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Development of Semantic Ontology Modeling in Knowledge Representation of Balinese Gamelan Instruments

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Abstract

Indonesia has many types of cultural and artistic heritage, which one is Balinese gamelan. Knowledge of Balinese gamelan still tends to be less explicitly collected. This result the cultural heritage knowledge, especially the Balinese gamelan challenging to be learned by the young and future Balinese generation. Therefore, the knowledge of Balinese gamelan information should be documented well, especially in the digital form. In this research, we develop an ontology for Balinese cultural heritage, specifically the gamelan Bali. This ontology can be used to capture, document, and represent knowledge surrounds the Balinese gamelan domain. The construction of the ontology model was carried out using the Methontology methodology. The gamelan ontology has 112 classes, 31 datatype properties, 53 object properties, and 289 instances. Further research needs to carry out in order to evaluate and improve the quality of ontology, and follow-up by the implementation into a semantic web-based application.

Keywords: *Balinese Gamelan, Digital Heritage, Knowledge Management, Ontology, Semantic Web, Protégé*

1. Introduction

The number of *gamelan* scattered in an area in Indonesia, especially in the Province of Bali and the instruments are very diverse. The diversity of information about Balinese *gamelan* must be well described.

Kolozali proposes a design in the design of musical instrument ontology based on the classification of the Hornbostel and Sach schemes which classifies the main role of each instrument [1]. This design was an inspiration to develop the ontology of traditional musical instruments in Indonesia. Ontology of traditional instruments uses the origin criteria of instruments, sound sources, basic ingredients, and how to play as detailed information of each instrument.

Because of the complexity of the scope of the characteristics of musical instruments, a representation of semantic web-based knowledge is needed. [2] Technically, a knowledge is represented in the form of classes, description of data, placement, and objects in an ontology scheme. [3] Knowledge is represented by using Protege software with the hope of renewal that is flexible and can be implemented into other forms of knowledge.

In this study, the ontology that summarizes gamelan instruments cannot yet represent the wealth of musical instruments in Indonesia. [4] Especially in Bali, which is a region rich in traditional musical instruments (gamelan). [5] Therefore, the authors propose research to represent knowledge of traditional Balinese instruments into a Balinese gamelan ontology scheme, so that data on relevant Balinese gamelan can be used and organized easily. This is inseparable from the fact that knowledge of Balinese gamelan is still in the form of tacit knowledge. This means that Balinese gamelan knowledge is hereditary, so that only traditional citizens understand it.

Thus, when the knowledge of traditional instruments that have been acquired is explicitly collected into an ontology scheme, the ease of organization and data management will be more secure, thanks to the ontology of Indonesian traditional musical instruments. [6]

In this study, the authors propose semantic web ontology modeling in the domain of *gamelan's* knowledge in Bali. The method adopted in this study is the Method of Methodology. This research is useful to better understand the implementation of semantic ontology in constructing an ontology model that represents the domain of knowledge about games in Bali. This research is expected to be able to build a Balinese game ontology model that has good design quality by utilizing the methodology of Methontology.

This research is organized as follows. Section 2 explains some of the literature related to this research. Section 3 contains the methodology that will be used in developing Balinese gamelan dialogue, in this case the Methontology method. Section 4 outlines the results and discussion of this study, which includes a description of the built ontology. Finally, section 5 presents the conclusions of this study, as well as suggestions for further research.

2. Related Literature

2.1. Semantic Web

The semantic web is the result of the web today, where information has better-defined meanings by seeking perceptual similarities between concepts, to exist, thus enabling humans and computers to optimize optimally [7].

W3C (World Wide Web Consortium) provides a vision of the semantic web that is the idea of having data on the web that is defined and connected in such a way that it can be used by machines, not only for display but also for the purpose of automation, integration and reuse of data between various applications [7].

Semantic web indicates that the meaning of data on the web can be understood, both by humans and by computers [8]. In order to be processed by a machine, web documents are denoted by metadata.

2.2. Ontology

Ontology is a way to represent knowledge from a set of concepts in an information domain and the relationships between these concepts, so that the ontology can be used for semantic presentation of information and organizing and mapping the collection of information resources systematically and structured. This is very useful in terms of data interoperability because it can be done in a more effective and efficient manner [6].

