Measuring Design Complexity of Cultural Heritage Ontologies

Bilal Ben Mahria, Ilham Chaker and Azeddine Zahi
Dept. of Computer Science, Faculty of Science and Technology, BP.2202 Imouzzer Street, Fez, Morocco

Keywords: Cultural Heritage, Size of Vocabulary, Tree Impurity, Coupling, Maintenance, Ontology Evaluation.

Abstract: Nowadays, Ontologies have become widely used to design formalism for knowledge representation, and are considered as the foundation for the Semantic Web. However, with their widespread usage, a question of their complexity evaluation increased even more, especially in some domains that currently know a cruise number of ontologies like Cultural Heritage. In this paper, we present an analysis of the advanced metrics for measuring the design complexity of existing cultural heritage ontologies (CH). In this context, the main goals of this study are to (i) present advanced metrics such as the size of vocabulary, the tree impurity, coupling, average number of path per concept, and average path length, in order to analyze the advanced complexity features of the CH ontologies and their impact on the reuse and evolution of the CH ontologies; (ii) Help developers to decide whether the ontology is over complex that it needs some simplification or re-building; (iii) Make developers clearly realize the impact of the size and scale of ontology. In order to reach these goals, a set of twenty CH ontologies are gathered from the web to measure and analyze their advanced complexity metrics. By analyzing the size of vocabulary, the average number of paths per concept, and average path length, the evaluation results exhibit that the CH ontologies studied are highly complex. In addition, the CH ontologies cannot be easily maintained due to the findings reached through the analysis of the tree impurity and coupling.

1 INTRODUCTION

An ontology has been previously defined as a formal, explicit specification of a shared conceptualization where the conceptualization in this context refers to the abstraction of a domain of knowledge(Guarino & Poli, 1993). This abstraction is increasingly used in various fields such as data exchange, data integration, and the biggest of which is the semantic web(Maedche & Staab, 2001). This apparent increase in the use of ontologies has procured an increase in the number of ontologies in existence which in turn has promoted the need for evaluating the ontologies.

Ontology evaluation is an important issue that must be addressed in many situations. For instance, during the process of developing an ontology, the evaluation is important to guarantee that what is built meets the application requirements. Generally, the ontology evaluation is defined as the process of measuring the quality of an ontology with regard to a set of criteria that consist of determining which in a collection of ontologies would suit a particular purpose(Brank et al., 2005). In addition, an important definition of ontology evaluation has been suggested by (Gómez-Pérez, 2004) and later echoed by (Vrandečić, 2009). In these works, the evaluation process is categorized into two major areas: Verification and Validation. The former is concerned with building an ontology correctly by measuring the accuracy, completeness, conciseness and consistency metrics, etc. The latter, on the other hand, is about building the correct ontology by checking the quality of the ontology design. The ontology design is commonly referred to as the ontology complexity.

Generally Speaking, measuring the complexity of an ontology gives some insight for developers to help them better understand, reuse, reduce maintenance requirements and integrate ontologies, as well as help users to select the ontology that meets their needs best. In fact, the complexity of ontology increases as the ontology grows in size and as ontology evolves, the management of the complexity and the maintenance increases. Therefore, as ontologies grow in size and numbers, it is important to measure their complexity quantitatively. It is well known that "you cannot control what you cannot measure"(DeMarco, 1982). Quantitative measurement of complexity can help ontology developers and maintainers better

Ben Mahria, B., Chaker, I. and Zahi, A.
Measuring Design Complexity of Cultural Heritage Ontologies.
DOI: 10.5220/0010016501330140
In *Proceedings of the 12th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management (IC3K 2020) - Volume 2: KEOD*, pages 133-140
ISBN: 978-989-758-474-9

understand the current status of the ontology, better evaluate its design and control its development process. Nowadays, one of the active areas of the ontology development is the cultural heritage domain where a large number of ontologies are being developed to study memory organizations that includes libraries, archives, and museums of different kinds specializing in particular areas of CH, such as museums, archaeological museums, cultural history museums, and science museums, etc (Doerr, 2009; Hyvönen, 2009).

