Knowledge Graph Enhanced Community Consensus: a Scenario-based Knowledge Construction on Buddha Images

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ABSTRACT

*This paper presents an improvement of collaborative activities in a knowledge-graph construction framework, so-called Community-Driven Ontology-based Application Management (CD-OAM). It facilitates domain experts to make a consensus with the corresponding concept of the Buddha Image (BDI) ontology. Real-world concepts of Buddha Image are described as entities and relationships in a knowledge graph. mapping the sources of knowledge (reference documents, discussion context, and existing ontology). In our scenario, domain experts of different perspectives pointed out epistemological discrepancies of the same concept definition, while identifying the origin of the big Buddha's head in Bangkok National Museum. Their consensus provided us to understand the reasons for different concept properties by referencing evidence.

CCS CONCEPTS

• **Information systems**; • **Resource Description Framework (RDF)**; • **Computing methodologies**; • **Ontology engineering**;

KEYWORDS

Knowledge graph, Knowledge construction, Community-driven approach, Semantic Web, Ontology development, Knowledge engineering, Community consensus

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1 INTRODUCTION

Knowledge acquisitions process [13] is an approach to identify concepts and relationships in discussions of any particular domain. Hashim and Noah [4] employed the process with a semantic online forum to collect and analyze knowledge in a particular domain.

This paper employs the knowledge acquisitions process with a semantic online forum to improve a knowledge-graph construction framework, called Community-Driven Ontology-based Application Management (CD-OAM)[1]. This framework provides features to facilitate specialists to reach a consensus. To illustrate a genuine situation instead of abstract statements, Specification by Example (SBE) [1] approach is used to elaborate knowledge construction in a case study on a masterpiece remnant of Buddha Image, the Sian Yai[2].

We aim to employ a domain ontology called Buddha Image (BDI), to support collaborative activities between knowledge-engineers and art-historians. Our collaborative framework serves as an academic forum that raises reasonable questions rather than to relies on traditional beliefs. To reach a consensus, referenced evidence is highlighted in the discussion as a reason of concept formation and maintenance.

2 BACKGROUND AND RELATED WORK

2.1 Acquiring Knowledge

For the essential technology of the Semantic Web, an ontology [5] encompasses terminologies to represent formal naming and definition of the categories, properties, and relations between the concepts in particular domains. Domain ontologies [10] then perform a prominent role to accomplish interoperability across heterogeneous domains and systems.

[1] CD-OAM: Community-Driven Ontology-based Application Management (https://kgnlp.language-semantic.org/cdoam/).
[2] A Mystery of the Sian Yai. https://www.youtube.com/watch?v=2XnjZIK2Fok

Knowledge acquisition is a process of defining rules and ontologies [13]. The process includes three steps: (1) to identify the key concepts and their relationships in any particular domain, (2) to produce precise unambiguous text definitions for concepts and relationships, and (3) to identify terms referring to concepts and their relationships. In ontology design, the knowledge acquisition process [4] requires stakeholders' involvement to clarify their understanding including ambiguous terms, bilingual posting, and the subjective nature of various metadata to better evaluate the meaning.

A method of knowledge acquisition enables stakeholders to represent candidate facts from an information extraction system, as a knowledge graph (KG) [3]. KG construction requires in-depth knowledge of stockholders. Therefore, the process of knowledge acquisitions in this paper was conducted through two collaborative scenarios: the former is the brainchild of knowledge acquisition [13] and the latter is discussion forums [4]. The knowledge acquisition process is applied to collect knowledge and to precise the different opinions between experts.

2.2 Environments for Ontology Development

Three features manifest in usable ontologies [6]: coverage, consensus, and accessibility. In several related works, an environment is provided for building and assessing ontology development. First, Hashim and Noah [4] provided a semantic online forum concerned with question-answer knowledge. Missikoff [6] presented an approach to support domain experts in populating a domain ontology and obtaining a shared consensus on its content. Akkharawoot et al. [11] incorporated the process of ontology development into the Scrum process in the same fashion in software engineering. They proposed a Scrum-based ontology development platform to promote collaborative activities among different roles of stakeholders.

