

# Ontology Evaluation & Competency Questions

## Application to the TAO CI Project

WEI Tong

### Evaluation

References:  
- Suarez-Figueroa, M. C., & Gómez-Pérez, A. (2008). First attempt towards a standard glossary of ontology engineering terminology. *Proceedings of the 8th International Conference on Terminology and Knowledge Engineering*, 1–16.

**Definition:** the activity of checking the technical quality of an ontology against a *frame of reference* (Suarez-Figueroa & Gómez-Pérez, 2008).

Frame of reference denotes a set of representative resources that sets a baseline value against which the ontology should be compared (Sabou & Fernandez, 2012).  
*It could be requirements specifications, competency questions or the real-world.*

#### Ontology verification

refers to building the ontology correctly, that is, ensuring that its definitions implement correctly the ontology requirements and competency questions, or function correctly in the real world.

↓ answer

Are you producing the ontology *in the right way*?

#### Ontology validation

refers to whether the meaning of the ontology definitions really model the real world for which the ontology was created. The goal is to prove that the world model (if it exists and is known) is compliant with the world modeled formally.

↓ answer

Are you producing the *right ontology*?

References:  
- Sabou, M., & Fernandez, M. (2012). Ontology (network) evaluation. In *Ontology engineering in a networked world* (pp. 193–212). Springer.

### Evaluation

#### Validation & Verification

- 1) They are two different aspects of ontology evaluation, but they are both important.
- 2) Ontology validation is an important part of assessing the quality of an ontology, and usually the only way to assure the correctness of the knowledge encoded in the ontology. But most validation approaches require the close cooperation of domain and ontology engineering experts. Validation often can not be performed automatically.
- 3) Ontology verification usually focuses on the automatic evaluation approaches.

### Evaluation

Reference:  
- Raad, J., & Cruz, C. (2015). *A survey on ontology evaluation methods*

#### Criteria:

- Accuracy:** is a criterion that states if the definitions, descriptions of classes, properties, and individuals in an ontology are correct.
- Consistency:** refers to whether it is possible to obtain contradictory conclusions from valid input definitions.
- Completeness:** measures if the domain of interest is appropriately covered in this ontology.
- Conciseness:** is the criteria that states if the ontology includes irrelevant elements with regards to the domain to be covered.
- Adaptability:** measures how far the ontology anticipates its uses. An ontology should offer the conceptual foundation for a range of anticipated tasks.
- Clarity:** measures how effectively the ontology communicates the intended meaning of the defined terms. Definitions should be objective and independent of the context.
- Computational efficiency:** measures the ability of the used tools to work with the ontology, in particular the speed that need to fulfil the required tasks.

One good ontology does not perform equally well with regards to all these criteria. The first task of the evaluator is therefore to choose the criteria relevant for the given evaluation and then to choose the proper evaluation methods to assess how well the ontology meets these criteria.

## Evaluation

### Methods

- Gold Standard-based
- Corpus-based
- Criteria based
- Task-based

	Gold	Corpus	Task	Criteria
Accuracy				
Completeness				
Conciseness				
Adaptability				
Clarity				
Computational Efficiency				
Consistency				

Table 1. An overview of approaches to ontology evaluation.

Level	Approach to evaluation			
	Golden standard	Application-based	Data-driven	Assessment by humans
Lexical, vocabulary, concept, data	x	x	x	x
Hierarchy, taxonomy	x	x	x	x
Other semantic relations	x	x	x	x
Context, application		x		x
Syntactic	x			x
Structure, architecture, design				x

## Evaluation

### Methods

#### Gold Standard-based

Gold standard based approaches which are also known as *ontology alignment* or *ontology mapping* are the most straight-forward approach.

This type of approach attempts to compare the learned ontology with a previously created reference ontology known as the gold standard.

## Evaluation

### Methods

#### Corpus-based

Corpus-based approaches, also known as data driven approaches, are used to evaluate how far an ontology sufficiently covers a given domain. The concept of this type of approach is to compare the learned ontology with the content of a text corpus that covers significantly a given domain.

One basic approach is to perform an automated term extraction on the corpus and simply count the number of concepts that overlap between the ontology and the corpus.

Another approach is to use a vector space representation of the concepts in both the corpus and the ontology under evaluation in order to measure the fit between them.

