



A Domain-Specific Formal Ontology for Archaeological Knowledge Sharing and Reusing

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Preface

- ✍ With the widespread use of computers and the World Wide Web, inherent heterogeneity and distribution of domain knowledge strongly prevent it from sharing and reusing across different agents and domains.
- ✍ Formal ontologies have been viewed as a promising means to tackle this problem



Basic Concepts

- ✍ Ontology
- ✍ Individual space
- ✍ Is-specialization relationship
- ✍ Part-of relationship




Part-of relationship

- ✍ Integral-object /Component
- ✍ Area/Place
- ✍ Activity/Feature
- ✍ Collection/Member
- ✍ Mass/Portion.



Ontology

Definition of ontology

-  A domain-specific ontology of archaeology is an explicit and formal specification of a shared conceptualization of archaeology.

Content of ontology

The domain ontology is composed of categories, their relationships and formal axioms that constrain the interpretation and use of these terms.



A Domain-Specific Formal Ontology of Archaeology

- ✍ Design principles
- ✍ The representation of ontology
- ✍ The Content of the ontology



Design principles

- ✍ Sharability and reusability.
- ✍ Clarity and objectivity
- ✍ Completeness
- ✍ Transformation
- ✍ Readability
- ✍ Appellation Standardization



The ontology representation

- ✍ combination of a frame formalism and the first-order predicate calculus



A Frame Formalism

- ✍ The category body consists of a (unordered) list of slots. A slot is classified as an attribute or a relationship. It may have a number of facets. A slot facet provides additional information for a slot.



A Frame Formalism (Cont.)

- ✍ Type: The value type of the slot. This facet is mandatory for all slots.
- ✍ Domain: The set of complete values the slot can assume
- ✍ Default: The default value of the slot
- ✍ Unit: The unit of the slot value
- ✍ Synonym: The synonyms of the slot
- ✍ Parasyonym: The parasyonyms of the slot
- ✍ Antonym: The antonyms of the slot
- ✍ Reverse: The reverse slot of the slot. For example, the reverse of the slot have-member is is-member-of.
- ✍ Property: The properties which the slot has.
- ✍ Facet: The domain-specific facets that the slot is subject to
- ✍ Related slots: The relevant slots related to the slot
- ✍ Comment: The informal comment on the slot



The Content of the domain ontology of Archaeology

- ✍ Categories
- ✍ Relationships of categories
- ✍ The backbone structure of categories
- ✍ Semantic Axioms
- ✍ Archaeological Knowledge Representation



The backbone structure of categories

- ✍ Part-order structure
- ✍ Is-specialization relationship
- ✍ Part-of relationship



Semantic Axioms

- ✍ Membership Axioms of Categories
- ✍ Slot Axioms of Categories
- ✍ Inter-categories Axioms



Membership Axioms of Categories

- ✍ For each category, there are some axioms for determining whether an instance or individual belongs to it.

Axiom 3. $\text{Artifact}(a) \wedge \text{Relic}(a) \wedge \exists b \exists c ((\text{Producer}(a, b) \wedge \text{Frame}_a) \wedge (\text{Have-Use}(a, c) \wedge \text{Frame}_a))$

Axiom 4. $\text{Stone}(a) \wedge \text{Artifact}(a) \wedge (\text{Producing-Material}(a, \text{stone}) \wedge \text{Frame}_a)$

Axiom 5. $\text{Ground-Stone}(a) \wedge \text{Stone}(a) \wedge (\text{Producing-Method}(a, \text{ground}) \wedge \text{Frame}_a)$

Axiom 6. $\text{Metalwork}(a) \wedge \text{Artifact}(a) \wedge (\text{Producing-Material}(a, \text{metal}) \wedge \text{Frame}_a)$

Axiom 7. $\text{Ironware}(a) \wedge \text{Metalwork}(a) \wedge (\text{Producing-Material}(a, \text{iron}) \wedge \text{Frame}_a)$



Slot Axioms of Categories

- ✍ Slots

- ✍ Attributes

- ✍ Relationships



Inter-categories Axioms

- Two types of inter-category relationships
 - Category-level
 - Slot-level relationships

Axiom 15. Relics (a) ? (Artifact (a) ?? Ecofact (a) ?? Worked-on-Object (a))?(? Artifact (a) ?Ecofact(a) ?? Worked-on-Object (a)) ? (? Artifact (a) ?? Ecofact (a) ?Worked-on-Object (a))

Axiom 16. Archaeological-Culture (a)? ?b (Archaeological-Site (b) ? Part-of (b, a))

Axiom 17. Archaeological-Culture (a) ? ?b (Artifact (b) ? Part-of (b, a))



Knowledge Acquisition and Inference Based on the Domain-Specific Ontology

- ✍ The ontology-driven archaeological knowledge acquisition process
- ✍ knowledge analysis, and knowledge inference, and knowledge discovery



A Comparison with CRM

- ✍ The object-oriented conceptual reference model (i.e., CRM) of the ICOM-CIDOC
- ✍ Objects
- ✍ Relationships
- ✍ Semantic constraint: formal axioms



Conclusion

- ✍ Since domain knowledge is described in a formal, explicit and structured way to provide a commonly agreed understanding of archaeology, it can be shared and reused across different agents and knowledge bases.
- ✍ We adopt a combination of a frame formalism and first-order predicate calculus as the ontology representation language. The language can describe the hyponyms, the meronyms, logical relations about categories and individuals.



Future work

- ✍ How to utilize axioms to discover unknown knowledge?
- ✍ How to find potential applications of ontology?
- ✍ How to formalize our ontology development method so that more fundamental issues can be tackled vigorously (e.g. consistency, redundancy, and completeness of ontological axioms)?