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Annotating OGC web feature services automatically for generating geospatial knowledge graphs

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Abstract

The Spatial Data Infrastructure initiatives are now broadly developed and deployed. However, while plenty of tools use them, some tasks are still complex to perform by non-expert users, such as finding, accessing, and using some of their related OGC Web Services (OWS). One of the main reasons for these challenges is associated with semantic heterogeneity within these services. This entails a lack of proper descriptions and requires knowledge about data structure and domain-specific query languages to discover and retrieve these services. Semantic annotations of OWS play a crucial role in achieving semantic interoperability and addressing these associated challenges. In this article we describe an approach for enabling the automatic generation of semantic annotations of Web Feature Services (WFS) at their three request levels (GetCapabilities, DescribeFeatureType, and GetFeature), which are used to generate knowledge graphs. This approach uses various external services, ontological resources (POSM, DBpedia, GeoSPARQL, GeoNames, and datos.ign.es vocabularies), and knowledge bases (DBpedia and datos.ign.es). Moreover, this approach enables us to validate annotations obtained as a previous step to generating geospatial knowledge graphs. Additionally, we present our proposal through an application case and assess it using a representative set of 21 WFS services, achieving an average of 46.70% annotations, of which 22.29% and 35.52% were validated using DBpedia and

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- 1 Abhayaratna, J., van den Brink, L., Car, N., Atkinson, R., Homburg, T., Knibbe, F., Thiery, F.
(2020) *OGC benefits of representing spatial data using semantic and graph technologies*. Cited 4 times.
Retrieved from
<http://docs.ogc.org/wp/19-078r1/19-078r1.html>

- 2 Auer, S., Bizer, C., Kobilarov, G., Lehmann, J., Cyganiak, R., Ives, Z.
DBpedia: A nucleus for a Web of open data ([Open Access](#))

(2007) *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 4825 LNCS, pp. 722-735. Cited 2277 times.
ISBN: 3540762973; 978-354076297-3
doi: 10.1007/978-3-540-76298-0_52

[View at Publisher](#)

- 3 Bechhofer, S., Carr, L., Goble, C., Kampa, S., Miles-Board, T.
The semantics of semantic annotation ([Open Access](#))

(2002) *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 2519 LNCS, pp. 1152-1167. Cited 34 times.
<https://www.springer.com/series/558>
ISBN: 3540001069; 978-354000106-5
doi: 10.1007/3-540-36124-3_73

[View at Publisher](#)

- 4 BernersLee, T.
(2006) *Linked data design issues*. Cited 870 times.
Retrieved from
<https://www.w3.org/DesignIssues/LinkedData.html>

- 5 Brachman, R.J.
On the epistemological status of semantic networks
(1979) *Associative networks*, pp. 3-50. Cited 344 times.
N. V. Findler, (Ed.),, Orlando, FL, Academic Press
<https://doi.org/10.1016/B978-0-12-256380-5.50007-4>

- 6 Bucher, B., Folmer, E., Brennan, R., Beek, W., Hbeich, E., Wriehausen, F., Di Donato, P.
(2021) *Spatial linked data in Europe: Report from spatial linked data session at knowledge graph in action*. Cited 3 times.
Retrieved from
http://www.eurosdrr.net/sites/default/files/uploadedfiles/eurosdrr_publication_ndeg_73.pdf
-

- 7 Corcho, O.
Ontology based document annotation: Trends and open research problems ([Open Access](#))

(2006) *International Journal of Metadata, Semantics and Ontologies*, 1 (1), pp. 47-57. Cited 65 times.
<http://www.inderscience.com/ijmso>
doi: 10.1504/IJMISO.2006.008769

View at Publisher
-

- 8 Cromptvoets, J.
(2006) *National spatial data clearinghouses: Worldwide development and impact*. Cited 25 times.
(Unpublished PhD dissertation), Wageningen, The Netherlands, Wageningen University
-

- 9 Dareshiri, S., Farnaghi, M., Sahelgozin, M.
A recommender geoportal for geospatial resource discovery and recommendation

(2019) *Journal of Spatial Science*, 64 (1), pp. 49-71. Cited 3 times.
<http://www.tandfonline.com/toc/tjss20/current>
doi: 10.1080/14498596.2017.1397559

View at Publisher
-

- 10 De Andrade, F.G., De Souza Baptista, C., Henriques, H.B.
Semantic annotation of geodata based on linked-open data

(2015) *7th International ACM Conference on Management of Computational and Collective Intelligence in Digital EcoSystems, MEDES 2015*, pp. 9-16. Cited 3 times.
ISBN: 978-145033480-8
doi: 10.1145/2857218.2857220