## Evaluation

### Methods

#### Task-based

Task-based approaches try to measure how far an ontology helps improving the results of a certain task. This type of evaluation considers that a given ontology is intended for a particular task, and is only evaluated according to its performance in this task, regardless of all structural characteristics.

## Evaluation

### Methods

#### Criteria based

Criteria-based approaches measure how far an ontology or taxonomy adheres to certain desirable criteria. One can distinguish between measures related to the *structure of an ontology* and *more sophisticated measures*.

#### Structure - based

Structure-based approaches compute various structure properties in order to evaluate a given taxonomy. Such as, OOPS, OntoMetrics

#### Complex and Expert based

There are a lot of complex ontology evaluation measures that try to incorporate many aspects of ontology quality. Such as, OntoClean

## Evaluation

### Tools:

#### ❖ OOPS!

OOPS! (Ontology Pitfall Scanner!) is an on-line service intended to help ontology developers, mainly newcomers, during the ontology validation activity, who is unfamiliar with description logics and ontology implementation language.

The system provides three indicators: critical, important, minor.

**Critical:** It is crucial to correct the pitfall. Otherwise, it could affect the ontology consistency, reasoning and applicability, among others.

**Important:** Though not critical for ontology function, it is important to correct this type of pitfall.

**Minor:** It does not represent a problem. However, correcting it makes the ontology better organized and user friendly.

## Evaluation

### Tools:

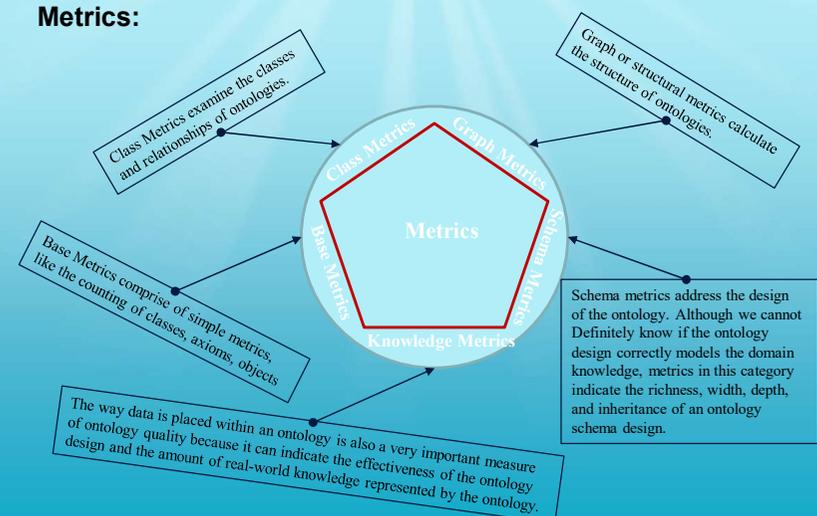
#### ❖ OntoMetrics

OntoMetrics is a web-based tool that validates and displays statistics about a given ontology.

It was based on the metrics, which include class metrics, schema metrics, base metrics, graph metrics, knowledge metrics.

## Evaluation

### Metrics:



## Competency Question-driven Approach

References:  
 - "Towards Competency Question-Driven Ontology Authoring" V. Presutti et al. (Eds.); ESWC 2014, LNCS 8465, pp. 752–767, 2014. c Springer International Publishing Switzerland 2014

**Definition?** "A competency question (CQ) is a natural language sentence that expresses a pattern for a type of questions people expect an ontology to answer."

### Why?

- 1) For specification:** to determine the scope, the granularity, the main classes, properties, relations
- 2) For Validation:** From Competency Questions To Authoring Tests Using SPARQL, Reasoning with OWL, SWRL

## Competency Question-driven Approach

References:  
 - "Towards Competency Question-Driven Ontology Authoring" V. Presutti et al. (Eds.); ESWC 2014, LNCS 8465, pp. 752–767, 2014. c Springer International Publishing Switzerland 2014

### Formulation of CQs

- 1) Natural Language (informal CQs)
  - Which mammals eat grass? (in an animal ontology)
  - Which process implement an algorithm? (in a software engineering ontology)
- 2) Formal language (formal CQs) translating into SPARQL, DL
  - Select ?m where {?m type Mammal . ?g type Grass . ?m eat ?g}
  - Select ?p where {?p type Process . \$X type Algorithm . ?p implements \$X}

