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From the Development to the Evaluation of the MOTunAr Ontology

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ABSTRACT

The focus of reasoning and interpreting in the knowledge engineering field is moving from 'data processing' to 'concept processing', it means that we focus more on the semantic aspects which are considered a significant challenge in the modern information system. Ontology is commonly considered as the solution which serves as a representative of the semantics of any domain. In the archaeological field, the gathered data dispersed a significant set of incoherent and heterogeneous sources (e.g., excavation reports, archives, etc.) and appear in various formats and may be uniquely accessed over broken mode since given than the joining between recording data is insufficient. In the area of the Tunisian archaeological field, heterogeneity is a dominant characteristic so that ontologies present an efficient solution to the semantic heterogeneity issue. Our ongoing research is oriented to develop a multimedia ontology of the Tunisian archaeological field. This ontology aims to describe the whole Tunisian archaeological sites. We profited from the different available sources that describe this domain. The development of the MOTunAr ontology will be realized in 6 steps. The principal ones will be detailed in this paper. MOWL will be used as a knowledge representation language that permits us to represent the multimedia knowledge used in our experiments.

Keywords: ***Archaeology, Axioms, Concept, Ontology, Relations.***

I. INTRODUCTION

Large, heterogeneous, and diverse data on cultural heritage (CH) exist in museums, government publications, art galleries, and other CH institutions. These data have recently adapted advanced metadata models to better organize them [1]. It provides enhanced data services for visitors of their physical collections and their digital counterparts. Among several existing metadata models, we can cite the ontologies of the semantic Web. The latter is the most used because of their increased expressiveness. These ontologies represent complex semantic relationships between CH entities. These relationships go back to the multiple properties that ontologies benefit from, such as extensibility, generality, and inference support [1].

Besides, to improve our information retrieval system, we are developing the ontology of Tunisian archaeology. It is a terminal-ontological resource for the field of Tunisian archaeology and heritage. This resource contains all the relevant concepts, the relationships between the concepts while respecting the names in the documents of archaeologists [2]. It will be used on the one hand in annotation and indexing of images related to an archaeological site and on the other hand in the search for information in annotated images.

On the other hand, the creation of ontology is based on various sources of knowledge, including unstructured sources (e.g., web pages), semi-structured sources (e.g., dictionaries), and structured sources (e.g., database). For this objective, we propose the two hypotheses to benefit from these various sources:

- The sources have different interests that should be taken into consideration during the development of the ontology.
- The confidence related to such information increases when this one appears in serval sources.

In order to take into account these two hypotheses, 1) each source have a score of interest that explains its relevance, dependent on this score, a source of information is used to extract data or it is rejected from the knowledge base of our ontology, 2) each extracted information have a score of confidence is intimately related to the origin of information (i.e., if the score of interest of this information is raised the score of confidence of information increase automatically) as well as the presence of this information in many sources. Depending on the score of confidence extracted information is accepted or is rejected.

To develop this ontology, we have set 6 steps, but the main ones are described in this document. This project shows that the viability of these resources could involve a precise articulation of concepts and terms, in addition to such a precondition that can be achieved through the implementation of procedures based on the meta-modeling architecture. Meta-modeling makes it possible to represent, at the same time, all the systems of organization of knowledge and the structures of knowledge required.

The rest of this paper is organized as follows: In section 2, we introduce the related works. Section 3 presents the implementation of MOWL. Section 4 details the general process of our contribution. Section 5 presents the different steps that aim to create the MOTunAr ontology. Section 6 shows an experiments part. Section 7 presents the evaluations of the MOTunAr ontology based on specific criteria and some analysis. Section 8 presents the future works. Finally, Section 9 concludes this paper

II. Related Work

Ontology is defined as an explicit formal conceptualization of different fields of interest [3]. They are increasingly used in various domains such as information extraction, knowledge management, and the archaeological field. In this section, we want to present some already developed ontology with the terms used in the archaeological field.

PARCOURS(Cultural Heritage and Restoration-Conservation: Ontology for the Use of a Reference Framework common to the different data sources) as a very known ontological model [4] allows providing a uniform interrogation of the heterogeneous data sources existing in databases. Besides, the conservation status of heritage buildings can be described by different formats of data (e.g., images, analytical data, scientific imaging, etc.). PARCOURS ontological model aims mainly to provide a common vocabulary for the heterogeneous data. Also, this model makes in relation heterogeneous and voluminous data coming from different data sources to aid the expert to have clear and pertinent information about a specific entity [4]. This approach is based on existing databases. Thus, to apply this approach, the input data should be structured. For our case, the input data are in different formats (i.e., structured, semi-structured, and not structured). Therefore, the implementation of the PARCOURS model approach is not possible for the Tunisian archaeological field.

Based on the 2D/3D semantic annotation, Messouadi developed an ontology that aims mainly to support the conservation status of heritage buildings[5]. Messouadi fused the semantic, spatial, and morphological dimensions to take into consideration the quantitative and qualitative aspects of data. The generated ontology assists Eritrean's experts to ensure a clear and flexible decision by the implementation of various information, knowledge, and data for the control and description of the different stone degradation phenomena[5]. This approach is mainly based on the CIDOC-CRM ontology, and it aims to design the entities that aid to conserve the archaeological monuments.

many other ontologies have been developed that aim to design the data involved in the archaeological field[6], [7]. Despite the importance of these ontologies, the type of the input data (i.e., structured data), and the requirements of the developed ontology (e.g., conservation, diagnostic, etc.) make the reuse of these approaches not very easy. Therefore, it seems not possible to apply these approaches to the Tunisian archaeological field.

In contrast, the CIDOC CRM ontology, the CARE ontology, and the Mallik ontology are the main pillars of our approach. Thus, we try in this section to detail these ontologies and we elaborate on a comparison between them.

A. CIDOC-CRM Ontology

The CIDOC-CRM (**C**onceptual **R**eference **M**odel) was developed to structure and describe the heterogeneous and huge data involved in the CH domain as well as the libraries and museums. The goal of this ontology is to transform the hybrid and heterogeneous knowledge sources into one comprehensive and coherent resource. CIDOC-CRM is considered as a "core Ontology" and it is based on the class "event" to define all other entities. Indeed, an instance of the class "event" could include other instances origin to the next classes [8]:

- Actor: an instance of an "event" is induced by an actor.
- Conceptual/Physical object: a group of objects that could be either physical or conceptual objects that are influenced by an instance of the class "event".
- Space: the place where an event has happened.
- Chronology: the temporal entity that defines the time of happiness of an event.
- Appellation and Type: the noun "Appellation" and the "Type" which could be added to all those entities (e.g., actor, event, temporal entity, etc.) to categorize them.

The CIDOC-CRM ontology has been implemented in different versions, the 4.0 version is the most used one and it encompasses 132 proprieties and 80 classes[9]. CIDOC-CRM was designed and developed on RDBMS, OWL, RDF, and some other types and formats of representation [10].

Much research was based on the CIDOC-CRM as core ontology[11]–[14], basically thanks to its capacities to mix between the "heterogeneous data" and "the ease of use" [9]. In fact, the class "event" and its implementation yield good results to describe the CH information; however, this information could be presented in different formats (e.g., image, music, text, and video) however the multimedia content did not have to consider by the CIDOC-CRM ontology.

B. CARE Ontology

CARE project is a European project that aims to describe the different Christian edifices existing in Europe. Wiki Bridge presents the base of this project. It is a semantic wiki that imported the CARE ontology as an OWL file to overcome the semantic gap. The CARE ontology includes 715 instances and 124 classes [11].

CARE ontology is based on the CIDOC-CRM ontology as core ontology. The protégé editor and the OWL language are the principal tools used in the creation of this ontology. CARE ontology encompasses four parts [11]:

- Religious concept: it describes the different entities and elements of the religious edifices. The class E24PhyicalObject mapped from the CIDOC-CRM ontology integrates all the terms related to these religious edifices.
- Architectural element: the different entities related to the architectural context (e.g., dimensions, the construction decorations, techniques, etc.) are defined by a set of concepts.
- Spatial relations: the spatial entity is described by different concepts (e.g., the orientation propriety, the distance propriety, the topology propriety, the annotation propriety, etc.).
- Temporal relation: the class “E52TimeSpan” mapped from CIDOC-CRM ontology involved the entities and concepts that describe the temporal entity. The class Activity of CIDOC-CRM is applied as well as their different subclasses are also eligible for use (e.g., E11Modicfiation, E81Transformation, etc.).