In brief, Cultural Heritage (CH) refers to the legacy of physical objects, environment, traditions, and knowledge of a society that are inherited from the past, maintained and developed further in the present, and preserved (conserved) for the benefit of future generations. The vital importance of preserving cultural heritage for the populations, has led to an increased number of ontologies in this domain. Thus, these ontologies can be grouped into six categories: General Concept Ontologies, Actor Ontologies, Place Ontologies, Time and period ontologies, Event Ontologies and Domain Nomenclatures or terminologies (Hyvönen, 2012). In this context, the evaluation of the existing CH ontologies becomes a necessity.

Although few studies have been conducted on the assessment of this cultural content (Nafis et al., 2019; Orme et al., 2006; Zhe et al., 2006), there are still many issues that have not been sufficiently addressed. In this regard, the main goals of this paper are to: (i) Present advanced metrics such as the size of vocabulary, the tree impurity, coupling, average number of path per concept, and average path length in order to discuss the advanced complexity features of the CH ontologies and their impact on the reuse and evolution of these ontologies. (ii) Help developers to decide whether the ontology is over complex that it needs some simplification or re-building. (iii) Make developers clearly realize the impact of the size and scale of ontology.

To the best of our knowledge, there is a shortage of studies which focus on the analysis of the quality of CH ontologies to consolidate their reuse, maintenance and evolution. In fact, this work attempts to fill this gap by identifying and evaluating existing CH ontologies on the web. A set of 20 ontologies of the CH domain are downloaded on the web and a set of quantitative quality metrics adopted and combined from different works (Orme et al., 2006; Ouyang et al., 2011; Tartir et al., 2010; Zhang et al., 2010; Zhe et al., 2006) are applied to evaluate the ontology based on the complexity features. The experimental results show that the majority of the CH ontologies are highly complex and cannot be easily maintained.

The outline of this paper is demonstrated as follows. In Sect. 2, we present the related work, which describes the most popular works that studied the assessment of the cultural heritage ontologies. In Sect. 3, we detail some challenges and limitations of the cultural heritage domain. In Sect. 4, we outline some common Formal notations. In section 5, we describe the advanced features metrics to analyze the complexity of the cultural heritage ontologies. Section 6 is devoted to introducing the experiment studies and discussions. Finally, Sect. 7 concludes the paper and suggests directions for future works.

2 RELATED WORKS

Considerable amounts of studies have been conducted on measuring the ontologies complexity. With regard to the CH domain, there is a lack of studies that are addressed to measure the complexity of the Cultural heritage ontologies(Nafis et al., 2019; Orme et al., 2006; Zhe et al., 2006). (Nafis et al., 2019) did a study to enable users to select suitable CH ontologies for use when building applications that integrate Cultural heritage content. (Orme et al., 2006) measure the ontology complexity using a single metric that is coupling. Inspired from the principles of the object oriented class diagram (Nikiforova et al., 2011), (Zhe et al., 2006) used three metrics called the number of root classes, the number of leaf class, and the average depth of inheritance tree to measure the CH ontology complexity. However, these studies suffer from one of the following limitations. First, they confused the validation of the ontology with its verification (Nafis et al., 2019). Second, they relied on primitive metrics (such as number of classes, number of properties, instances, root and leaf classes, etc.) in order to study the design of the ontology(Nafis et al., 2019; Zhe et al., 2006). Indeed, it is meaningless to measure the design of the ontology by using only primitive metrics as we will argue in this work. Third, they consider ontology complexity as a one-dimensional construct, which is based on class-level metrics, while the complexity cannot be measured directly using single level metrics (Nafis et al., 2019; Orme et al., 2006; Zhe et al., 2006). Finally, (Nafis et al., 2019)take into consideration the extensional (Number of instances) level of the ontology to study the complexity while the complexity must be measured based on the intentional level of the ontology and the extensional level must be ignored .

Based on our knowledge, this work represents the first study of the evaluation design complexity of ontologies in the Cultural Heritage domain. This evolution is based on some Advanced Complexity Metrics.

