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MINOR HISTORICAL CENTRES ONTOLOGY ENRICHMENT AND POPULATION: AN HAMLET CASE STUDY

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ABSTRACT:
The main topic of this work focuses on the semantic, historical and spatial documentation of Minor Historical Centres (MHC) with a focus on (semi-abandoned alpine) hamlets. The key point is the possibility to standardise spatial information in the domain of MHC and their related cultural, architectural, built and landscape heritage. This work analyses the notions of historical centre and ancient area, which took different meanings and evolved over the centuries. MHC are historical part of cities, villages and hamlets (urban, rural, minor or abandoned) with cultural, social and economic values. Thus, MHC need to be preserved, documented and safeguarded. The spatial and semantic documentation is a fundamental tool for increasing their knowledge. In these places, many actors and stakeholders are involved in different activities, and for this reason, they need to share common knowledge and use a unique language. In this regard, spatial ontology is of relevant interest and usability. Ontologies are conceptual structures that formalise specific knowledge and create a unique and standard thesaurus that ensures semantic interoperability. This paper is part of a PhD research targeted at developing an ontology containing helpful information to manage, share and collect data on MHC due to the lack of an interoperable structure to formalise such knowledge. The main aim is to populate and enrich the already developed ontological structure with data of a mountain semi-abandoned hamlet: Pomieri. The methodological workflow is validated, enriching and populating the ontology, adding classes and instances with information and unstructured data of a real data case study.

1. INTRODUCTION AND BACKGROUND

Minor Historical centres (MHC) express cultural heritage values and urban characteristics. They are intended as a historical part of cities, villages and hamlets (urban, rural, minor or abandoned) with cultural, social and economic values. For this reason, numerous historians, architects, urban planners, and restorers have recognised the great importance of the documentation and the preservation of these centres. These usually abandoned places need to be documented and valorised to be re-habited. A real new strategy is provided by the necessity for sustainable environmental opportunities, such as decentralisation, revitalisation, development and re-inhabitation of the countryside and minor historical centres in the hinterlands. This scenario has been reinforced by the recent pandemic crisis of COVID-19 (Boeri, 2020; Istituto di Architettura Montana, 2020; Koolhaas, 2020). Together with climate change issues in cities (Cassar & Pender, 2003; Mercalli, 2020; Rosenzweig et al., 2011), the pandemic has temporarily led to a trend of city dwellers moving to rural areas. Moreover, many people have adopted a new thought of "slow living". The idea is to "slow down" to promote the creation of new networks in the hinterlands, enhancing part-time teleworking and rural activities.

The use of digital ontologies, particularly geospatial ontologies, could represent an effective and innovative method to share common knowledge among the different actors and use cases involved in MHC activities and tasks. Hence, ontologies can be considered conceptual structures able to formalise explicit knowledge, and they are beneficial in creating a unique and standard thesaurus and ensuring semantic interoperability. In this way, different users and stakeholders can "talk together" and understand common characteristics, dynamics and features of MHC.
This paper is part of a PhD research (Colucci, 2022 forthcoming) targeted at developing an ontology containing helpful information to manage, share and collect data on historical centres due to the lack of an interoperable structure able to semantically formalise such knowledge.
The present work aims to populate and enrich the already developed spatial ontology for MHC with data of a mountain hamlet subject to risk and hazards phenomena. As abovementioned, the design and implementation of this ontological structure can help various actors involved in the decision-making process of small urban and rural areas in different scenarios. For this purpose, the methodological workflow is validated, enriching and populating the MHC ontology, adding classes and instances with information and unstructured data of a real data case study. In this way, the domain ontology of MHC became an application ontology.

1.1 The notion of Minor Historical Centre

Before describing in detail the semantic notions of the ontology, it is necessary to investigate the different definitions of MHC and their evolution over the years.
Firstly, we can state that MHC lies inside the domain of built, urban and architectural heritage due to its characteristics and social, historical and cultural values. Hence, it is included in cultural heritage, architectural heritage, built heritage, historic urban landscape, urban heritage definitions (UNESCO, 1972,

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1992, 2002, 2003, 2009, 2011). These intrinsic attributes underline the importance of documenting them (spatially and semantically) to preserve their cultural values.