## Competency Question-driven Approach

References:  
 - "Towards Competency Question-Driven Ontology Authoring" V. Presutti et al. (Eds.); ESWC 2014, LNCS 8465, pp. 752–767, 2014. c Springer International Publishing Switzerland 2014

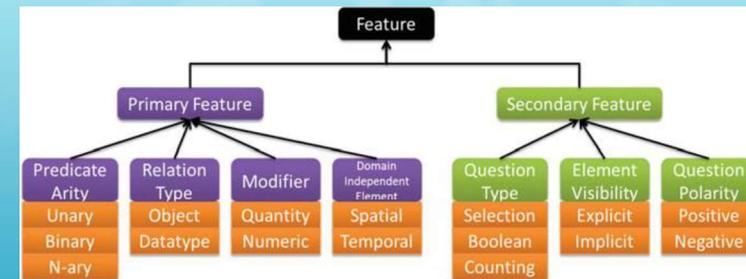
**Table 4.1** CQ Archetypes (PA = Predicate Arity, RT = Relation Type, M = Modifier, DE = Domain-independent Element; obj. = object property relation, data. = datatype property relation, num. = numeric modifier, quan. = quantitative modifier, tem. = temporal element, spa. = spatial element; CE = class expression, OPE = object property expression, DP = datatype property, I = individual, NM = numeric modifier, PE = property expression, QM = quantity modifier)

ID	Pattern	Example	PA	RT	M	DE
1	Which [CE1] [OPE] [CE2]?	Which pizzas contain pork?	2	obj.		
2	How much does [CE] [DP]?	How much does Margherita Pizza weigh?	2	data.		
3	What type of [CE] is [I]?	What type of software (API, Desktop application, etc.) is it?	1			
4	Is the [CE1] [CE2]?	Is the software open-source development?	2			
5	What [CE] has the [NM] [DP]?	What pizza has the lowest price?	2	data.	num.	
6	What is the [NM] [CE1] to [OPE] [CE2]?	What is the best/fastest/most robust software to read/edit this data?	3	both	num.	
7	Where do I [OPE] [CE]?	Where do I get updates?	2	obj.		spa.
8	Which are [CE]?	Which are gluten-free bases?	1			
9	When did/was [CE] [PE]?	When was the 1.0 version released?	2	data.		tem.
10	What [CE1] do I need to [OPE] [CE2]?	What hardware do I need to run this software?	3	obj.		
11	Which [CE1] [OPE] [QM] [CE2]?	Which pizza has the most toppings?	2	obj.	quan.	
12	Do [CE1] have [QM] values of [DP]?	Do pizzas have different values of size?	2	data.	quan.	

## Competency Question-driven Approach

References:  
 - "Towards Competency Question-Driven Ontology Authoring" V. Presutti et al. (Eds.); ESWC 2014, LNCS 8465, pp. 752–767, 2014. c Springer International Publishing Switzerland 2014

### CQ feature hierarchy



## TAO Ci Evaluation & CQs

Example:  
----- TAO CI ontology evaluation

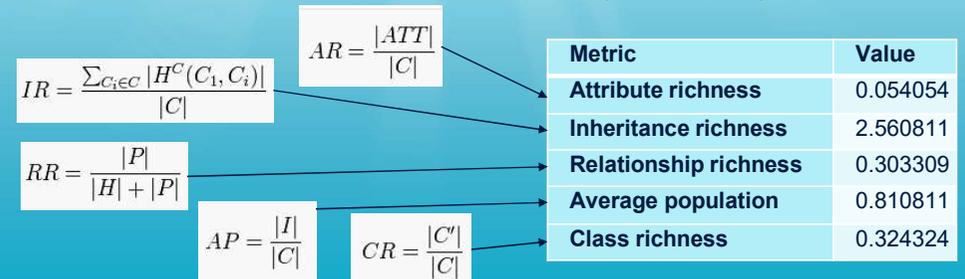
## TAO Ci Evaluation & CQs

### Ontology quality:

OOPS! supplies three indicators: critical, important, minor. In the case of TAO CI ontology, OOPS! did not detect any critical and important pitfalls. The **Consistency, accuracy, and conciseness** are evaluated.

### Domain coverage:

The TAO CI ontology was submitted to OntoMetrics tool to evaluate the domain coverage of ontology. The results are all kinds of metrics, which could evaluate the **accuracy, conciseness, clarity** etc.



