Development of ICH Knowledge Organization System for Ontology-Based Approach

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Abstract

This study aims to develop an ontology-based knowledge organization system (KOS) for intangible cultural heritage (ICH). The proposed methodology applies ontology techniques to construct a structured knowledge framework, enhancing knowledge sharing and reuse, which are critical components in knowledge-based management systems. We developed the ICH ontology model using the HOZO ontology editor, enabling us to classify and arrange ICH knowledge hierarchically into five sub-domains: Oral Traditions, Performing Arts, Social Practices, Rituals and Festive Events, Knowledge and Practices Concerning Nature and the Universe, and Skills to Produce Traditional Crafts. To ensure the quality and effectiveness of the ontology, researchers used the WIDOCO tool for comprehensive documentation and employed the Oops! (Ontology Pitfall Scanner) tool to identify and rectify common pitfalls. The ontology was made publicly accessible via a dedicated web portal, facilitating its use by other researchers and contributing to the advancement of ICH informatics. Additionally, a semantic search application demonstrated the practical utility of the ontology, showcasing its capacity to handle complex queries. The evaluation process confirmed the ontology's robustness, ensuring its alignment with contemporary trends in digital humanities and semantic web technologies. This research underscores the significance of a well-structured ontology in enhancing the understanding, preservation, and dissemination of ICH, providing a robust framework for future advancements in the field.

Keywords: Intangible Cultural Heritage, Knowledge Organization System, Ontology, Semantic web, Knowledge-based Systems.

Understanding Intangible Cultural Heritage (ICH) plays a crucial role in preserving cultural diversity amid the increasing effects of globalization. Learning about the intangible heritage of various communities fosters intercultural dialogue and promotes respect for different ways of life. The significance of ICH lies not in the cultural expressions themselves but in the vast knowledge and skills passed down through generations. This transfer of knowledge

holds social and economic value, benefiting not only small groups but also mainstream society, and is equally vital for developing and developed nations (UNESCO, 2012a).

Currently, intangible cultural heritage (ICH) knowledge is collected and stored across various platforms, including databases, websites, and digital libraries, and is often dispersed across different locations and languages. This fragmentation presents a significant challenge for querying and retrieving information efficiently. Consequently, information academics continually seek solutions to enhance the organization and structure of knowledge within this domain. One promising methodology is the ontology approach, which leverages semantic and knowledge representation techniques and other knowledge-based systems to improve the performance and effectiveness of information systems. The ontology approach facilitates better access, management, and utilization of ICH knowledge by providing a more structured and interconnected framework. The tacit nature of craft presents a barrier to the sustainability of intangible cultural heritage (ICH) crafts, complicating knowledge sharing across domains, particularly in craft-design collaborations. This issue necessitates a significant discussion on tacit knowledge within university-based collaborations. Despite its importance, there remains a lack of a systematic structure for guiding academics and artisans in sustainable and profound knowledge sharing. Guo and Ahn (2023) explore the relationship between craft-design collaboration, tacit knowledge sharing, and sustainability within the context of ICH crafts in China. Utilizing a qualitative approach grounded in knowledge management, they conducted semi-structured interviews with artisans and academics in China's Belt and Road regions, focusing on the four dimensions of craft-design collaboration. Their study underscores the potential for sustainable and dynamic knowledge sharing in university-based collaborations through knowledge accumulation, expression, diffusion, and reflection. Moreover, they emphasize integrating craft-design collaboration and knowledge management as essential future skills to enhance the sustainability impact of ICH crafts.

Transitioning to another critical perspective, Fan, Sun, and Zhang (2023) highlight the importance of visualizing intangible cultural heritage's spatiotemporal data from a digital humanities viewpoint. They argue that such visualization is crucial for promoting the protection and inheritance of ICH. Their research into the spatiotemporal semantic model of ICH reveals multiple relationships within heritage spaces, aiding in the semantic description and effective expression of spatiotemporal data. This approach contributes to the broader understanding and preservation of ICH by providing a structured framework for capturing the complex dynamics of cultural spaces.