The notion of MHC takes different meanings depending on the context and the period in which it is applied. The concept of HC (Historical Centres) evolved over the year, including in its semantic and spatial definitions also minor and small centres such as historic urban cores and parts of cities, rural villages and semi-abandoned hamlets. Moreover, the different semantic meanings of HC have changed over time, and therefore it is necessary to understand the evolution of the concept in the last 50 years.
The first definition of Historical centres appeared in 1967 in the Commissione Franceschini, Declaration XL. Astengo defined HC as "urban settlement structures that constitute cultural unity or the original and authentic part of settlements".
In 1969, the word historical centres appeared in the Dizionario Enciclopedico di Architettura e Urbanistica (Encyclopaedic Urban and Architecture Dictionary). They are defined as the "core of a city that constitutes a complex linked to particular historical moments due to formal, typological and urban characteristics". Sometimes the concept of the historic centre is extended to the whole city when it represents a living testimony of other eras. The term was spread by the most recent town planning legislation, which dealt with the problem of the conservation, rehabilitation and enhancement of the historical centre.
Predieri (1971) introduced the concept of minor historical centres in his report for the "VI Convegno A. NCSA".
Rolli (2005) included minor historical centres and small villages and hamlets in the definition of minor historical centres.

1.2 Ontologies in the geospatial domain

After having defined the semantic notions of MHC (§ 1.1), this section reports the connotation of ontologies in the present work.
The word "ontology" takes different meanings depending on the context where it is applied. In computer science, ontology is an information object or computational artefact,
The most cited definitions of ontology are:

- "Explicit specification of a conceptualisation" (Gruber, 1993);
- "Formal specification of a shared conceptualisation" (Borst, 1997);
- "Formal, explicit specification of a shared conceptualisation" (Studer et al., 1998).

In the field of Artificial Intelligence and the Semantic Web, ontologies were initially used to conceptualise some parts of the real world. The first objective was to allow the software system to "reason" about real-world entities.
A spatial ontology defines the general concepts of spatial objects and their relations to spatial application domains. "Etymologically, geography means the description of the Earth, while ontology refers to the discourse about existing things. Hence, geographic ontology means describing things existing on Earth, i.e., geographic features". Ontologies are used in the AI field and information technologies to describe information in a specific domain as semantic networks useful for the interoperability of spatial databases (Laurini & Kazar, 2016).
It is possible to consider the ontologies applied in GIScience (Geographic Information Science/System) as domain ontologies. These "are often called geographic ontologies or geo-ontologies" (Fonseca et al., 2006; Tomai & Kavouras, 2004). The W3C standards also define geospatial ontologies (https://www.w3.org/2005/Incubator/geo/XGR-geo-ont-20071023/#glossary).

The present work falls into the geospatial domain ontology concept because MHC has been semantically described considering both historical and spatial information and object.

2. THE DEVELOPED MHC ONTOLOGY

This section presents the workflow followed to develop the MHC ontology starting from existing standards and ontologies in the built heritage domain.

2.1 Existing ontologies, standards and conceptualisations

There are many ontologies, standards, vocabularies, conceptualisations and regulations for geographic information and architectural heritage representation. These include the core ontology CIDOC-CRM and its specifications (https://www.cidoc-crm.org/), the Getty Vocabularies (https://www.getty.edu/research/tools/vocabularies/), the CityGML standards for built heritage and buildings' representation with different level of details (https://www.ogc.org/standards/citygml) and many others (as reported in Colucci et al., 2020). Moreover, many researchers have tried to define ontologies in the built heritage domain.
In urban and built heritage, many applications and communities are involved in the processes and activities for the management, development, and enhancement of cultural heritage, buildings, and cities. In this scenario, it is possible to mention restoration, conservation, documentation, risk management activities and planning disciplines. In this regard, some research on ontologies for representing built heritage at different scales and varying granularity levels has been carried out. Some examples are the work of Teller et al. (2007) to define ontologies for urban development and the study of Berdier & Roussey (2007) to describe ontologies in urban domain areas.
In the framework of architectural built heritage, few attempts have been made to design an ontology (Messaoudi et al., 2015; Kokla et al., 2019; Acierno et al., 2017, 2019).
Despite this already developed knowledge and core or domain ontology, none of these studies focused on an application ontology for hamlets and villages. Thus, due to the lack of a formal ontology for MHC, the investigation of Colucci (2022, forthcoming) aimed to define a geospatial ontology in such a domain.

