

PhD position in Computer Science

Title : Detection and Semantic Annotation of Changes in Geospatial Data

Établissement : [Grenoble](#) INP

École doctorale : [MSTII - Mathématiques, Sciences et technologies de l'information, Informatique](#)

Spécialité : Computer Science

Unité de recherche : [Laboratoire d'Informatique de Grenoble](#)

Équipe : STORIES

Encadrement de la thèse : **Marlène VILLANOVA**

Co-encadrants : **Camille BERNARD et Matthieu VIRY**

Financement : ANR GEvoK

Expected start date: October 1, 2026

Application deadline: July 17, 2026, at 11:59 PM (local time)

Keywords: geographic data, spatio-temporal ontologies, knowledge graphs, machine learning, symbolic AI, LLMs, change detection.

Required profile and skills:

The candidate must hold a Master's degree in Computer Science, Geomatics, Data Science, or Artificial Intelligence.

- Strong knowledge of Python and machine learning (classification, anomaly detection, clustering);
- Knowledge of Semantic Web technologies and knowledge representation (RDF, OWL, SPARQL);
- Basic knowledge of geographic data processing; familiarity with QGIS and spatial data formats (GeoJSON, shapefile, etc.);
- Autonomy, rigor, analytical skills, and interest in hybrid AI / geospatial approaches.

Required level of French: Upper intermediate (B2)

Required level of English: Upper intermediate (B2)

PhD Project Summary:

Geographic databases such as OpenStreetMap (OSM) and the IGN BD TOPO are continuously evolving to reflect territorial transformations. Identifying, describing, and characterizing the changes occurring in these geospatial databases over time is a major challenge for understanding and analyzing the evolution of territories.

This PhD is part of the ANR GEvoK project (Geographic Entities Evolution in Knowledge Graphs), which aims at the automatic detection and semantic annotation of geographic changes from heterogeneous data sources, including satellite imagery and collaborative datasets such as OpenStreetMap.

The proposed approach combines artificial intelligence techniques for the automatic detection of temporal changes, Semantic Web technologies for representing and enriching the knowledge derived from these detections, and large language models (LLMs) for querying the resulting knowledge bases and generating natural language narratives describing observed changes.

Topics: detection and description of changes in geospatial data; implementation of a full processing pipeline ranging from change detection using AI and machine learning methods, to change description using symbolic AI, and finally querying and narrative generation of temporal evolutions using LLMs.

Domain: This PhD topic lies at the intersection of artificial intelligence (machine learning, knowledge graphs, and Semantic Web-based symbolic AI) and geographic information science, given the nature of the data being processed.

Objectives and Context:

Human societies rely on geographic information to describe physical (e.g., schools, roads, cycle lanes) or virtual (e.g., administrative zoning) features that constitute their territories. In Geographic Information Science, the representation of such geographic entities is well established. However, representing and contextualizing the changes these entities undergo over time—driven, for example, by urban policies promoting low-carbon mobility—remains a major challenge.

These complex phenomena, also referred to as territorial transformations or spatial-temporal changes, involve one or several geographic entities that evolve at a given time or over a defined period under various pressures. Today, documenting these transformations in a machine-readable and computationally exploitable form is still largely absent.

In urban analysis, geographic databases describe—through standards such as CityGML or other formats—the built environment, transport networks, and urban infrastructure. Some open and collaborative databases such as OpenStreetMap (OSM) are often more up to date than official datasets due to continuous user contributions, thereby indirectly capturing urban evolution. Another more marginal initiative, OpenHistoricalMap (OHM), uses the OSM framework to build an open, editable historical map. However, none of these databases or standards explicitly model or document the changes undergone by geographic entities (e.g., transport networks, streets, cycle lanes, etc.).

Although some datasets, such as the IGN BD TOPO, provide differences between successive versions, these differences do not qualify or semantically describe the nature of the changes. Consequently, monitoring urban evolution remains difficult due to the lack of standards for representing territorial transformations. Yet, adopting a shared vocabulary for describing urban changes would make it possible to quantify them, define indicators of urban evolution, and facilitate comparisons between cities with similar or divergent trajectories.

In response to the lack of structured data describing territorial changes, and the absence of standardized tools for representing such transformations in urban planning and land-use monitoring, the objective of this PhD is to automate the detection and description of territorial

changes, and to build temporal sequences of these changes in order to characterize territorial trajectories. These change catalogues will support interoperability between systems and provide a foundation for broader community adoption. They will take the form of Spatiotemporal Knowledge Graphs (ST-KGs), designed according to FAIR principles (Findable, Accessible, Interoperable, Reusable), ensuring accessibility and reuse, notably for digital twins of territories and predictive AI systems aimed at forecasting urban evolution based on historical data.