Here, we employ the three essential features for supporting the knowledge acquisition process. First, a semantic online forum allows stakeholders to access a knowledge graph through their discussions in a particular domain. Second, the knowledge acquisition process is organized to perform a Scrum model that can organized collaborative activities of stakeholders (e.g., domain experts, knowledge engineers, etc.) through an ontology development cycle. Lastly, the provided environment supports stakeholders to achieve in promoting candidate concepts in a community consensus.

3 KNOWLEDGE CONSTRUCTION

3.1 Knowledge Co-creation Framework

As illustrated in Figure 1, a community-driven ontology-based application management framework, called CD-OAM framework [11], was designed to facilitate a collaboration of different stakeholders in knowledge sharing and curation. In the client tier, domain experts and knowledge engineers work side by side to co-create the knowledge graph. In the business tier, community services, e.g., discussion forums and the voting mechanism, are provided. Knowledge management services are also provided for ease of data manipulation. Finally, the data tier is the wrapper of an underlying relational database.

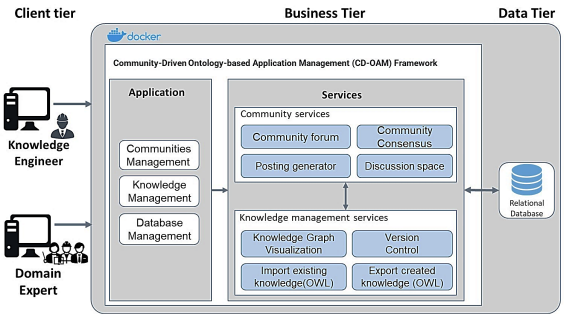

Figure 1: A system architecture of a community-driven ontology-based application management (CD-OAM) framework [11].

3.2 User-defined Ontology Development

As a knowledge co-creation framework, the CD-OAM framework was designed to capture the user's preferences and characteristics of stakeholders. Their domain ontologies represent personalization based on their user's profiles.

Several studies have constructed, reused, and made a consensus for improving shared domain ontologies. Pratiwi et al. [8] proposed a personalized approach to support an e-coaching system that is tailored to the user's characteristics. Al-Nazer et al. [2] developed a framework based on a user profiling technique for supporting food recommendations.

Here, the CD-OAM framework was designed based on a user profiling technique to support a core component in the KG construction. A knowledge graph model corresponding to the users' profile is used to improve the domain ontology. The objective of this work is to collect knowledge through experts' discussion. Besides, Web Ontology Language (OWL) [9] is used to present the experts' characteristics through the manifesting concept and relations.

4 ONTOLOGICAL ENGINEERING PROCESSES

This paper improved the BDI ontology [12] using ontological engineering processes. We analyzed the characteristics of Buddha images and designed a user-defined ontology. Each step followed the instruction of Noy and McGuinness [7]. The methodology of ontology development provides us with detailed processes for creating the BDI ontology based on domain expert knowledge.

As illustrated in Figure 2, three resources of knowledge are gathered as follows. First reference documents (1) are characteristics of Buddha image knowledge, and the second source of knowledge is domain experts (2) give comments and advise us in the ontological process engineering processes. Lastly, existing ontologies (3) provide us to describe existing knowledge that can be referenced in the Buddha image domain.

5 COLLABORATIVE USE CASE SCENARIO

5.1 Use Case Scenario

To illustrate an authentic situation in an academic forum, the Specification by Example (SBE) [1] approach has been used for conceptual knowledge apprehension. A collaborative scenario in Buddha image

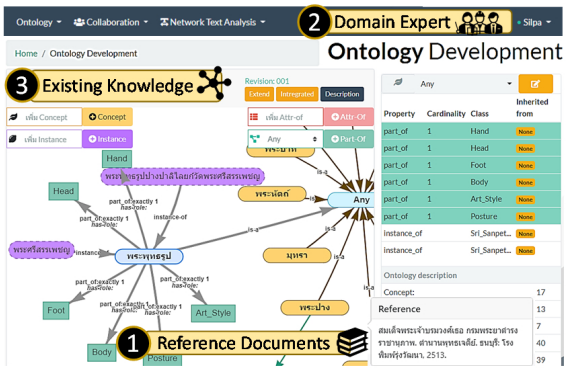

Figure 2: Sources of knowledge for ontology development.

