Connection & Knowledge: from AR to AI. The Case of Sicilian Lighthouses

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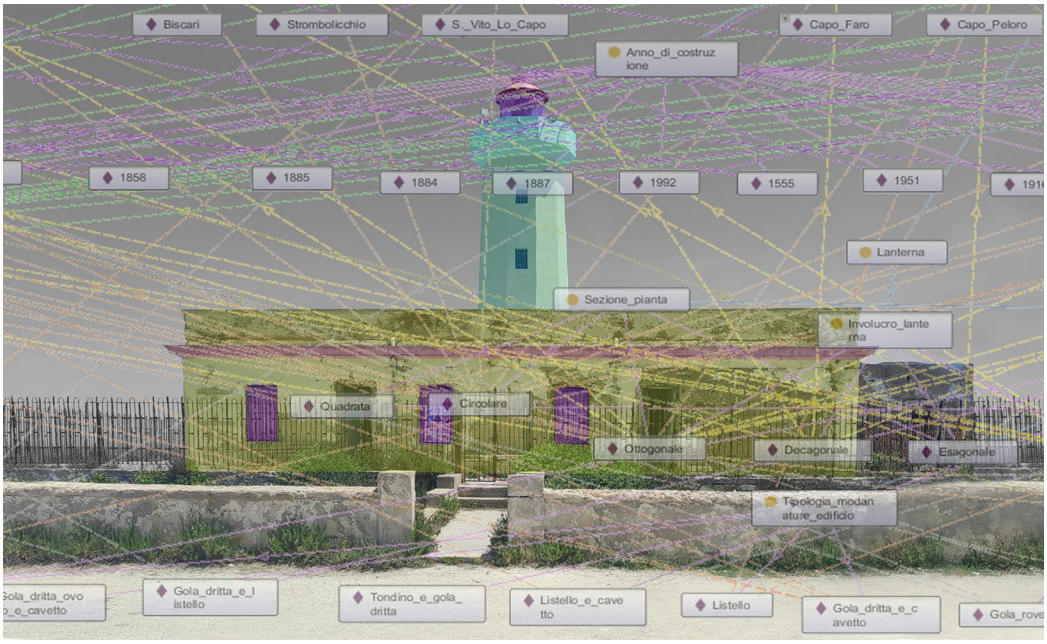
Abstract

The development of ever new and innovative technologies is now able to significantly enrich the numerous possibilities in the field of research, use, enhancement and understanding of the existing cultural heritage. In this sense, the initiatives in the field of augmented reality and artificial intelligence appear to be a possible asset through which to undertake connection and mixing networks between the intrinsic and extrinsic data that characterize buildings. The use of semantic and ontological data – that is fields based on an increasingly solid interoperability and exchange of data – make it possible to develop a mutual knowledge in a relationship of connection between territory and architecture. This contribution, therefore, investigates the possible application of augmented reality and artificial intelligence in the context of Sicilian lighthouses, or a heritage characterized by well-defined architectural and landscape components.

Keywords
knowledge, connection, sicilian lighthouses, semantics, ontology.



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Introduction. Technology, Semantics and Lighthouses