3 CULTURAL HERITAGE (CH) DOMAIN CHALLENGES

3.1 Cultural Heritage Domain

In a narrower sense, we may regard the cultural heritage as the things protected by the memory institutions such as museums, sites and monuments records ("SMR"), archives and libraries. Their international umbrella organizations are: the International Council of Museums (ICOM [1]) the International Federation of Library Associations (IFLA[2]) and the International Council of Archives (ICA[3]). They maintain their specific documentation policies and standards. CH can be divided into three subareas(Hyvönen, 2012):

Tangible Cultural Heritage consists of concrete cultural objects, such as artifacts, works of art, buildings, and books(Vecco, 2010).

Intangible Cultural Heritage includes phenomena such as traditions, language, handicraft skills, folklore, and knowledge (Vecco, 2010).

Natural Cultural Heritage consists of culturally significant landscapes, biodiversity, and geodiversity (Harrison, 2015).

3.2 CH Ontologies Types by Major Domains

Major ontology types needed in CH applications can be classified by their domain of discourse as follows.

General Concept Ontologies. These ontologies include general concepts, such as object types (chair, painting, book, etc.) or materials (steel, wool, wood, etc.). Concepts in keyword thesauri typically fall in this category, excluding free keywords, such as place and person names (Hyvönen, 2012).

Actor Ontologies. These ontologies encompass a set of individual persons, organizations, and groups. In libraries, actor ontologies are called authority files(Hyvönen, 2012).

Place Ontologies. These ontologies contain lists of individual places. In land surveying, place ontologies are called gazetteers(Hyvönen, 2012).

Time and Period Ontologies. Time ontologies identify the way in which time is exemplified, and may list particular periods of time for shared reference, such as "18th century," "'Iron Age," "Almohad Period," etc(Hyvönen, 2012).

Event Ontologies Events are the semantic key that associates actors, objects, places, and time together. Event ontologies are repositories for listing references to individual's events, such as "Battle of Rio Salado" or "Independence of Morocco," so that they can be referred to in different metadata records for interoperability (Hyvönen, 2012).

Domain Nomenclatures or Terminologies. Various areas use particular nomenclatures, which roughly match to free keywords of thesauri. For example, there are name lists and taxonomies for plants and animals, minerals, chemical compounds, diseases, medicines, trademarks, etc(Hyvönen, 2012).

3.3 CH Domain Challenges

CH collection data has many specific characteristic features, such as the following (Koch et al., 2019).

Multi-format. The contents are provided in different forms, such as text documents, images, audio tracks, videos, collection items, and learning objects.

Multi-topical. The contents are attached to various topics, such as art, history, artifacts, and traditions.

Multi-lingual. The content is available in different languages.

Multi-cultural. The content is linked and explained in terms of different cultures, such as religions or national traditions in the West and East.

Multi-targeted. The contents are often addressed to both laymen and experts, young and old.

The fundamental problem area in dealing with CH data is to make the content mutually interoperable so that it can be searched, linked, and presented in a harmonized way across the outlines of the datasets and data silos. In fact, the major reason for interoperability problems in CH content publishing is the Multi-Organizational nature in which CH content is collected, maintained, and published. The content with their own established standards and best practices, by media organizations, and cultural associations. In fact, ontologies provide a perfect

[1] http://www.icom.org

[2] http://www.ifla.org

[3] http://www.ica.org

mechanism to bypass all these limitations(Hyvönen, 2012).

4 FORMAL NOTATION AND THE GRAPH-CENTRIC REPRESENTATION OF ONTOLOGIES

4.1 Graph-Centric Representation of Ontologies.

In order to present the ontology complexity metrics, we provide a graph-centric view for OWL ontologies(Zhe et al., 2006). More precisely, an ontology can be seen as a directed labelled graph $G = \langle N, P, E \rangle$ where N a set of nodes representing classes and individuals; P is a set of nodes representing properties; and E is a set of edges representing property instances and other relationships between nodes in the graph G. $E \subseteq N \times P \times N$. N includes both N_n (Named Classes and Individuals) and N_a(Anonymous classes and individuals). P contains P_n (user defined Properties) and P_a (OWL/RDFS properties such as rdfs:subClassOf and owl:disjointWith).

The inheritance hierarchy of an ontology can be described as $G' = \langle N', P', E' \rangle$, where N' is the set of nodes representing classes P' is the RDF property rdfs:subClassOf and E' is the set of edges representing the inheritance relationship (rdfs:subClassOf) among classes (Zhang et al., 2010).