Further, Huang and Xu (2022) emphasize the growing societal attention towards protecting ICH, acknowledging its role as a cultural treasure and a representation of national soft power. They advocate for the effective organization and management of ICH knowledge, which underpins its protection, dissemination, and inheritance. Utilizing ontology and linked data technology, their research organizes ICH knowledge semantically, facilitating the structured expression of diverse resource data. They outline the process of ICH knowledge organization, including key steps like entity-to-RDF conversion and linked data publication. Their work demonstrates the potential of linked data technology to standardize ICH knowledge management, significantly impacting the preservation and inheritance of China's cultural heritage.

In a different context, Adamou et al. (2023) explore the intangible aspects of Southern Chinese martial arts, focusing on the technical, stylistic, and epistemic dimensions. They present a computational approach to investigate cultural contact within martial arts using Semantic Web standards and formal knowledge. Starting with a

modular domain ontology, they extract knowledge from archival materials and generate a dataset modeled after the ontology. They infer potential cultural contacts by combining this knowledge base with a rule model. Their results illustrate how an inference-based computational model can uncover significant insights within the largely unexplored domain of ICH, offering a robust framework for further statistical and machine learning applications.

Finally, Fan (2023) addresses the digital development and utilization of China's ICH resources, proposing a linked data-based approach to combat ICH resource theft and promote knowledge integration. This study uses knowledge organization theory and semantic web technology to describe digital resource objects and build a conceptual model for ICH. Establishing semantic associations facilitates better knowledge granularity and visualization. The findings provide a comprehensive solution for the digital development of ICH in China, enhancing semantic retrieval and multi-dimensional knowledge discovery, thereby advancing the field's theoretical and practical applications.

This paper comprehensively examines the development and application of an ontology-based approach to managing intangible cultural heritage (ICH) knowledge. It provides a detailed review of related works and tools that have informed the construction of the ontology framework, offering insights into existing methodologies and their limitations. We introduce the proposed framework for ICH knowledge, outlining its conceptual foundations, structure, intended applications, and potential benefits. We present the results of system knowledge organization, accompanied by an in-depth discussion of the findings, which emphasizes the practical implications and effectiveness of the framework in addressing the complexities of ICH knowledge management. The paper concludes by summarizing the key contributions and findings and outlining potential directions for future research, emphasizing the ongoing need for innovation and refinement in the digital preservation and dissemination of intangible cultural heritage.

Related Works

2.1 What is a Knowledge Organization System: KOS

Networked Knowledge Organization Systems/Services/Structures (NKOS) discusses functional and data models designed to enable knowledge organization systems/services (KOS). These KOS include classification systems, thesauri, gazetteers, and ontologies and are implemented as networked, interactive information services. They aim to support describing and retrieving diverse information resources via web technologies. The KOS model represents the fundamental semantic structure of a given domain. These systems can significantly enhance resource discovery and retrieval processes when implemented as web-based services. They function as semantic road maps, providing a common orientation for indexers and future users, whether human or machine, facilitating a more cohesive and efficient interaction with information resources (Tudhop & Koch, 2006). The NKOS initiative is dedicated to advancing the functional and data models that enable various knowledge organization systems and services (KOS). These systems include classification systems, thesauri, gazetteers, and ontologies, all designed to function as networked, interactive information services. NKOS aims to support describing and retrieving diverse information resources via the Internet. By modeling the underlying semantic structures of specific domains, these tools enhance information retrieval, facilitate knowledge discovery, contribute to language engineering, and support the development of the Semantic Web (Busch & Tudhope, 2020; Mayr et al., 2016).