Scientific progress in the field of augmented reality, artificial intelligence and virtual reality are today applications to which numerous fields of research and studies are addressed, in order to ensure an increasingly effective enhancement and dissemination of cultural heritage [De Paolis 2012]. Augmented reality applied to cultural heritage allows a more in-depth view of architecture, also usable at a distance, through which to discover new formal and compositional connections. In the context of augmented reality, the semanticization of cultural heritage can represent a strategy for a simpler reinterpretation of the artefact in both intellectual and virtual terms, to be implemented through visual expedients such as projections and cognitive maps, in order to highlight relationships and compositional determinants [Croce et al. 2020].
Nowadays the mix of knowledge and disciplines through which to obtain ever more in-depth and interactive levels of knowledge of the artefact becomes increasingly fundamental. If on the one hand augmented reality is configured as a tool suitable for an increasingly immersive use of cultural heritage, it needs a new interpretation and to be combined with new directions: this is the case of artificial intelligence, or a discipline addressed to the reasoning of the intelligent system to which numerous addresses and fields of study are approached. In general, research based on "intelligent" behaviors is carried out by breaking down into sub-problems – an action therefore common to the semantization of the object in interconnected systems – including the ontological method [Grasso 2012]. It is in the context of augmented reality and ontology that the landmark architectures of each coastline are inserted, a guiding address for sailors and protagonist of suggestive stories: lighthouses. These types of architectures, in fact, are characterized by well-defined and common compositional groups and sub-groups for the different lighthouses located in the territory. The use of semantics applied to lighthouses – in this contribution located in Sicily – makes it possible to develop applications in the field of augmented reality, through which to view unpublished knowledge, and of ontology, thanks to which to frame existing but also new connections cognitive.
In the field of semantics applied to lighthouses, in fact, it is possible to significantly distinguish those that are configured as the fundamental characteristics of the main structure. The lighthouse building, the tower and the lantern represent the three basic macro groups that enclose the formal features of the building. They convey the individual and decorative elements of the building – moldings, ashlar, compositional types, etc. – that is, common characteristics that can be traced in certain geographic locations or in specific architectural cultures. It is precisely these characteristics that make up a subgroup of the semantic apparatus, making the classification of the lighthouses an inverted pyramid decomposition in which the starting point is represented by the total and the arrival point are the small parts that make up the building. It should be emphasized that semanticization by parts is not understood as an alienation of the elements in view of self-sufficient objects, but rather as a detailed study of the same aimed at understanding the relationships and recurring characteristics [1] [Zerbetto 1998]. By using augmented reality combined with ontological maps, we want to hypothesize the creation of an application capable of combining these two sciences towards a single interface through which historical, architectural and cultural characteristics can be viewed in real time.

Semantics and Augmented Reality at the Service of Knowledge

As is well known, the learning of knowledge can take place effectively through the transposition of knowledge on analog-digital representations, all aimed at safeguarding and forming a society linked to the memory and historicity of places [Bortolotti et al. 2008]. These technologies, profoundly pervasive, enhance and modify the conception of space, expanding the real experience through increasingly immersive virtual spaces, that is, as Myron Krueger intended them, spaces so immersive as to seem real, in a dense human-machine relationship [Krueger 1985]. Although the use of mixed reality is configured as a tool with an innovative capacity – allowing us to position digital objects in the physical world, or even be ourselves present in both the physical and digital world – in this discussion also reality augmented, it is

capable of enriching human sensory perception through cognitive information derived from ontological knowledge.
As previously mentioned, the protagonists of this discussion are the Sicilian lighthouses, that is, architectures that welcome, in addition to a vast history and material and immaterial tradition, an identity and defined architectural composition. In this sense, in fact, the lighthouses, in addition to their intrinsic geometric characteristics, can be distinguished and classified through a formal and compositional cataloging of the building organism in recurring structures. The main structure of the lighthouse can therefore be broken down into three main volumes: the building [2], the tower and the lantern, which are elements that, with the exception of the building, we find in every single coastal architecture [3]. The previous volumetric identities can be distinguished in several semantic-structural classifications, among which we recall: the one-level, two-level or three-level block for the building component; the tower with a square, circular, octagonal or mixed plan for the tower; the lantern with an octagonal, decagonal, dodecagonal plan. The individual decorative elements and openings of the architecture are conveyed in them – moldings, ashlar, shelves, square openings, circular openings, etc. – capable of characterizing the building while representing an element common to other buildings of the same type (Fig. 1).
Net of a semantic classification applied to all cases of Sicilian lighthouses, it is possible to hypothesize the transposition of the same data through the creation of intuitive applications, using the technology/methodology of AR and VR. On the one hand, by positioning beacons near a defined lighthouse, it is possible to access an augmented reality interface, on the other hand, the use of viewers, regardless of where you are, makes it possible to use a digital space of lighthouses, addressed in both cases to knowledge. In particular, virtual reality allows access to the three-dimensional model through the personification of the user according to an avatar, through which it is possible to rotate the model, observe the details from every angle

