

Representing Neural Connectivity in the Foundational Model of Anatomy Ontology

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Abstract

Our current effort focuses on representing connectivity relationships between gray and white matter structures in the Foundational Model of Anatomy Ontology (FMA)¹. There are a number of terms used that imply either structural or functional relationship, but the semantics have not been made formally explicit in the ontology. In this work we propose a set of definitions to disambiguate and clarify the terminologies describing the types of connectivity relationships that exist between gray and white matter structures at different levels of granularity.

The primary focus of this work is to augment the neuroanatomy content in the Foundational Model of Anatomy (FMA) using spatial relations that primarily deal with neural connectivity between different gray matter structures, in the brain and the spinal cord, and the white matter tracts that connect these structures. However, the representation of connectivity in classical anatomy is limited, and emerging technologies, such as diffusion tensor imaging, are providing more information on the properties of white matter tracts and the possible use of this information to derive more refined cortical brain parcellations. Therefore, parallel ontological representations are needed to capture and accommodate newly updated knowledge models. As a canonical model of structural brain networks emerges an ontological framework will be essential for understanding nervous system function across spatial scales.

Most white matter structures have been incorporated into the FMA taxonomy, and connectivity relationships between many nuclei of the brain have been elaborated, but connectivity between gray and white matter structures are currently being implemented. For example, the FMA states that the globus pallidus *receives_input_from* the caudate nucleus and *sends_output_to* the superior colliculus. Now we need to specify the white matter tracts responsible for the connection and the connection properties. We specify connectivity using existing FMA relations, as well as new relations, for association, commissural and projection tracts and fibers. We are also representing complete pathways,

which include both nuclei and tracts as properties of those pathways. We hereby propose the following definitions for the different connectivity relations:

Innervate: a connectivity relation where a neurite of one neuron synapses with a neurite or a region of the soma of another neuron or a region of a muscle cell or a gland cell.

Synapse_with: a connectivity relation where there is apposition between the presynaptic membrane of a neurite of one neuron and the postsynaptic membrane of one or more neurites of another neuron or a region of a muscle cell or a gland cell and some form of neurotransmission is evident between them.

Project_to: 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 other brain regions. This relation may be synonymous with *'terminate_in'*.

Project_from: a connectivity relation where individual axons comprising a fiber tract are parts of a collection of neurons located in one or more brain regions. This relation may be synonymous with *'originate_in'*.

Send_output_to: a subproperty of project_to relation where neurotransmission is sent from one brain region to one or more other brain regions.

Receive_input_from: a subproperty of project_from relation where neurotransmission is received by one brain region from one or more other brain regions.

Has_pathway: a connectivity relation where a collection of neurons located in brain region A sends_output_to a collection of neurons located in B via axons comprising the fiber tract from brain region

References

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