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The 1st International Conference on Information Technology and Security (IC-ITechs)

November 27, 2014

Editors & Reviewers:

Tri Y. Evelina, SE, MM Daniel
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GREETINGS

Head of Committee IC-Itechs

For all delegation participants and invited guest, welcome to International Conference on Information Technology and Security (IC-Itechs) 2014 in Malang, Indonesia.

This conference is part of the framework of ICT development and security system that became one of the activities in STIKI and STTAR. this forum resulted in some references on the application of ICT. This activity is related to the movement of ICT development for Indonesia.

IC-Itechs aims to be a forum for communication between researchers, activists, system developers, industrial players and all communications ICT Indonesia and abroad.

The forum is expected to continue to be held continuously and periodically, so we hope this conference give real contribution and direct impact for ICT development.

Finally, we would like to say thanks for all participant and event organizer who involved in the held of the IC-Itechs 2014. We hope all participant and keynote speakers got benefit from this conference.

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LIST OF CONTENT

Building a Spatio-Temporal Ontology for Artifacts Knowledge Management

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Abstract

The knowledge that embedded in a historical artifact can have multidimensional information, such as time (temporal) and place (spatial) dimension. The temporal dimension indicates when the artifact had been used in the past, while spatial dimension points the location of people who had been using it at the time. Both of these information provide a general overview of the civilization conditions at the artifacts time. In most cases, the spatio-temporal information that attached to an artifact can be used to furnish the missing information of the other artifacts. If the museum managers are able to connect artifacts based on their spatio-temporal information, presenting artifacts historical value to visitors will be more continuous and complete. However, this kind of management needs could not be facilitated by any existing conventional database systems today. The author proposed an ontology approach for storing artifacts' spatio-temporal information in digital form. This ontology is equipped with rules to perform reasoning thus spatio-temporal information among artifacts could be connected automatically. The result shows that the spatio-temporal ontology can be implemented in order to complete information linkage among the artifacts.

Keywords: *spatio-temporal ontology, historical artifacts, artifacts knowledge management*

1. INTRODUCTION

Knowledge management of artifacts in the museum is not an easy matter, especially if it has a huge number of collections. There are around 140,000 historical objects, including artifacts, stored at Museum Nasional, which is the largest and most comprehensive museum in Indonesia[1]. The various dimensions of information attached in a historical objects complicates artifacts knowledge management. An artifact can have multidimensional information in terms of the time of manufacture, location of the discovery, its usefulness in the past, the people civilizations at the time, and so on[2].

An artifact may have relevance to other artifacts based on their spatio-temporal information. Artifacts that were used by people in the same time can describe the civilization and culture of the period. While artifacts that were found in the same location even though in different time could tell the development of the civilization through the time. Furthermore, by utilizing the concept of spatio-temporal, information that embedded in an artifact can be used to furnish missing information in the other artifacts. Finding the spatio-temporal linkage among artifacts could be done by hand or by using a catalog systems. Unfortunately, there is still no conventional database system which can preserve the concepts of spatio-temporal data storage today [3].

Based on these reasons, it needs a storage method which can interpret the concept of spatio-temporal more than just a date time or location coordinates. This method should able to understand the meaning of past – present – and future in the terms of time as well as draw conclusions through reasoning process of spatio-temporal relationships among artifacts without having to connect them explicitly. In the other words, users only need to enter the date time and place of such an artifact was found, then the system will process and automatically correlate it with spatio-temporal information from several existing associated artifacts.

We can implement ontology as an approach method to store spatio-temporal information. Ontology is well known in terms of its flexibility in managing information and draw conclusions by applying rules which have been defined previously, in order to generate new information [4]. An ontology-based system will be easily integrated with the other systems as long as they have approximate context in their domain [5]. British Museum project is an example of the successful application of ontology in the museum collections management that can be accessed by public[6].

There are several spatio-temporal ontology works that have been done previously by researchers. Spatio-temporal ontology representation, reasoning, and querying have been facilitated by SOWL [4, 7]. SOWL are built upon standards of the Semantic Web and 4D-fluents approach for representing the evolution of temporal information in ontologies. SOWL illustrates how spatial information, spatio-temporal and evolution in space and time can be efficiently represented in OWL. Some other works discussed about selection of spatio-temporal granularity according to the reality and its domain. Failure in choosing granularity may lead the reasoning process to generate unexpected results which are unfit in reality. Furthermore, the works in concepts and relationship refinement of ontology have been done by Chang et. al [8, 9]. Both works mainly focused on relationship among events in term of social and ethnography.