2.2 MHC ontology design

Thus, as mentioned before, starting from the existing formalised knowledge and conceptualisation (§ 2.1), the MHC ontology has been designed following some approaches.
The core of the work focused on defining semantic classes, their definitions and relations representing geographical objects of built and territorial heritage.
The approach used was the Ontology Development 101 Guide (Noy and McGuinness, 2001), with the iterative process reported in Figure 1.

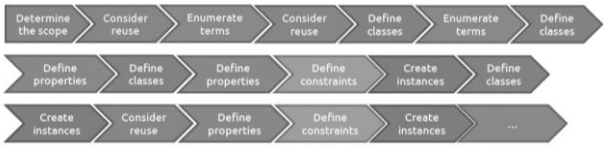


Figure 1. Ontology101 Guide (Standford University, Noy and McGuinness, 2001).

Classes (objects) and relations (properties) have been implemented in Protégé (https://protege.stanford.edu/), an open-source ontology editor and framework for building intelligent systems.

Then, the MHC ontology documentation was published at the link:

- https://w3id.org/lode/owlapi/http://purl.org/net/mh-centre_v1.

Here all the classes and properties of the ontologies have been reported. It is possible to download the ontology file in OWL or XML formats.

After the ontology design, to validate and improve the ontology, it is necessary to add some examples of real case studies. Hence, the following sections aim to report an example of a possible ontology population and enrichment with data from a mountain hamlet case study.

3. ONTOLOGY APPLICATION: THE POMIERI HAMLET

The Italian mountain hamlet of Pomieri is located in the municipality of Prali in the Piedmont Region. Its old name in dialect is "Li Poumie", which means "the apple trees". It is situated in a mountain area in the Germanasca Valley at 1511 m. A.s.l.. As regards its morphology, Pomieri and the entire municipality of Prali are characterised by relatively steep slopes. Consequently, they are naturally exposed to snow slides, landslides and avalanches. Figure 2 shows the hamlet.



Figure 2. Aerial view of Pomieri hamlet case study.

3.1 Case study selection

Pomieri has been selected as a representative use case for the MHC ontology and, in particular, a specific hamlet case study to apply the MHC ontology. It fulfils the notions of a semi-abandoned hamlet with the potential to use new urban planning projects to reinhabit the Alps, as also underlined recently by the Italian PNRR (Piano Nazionale di Ripresa e Resilienza per i territori - National Recovery and Resilience Plan for the territories) for historical hamlets (https://www.regione.piemonte.it/web/temi/cultura-turismo-sport/cultura/pnrr-1-miliardo-euro-per-rilancio-250-borghi-storici). Moreover, natural phenomena like avalanches and landslides damaged the Pomieri hamlet (Colucci, 2022). Hence, it requires historical and spatial documentation for restoration, valorisation, and sustainable urban resilient planning.
This approach also shows the potential reuse of the MHC knowledge. Finally, the proposed methodological workflow underlines that the ontological structure could be applied in a whole or part to specific case studies becoming an application ontology.

3.2 Available semantic data sources

To describe the Pomieri hamlet, an in-depth investigation of existing unstructured sources, such as texts, documentation, rules, and plans, has been carried out. It is possible to find many regulations and plans describing the area of Prali.
The first important document from the landscape values point of view is the Regional Landscape Plan (Piano Paesaggistico Regionale, PPR). Some other specific existing documents are the General Plan of the Mountain Community of the Chisone and Germanasca Valleys, PRGCM (Piano Regolatore Generale della Comunità Montana Valli Chisone e Germanasca), the Intercomuncal general Regulatory Plan the PRGI (Piano Regolatore Generale Intercomunale, Unione Montana dei Comuni Valli Chisone e Germanasca, PRGI) and the Building Regulation of Prali.
These data could be helpful to be integrated into the application ontology to describe the hamlet and its context.

