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GeoChangeViz: visualizing Knowledge Graphs about changes in geographical divisions

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Abstract

Geographical divisions (GD) being administrative, parcel or census divisions frequently change over time. When such changes are not well documented, they introduce biases in the understanding of the evolution of such a given area. To cope with this problem, we have designed a Knowledge Graph (KG) that allows for the description of many GDs in the world and the changes they undergone over time. In this demo, we present a Web application called GeoChange-Viz that connects to this KG and provides spatial planners with an innovative tool for geovisualizing and understanding territorial changes over time.

Keywords

Spatiotemporal Knowledge Graph, Knowledge Graph visualization, Linked Geospatial Data

1. Introduction

All over the world, different kinds of Geographical divisions (GD) (being administrative, electoral, census or parcel divisions) are defined by (local) authorities. Following administrative or political reforms and decrees, the boundaries, name or identifier of these GD change over time. For instance, in the United States, census units are frequently redefined to maintain an equivalent number of inhabitants per unit. When such changes are not well documented, they are major obstacles to the understanding of a study area. As a result, decision-makers and spatial planners need tools to monitor these territorial changes and avoid many errors when analyzing data series collected on divisions that have changed. In this demo, we present the *GeoChange-Viz* Web application designed to assist spatial planners in the monitoring of changes their study areas have undergone. GeoChange-Viz is based on a Knowledge Graph (KG) we have designed [1], called GeoChange KG[1]. This GeoChange KG describes GD and their evolution over time. It

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[1]http://steamerlod.imag.fr/sparql

provides rich descriptions of GD changes, using terms such as *Split, Merge, Name* or *Identifier change, etc.* Moreover, the GeoChange KG is enriched with data from the Open Data Web. The GeoChange-Viz application exploits the structure of this KG to show, by means of innovative graphical components, GD changes along the lifelines of Territorial Units (TU) (i.e., each division of the geographical space in the GD).

2. The GeoChange Knowledge Graph

In [2], we have presented the TSN[2] (*Territorial Statistical Nomenclature*) ontology whose terms are generic enough to allow for the description of any multi-levels GD that can be found around in the world. This ontology goes hand in hand with the *TSN-Change ontology*[3] which consists of a generic vocabulary for the description of changes in GD (using terms such as name/identifier/boundaries change, merging or splitting of TUs, *etc.*). In this vocabulary, distinctions are made between changes where the identifiers of the geographical areas persist after change or not (e.g, fusion *vs* integration). This ensure a clear understanding of the changes and avoid misinterpreting data when a TU does not change its identifier over the versions of a GD, even though it has undergone major geographical changes. The TSN and TSN-Change ontologies are based on (standards) ontologies and frameworks such as GeoSPARQL [3], OWL-Time [4], PAV [5], DCTerms[4], BFO [6]. In [7], we have presented a framework named *Theseus* to populate the TSN and TSN-Change ontologies. It is based on an algorithm defined for the detection and semantic annotation of territorial changes. Using the Theseus framework, the GeoChange KG can be populated with the description of various GD and versions. So far, the graph contains the description of diverse GD (covering respectively the evolution, over a given period, of GD in Switzerland, Australia, European Union and France). This graph, dedicated to the description of changes in GD, follows a specific structure that is named "Multi-levels change graph". This structure is inspired by [8] while adding the notion of "multi-level", since changes that occur at one given level of the GD (e.g., state level) propagate to changes impacting lower divisions (e.g., districts). The scenario of the demo presented here is based on a French GD called *AdminExpress* [5], in versions 2015 and 2016, which is composed of 3 French administrative levels: regions, departments and municipalities[6]. The Figure 1 is an extract of the GeoChange KG showing a change event that has occurred at level 2 (municipalities, see label L2 of the nodes in Figure 1) in this GD, between years 2015 and 2016: the *integration* of a municipality (circled green node with label V2015_L2_38021) into another (circled green node with label V2015_L2_38225) municipality, results in the new municipality with code V2016_L2_38225. In the following section, we show how the GeoChange-Viz application can be used to geo-visualize this graph, and make it available to an audience with no technical background in KG.

[2] http://purl.org/net/tsn#
[3] http://purl.org/net/tsnchange#
[4] https://www.dublincore.org/specifications/dublin-core/dcmi-terms/
[5] Source https://geoservices.ign.fr/adminexpress
[6] Please, note that in the demo video, only an extract of this GD (covering the French region AURA) is loaded from the GeoChange KG, under the name GeoflAURA.

3. The GeoChange-Viz Web Application

The GeoChange-Viz application connects to the GeoChange KG and guides users, step by step, in their understanding of territorial changes. In a similar approach to the SexTant application [9], GeoChange-Viz focuses on the visualisation of the temporal dimension of linked geospatial data. In [10], the authors present a generic model for delivering time-evolving 3D city models for Web visualization. They describe *transitions* between two versions of a geographic feature. They propose to link documents to these transitions which help to give elements of proofs regarding how geographic features evolve in time. Our approach is also to describe the changes (or transitions) between two versions of a GD, by semantizing these changes and searching the Web for documents that can explain their causes. Indeed, each year, Urban Planning Authoritative Services (UPAS) must identify *where, when, how much, why* and *how* territorial changes took place, in order to maintain their expertise on their study area and to transfer their statistical data into the latest version of the GD. In particular, knowing *how* the TUs change over time (i.e., the nature of the change event) helps them in determining the appropriated statistical data processing for this transfer. In this demo, we will progressively show how such an UPAS can answer these *where, when, how much, why* and *how* questions from the application.