The implementation of the CARE ontology provides the expressiveness and the flexibility to support various formats of representation of data. Furthermore, the multi-disciplinary (topographers, archeologists, art historians, historians, etc.) is guaranteed to assure a collaborative data collecting task which merges knowledge from different disciplines[11]. On the other hand, the CARE ontology as the CIDOC-CRM ontology has not taken into account the multimedia content involved in the archaeological field. Besides, CARE ontology is only directed to the Christian edifices thus, this ontology cannot be applied to other types of archaeological entities.

C. *Mallik Ontology*

Mallik's approach consists of implementing a framework based on a multimedia ontology. This ontology can relate and combine digital objects with contextual data [12]. The implementation of the framework is distributed into four stages:

- Knowledge acquisition: this step aims to collect the specialized data related to each domain. The textual data are employed by the domain experts to create a basic ontology. This ontology declares the domain concepts, their proprieties, and their relations. The multimedia data are used to construct a digital collection. The domain experts added conceptual labels to annotate the multimedia data. These labels answer to the main domain concepts [15].
- Ontology Learning: The “media classifier” is developed during this stage aims to detect the media patterns. The implementation of MOWL allows to support of the probable reasoning and the Bayesian network as well as to represent the several concepts or the uncertainty inherent in their specific relations. The FBN (Full Bayesian Network) is implemented to create a probable relation between the class and the media content. If a new label is added to the multimedia data, this technique is newly applied, and the developed ontology is updated [15].
- Application: the implementation of MOWL allows us to detect the domain concepts. The different media classifiers are developed to collect the media pattern. These patterns are related to the multimedia nodes defined in the ontology. The annotations of multimedia nodes are generated based on the domain concepts. These annotations allow the generation of semantic hyperlinks for the digital collection [15].
- Evaluation: each stage is constantly evaluated to guarantee the scalability and integrity of “the developed ontology”. In fact, the users and the domains experts have applied new modification that exists in the real world, to support the task of updating knowledge [15].

MOWL generates perceptual models due to its capacities to manipulate the inherent uncertainties oriented to the media proprieties [12]. Furthermore, implementing the FBN that allows ensuring probable reasoning was satisfying. Thus, the multimedia ontology is developed and the task of updating data is regularly taken in charge. On the other hand, the multimedia ontology generated by the domain experts does not present a standard model, thus the reuse and the mapping of this ontology seem to be not very simple.

D. *Comparison of Selected Ontologies*

CIDOC-CRM is imported as a core or reference ontology in various research. It proved its capacity to generate an efficient ontology from voluminous and heterogeneous data [3]. CARE ontology was based on the CIDOC-CRM as core ontology. It implements some classes and properties from CIDOC-CRM and defines specific classes and subclasses that design the religious entities. Thus, a more adequate ontology is created. On the other hand, CARE ontology as well as CIDOC-CRM ontology didn’t support the multimedia content that can be existed on the collected archaeological data [11]. Thus, “Mallik” has applied the MOWL language to overcome this default. In fact, the multimedia ontology generated by “Mallik” supports not only the multimedia aspect but also the uncertain aspect of gathered. These capacities are due to the perceptual model that is generated by the implementation of FBN as well as the MOWL language. Furthermore, thanks to these tools the generated ontology is periodically updated. The multimedia ontology generated by “Mallik” does not correspond to standard models. Therefore, the reuse and the mapping of this ontology seem to be not very simple [12].

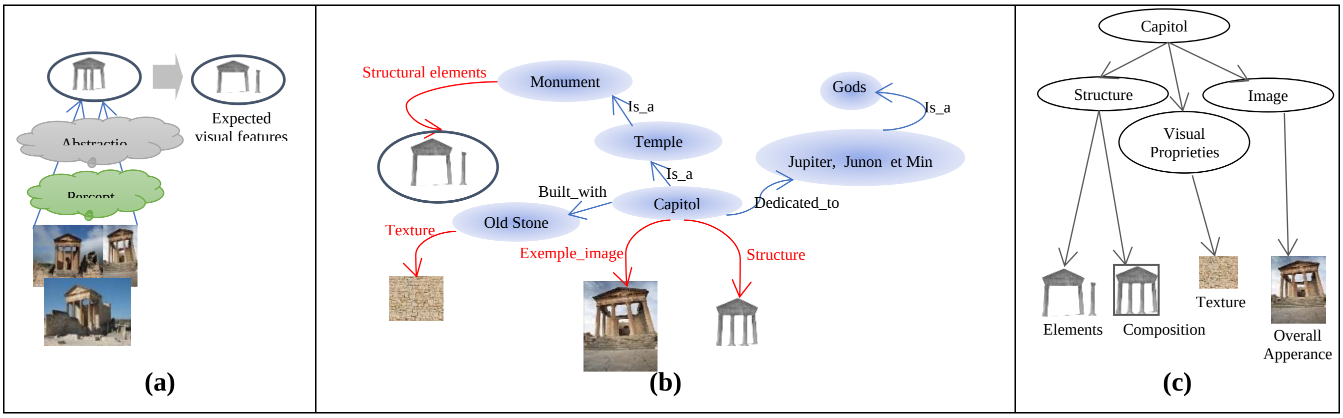


Fig. 1. **a** Perceptual modelling, **b** multimedia ontology of Tunisian monuments, **c** observation model of Capitol

TABLE I. COMPARISON OF SELECTED ONTOLOGIES

Criteria Ontology	Language	Number of entities	Multimedia continent	Possibility of mapping
CIDOC-CRM	OWL /RDF	132 properties and 80 classes	-	+
CARE	OWL	715 instances and 124 classes	-	+
Mallik Ontology	MOWL	-	+	-

III. MOTUNAR REPRESENTATION THROUGH MOWL

The classical ontologies used text to express the various concepts and the main properties. Thus, they used the traditional ontology language to describe data (e.g., RDF, XML, OWL, etc.). Consequently, it seems to be simple to implement such ontology to support semantic text processing. For MOTunAr ontology we have applied the MOWL language that ensures the creation of Perceptual Modeling. Thus, semantic processing of multimedia content applied ontology primitives that enable the Perceptual Modeling of the domain concepts according to their observable media properties. An example of Perceptual Modeling is shown in Fig.1.a. Such modeling needs to encode the inherent uncertainties which are associated with media properties of concepts media manifestation

A. MOWL Relations

The relations between the concepts play an important role in concept-recognition. For example, the visual characteristics of the stone in which it was built can be an important guide to identifying a medieval monument (as shown in Fig.1.b). To allow such reasoning, MOWL provides a class of relations that implies the "propagation" of media properties [16].

B. Specifying Spatio-Temporal Relations

Complex multimedia events can be described in MOWL with component multimedia objects. The spatial and temporal relationships between these events are defined with formal semantics. The latter corresponds and can be executed using an extended MPEG-7 query engine proposed in. A multimedia ontology must be capable of specifying these concepts in terms of the spatial/temporal relationships between these components. MOWL defines a subclass of multimedia objects called <ComplexObject>. This subclass represents the composition of multimedia objects linked by spatial or temporal relationships. Each complex object is defined by two media objects and a relationship. This relation can be spatial, temporal, or reference. One of the two media objects is the subject of the predicate relation, and the other is the subject of the predicate [16].

C. Uncertainty Specification

The relationships between informational objects and concepts are causal and generally uncertain. Therefore, they are probabilistic in nature. MOWL makes it possible to specify the uncertainty of these correlations in the multimedia field. It provides property structures to define conditional probability tables (CPTs). It also makes it possible to associate them with media objects and concepts[16]. Reasoning with Bayesian Networks the available knowledge in MOWL ontology is used to construct an observation model (OM) for a concept. This model is used for the recognition of the concept. To build it, two reasoning steps are needed [16].

