Extending NI-DM to share the results and provenance of a neuroimaging study: an example with SPM

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Introduction

While data sharing is prevalent, if not mandatory, in other disciplines, data sharing in neuroimaging is largely still confined to a table of coordinates in a published paper.

Routine sharing of imaging data (e.g., 3D "activation" volumes, raw/ pre-processed data and associated metadata) would facilitate reproducibility/replication studies, meta-analyses and eventually support new discoveries in neuroscience or medicine [2].

In [3], we introduced the Neuroimaging Data Model (NI-DM), a domain-specific extension of the recently-approved W3C recommendation, PROV-DM [6].

Here, we extend NI-DM with NIDM-Results to model the results of statistical parametric mapping studies, such as fMRI brain mapping results, and their provenance (from model fitting to inference). We also provide a publicly-available specification of a domain-specific object model for the SPM software [7].

Methods

Through a weekly video conferences and focused workshops with experts in neuroimaging data analysis, we defined a recommended minimal set of neuroimaging metadata to be reported for SPM analyses. Each metadata term was assigned a Uniform Resource Identifier (URI) and definition to unambiguously represent a given concept.

Working with the SPM developers, we created an object model that balances complexity with expressivity and developed a formal specification document following the guidance of the W3C.

Results

A lexicon of terms was defined to capture general brain mapping analysis terms and, when appropriate terms were not found in existing terminologies, SPM-specific terms. Using the defined terms, the SPM results were modeled as PROV entities, activities, and agents with corresponding properties and attributes.

Figure 1 shows a simplified graph of the proposed data model and Figure 2 presents an example entity describing a cluster-statistic.

An automatic RDF serialization was developed within the SPM software to implement NI-DM as part of the official SPM12 release.

Conclusion

We have used NI-DM to represent brain mapping statistical results in SPM. Future work consists of publishing the neuroimaging terms in a public index and repeating the process for FSL [8] and AFNI [9]. We envision this work to ease the process of submitting neuroimaging results to journals during publication and facilitate meta-analyses.

References


SPM Data Model: Overview

Fig. 1: Overview of a neuroimaging experiment workflow and NI-DM components.

Fig. 2: A) Conceptual overview of the SPM statistical estimation and inference workflow. B) Overview of the proposed NI-DM extension which models the results of a neuroimaging study in SPM including entities (yellow), activities (blue) and agent (green).

Full specification available at: http://nidm.nidash.org/specs

Example of ClusterStatistic entity

Graphical representation:

SPARQL query: “Find cluster entities with p<0.05 FWE corrected”

More queries at: http://nidm.nidash.org/specs

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