emerald PUBLISHING

The Electronic l

Ontology for preserving the knowledge base of traditional dances, OTD

Journal:	*The Electronic Library*
Manuscript ID	EL-11-2019-0258.R3
Manuscript Type:	Article
Keywords:	Semantic web, Dance ontology, Culture preservation, Web 3.0, Folk dance, Digital humanities

Ontology for preserving the knowledge base of traditional dances (OTD)

Abstract

Purpose - Systematic organization of domain knowledge has many advantages in archiving, sharing, and retrieval of information. Ontologies provide a cushion for such practices in the semantic web environment. The current study aims to develop an ontology that can preserve the knowledge base of traditional dance practices.

Design/methodology/approach - It is hypothesized that an ontology-based approach for the chosen domain might boost collaborative research prospects in the domain. A systematic methodology was developed for modelling the ontology based on the analytico-synthetic rule of library classification. Protégé 5.2 was used as an editor for the ontology using the ontology web language (OWL) combined with description logic (DL) axioms. Ontology was later implemented in a local GraphDB repository to run queries over it.

Findings - The developed Ontology on Traditional Dances (OTD) was tested using the dances of the Rabha tribes of North East India. Rabha tribes are from an indigenous mongoloid community and have a robust presence in South East Asian countries, such as Myanmar, Thailand, Bangladesh, Bhutan, and Nepal. The result from Hermit reasoner found the presence of no logical inconsistency in the ontology, while the OOPs pitfall checker tool reported no major internal inconsistency. The induced knowledge base of traditional dances of the Rabha's in the developed OTD was further validated based on some competency questions.

Research implications - In the growing trend of globalization, preservation of the cultural knowledge base of human societies is an important issue. Traditional dances reflect a strong base of the cultural heritage of human societies as they are closely related to the lifestyle, habitat, religious practices, and festivals of a specific community.

Originality/value - The current study is exclusively designed, keeping in mind the variables of traditional dance domain based on a survey of the user and domain-specific need. The ontology finds probable uses in traditional knowledge information systems, lifestyle-based e-commerce sites, and e-learning platforms.

Keywords: Semantic web, Dance ontology, Culture preservation, Web 3.0, Folk dance, Digital humanities

Paper type: Research paper

Web Protégé link to the ontology: https://webprotege.stanford.edu/#projects/39ad20f6-1783-47f5-9e9c-8d42eaffde9c/edit/Classes

Google drive link to raw file OTD.owl:
https://drive.google.com/file/d/1x4AlxV8gnVMdqM54LXTK5Z8e9ju0wtGH/view?usp=sharing

1. Introduction

The domain of culture and cultural heritage is quite rich, and the preservation of such precious information sources has gained much importance because they reflect a strong base of human evolution as a societal being. Culture and cultural heritage information sources are not only limited to arts and artistic objects stored in memory institutions, such as museums and archives, but they have a more extensive scope with broader spectrum relating to human activities, traditions or living expressions inherited from our ancestors and passed on to our descendants (UNESCO, 2006). The intangible cultural heritage convention of UNESCO is a global attempt to preserve the cultural diversity of human communities in the growing trend of globalization. The development of information systems for collective preservation of such cultural knowledge bases following standard knowledge organization systems (KOS) helps in

collection management, conservation, research, and the presentation process (Doerr, 2009). Folk or traditional dances of different communities of the world form a strong base of inclusive, representative diversity of cultural practices. From the broader domain of cultural heritage, traditional dances give a smaller accurate picture of sociological, economic, traditional and religious beliefs, and the survival process of various tribes. The cultural expressivity of traditional or folk dances also includes the practices concerning nature, knowhow, and skills about different activities, dresses, and lifestyles of communities. A systematic process to represent the rich knowledge base of traditional dances is thought to have greater importance in the domain of cultural heritage preservation.

Systematic knowledge organization system (SKOS) has different approaches. Libraries have developed metadata schemas for dedicated storing of the bibliographic information of their collection based on which they provide services (Kalita and Deka, 2020). Schema-based knowledge organization has been successful in domains, such as e-commerce. The semantic web has provided a better scope for the collaborative knowledge organization process. Intelligent information search with added interoperability and automatic knowledge extraction by machines are the two key areas where semantic web has succeeded. Ontology under semantic web works as a structured schema for a certain knowledge base. One of the most famous definitions for *ontology* is Gruber's (1993, pp. 199) that states that, "Ontology is a specification of a conceptualization". It became a trendy term in the 1990s as a tool of knowledge representation for expert systems. Now, the ontology development research is a big area, and many well-established large domains have shifted towards the ontology-based knowledge organization process. However, there is very sparse development seen regarding the use of ontology in the domain of cultural heritage preservation (a detailed discussion is available in Section 2.1). Traditional dances are a single source output of various socio-cultural, socio-economic, and socio-religious activities of various communities and the accumulated knowledge base of traditional dances can serve various information needs of a diverse population. An ontology for traditional dances is thought to be feasible as:

- Traditional dances being an amalgamation of social customs, cultural rituals, religious beliefs, and lifestyles of different communities; an ontology-based structured schema for its knowledge base shall be quite useful. The ontology would streamline the documentation process about the various aspects of dances, facilitating collaborative research, and can work as a one-stop point for smart information retrieval about any traditional dance.
- An ontology would create a scalable abstract system for the socio-cultural elements associated with traditional dances. This would facilitate information search at various levels with various use intentions. For example, a fashion blogger might search for information about traditional dresses associated with particular traditional dances of a specific community while a textile expert may wish to learn about the detailed pattern of their preparation. Same information might also be sought for by a dancer while re-creating the dances. Also, a musician or an archaeologist might look for information about the instruments used in the dance performances. Logical knowledge inferencing property would make the knowledge base usable for third party applications, such as lifestyle-based e-commerce sites, e-learning platforms, and so on. This encourages the preservation of the knowledge base of traditional dances for their multi-notional uses.

The study is divided into the following sections. Section 2 includes the literature review while Section 3 describes how traditional dance have been conceptualised for the study. Section 4 objectifies the study and also introduces the methodology used to achieve it. Section 5 describes the details of each step under methodology, as well as the work done, and Section 6 covers the conclusions drawn from the study.