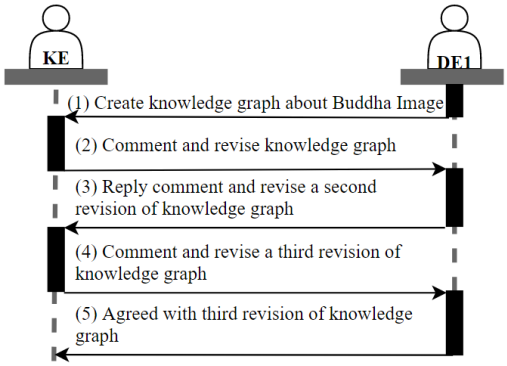

Figure 3: Knowledge co-creation: A domain expert and a knowledge engineer discuss and revise a domain ontology.

introduces a knowledge-sharing situation of distinct Thai art historians to unfold a mystery. According to distinguished approaches, each expert explicates the collaborative activities. To explain such collaborations, the SBE approach is applied for this reason.

Prominently displayed at the center of Sivamok Piman Throne Hall, Bangkok National Museum, it is an origin-unknown big Buddha head, commonly known as Sian Yai 'big head.' This remnant, the Sian Yai, is undoubtedly regarded as the most important masterpiece of the Ayutthaya period. Unfortunately, its story and time of creation are still obscure and debatable. The only one recorded information is that the Sian Yai was found at the main chapel of Wat Phra Si Sanphet, the royal temple of Ayutthaya's ancient palace. As a renowned masterpiece, two hypotheses have been raised by two schools of thought in Art History.

Hypothesis A: The Sian Yai may belong to Phra Pa Lilai, a seated Buddha image, and be built in the reign of King Prasat Thong. This hypothesis is supported by art historical methodology and documents, architectural and sculptural calculation.

Hypothesis B: The Sian Yai is may belong to Phra Si Sanphet, the most important standing Buddha image, that was once located in the main chapel of the ancient palace of Ayutthaya. This hypothesis is supported by its size and height, recorded information, and found-remnant location.

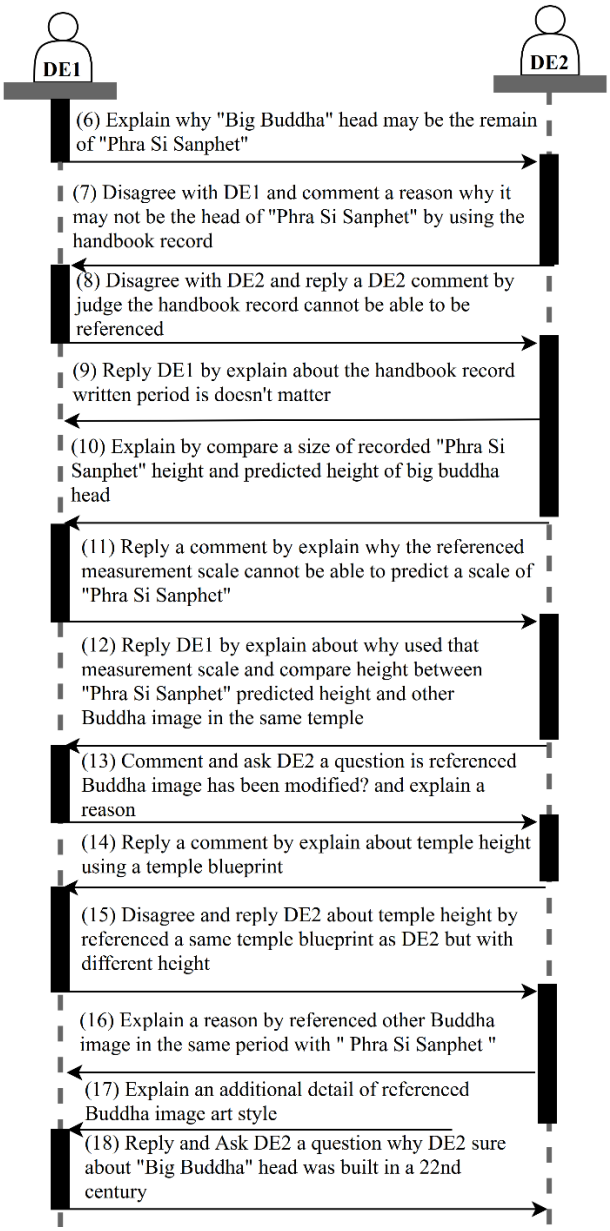

Figure 4: Consensus establishment: Two domain experts are discussed and made community endorsement.

