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The Neuroimaging Data Model (NIDM) API

Project URL: http://nidm-api.readthedocs.org

Vanessa Sochat[1*] and B Nolan Nichols[2,3]

1 Introduction

The sharing of brain research can be aided by the Neuroimaging Data Model (NIDM) [1, 2, 3]. NIDM provides a community-based framework for developing data exchange standards that describe the primary observations, computational workflows, and derived results of neuroimaging studies [4]. While work is underway to integrate NIDM into the software used by the human brain mapping community, only low-level tools are currently available to access and query NIDM documents that rely on a graph-based representation called the Resource Description Framework (RDF) [5]. Further, technologies like RDF and the corresponding query language, SPARQL [6], pose a steep learning curve for users of standard Web development workflows. With the recent migration of tools for neuroimaging meta analysis [7, 8], sharing [9, 10, 11, 12, 13, 14, 15, 16, 17], and visualization [18, 19, 20] into the Web browser, Web developers will be incentivized by the ability to easily integrate brain data into Web applications using familiar languages and formats. The formats of choice for web development tend to be JavaScript and JavaScript Object Notation (JSON) [21, 22], commonly provided by way of an Application Programming Interface (API). The goal of this Brainhack project was to develop infrastructure to serve NIDM documents and queries using an API with a syntax that allows for the easy development of Web-based tools for the neuroimaging community.

2 Approach

The `nidm-api` [23] is a RESTful API and Web application that provides a simplified view of NIDM documents using formats that are accessible to Web developers and researchers without expertise in Linked Open Data (LOD) technologies. It includes two components. First, the `nidm-api` is a Python-based executable that works both as a command-line tool to run queries over NIDM documents, as well as to serve a RESTful API to allow a local or cloud-based server to execute queries on documents accessible by URL. Second, `nidm-queries` is a repository of SPARQL queries that the `nidm-api` application dynamically downloads, validates, and serves upon starting the application. This strategy means that NIDM developers can collaboratively construct SPARQL queries without requiring Web developers to gain expertise in LOD technology. The `nidm-api`, along with serving the queries, also provides a graphical Web interfaces to contribute new queries to the shared repository. By way of being a Python Flask [24] application, this makes the application able to perform as both an executable to serve the API [25], along with a set of functions that can be integrated into other Python-based frameworks [26] or cloud platforms that provide Python accessibility [27, 28].

3 Results

Using the API: Installation produces an executable, "nidm" that when run, downloads, validates, and provides a summary of available queries in the `nidm-queries` repository. A query can be further investigated by selecting its unique identifier:

http://localhost:8088/api/7950f524-90e8-4d54-ad6d-7b22af2e895d

and can then be executed in a RESTful fashion by including a variable to point to a local path or URL of a NIDM document:

*Correspondence: vsochat@stanford.edu
[1]Program in Biomedical Informatics, Stanford University, Stanford, 1265 Welch Road, 94306, California, USA
Full list of author information is available at the end of the article

http://localhost:8088/api/query/7950f524-90e8-4d54-ad6d-7b22af2e895d?ttl=/home/nidm.ttl

The API then runs the query over the document, and returns the result to the user in JSON. The same functionality can be achieved on the command line command line in the case that it is desired to integrate it directly into a server-based Python application.

Generating new queries: Researchers familiar with LOD can run the application in the same fashion, and go to a URL in their local browser:

http://localhost:8088/query/new

to reveal an interface to generate new queries. The web interface asks for a set of variables that are necessary for the `nidm-api` to serve the query. The query can be previewed, and then downloaded as a JSON object that can be submit to the `nidm-queries` repository to be added to the application.

Applications using NIDM: As an example of the utility of the NIDM standard, the NIDM results object model [29] has recently been integrated into the NeuroVault database, meaning that neuroimaging researchers can export results pertaining to statistical brain maps from common software [30] into NeuroVault. An nidm-viewer that runs queries over the nidm-results can then parse the coordinates and statistical parameters associated with significant locations of activations to be rendered in a table alongside a visualization of the brain map itself (Figure 1 and example). The raw data and parameters of the analysis are thus immediately available for sharing and publication, programatically accessible, and viewed from any web browser.