2. Review of the literature

2.1 Ontology in cultural heritage preservation

The domain of culture and cultural heritage is very diverse and multi-notional. Cultural heritage contains every activity of human life from what people eat, what they wear, how they celebrate, to whom do they pray, and so forth. Ontology in this domain is expected to represent the complexity of such activities with data points in a machine-readable format. The International Committee for Documentation (CIDOC), an institution of the International Council for Museums, developed the conceptual reference model (CRM) known as CIDOC-CRM as a large project to create linked open data harmonising between libraries, museums, archives, and cultural datasets. CIDOC-CRM resulted in a core ontology for the cultural heritage domain. The object-oriented model of CIDOC-CRM took a bottom-up approach enabling the exhaustive representation of the knowledge base with the possibility of adding multiple use cases. Another such core ontology similar to CRM is the ABC ontology under the Harmony Project (Doerr, 2009). The ABC ontology (Lagoze and Hunter, 2001) is a much smaller ontology than CIDOC-CRM, and its main aim is to integrate information of multimedia objects under digital libraries. ABC worked under the FRBR philosophy and had 13 classes and 14 properties. Along with these core ontologies, there are some domain-specific ontologies under cultural heritage and indigenous knowledge bases. Haron and Hamiz (2014) worked on an ontology for the traditional Malaysian confinement dietary practices. The ontology took a rigorous approach of directly converting unstructured data to ontology form with expert advice. Stanley and Astudillo (2013) proposed an ontowiki model harnessing the expressive power of ontology with UNESCO's intangible cultural heritage (ICH) classification. They applied their model to Chilian ICHs and found better results than the traditional catalogue-based storage of information. Chaikhambung and Tuamsuk (2016) developed an ontology for the ethnic groups of Thailand. They used classification theory used in libraries for content analysis and then proceeded to knowledge organization in the ontology. Kolozali *et al*. (2011) devised the complex domain of musical instruments to an ontology form in the musical instruments ontology. Their ontology was inspired by von Hornbostel and Sachs' (1914) classification of musical instruments which claimed suitable for information storage about musical instruments. A metadata model for folk songs (Goienetxea *et al*., 2010) was proposed based on the ontology web language (OWL) using the CIDOC-CRM as a reference model. The study used Basque folk songs as a working model to devise the ontology and showed complex query results based on description logic (DL) interference.

2.2 Ontology on dance culture

Ontology, as a logical process of knowledge organization, have tremendous possibilities in artificial intelligence-based information processing regarding dances. El Raheb and Ioannidis, (2011) proposed a knowledge base system where labanotation information about choreographic elements was incorporated using OWL 2, and they named it *dance ontology*. It was the first one of its kind and approach in this domain, and SPARQL queries regarding steps and movements about dances that could be made based on DL-based interference rules. Chau and Thuy (2018) proposed annotations for an ontology for Vietnamese folk dances. They made an in-depth analysis of various components of folk dances and also added labanotation notions for the dance movements using DL-lite logical axioms in the OWL 2 language. Ma *et al*. (2018) worked on a schema for semantic modelling of Vietnamese traditional dances. Their modelling approach was limited to a basic categorization of dances based on their associated accomplishments, such as dresses, festivals, regions, instruments, and so on, with no facility to add other information about the dances (i.e., one could only categorize dances using the ontology). Telli *et al*. (2018) devised an ontology for the dance

movements of Vietnamese dances. They created a dataset of Vietnamese dance movements (e.g., hip movement, arm movement inspired by labanotation) with their descriptions which could be queried using the semantic query-enhanced web rule language.

Summerising from the reviewed literature, the ontologies discussed under Section 2.1 are mostly limited to specific cultural objects, instruments, items, and songs that have physical existence and are stored in memory institutions, libraries, and so on, while the ontologies discussed under Section 2.2 dealt with dances that have some kind of recorded existence, such as labanotation or only limited to just categorizing the dances. A combined knowledge base that can be used for re-creating the dances having information about items, individuals, and forms is the aim of the present study.

3. Conceptualizing traditional dance

Traditional dance is a synonymous term of folk dance. The Merriam Webster dictionary (2019) defines *folk dance* as "a dance that originates as a ritual among and is characteristic of the common people of a country, and that is transmitted from generation to generation with increasing secularization". The term *traditional dancing* is used when the focal emphasis is on the cultural roots of the dance (Manning, n.d.). These dances do not have any governing rules, rather they emerge spontaneously, without much rigidity in forms. Traditional dances have a close relationship with the every day practices of human life, such as agriculture and farming, festivals, rituals, folk beliefs, and so forth. It is to be mentioned that traditional or folk dances do not include the classical dance forms that have rigid governing rules and structural procedures. For example, the Bhangra of Punjab, Bihu of Assam, Gaur dance of Chttishgarh, and Hojagiri of Tripura are traditional dance forms of India from various states related to various communities.

4. Objective and methodology for the study

The prime objective of the study is to develop an ontology that can represent the knowledge base of Indian traditional dances in the semantic web environment. India is home to many different communities, and each community has their own distinct cultural practices. Traditional dances, excluding the classical form, is what is taken here as a domain in the study to develop the ontology. Later, the ontology will be populated taking the example of traditional dances of the Rabha community of North East India, and the suitability of the ontology was tested based on that. The reason for choosing the Rabha tribe as a primary domain to test the ontology is because of their strong presence and large cultural similarity with other South East Asian region's tribes. The Rabhas are from an indigenous mongoloid community that has a strong presence in the Northeastern part of India, along with Nepal, Bhutan, Thailand, Myanmar, and Bangladesh (Gait, 1905).

There are various tried and tested ontology development methodologies, such as the Toronto virtual enterprise (TOVE) methodology (Grüninger and Fox, 1995) describing the ontology development and maintenance process, the DILIGENT methodology (Vrandecic *et al*., 2005) focussing on the ontology evolution process, and the ENTERPRISE model (Uschold *et al*., 1995) assessing the formal and informal phases of ontology development. A more extensive review regarding various such processes of ontology development can be found in Cristani and Cuel (2005). However, there is no single correct step-by-step direction of ontology development (Noy and McGuinness, 2001) and choosing a methodology for ontology development highly depends on the domain complexity and the objective of the to be developed ontology. From various literature, the domain of traditional dance has proved to be multi-notional with many variables without much rigidity. Therefore, a step-by-step procedure (shown in Figure 1) was designed for the current study inspired by the YAMO approach (Dutta *et al*., 2015). The YAMO methodology is based on Ranganathan's (1967)

analytico-synthetic approach of library classification with added flavours of the faceted rule of colon classification scheme. The faceted approach gives a modular approach to the ontology development process. Ontology classes can be prepared based on homogeneity with the possibility of making the ontology hospitable to other future addition of classes. Each independent class can be treated as a sub-domain under the more significant domain, and those sub-domains can be further narrowed down to micro concepts with a top-down or bottom-up approach. Further facets help to create some intuitive terms under a domain that ultimately helps in information retrieval for a user. Later, those classes can be related to logical properties following DL axioms.

A nine step procedure was identified for the current study, as indicated in Figure 1.