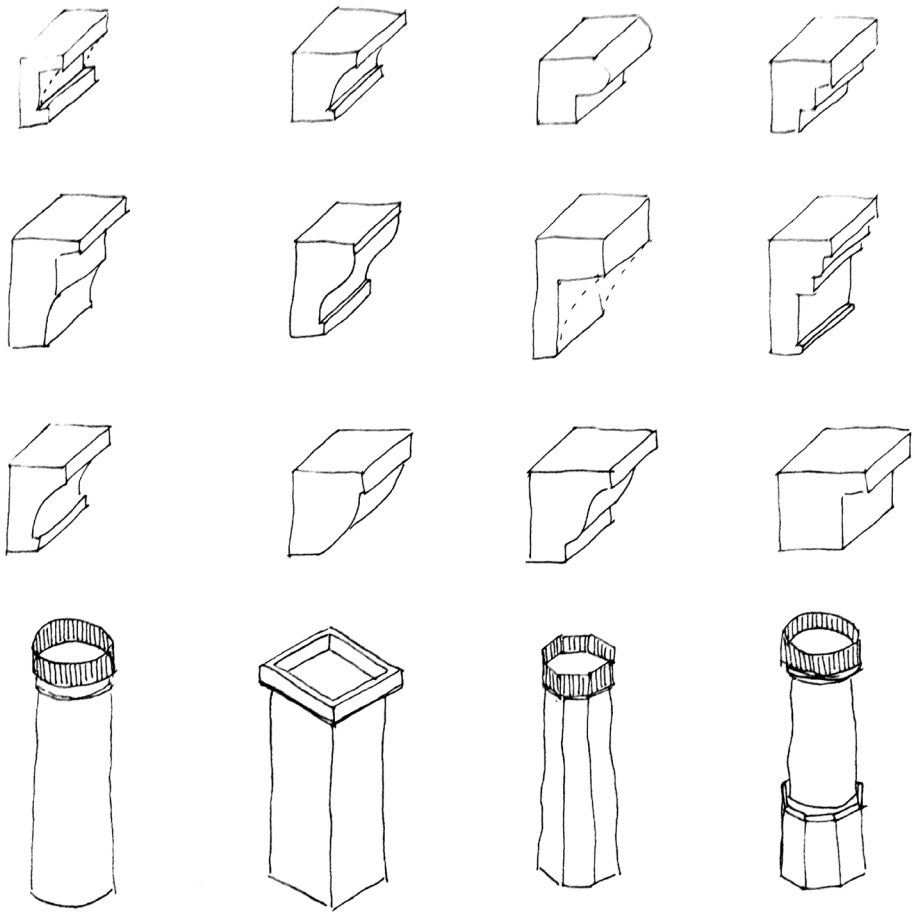

Fig. 1. Recurring semantics.

and at the same time view the semantic characterizations identified by the different colors of the model. Wearing a common VR viewer it is therefore possible to immerse yourself in an interactive knowledge space through which to view not only the architecture, arranged according to geographical location, but also to know its semantics and history (Fig. 2). At the same time, through the augmented reality application it is possible to access the same semantic classifications of the building using only the smartphone, being able to view the same identified by the colors by directing the camera of the digital instrument towards the existing architecture (Fig. 3). The interactive application allows you to select the single semantic classification in order to be connected to the ontological structure loaded into the system, subject of the next chapter, making the cultural experience increasingly aware and interesting towards users, also ensuring the usability of the data not only to an expert audience.
As regards the uses, therefore, this applicative hypothesis appears to be addressed exclusively for tourism purposes, for knowledge and dissemination of the heritage of lighthouses, as it is based on a level of knowledge of the architectures that is not deep enough to define an operational tool aimed at maintenance and restorations, even if it can constitute a solid basis.