View at Publisher
-

- 11 Djezzar, M., Hemam, M., Maimour, M., Amara, F.Z., Falek, K., Seghir, Z.A.
An approach for Semantic Enrichment of Sensor Data

(2018) *Proceedings - PAIS 2018: International Conference on Pattern Analysis and Intelligent Systems*, art. no. 8598506.
<http://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?punumber=8579098>
ISBN: 978-153864238-2
doi: 10.1109/PAIS.2018.8598506

View at Publisher
-

- 12 Egenhofer, M.J.
Toward the Semantic Geospatial Web

(2002) *Proceedings of the ACM Workshop on Advances in Geographic Information Systems*, pp. 1-4. Cited 267 times.
doi: 10.1145/585147.585148

View at Publisher
-
- 13 Ehrlinger, L., Woß, W.
Towards a definition of knowledge graphs
(2016) *Proceedings of the 12th International Conference on Semantic Systems*, pp. 1-4. Cited 174 times.
Leipzig, Germany (, New York, NY, ACM, Retrieved from
<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.1054.8298&rep=rep1&type=pdf>
-
- 14 Ferragina, P., Scaiella, U.
TAGME: On-the-fly annotation of short text fragments (by Wikipedia entities)

(2010) *International Conference on Information and Knowledge Management, Proceedings*, pp. 1625-1628. Cited 464 times.
ISBN: 978-145030099-5
doi: 10.1145/1871437.1871689

View at Publisher
-
- 15 Friis-Christensen, A., Lucchi, R., Lutz, M., Ostländer, N.
Service chaining architectures for applications implementing distributed geographic information processing

(2009) *International Journal of Geographical Information Science*, 23 (5), pp. 561-580. Cited 64 times.
doi: 10.1080/13658810802665570

View at Publisher
-
- 16 Georgiadou, Y., Rodriguez-Pabón, O., Lance, K.T.
Spatial data infrastructure (SDI) and E-governance: A quest for appropriate evaluation approaches

(2006) *URISA Journal*, 18 (2), pp. 43-55. Cited 24 times.
http://www.urisa.org/files/2Georgiadou_sdi.pdf
-
- 17 Giuliani, G., Lacroix, P., Guigoz, Y., Roncella, R., Bigagli, L., Santoro, M., Mazzetti, P., (...), Lehmann, A.
Bringing GEOSS Services into Practice: A Capacity Building Resource on Spatial Data Infrastructures (SDI)

(2017) *Transactions in GIS*, 21 (4), pp. 811-824. Cited 22 times.
<http://www.blackwellpublishers.co.uk/journals/TGIS/descript.htm>
doi: 10.1111/tgis.12209

View at Publisher
-

-
- 18 Gruber, T.R.
Toward principles for the design of ontologies used for knowledge sharing
(1995) *International Journal of Human - Computer Studies*, 43 (5-6), pp. 907-928. Cited 4035 times.
doi: 10.1006/ijhc.1995.1081
View at Publisher
-
- 19 (2012) *The SDI cookbook*. Cited 5 times.
Retrieved from
<http://gsdiassociation.org/images/publications/cookbooks/SDICookbookfromWiki2012update.pdf>
-
- 20 Huang, W., Harrie, L.
Towards knowledge-based geovisualisation using Semantic Web technologies: a knowledge representation approach coupling ontologies and rules (Open Access)
(2020) *International Journal of Digital Earth*, 13 (9), pp. 976-997. Cited 7 times.
<http://www.tandfonline.com/toc/tjde20/current>
doi: 10.1080/17538947.2019.1604835
View at Publisher
-
- 21 Huang, W., Raza, S.A., Mirzov, O., Harrie, L.
Assessment and benchmarking of spatially enabled RDF stores for the next generation of spatial data infrastructure (Open Access)
(2019) *ISPRS International Journal of Geo-Information*, 8 (7), art. no. 310. Cited 9 times.
<https://www.mdpi.com/2220-9964/8/7>
doi: 10.3390/ijgi8070310
View at Publisher
-
- 22 Janowicz, K., Schade, S., Bröring, A., Keßler, C., Maué, P., Stasch, C.
Semantic enablement for spatial data infrastructures
(2010) *Transactions in GIS*, 14 (2), pp. 111-129. Cited 125 times.
doi: 10.1111/j.1467-9671.2010.01186.x
View at Publisher
-
- 23 Jiang, L., Yue, P., Kuhn, W., Zhang, C., Yu, C., Guo, X.
Advancing interoperability of geospatial data provenance on the web: Gap analysis and strategies
(2018) *Computers and Geosciences*, 117, pp. 21-31. Cited 14 times.
www.elsevier.com/inca/publications/store/3/9/8/
doi: 10.1016/j.cageo.2018.05.001
View at Publisher
-