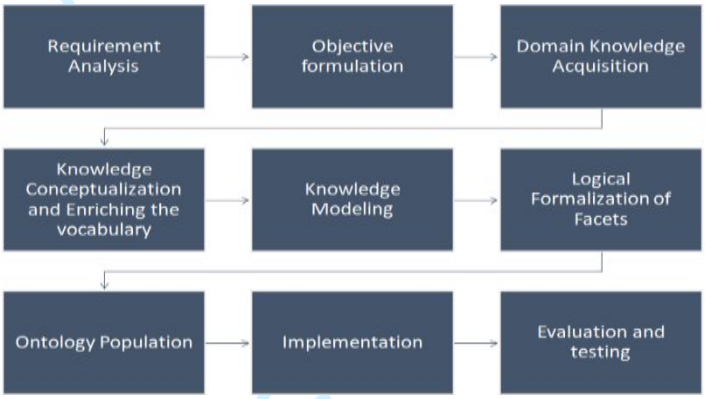

Figure 1. Steps for ontology development

5. Development of the ontology

5.1 Requirement analysis

At this step, a study of existing ontologies under the dance domain was completed, the approaches were studied, and an analysis of the gap areas in the domain was conducted. As highlighted in the Literature review (Section 2.2), there are a few ontologies that relate to dance and dance movements, but they have functional limitations that would not accommodate traditional dances. For example, the dance ontology of El Raheb and Ioannidis (2011) aimed to capture labanotation information of dance movements, whereas traditional dances have hardly any labanotation information as these dances are passed on from generation to generation and have few governing rules. Chau and Thuy (2018) adopted the same approach for their Vietnamese folk dance ontology. Telli *et al.* (2018) used a collection of images replicating dance movements in Vietnamese dances and created the ontology so that queries can be run to retrieve those images for specific dance movements. An ontology for traditional dances should be representative of the required accomplishments to reprise the dance, as well as the aesthetic feel of the dance and the associated religious or social or seasonal beliefs of the related community with the dance, all of which are missing in the consulted developed ontologies.

5.2 Objective formulation

Traditional dances comprise a substantial part of the sociology, lifestyle, economy, and festivities of the tribe to which they are associated. Also, as it is a dance, it includes lots of choreographic gestures. Music, musical instruments, and dance props are prevalent entities of traditional dances. The overall knowledge base of traditional dances is intangible. The dance itself is not a permanent entity, and it can only be realized and enjoyed during the performance only, unlike stories or novels. Moreover, the preservation part of the cultural basis of ethnic tribes is an active motivating scenario for the ontology on traditional dances.

The developed ontology should be useful for a student, teacher or researchers to discover the information; it should be useful for a choreographer to find information for re-creating the dances; and it should be capable enough for a historian or archivist to store the information about traditional dances in a structured approach. Several motivating scenarios for the ontology are (but are not limited to these):

- Which community have what different traditional dance(s)?
- What are the different types of traditional dances?
- Traditional dances are related to what occasions?
- What different ornaments, dresses, headgears are there for traditional dances?
- What are the music, musical instruments, lyrics of traditional dances?
- Information about different tribes.
- What type of clothes do different communities wear and how are they prepared?
- Who are the people involved in traditional dances?

5.3 Domain knowledge acquisition

The domain knowledge acquisition part was divided into three parts. First, how information is documented in museums and archives. Moreover, a description of information sources in documentary sources is an essential part of it. Second, how domain experts perceive domain knowledge. Third is what information do consumers seek in that particular domain.

A critical step about what information to be modelled highly depends upon what is the knowledge of the developer under that particular domain. As the ontology aims to harness information about the various facets of traditional dances, the information stored in it is thought to have probable use scenarios, such as dancers to reprise the dance for performances; researchers to gain knowledge about the ethnic knowledge base of dance, and so on, therefore, at first various documentary sources, such as books, articles, notes, and so forth, were consulted to gain the necessary knowledge. Museums and archives were paid a visit. Especially, information about how dances, traditional clothes, war weapons, agricultural and other lifestyle tools are catalogued in museums was given more importance as this might help in facet discovery. Also, the information display structure of museums for such items was given significant importance. Some recorded literature (Baruah, 2004; Rabha, 2002) about the cultural and societal styles of the Rabhas were also consulted in this process.

Interviews with experts formed a significant part of the knowledge acquisition process. Also, to get a thorough viewpoint about how people seek information and what people may prioritize in learning about traditional dances, as well as details about some probable scenarios were collected with some open-ended opinions by surveying 50 participants. The participants were comprised of a domain expert, researchers, and general students working on their Master's degrees. They were asked to list out a maximum of ten different scenarios which they would like to learn from an expert system in the traditional dance domain. The responses collected were analysed and grouped based on their similar meanings. Table I lists the overall top scenarios that were given by the respondents.

Table I. Scenarios of information seeking in the traditional dance domain

Type of scenarios	**No. of responses**
Questions related to various dance types of different communities	44
Questions on dance and its related occasions	39
Questions on the performance style of dances	38
Questions on the aesthetic feel of the dance regarding costumes, ornaments, and so on	42
Questions on music and musical instruments	44

Questions on the gender of participants in the dance	41
Questions on the performance season of the dance	37

5.4 Knowledge conceptualization and enriching the vocabulary

The knowledge acquisition process about traditional dances was able to ignite ideas and fire the imagination of the researcher into a picturesque shape. It helped to comprehend the scope, coverage, and limitations of the facets of folk dance. The different catalogues of museums consulted during the knowledge acquisition process helped to identify the key terms that are used to catalogue different dance-related items, such as weapons, instruments, agricultural tools, musical instruments, and dresses of different tribes and communities. The relevant definitions for such terms were searched for in thesauri and dictionaries. A large pool of terms was created in this step, and then an abstraction was prepared to bring similar entities together. Different conflicting scenarios arose during the conceptualization process like the following examples:

- Various agricultural tools are also used as weapons during war and as a hunting tool in various communities and tribes. In dances, those tools are used as dance props. For such situations, the primary use of the tool was considered for deciding if that tool will be an agricultural tool, a war tool or a hunting tool.
- Similarly, some musical instruments are also used as a dance prop during a performance, such as the *gogona* of the Assamese Bihu dance. It is primarily a musical instrument but also used as a dance prop in some movements. In such cases, the primary role of the instrument was considered while making that item a part of any class. For example, *gogona* was made part of the musical instruments group.

Vocabulary is an essential element of ontology. It is evident that in the traditional dance domain, there may be items with synonyms. There may be multiple candidate terms for a single concept – for example, the dress of different dances. Dresses can also be termed as costume, attire, clothing, and so on. In the case of a performance, the word *costume* is more suitable, but from the context of cultural heritage, the word *dress* has a more inclusive feel to it. Ranganathan's (1967) canon of sought heading principle, which states use the popular term, is relatable to this abstraction process of vocabulary standardization. Table II represents how various sources define the concept of *costume*. The comments of a domain expert were considered for this purpose, and the Dewey Decimal classification schedule was alswo used for term standardization. Conceptualization was inspired by the probable scenarios that ontology users may seek for information.

Table II. Different variations of meaning for similar concepts

Word	**Definition source**	**Definition**
Clothing	Wikipedia	"is a collective term for items worn on the body. Clothing is typically made of fabrics or textiles but over time has included garments made from animal skin or other thin sheets of materials put together."
	Wordnet	"a covering designed to be worn on a person's body"
	Cambridge Online Dictionary	"clothes, especially clothes of a particular type or those worn in a particular situation"
Dress	Wikipedia	"A dress (also known as a frock or a gown) is a garment traditionally worn by women or girls consisting of a skirt with an attached bodice (or a matching bodice giving the effect of a one-piece garment). It consists of a top piece that covers the torso and hangs down over the legs. A dress can be

		any one-piece garment containing a skirt of any length and can be formal or casual."
	Wordnet	"clothing of a distinctive style or for a particular occasion"
	Cambridge Online Dictionary	"used, especially in combination, to refer to clothes of a particular type, especially those worn in particular situations"
Costume	Wikipedia	"is the distinctive style of dress of an individual or group that reflects class, gender, profession, ethnicity, nationality, activity or epoch"
	Wordnet	"the prevalent fashion of dress (including accessories and hairstyle as well as garments)"
	Cambridge Online Dictionary	"the set of clothes typical of a particular country or period of history, or suitable for a particular activity"

5.5 Knowledge modelling

Knowledge modelling involves two tasks, facet discovery about the traditional dances and class hierarchy building with the relationship among them. It includes a formal process to represent the acquired domain knowledge for ontology.