## TAO Ci Evaluation & CQs

### Competency Questions

Domain	Ceramics vessels of Chinese cultural heritage
Date	2020-4-20
Ontology scopes	<ol style="list-style-type: none"> <li>Providing a model for museums to publish open data of Chinese ceramic vessels</li> <li>Constructing the knowledge graph of cultural heritage based on ISO 704 and ISO 1087.</li> <li>Building a multi-linguistic term e-dictionary of ceramic vessels.</li> <li>Preserving terms of cultural heritage in Chinese ceramic vessels.</li> </ol>

CQ	Competency question
CQ1	What are the types (subclasses) of Vase (class) ?
CQ2	What are the Chinese and English terms of vases?
CQ3	What are the vase images ?
CQ4	Which material is the vessel made of?
CQ5	What are the vase X?
-----	

## TAO Ci Evaluation & CQs

### SPARQL for CQ:

```

PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX oct: <http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#>

SELECT ?x ?name
WHERE {?x rdfs:subClassOf oct:Vase.
      ?x skos:prefLabel ?name.
      FILTER (lang(?name)='zh')}
}

SELECT distinct ?name_en ?name_zh
WHERE {?x rdfs:subClassOf oct:Vase.
      ?x skos:prefLabel ?name_en.
      ?x skos:prefLabel ?name_zh.
      FILTER (lang(?name_en)='en')
      FILTER (lang(?name_zh)='zh')}
}

SELECT distinct ?x ?name_eng ?name_zh ?img
WHERE {?x rdf:type owl:NamedIndividual.
      ?x skos:prefLabel ?name_eng.
      ?x skos:prefLabel ?name_zh.
      FILTER (lang(?name_eng)='en').
      FILTER (lang(?name_zh)='zh').
      ?x oct:image ?img
}
    
```

→ Q1

→ Q2

→ Q3

## TAO Ci Evaluation & CQs

**CQ1:** What are the types (subclasses) of Vase (class) ?

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX oct: <http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#>
```

```
SELECT ?x ?name
WHERE {?x rdfs:subClassOf oct:Vase.
      ?x skos:prefLabel ?name.
      FILTER (lang(?name)='zh')}
}
```

x	name
<a href="http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#ArrowVase_I">http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#ArrowVase_I</a>	“贯耳瓶”@zh
<a href="http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#ArrowVase_II">http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#ArrowVase_II</a>	“贯耳瓶”@zh
<a href="http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#ArrowVase_III">http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#ArrowVase_III</a>	“贯耳瓶”@zh
<a href="http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#Awl-handle-shapedVase">http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#Awl-handle-shapedVase</a>	“玉壶春瓶”@zh
<a href="http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#BottleVase">http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#BottleVase</a>	“锤把瓶”@zh
<a href="http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#CircleRouleauVase">http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#CircleRouleauVase</a>	“软棒槌瓶”@zh
<a href="http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#Cong-shapedVase">http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#Cong-shapedVase</a>	“琮式瓶”@zh
<a href="http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#CylindricalVase">http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#CylindricalVase</a>	“筒瓶”@zh
<a href="http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#Double-tubeVase">http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#Double-tubeVase</a>	“多管瓶”@zh
<a href="http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#DoubleGourdShapedVase_I">http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#DoubleGourdShapedVase_I</a>	“葫芦瓶”@zh
<a href="http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#DoubleGourdShapedVase_II">http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#DoubleGourdShapedVase_II</a>	“葫芦瓶”@zh
<a href="http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#DoubleGourdShapedVase_III">http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#DoubleGourdShapedVase_III</a>	“葫芦瓶”@zh
<a href="http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#Gall-BladderVase_I">http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#Gall-BladderVase_I</a>	“胆式瓶”@zh
<a href="http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#Gall-BladderVase_II">http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#Gall-BladderVase_II</a>	“胆式瓶”@zh
<a href="http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#GarlicVase_I">http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#GarlicVase_I</a>	“蒜头瓶”@zh
<a href="http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#GarlicVase_II">http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#GarlicVase_II</a>	“蒜头瓶”@zh
<a href="http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#Lantern-shapedVase">http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#Lantern-shapedVase</a>	“灯笼瓶”@zh

<https://data.bnf.fr/current/sparql.html>

Sponging:

Retrieve all missing remote RDF data that might be useful

## TAO Ci Evaluation & CQs

**CQ2:** What are the Chinese and English terms of vases?

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX oct: <http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#>
```

```
SELECT distinct ?name_en ?name_zh
WHERE {
  ?x rdfs:subClassOf oct:Vase.
  ?x skos:prefLabel ?name_en.
  ?x skos:prefLabel ?name_zh.
  FILTER (lang(?name_en)='en')
  FILTER (lang(?name_zh)='zh')}
}
```