Main Tasks of the PhD Candidate:

- Study the data structures of OpenStreetMap (OSM) and IGN BD TOPO (data models, granularity, semantics, attributes). Use QGIS and Python for data exploration and preprocessing;
- Design an automatic change detection approach using AI techniques (classification, clustering, or supervised/unsupervised learning depending on data availability), leveraging geospatial machine learning tools (e.g., scikit-learn, PyTorch/TensorFlow, GeoPandas, Shapely);
- Develop a semantic model (ontology) to describe and annotate detected changes using Semantic Web technologies (RDF, OWL, SPARQL);
- Integrate results into a geographic Knowledge Graph (KG);
- Enrich the KG with contextual information from the Web or Large Language Models (LLMs) to better explain and validate detected changes (causes, pressures, timestamps, geopolitical or environmental context, etc.);
- Publish and disseminate the KG to a wide audience (experts, researchers, citizens) through natural language interfaces based on LLMs (avoiding direct SPARQL usage) and through metrics for analyzing changes.

Methodology:

To generate FAIR data describing the history of territories, Semantic Web technologies and Knowledge Graphs (KGs) represent a suitable approach. KGs structure data as nodes connected by semantically defined edges, making them well suited to represent spatial, temporal, and lineage relationships between geographic entities.

Moreover, KGs embedded in the Linked Open Data (LOD) ecosystem offer opportunities for dynamic enrichment, thereby increasing their expressiveness and usefulness for territorial change analysis. Enrichment of geographic entities can be achieved by linking them to external KGs such as Wikidata, providing additional encyclopedic knowledge. Description logics and ontologies enable the inference of implicit relationships, improving knowledge completeness. Furthermore, integrating KGs with Large Language Models (LLMs) opens new perspectives for enrichment and interaction. On the one hand, LLMs can extract and structure information from textual corpora. On the other hand, this synergy enables natural language querying of KGs, allowing users to interact with complex spatio-temporal datasets without requiring formal query languages. This approach democratizes access to KGs and supports the development of intelligent applications combining symbolic reasoning with natural language understanding.

Expected Results:

- A state-of-the-art review of existing ontologies for change description, existing knowledge graphs in this domain, and methods for change detection in vector geospatial data;
- Design and publication in the Linked Open Data cloud of a generic ontology for territorial change description;
- Design and development of an ontology module for trajectories aimed at representing territorial evolution as semantic trajectories composed of episodes (i.e., detected trends) and events marking transitions between episodes;
- Design and development of an interactive application supporting expert dialogue for building domain-specific ontologies from a generic domain ontology. This tool will include:
 - an interactive interface enabling dialogue between domain experts and modelers;
 - functionalities to translate generic concepts into domain-specific vocabularies;
- Ensuring consistency of generated terminologies with existing standards in each discipline through bibliographic review and expert validation;
- Evaluation of the tool with domain experts to assess usability and relevance. Tests will be conducted to generate at least two application ontologies for the case studies;
- Structuring and documentation of the generated ontological models to ensure reusability;
- Development of a supported methodology for detecting and describing territorial changes;
- Creation of a Spatio-Temporal Knowledge Graph published in the Linked Open Data cloud, describing territorial changes in the cities of Grenoble and Paris;
- Dissemination and valorization: scientific publications, documentation and open-source release of developed code, and presentation of results to both the computer science community and interdisciplinary stakeholders involved in territorial trajectory analysis.

Supervision and Hosting Environment: The PhD will take place at the Grenoble Informatics Laboratory (Laboratoire d'Informatique de Grenoble, LIG) (<https://www.liglab.fr/fr>), within the STORIES team (<https://lig-stories.imag.fr/>), a research group dedicated to the study of temporal evolution and trajectories. The team's research areas include geographic information systems, applied artificial intelligence, and knowledge engineering.

Supervision will be provided by Marlène Villanova (Professor of Computer Science at Université Grenoble Alpes), Camille Bernard (Associate Professor in Computer Science at Grenoble INP), and Matthieu Viry (Research Engineer at CNRS, UAR RIATE), ensuring regular follow-up and complementary expertise in geomatics, artificial intelligence, and semantic technologies.

Scientific and Financial Conditions: The PhD candidate will be hosted at LIG within the STORIES team. The doctoral fellowship is funded through the ANR GEvoK project (ANR-25-CE23-6986, 2026–2029) (<https://lig-gevok-anr.imag.fr/>).

Research Valorisation and Dissemination:

The contributions and results of the PhD research will be disseminated and promoted through:

- Publications in high-level conferences and journals (e.g., Journal of Semantic Web, ISWC, ESWC, IJGIS, ACM SIGSPATIAL, etc.);
- Oral presentations to both the computer science community and interdisciplinary audiences studying territorial trajectories (geographers, sociologists, demographers, political scientists, etc.);
- Release of territorial trajectory datasets to the research community as benchmarks, in compliance with GDPR regulations;
- Open-source publication of code, ontologies, and Knowledge Graphs via Git repositories.

References:

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Application Procedure

Applicants should send a CV, a cover letter, and a Master's (M2) transcript to: camille.bernard@univ-grenoble-alpes.fr; matthieu.viry@cnrs.fr; marlene.villanova@univ-grenoble-alpes.fr

Application deadline: June 26, 2026