A quality ontology requires a good depth of term hierarchies but with reduced complexities and the faceted approach provides that readily in ontology building (Doerr, 2009). The prime facets that comprise traditional dances are presented in Table III. These facets comprised the first level of categorization under "owl:Thing".

For each facet, further necessary sub-facets were prepared based on a top-down approach. The more significant facets were broken down to narrower sub-concepts following the canon of prepotency of colon classification (Ranganathan, 1967). For example, the facet *costume* were further grouped based on their wearing pattern and wearing style generally done in day-to-day life to some sub-concepts, such as "Blousetype", "MufflerType", "Headgear", "ShirtType", "TurbanType", "VeilType", "WaistCloth", "WrapperType", and so on. Costumes of a particular community have particular design languages where the look, colour, preparation methods, yarns, and so forth have distinct characteristics and are unique to that community only which is also reflected in the aesthetic feel of the performance of the dances. These might not be essential for re-creation of a dance performance but essential for a textile expert or fashion designer. Therefore, a macro class "CostumeDesignLanguage" was added having the mentioned subclasses. Similarly, for occasions, it was further sub-grouped as agrian occasion, rituals, festivals, and so forth. Figure 2 shows the class hierarchy from first to third level in three columns from left to right. In Figure 2, the first level of a class can be related with the facets mentioned in Table III, and some facets in Table III were clubbed to a macro class (e.g., Music and Dance Instruments were clubbed as "Instruments" class in the first level of the hierarchy) in Figure 2. With the common facets of Table III, some additional superclasses were also needed to be created in the first level of the class hierarchy. For example, the superclass "ReplicaItems" was created as in traditional dances some dance props are used that replicate different natural objects, such as animals and so on (e.g., in the performance of the *maseleka* traditional dance of the Rabha tribe, a wooden dance prop is used that represents a bird). Similarly, participating genders in dancing have different roles in a dance, for which the superclass "Roles" was created. Different communities have different mythologies, and in different mythologies various aspects of God exist, so the superclass "God" in the first level of the class hierarchy was created.

Table III. Some select facets that comprise traditional dances

Music	It can be directly referred to as *folk music*. The lyrics are simple and are also easy to sing.
Musical instruments	The instruments are all traditional and handmade.
Dance props or dance instruments	Traditional dances usually use many day-to-day tools, such as agricultural tools, fishing tools, weaponry, and so on, used as dance props.
Occasion	Dances are usually performed on occasions. Occasions can be seasonal, ritualistic, agriculture, religious.
Time	Traditional dances are usually performed at a specific time or season of the year. Usually, a season of the year is inferred when a particular traditional dance is performed.
Location	The location usually means that of the community to which a particular traditional dance is related.
Costume	While performing traditional dances, the participants usually wear the traditional dresses of their community. Communities or tribes have distinct identities about the colour, size, and wearing pattern of dresses.
Community	The community associated with a particular traditional dance.
Gender of dancers	Traditional dances are gender-specific and, therefore, the gender of the participants is an important aspect of traditional dances.

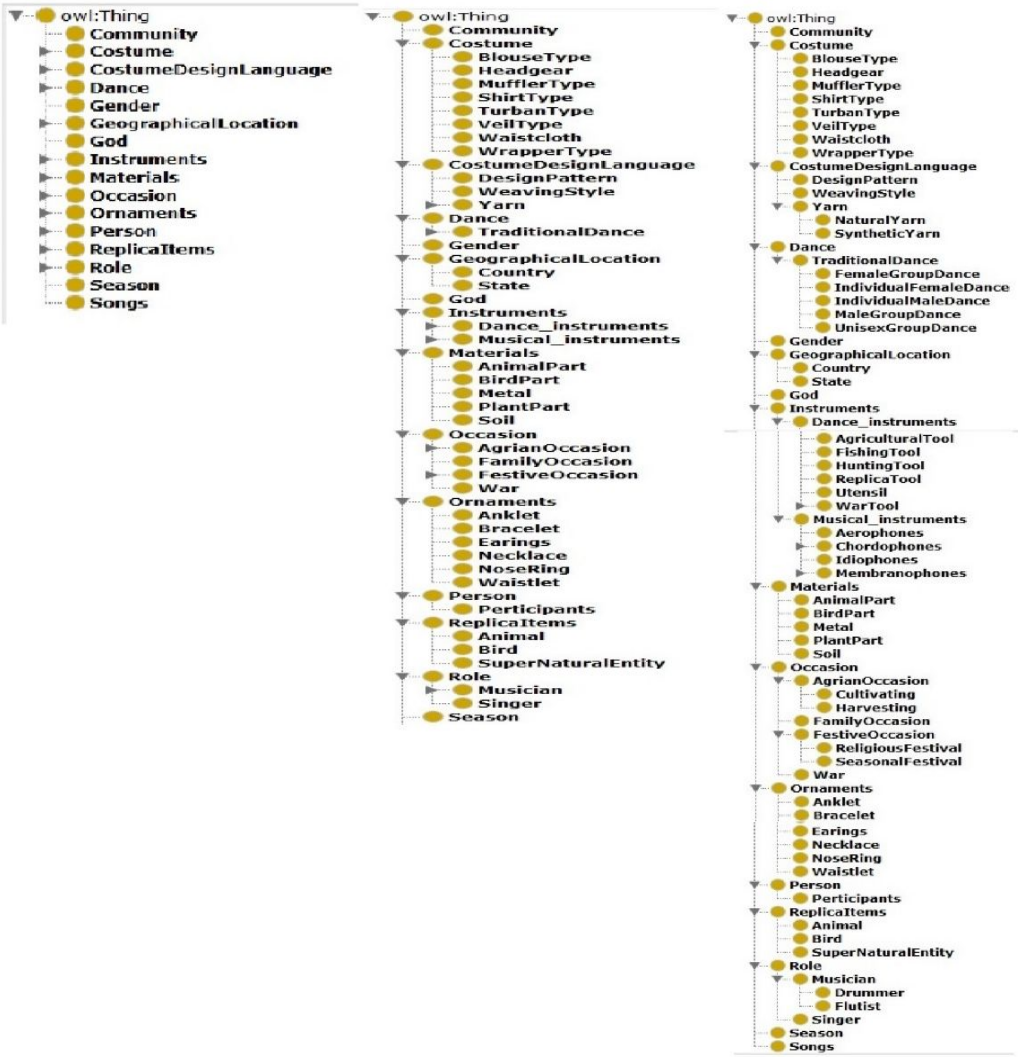

Figure 2. From left to right columns show the first, second, and third levels of class hierarchy in the OTD

