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MapGenOnto: A Shared Ontology for Map Generalisation and Multi-Scale Visualisation

Guillaume Touya[a]*

[a] *LASTIG, Univ Gustave Eiffel, ENSG, IGN, F-94160 Saint-Mandé, France, firstname.lastname@ign.fr*

* Corresponding Author

Abstract: The usefulness of ontologies for map generalisation and on-demand mapping has been acknowledged by the research community for now more than ten years. But past attempts to build an ontology that shares the conceptualisation views of the community have fell short for now, maybe due to a lack of direct use cases. MapGenOnto is a new attempt to gather researchers around a shared ontology that covers the description of the geography and the map, and also the generalisation processes used to generalise this map. This short paper briefly describes the backbone concepts of this ontology, and then presents a use case to describe cross-platform ScaleMaster2.0 specifications.

Keywords: map generalisation, multi-scale, ontology, spatial relations, constraints

1. Introduction

Modelling the geography behind the map is a key step to design successful automated generalisation systems. Fifteen years ago, when ontologies started being popular in geographical information science, researchers proposed to use this formalism to model map generalisation processes (Dutton and Edwardes, 2006, Regnauld, 2007, Lüscher et al., 2008). An ontology is "a formal, explicit specification of a shared conceptualization" (Gruber, 1995), which means that it is a formal model of the concepts, objects, properties, with an explicit representation that enables logical reasoning on these concepts. So ontologies can be useful tools in map generalisation in two main ways: (1) defining a shared vocabulary of the concepts handled in map generalisation (Touya et al., 2010); (2) enabling logical reasoning on these concepts (Gould and Chaudhry, 2012). Automated or semi-automated on-demand mapping systems would benefit from both uses (Balley and Regnauld, 2011, Gould and Mackaness, 2016), so there is a real need for a usable ontology of map generalisation concepts. But the definition of an ontology cited above contains the word "shared", and this word explains the challenge of building an ontology: the users, or at least several designers need to agree on this formalisation of the concepts. Building on the discussions of a workshop organised in 2014 by the ICA commission on map generalisation and multiple representation (Mackaness et al., 2015), a first version of such an ontology was made available on the website of the commission, but it did not draw so much attention from the community. As a consequence, it can hardly be considered as a shared conceptualisation. MapGenOnto is a new iteration of this first shared ontology, and a new attempt to specify this shared conceptualisation of map generalisation. In the discussions during past workshops, it was highlighted that the ontology should be accompanied by actual uses to foster the collaborative enrichment and use of the ontology. So this paper also contains a direct application of this ontology to make the ScaleMaster2.0 model portable across platforms.

2. MapGenOnto

MapGenOnto is available on the web and cannot be completely presented in this short paper. Figure 1 presents some of the main backbone concepts of MapGenOnto. The concepts in red in Figure 1 are a mix of the concepts proposed in CollaGen (Touya et al., 2010) and by (Gould and Mackaness, 2016), to model how algorithms are chained in an automated generalisation process (Regnauld et al., 2014): a generalisation *Model* encapsulates *Operations* and both *have effects* on a *Remedy* that *relieves* a *Conflict*. In the figure, the relation *applies to* of the *Algorithm* concept means that the range of the relation is a *Landscape* (e.g. urban area) and/or a *Scale range* (e.g. 1:25k to 1:50k), and/or a *Feature type*, and/or a *Geometry*. The same relation exists with *Process* but it is not drawn in Figure 1.

The blue concepts in Figure 1 correspond to a mix of the ontologies we previously proposed to describe the features contained in a map, including the spatial relations (Touya et al., 2010, Touya et al., 2014). For now, the topological relations included in the ontology are a port of the DE-9IM model (Egenhofer et al., 1994), but we plan to replace this port by an inclusion of the topology ontology that was designed for the GeoSPARQL standard[1], which also includes formal concepts of the RCC8 topology model (Randell et al., 1992).

The *Cartographic property* concept enables a description of the properties/characteristics useful for generalisation (e.g. road importance, building area...). Similarly to a cartographic property, we included a *Geographic property* concept (not displayed in Figure 1), to represent properties related to the geographic function of the map feature, because these properties are sometimes important to make decisions during the generalisation process.