-**The first reasoning** is necessary for the derivation of an observation model for a concept. It requires the exploration of the neighborhood of a concept and the gathering of media properties of neighboring concepts, wherever the propagation of media property is implicit.

-**The second reasoning** is useful for the recognition of the concept. After the creation of an observation model for a concept, the OM can be used for the recognition of the concept. In our research, we use addictive reasoning that exploits the causal relationship captured in OM (Fig.1.c).

IV. General Process

As we have already mentioned, we propose to build an ontology and transform non-ontological sources. This general process, presented in Fig.2, consists of three steps: 1) Analysis of sources, 2) Transformation of sources, and 3) Knowledge Base Merge.

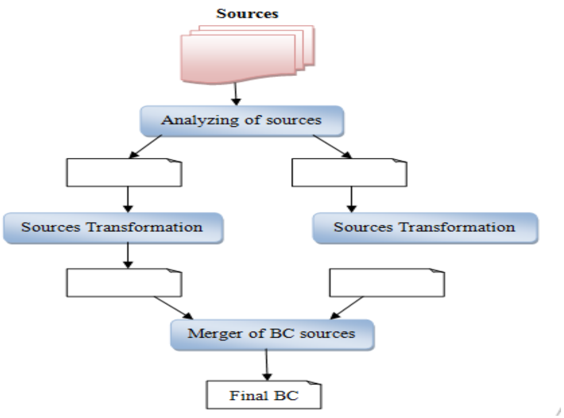


Fig. 2. General Process

A. Analysis of Sources

This preliminary phase of the process is used to enumerate the sources that will be considered in future steps (see Fig.3). To select the most suitable sources, it is important to specify the reasons why a source is appropriate and the criteria to be observed on a source to select it. We have defined four main criteria that we use for interaction with the expert: 1) The reputation of the source, 2) The freshness of the source, 3) The adequacy of the source to the target, and 4) The clarity of the source model.

Once the sources have been chosen, we analyze them and represent them by the different levels of abstraction. In other words, this step is designed to identify what is concerned with data modeling, implementation structuring or implementation syntax. It is divided into three tasks that are defined as follows:

- **Task 1.1: Data Recovery**: it retrieves all the data and documentation related to the source.
- **Task 1.2: Conceptual abstraction**: it determines the model used to represent the data. This model can be specified in the documentation; otherwise, it will have to be manually reconstructed.
- **Task 1.3: An exploration of the information**: it is used either to define the format of the data
- implementation of the documentation or manually reconstruct the document.

Our objective in this process is to find common knowledge from many sources. Depending on their quality, the different sources do not necessarily have the same interest. Therefore, knowledge derived from a good quality source will carry more weight than knowledge obtained from a lower quality source.

B. Sources Transformation

This second step assists in the transformation of the Non-Ontological Source (RNO) according to the elements identified in the first step. This transformation will be done according to existing transformation schemas (if possible). For this purpose, three tasks are specified:

- **Task 2.1: Search for an adapted transformation pattern**: it is possible to make this search in the ODP Portal (Ontology Designed Patterns). This portal groups the designed patterns as well as the transformation patterns.

If there is an adapted transformation pattern to the source, we apply task 2.2a, otherwise, we apply task 2.2b.

- **Task 2.2a: Application of the transformation** if a pattern is found.
- **Task 2.2b: Definition of an ad-hoc transformation method** a generalization of this method to create a new pattern if no adapted pattern has been found.
- **Task 2.3: Manual correction**: it enables to retake the updated transformation to manually correct the various errors that can appear.

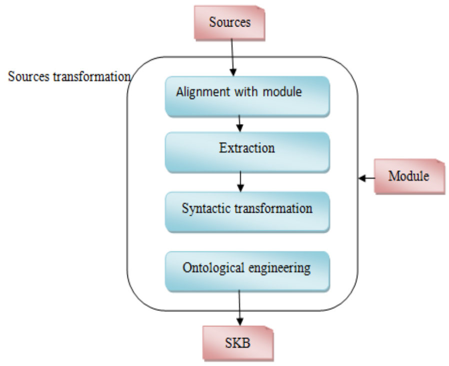


Fig. 3. Source Transformation Process

1) Transformation Process

The transformation patterns are used to specify the transformation of a given type of source and model. These patterns are often too generic to be directly applied to a source. Therefore, it is essential to customize them to adapt them to the needs of the transformation. To generate a Source Knowledge Base (SKB) from any source, we identify a process that includes four steps:

- **Alignment:** in this way, it is possible to specify which elements in the source correspond to the classes of the module.
- **Extraction**: all the elements of the source belonging to the studied field are extracted.

- **Syntax transformation:** a syntax transformation is performed following the selected transformation pattern.
- **Re-engineering**: the transformed and the extracted elements are associated with the ontological module to enrich it by using a relation named "subClassOf" or "instanceOf".

2) Transformation Pattern

In order to realize the step of the automatic transformation of the sources, we use the work presented in [17]. We try to use these transformation patterns through the involvement of the ontological module in the process. We suggest a clarification of the elements to be processed by the reuse of the disambiguation rules adapted to the domain. Also, we propose to represent these rules in the form of an expert ontological modeling unit and a methodological transformation pattern.

In addition, we suggest representing these bases in the form of a systematic transformation model and a specialized existential modeling unit. Then, using the specific clarification in a field [17], [18]by the use of a module, we adapt the creation of a transformation pattern.

A transformation pattern is in the form of a source transformed. It can be assimilated into a set of rules that we apply to the indicated algorithm to obtain the desired transformation. Experts define a transformation pattern for each source by adapting the ontological module used. In this way, a source knowledge base (SKB) is generated for each considered source. These SKBs form the transformed sources while respecting the objective specified by the module.

C. Merging knowledge bases

As introduced in the general process, and after obtaining the source knowledge bases, we merge them to obtain the final knowledge base. This SKBs merger phase is divided into several stages. The input of this process consists of the different SKBs that we consider as merged. We wish to obtain, as a result, the final knowledge base. The latter is the result of different SKBs merger processes. To realize it, we require the following four steps:

- **Alignment of the source knowledge bases:** it creates the correspondences between all the pairs of SKBs considered.
- **Candidate generation:** the candidates of the ontological elements or the relation are generated from the correspondences presented between the SKB. These candidates are potential elements for the final knowledge base.
- **Calculation of the confidence:** We associate a confidence score with each candidate. This score represents the consensual confidence of a candidate. It becomes higher when items are found in several sources.
- **Discovery of the optimal extension:** when candidates share common ontological elements, we consider a notion of incompatibility between them. From these incompatibilities, an extension as a subset of non-compatible candidates is defined. This step allows us to discover the optimal extension, which is the extension that maximizes the confidence of the candidates.

D. Calculation of a Candidate's Confidence

We generate candidates to identify which elements could potentially appear in the final knowledge base. In fact, this potential membership is estimated on the basis of a confidence score attributed to each candidate according to his appearance in the different sources. We conclude that if a candidate involves several sources, then these sources match this representation. Therefore, we try to determine the level of consensus of the candidate in the context of the multi-source transformation process.

In addition, the Candidate's Confidence is considered as the number of occurrences of each candidate. For each candidate, we calculate the number of its occurrence. Based on this score of confidence the candidates are devised in two subsets:

- **Candidates with a high score of confidence:** these candidates are automatically added to the final set of candidates' terms.
- **Candidates with a low score of confidence**: these candidates are firstly examined by a domain expert who adds a decision about these terms if is an important candidate then it is added to the final set of candidates else it is rejected.

Thus, the calculation of the Candidate's Confidence allows reducing the manual intervention. On another hand, the domain expert should verify only the candidate with a low score of confidence not the whole of terms.

V. Steps of Creating the MOTunAr Ontology

The creation of the MOTunAr ontology is divided into six steps.