4. METHODOLOGICAL WORKFLOW and RESULTS

The methodology of this work starts by analysing unstructured data and manually extracting useful information to describe the hamlet. Subsequently, this material has been subdivided into classes and properties of instances and added to the existing MHC ontology to enrich it with new content describing mountain villages (Figure 3).

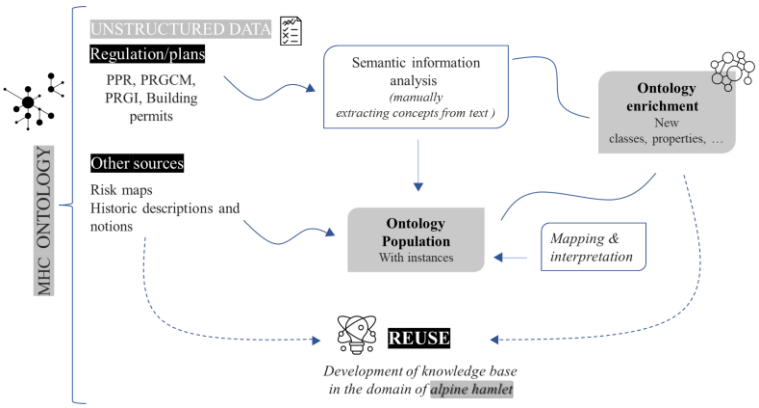


Figure 3. Ontology enrichment and population workflow with data from Pomieri.

The central part of the workflow regards ontology enrichment and population. Ontology enrichment is "the task of extending an existing ontology with additional concepts and semantic relations and placing them at the correct position in the ontology" (Petasis et al., 2011). Ontology population "is the task of adding new instances of concepts to the ontology" (Kokla et al., 2018; Petasis et al., 2011).

It is possible to summarise the steps of the workflow as follows:

- Selection and Semantic Analysis of unstructured data;
- Formalisation of new concepts and relations;
- Mapping and comparison of the new concepts and relations to the MHC ontology, checking possible semantic information not considered in the first part of the ontology design;
- Ontology updating to revise and integrate the ontology (in Protégé) according to the previous mapping.

4.1 Ontology Enrichment

The core of this methodology focuses on extracting different information from the sources mentioned in paragraph 3.2. Landscape plans and regulation documents have been analysed to identify new classes and relations for the spatial and temporal documentation of alpine hamlets. Various texts from these regulations are reported below. Concepts (classes) to be integrated into the MHC ontology are highlighted in grey, instances (examples) in dark yellow, data properties (relations) in jade-green, and object properties (characteristics) in red. This information has been mapped to the existing MHC ontology in Protégé to identify possible equivalences or overlapping. The first classes added to the ontology are "mountain hamlet" and "alpine settlement", which are both subclasses of the MHC entity "hamlet".

Excerpts of texts of Landscape Areas Sheets and Implementation Rules of PPR documents are reported below (Regione Piemonte, 2008) (Figure 4).

"The Ambito/Area 41 includes the Val Germanasca with municipality of Inverso Pinasca (40-41), Massello (41), Perrero (41), Pomaretto, (41), Prali (41), Salza di Pinerolo (41)."
"The municipality of Prali is identified in the documents of the PPR with the numeric codes 4104, 4105, 4106.
Area 41 is essentially defined by the basin of the Germanasca stream with its tributaries (Massello, Salza, Prali) from its sources to the confluence with the Chisone stream at Pomaretto (To)".

"The area is characterised by:
- the presence, in the high-alpine area, of a system of roads and mule tracks that connected the various military structures, now being abandoned, but with a significant impact on the landscape. These infrastructures allow access to some panoramic points, such as the vast plateau of 13 lakes of glacial origin;
- the talc mines (Prali) are still mined and processed today in one of the most important mining complexes in Italy;
- the SIC Val Troncea and the Conca Cialancia Natural Park are linked to the subalpine forest and alpine environments of naturalistic and landscape value."

Figure 4. Concepts, relations and properties from PPT documents.

The other documents considered for the semantic information analysis are related to the PRGCM and the PRGI. Different texts are available, and three have been selected (1-3).