The *Geometry* concept reuses an upper level ontology from the literature that models GIS geometries (Hamdi et al., 2014). It is important to reuse as much as possible existing standard ontology in geographical information science to

[1] http://www.opengis.net/ont/geosparql

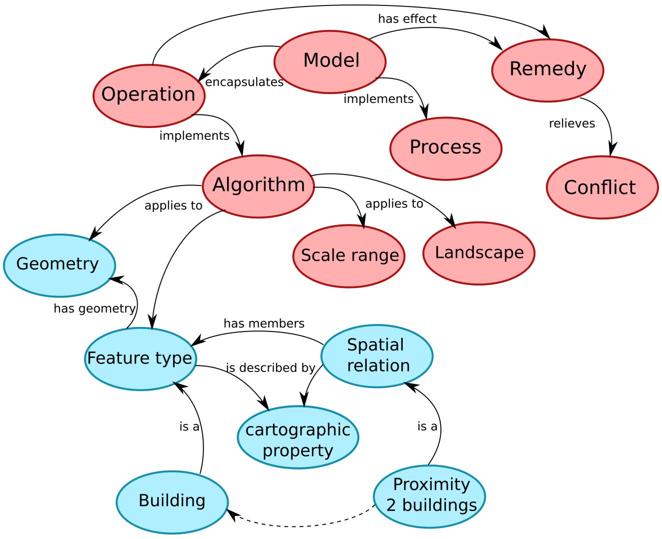

Figure 1. Figure placement and numbering: the famous ICA logo.

maximise future connections of MapGenOnto with other Semantic Web initiatives.

Then, as shown with the *Building* and *Proximity 2 buildings* concepts in Figure 1, each of these backbone concepts has more specific sub-concepts. For instance, *Filtering* or *Displacement* are sub-concepts of *Operation*, while *Douglas_Peucker* is a sub-concept of *Algorithm* that implements the *Filtering* concept.

3. Using MapGenOnto in the ScaleMaster2.0

The remainder of the abstract describes how this ontology is used in the ScaleMaster2.0 model (Touya and Girres, 2013) to make it portable and cross-platform. The code below is an extract of an XML-encoded ScaleMaster2.0 that describes how to generate multi-scale maps with OpenStreetMap data. This extracts corresponds to the generalisation of water lines at the 1:50k scale. There is only one generalisation algorithm required, a Raposo hexagon-based filtering of the geometry (Raposo, 2013). The name of the algorithm *raposo*, as well as the parameter name and type are directly extracted from the ontology. So, the same ScaleMaster2.0 can be used in different software solutions, without changing the way feature type, their properties, algorithm and their parameters, are named. To use this ScaleMaster2.0 in the CartAGen (Touya et al., 2019) implementation of the model, we just need to add a configuration file that annotates the feature type and the algorithms with their ontology counterpart. For instance, for CartAGen, the *raposo* algorithm is implemented in the *RaposoSimplification* Java class.

```
<generalisation-processes>
 <process priority= 0>
  <name>raposo</name>
  <params>
   <parameter name="use_method_1" type="
       Boolean">true</parameter>
  </params>
 </process>
</generalisation-processes>
```

4. Conclusion and Future Work

To conclude, the MapGenOnto is an attempt for a shared ontology of the map generalisation domain, which can be useful to design generic models independent from the implementation in a GIS software, or to carry out logical inferences in automated systems (Gould and Mackaness, 2016). MapGenOnto tries to synthesize the past propositions of ontologies for map generalisation, but is clearly an on-going project, far from complete. Most of the concepts that subsume the backbone concepts presented here, are missing in the ontology. MapGenOnto is made available on WebProtégé , a platform that enables collaborative work, so it is up to the map generalisation community to adopt and enrich it. In the meantime, we plan to enrich it through use cases in the open source CartAGen platform (Touya et al., 2019), for instance by finalising the open source implementation of the CollaGen model (Touya et al., 2010, Touya and Duchêne, 2011). We also plan to enrich the representation of scale and level of detail in the ontology, for instance by adapting the ontology design pattern proposed for map scaling (Carral et al., 2013). Finally, in the context of deep learning pattern recognition (Touya and Lokhat, 2020), we plan to use the ontology to annotate the complex features to be recognised in the map images, revamping the work from Lüscher (Lüscher et al., 2008).

References

Balley, S. and Regnauld, N., 2011. Models and Standards for On-Demand Mapping. In: *Proceedings of 25th International Cartographic Conference (ICC'11)*, Paris, France.

Carral, D., Scheider, S., Janowicz, K., Vardeman, C., Krisnadhi, A. and Hitzler, P., 2013. An Ontology Design Pattern for Cartographic Map Scaling. In: P. Cimiano, O. Corcho, V. Presutti, L. Hollink and S. Rudolph (eds), *The Semantic Web: Semantics and Big Data*, Lecture Notes in Computer Science, Vol. 7882, Springer Berlin Heidelberg, pp. 76–93.