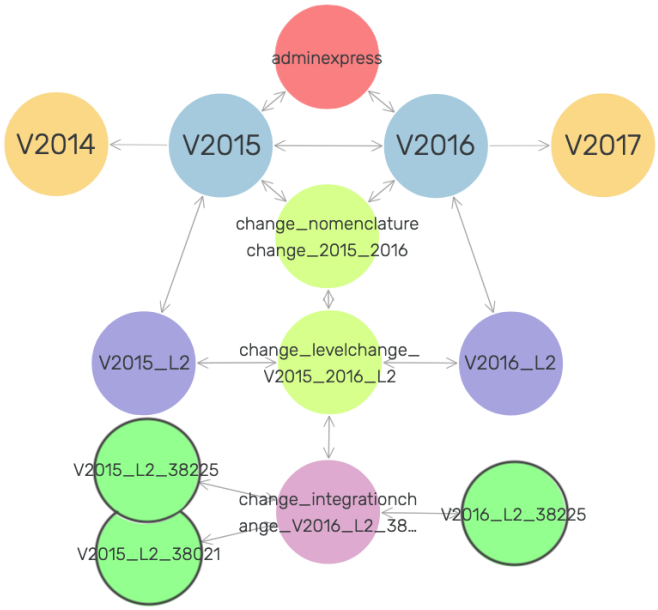

Figure 1: Excerpt of the GeoChange KG showing the merger of two municipalities between 2015 and 2016, in the french AdminExpress GD (bottom part of the graph: integration of V2015_L2_38021 into V2015_L2_38225 resulting in V2016_L2_38225)

Where? When? How much? Within GeoChange-Viz, several UIs have been designed to understand territorial changes step by step. In particular, the UI named *Synchronised maps* helps the user to quickly identify *where* the changes have taken place, using a set of colors highlighting the changes on the map according to their nature (on the contrary, unchanged units are kept grey) (see Figure 2). The two synchronized maps are dated (giving information

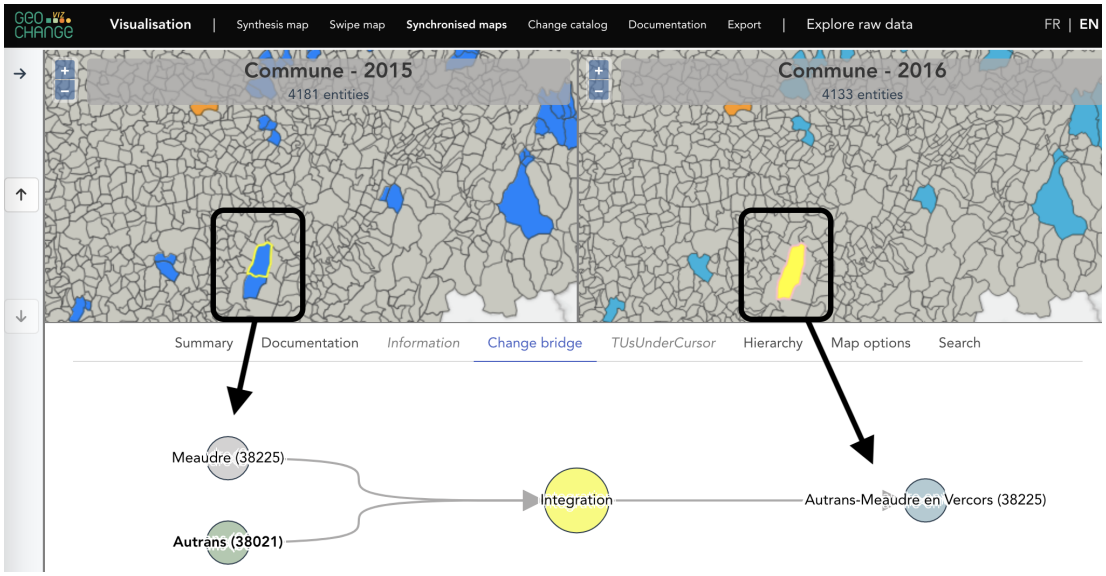

Figure 2: Visualization of the KG shown by Figure 1 in the GeoChange-Viz App: the synchronized maps and the *Change Bridge* component render the merger of two municipalities in France, between 2015 and 2016.

on the *When*): the map on the right shows the TUs before the change event and, on the left, the TUs after the change event. Below the map, a bar graph quantifies the number of TUs impacted. Also, the *Change Catalog* tab lists and quantifies the change events, according to their nature (providing information on the *How much*).

Why? How? By selecting a TU on the map, the user accesses its description, enriched with external descriptions (e.g., links to LOD Wikipedia, Geonames and Wikidata representations of the TU) that, most of the time, confirm the territorial change and explain it. Similarly, when the information is available on the Web, the GeoChange KG connects to legislation (providing information on the *Why*). Also, a UI component named *Change Bridge* gives the user access to a visualization of a bunch of the GeoChange KG with semantic labels describing the nature of the change event (providing information on the *How*). For instance, as shown in the Figure 2, the user has selected a municipality on the right map and, in the *Change Bridge* component, s-he learns that this TU has merged with another. As one of the merging TUs keeps its identifier after the change event, the change event is described as an *Integration* in the GeoChange KG. This precision is important as it may alert users and avoid misinterpretation of statistical data that refer to a TU using its unchanged identifier while its boundaries and, consequently, probably its number of inhabitants, have changed.

4. Conclusion

In this demo, we have shown how the use of semantic Web technologies with UI can help spatial planners in understanding how GD evolve over time. KGs are here first used to represent GDs and the changes they are subject to, and then enriched by contextual information that brings

explanations for the observed evolution. Our future work will consist in carrying out a study on the use of the application in order to reinforce the key functionalities of the application.
Demo link: https://videos.univ-grenoble-alpes.fr/video/26646-demo-GeoChange-Viz-iswc-2023mp4
Password: 2023-geochange-iswc

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