5.6 Logical formalization for the facets

Bhattacharyya (1979) gave a modified notion of the faceted rule of Ranganathan with his DERA perspective. DERA stands for Domain, Entity, Relation, and Attribute. The Domain here is a composite of Entity, Relation, and Attribute (i.e., D= <E, R, A>). An entity represents facets of a concept that contain a group of items that have conceptual similarities. The group of items can be relatable to real-world objects or instances. For the domain of traditional dance, these can be related to the facets presented in Table III. Relation represents facets or concepts that help to connect two Entities. For example, for the domain of traditional dances, dances are related to some communities. So a relation (or property) *relatedCommunity* will connect dances to communities. Term hierarchies here can be realised with *is-a* relation. The DERA perspective stands closer to the OWL Subject, Predicate, and Object analogy. An attribute consists of facets that represent some qualitative or quantitative values of Entities. For example, in the domain of traditional dances, different costumes are worn, and those costumes have different colour, size, design patterns. Relation of attribute names to their values is realised with *value-of* relation while the relation of entity to attribute is realised with *is-a* relation. An excerpt of the TBox and ABox axioms for the Indian traditional dance *bhangra* is shown in Table IV. An example of the OWL syntax for *WarTools* under *Dance Instruments* is represented as:

```
<owl:Class
rdf:about="http://www.semanticweb.org/deep/ontologies/2018/4/otd#WarTool">
<rdfs:subClassOf
rdf:resource="http://www.semanticweb.org/deep/ontologies/2018/4/otd#Dance_instru
ments"/>
<rdfs:comment xml:lang="en">Weaponery used in Wars.</rdfs:comment>
</owl:Class>
```

Similarly OWL syntax for the property *requiredDanceInstruments*:

```
<owl:ObjectProperty
rdf:about="http://www.semanticweb.org/deep/ontologies/2018/4/otd#requiredDanceI
nstruments">
<rdfs:domain
rdf:resource="http://www.semanticweb.org/deep/ontologies/2018/4/otd#Dance"/><rd
fs:range
rdf:resource="http://www.semanticweb.org/deep/ontologies/2018/4/otd#Dance_instru
ments"/>
</owl:ObjectProperty>
```

5.7 Ontology population

The created ontology was filled with data points collected from various sources about the Rabha traditional dances. Objective-based data collection was made based on the created ontology, and those were filled up. Table V shows the metrics of the developed ontology with populated individuals from the domain of Rabha traditional dances. Figure 3 gives the graphical overview of the Rabha's *hamjhar* dance realised via OTD.

Table IV. Excerpt of DL logical formulation for the ontology

TBox logical axioms	**ABox logical axioms for the dance bhangra**
Dance ≡ MaleGroupDance **U** FemaleGroupDance **U**UnisexGroupDance	UnisexGroupDance (Bhangra) Community (Punjabi)

U IndividualMaleDance **U** IndividualFemaleDance	*relatedCommunity* (Bhangra, Punjabi) AgrianOccasion (Baisakhi) *performaceOccasion* (Bhangra, Baisakhi) WrapperType (Tehmat) *associatedGender* (Tehmat, Male) ShirtType (Kurta) *associatedGender* (Kurta, Male) *requiredCostume* (Bhangra, Tehmat) *requiredCostume* (Bhangra, Kurta)
MaleGroupDance ≡ Dance ⊓ FemaleGroupDance **U**UnisexGroupDance **U** IndividualMaleDance **U** IndividualFemaleDance	
Costume ≡ MaleCostume **U**FemaleCostume**U**UnisexCostume	
CostumeType ≡ JacketType **U**WrapperType**U**MufflerType**U**HeadGear	

Table V. Metrics of the developed OTD

Parameters	**Counts**
Axiom	632
Logical axioms count	392
Declaration axioms count	191
Class count	92
Object property count	30
Data property count	12
Individual count	59
DL expressivity	ALCHIF(D)

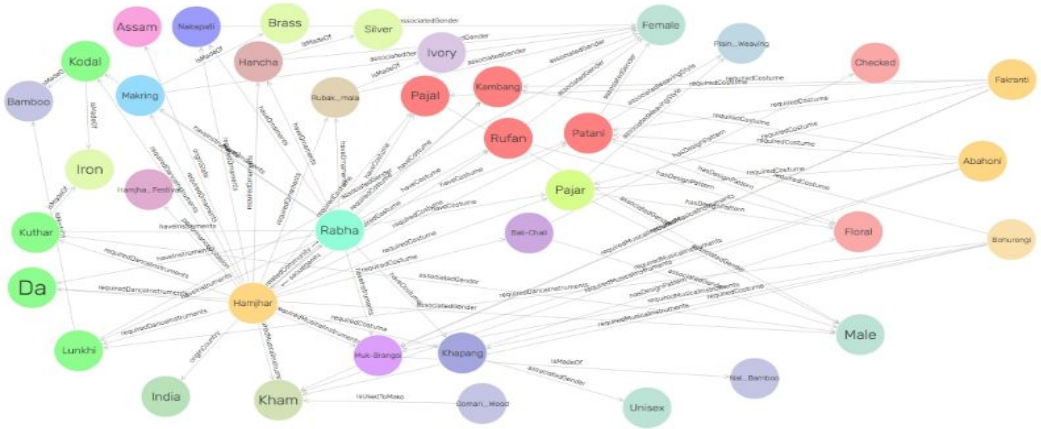

Figure 3. Rabha traditional dance *hamjhar* represented in OTD

5.8 Implementation

The Protégé tool was used for the development of the ontology. Protégé 5.2 uses OWL for ontology creation. The overall ontology statistics are presented in Table V. A SPARQL endpoint for the created instance of the populated ontology was created using GraphDB (version 8.11). Later SPARQL queries were performed over the GraphDB endpoint and visualizations were made. Figure 4 presents the OTD implementation process.

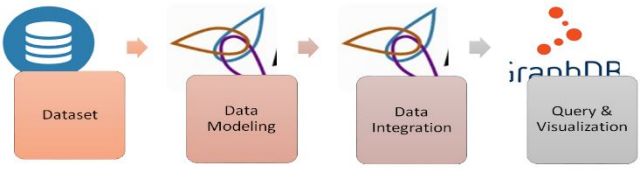

Figure 4. Implementation of the developed ontology

5.9 Evaluation and testing

Ontology evaluation is a critical step, and overall performance of the ontology is tested here. Two critical steps were performed. First, the syntactic correctness and internal consistency of the ontology were checked, and, in the second step, the ontology has undergone a competency check. The competency question (CQ) process is recognised as an accepted standard procedure for medical ontology testing (Abacha *et al*., 2013; Bezerra *et al*., 2013). CQs are also used as a validation step for the ontology as this is done with the human-based approach.