A. Step one: Filtering in the Field

The memberships of a class related to the studied domain are clarified by an external resource. This task is based on the result of the automatic filtering of data. A set of modules would be implemented to limit this domain. The alignment between the resource and these modules presents the first stage of the task of extraction. To guarantee the reliability, the task of alignment could be made by manual or technical terminological alignment. The classes encompassed in the generated module are few. Thus, the alignment could be made manually. Much ontology is already developed and available in electronic formats with different types and is directed to several domains. We profit from those developing ontologies by importing them as a reference or core ontology. For the MOTunAr ontology, we import the CIDOC-CRM [8] ontology and the CARE [11] ontology as the reference ontologies. However, according to this first step, the task of extraction of the different classes could be made by the same simple method. A generic resource ensures disambiguation to detect the rising list of hyper names for each extracted class. The extracted class is considered as a part of a domain if one of their hyper names is at the same time one of the terms aligned with the module. Otherwise, this class is not considered as a part of the domain and would not be exported to the final resources. In doing so, we would obtain a set of potential classes related to the domain of study. Indeed, the list of classes defines several existing periods in Tunisian history (e.g., the Islamic period, the Roman period, etc.).

B. Step two: Validation of the Classes

Once the previous step has been completed, an extracted class would maybe represent a class entity or maybe it would define a relation that can exist between other classes. Thus, the existence of this extracted class in the final list is not always guaranteed. This type of problem is the result of the nature of the sources studied, which differs from those presented in the ontology. To validate these classes, we envisage intersecting the treatment of several sources and resources during this step. For example, the confidence of existence increases if a class obtained from a first source is similar to a class extracted from a second source. Also, this confidence increases, in the previous step, if the class is aligned with an element of a generic resource.

In our ontology, two main classes are defined (*T1-Archaeological-Entity, T2-Archaeological-Coordinates)*; each one of these classes defines a hierarchy of subclasses that are presented in the following section.

C. Step Three: The Hierarchy of Subclass

We propose the below hierarchy for the various classes included in MOTunAr ontology [19]:

- **T1-Archaeological-Entity**

Archaeological entities aim to model archaeological sites and monuments. Two subclasses are added to this class: 1) T11-Site, and 2) T12-Monument.

- **T11-Site** is a site (or multiple physical places) in which indications of previous past activities are conserved (either historic primitive or recent), and which perhaps has been explored utilizing the science of archaeology and by consequence represents a section of the archaeological record [20]. Sites differ and could have some or no observable remains on the ground, to establishments and some other structures which are under use.
- **T12-Monument**: an object or entity sat up in remembrance of a human being or an event and some other things like buildings and antique pillars, or statues. Any structure or building remaining from gone ages is considered as having great historical as well as archaeological significance [21].

- **T2-Archaeological-Coordinates**

The different archaeological entities are described by an archaeological knowledge presented by the main class "T2-Archaeological-Coordinates". Archaeological coordinates include all knowledge related to the archaeological entities. This main class defines seven subclasses [19]: 1) T21-Appellation, 2) T22-Anthroponym, 3) T23-People, 4) T24-Temporal-Entity, 5) T25-Spatial-Entity, 6) T26-Physical-Object, and 7) T27-Conceptual-Object.

T21-Appellation*:* it is equivalent to E41-Appellation Class from CIDOC-CRM. Also, we have associated with this class, three subclasses which are:

-T211-Identifier: it is a code associated by the INP to the archaeological entities in order to be authenticated [21].

-T212-Old-Name: An archaeological entity may have one or more old names that are different from its current name.

-T213-Current-Name: The current name may be the same as the old one; it can be single or several names that differ from one nationality to another.

T22-Anthroponym: it defines all names of persons (heroes, gods, etc.) related to the various monument. *Into* this class we have defined three subclasses:

-T221-Hero: According to history Heroes and Heroines could be both real and just fiction, it could present an example of arts or the human myths, which deserved to have poetry and songs describing their legendary actions [22].

-T222-Religious-Person: This is a person who has a deep liaison to a certain religion. He could be a prophet, saint, priest, goddess, etc.

-T223-Divinity: this subclass defines the different divinities referred from one era to another.

T23-People: it designs the names of inhabitants of a city mentioned in a historical document. They are the people of a country *who made* its history. For this class we have defined the subclasses:

-T231-People-Appellation: this is the name given to the inhabitants of a specific place during a specific period.

-T232-Civilization: civilization is a group of aspects that depicts a specific community, a nation, a region, a group of people, in different fields [21].

-T233-Emperor: it defines the one who is at the top of the pyramid or the king, the Bey, the Caliph, etc.

T24-Temporal-Entity*:* it is a mapped class from CIDOC-CRM ontology. This class is defined in order to modulate the different time concepts. A hierarchy of subclasses was associated to this class:

-T241-Event: an event is anything that happens or appears to be of particular importance in the news. It is a phenomenon considered to be localized and instantaneous, occurring at a definite point in time. An event is anything capable of modifying the internal reality of a subject (external fact, representation, etc.). T241-Event includes as subclasses: 1) T2411-Event-of-modification, 2) T2412-Beginning-Of-Existence, and 3) T2413-End-Of-Existence.

-T242-Chronological Slice: This subclass describes a temporal range. It has duration, a beginning, and an end. The

T242-Chronological Slice class is implemented to define the event instance or the temporal range of periods. The same instance of this subclass can be identified either by different means of one or various time appellations. Moreover, the same periods are considered as characteristic periods (e.g., middle Ages, Antiquity, etc.). This class includes the following subclasses: 1) T2421-Absolute-Dating, 2) T2422-Periodization, and 3) T2423-Century.

T25-Spatial-Entity: it describes any entity oriented to the space and location of the different monuments or sites. A set of subclasses are added to the T25-Spatial-Entity class:

-T251-Name-Place: this is a proper identification related to a certain place. This name could be symmetric, Anthropology derived or followed by a combination of suffixes (tag + personal name) [21].

-T252-Geographical-Coordinates: the geographical coordinates make it possible to locate a place on the earth due to three measurements: altitude, longitude, and latitude [21].

-T253-Municipality: it is the administrative territory of a municipal-type structure that could have one single district or multiple societies (cities, countryside, etc.) [21].

-T254-Surface: it defines its boundaries compared to the rest of the universe items [21].

-T255-Delimitation: It defines a line of delineation between all kinds of geographical units, whatever they are material, physical, non-human or human [21].

-T256-Structure: it presents the archaeological site structure on the map.

-257-Current Occupation: An archaeological site can change in profile over time, for example a site can be a church but over time it changes to a theater.

T26-Physical-Object: it is alignments with the class "E24-Quelques-Choses-De-Matériel-Et-De-Fabrique" existing in CIDOC-CRM ontology in this class we want to model every physical entity. We have mainly focused on materials and on the architectural design of the archaeological entities. Indeed, for this class, we associate the set of subclasses:

-T261-Architectural-Element: it is a real and complex object made from several parts and formed of various materials: stone, terracotta, plaster, Cement, mimic wood. It also has a specific diameter that allows it to carry more or less heavy objects depending on its height. It has a story and some specific appearances, details, and forms [20]. This class defines four subclasses: 1) T2611-Decoration, 2) T2612-Architectural-Ornament, 3) T2613-Sculpture, and 4) T2614-Architectural-Style.

-T262-Materials: it defines any material used generally in the creation of an item. This item usually forms a part of a subset. By consequence it is considered as the main material selected for its unique properties and exploited for some special use.

-T263-Legal-Statute: a monument or a site can have legal status, either private or public.

T27-Conceptual-Object: it is a mapped subclass from CIDOC-CRM. This class defines all information related to archaeological entities, and they are not physical ones. Two main subclasses are associated with this class: T271-Description-Of-Site, and T272-Documentation.

-T271-Description-Of-Site: we try to provide a detailed description of the archaeological entity or site in question. Then we associate to this class a set of subclasses to be enabled to modulate as possible details. The hierarchy of these subclasses is defined as follows: 1) T2711Category, 2) T2712-General-Data, 3) T2713-State-of-Conservation, 4) T2714-State-Of-Research, 5) T2715-Number-Of-Monuments, and 6) T2716-World-Heritage.

-T272-Documentation presents the source of the information on which we rely to describe the entities in question. This object can be textual (documents) presented by the subclass T2721-Document or visual (image) presented by the subclass T2722-Visual-Element.