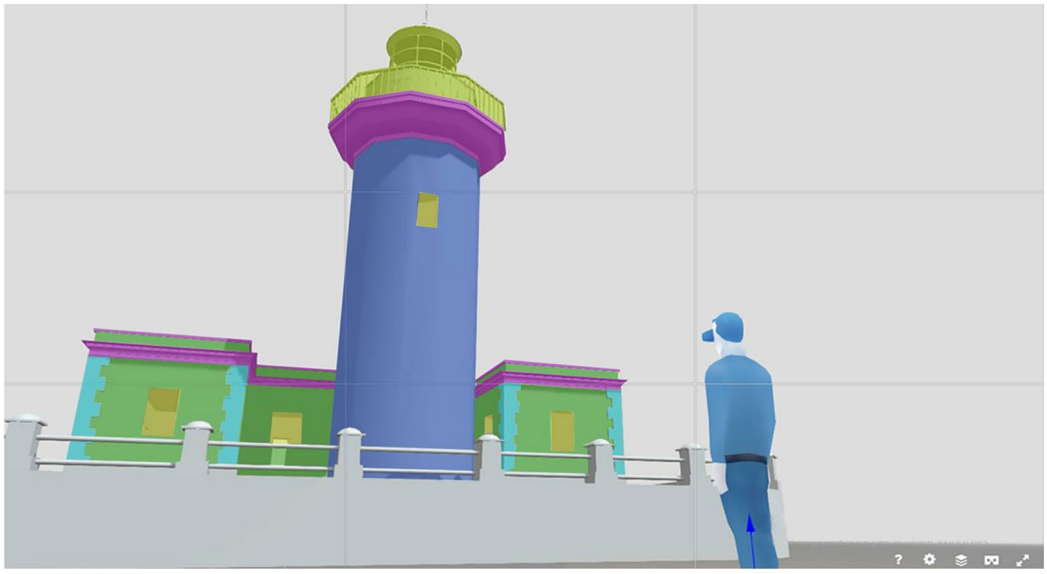

Fig. 2. Virtual Reality applied to lighthouses: semantics and fruition.

Fig. 3. Between Augmented Reality and semantics: connections of knowledge.

Finally, it should be emphasized that, if on the one hand the collection of data and semantics is configured as an action already in place, on the other hand, the development of this application is still in the creation phase.

Artificial Intelligence: Ontologies and Maps of Knowledge

There are several definitions of ontology: from a philosophical point of view it is a "systematic explanation of being"; from the computer science point of view we recall that of Gruber who defines it as an "explicit specification of a conceptualization" [Gruber 1995]; Borst defines it as "a formal specification of a shared conceptualization" [Borst 1997] while according to Guarino "it defines a logical theory that gives an explicit and partial justification of a conceptualization" [Guarino 2000]. But the definition that best matches the content of this contribution is undoubtedly the one asserted by Swartout in 1996: "an ontology is a structured set of terms that describe a domain and which can be used as a skeleton for the creation of a knowledge base" [Swartout 1996]. At an operational level, in fact, ontology represents a shared conceptualization of a certain domain and is based on the definition of the concepts and relationships that characterize the knowledge of the chosen domain, making it possible on the one hand to intelligently organize already known information, and on the other hand to establish new deducible assertions, or new knowledge [4].
Formal ontology, entered by law in the field of artificial intelligence and the representation of knowledge, is configured as a first-order theory that can be divided into two well-defined parts: syntax and semantics. If in augmented reality semantics is treated as an expedient for analysis, in ontology it takes on deeper meanings, capable of putting all data into a dense interoperable relationship through a domain. But why is ontology configured as the perfect method for cataloging the semantics of cultural heritage? This is because, in fact, ontology improves the management/understanding and access to the complexity of data, as well as improving its implementation and interoperability, in which semantics is configured as the most effective cataloging tool [Acierno et al. 2017].
There are different models for the organization of information in ontology, but to better represent the data and describe the type of relationship that binds the elements, it is necessary to understand what an ontology is and the use of specific terminologies (Fig. 4) for the domain we want to refer to. This is because the different terms can have multiple meanings, based on the field of study, and also because the definition of a specific terminology makes it possible to link the ontology and other IT and enhancement processes [5]. The first step to be faced in creating an ontology is defining the goal based on the data and therefore defining the questions to which you want to give an answer. The data is collected and analyzed in order to meet the intended objective, with subsequent cleaning of the data. Net of an optimal data collection, we proceed with the creation of the