5.9.1 Internal consistency check

For syntactic correctness and internal consistency check, the reasoner program that comes bundled with the Protégé tool was used. Hermit reasoner was used for this purpose that helps greatly for logical consistency check. The binary result from the reasoner showed the presence of no logical inconsistency in the ontology. Further, the ontology was subjected to a criteria-based "pitfall check" in the platform-independent online tool OOPS! (Poveda-Villalón *et al*., 2014) that detects errors in an ontology according to a catalogue of 41 types of errors. It helps developers to identify general pitfalls during the verification process. The pitfall scanner OOPS! reports the errors in three categories, viz.; minor, important, and critical. *Minor* type pitfalls are not really a problem for the ontology but correcting these makes the ontology look nicer; *important* type pitfalls are not critical for the functioning of the ontology, but correcting these would make the ontology more authenticated; and *critical* type pitfalls affects the consistency, reasoning, applicability of the ontology and, therefore, are suggested for correction. The detailed OOPS! pitfall scanned reported errors for the OTD are presented in Table VI. As per the OOPS! report, the developed OTD had seven pitfalls, out which five are *minor* type and two are *important* type. As per OOPS! suggestion, these type of pitfalls do not hamper the ontology from functioning. OOPS! did not report the presence of any *critical* type inconsistencies in the ontology that requires correction. The related aspect (Tiwari and Jain, 2018) for each pitfall on the developed ontology is also reported in Table IV.

Details of the pitfalls and the approaches for modification:

i. P04 is reported (*minor* type) because the developed OTD have some class assertions which are not connected to any property assertion. Two class "GeographicalLocation" and "CostumeDesignLanguage" have not been connected to any property value as property values were used to connect the subclasses of these said classes.
ii. P08 is reported (*minor* type) because annotations to some object property and class instance assertions have not been made. All annotations are not necessary as a developer can easily understand the uses of an object property by the declared domain and range.
iii. P11 pitfall (*important* type) shows missing a domain and range for some properties. But this pitfall was reported for the properties which were already mentioned as inverse properties in the OTD.

iv. P13 pitfall (*minor* type) suggested some object properties which can be declared as inverse. But for the specific domain of the OTD, this was not necessary for all.

v. P22 pitfall (*minor* type) detected uses of different naming conventions in the OTD. This was reported because for some long class names the symbol "-" (dash) was used, but for short class names, it was not used. A modification was not necessary.

vi. P30 suggested (*important* type) class "Country" and "State" to be equivalent class as they both were using the same domain "Dance" for two different object properties, viz.; *originCountry* and *originState.* A modification was not necessary keeping in mind the assertions of real-world assumptions.

vii. P41 (*minor* type) reports about uses of no license agreement in the OTD.

Table VI. Pitfalls detected in the OTD in the OOPS! tool

Pitfall identity as per OOPS! catalogue	**Pitfall description**	**Importance level**	**Cases**	**Related aspect of the OTD**
P04	Creating unconnected ontology elements	Minor	2	Completeness
P08	Missing annotations	Minor	132	Clarity
P11	Missing domain and range in properties	Important	10	Inference
P13	Inverse relationship not explicitly declared	Minor	17	Inference
P22	Using different naming conventions in the ontology	Minor	-	Clarity
P30	Equivalent classes not explicitly defined	Important	1	Inference
P41	No license declared	Minor	-	Ontology metadata

5.9.2 External validation of the ontology via CQ scenarios

External validation of the OTD was done through a competency check. The CQ check was done through the human-based approach. CQs are natural language questions relating to the ontology scope and can be considered as a functional requirement which a developed ontology should be able to answer (Uschold and Grüninger, 1996). Ontology validation via CQ-based SPARQL querries is a suggested practice in many methodologies (Wiśniewski *et al*., 2019). For the current study some competency questions were designed based on expert opinions, as shown in Table I. A SPARQL endpoint was created in a local machine using the GraphDB running in port 7200. The equivalent SPARQL queries for the CQs were designed. The query result was then put to evaluation by domain experts who were mostly comprised of researchers working in the domain. The domain experts were asked to rank their satisfaction level to each of the CQ query results from the SPARQL endpoint of the OTD on a scale of ten. The satisfaction level against each CQ is shown in Table VII. The average satisfaction level to each CQ scenario result remained above seven out of ten, CQ4 and CQ5 being the lowest. As the ontology was populated with instances from traditional dances from the Rabha community only, therefore, the satisfaction level is only related to the information elements regarding those dances only. The SPARQL query result from the GraphDB is shown in Figures 5 through 9.

Table VII. Satisfaction level to CQ scenario SPARQL query results by domain experts

Evaluation instances	CQ1	CQ2	CQ3	CQ4	CQ5
Evaluator 1	9	7	9	8	9
Evaluator 2	8	9	7	9	6
Evaluator 3	7	8	8	8	8
Evaluator 4	9	9	9	7	7
Evaluator 5	9	8	8	8	8
Evaluator 6	7	9	9	9	8
Evaluator 7	9	9	7	8	8
Evaluator 8	8	7	8	8	7
Evaluator 9	9	9	9	9	9
Evaluator 10	7	8	8	7	8
Evaluator 11	7	8	6	6	7
Evaluator 12	8	8	8	8	8
Evaluator 13	8	6	7	6	7
Evaluator 14	9	8	8	7	7
Evaluator 15	9	9	7	8	8
Evaluator 16	8	9	7	9	9
Evaluator 17	8	8	8	8	8
Evaluator 18	8	7	8	8	7
Evaluator 19	10	9	9	9	9
Evaluator 20	8	8	7	9	8
Evaluator 21	9	7	9	9	8
Evaluator 22	7	6	9	8	8
Evaluator 23	9	8	8	8	9
Evaluator 24	9	8	8	7	7
Evaluator 25	8	9	9	8	8
Evaluator 26	9	8	7	7	6
Evaluator 27	8	7	9	7	8
Evaluator 28	9	8	8	7	7
Evaluator 29	8	9	7	8	7
Evaluator 30	8	8	7	8	8
Average	**8.30**	**8.03**	**7.93**	**7.87**	**7.73**

The CQ scenarios are as follows:
CQ1: Name of different traditional dances of different communities.

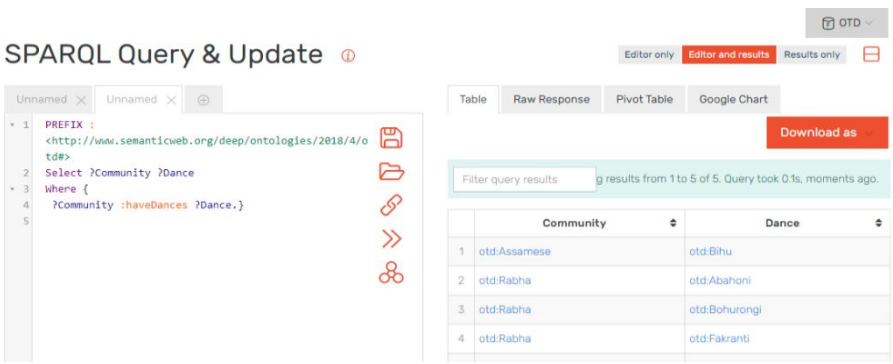

Figure 5. SPARQL query for CQ1

CQ2: Related festivals to a particular traditional dance.