The set of Knowledge Organization Systems (KOSs) encompasses various models adapted

from Hodge's (2000) Networked Knowledge Organization Systems/Services framework:

- Classification and Categorization
- Categorization Schemes: Broad grouping systems.
- Classification Schemes: Hierarchical or faceted systems using numeric or alphabetic codes to represent topics.
- Subject Headings: Controlled term schemes that describe subjects in collections and rules for forming compound headings.
- Taxonomies: Structured divisions of items into categories based on defined characteristics.

- Metadata-like Models
- Directories: Lists of names with associated contact details.
- Gazetteers: Geospatial dictionaries listing named places and their types, with spatial or explicitly defined relationships (e.g., "IsPartOf"). These can also be extended to represent events or periods through geospatial and temporal relationships (Hill, 2000).

- Relationship Models
- Ontologies (Concept Spaces): Concept models representing complex relationships, complete with rules and axioms often missing in simpler semantic networks.
- Semantic Networks: Networks of terms representing concepts connected by varied relationships.
- Thesauri: Structured lists of terms representing concepts and their hierarchical, equivalent, and associative relationships based on NISO (National Information Standards Organization (U.S.), 1994) and ISO (International Organization for Standardization (ISO), 1986) standards. Roget-style thesauri focus mainly on synonymy with additional classification categories.

- Term Lists
- Authority Files: Lists controlling variant names of entities or domain values for specific fields.
- Dictionaries: Alphabetical lists of terms and definitions may offer variant meanings for terms.
- Glossaries: Alphabetical lists of terms, typically with definitions.

This structure offers an overview of diverse knowledge organization approaches for data management and representation tasks.

2.2 Using Ontology with Knowledge-based Systems

The use of ontologies has been consistently associated with knowledge management because of its main conceptual purposes such as supporting knowledge sharing, acquisition, and knowledge representation. These are true related to knowledge engineering itself and its tasks, which are, de facto, knowledge tasks. The enormous challenges faced by knowledge engineering in developing knowledge-based systems are mainly related to the high costs of knowledge acquisition and the lack of commonsense knowledge. The adoption of an ontology can help overcome these challenges (O'Leary DE, 1998). Heeptaisong and Shivihok (2012) developed a soil knowledge-based system (SOKS) that leverages ontology to enhance information retrieval. By incorporating the XPath algorithm and automatic term weighting, their system outperformed traditional systems with a precision value of 0.9. It supports knowledge sharing and reuse and vital knowledge management components and allows searches across diverse sources such as HTML, databases, and digital libraries.

The rise of the Internet has spurred research into more efficient ways of obtaining precise information from vast datasets. Ming et al. (2009) utilized ontology for intelligent web searches, specifically within the agricultural sector. Their system, based on native XML databases like Tamino and integrating XML and JSP technologies, exemplifies this by facilitating intuitive, user-driven information retrieval. By understanding user needs through interactive elements like clicks, the system enhances search

relevance and accuracy, a model that can be extended to other shared information resources.

Addressing the challenges posed by the exponential growth of electronic data, Aminu et al. (2019) proposed an ontology-based solution for managing agricultural information, particularly focusing on soils and fertilizers relevant to maize crops. Their OWL-based ontology combines Fox-Gruninger, Methontology, and FAO methodologies, ensuring accurate and validated knowledge representation. This system provides precise and timely information, significantly improving decision-making processes related to crop yields.

Integrating ontology-based knowledge representation in autonomous robots has become increasingly important for their role in domestic, hospital, and industrial settings. Manzoor et al. (2021) reviewed recent advancements in this field, highlighting the efficiency of these systems in processing complex tasks. Their survey examined various knowledge-based systems across multiple dimensions, offering insights into effective solutions and identifying future research directions to enhance the functionality of robotic applications.

Finally, the complexity of modern information systems necessitates a shift towards software-driven knowledge-based decision-making, as discussed by Burov et al. (2020). They identified the limitations of traditional ontology designs, such as subjectivity and complexity, and proposed using multiple networked ontologies to address these issues. Their approach emphasizes the importance of adaptable knowledge representation, advocating for a versatile system capable of changing formats based on specific tasks, with a central repository utilizing a language based on multisort algebras.