Term	Definition	Source
Lighthouse	Light signaling instrument, consisting of a projector of white or red or green light, with a range of 10 to 40 miles, usually implanted in a solid tower construction or in another suitable building, on the most visible points of the coast (ends of the piers, promontories, rocks), to serve as a fixed point of reference for night navigation; it is said characteristic of a f. the type of light emission (continuous or intermittent) and its range. In some cases it is mounted on a float (light boat, light ship). [...]	Treccani dictionary Url: https://www.treccani.it/vocabolario/faro/
Nominal range of the light source	The range of the headlights can be divided into nominal, geographical and luminous range. The nominal range, on the other hand, is independent of atmospheric conditions and is defined as the light range that the lighthouse would have under standard conditions, with a meteorological visibility of at least 10 miles. The nominal range of a lighthouse is from 10 miles to 40 miles.	Sites specialized in boating; lessons for the acquisition of a nautical license. Url: https://www.nauticando.net/lezioni-di-nautica/segnalamenti-ottici-marittimi/; https://www.mkonsulting.it/joomla/images/Navigazione/fari%20e%20segnali%20da%20nebbia.pdf.
Lantern	Part of the architectural complex of the lighthouse, the lantern is the glass structure that contains and protects the lamp and the optics. Generally circular in shape, but also polygonal, the lantern is made with special technical devices to be as transparent as possible to the light signal emitted by the optic [...]. Finally, on the tower there are one or more hanging galleries (the "terrace" or "gallery"), outside the service room and the lantern, the latter mainly to allow cleaning of the external surface of the lantern windows.	Sites specialized in boating and officers. Url: https://www.nps.gov/maritime/; https://www.mkonsulting.it/joomla/images/Navigazione/fari%20e%20segnali%20da%20nebbia.pdf. Libro: L'architettura dei fari italiani

Fig. 4. Ontological terminologies.

semantic model and its transposition into OWL. In order to optimize the usability of the created ontology, it is possible to create an interface that contains it in which to report the "competency question", or the questions that we can answer with our ontology.
To better clarify the practical creation and theoretical existence of an ontology, we want to emphasize that there are three main elements in it: the classes that represent the general concepts of the domain; the properties that define the type of relationships that exist between the classes; the instances representing real world objects that are part of a given class (Fig. 5). In the ontology of Sicilian lighthouses, the creation of classes and dominion are placed side by side with the semantic decomposition previously exposed: building, tower, lantern. For each class, therefore, the instances that make up the classes and subclasses are associated, explaining what are the individual decorative components and the openings of the architecture belonging to the three macrogroups. Associated the instances with the semantics, it is possible to define the object relationships, or the object properties, in the "individuals" section, through which it is possible to record all the relationships between the identities that make up each specific lighthouse. Net of the creation of an ontology of Sicilian lighthouses, it is possible to generate the "knowledge graph", that is the representation of the entities of the real world according to their relationships organized by means of a graph with nodes, through which it is possible to highlight classes and relationships. The graphic data can be used according to two interpretations: focusing the interest on the single lighthouse (Fig. 6) or deriving the knowledge starting from the semantic clusters up to the architectures associated with certain semantic characteristics (Fig. 7).

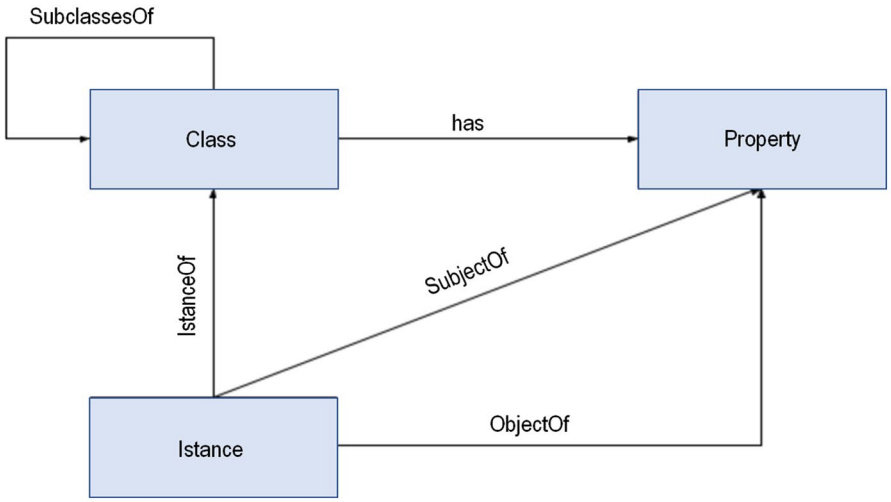

Fig. 5. Relationships: classes, instances and connections.