4.2 Common Formal Notation

We use the following formal notation to represent some terms that we will need for discussing the complexity metrics. Small letters are used to identify the notations related to concepts and relations, while capital letters are used to identify the terminology related to ontology and some metrics(Zhe et al., 2006).

$C = \{c_1, c_2, c_3, \dots, c_m\}$: The set of m classes defined in the ontology.

$R = \{r_1, r_2, r_3 \dots, r_m\}$: The set of relations each class has.

$P = \{p_1, p_2, p_3, \dots, p_m\}$: The set of paths each class has. In fact, a different path has its own length, thus the path length is defined as the sum of relations on the path.

$pl_i = \{pl_{i,1}, pl_{i,2}, \dots, pl_{i,p_i}\}$: represent the set of path length of class c_i. Path length of a particular class states that the semantic distance between the class and the general class. Therefore, the set of path length of all classes in ontology is presented as: $PL = \{\{pl_{1,1}, \dots, pl_{1,p_1}\}, \dots, \{pl_{m,1}, \dots, pl_{m,p_m}\}\}$.

5 ADVANCED COMPLEXITY METRICS OF ONTOLOGY

The advanced complexity metrics used in this work includes: size of Vocabulary (SOV), Tree impurity, the average number of paths per concept, the average path length of ontology and coupling(Zhang et al., 2010).

5.1 The Size of Vocabulary (SOV)

SOV measures the size of the vocabulary using primitive metrics such as number of class. Given a graph $G = \langle N, P, E \rangle$ of an ontology, SOV is defined as the sum of the named classes and named individuals (N_n) and user defined properties (P_n):

$$SOV = |N_n| + |P_n| \quad (1)$$

A higher SOV implies that the ontology is big in size and would require a lot of time and effort to build and maintain it.

5.2 Tree Impurity (TIP)

This metric is used to measure how far an ontology inheritance hierarchy $G' = \langle N', P', E' \rangle$ deviates from a tree (Zhang et al., 2010). It is defined as:

$$TIP = |E'| - |N'| + 1 \quad (2)$$

Where E' is the number of rdfs:subClassOf edges and N' is the number of nodes (including both named and anonymous) in an ontology's inheritance hierarchy. The greater the TIP, the more an ontology's inheritance hierarchy deviates from a pure tree structure, and the greater the complexity of an ontology. A $TIP = 0$ means that the inheritance hierarchy is a tree.

5.3 Average Number of Paths per Concept

The average number of paths per concept (ρ) - indicates the average connectivity degree of a concept to the root concept in the ontology inheritance hierarchy(Lourdusamy & John, 2018). It is defined as ratio of the total number of path on the total number of classes (m):

$$\rho = \frac{\sum_{i=1}^{m} p_i}{m} \quad (3)$$

For any ontology, ρ must be greater than or equal to 1 (each concept must have a parent except for the general concept). If $\rho = 1$, then the ontology is a tree (each concept has a single parent, and thus a single path to the most general concept). An ontology with a higher ρ states that changes in a class would have a large impact on its subclasses (each concept has multiple parents, and thus multiple paths to the most general concept).

5.4 The Average Path Length

The average path length ($\overline{\Lambda}$) indicates the average number of concepts in a path in the ontology(Zhe et al., 2006). It is defined as:

$$\overline{\Lambda} = \frac{\sum_{i=1}^{m} \sum_{k=1}^{p_i} pl_{i,k}}{\sum_{i=1}^{m} p_i} \quad (4)$$

This metric is obtained from the ratio of the sum of the path lengths *($pl_{i,k}$)* of each of the m concepts in the ontology over the sum of the number of paths (p_i) of concepts. An ontology with a bigger $\overline{\Lambda}$ indicates that there are too many inheritance relationships in the ontology; as a consequence, the management and manipulation of concepts in such ontology could be a complex task.

