limbic	l lobe oral lobe al lobe tal lobe i lobe	C Cortex of right frontal C Cortex of right tempo C Cortex of right pariets C Cortex of right occipi C Cortex of right insula C Cortex of right limbic	l lobe oral lobe al lobe tal lobe i lobe
	Constitutional Part Of	sphere	Constitutional Part	
	Member Of	V + -		
	Attributed Part			١
	related part	anatomical/arbitrary	shared/unshared	pa
	Right neocortex	Anatomical	Unshared	Partition 1
	Right archicortex	Anatomical	Unshared	Partition 1
	Right paleocortex	Anatomical	Unshared	Partition 1





Constitutional Part

- C Plexiform layer of right cerebral cortex C External granular layer of right cerebral cortex C External pyramidal layer of right cerebral cortex C Internal granular layer of right cerebral cortex C Internal pyramidal layer of right cerebral cortex
- C Multiform layer of right cerebral cortex



... or regional part based on cytoarchitectonics

C Region of cerebral cortex
 C Cortex of lobe of cerebral hemisphere
 C Region of cortex of frontal lobe
 C Region of cortex of frontal lobe
 C Right neocortex
 C Right neocortex
 C Left neocortex
 C Allocortex
 C Mesocortex
 C Brodmann area
 C Broca's area

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Granularity



Granularity



Extend ontology to subcellular and macromolecular entities