Editeur SPARQL de data.bnf.fr

Graphe par défaut (IRI)

<http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl>

Requête

```
1 PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
2 PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
3 PREFIX owl: <http://www.w3.org/2002/07/owl#>
4 PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
5 PREFIX oct: <http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#>
6
7 SELECT distinct ?name_en ?name_zh
8 WHERE {
9   ?x rdfs:subClassOf oct:Vase.
10  ?x skos:prefLabel ?name_en.
11  ?x skos:prefLabel ?name_zh.
12  FILTER (lang(?name_en)='en')
13  FILTER (lang(?name_zh)='zh')}
14 }
```

name_en	name_zh
"gall-bladder Vase"@en	“胆式瓶”@zh
"arrow vase"@en	“贯耳瓶”@zh
"awl-handle-shaped vase"@en	“锤把瓶”@zh
"bottle Vase"@en	“玉壶春瓶”@zh
"circle rouleau vase"@en	“软棒槌瓶”@zh
"Cong-shaped Vase"@en	“琮式瓶”@zh
"cylindrical vase"@en	“筒瓶”@zh
"double-tube vase"@en	“多管瓶”@zh
"double gourd shaped vase"@en	“葫芦瓶”@zh
"garlic vase"@en	“蒜头瓶”@zh
"lantern-shaped Vase"@en	“灯笼瓶”@zh
"long-necked vase with outward mouth"@en	“撇口长颈瓶”@zh
"moon shaped vase"@en	“宝月瓶”@zh

## TAO Ci Evaluation & CQs

**CQ3:** What are the vase images ?

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX oct: <http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#>
```

```
SELECT distinct ?x ?name_eng ?name_zh ?img
WHERE {
  ?x rdf:type owl:NamedIndividual.
  ?x skos:prefLabel ?name_eng.
  ?x skos:prefLabel ?name_zh.
  ?x skos:prefLabel ?name_zh.
  FILTER (lang(?name_eng)='en').
  FILTER (lang(?name_zh)='zh').
  ?x oct:image ?img
}
```

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX oct: <http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#>

SELECT distinct ?x ?name_eng ?name_zh ?img
WHERE {
  ?x rdf:type owl:NamedIndividual.
  ?x skos:prefLabel ?name_eng.
  ?x skos:prefLabel ?name_zh.
  FILTER (lang(?name_eng)='en').
  FILTER (lang(?name_zh)='zh').
  ?x oct:image ?img
}
```



x	name_eng	name_zh	img
<a href="http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#ArrowVase01">http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#ArrowVase01</a>	"blue-and-white arrow vase painted with lotus flowers and eight treasures. Qianlong mark of Qing dynasty"@en	“清乾隆青花莲花托八宝纹贯耳瓶”@zh	<a href="https://www.dcm.org.cn/Uploads/Picture/6/3664.jpg">https://www.dcm.org.cn/Uploads/Picture/6/3664.jpg</a>
<a href="http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#ArrowVase02">http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#ArrowVase02</a>	"blue-and-white arrow vase painted with lotus flowers. Qianlong mark of Qing dynasty"@en	“清乾隆青花莲纹贯耳瓶”@zh	<a href="https://www.dcm.org.cn/Uploads/Picture/6/3710.jpg">https://www.dcm.org.cn/Uploads/Picture/6/3710.jpg</a>
<a href="http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#ArrowVase03">http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl#ArrowVase03</a>	"deng green glaze arrow vase, Xianlong mark of Qing dynasty"@en	“清康熙绿釉青釉古胆瓶”@zh	<a href="https://www.dcm.org.cn/Uploads/Picture/6/16328.jpg">https://www.dcm.org.cn/Uploads/Picture/6/16328.jpg</a>

## TAO Ci Evaluation & CQs

**Summary:**

The ontology could achieve the all the CQs. It validate the ontology’s **Completeness, Adaptability.**

The OOPS, OntoMetrics, and CQs evaluate the TAO Ci ontology’s **Consistency, accuracy, conciseness, Completeness, Adaptability, and Clarity.**

# Progress of Ph.d work

## Background

### 1. Interdisciplines background

- Computer science (AI – knowledge representation; Semantic Web- linked data)

- Linguistics (Terminology)
- Archeology (Cultural heritage)

### 2. Cultural Heritage background

- publishing cultural heritage data
- developing the tool for cultural heritage work.

