ICBO: International Conference on Biomedical Ontologies · Buffalo, NY, USA
Doctoral & Post-Doctoral Consortium, July 27, 2011

The Foundational Model of Neuroanatomy Ontology: An Ontology Framework to Support Neuroanatomical Data Integration

B. Nolan Nichols[1], Jose L.V. Mejino Jr.[2], James F. Brinkley[1,2]

[1]University of Washington, Biomedical and Health Informatics, Seattle, WA, USA
[2]University of Washington, Biological Structure, Seattle, WA, USA

Keywords: Biomedical Informatics, Ontology, Semantic Web, Neuroinformatics

A basic requirement for facilitating the integration and analysis of neuroscience data from diverse sources is a well-structured ontology that can support multi-modal and multi-scale neuroscience applications. Here we show how a reference ontology, the Foundational Model of Anatomy (FMA) Ontology [1], meets data integration needs by applying a disciplined modeling approach to create an application ontology for neuroscience called the Foundational Model of Neuroanatomy (FMN) Ontology. The FMN provides a structural semantic framework useful for correlating and aligning disparate views of neuroanatomy, such as those present in the different ontologies and controlled terminologies used in neuroinformatics. The labels used in brain atlases are a form of controlled terminology that are frequently used to label neuroimaging result data sets, which creates an opportunity to integrate annotated data based on anatomical and structural relationships [2]. However, different brain atlases use distinct parcellation schemes that represent neuroanatomical structures and regions at different levels of granularity and also model different properties of neuroanatomical entities (e.g., cortical gray matter vs. white matter connectivity). In order to reconcile the labels used in several brain atlases, we enriched the FMA with additional neuroanatomical classes and properties to capture the semantics implicitly expressed in each brain atlas terminology.

By capturing the semantics implied in brain atlases, the FMN enables the correlation of annotated neuroimaging data sets that measure distinct or overlapping aspects of brain structure and function. After mapping the anatomical labels used by common brain atlases (e.g., AAL, FreeSurfer, Talairach, and JHU-DTI-81) to FMA classes, we can now use the rich spatio-structural relation network (e.g. partonomy, connectivity) of the FMA to determine the precise relationships between the structures represented both within and across different brain atlases. We specifically elaborated on parthood relationships to establish a granularity association between gray matter regions (e.g. gray matter of precentral gyrus *part_of* precentral gyrus) and within white matter tracts (arcuate fasciculus part_of superior longitudinal fasciculus). In addition we represented the neural connectivity relationships between gray and white matter structures.

To formalize structural connectivity in the FMA, we developed a set of definitions to disambiguate and clarify the terminologies used for describing the types of connectivity relationships that exist between gray and white matter structures (e.g. *projects_to*, *projects_from)*. The *projects_to* property is a connectivity relation where individual axons comprising a fiber tract originating from one or more brain regions synapse with neurites or somas of a collection of neurons located in one or more brain regions. The p*rojects_from* property is a connectivity relation where individual axons comprising a fiber tract are parts of a collection of neurons located in one or more brain regions. The extended FMA can cross-correlate atlases using both part and connectivity relations, allowing measurements of white matter structures annotated with one atlas to be semantically integrated with measurements of gray matter structures annotated with a different atlas (Figure 1).

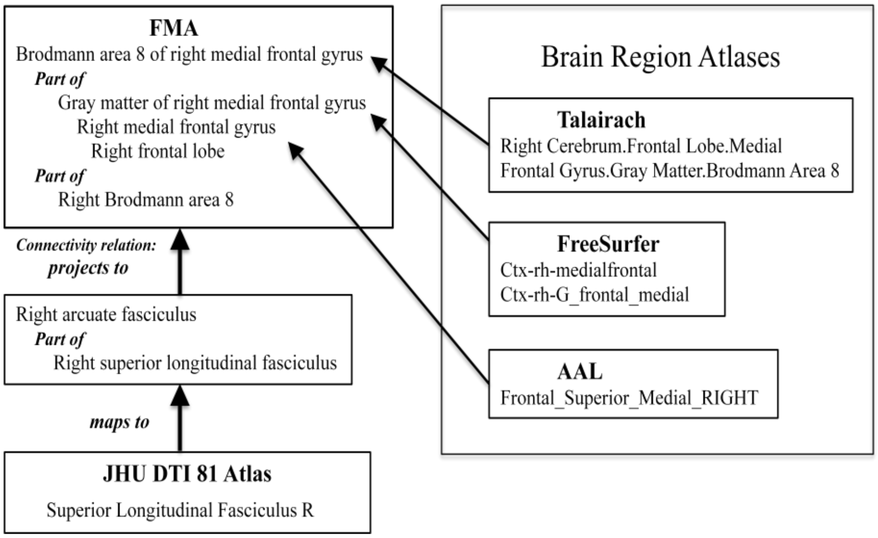

Figure 1. Cross-correlation of white matter tract with the different gray matter regions.

References

1. Rosse, C., Mejino, J.L.V.: A Reference Ontology for Biomedical Informatics: the Foundational Model of Anatomy. J. Bio. Info. 36, 478–500 (2003)
2. Turner, J.A., Mejino, J.L.V., Brinkley, J.F., Detwiler, L.T., Lee, H.J., Martone, M.E., Rubin, D.L.: Application of neuroanatomical ontologies for neuroimaging data annotation. Front. Neuroinform. 4(10), 1–12 (2010).