D. Step Four: Disambiguation of the Relations

According to our study, it is simple to discover the existence of a relation (object properties) between two classes. Our objective is to clarify these relations. In the literature, we have found that the most efficient methods for extracting relations are based on the corpus studied. Among the existing studies, there are those dealing with the automatic extraction of relations from a thesaurus [14]. Also, these researches use the corpus. We should, therefore, envisage the automatic processing of the corpus to demystify these relations. Nevertheless, we intend to validate the disambiguation achieved through an alignment of the relations. If the relations are presented in various sources and resources, the confidence in this relation will increase more and more. For our ontology we have devised the relations on three kinds:

- Hierarchical relations: it is used to structure the ontologies. It strongly allows the inheritance of properties and it is a choice that has been imposed since Aristotle. This relation must be then supplemented by other relations to express the semantics of the field. Four hierarchical relations are associated to our ontology: 1) is-part-of, 2) more-generic-than, 3) more-specific-than, and 4) is-a. To define the hierarchical relations we applied the algorithm of hierarchical relation definition.

Algorithm 2: Hierarchical relation definition.

Input: Training set O= {(C1, C2, R}, /* *C1, C2 are the concepts for which we try to define a hierarchical relation; R is anonym relation among C1, C2* */
Output: HR
Randomly initialize θ;
While training is not terminated do
Switch R
Case Subsumption:
        HR← is-a;
        Is-a (C1, C2);
        Break;
Case Generalization:
        HR← is-more-generic-than;
        Is-more-generic-than (C1, C2);

Break;
Case Specification:
HR← is-more-specific-than;
Is-more-specific-than (C1, C2);
Break;
Case Part:
HR← is-part-of;
Is-part-of (C1, C2);
Break;
Default:
HR← ϴ;

- Associative relations: the relations link the concepts together to construct complex conceptual representations. If the constructed knowledge corresponds to a concept in the modeled world, the latter is called defined, as opposed to the concepts inserted in the tree of ontology which are said to be primitive. As an example of associative relation, we are associated to our ontology P1-is-associated-with, P2-is-garanted-to, etc. To define the associative relations, we applied the algorithm of the associative relation definition.

Algorithm 3: Associative relation definition

Input: Training set O= {(C1, C2, R}, RES, S/* *C1, C2 are the concepts for which we try to define an associative relation; R is anonym relation among C1, C2 */*
/ resources RES and sources S*/*
Output: AR, SOC /* AR is the associative relation which we want to extract; SOC is the score of confidence*/
Randomly initialize θ;
While training is not terminated do
If exit(R) ==true then/* exist is a function which search the candidate relation R on the resources RES and sources S*/
SOC++; /* score of confidence of the relation R increase when it exists in different documents*/
If SOC>=2 then
AR← R;
Else
R is rejected; /*if the score of confidence is less than 2 the relation R is rejected from the list of relations candidates*/

- Semantic relations: The semantic relations are different from the relations usually used in UML conceptual representation (inheritance, aggregation, etc.) [11]. Many semantic relations could exist between two concepts such as identity, equivalence, synonymy relation (e.g., we use the two UP "use-for" and UPD "use to designate" relations to model synonymy relations). For example, P4-is-cited-in, P11-has-followed, P13-is-replaced-by, etc. To define the semantic relations we applied the algorithm of the semantic relation definition.

Algorithm 4: Semantic relation definition.

Input: Training set O= {(C1, C2,, Cn, R}, n, m/* *C1, C2 are the concepts for which we try to define a hierarchical relation; R is anonym relation among C1, C2 */*
/ n is the number of lines; m is the number of column*/*
Output: SR,
Randomly initialize θ;
While training is not terminated do
for i := 1 to n do
for j:= 1 to m do
if R(Ci, Cj) then
SR←R;

The definition of relations is controlled by the definition of axioms which are declared in the following section.

E. Step Five: Define the Axioms

In the research of [18], the authors indicate that it is recommended to apply a reasoner to deduce the various hierarchical relations (i.e., SubClassOf) rather than to explicitly express the theme. Therefore, the definition of the related axioms for each defined class is more important than the definition of the hierarchy. For this reason, we are focused on the definition of some axioms in our MOTunAr that will enable us to infer for the extracted classes the hierarchical relations.

For our multimedia ontology, we want to define the axioms depending on the controlling objects (classes, object properties, data properties, etc.). In this paper we have defined the axioms related to the classes and the axioms linked to the relations (object properties). The other axioms will be detailed in future works.

- Class Expression Axioms

These axioms provide established relations between classes. In our work three axioms are declared [23]: 1) SubClassOf axiom, 2) Equivalent Classes axiom, and 3) Disjoint Classes axiom.

- SubClassOf Axioms: SubClassOf (C1, C2) is a fundamental axiom which is used to define a class hierarchy. This axiom states that the class C1 is a subclass (more specific than) of the class C2: SubClassOf (T212-Old-Name, T21-Appellation).
- Equivalent Classes axioms: two classes C1 and C2 are equivalent classes that means C1 can be replaced with C2 and the meaning of the ontology is still unchanged. This axiom is equivalent to the two following axioms: 1) SubClassOf (C1, C2), and 2) SubClassOf (C2, C1).
- Disjoint Classes: Disjoint Classes (C1 ... Cn): these axioms state that an individual which is an example of Ci cannot be an example of Cj for $i \neq j$.

- Object Properties Axioms

The property of the SubObjectOf axiom enables the definition of the extension of one item's property; this expression is involved in the extension of another item's property expression. The property of an Equivalent Object of axiom clarifies that the extensions of many item's property expressions are equivalent. The Disjoint Object Property of axiom enables to state that the extensions of many items' property expressions are two at a time disjoint which means they do not share out pairs of linked individuals. The Inverse Object Properties of axiom could be used to explain that two item property expressions are the opposite of each other. The item Property field and the item Property scope axioms could be used to limit the first and the second body, sequentially, linked by an item property expression to be examples of the particular category expression. The Functional Object Property axiom enables one to explain that an item property expression is effective, which means that each person could have at least one outgoing linkage to the particular item property expression. The Inverse Functional Object Property axiom enables one to explain that an item property expression is reverse-functional which means that each person could have at least one incoming linkage of the particular item property expression. Lastly, the Reflexive Object Property, Irreflexive Object Property, Symmetric Object Property, Asymmetric Object Property, and Transitive Object Property axioms enable one to explain that an item property expression is reflexive, irreflexive, symmetric, asymmetric, or transitive, sequentially.

The rest of the axioms are linked to the Data properties are under view and examination.

F. Step Six: Define the Instances

The instances consist of examples that represent the current element. For example, creating an instance of a class consists of to create a real object based on abstract objects. This step aims to give values for each defined entity and declares their relations [2]. This step is not yet achieved, and it will be detailed in future works.

VI. Experiments

The memberships of a class related to the studied domain are clarified by an external resource. This task is based on the result of the automatic filtering of data. A set of modules would be implemented to limit this domain. The alignment between the resource and these modules presents the first stage of the task of extraction. To guarantee the reliability, the task of alignment could be made by manual or technical terminological alignment.

This experiment is devised into three sub-experiments; in the first one we define the hierarchy of subclasses described in section (**5.3**) based on the protégé editor. Part two aims to define the set of relations, we detail in this experiment the different kinds of relations involved on the MOTunAr ontology associated. The last part presents the basic axioms for our ontology.

A. Subexpriment1: defining subclasses

Protégé editor is used to defining our classes and the subclasses that are defined in section **(5.3).** Two main classes are defined T1-Archaelogical-Entity and T2-Archaeological-Coordinates. Each one of them defines a set of subclasses (fig.4).

To guarantee the interoperability of our ontologies we have based on the CIDOC CRM ontology. Since 2006, CIDOC CRM is considered an ISO standard (21127:2006) that aims to exchange cultural heritage. In addition, we have implemented the CARE ontology that is based on the CIDOC CRM ontology (i.e., guarantee the same level of interoperability) and defined more specifics terms. Thus, our defined classes are a rapprochement between the extracted candidates terms and the classes defined by the CIDOC CRM ontology and CARE ontology. This rapprochement is based on the descriptions associated with each entity defined by these references ontologies. For example, CIDOC CRM ontology defines the entity "E24 Physical Man-Made Thing" as "all persistent physical items that are purposely created by human activity". Thus, based on this definition we have created our class "T26-Physical-Object" and we have added a set of subclasses based on the different definitions given by the CARE ontology.