5.5 Coupling

Coupling reflects the number of external classes from imported ontologies that are referenced in the intern (local) ontology. Similar to measuring the software modules coupling metrics, coupling of ontologies measures the relatedness of the local ontology with other existing ontologies or vocabularies that are used for building this ontology(Ouyang et al., 2011). It is defined as:

$$Coup(O_i) = \frac{Ref(O_i)}{NEC(O_i)} \quad (5)$$

Where $Ref(O_i)$the number of external classes is referenced and $NEC(O_i)$ represents the number of external classes. The stronger coupling in ontologies, the more difficult to understand, maintain, and more complex the systems that use these ontologies.

6 EXPERIMENTS SETUP

A set of appropriate experiments have been arranged in order to study the complexity of the well-known selected Cultural Heritage ontologies. The detailed information of these datasets is summarized in Table 1. As proof of concept, the advanced complexity metrics are computed using Java OWL API (Horridge & Bechhofer, 2011). Finally, it is important to note that all the experimental simulations were conducted on a personal computer under Windows 10, with intel core i7 2.70 GHZ processor and 16 GB RAM.

6.1 Datasets

The dataset is composed of 20 ontologies of the CH domain. Each ontology in the dataset is assigned an index O_i, $1 \leq i \leq 20$ to facilitate its reference in the discussion. Table 1 shows the list of ontologies in the dataset with their names and web links. The XML files are web documents that include the RDF/OWL files of the corresponding ontologies.

Table 1: The studied CH ontologies.

Index	Ontology	Category	Web Link
O_1	FRBR	Actor	https://vocab.org/frbr/core
O_2	Hico	Event	http://hico.sourceforge.net/
O_3	Bio	Actor	https://vocab.org/bio/
O_4	Cito	Event	https://w3id.org/spar/cito/
O_5	Pro	Event	https://w3id.org/spar/pro/
O_6	bibo	Actor	http://bibliontology.com/
O_7	Fabio	Actor	https://lov.linkeddata.es/dataset
O_8	Cidoc	Event+Actor+Palce	http://www.cidoc-crm.org/
O_9	Cultur	Event	https://lov.linkeddata.es/dataset/
O_{10}	CulturalOn	Event	https://lov.linkeddata.es/dataset/
O_{11}	Event	Event	https://lov.linkeddata.es/dataset/
O_{12}	SEAS	Event	https://lov.linkeddata.es/dataset/l
O_{13}	SEM	Event	https://lov.linkeddata.es/dataset/l
O_{14}	Tp	Place	https://lov.linkeddata.es/dataset/l
O_{15}	DOLCE	Event	http://www.ontologydesignpatter
O_{16}	GVP	Event+Place	https://lov.linkeddata.es/dataset/l
O_{17}	Ctlog	Event	https://lov.linkeddata.es/dataset/l
O_{18}	Cdesc	Event+Place+Actor	https://lov.linkeddata.es/dataset/l
O_{19}	Drammar	Event+Actor+Place	https://lov.linkeddata.es/dataset/l
O_{20}	ddesc	Event+Place+Actor	https://lov.linkeddata.es/dataset/l

6.2 Primitive Metrics

In order to calculate the advanced complexity metrics for all the ontologies in the dataset, it was necessary to specify the basic semantic characteristics of these ontologies such as the number of classes, properties(Datatype Properties and Object Properties) and instances. Overall, Figure 1 shows that the majority of selected ontologies for this study had a high number of primitive metrics.

6.3 Experimental Result and Discussions

The main goal of this work is to analyze the advanced complexity features of the CH ontologies and their impact on the ontology evolution and reuse. In this context, each one of the advanced complexity metrics is calculated and discussed in the following sections.

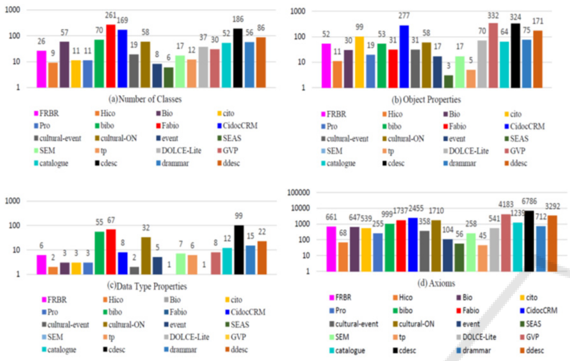

Figure 1: The primitive metrics of the studied CH ontologies.