By utilizing the result of previous works, we propose to refine the concept of relations among objects in spatio-temporal domain ontology for artifacts knowledge management. We use SOWL for knowledge representation, thus our proposed ontology can not only meet the museum needs but flexibly integrate with other systems in the future.

2. RESEARCH METHOD

The main steps of building an ontology are described as three phases: ontology capture, ontology coding and ontology mapping[10]. This work only focused on ontology capture and ontology coding.

Concepts and Relationships

The result of ontology capture is the collection of key concepts and relations in knowledge domain. The definition of the concepts and relations should be specified. By processing raw data collected from Museum Nasional Jakarta, we extracted some key concepts related to artifacts. Most of the data describe about the physical dimension of artifact, and time and place when the artifact was discovered. Based on those, we classify the essential entities participating inspatio-temporal relationships of artifacts into 13 classes (in Bahasa Indonesia). These classes are shown in Table 1.

Some classes probably do not fit with our common knowledge about terms, however we tried to resemble the artifact data as similar as possible. For example, people may consider a place coordinate as the smallest measurement unit to point a location, yet since the most precise location gathered from museum about an artifacts discovery is *desa*, hence we concluded it as the smallest region of Lokasi. As a consequence, we equipped Lokasi with coordinate value as referred in Geo (WGS84 lat/long) ontology, the geo ontology which well used for spatial domain. Another uncommon class is WaktuPoint which represent a single point of time in datetime. In the artifacts domain, we restricted the value of WaktuPoint as integer, since the precise datetime of artifact discovery is rarely known. Most cases, they use century (a hundred years) as a time point of artifact discovery. For example, if an artifacts has found in 100 BC, then we store it as -100 (a negative integer) in WaktuPoint. By storing time points in numerical form, a mathematical calculation would be able to perform on them.

Table 1. Class Concepts in the proposed ontology

Concepts/Class	Superclass	Description	Value
Artefak	-	Historical objects as an museum collection	Literal
Lokasi	-	A topographic location where the artifacts was found. It can be divided into several administrative regions.	Literal, geo:lat, geo:long
Desa	Lokasi	The lower level of administration level of Kelurahan. We considered it as the smallest administrative region in the artifacts domain.	Literal
Kelurahan	Lokasi	The fourth level of administrative region	Literal
Kecamatan	Lokasi	The third level of administrative region	Literal
Kota	Lokasi	The second level of administrative region	Literal
Kabupaten	Lokasi	The second level of administrative region	Literal
Propinsi	Lokasi	Province, the first level of administrative region	Literal
Waktu	-	Any time point or time interval along the universal timeline when the artifact was found	-
WaktuPoint	Waktu	A single time point	Integer
WaktuInterval	Waktu	A period of time	Literal
Era	Waktu	A period of time that has name in the history domain	Literal
Dinasti	Waktu	A period of time named as a name of kingdom since it represents the kingdom's era	Literal

Relationships between two classes in ontology are called *object property*. Relations keep the meaning of a class if it connects to the other class. We divided relations into two main subjects: spatial relations and temporal relations. An object property is defined by its domain, range, and characteristics. These three properties play role in the reasoning process, specially the characteristic which makes the defined relationships sounded. Table 2 shows the object property of the proposed ontology. For example, terletakDi has a transitive characteristics. If A terletakDi B, and B terletakDi C, the reasoned will concluded that A is terletakDi C. The same things applied to sebelum (before) which is inverse of setelah (after). If T1 sebelum T2, then it will draw conclusion that T2 setelah T1.