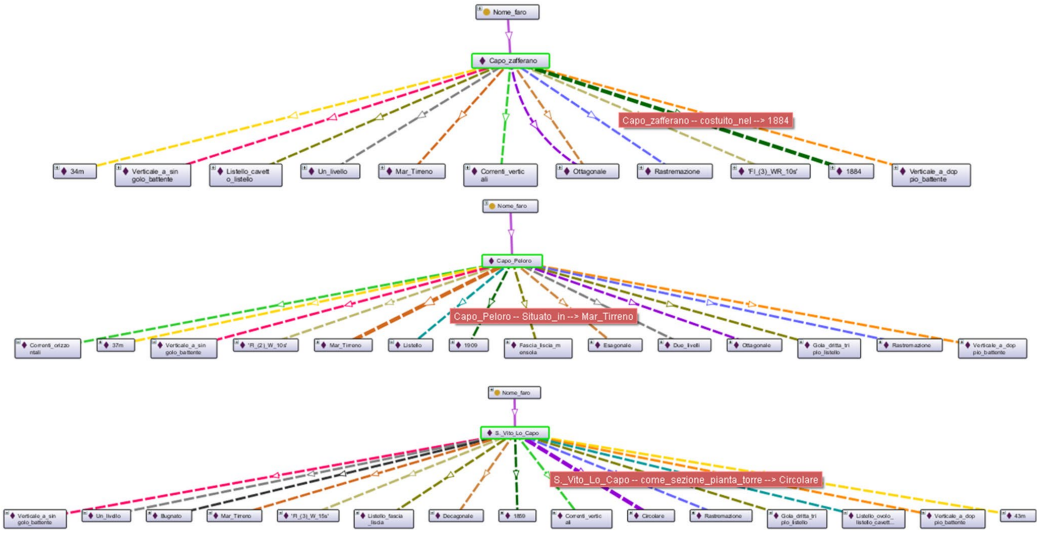

Fig. 6. The ontology of lighthouses: bottom-up approach.