6.3.1 Size of the Vocabulary (SOV)

Figure 2 presents the results of the SOV the measurement for all ontologies in the dataset. The SOV ranges from 11 to 655, showing different amounts of vocabulary used. The majority of ontologies have a SOV between 50 and 700, followed by those with a SOV between 20 and 40. These results indicate that it would be beneficial for semantic web developers in the CH domain to consider the reuse of these ontologies (bibliographic ontology (O_7 , SOV=374), Event ontology (O_8, SOV=454), Place ontology (O_{16} and O_{20} , SOV=430 and 372) and General ontology (O_{18}, SOV=655)) rather than trying to build new related ontologies de novo. SOV of these ontologies also states that they would require a larger amount of time and effort to re-build and maintain(Zhang et al., 2010).

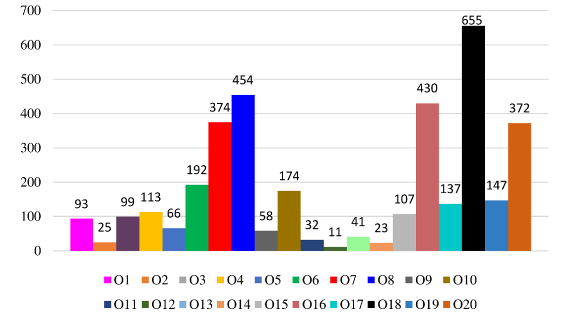

Figure 2: The Size of Vocabulary of the studied ontologies.

6.3.2 Average Path Length ($\overline{\Lambda}$), and Average Number of Paths per Concept (ρ)

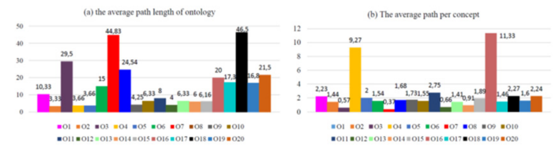

Figure 3: the average path length and number of Paths per concepts.

Figure 3 presents a joint analysis of the average path length of the ontology and the average number path per concept. These two metrics for all ontologies are grouped into 2 ranges. The two ranges for $\overline{\Lambda}$ are: $0 \le \overline{\Lambda} < 10$ and $10 \le \overline{\Lambda} \le 50$. Figure 3(a) depicts that the majority of ontologies have $\overline{\Lambda}$ in the range $0 \le \overline{\Lambda} < 50$, while others in the first range. This indicates that the ontologies have a high $\overline{\Lambda}$. Therefore, a greater $\overline{\Lambda}$ shows that the class resides deeper in the inheritance hierarchy and reuse more information from its ancestors such as O_{18}, O_7, O_8, etc. A high $\overline{\Lambda}$ also states that the class is more difficult to maintain as it is likely to be affected by changes in any of its ancestors. In the same context, the two ranges for ρ are: $\rho < 1$ and $\rho \ge 1$. From the analysis of the value of the ρ (Figure 3 (b)), one can confirm that the most of ontologies in the datasets have multiple path from the root class to a given class, which indicates that nearly all ontologies relies on the network (graph) model type rather than hierarchical model type (Tree)(Baliyan & Kumar, 2016). More precisely, ontologies with small ρ ($\rho < 1$) indicate that changes in a class would have a less impact on its subclasses(Zhe et al., 2006).

6.3.3 Tree Impurity (TIP)

Figure 4 presents results of computing TIP for all the ontologies in the dataset. It is noticed that an important number of ontologies have TIP between

100 and 2500 followed by those with TIP below 40. This empirical result shows that the most of ontologies adopt multiple inheritance (TIP>>0) and their inheritance hierarchy deviates heavily from a pure tree structure (O_7 =1377, O_{13} O_8 =2295, O_{20} =2446, etc.). Specifically, this indicate that this ontologies cannot be easily maintained except O_2, O_{11}, O_{14} which have TIP 42,21,20,29 respectively.