Dutton, G. and Edwardes, A., 2006. Ontological Modeling of Geographical Relationships for Map Generalization. In: *9th ICA Workshop on Generalisation and Multiple Representation*, Portland, USA.

Egenhofer, M. J., Clementini, E. and Di Felice, P., 1994. Topological relations between regions with holes. *International Journal of Geographical Information Science* 8(2), pp. 129–142.

Gould, N. and Chaudhry, O. Z., 2012. An Ontological approach to On-demand Mapping. In: *Proceedings of 15th ICA Generalisation Workshop*, Istanbul, Turkey.

Gould, N. and Mackaness, W., 2016. From taxonomies to ontologies: formalizing generalization knowledge for on-demand mapping. *Cartography and Geographic Information Science* 43(3), pp. 208–222.

Gruber, T. R., 1995. Toward principles for the design of ontologies used for knowledge sharing? *International Journal of Human-Computer Studies* 43(5-6), pp. 907–928.

Hamdi, F., Abadie, N., Bucher, B. and Feliachi, A., 2014. GeomRDF: A Geodata Converter with a Fine-Grained Structured Representation of Geometry in the Web. In: *1st International Workshop on Geospatial Linked Data (GeoLD 2014). In Conjunction with the 10th International Conference on Semantic Systems*, Leipzig, Germany.

Lüscher, P., Weibel, R. and Mackaness, W. A., 2008. Where is the Terraced House? On the Use of Ontologies for Recognition of Urban Concepts in Cartographic Databases. In: A. Ruas and C. Gold (eds), *Headway in Spatial Data Handling*, pp. 449–466.

Mackaness, W. A., Gould, N., Bechhofer, S., Burghardt, D., Duchene, C., Stevens, R. and Touya, G., 2015. Thematic workshop on building an ontology of generalisation for on-demand mapping. In: *Proceedings of 4th UK Ontology Network Workshop*, Leeds, UK.

Randell, D. A., Cui, Z. and Cohn, A. G., 1992. A Spatial Logic based on Regions and Connection. In: *Proceedings of 3rd International Conference on Knowledge Representation and Reasoning*, Morgan Kaufmann Publishers Inc., pp. 165–176.

Raposo, P., 2013. Scale-specific automated line simplification by vertex clustering on a hexagonal tessellation. *Cartography and Geographic Information Science* 40(5), pp. 427–443.

Regnauld, N., 2007. Evolving from automating existing map production systems to producing maps on demand automatically. In: *10th ICA Workshop on Generalisation and Multiple Representation*, ICA. event-place: Moscow, Russia.

Regnauld, N., Touya, G., Gould, N. and Foerster, T., 2014. Process Modelling, Web Services and Geoprocessing. In: D. Burghardt, C. Duchêne and W. Mackaness (eds), *Abstracting Geographic Information in a Data Rich World*, Springer, Berlin Heidelberg, pp. 198–225.

Touya, G. and Duchêne, C., 2011. CollaGen: Collaboration between automatic cartographic Generalisation Processes. Lecture Notes in Geoinformation and Cartography, Vol. 1, Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 541–558.

Touya, G. and Girres, J.-F., 2013. ScaleMaster 2.0: a ScaleMaster extension to monitor automatic multi-scales generalizations. *Cartography and Geographic Information Science* 40(3), pp. 192–200.

Touya, G. and Lokhat, I., 2020. Deep Learning for Enrichment of Vector Spatial Databases: Application to Highway Interchange. *ACM Transactions on Spatial Algorithms and Systems* 6(3), pp. 21. Publisher: ACM.

Touya, G., Bucher, B., Falquet, G., Jaara, K. and Steiniger, S., 2014. Modelling Geographic Relationships in Automated Environments. In: D. Burghardt, C. Duchêne and W. Mackaness (eds), *Abstracting Geographic Information in a Data Rich World*, Springer, Berlin Heidelberg, pp. 53–82.

Touya, G., Duchêne, C. and Ruas, A., 2010. Collaborative Generalisation: Formalisation of Generalisation Knowledge to Orchestrate Different Cartographic Generalisation Processes. In: S. Fabrikant, T. Reichenbacher, M. van Kreveld and C. Schlieder (eds), *Geographic Information Science*, Lecture Notes in Computer Science, Vol. 6292, Springer Berlin / Heidelberg, Berlin, Heidelberg, pp. 264–278.

Touya, G., Lokhat, I. and Duchêne, C., 2019. CartAGen: an Open Source Research Platform for Map Generalization. *Proceedings of the ICA* 2, pp. 1–9.