In conclusion, these studies underscore the transformative potential of ontology-based systems across various domains, from soil management and agriculture to robotics and complex information systems. These systems' continuous evolution and refinement promise significant advancements in precision, efficiency, and adaptability in knowledge management and retrieval.

The term "ontology," originally used by Greek philosophers, now describes relationships between concepts, data, and entities. For instance, Dhani and Bhatt's ontology addresses Indian court cases on intellectual property rights (IPR). Future advancements in legal ontologies likely involve collaboration between computer and legal experts (Deroy et al., 2024). Ontologies are fundamental in biomedical, environmental, and food sciences, representing consensus knowledge in a precise and computable form. However, constructing and maintaining them demands substantial resources and expert collaboration. To address this, Toro et al. (2023) introduce Dynamic Retrieval Augmented Generation of Ontologies using AI (DRAGON-AI), leveraging Large Language Models (LLMs) and Retrieval Augmented Generation (RAG) to generate ontology components from existing ontologies and unstructured text sources.

Neural networks, essential for solving various problems, are often viewed as black boxes due to their lack of human-interpretable evidence. We address this by leveraging ontologies to build classifiers that map a neural network model's internal state to ontology concepts, generating symbolic justifications for the network’s outputs. Using an image classification problem as a case study, we map the internal state of a neural network to ontology concepts, examine result alignment with our understanding, and analyze the symbolic justifications derived from this method (Ribeiro & Leite, 2021).

Synthesizing advancements in ontology and neural network, interpretability highlight the growing importance of structured data and explainable AI in various domains. Integrating ontology-based methods in AI can enhance transparency and trust, advancing both legal practice and computational sciences. The transition of Artificial Intelligence (AI) towards the use of ontologies is still in its early stages,

resulting in a limited number of successful applications. While some applications employ elements of ontologies as a representation formalism, most ontology-based implementations remain study prototypes. The anticipated benefits of facilitating knowledge sharing through the reuse and merging of ontologies have proven to be more challenging than initially predicted (Weber & Kaplan, 2003).

2.3 Related articles

Soergel et al. (2004) explore the transition from a traditional Knowledge Organization System (KOS), such as a thesaurus, to an ontology, aiming to enhance terminological richness and formal structuring for conceptual reasoning. Their focus on the AGROVOC thesaurus involves developing specific relationship types and proposing a 'rules-as-you-go' approach to streamline reengineering (Soergel et al., 2004). In a related domain, Smith et al. (2006) discuss the development of a concept-based Digital Learning Environment for geography courses, highlighting the integration of domain KOS with metadata and learning models, enhanced by diverse visualization tools to facilitate scientific concept teaching (Smith et al., 2006). Veltman (2006) critiques the 'Semantic Web' for its static meaning framework, advocating for a cultural semantic web that accounts for dynamic knowledge and cultural diversity, proposing innovative visualization methods to reflect the evolving nature of knowledge and its cultural contexts (Veltman, 2006).

In the context of intangible cultural heritage (ICH) preservation, various methodologies and digital technologies have been explored to enhance cultural transmission, innovation, and audience engagement. Hou et al. (2022) examine advancements in the digitization lifecycle of ICH resources, focusing on archiving, computational encoding, and conceptual representation, identifying both progress and gaps in current practices. Similarly, Liu et al. (2023) present the potential of digital making for revitalizing ICH handicrafts, using Hairy Monkey craftsmanship as a case study. They demonstrate how integrating digital technologies with traditional crafts rejuvenates ICH through creative expression, illustrating the mutual benefits of this intersection.