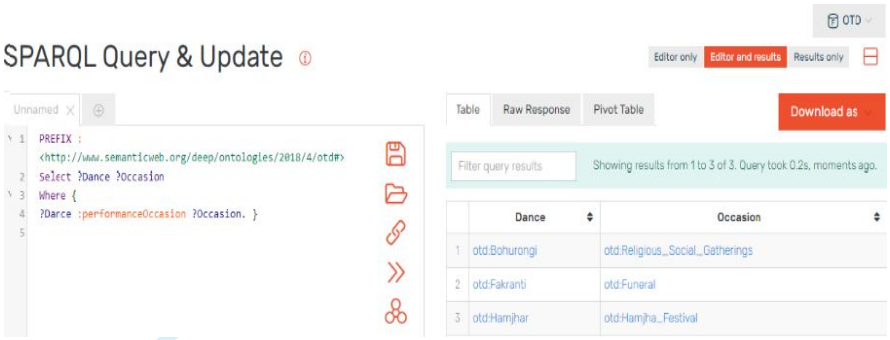

Figure 6. SPARQL query for CQ2

CQ3: Ornaments used in traditional dance performance.

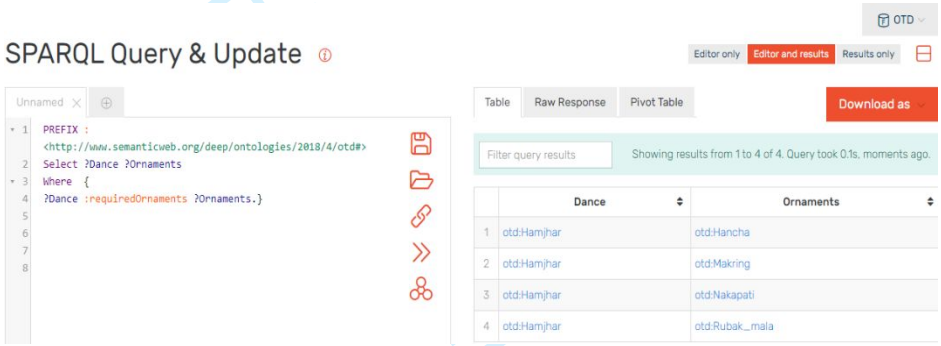

Figure 7. SPARQL query for CQ3

CQ4: Different ornaments worn in different traditional dances and the gender who wear them.

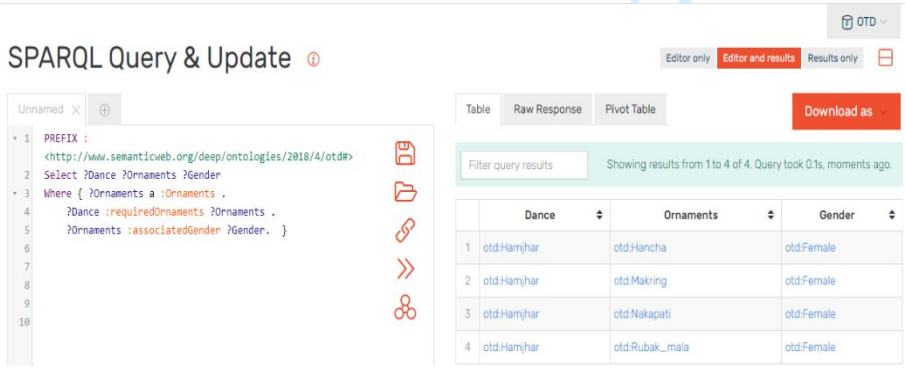

Figure 8. SPARQL query for CQ4

CQ5: What kind of dresses a particular community wears in traditional dances.

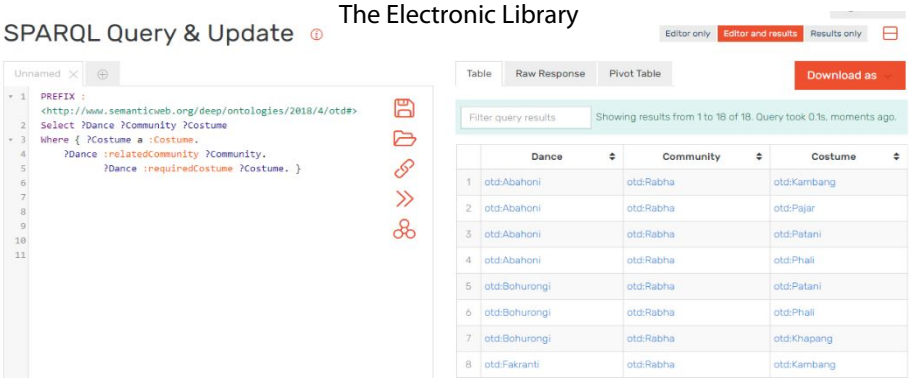

Figure 9. SPARQL query for CQ5

6. Conclusion

There is much research needed regarding ontology development in the domain of cultural heritage. The domain of cultural heritage is very complex as the activities and processes under it are not rigid, rather they vary with time as societal processes keep changing. Preservation of knowledge from the cultural heritage domain within the best suitable and most useful manner is essential to support global collaborative research. Traditional dances have been a most significant part of human societies of different communities, and they form a considerable part of the overall culture of a community. The ontology on traditional dances (OTD) proposed here is developed on some probable scenarios collected based on a survey of experts and is modelled using the faceted rule of library classification of Ranganathan (1967). The domain knowledge of traditional dances of the Rabha tribes of North East India was chosen to model the ontology based on probable expert suggested scenarios using the faceted rule.

Shared knowledge increases the effectiveness of the knowledge inference and creation process. The OTD aims to preserve the cultural knowledge base of traditional dances so that effective information retrieval is possible. The proposed OTD takes a simple approach to model the complicated knowledge base of traditional dances storing information elements about those dances which can give "what", "when", "which", "whose who" kind of information. Coming in line with UNESCO's greater goal of preservation of the intangible cultural heritage of the world, this OTD brings the possibility of having a large structured knowledge base for all the traditional dances of the world which can be a foundation of various smart services in the semantic web environment. The OTD proposes a procedure of documentation for the facets of traditional dances which can be useful from the context of culture preservation also. Further additions and development to the OTD are possible because of the faceted approach that was adopted during its development process.

References

Abacha, A.B., Marcos, D.S. and Cédric, P. (2013), "Medical ontology validation through question answering", in Peek, N., Morales, M., Roque, L. and Peleg, M. (Eds.), *Proceedings of 14th Conference on Artificial Intelligence in Medicine in Europe*, Springer, Berlin, pp. 196-205.

Baruah, A. (2004), "A study on folk beliefs and customs associated with child rearing practices among the Rabhas of Bikali area Goalpara district Assam", PhD thesis, Gauhati University, Guwahati, available at: https://shodhganga.inflibnet.ac.in/handle/10603/66470 (accessed 29 July 2020).