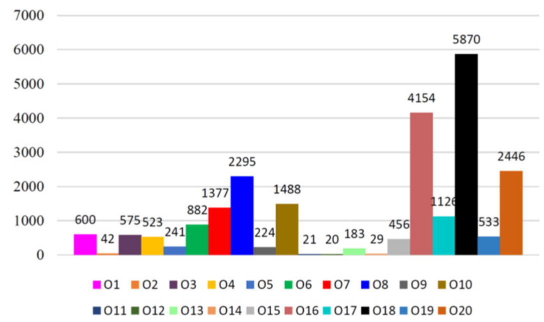

Figure 4: The Tree Impurity of the studied ontologies.

6.3.4 Coupling

Considering the result presented in Figure 5, It is clearly seen that the coupling of the following ontologies: O_8, O_9, O_{11}, O_{15}, O_{17}, O_{18}, O_{19}, O_{20} is greater than 0.5 which indicates that all these ontologies are related with other existing vocabularies and contain a high number of external classes and references to external classes. For instance the coupling of CIDOC-CRM is 0.88, this value states that the O_8 has a strong coupling. Therefore, the ontologies with a strong coupling are the more difficult to understand and maintain(Orme et al., 2006).

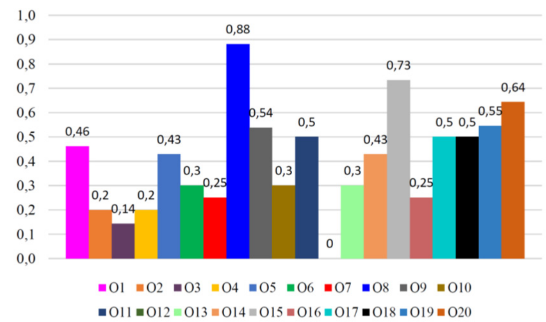

Figure 5: The coupling measure of the studied ontologies.

Broadly speaking, by using these metrics, we find that the large size of vocabulary, bigger average Number of Paths per concept (ρ) and average path length ($\overline{\Lambda}$) indicate that CH ontologies in the dataset are highly complex. Therefore, it would be advised to consider the reuse and sharing of these ontologies rather than trying to build similar ontologies from scratch. By means of the TIP metric, the ontology engineer can check if the design of the ontology follows good classification principles. Through the coupling metric, the ontology engineer can check the relatedness of the local ontology with external ontologies. Therefore, the analysis of the TIP and coupling revealed that the majority of studied CH ontologies can be difficult to maintain.

One may perceive that the larger the number of classes, properties, and axioms is a strong point to study the ontology complexity and they consider that the larger number of primitive metrics, the more complex an ontology is. However, we will argue that it is very difficult to measure ontology complexity with primitive metrics. Take the Fabio ontology as an example. It is one of the largest ontologies with 261 classes. Another ontology, the CIDOC-CRM (169 classes) that contains a number of classes less than Fabio ontology. However, the empirical result shows that CIDOC-CRM has a large TIP compared to Fabio ontology TIP (CIDOC-CRM TIP = 2295, Fabio TIP =1377. In addition, the coupling metric exhibits that CIDOC-CRM has a stronger coupling (Coupling = 0.87) than FABIO ontology (Coupling = 0.37). In other words, we cannot use the primitive metrics to measure the ontology complexity aspect in order to achieve more complete understanding of these ontologies.

7 CONCLUSION

In this paper, we have provided an analysis of some advanced complexity metrics of 20 cultural heritage ontologies. These metrics encompass the size of vocabulary (SOV), the tree impurity (TIP), coupling, average path length ($\overline{\Lambda}$), and average Number of Paths per Concept (ρ). This empirical evaluation shows that the provided metrics can differentiate ontologies with distinct degree of complexity. The metrics could serve as ‘‘indicators” of the ontology complexity, helping ontologist to understand the development status, gain an overall picture of ontology complexity, and identify potential problematic areas. The evaluation result portrays that the majority of these ontologies have large SOV, bigger average path length and average number of paths per concept. These findings indicate that the CH ontologies in the dataset are highly complex. In this context, it is better to consider the reuse and sharing of these ontologies in the CH domain rather than trying to build similar ontologies from scratch. Furthermore, the analysis of TIP and coupling reveals that the studied CH ontologies cannot be easily maintained. In the future, we plan to develop a system for distinguishing the ontologies based on their level of complexity. We will then further study the correlation between the ontology validation (Complexity) and the ontology verification (Correctness).