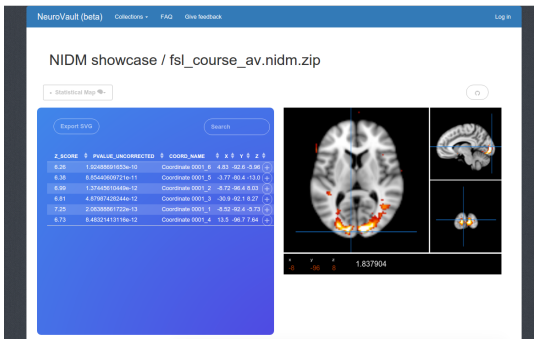

Figure 1. The nidm-viewer in the NeuroVault database queries nidm-result objects to generate an interactive table and statistical brain map.

4 Conclusions

By separating queries from the software to serve them, development of both can be optimized, and the NIDM standard more easily deployed into tools to empower neuroimaging researchers to explore and synthesize results, workflows, and experiments. This application will be extended to return more modern and desired outputs such as images and interactive graphs [31], and additional functionality will be added as the NIDM experiment, workflows, and results standards are further developed. The software and queries are both publicly available and open to contributions.

Availability of Supporting Data
More information about this project can be found at: http://nidm-api.readthedocs.org. Further data and files supporting this project are hosted in the *INCF NIDASH* repositories https://github.com/incf-nidash/nidm-api and https://github.com/incf-nidash/nidm-queries.

Competing interests
None

Author's contributions
VS and NN wrote the software and wrote the report.

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Author details
[1]Program in Biomedical Informatics, Stanford University, Stanford, 1265 Welch Road, 94306, California, USA. [2]SRI International, Menlo Park, 333 Ravenswood Ave, 94025, California, USA. [3]Department of Psychiatry and Behavioral Sciences, Stanford University, Stanford, 1265 Welch Road, 94306, California, USA.

References

1. Keator, D.B., Helmer, K., Steffener, J., Turner, J.A., Van Erp, T.G.M., Gadde, S., Ashish, N., Burns, G.A., Nichols, B.N.: Towards structured sharing of raw and derived neuroimaging data across existing resources. Neuroimage **82**, 647–661 (2013)
2. Neuroimaging Data Model Overview (NIDM-Overview). http://nidm.nidash.org/specs/nidm-overview.html. Accessed: 2015-11-24
3. NIDM Specifications. http://nidm.nidash.org/specs/. Accessed: 2015-11-3
4. - Neuroimaging Data Model. http://nidm.nidash.org/. Accessed: 2015-11-24
5. RDF - Semantic Web Standards. http://www.w3.org/RDF/. Accessed: 2015-11-24
6. SPARQL Query Language for RDF. http://www.w3.org/TR/rdf-sparql-query/. Accessed: 2015-11-24
7. Yarkoni, T., Poldrack, R.A., Nichols, T.E., Van Essen, D.C., Wager, T.D.: Large-scale automated synthesis of human functional neuroimaging data. Nat. Methods **8**(8), 665–670 (2011)
8. Reid, A.T., Bzdok, D., Genon, S., Langner, R., Müller, V.I., Eickhoff, C.R., Hoffstaedter, F., Cieslik, E.-C., Fox, P.T., Laird, A.R., Amunts, K., Eickhoff, S.B.: ANIMA: A data-sharing initiative for neuroimaging meta-analyses. Neuroimage (2015)
9. Crawford, K.L., Neu, S.C., Toga, A.W.: The image and data archive at the laboratory of neuro imaging. Neuroimage **124**(Pt B), 1080–1083 (2016)