Table 2. Refinement of spatio-temporal relationships

Spatial Relationships				
Object Property	Domain	Range	Characteristics	Description
hasLokasi	Artifact	Lokasi	-	This object property describes the relation between an artifact and a location where it was found.
terletakDi	Lokasi	Lokasi	transitive	It represents a small region which is a part of a bigger region.
Temporal Relationships				
hasWaktu	Artifak	Waktu	-	This object property describes the relation between an artifact and a time when it had been used in the past.
AwalFn	WaktuInterval	WaktuPoint	functional	It represents the start of a time interval in time point.
AkhirFn	WaktuInterval	WaktuPoint	functional	It represents the end of a time interval in time point.
sebelum	Waktu	Waktu	transitive, inverse of *setelah*	A time (time interval or time point) happens before the other time.
setelah	Waktu	Waktu	transitive, inverse of *sebelum*	A time happens after the other time.
overlap	Waktu	Waktu	symmetric	A time interval occurs within the other time interval.
digunakanSebelum	Artefak	Artefak	Inverse of digunakanSetelah	A relationship between two artifacts, which one artifact had been used in the time period before another one.
digunakanBersamaan	Artefak	Artefak	symmetric	A temporal relationship between two artifacts, represents that both probably have been used in the same time period in the past.

Rules and Reasoning

The characteristics embedded in an object property sometimes are not sufficient to use by reasoning to draw a new fact based on its reality. In this case we need an additional rules to be defined in SWRL (Semantic Web Rule Language). SWRL facilitates the important rules which can be writtenas formulas.

In this work, we decided to create some rules regarding to spatio-temporal relationships since the gathered artifact data in museum are rarely comprehensive. For example, we have a tacit knowledge that 12 BC was happened before 10 BC, and so with a bigger integer value in BC would happen before a smaller integer in BC. Linking each atomic century with the others seems impossible due to the data massiveness. By using rules, we may need to assert few fact about several centuries that happen before the other centuries, then the reasoned will process these facts and complete all of linkage among centuries automatically. These are the rules made in the artifacts ontology.

Spatial Rules:

R1: WaktuInterval(?i1), WaktuInterval(?i2), AwalFn(?i2,?s2), AkhirFn(?i1,?e1), sebelum(?e1,?s2) ->sebelum(?i1,?i2)

R2: WaktuPoint(?p1), hasWaktuVal(?t1), WaktuPoint(?p2), hasWaktuVal(?t2), swrlb:greaterThan(?t2,?t1) ->sebelum(?p1,?p2)

R3: WaktuInterval(?i), AkhirFn(?i,?e), hasWaktuVal(?e,?t1), WaktuPoint(?p),hasWaktuVal(?p,?t2), swrlb:greaterThan(?t2,?t1) ->sebelum(?i,?p)

R4: WaktuPoint(?p), hasWaktuVal(?p.?t1), WaktuInterval(?i), AwalFn(?i,?s), hasWaktuVal(?s,?t2), swrlb:greaterThan(?t2,?t1) ->sebelum(?p,?i)

R5: WaktuInterval(?i1), AkhirFn(?i1,?t1), WaktuInterval(?i2), AwalFn(?i2,?t2), setelah(?t1,?t2) -> overlap(?i1,?i2)

R6: WaktuInterval(?i), AwalFn(?i,?s), AkhirFn(?i,?e), hasWaktuVal(?s,?ts), hasWaktuVal(?e,?te), WaktuPoint(?p), hasWaktuVal(?p,?tp), swrlb:greaterThanOrEqual(?tp,?ts), swrlb:lessThanOrEqual(?tp,?te) -> overlap(?i,?p)

R7: Artefak(?a), Artefak(?b), hasWaktu(?a,?ta), hasWaktu(?b,?tb), sebelum(?a,?b) ->digunakanSebelum(?a,?b)

R8: Artefak(?a), Artefak(?b), hasWaktu(?a,?ta), hasWaktu(?b,?tb), overlap(?a,?b) ->digunakanBersamaan(?a,?b)

Temporal Rules:

R9: Artefak(?a), hasLokasi(?a,?l), terletakDi(?l,?r) ->hasLokasi(?a,?r)

3. RESULT AND DISCUSSION

The ontology has built and tested using Protégé 5.0 beta and HemiTreasoner. We gathered the artifacts data source from Museum Nasional Indonesia for experimental purposes. Based on the original source, some of artifact's spatio-temporal data are recorded in various formats. Yet our ontology can deal with it, since each class in our ontology has been designed to store spatio-temporal data in several granular unit of time and place. Table 3shows an example of some artifacts data with various unit of time and place in artifacts domain.