1) The first one is the document "Relazione, tav 7.11" (Unione Montana dei Comuni Valli Chisone e Germanasca et al., 2013). For the hamlet of Pomieri it reports the Avalanche Phenomena of winter 2008-2009 with a map (Figures 5 and 6).

"In the Municipality of Prali, the main damage is mainly related to the torrential activity of some tributaries of the Germanasca stream, near the Pomieri hamlet".

Figure 5. Concepts, relations and properties from the "Relazione, tav 7.11".



Figure 6. Map of the avalanche area of winter 2008-2009.

2) The second one is the "Zone di Recupero e Sviluppo", Recovery and developments area, scale 1:1000 (Comunità Montana Del Pinerolese, 2012); PRGI - Structural variant of adaptation to the PAI. From the map of this document (Figures 7 and 8), it is possible to extract information related to the buildings needing mandatory interventions of:

"restoration (philological and conservative restoration and conservative renovation) and some other objects of the hamlet (such as fountains, architectural elements, sundials, votive towers, frescoes, decorations, newsstands, fountains and ovens)".

Figure 7. Concepts, relations and properties from the PRGI.

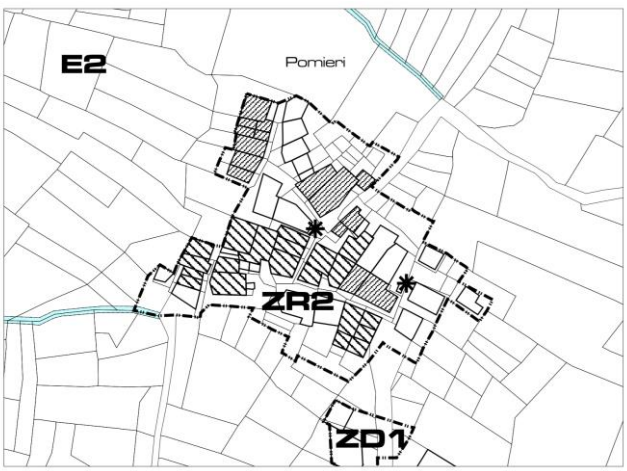


Figure 8. Recovery and developments area of Pomieri (scale 1:1000), ZR2 express Recovery areas and ZD1, development zone, * are fountains or ovens. Buildings on the north need philological restoration, and buildings in the south of the hamlet need conservative renovation activities.

3) The document "Schede e Tabelle di Zona", Zone Cards and Tables, (Comunità Montana Del Pinerolese, 2013), reports the zone ZR2 of Pomieri. It indicates some urbanistic and construction indicators and some norms (Figure 9).

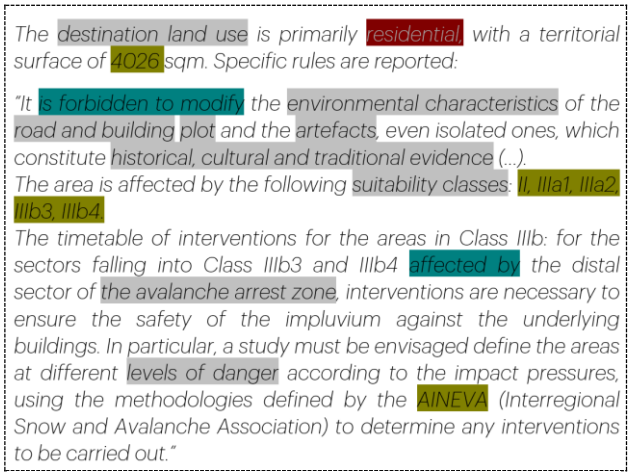


Figure 9. Concepts, relations and properties from the document "Schede e Tabelle di Zona.

The Building Regulation of Prali, "Regolamento edilizio" (Comune di Prali & Città Metropolitana Torino, 2018) reports some rules concerning building construction and materials (Figure 10).

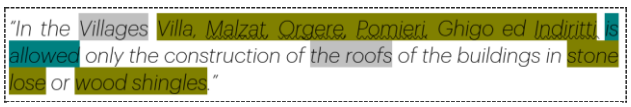


Figure 10. Concepts, relations and properties from the Building Regulation of Prali.