10. Landis, D., Courtney, W., Dieringer, C., Kelly, R., King, M., Miller, B., Wang, R., Wood, D., Turner, J.A., Calhoun, V.D.: COINS data exchange: An open platform for compiling, curating, and disseminating neuroimaging data. Neuroimage **124**(Pt B), 1084–1088 (2016)
11. Book, G.A., Stevens, M.C., Assaf, M., Glahn, D.C., Pearlson, G.D.: Neuroimaging data sharing on the neuroinformatics database platform. Neuroimage **124**(Pt B), 1089–1092 (2016)
12. Herrick, R., Horton, W., Olsen, T., McKay, M., Archie, K.A., Marcus, D.S.: XNAT central: Open sourcing imaging research data. Neuroimage **124**(Pt B), 1093–1096 (2016)
13. Hodge, M.R., Horton, W., Brown, T., Herrick, R., Olsen, T., Hileman, M.E., McKay, M., Archie, K.A., Cler, E., Harms, M.P., Burgess, G.C., Glasser, M.F., Elam, J.S., Curtiss, S.W., Barch, D.M., Oostenveld, R., Larson-Prior, L.J., Ugurbil, K., Van Essen, D.C., Marcus, D.S.: ConnectomeDB-Sharing human brain connectivity data. Neuroimage **124**(Pt B), 1102–1107 (2016)
14. Jernigan, T.L., Brown, T.T., Hagler, D.J. Jr, Akshoomoff, N., Bartsch, H., Newman, E., Thompson, W.K., Bloss, C.S., Murray, S.S., Schork, N., Kennedy, D.N., Kuperman, J.M., McCabe, C., Chung, Y., Libiger, O., Maddox, M., Casey, B.J., Chang, L., Ernst, T.M., Frazier, J.A., Gruen, J.R., Sowell, E.R., Kenet, T., Kaufmann, W.E., Mostofsky, S., Amaral, D.G., Dale, A.M., Pediatric Imaging, Neurocognition and Genetics Study: The pediatric imaging, neurocognition, and genetics (PING) data repository. Neuroimage **124**(Pt B), 1149–1154 (2016)
15. Kini, L.G., Davis, K.A., Wagenaar, J.B.: Data integration: Combined imaging and electrophysiology data in the cloud. Neuroimage **124**(Pt B), 1175–1181 (2016)
16. Wang, L., Alpert, K.I., Calhoun, V.D., Cobia, D.J., Keator, D.B., King, M.D., Kogan, A., Landis, D., Tallis, M., Turner, M.D., Potkin, S.G., Turner, J.A., Ambite, J.L.: SchizConnect: Mediating neuroimaging databases on schizophrenia and related disorders for large-scale integration. Neuroimage **124**(Pt B), 1155–1167 (2016)
17. Gorgolewski, K.J., Varoquaux, G., Rivera, G., Schwarz, Y., Ghosh, S.S., Maumet, C., Sochat, V.V., Nichols, T.E., Poldrack, R.A., Poline, J.-B., Yarkoni, T., Margulies, D.S.: NeuroVault.org: a web-based repository for collecting and sharing unthresholded statistical maps of the human brain. Front. Neuroinform. **9** (2015)
18. Gutman, D.A., Dunn, W.D. Jr, Cobb, J., Stoner, R.M., Kalpathy-Cramer, J., Erickson, B.: Web based tools for visualizing imaging data and development of XNATView, a zero footprint image viewer. Front. Neuroinform. **8**, 53 (2014)
19. Gao, J.S., Huth, A.G., Lescroart, M.D., Gallant, J.L.: Pycortex: an interactive surface visualizer for fMRI. Front. Neuroinform. **9** (2015)
20. Research Imaging Institute — Mango. http://ric.uthscsa.edu/mango/index.html. Accessed: 2015-11-24
21. Wikipedia contributors: JSON. https://en.wikipedia.org/w/index.php?title=JSON&oldid=692109528. Accessed: 2015-11-24 (2015)
22. GitHut - Programming Languages and GitHub. http://githut.info/. Accessed: 2015-11-24
23. NIDM API — nidm 1.0 documentation. http://nidm-api.readthedocs.org/en/latest/. Accessed: 2015-11-24
24. Welcome to Flask — Flask Documentation (0.10). http://flask.pocoo.org/docs/0.10/. Accessed: 2015-11-3
25. Flask-RESTful — Flask-RESTful 0.2.1 documentation. http://flask-restful-cn.readthedocs.org/en/0.3.4/. Accessed: 2015-11-24
26. The Web framework for perfectionists with deadlines — Django. https://www.djangoproject.com/. Accessed: 2015-11-4
27. AWS Python Developer Center. https://aws.amazon.com/python/
28. Google: Python Runtime Environment. https://cloud.google.com/appengine/docs/python/. Accessed: 2015-11-24
29. NIDM-Results 1.1.0. http://nidm.nidash.org/specs/nidm-results_110.html. Accessed: 2015-11-24
30. Jenkinson, M., Beckmann, C.F., Behrens, T.E.J., Woolrich, M.W., Smith, S.M.: FSL. Neuroimage **62**(2), 782–790 (2012)
31. Neo4j, the World's Leading Graph Database. http://neo4j.com/. Accessed: 2015-11-24