### 3. Terminology background

- ISO 704
- ISO 1087

### 4. Semantic Web background

- Linked data
- Knowledge Graph

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- Issues
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- Ch 3. Conclusion

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- Ch 2. Ontology
- Ch 3. Ontoterminology
- Ch 4. semantic web for CH

### Part V Ontoterminology of Chinese ceramic

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- Ch 2. Linguistic dimension
- Ch 3. Conceptual dimension
- Ch 4. Building TAO CI ontology in protégé.

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## Part II

### Ontology

- 2.1 definition
- 2.2 theoretical foundation of ontologies
- 2.3 Languages
- 2.4 Methods
- 2.5 Tools

### Ontoterminology

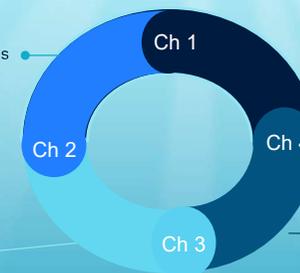
- 3.1 definition
- 3.2 theory
- 3.3 Language
- 3.4 Method
- 3.5 Tools

### Terminology

- 1.1 definition
- 1.2 Theory
- 1.3 Language
- 1.4 Method
- 1.5 Tools

### Semantic Web for CH

- 4.1 cultural heritage
- 4.2 semantic web
- 4.3 semantic web for CH
- 4.4 conclusion



## Part III: Chinese Ceramic Vessels

### Chinese ceramic of Ming and Qing dynasties

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- 2.2 Set of research objects
- 2.3 Presentation of vessels
- 2.4 Presentation of vases
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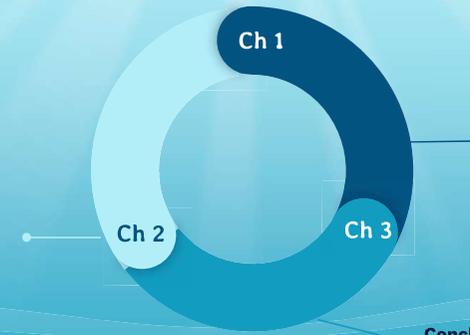
### Basic knowledge of Ceramics

- 1.1 Glaze and color
- 1.2 Period
- 1.3 Ornamentation
- 1.4 Kiln
- 1.5 Decoration craft
- 1.6 Inscription

## Part IV: Morphology of Chinese Terms

### Morphology, Phonology, and Meaning of Chinese Character

- 2.1 Chinese character morphology
- 2.2 Chinese character phonology
- 2.3 Chinese character meaning



### Evolution of Chinese character

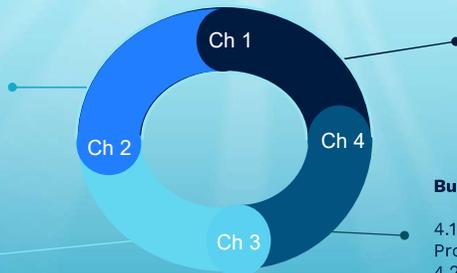
- 1.1 original characters
- 1.2 oracle-bone script
- 1.3 bronze script
- 1.4 Warring States characters
- 1.5 seal script
- 1.6 clerical script
- 1.7 regular script (including semi-cursive script and cursive script)

Conclusion

## Part V: The Ontoterminology of the Chinese Ceramic Vessels

### Linguistic Dimension

- 2.1 Identify the terms(names) corresponding to the vessels
- 2.2 Identify the terms(names) corresponding to the vases



### Methodology

### Building Tao Ci Ontology in Protégé

- 4.1 Implementing Ontoterminology in Protégé
- 4.2 Reusing Vocabularies & Ontologies
- 4.3 Linking and Mapping Other Resources
- 4.4 TAO CI Ontology

### Conceptual Dimension

- 3.1 Conceptual Model of Vessel
- 3.2 Conceptual Model of Vase

# Display

<http://www.dh.ketrc.com/otcontainer/data/OTContainer.owl>

<http://www.dh.ketrc.com/OTC/index.html>