Some of the benefits of using ontology [9], namely: 1) Ontology can share understanding or definition of concepts in a domain (information sharing); 2) Ontology provides a way to reuse knowledge domains (reusable knowledge domains); 3) Ontology makes explicit assumptions about a domain; 4) Ontology together with description languages (such as RDF Schema), provides a way to encode knowledge and semantics such as machine-understand; 5) Ontology allows automated processing of machines on a large scale.

Ontology has been widely used in many studies to solve problems ranging from health to education [4,10,11,12,13,14].

2.3. Bali and Balinese Culture

Bali Island is one of the provinces in Indonesia which has a rich culture. Balinese culture is preserved through daily practices and religious ceremonies that keep ancestral traditions alive. This tradition continues from generation to generation through experiences that are reflected in every activity carried out related to Balinese culture.

Balinese culture is built on traditional Balinese communities such as traditional villages or *pakraman*, *banjar*, and *sekaa* villages. Religious ceremonies, which are the thoughts and attitudes of the Balinese, continue as often and as important as before, and have remained relatively unchanged for years regardless of modernization trends [15,16].

One of the cultural heritages of Bali is gamelan. Gamelan is an ancient traditional musical instrument consisting of percussion, string, wind, string and so on, which is widely known in the Indonesian archipelago [5]. In Bali, gamelan is usually owned by every traditional Balinese community (*adat* village, *adat banjar*, and *sekaa*).

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Balinese gamelan is different from other Indonesian gamelan. Balinese gamelan is made from a set of instruments, but these instruments are paired in their settings. Two instruments of the same size and construction are adjusted to complement each other, one with a slightly lower tone (*pengumbang*) and the other slightly higher pitched (*pengisep*). Simultaneous pitching of the two instruments is not an identical frequency. When they are played together, the result is an acoustic beating called *ombak* or literally "waves". This results in the characteristics of sparkling Balinese gamelan songs.

There are many types of Balinese gamelan ensembles, and vary greatly in size, instrument composition, repertoire, age and function. According to the era of its emergence, Balinese gamelan is divided into three broad lines, namely *Wayah* Gamelan, Intermediate Gamelan and *Anyar* Gamelan [17]. Meanwhile, the gamelan used in the ceremony is distinguished by the type and procession of *Yadnya* which is performed in accordance with the concept of the *Panca Yadnya*. [18]

2.4. Digital Preservation Within Cultural Heritage

Cultural heritage domain specifically those who are working at the digital heritage domain start to use ontology to capture, document, represent, and share the cultural resources across different computer agents. Furthermore, the involvement of the public in developing the ontology give a positive feedback in terms of scale up the number of cultural resources available on the Internet [2].

Meanwhile, digital cultural heritage is the use of digital media in services to preserve cultural or natural heritage. The Charter on the Preservation of Digital Heritage UNESCO defines digital cultural heritage as embracing "cultural, educational, scientific, and administrative resources, as well as technical, legal, medical, and other types of information created digitally, or converted to digital forms from analogous resources there is ".

Cultural heritage tends to be seen as a product of physical cultural traditions and spiritual achievements in the form of past values. In this digital age, cultural heritage institutions such as galleries, archives, museums and libraries (GLAM) have begun to identify the need to digitize their various collections and make them available online [19].

There are various reasons why collections of cultural heritage must be available online. The most important goal is to make old cultural knowledge accessible, further developed, and passed onto future generations [16]. Also, this will allow students, researchers, teachers, and the community to explore and connect with their past. This collection of cultural heritage includes sites, objects, and intangible things that have cultural, historical, aesthetic, archaeological, scientific, ethical or anthropological values for groups and individuals [20]. Several digital works and project initiatives have been carried out to prevent the erosion of cultural knowledge in Indonesia [4,16,21,22,23,24,25,26,27].