To unfold and clarify these disputable hypotheses, the academic forum is set up with two objectives: 1) qualifying effective data with the art historical methodology and documents and 2) performing Thai traditional architectural calculation and recognizing sculptural pattern. Therefore, the academic forum serves as a debate framework for art historians, knowledge engineers, and general audience.

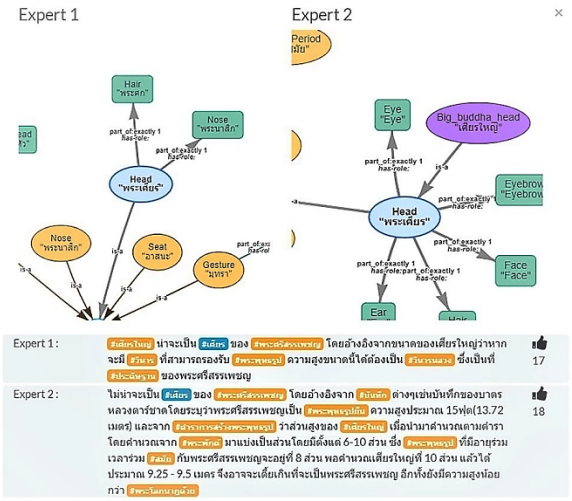

Figure 5: A knowledge construction system from CD-OAM framework supporting a concept endorsement system.

5.2 Roles and Collaborative Activities

Here, the SBE approach is used to elaborate on two collaborative use case scenarios represented with stakeholders' abbreviations and activities. There are two key scenarios, where the SBE approach can effectively facilitate the knowledge curation process.

In the first scenario, knowledge curation is sped up with the help of knowledge engineers. Figure 3 illustrates knowledge co-creation, where the first collaborative scenario of a discussion between a knowledge engineer (KE) and a domain expert (DE1) for conceptualizing knowledge. We can see that the domain expert works side by side with the knowledge engineer in revising the knowledge graph without actual programming.

In the second scenario, community consensus can also be reached via our platform. Figure 4 illustrates a consensus establishment, where two art historians have different perspectives and understandings. Different perspectives and misunderstandings can occur during their collaborative activities. The CD-OAM framework supports the collaborative activities of different stakeholders' perspectives in the same domain.

The framework provides a voting mechanism for establishing a consensus. This feature allows stakeholders to communicate and make a consensus through the semantic-based forum in order to resolve their conflicts. Figure 5 shows the voting mechanism, where those stakeholders can ask and reach a consensus by casting a vote. Referenced evidence is highlighted in the discussion as a supporting reason of each proposal. The improved BDI ontology is shared concept roles. A merging of "Head" concept's properties is generated by RDFLib and represented in the W3C OWL [9].

6 DISCUSSION AND CONCLUSION

Through the semantic-based forum with knowledge acquisition, two Thai art historians with distinct approaches on the Sian Yai could define their key concepts which related to the BDI ontology, and could realize in which their concepts were located on KG.

This paper presents an elaborated KG construction and collaboration between stakeholders to reach a community consensus on a specific domain. The key contributions of our approach are: (1) CD-OAM facilitating the pundits to reach a consensus, (2) the knowledge graph, from BDI ontology, stimulating a community of Thai art historians to enhance their findings and understandings, analytically.

To reach a consensus in the expert community, stakeholders can use the CD-OAM framework to discuss, visualize, and compare different knowledge perspectives either a new agreement or modified knowledge. Additionally, the conflict situations in a collaborative scenario are illustrated. They could reduce confusion and reach a consensus.

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