- 24 Jones, J., Kuhn, W., Keßler, C., Scheider, S.
Making the web of data available via web feature services
([Open Access](#))
- (2014) *Lecture Notes in Geoinformation and Cartography*, pp. 341-361. Cited 19 times.
ISBN: 978-331903610-6
doi: 10.1007/978-3-319-03611-3_20
- [View at Publisher](#)
-
- 25 Kalantari, M., Rajabifard, A., Olfat, H., Pettit, C., Keshtiarast, A.
Automatic spatial metadata systems—the case of Australian urban research infrastructure network
- (2017) *Cartography and Geographic Information Science*, 44 (4), pp. 327-337. Cited 7 times.
<http://www.tandfonline.com/toc/tcag20/current#.UX5YJbWmio4>
doi: 10.1080/15230406.2016.1154805
- [View at Publisher](#)
-
- 26 Kiryakov, A., Popov, B., Terziev, I., Manov, D., Ognyanoff, D.
Semantic annotation, indexing, and retrieval
- (2004) *Web Semantics*, 2 (1), pp. 49-79. Cited 449 times.
doi: 10.1016/j.websem.2004.07.005
- [View at Publisher](#)
-
- 27 Klien, E., Lutz, M.
The role of spatial relations in automating the semantic annotation of geodata
- (2005) *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 3693 LNCS, pp. 133-148. Cited 27 times.
ISBN: 354028964X; 978-354028964-7
doi: 10.1007/11556114_9
- [View at Publisher](#)
-
- 28 Klien, E., Lutz, M., Kuhn, W.
Ontology-based discovery of geographic information services - An application in disaster management
- (2006) *Computers, Environment and Urban Systems*, 30 (1), pp. 102-123. Cited 125 times.
doi: 10.1016/j.compenvurbsys.2005.04.002
- [View at Publisher](#)
-
- 29 Kuhn, W.
Geospatial semantics: Why, of what, and how? ([Open Access](#))
- (2005) *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 3534 LNCS, pp. 1-24. Cited 116 times.
<https://www.springer.com/series/558>
ISBN: 3540262253; 978-354026225-1
doi: 10.1007/11496168_1
- [View at Publisher](#)
-

-
- 30 Lemmens, R., Wytzisk, A., de By, R., Granell, C., Gould, M., van Oosterom, P.
Integrating semantic and syntactic descriptions to chain geographic services
(2006) *IEEE Internet Computing*, 10 (5), pp. 42-52. Cited 64 times.
doi: 10.1109/MIC.2006.106
[View at Publisher](#)
-
- 31 Liao, Y., Lezoche, M., Panetto, H., Boudjlida, N., Loures, E.R.
Semantic annotation for knowledge explicitation in a product lifecycle management context: A survey ([Open Access](#))
(2015) *Computers in Industry*, 71, art. no. 2670, pp. 24-34. Cited 37 times.
<https://www.journals.elsevier.com/computers-in-industry>
doi: 10.1016/j.compind.2015.03.005
[View at Publisher](#)
-
- 32 Liao, Y., Lezoche, M., Panetto, H., Boudjlida, N.
Why, where and how to use semantic annotation for systems interoperability
(2011) *Proceedings of the First UNITE Doctoral Symposium*, pp. 71-78. Cited 7 times.
Bucarest, Romania
-
- 33 Lutz, M., Sprado, J., Klien, E., Schubert, C., Christ, I.
Overcoming semantic heterogeneity in spatial data infrastructures
(2009) *Computers and Geosciences*, 35 (4), pp. 739-752. Cited 63 times.
doi: 10.1016/j.cageo.2007.09.017
[View at Publisher](#)
-
- 34 Lutz, M., Einspanier, U., Klien, E., Huebner, S.
An architecture for ontology-based discovery and retrieval of geographic information
(2004) *Proceedings of the Seventh AGILE Conference on Geographic Information Science*, pp. 574-578. Cited 35 times.
Crete, Greece
-
- 35 Lutz, M., Klien, E.
Ontology-based retrieval of geographic information
(2006) *International Journal of Geographical Information Science*, 20 (3), pp. 233-260. Cited 158 times.
doi: 10.1080/13658810500287107
[View at Publisher](#)
-
- 36 Lutz, M.
Ontology-Based descriptions for semantic discovery and composition of geoprocessing services
(2007) *GeoInformatica*, 11 (1), pp. 1-36. Cited 86 times.
doi: 10.1007/s10707-006-7635-9
[View at Publisher](#)
-