The abovementioned sources describe plans, building permit procedures, risk phenomena, and restoration actions. Adding to the MHC ontology this information can be helpful to create a unique structure in which it is possible to store various regulation data. In this way, common semantic knowledge is shared among administrations, municipality bodies, civil protection services, architects, and restorers to reach common aims. These documents of the historical centre of Pomieri have been reported as examples of possible classes, relations and instances that could be added to the ontology to enrich the MHC knowledge domain for several purposes.

Some other sources could be considered to improve the knowledge of the hamlet of Pomieri. The following paragraph lists some of them:

The text of Società di Studi Valdesi (2012) has been analysed. Historical descriptions and notions related to Waldensian settlements, partisans in the second world war, natural disasters (such as *landslides* and *avalanches*) and interventions for the ski lifts are reported. Classes and instances can be implemented in the ontology for possible historical documentation purposes (Figure 11).

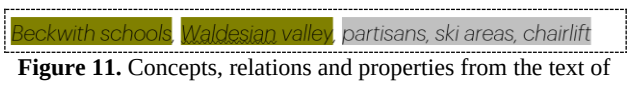


Figure 11. Concepts, relations and properties from the text of Società di Studi Valdesi (2012).

Other information is related to some statistics of ISTAT or Eurostat datasets (Figure 12, https://ec.europa.eu/eurostat/web/cities/data/database) on:



Figure 12. Concepts, relations and properties from ISTAT.

Information related to tourism could be handy to investigate turnout flows linked to the different seasons and villages (Figue 13). Tourist activities in Prali are related to:



Figure 13. Concepts, relations and properties of tourism.

In addition to the risk classes reported in the PRGI and in the PRG it is possible to add classes of risks (Figure 14) such as:

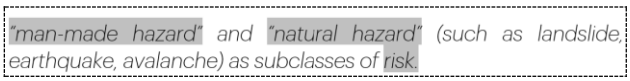


Figure 14. Concepts, relations and properties of hazards.

A classification of risks is available in The International Disaster Database developed by Centre Research of Epidemiology Disaster (CRED, https://www.emdat.be/classification).

The last domain of interest of the mountain area of Prali regards its networks (Figure 15).

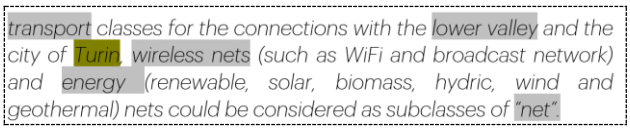


Figure 15. Concepts, relations and properties of networks.

Finally, the ontology updating was aimed to revise and integrate the ontology according to the mapping. The ontology structure has been implemented by mapping the new classes and relations in Protégé after having analysed documents related to different activities in which the municipality of Prali and the hamlet of Pomieri are involved.

4.2 Ontology population

This section presents examples of instances extracted from the texts and documents analysed in the ontology enrichment steps. Only a few have been added to the MHC ontology to prove the possibility of reusing such knowledge in various fields such as restoration actions, historical documentation, regional and city plans, and building permit processes. Further studies on historical documentation, risk description and restoration or planning activities can add many other instances from existing sources. Table 1 shows some examples of triples with instances, classes (C) and predicates from case study sources.

Table 1. Some examples of triples of instances, classes (C) and properties from case study sources and documents.

Subject	predicate	Object
Ambito/Area 41 of PPR	*includes*	Val Germanasca
Prali	*is located in*	Val Germanasca
Pomieri	*is in the municipality of*	Prali
Pomieri	*is a*	Minor historical

		centre (C)
Prali	*is in the region*	Piedmont
Prali	*is in the province of*	Turin
Pomieri	*is a*	Mountain hamlet (C)
Prali	*is identified with*	Numeric code
Numeric code	*has number*	4104 – 4105 – 4106
Val Germanasca	*borders with*	Val Chisone
Val Germanasca	*borders with*	Val Pellice
Area 41	*is characterised by*	Panoramic point
Panoramic point	*is*	Plateau of 13 lakes
Prali	*has istat code*	1202
Wood Surface area	*has dimension (ha)*	2821,3
Recovery area of Prali	*is identified with the code*	ZR2
Development area of Prali	*is identified with the code*	ZD1
Prali	*have*	Ecomuseum of mines

4.3 Implementation of classes, relations and instances

This section reports some examples of instances of the Pomieri case study implemented in Protégé in the MHC ontology. Only a few have been added to the MHC ontology to prove the possibility of reusing such knowledge in various fields such as restoration actions, historical documentation, regional and city plans, and building permit processes. Figure 5 shows some examples of implemented classes, relations and instances (OntoGraf viewer in Protègè).