The consistency of the ontology is always verified based on the Pellet reasoner, and the OOPS online service [24].

The classes interact between them among the relations that are presented in the subexpriment2.

B. Subexpriment2: defining relations

as we were noted in section (5.4) the relations are devised on hierarchical relations (HR), associative relations (AR), and semantic relations (SR).

Based on the Hierarchical relation definition algorithm, four HR have been associated to our MOTunAr:

- Subsumption "is-a" to declare a subclass as a class: is-a (T221-Hero, T22-Anthroponym).
- Generalization "more-generic-than" to declare class more generic than other classes or subclasses: more-generic-than (T25-Spatial-Entity, T251-Name-Place).
- Specification "more-specific-than" to declare class more specific than other classes or subclasses: more-specific-than (T251-Name-Place, T25-Spatial-Entity).
- Part-of "is-part-of" to declare the class as a part of other classes or subclasses is-part-of (T211-Identifier, T21-Appellation).

The associative relations and the semantic relations are extracted based on the correspondent algorithms (i.e., The Associative relation definition algorithm, and the Semantic relation definition algorithm).

For example, for the architectural element which presents a base entity for our set of knowledge related to the archaeological field, the high technicality of the descriptions (name and organization of the parts of a site, techniques of construction, elements of decoration, etc.) supplied by the archaeologists made the realization of the ontology possible. Therefore, it's possible to work with a formal representation of the knowledge of the elements of architecture in:

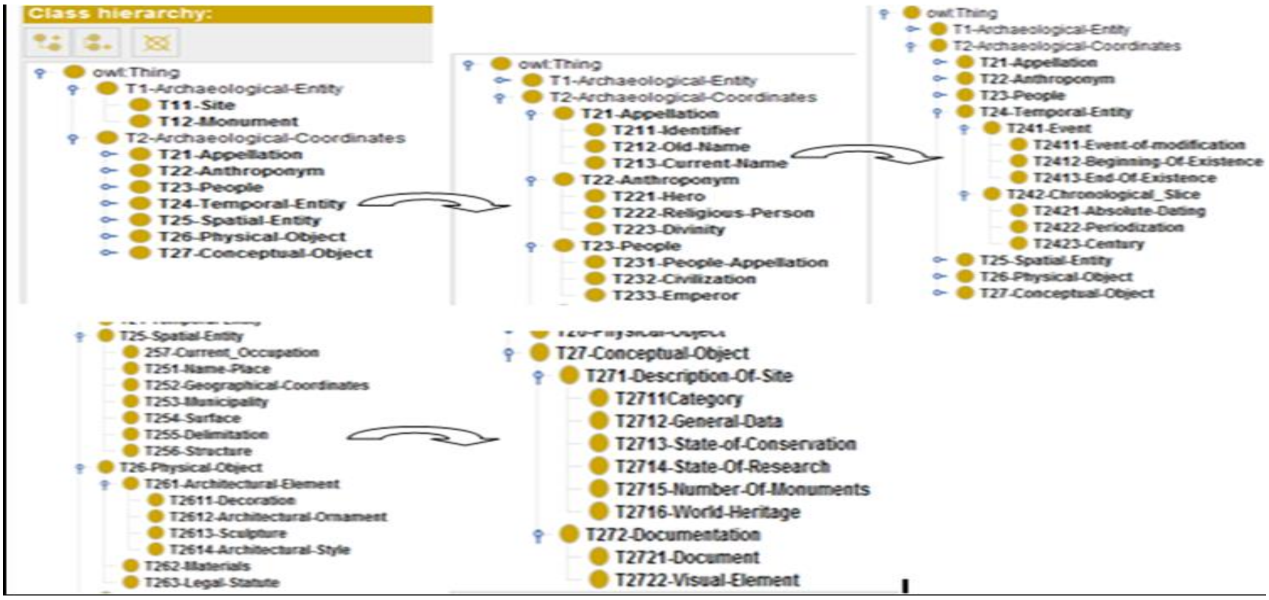


Fig. 4. Hierarchy of classes developed with protégé editor

1. Classifying the elements of the architecture of a site: mausoleum, Temple, Forum, Theater, Capitol, Arc, Market, Mosque, Church, Houses;
2. Defining the relations between the elements. Goulette[25]enumerated the different relations between elements: part-all relations, special relations, and relations of composition.
   In our analysis, we also must take the relations that an element of architecture can have with a technique of construction, a stylistic element, etc.
3. Establishing a correspondence between the elements of architecture, the corresponding period, and the religious domain.
4. For this purpose, we have used the significance given by an element; for example, a temple indicates the Roman period, etc.
5. Finally, we take into account the temporal dimension.

Through this approach, we have developed a set of concepts connected to architectural terms and organized by metronomic relationships (morphological decomposition) and representational (dimensions, materials, space relations) relations. Our ontology should take into account the set of the archaeological data: artifacts, such architectural buildings, architectural elements and intangible data such as measurements, directions, associations between elements and interpretation data. We wish to consider the following two axes:

1. The use of specialized concepts
2. The consideration of domains related to the traditional archaeology, including the study of material characterization, characteristics specific to the period and to the religion.

Table II shows some defined relations and put forwards its descriptions.

TABLE II. DESCRIPTION OF RELATIONS

Object Property	Description
P1-is- associated-to ≡ P2-is-granted-to ≡ P3-is- linked-to (AR)	-These properties express the relations that can link the Appellation concept with other concepts and sub-concepts. -The names, whatever the present or ancient ones, are given to designate the different archaeological terms of which they are part of our ontology. -The identifiers are associated to authenticate the different concepts.
P4-is-cited-in (SR)	-The names used are the origin of the informative objects. -We refer to books, archaeological articles, web links, etc. to have correct, relevant, and complete information.
P5-is-detailed-in (SR)	-We can detail the different appellations put forward, and for any information related to these different appellations.
P6-is-identified-by (AR)	Each entity should have an identifier to differentiate from the others.
P7-have (AR)	The majority of declared terms (e.g., hero, people, civilization, place, etc.) have an appellation that can be changed over time. Therefore, we can have a current appellation (T213-Current-Name) and an old appellation (T212-Old-Name).
P10-is-a (HR)	Define especially the hierarchical relations between classes and subclasses, for example, the subclasses T212-Old-Name is-a T21-Appellation.
P51-UP≡P52-UPD (SR)	UP (Utiliser-Pour) and UDP (Utiliser-Pour-Désigner) are used to refer to the synonym relation which is a specific semantic relation.

P12-was-invented (SR)	T223-Divinity can be invented by a T221-Hero or a T222-Religious-Person.
P13-is-remplaced-by (SR)	T223-Divinity can be replaced by another T223-Divinity.
P53-is-more-specific-than (HR)	Is used to define a hierarchical relation, for example, a T221-Hero is more specific than T22-Anthroponym.
P54-is-more-generic-than (HR)	It is an inverse of the "P53-is-more-specific-than" relation. For example, a T22-Anthroponym is more generic than T221-Hero.
P43-was-participed (SR)	It is a semantic relation. Many people (heroes, religious-person, and emperor) can participate in an event.

C. *Subexpriment3: defining the axioms*

The axioms are declared to define the semantics of the several classes and relations. They added a specification to the definition of the different entities. We have defined the axioms in section **(5.5)**. MOTunAr involved two kinds of axioms:

- Axioms related to classes and subclasses: we declare two concepts as disjoint concepts, equivalent concepts. Also, a class can be defined as a subClassOf of another class.
- Axioms related to object proprieties: we declare relations as function relations, reflexive/ irreflexive relations, inverse relations, etc.

in this Sub experiment we show in fig.5 some axioms related to the classes. These axioms are defined via the protégé editor. Furthermore, a set of Object Properties axioms are detailed in the table III .