- 37 Lutz, M., Kolas, D.
Rule-based discovery in spatial data infrastructure

(2007) *Transactions in GIS*, 11 (3), pp. 317-336. Cited 34 times.
doi: 10.1111/j.1467-9671.2007.01048.x

View at Publisher
-
- 38 Macário, C.G.N., De Sousa, S.R., Medeiros, C.B.
Annotating geospatial data based on its semantics

(2009) *GIS: Proceedings of the ACM International Symposium on Advances in Geographic Information Systems*, pp. 81-90. Cited 9 times.
ISBN: 978-160558649-6
doi: 10.1145/1653771.1653786

View at Publisher
-
- 39 Masser, I., Rajabifard, A., Williamson, I.
Spatially enabling governments through SDI implementation
(Open Access)

(2008) *International Journal of Geographical Information Science*, 22 (1), pp. 5-20. Cited 51 times.
doi: 10.1080/13658810601177751

View at Publisher
-
- 40 Maué, P.
An extensible semantic catalogue for geospatial web services
(2008) *International Journal of Spatial Data Infrastructures Research*, 3, pp. 168-191. Cited 10 times.
-
- 41 Maué, P., Michels, H., Roth, M.
Injecting semantic annotations into (geospatial) Web service descriptions

(2012) *Semantic Web*, 3 (4), pp. 385-395. Cited 7 times.
doi: 10.3233/SW-2012-0061

View at Publisher
-
- 42 Maué, P., Schade, S., Duchesne, P.
(2009) *Semantic annotations in OGC standards*. Cited 12 times.
Retrieved from
<https://portal.ogc.org/files/?artifactid=34916>
-
- 43 McDonald, J., LevineClark, M.
(2017) *Encyclopedia of library and information sciences*. Cited 7 times.
(Eds.), (4th ed., Boca Raton, FL, CRC Press
-

-
- 44 Mendes, P.N., Jakob, M., García-Silva, A., Bizer, C.
DBpedia spotlight: Shedding light on the web of documents

(2011) *ACM International Conference Proceeding Series*, pp. 1-8. Cited 723 times.
ISBN: 978-145030621-8
doi: 10.1145/2063518.2063519

View at Publisher
-
- 45 Moro, A., Raganato, A., Navigli, R.
Entity linking meets word sense disambiguation: A unified approach
(2014) *Transactions of the Association for Computational Linguistics*, 2, pp. 231-244. Cited 495 times.
<https://doi.org/10.1162/tacla00179>
-
- 46 Newell, A.
The knowledge level

(1982) *Artificial Intelligence*, 18 (1), pp. 87-127. Cited 1238 times.
doi: 10.1016/0004-3702(82)90012-1

View at Publisher
-
- 47 Oren, E., Moller, K., Scerri, S., Handschuh, S., Sinte, M.
What are semantic annotations
(2006) *DERI Galway*, 9, p. 62. Cited 44 times.
-
- 48 Paulheim, H.
Knowledge graph refinement: A survey of approaches and evaluation methods

(2017) *Semantic Web*, 8 (3), pp. 489-508. Cited 489 times.
www.semantic-web-journal.net/
doi: 10.3233/SW-160218

View at Publisher
-
- 49 Perry, M., Herring, J.
(2012) *GeoSPARQL: A geographic query language for RDF data*. Cited 227 times.
(Eds.), Retrieved from
<https://portal.opengeospatial.org/files/?artifactid=47664>
-
- 50 Phillips, A., Williamson, I., Ezigbalike, C.
Spatial data infrastructure concepts

(1999) *Australian Surveyor*, 44 (1), pp. 20-28. Cited 21 times.
doi: 10.1080/00050351.1999.10558768