Further exploring digital applications, Chan and Cai (2023) document the creation of a virtual museum for the Hungry Ghosts Festival in Hong Kong. Their study highlights how participatory approaches and virtual technologies can preserve and present ICH, fostering a sense of global connection by allowing access to cultural practices traditionally limited by geography and time. Adamou et al. (2023) build on this concept by using semantic technologies and formal knowledge representation to investigate cultural contact within Southern Chinese martial arts, demonstrating how digital tools can model and infer cultural transmission in underexplored ICH domains.

Chung (2023) shifts focus to the performing arts, exploring the adoption of technology by Cantonese opera practitioners. His study reveals the complex negotiation between modern technology and traditional values in ICH transmission, emphasizing the need for a balanced integration that preserves core cultural identities. Liu et al. (2024) contribute to this discussion by developing a scale to measure tourists' perceptions of ICH, identifying key dimensions such as transmission, vitality, and association influencing sustainable tourism and ICH preservation.

Lastly, Wu (2023) proposes a design method combining root carving craftsmanship with digital technology. The study illustrates how integrating storytelling into product design enhances cultural transmission, further supporting that technology can effectively promote regional ICH.

These studies collectively illustrate how digital innovations, from virtual museums to semantic technologies, contribute to preserving, transmitting, and reimagining ICH. They also emphasize the importance of maintaining cultural authenticity and integrity, providing

reassurance to the audience about the preservation of ICH in the face of technological advancement.

Methodology

As illustrated in Figure 1, the ICH Ontology Development Workflow was instrumental in creating a comprehensive and robust ontology for Intangible Cultural Heritage (ICH). This systematic approach encompassed several critical stages, each employing specialized techniques to ensure the ontology's accuracy, completeness, and practical utility. From initial domain analysis to final publication, the workflow guided the meticulous process of transforming complex cultural knowledge into a structured, machine-readable format. Each stage is built upon the previous one, culminating in a well-documented, evaluated, and refined ontology ready for application in ICH research and preservation efforts.

Figure 1: ICH Ontology Development Workflow. Source: The authors.

3.1 Development of ICH Knowledge framework

3.1.1 ICH Knowledge Domain

The concept of 'cultural heritage' has significantly evolved in recent decades, largely due to initiatives by UNESCO. Cultural heritage now encompasses more than just monuments and collections of objects. It also includes traditions and living expressions inherited from our ancestors and passed down to future generations. These include oral traditions, performing arts, social practices, rituals, festive events, knowledge and practices related to nature and the universe, and the skills to produce traditional crafts (UNESCO, 2012b).

3.1.2 ICH Knowledge Structure summary

We systematically categorized and classified the Intangible Cultural Heritage (ICH) knowledge domain into meaningful associations, resulting in five sub-knowledge domains encompassing seventy-seven classes. Specifically, the sub-knowledge domains are Oral Traditions with fourteen classes; performing Arts with six classes; Social Practices, Rituals, and Festive Events with twenty-four classes; knowledge and Practices Concerning Nature and the Universe with twenty classes; and Skills to Produce Traditional Crafts with thirteen classes.

We analyzed, synthesized, designed, and reorganized the ICH knowledge domain into a scientifically structured taxonomy. This involved grouping and ordering the knowledge elements and illustrating their hierarchical relationships. The outcome reveals the structured ICH knowledge domain in a tree-structure format. This hierarchical organization includes subordinate, superordinate, and coordinate relationships, serving as the foundation for developing the ICH knowledge organization system.

- Intangible Cultural Heritage Concept

Oral traditions

- Prayers
- Songs
- Legends
- Dramatic performances
- Epic songs
- Tales
- Proverbs
- Spoken
- Chants
- Charms
- Riddles
- Poems
- Myths
- Nursery rhymes

Performing arts

- Dance
- Theatre
- Pantomime

- Sung verse
- Vocal
- Instrumental music

III. Social practices, rituals and festive events

- Special clothing
- Kinship and ritual kinship ceremonies
- Settlement patterns
- Culinary traditions
- Worship rites
- Seasonal ceremonies
- Rites of passage
- Practices specific to men or women only
- Birth
- Special gestures and words
- Recitations
- Hunting
- Traditional games
- Fishing
- Traditional sports
- Processions
- Wedding
- More
- Animal sacrifice
- Songs or dances
- Traditional legal systems
- Special food
- Oaths of allegiance
- Funeral rituals