3. Research Methods

The method used in this research is the Methontology method. Methontology method is one methodology of ontology model development that has advantages related to the description of each activity that must be carried out in detail. In addition, the method of Methontology also has the ability that the built ontology can be reused for further system development [28]. Due to time constraints, this research only covers up until the implementation stage. The following are the stages of the Methontology method.

3.1. Specification Stage

The purpose of the specification phase is to produce informal, semi-formal or formal ontology specification documents written in natural language, each using a set of intermediate representations or using competency questions.

3.2. Knowledge Acquisition Stage

Knowledge acquisition is an independent activity in the ontology development process. Most of the acquisitions are conducted in conjunction with the requirements specification phase, and decrease as the process of developing ontology moves forward.

3.3. Conceptualization Stage

In this section domain knowledge will be arranged in a conceptual model that describes problems and solutions in terms of domain vocabulary identified in ontology specification activities. The first thing to

do is build a complete glossary. The term includes concepts, instances, verbs, and properties. So, the glossary identifies and collects all useful and potentially usable domain knowledge and its meanings.

3.4. Integration Stage

In this stage, consideration is made of reusing definitions that have been built into ontology.

3.5. Implementation Stage

This stage is the implementation process of ontology design.

3.6. Evaluation Stage

Evaluation means carrying out a technical assessment of the ontology, software environment, and documentation in relation to the terms of reference (in our case the requirements specification document) during each phase and between the phases of their life cycle. Evaluation summarizes the terms Verification and Validation. Verification refers to technical processes that ensure the ontology is correct, the related software environment, and documentation with respect to terms of reference during each phase and between phases of their life cycle.

3.7. Documentation Stage

There are no agreed guidelines on how to document the ontology. In many cases, the only documentation available is in the ontology code, natural language texts attached to formal definitions, and papers published in conferences and journals governing important questions from the built ontology.

4. Result and Discussion

In developing this ontology, the author does not use all the existing stages because at certain stages these components cannot be defined. The following are the results and discussion of this research.

4.1. Specification Stage

The purpose of the specification stage is to produce informal, semi-formal or formal ontology specification documents written in natural language, each using a set of intermediate representations or using competency questions. The following is a description of the Balinese gamelan ontology.

a. Domain: Balinese Gamelan
b. Date: May 15, 2019
c. Objectives: To build ontology models to facilitate the classification of gamelan
d. Level of Formality: Semi-formal.
e. Scope: Balinese Gamelan
f. Knowledge Sources: Books, journals, internet

4.2. Knowledge Acquisition Stage

Knowledge acquisition is an independent activity in the ontology development process. Most of the acquisitions are carried out in conjunction with the requirements specification phase, and decrease with the ontology development process.

The techniques we use in the phase of knowledge acquisition of Balinese Gamelan ontology are as follows.

a. Discuss among the domain of expert and ontology engineer to develop an initial draft of the requirement specification document.
b. Informal text analysis, to study the main concepts given in the book and study handbook.
c. Formal text analysis. The first thing to do is to identify the structure that will be detected (definition, affirmation, etc.) and the type of knowledge contributed by each (concepts, attributes, values, and relationships).

The data used in this study is gamelan data in the Province of Bali. This data was obtained both from books, journals, and reliable internet sources. The data used are 9 types of gamelan barriers and 12 kinds of gamelan instruments in the Province of Bali as sample data.

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4.3. Conceptualization Stage

Conceptualization of ontology aims to organize and manage knowledge gained during the knowledge acquisition process. When a conceptual model is built, the methodology proposes to change the conceptual model into a formal model, which is then implemented in the language of ontology implementation.

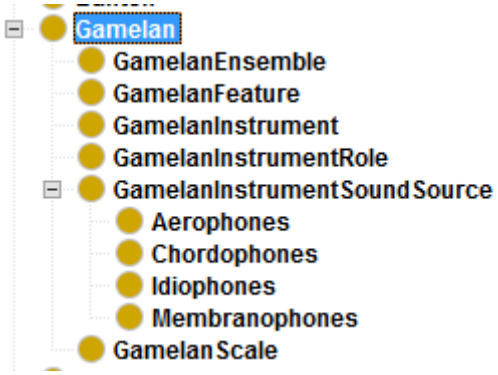
In compiling domain knowledge in a conceptual model that describes the problem and its solution in terms of the domain vocabulary identified in the ontology specification activity, we construct a complete Glossary of Terms that includes concepts, instances, verbs, and properties. Glossary identifies and collects all useful and potentially usable domain knowledge and its meanings.