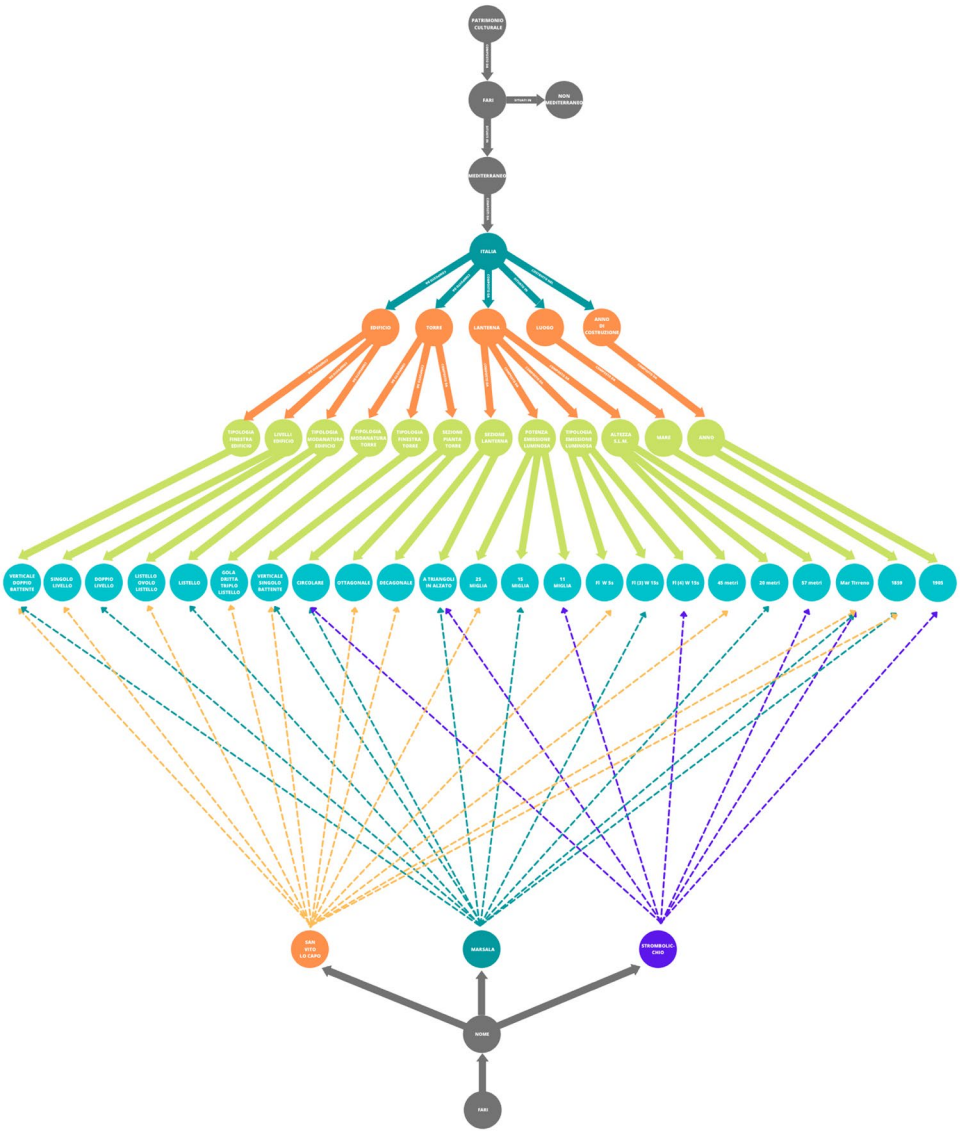

Fig. 7. The ontology of lighthouses: top-down approach.

Conclusions: Augmented Reality, Ontology and Reproducibility

If in augmented reality semantics is treated as an expedient for analysis, in ontology it takes on deeper meanings, capable of putting all data into a dense interoperable relationship through a domain. The use of open source software makes it possible to connect – through the creation of object properties, data properties and classifications – of the etymologies and common identification systems of the different elements of the building that are to be taken into consideration, creating not only an intelligent and interactive system of connections but also a process of deep knowledge of the building. In this sense, the contamination of ontological sciences in augmented reality applications makes it possible to manage both visual semantic data and the "competency question", useful for understanding and knowing the connections between the building and the rest of the architectures present in the domain. To validate the potential of the use of ontological sciences there is the possibility of – in addition to intelligently organizing the information already known – to establish new deducible assertions, or new knowledge, useful for making the interface always modifiable and integrable with further data, establishing a process of in-depth knowledge of the building and its relationship with similar architectural structures.
Ultimately, the ontological and semantic methodology makes it possible to reproduce the process as the semantic classification is often applicable to all that cultural heritage including peculiar and

recurring compositional characteristics, as in the case of lighthouses. In addition, ontological sciences today represent researches aimed mostly at an audience of specialists who, associated with an augmented reality interface, can be used through a simple application on a smartphone to be used on site or remotely, in line with those that are the cultural development guidelines based on edutainment [McLuhan 1964].

Notes

[1] As the Gestalt maintains, "Knowledge cannot be broken down into simple elements. The whole is more than the sum of the single parts", that is, the totality of the perceived is defined not by the sum of the single parts but by the sensory activations that arouse the single parts side by side, in a complex totality [Zerbetto 1998].

[2] In this discussion, the term "building" means the structure in which the lighthouse's residence and/or office is located and not the totality of the architectural structure.

[3] By lighthouses we mean those architectures that include a masonry structure, thus not considering lighthouses with a metal structure.

[4] In the case of the ontology of Sicilian lighthouses, the data already known are inherent to the year of construction, the type of light emission, although these data are still not always easily friable. On the other hand, all that concerns the semantics of the lighthouse is part of the increase in knowledge, that is, the decomposition of the individual parts of the building through the study of recurring languages.

[5] In this sense, in fact, the use of specific terminologies makes it possible to connect computer knowledge with different digital environments such as, for example, parametric modeling, to be connected using element IDs.

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