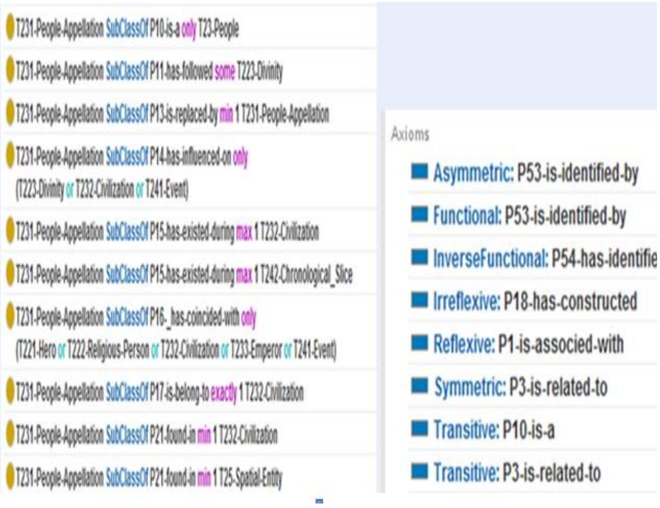


Fig. 5. Example of axioms defined with protégé editor

TABLE III. EXAMPLES OF OBJECT PROPERTIES AXIOMS

Designation	Syntax	Protégé declaration examples
Reflexive property	(R^I) -is reflexive	Reflexive: P1-is-associated-with
Irreflexive property	(R^I) - is irreflexive	Irreflexive :P 18-has-constructed
Symmetric property	$R^I = (R^I)^-$	Symmetric: P3-is-related-to
Asymmetric property	$R^I = (R^I)$	Asymetric: P53-is-identified-by
Transitive property	$R^I = (R^I)^+$	Transitive: P10-is-a
Inverse property	$R^I = (R^I_0)^-$	P12-is-operated-by InverseOf P13-has-operated
Functional Property	R^I is Functional	Functional: P53-is-identified-by
Inverse Functional	(R^I) - is Functional	InverseFunctional: P54-has-identified
Domain/Domain	$R^I \subseteq C^I_i \times \Delta^I_D$	P1-is-associated-with Domain T2-Archaeological-Coordinates
Range/Range	$R^I \subseteq \Delta^I \times C^I_i$	P1-is-associated-with Range T1-Archaeological-Entity

VII. EVALUATION, AND ANALYSIS

As we have mentioned above, we have applied two tools to evaluate MOTunAr ontology: 1) Pellet reasoner from Protégé editor and 2) OOPS! Service.

Pellet does expertness analysis of ontology. The service reasoning find by Pellet help to debug for incompatibility and incoherence that can be detected Fig.6.a. To assure the quality of MOTunAr ontology, we have applied the OOPS! Service with the Pellet reasoner OntOlogy Pitfall Scanner! (OOPS!), is a service available at, http://oops.linkeddata.es/response.jsp. It aims to aid the ontology designer during the ontology evaluation task. OOPS! Executed independently of the ontology creation platform, this service produces pitfalls (i.e., bad practices in the task of development of ontology) that describe the errors detected among the tested ontology Fig.6.b.

in addition, The evaluation of MOTunAr via the Pellet reasoner, and the OOPS! Service provides its effectiveness.

To decide the quality of an ontology, the ontologies evaluation is based on a set of criteria. In our study, we have focused on five criteria:

- ***Clarity***: this criterion aims to evaluate: how much the ontology is effective in communicating the intended meaning of the declared terms; if the ontology is understandable; if the ontology is based on partial description or definitions [23].
- ***Completeness/competency***: here we evaluate: if the ontology can define all relevant terms and declares their lexical representation; if the ontology covers the domain of interest [23].
- ***Conciseness:*** this criterion aims to evaluate: if the ontology involves any redundant or irrelevant axioms; if the ontology defines only the essential terms [23].
- **Consistency /coherence:** Count the number of terms with ambiguous meaning [23].
- **Interoperability and Ease of use:** it aims to evaluate: if the ontology reuses or interacts with axioms from

other data systems; if ontology is easy to operate and it presents appropriate guidance [23].

Based on these criteria table IV shows a comparison between our MOTunAr and the two references ontologies used in our approach (i.e., CIDOC-CRM ontology, and CARE ontology).

TABLE IV. SUMMARY OF THE EVALUATION OF THE THREE ONTOLOGIES

Measure	CIDOC-CRM	CARE	MOTunAr
Clarity	✓	✓	✓
Competence/Completeness	+	+	✓
Conciseness	✓	+	✓
coherence	✓	✓	✓
Interoperability	✓	✓	✓
Ease of use	+	+	+

In the previous table, the '+' sign indicates that the ontology is performing well. The '✓' sign means that the results are excellent, and the '✗' sign indicates that the ontology is not performing well with the corresponding criterion.

The CIDOC-CRM has expressive power as a complete ontological model for the information modeling process for the cultural heritage domain. It structures them in an event-centric manner. But the CIDOC-CRM does not allow to easily be distinguishing the most appropriate class to model a specific entity. This problem is found because some of its classes share very similar meanings. For example, E22 Man-Made-Object and E19 Physical-Man-Made-Thing seem to be appropriate for the same modeling. On the other hand, the concepts in CIDOC-CRM are very systematically designed and linked. The user becomes familiar with the logic and structure of the model; its use is very fluid, whether for indexing or searching. The CIDOC-CRM is specified in a language-independent way and contains many expressions, including one in the vocabulary of the RDF schema [8].

The CIDOC-CRM effectively represents acquisition and custody information. Its expressiveness, at times, does not easily lend itself to a simple implementation of metadata to describe visual resources, e.g., information describing an image of the cultural heritage domain, such as its dimension, time of creation, format, technique, and resolution [19].

More than the definition of specific subclasses related to the religious entities, CARE ontology applied the CIDOC-CRM as "core ontology" and mapped from this one some classes. For example, the concept Element Architectural was added to describe floor, masonry, opening, etc. The set of concepts describing the religious buildings has been placed under the E24 Physical Man-Made Thing CIDOC-CRM.CARE is a generic ontology. It contains classes composed of high-level concepts related to Christian buildings. However, CARE's vocabulary is rather difficult to use and understand. This problem is encountered because its definition and guidelines for its users are unclear in certain cases. Similarly, the absence of examples in the use of terms, it imports from external vocabularies makes CARE, sometimes, incomprehensible [11]. On the other hand, CARE is a simple and general model for the description of cultural heritage information, which makes it suitable for indexing and retrieval of information [19]. However, CARE as CIDOC-CRM ontology did not support this multimedia dimension.

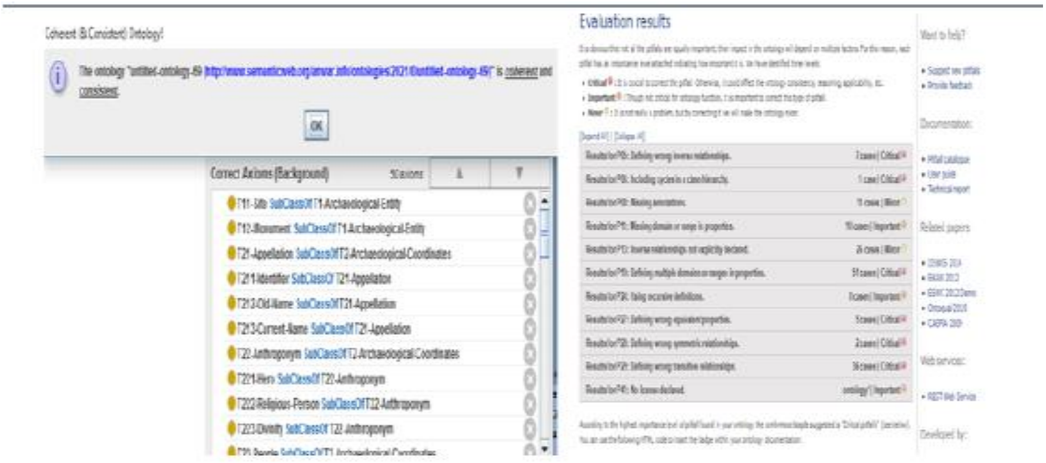
MOTunAr was benefited from a Tunisian archaeologist in order to have a correct meaning for the defined terms and be sure that the interest domain (i.e., archaeological domain) was successfully covered **(i.e., Completeness and Conciseness criteria are satisfied)** (fig.7.a)**.** The different terms in this ontology were defined via protégé editor. For each term we attached a label that contains its definitions. These attached definitions were extracted from relevant sources and resources **(i.e., clarity criterion is satisfied)** (fig.7.b)**.** The classes, subclasses and relations are very simple to understand either by an expert or by a simple user (e.g., appellation, hero, was-associated- is-a, etc.). Thus, MOTunAr is easy to operate, and users can understand and communicate the diversified information that exists in this ontology **(i.e., the easy to operate criterion is satisfied)** (fig.7.c). On another hand, in our approach we were using as reference ontology the CIDOC-CRM ontology which is considered as appropriate guidance and the specifications used on this ontology are very pertinent and flexible. Thus, our MOTunAr ontology anticipates these characters from the CIDOC-CRM ontology **(i.e., coherence criterion is satisfied)** (fig.7.d).