REFERENCES

Baliyan, N., & Kumar, S. (2016). A behavioral metrics suite for modular ontologies. *Proceedings of the Second International Conference on Information and Communication Technology for Competitive Strategies*, 1–4.

Brank, J., Grobelnik, M., & Mladenic, D. (2005). A survey of ontology evaluation techniques. *Proceedings of the conference on data mining and data warehouses (SiKDD 2005)*, 166–170.

DeMarco, T. (1982). *Controlling software projects : Management, measurement & estimation* (Vol. 1133). Yourdon Press New York.

Doerr, M. (2009). Ontologies for cultural heritage. In *Handbook on ontologies* (p. 463–486). Springer.

Gómez-Pérez, A. (2004). Ontology evaluation. In *Handbook on ontologies* (p. 251–273). Springer.

Guarino, N., & Poli, R. (1993). Toward principles for the design of ontologies used for knowledge sharing. *In Formal Ontology in Conceptual Analysis and Knowledge Representation, Kluwer Academic Publishers, in press. Substantial revision of paper presented at the International Workshop on Formal Ontology*.

Harrison, R. (2015). Beyond "natural" and "cultural" heritage : Toward an ontological politics of heritage in the age of Anthropocene. *Heritage & Society*, *8*(1), 24–42.

Horridge, M., & Bechhofer, S. (2011). The owl api : A java api for owl ontologies. *Semantic web*, *2*(1), 11–21.

Hyvönen, E. (2009). Semantic portals for cultural heritage. In *Handbook on ontologies* (p. 757–778). Springer.

Hyvönen, E. (2012). *Publishing and using cultural heritage linked data on the semantic web* (Vol. 3). Morgan & Claypool Publishers.

Koch, I., Freitas, N., Ribeiro, C., Lopes, C. T., & da Silva, J. R. (2019). Knowledge Graph Implementation of Archival Descriptions Through CIDOC-CRM. *International Conference on Theory and Practice of Digital Libraries*, 99–106.

Lourdusamy, R., & John, A. (2018). A review on metrics for ontology evaluation. *2018 2nd International Conference on Inventive Systems and Control (ICISC)*, 1415–1421.

Maedche, A., & Staab, S. (2001). Ontology learning for the semantic web. *IEEE Intelligent systems*, *16*(2), 72–79.

Nafis, F., Yahyaouy, A., & Aghoutane, B. (2019). Ontologies for the classification of cultural heritage data. *2019 International Conference on Wireless Technologies, Embedded and Intelligent Systems (WITS)*, 1–7.

Nikiforova, O., Sejans, J., & Cernickins, A. (2011). Role of UML class diagram in object-oriented software development. *Applied Computer Systems*, *44*(1), 65–74.

Orme, A. M., Tao, H., & Etzkorn, L. H. (2006). Coupling metrics for ontology-based system. *IEEE software*, *23*(2), 102–108.

Ouyang, L., Zou, B., Qu, M., & Zhang, C. (2011). A method of ontology evaluation based on coverage, cohesion and coupling. *2011 Eighth International Conference on Fuzzy Systems and Knowledge Discovery (FSKD)*, *4*, 2451–2455.

Tartir, S., Arpinar, I. B., & Sheth, A. P. (2010). Ontological evaluation and validation. In *Theory and applications of ontology : Computer applications* (p. 115–130). Springer.

Vecco, M. (2010). A definition of cultural heritage : From the tangible to the intangible. *Journal of Cultural Heritage*, *11*(3), 321–324.

Vrandečić, D. (2009). Ontology evaluation. In *Handbook on ontologies* (p. 293–313). Springer.

Zhang, H., Li, Y.-F., & Tan, H. B. K. (2010). Measuring design complexity of semantic web ontologies. *Journal of Systems and Software*, *83*(5), 803–814.

Zhe, Y., Zhang, D., & Chuan, Y. E. (2006). Evaluation metrics for ontology complexity and evolution analysis. *2006 IEEE International Conference on e-Business Engineering (ICEBE'06)*, 162–170.