IV. Knowledge and practices concerning nature and the universe

- Rituals
- Knowledge about local fauna
- Knowledge about local flora
- Traditional ecological wisdom
- Indigenous knowledge
- Traditional healing systems
- Social organizations
- Visual arts
- Possession rites
- Festivals
- Shamanism
- Languages
- Beliefs
- Cosmologies
- Initiatory rites

V. Skills to produce traditional crafts

- Tools
- Props for festivals and performing arts
- Costumes for festivals and performing arts
- Decorative art and ritual objects
- Objects used for storage
- Musical instruments
- Storage containers
- Transport and shelter
- Household utensils
- Jewellery
- Clothing
- Toys
- for education
- for amusement

The analysis stage of our Domain Analysis and Knowledge Acquisition was crucial in developing a comprehensive and robust ontology for Intangible Cultural Heritage (ICH). This stage involved several key steps and techniques. We began with an extensive review of ICH literature, UNESCO documents, and existing cultural heritage databases. This process allowed us to identify key concepts, relationships, and attributes within the ICH domain. We paid particular attention to the UNESCO classification of ICH domains (UNESCO, 2012b) to ensure our ontology aligned with internationally recognized categories.

1. Literature Review
   - Academic publications on ICH
   - UNESCO documents and reports
   - Existing cultural heritage databases
2. Concept Identification
   - Key terms and concepts in ICH
   - Relationships between concepts
   - Attributes of ICH elements
3. Classification Analysis
   - UNESCO ICH domains
   - Regional and local classifications of ICH
4. Expert Consultation
   - Interviews with cultural heritage experts
   - Feedback from ICH practitioners

5. Data Source Mapping

- Identification of primary ICH data sources

- Analysis of data structures in existing ICH databases

This structured approach to domain analysis ensured a comprehensive understanding of the ICH domain, forming a solid foundation for our ontology development.

3.2 ICH Ontology Scheme

We developed the ICH ontology framework utilizing the HOZO ontology editor software, a tool renowned for its efficacy in constructing and managing complex ontological structures. The framework was meticulously organized to encapsulate the comprehensive knowledge associated with ICH, ensuring a robust and scalable architecture. This process involved a detailed classification and hierarchical arrangement of concepts, relationships, and properties pertinent to the domain. As illustrated in Figure 2, the organization and structure of the ICH knowledge were systematically designed to facilitate intuitive navigation and retrieval of information. The figure visually represents the ontology's architecture, highlighting key components and their interconnections, which are critical for supporting advanced reasoning and knowledge management capabilities within the ICH domain.