4.4. Integration Stage

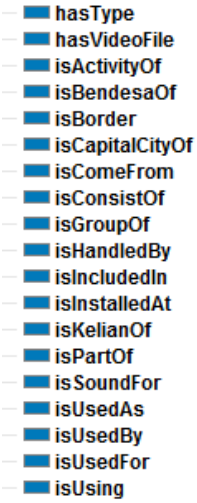
In considering the reuse of definitions that have been built into ontology, the authors examine meta-ontology to choose those that are more in accordance with the concept. The aim is to ensure that new and reused sets of content are based on the same basic set of terms. Then, the writer discovers which library of ontologies provides definitions of semantic terms and coherent implementation with terms identified in conceptualization.

4.5. Implementation Stage

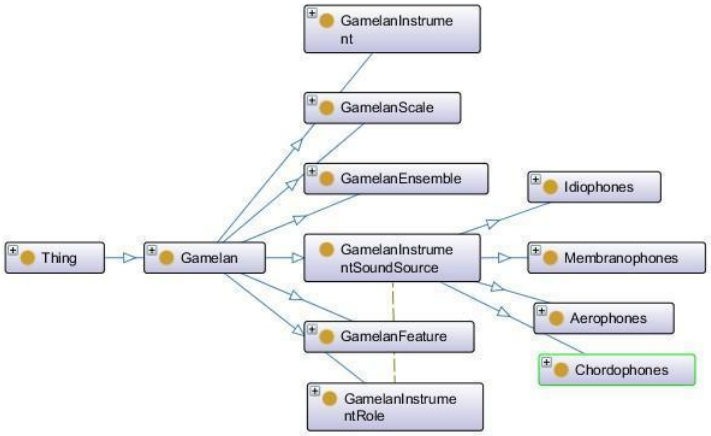
In its implementation we use the Protégé 4.3 desktop software. and the Protégé website (http://webprotege.stanford.edu). At first, we used the Protégé 4.3 software, but in the process where not all of the groups worked and only a few people worked. Therefore, the Protégé website is used so that all can work together so that the development of Balinese Gamelan ontology can be done together and hopefully can be completed faster than using the previous Protégé 4.3 software. Each ontology section is defined according to the results of each task stage in Methontology method, where the concept is defined as a class (Figure 1), ad hoc binary relations are defined as object properties (Figure 2), class attributes and instance attributes are defined as datatype properties, and instances are defined as individuals. The conceptual design of the ontology that has been carried out using Methontology method is then formalized using Protégé 4.3 and the Protégé website. In Protégé 4.3 software, each ontology section is defined according to the results of each task stage in Methontology method, where concepts are defined as classes, ad-hoc binary relations are defined as object properties, class attributes and instance attributes are defined as datatype properties, while on the Protégé website we collaborate on defining instances as individuals. Ontographs of this ontology can be seen in Figure 3.



Picture 1. Class of gamelan ontology



Picture 2. Object properties of gamelan ontology



Picture. Ontograph of gamelan ontology

4.6. Evaluation Stage

Evaluation summarizes the terms verification and validation. In this research, no ontology evaluation has been made.

4.7. Documentation Stage

The results of the documentation of the development of the Balinese semantic ontology of this Balinese gamelan are in the form of writing contained in this article itself.

5. Conclusion

The development of the Balinese *gamelan* ontology aims to capture, store, and represent knowledge of Balinese cultural heritage, especially Balinese *gamelan* that can be manipulated by the computer-based system. The *gamelan* ontology that is built based on the Methontology methodology has 112 classes, 31 datatype properties, 53 object properties, and 289 instances. Furthermore, the Balinese gamelan ontology can be used as a basis for the development of the *gamelan* semantic knowledge system in Bali. Further development should be done by evaluating the proposed ontology and implementing it on the semantic web technology.

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