Bezerra, C., Freitas, F. and Santana, F. (2013), "Evaluating ontologies with competency questions", in *Proceedings of the IEEE/WIC/ACM International Joint Conferences on Web Intelligence (WI) and Intelligent Agent Technologies*, IEEE, Atlanta, GA, pp. 284-285.

Bhattacharyya, G. (1979), "POPSI: Its fundamentals and procedure based on a general theory of subject indexing languages", *Library Science with a Slant to Documentation*, Vol. 16 No. 1, pp. 1-34.

Chaikhambung, J. and Tuamsuk, K. (2016), "Semantic ontology of knowledge of ethnic groups in Thailand", in *5th International Conference on Computer Science and Network Technology*, IEEE, China, pp. 859-861.

Chau, M.T. and Thuy, N. (2018), "A labanotation based ontology for Vietnamese folk dances", in *3rd International Conference on Digital Arts, Media and Technology*, IEEE, Chiangrai, pp. 75-80.

Cristani, M. and Cuel, R. (2005), "A survey on ontology creation methodologies" *International Journal on Semantic Web and Information System*, Vol. 1 No. 1, pp. 48-68.

Doerr, M. (2009), "Ontologies for cultural heritage", in Staab, S. and Studer, R. (Eds.), *Handbook on Ontologies*, Springer, New York, NY, pp. 463-486.

Dutta, B., Chatterjee, U. and Madali, D.P. (2015), "YAMO: Yet another methodology for large-scale faceted ontology development", *Journal of Knowledge Management*, Vol. 19 No. 1, pp. 6-24.

El Raheb, K. and Ioannidis, Y. (2011), "A labanotation based ontology for representing dance movement", in Efthimiou, E., Kouroupetroglou, G. and Fotinea, S. (Eds.), *Gesture and Sign Language in Human-Computer Interaction and Embodied Communication,* Springer, Berlin, pp. 106-117.

Gait, E.A. (1905), *A History of Assam,* Thacker Spink & Co., Calcutta.

Goienetxea, I., Arrieta, I., Bagüés, J., Cuesta, A., Leiñena, P. and Conklin, D. (2010), "Ontologies for representation of folk song metadata", Technical Report EHU-KZAA-TR-2012-01, University of the Basque Country, San Sebastian, Spain, available at: https://addi.ehu.es/bitstream/handle/10810/8053/tr12-1.pdf (accessed 28 October 2019).

Gruber, T. (1993), "A translation approach to portable ontologies", *Knowledge Acquisition*, Vol. 5 No. 2, pp. 199-220.

Grüninger, M. and Fox, M. (1995), "Methodology for the design and evaluation of ontologies", in *Workshop on Basic Ontological Issues in Knowledge Sharing*, Montreal.

Haron, H. and Hamiz, M. (2014), "An ontological model for indigenous knowledge of Malay confinement dietary", *Journal of Software*, Vol. 5 No. 2, pp. 1302-1314.

Kalita, D. and Deka, D. (2020), "Searching the great metadata timeline: A review of library metadata standards from linear cataloguing rules to ontology inspired metadata standards", *Library Hi Tech*, Vol. ahead-of-print No. ahead-of-print, https://doi.org/10.1108/LHT-08-2019-0168

Kealiinohomoku, J. (2019), "Folk dance", available at: www.britannica.com/art/folk-dance (accessed 2 November 2019).

Kolozali, S., Barthet, M., Fazekas, G. and Sandler, M. (2011), "Knowledge representation issues in musical instruments ontology design", in *12th International Society for Musical Information Retrieval Conference (ISMIR'11)*, Miami, FL, pp. 465-470.

Lagoze, C. and Hunter, J. (2001), "The ABC ontology and model", *Journal of Digital Information*, Vol. 2 No. 2, pp. 160-176.

Ma, T.-T., Benferhat, S., Bouraoui, Z., Tabia, K., Do, T.-N. and Nguyen, H.-H. (2018), "An ontology-based modelling of Vietnamese traditional dances", *International Conference on Software Engineering and Knowledge Engineering*, KSI Research, Pittsburgh, PA, available at: http://ksiresearchorg.ipage.com/seke/seke18paper/seke18paper_129.pdf

Manning, N. (n.d.), "What is traditional dancing?", available at: www.dancecentral.co.uk/DanceNtral/Articles/traditional.htm (accessed 28 July 2020).

Merriam Webster Dictionary (2019),"Folk dance", available at: www.merriam-webster.com/dictionary/folk%20dance (accessed 2 November 2019).

Noy, N. and McGuinness, D. (2001), "Ontology development 101: A guide to creating your first ontology", Stanford University, available at: https://protege.stanford.edu/publications/ontology_development/ontology101.pdf (accessed 18 November 2019).

Poveda-Villalón, M., Gómez-Pérez, A. and Suárez-Figueroa, M.C. (2014), "OOPS! (ontology pitfall scanner!): An on-line tool for ontology evaluation", *International Journal of Semantic Web and Information System,* Vol. 10 No. 2, pp. 7-34.

Rabha, R. (2002), *The Rabhas*, Anundoram Borooah Institute, Guwahati.

Ranganathan, S. (1967), *Prolegomena of Library Classification*, Asia Publishing House, New York, NY.

Stanley, R. and Astudillo, H. (2013), "Ontology and semantic wiki for an intangible cultural heritage inventory", in *39th Latin American Computing Conference*, IEEE, pp. 1-12.

Telli, A., Chau, M.T., Bourahla, M., Tabia, K. and Benferhat, S. (2018), "An ontology for classifying Vietnamese dance movements", in *Proceedings of the International Conference on Pattern Recognition and Artificial Intelligence*, pp. 23-29.

Tiwari, S. and Jain, S. (2018), "Ontologies as a semantic model in IoT", *International Journal of Computers and Applications*, Vol. 42 No. 3, pp. 233-243.

UNESCO (2006), "What is Intangible Cultural Heritage?", available at: https://ich.unesco.org/en/what-is-intangible-heritage-00003 (accessed 23 November 2019).

Uschold, M. and Grüninger, M. (1996), "Ontologies: Principles, methods and applications", *Knowledge Engineering Review*, Vol. 11 No. 2, pp. 93-136.

Uschold, M., King, M., Moralee, S. and Zorgios, Y. (1995), "The enterprise ontology", *The Knowledge Engineering Review*, Vol. 13 No. 1, pp. 31-89.

von Hornbostel, E.M. and Sachs, C. (1914), "Systematik der musikinstrumente" ("Classification of musical instruments"), translated by Baines, A. and Wachsmann, K.P., *The Galpin Society Journal L*, Vol. 4, pp. 3-29.

Vrandecic, D., Pinto, S., Tempich, C. and Sure, Y. (2005), "The DELIGENT knowledge processes", *Journal of Knowledge Management*, Vol. 9 No. 5, pp. 85-96.

Wiśniewski, D., Potoniec, J., Ławrynowicz, A. and Keet, M.C. (2019), "Analysis of ontology competency questions and their formalizations in SPARQL-OWL", *Journal of Web Semantics*, Vol. 59, p. 105098.