5. CONCLUSIONS AND FUTURE WORK

This work aims to validate the MHC ontology with real data from a case study.
The first section reported a state of the art of spatial ontologies in the CH domain, then a recognition of the meanings and evolution of MHC notions is reported. A brief overview of existing standards, vocabularies and ontologies for minor historical centres is reported. The central part of the paper focused on the MHC already developed ontology design. The final result of the present methodology is about the enrichment and population of such ontology with the Pomieri case study. Although only few instances have been added, this method is an explicative and replicable workflow proper to reuse HC knowledge in different areas of applications and scenarios.

Future research will include spatial data analysis and harmonisation in GIS to connect semantic data with spatial harmonised datasets through WebGIS applications. Many other instances of other disciplines or areas (such as building policies or management activities) can be added to the ontology.

Finally, future works could include machine learning or deep learning techniques to automatically extract semantic classes from existing unstructured data sources or annotate HC datasets (such as 3D models, point clouds and images of CH and Cultural Landscape), improving their semantic description. This latter perspective finds numerous parallel research directions, if we consider the trend also found in the context of Object-Based Image Analysis supported by Deep learning, that many researchers consider worthwhile to be guided by knowledge driven approaches.

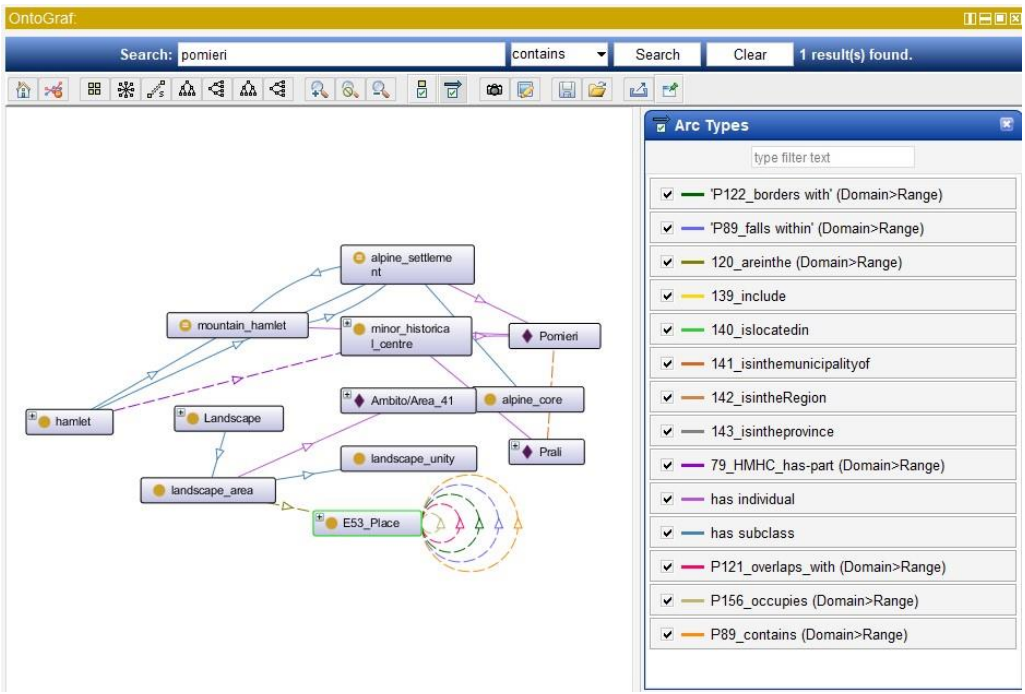


Figure 16. OntoGraf visualisation of classes and instances of the MHC ontology related to the Pomieri hamlet case study.

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