Table 3. List of Artifacts

ID	Artefact Name	Desa	Kecamatan	Kabupaten	Propinsi	Time
0024010	Parang	Sidodadi	-	Malang	JawaTimur	13 C
0008055	GentaPendeta	Sengguruh	Kepanjen	Malang	JawaTimur	10 C -12 C
0024125	Arit	Arjosari	-	Malang	JawaTimur	13 C - 14 C
0032159	PecahanGerabah	Rajadanu	Jepara	Kuningan	Jawa Barat	Neolitik

In this initial research, the experiments are focused on testing the completeness of inferred information obtained by reasoner. The 9 rules mentioned in the previous section have been activated in the tests and we used the feedback from an expert (museum officer/ MO) to validate the result. In this following example, as depicted in Figure 1, we gained all fact and inferred information about artifact *Parang*. Here the list of questions that can be answered in the result:

1. *Have Parang and Arit been found in JawaTimur? MO:Yes.*
2. *Have Parang and Arit probably been used in Malang's civilization in the same time? MO:Yes.*
3. *Had Parang been used after GentaPendeta in the same civilization? MO:Yes.*
4. *Had PecahanGerabah been used by people in the past before they used Parang? MO:Yes.*

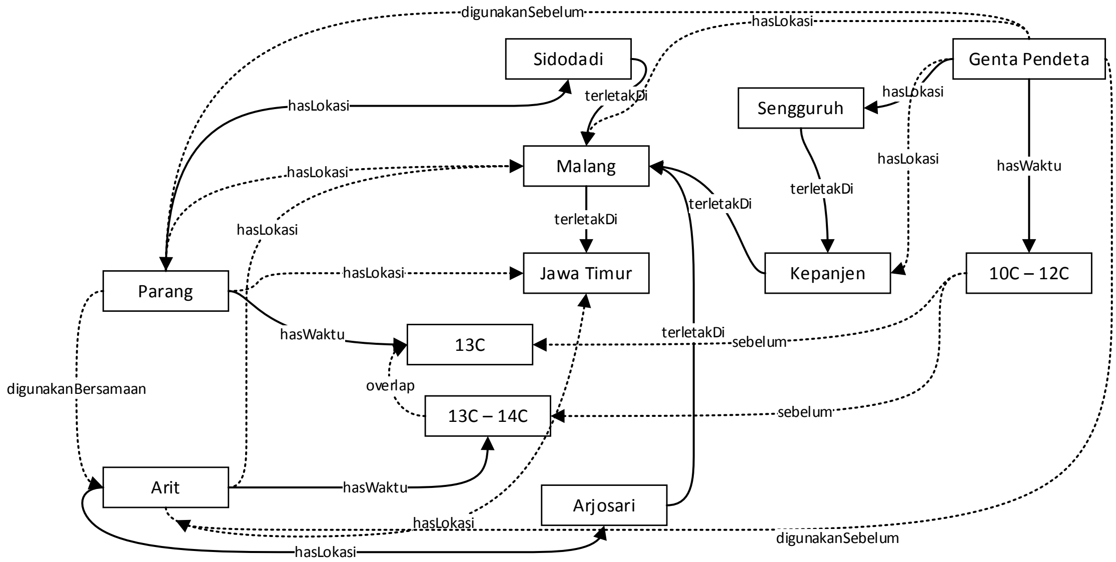

Figure 2. Original and Inferred Facts about Parang

4. CONCLUSION

Utilizing ontology approachforlinking spatio-temporal information among artifacts seems promising considered to the experimental result. The reasoner managed to obtain verifiable inferred facts about artifacts so far. Yet, the proposed ontology still needs a lot of refinement, specially in temporal reasoning rules that represents temporal connection between artifacts. We are going to complement the rules in the next work and later we will focus on modifying ontology to manage person-object relationships in terms of historical matters. However, the query process of data stored using ontology needs a long time to be completely executed. The is because all of possible spatio-temporal connection between an artifact and another artifacts should be drawn in a single model as the result of reasoning process which means the model will be dense and massive. In order to applying ontology upon a reasonable query time processing, the further researches are considerably needed.

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