Our MOTunAr ontology defines a class hierarchy that combines those defined by CIDOC-CRM and CARE and adds other concepts that can modulate very specific archaeological data. This ontology is in the process of generation, only the positive axioms have been defined. But it still presents a generic and simple to use ontology. The addition of more relevant axioms will make this model more robust, and the implementation of MOWL language will support the multimedia aspect of archaeological data.

VIII. FUTURE WORKS

Actually, for our MOTunAr ontology, we have defined the axioms related to the classes and subclasses as well as the axioms related to the relations [23]. In our ongoing research, we want to achieve the step of defining axioms. In addition, to define the whole axioms related to the various entities related to the MOTunAr ontology we want to base on a hybrid approach that mixed two different methods:

- Corrective method: this method is already initiated in this paper. It defines the axioms based on the available entities on ontology.



(a) (b)

Fig. 6.a. MOTunAr Ontology tested by the pellet reasoner, b. MOTunAr Ontology tested by OOPS Service

- Constructive method: it is based on the elimination models (its designs the knowledge that ontology should not define). The axioms defined in this method are a result of the elimination models [26].

Previously, if the step of defining axioms is achieved, we can evaluate our ontology depending on other criteria that controlled the efficiency of declared axioms (e.g., Conciseness, Interoperability, Consistent research, and query, etc.).

Also, after the implementation of declared axioms, we want to define the instance: the population step. This step remains to insert concept instances and relation instances into a creating ontology [27]. The population process does not modify the organization of the ontology, i.e., the class hierarchy and the relation are not changed. What modify are the instances of concepts and/or the instances of relations existing in the domain. The process of the population is based on an existing ontology that will be populated and an engine that allows extracting the instances of different entities will be applied. In our research, we will base on the BOEMIE methodology.

The main advantages between the BOEMIE method and the other approach existing in literature are [28]:

- The engine of extraction instances of concept/relation is not anticipated to extract instances of the composite classes. It is anticipated to extract just instances of the primitive classes. An evident benefit is a modification in the structure of the ontology becomes immune. The adaptation of the extraction engine is a necessity only when such “primitive” classes or relations related to “primitive” classes are modified.

- The ontology is applied to extract an instance of a «composite» class from an instance of populated “primitive” class either of the populated relation instances. Two main advantages of this approach that are1) the instances of the “composite” classes are constantly synchronized with the available formal definition added to the relevant classes, 2) the generation of “composite” instances, depending on the constraints and the rules imposed by the implemented ontology these rules ensure the consistency and efficiency of the ontology.

The MOTunAr will be developed based on the MOWL Language, in order to take into account, the multimedia content.

IX. Conclusion

Ontology is the result of a modeling process. The characterization of primitives, in ontology, is modeled to formally represent knowledge. These primitives are not data from the field that would be sufficient to determine, but rather, they are theoretical constructs for modeling purposes. Ontology is characterized by three levels: the semantic or interpretive level, the formal or referential level and the operational or computational level. In addition, the ontology depends not only on the field but also on the target task. Indeed, it is the context of the task that allows fixing the relevant characteristics of the signification of the semantic concepts in order to cancel the effects of the context. Furthermore, by describing the construction process, we have shown: (1) the need for an exact articulation of concepts and terms in such a resource; (2) the need for the development of a meta-modeling architecture to model all the necessary sources and knowledge structures. On another hand, the main difficulties that we have encountered are: (1) the definition of the conceptual field of RTO; (2) the lack of representativeness of the original corpus which forced us to stimulate a partially manual conceptualization process. Our research perspectives are: (1) a complete reorganization of the concepts to make our ontology more efficient, and (2) a study of the completeness of the terms with a test of the ontology in an application in progress.

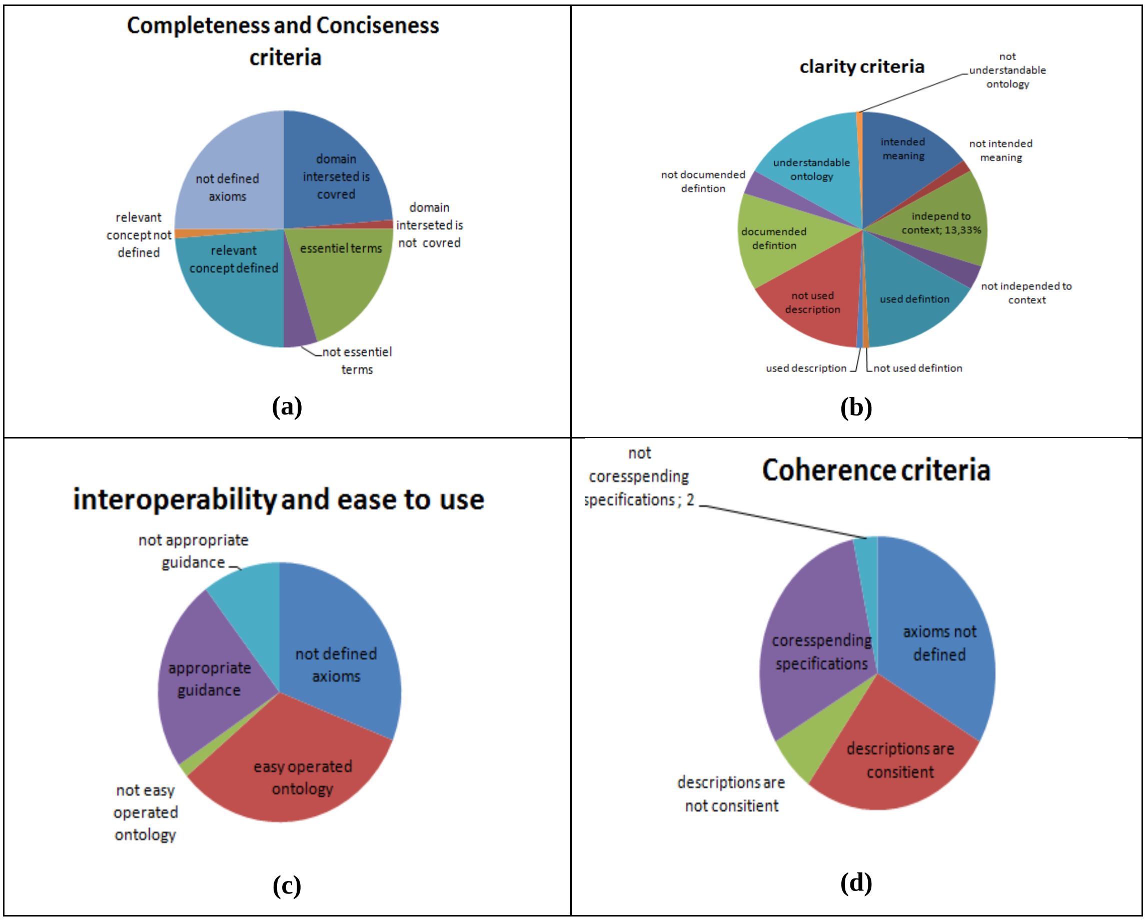


Fig. 7. a. Completeness and conscience criteria, b. clarity criterion, c. interoperability and ease to use criteria, d. coherence criterion

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