View at Publisher
-

- 51 Prudhomme, C., Homburg, T., Ponciano, J.-J., Boochs, F., Cruz, C., Roxin, A.-M.
Interpretation and automatic integration of geospatial data into the Semantic Web: Towards a process of automatic geospatial data interpretation, classification and integration using semantic technologies
(2020) *Computing*, 102 (2), pp. 365-391. Cited 8 times.
<http://www.springerlink.com/content/0010-485X>
doi: 10.1007/s00607-019-00701-y
View at Publisher
-
- 52 Saquicela, V., Vilches-Blázquez, L.M., Corcho, O.
Adding semantic annotations into (Geospatial) RESTful services (Open Access)
(2012) *International Journal on Semantic Web and Information Systems*, 8 (2), pp. 51-71. Cited 9 times.
doi: 10.4018/jswis.2012040103
View at Publisher
-
- 53 Tandy, J., van den Brink, L., Barnaghi, P.
(2017) *Spatial data on the web: Best practices*. Cited 22 times.
(Eds.), (W3C Working Group Note). Retrieved from
<https://www.w3.org/TR/sdw-bp/>
-
- 54 Vancauwenberghe, G., Valeckaite, K., Van Loenen, B., Donker, F.W.
Assessing the openness of spatial data infrastructures (SDI): Towards a map of open SDI
(2018) *International Journal of Spatial Data Infrastructures Research*, 13, pp. 88-100. Cited 7 times.
-
- 55 Vandembroucke, D., Crompvoets, J., Vancauwenberghe, G., Dessers, E., Van Orshoven, J.
A network perspective on spatial data infrastructures: Application to the sub-national SDI of flanders (Belgium)
(2009) *Transactions in GIS*, 13 (SUPPL. 1), pp. 105-122. Cited 31 times.
doi: 10.1111/j.1467-9671.2009.01166.x
View at Publisher
-
- 56 Vilches-Blázquez, L.M., Saavedra, J.
A framework for connecting two interoperability universes: OGC Web Feature Services and Linked Data
(2019) *Transactions in GIS*, 23 (1), pp. 22-47. Cited 9 times.
[http://onlinelibrary.wiley.com/journal/10.1111/\(ISSN\)1467-9671](http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1467-9671)
doi: 10.1111/tgis.12496
View at Publisher
-

- 57 Wiemann, S., Bernard, L.
Spatial data fusion in Spatial Data Infrastructures using Linked Data

(2016) *International Journal of Geographical Information Science*, 30 (4), pp. 613-636. Cited 38 times.
<http://www.tandf.co.uk/journals/titles/13658816.asp>
doi: 10.1080/13658816.2015.1084420

View at Publisher
-
- 58 Yu, F., West, G., Arnold, L., McMeekin, D., Moncrieff, S.
Automatic geospatial data conflation using semantic web technologies

(2016) *ACM International Conference Proceeding Series*, 01-05-February-2016, art. no. a57. Cited 4 times.
<http://portal.acm.org/>
ISBN: 978-145034042-7
doi: 10.1145/2843043.2843375

View at Publisher
-
- 59 Yue, P., Di, L., Zhao, P., Yang, W., Yu, G., Wei, Y.
Semantic augmentations for geospatial catalogue service

(2006) *International Geoscience and Remote Sensing Symposium (IGARSS)*, art. no. 4242042, pp. 3469-3472. Cited 19 times.
ISBN: 0780395107; 978-078039510-7
doi: 10.1109/IGARSS.2006.894

View at Publisher
-
- 60 Yue, P., Di, L., Yang, W., Yu, G., Zhao, P.
Semantics-based automatic composition of geospatial Web service chains

(2007) *Computers and Geosciences*, 33 (5), pp. 649-665. Cited 172 times.
doi: 10.1016/j.cageo.2006.09.003

View at Publisher
-
- 61 Yue, P., Di, L., Yang, W., Yu, G., Zhao, P., Gong, J.
Semantic web services-based process planning for earth science applications

(2009) *International Journal of Geographical Information Science*, 23 (9), pp. 1139-1163. Cited 38 times.
doi: 10.1080/13658810802032680

View at Publisher
-
- 62 Yue, P., Gong, J., Di, L., He, L., Wei, Y.
Integrating semantic web technologies and geospatial catalog services for geospatial information discovery and processing in cyberinfrastructure

(2011) *GeoInformatica*, 15 (2), pp. 273-303. Cited 56 times.
doi: 10.1007/s10707-009-0096-1

View at Publisher
-

- 63 Yue, P., Guo, X., Zhang, M., Jiang, L., Zhai, X.
Linked Data and SDI: The case on Web geoprocessing workflows

(2016) *ISPRS Journal of Photogrammetry and Remote Sensing*, 114, pp. 245-257. Cited 35 times.

www.elsevier.com/inca/publications/store/5/0/3/3/4/0

doi: 10.1016/j.isprsjprs.2015.11.009

[View at Publisher](#)

- 64 Zhao, T., Zhang, C., Li, W.
Accessing distributed WFS data through a RDF query interface
(2016) *Proceedings of the Ninth International Conference on Geographic Information Science*, pp. 376-379. Cited 3 times.
Montreal, QC, Canada (.). Retrieved from
<https://escholarship.org/content/qt9fs8s68v/qt9fs8s68v.pdf>

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