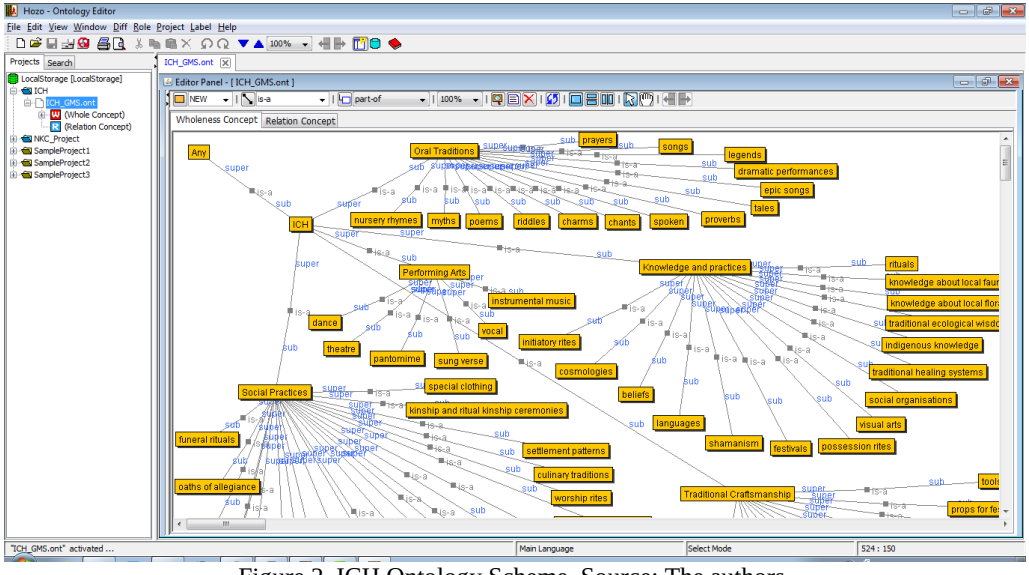

Figure 2. ICH Ontology Scheme. Source: The authors.

Table 1: Knowledge Ontology Structure Design

Supper Class	Class	Sub Class	Property
ICH	Oral traditions	Prayers	Is_a
		Songs	Is_a
		Legends	Is_a
		...	...
	Performing arts	Dance	Is_a
		Theatre	Is_a
		Pantomime	Is_a
		...	...

Supper Class	Class	Sub Class	Property
	Social practices, rituals and festive events	Special clothing	Is_a
		Settlement patterns	Is_a
		Worship rites	Is_a
		...	...
	Knowledge and practices concerning nature and the universe	Rituals	Is_a
		Knowledge about local fauna	Is_a
		Knowledge about local flora	Is_a
		...	...
	Skills to produce traditional crafts	Tools	Is_a
		Props for festivals and performing arts	Is_a
		Musical instruments	Is_a
		...	...

Source: The authors.

According to the classes and properties outlined in Table 1, the foundational ontology structure for an Intangible Cultural Heritage (ICH) scheme is developed through the relationships, properties, and hierarchical arrangements within the ICH domain itself (Figure. 2). This structure encompasses various types of classes and properties to describe diverse knowledge elements, including participants, dances, traditional attire, rituals, and musical instruments. For instance, the subclass "songs" falls under the class "Oral traditions," which is further categorized under the superclass "ICH." This hierarchical organization facilitates a comprehensive and detailed representation of ICH elements, ensuring each aspect is systematically classified and interconnected. Such a framework not only enhances the understanding and preservation of ICH but also supports advanced conceptual reasoning and semantic enrichment in this cultural domain.

The ontology documentation process utilized WIDOCO (Garijo, 2017), a widely acknowledged tool for producing comprehensive and standardized ontology documentation. This methodological approach comprised several critical steps:

1. Selection of an Appropriate Ontology Web Language (OWL) File Template: Ensured compatibility and adherence to semantic web standards.

2. Meticulous Metadata Input: Enhanced the ontology's discoverability and interoperability within the broader semantic web ecosystem.

3. Systematic Uploading of Textual Data: Included concept definitions, relationships, and axioms to populate the ontology structure.

Following these preparatory stages, all files related to the ICH ontology were uploaded and publicly accessible via a dedicated web portal (https://ischool.kku.ac.th/ICH_GMS/index-en.html). Figure 3 visually represents the WIDOCO-generated documentation interface, illustrating the organized presentation of the ontology's structure, classes, properties, and associated metadata. This rigorous documentation process not only ensures the ontology's accessibility but also facilitates its understanding and potential reuse by other researchers in intangible cultural heritage informatics.

Developing an ontology to encapsulate knowledge of ICH in Greater Mekong Subregion (GMS) countries represents a significant advancement in intangible cultural heritage informatics. This research aimed to create a comprehensive framework for defining and elucidating the concepts and relationships within tangible cultural heritage, specifically focusing on ICH in Thailand, Laos, Vietnam, and Cambodia. The study's innovative approach bridges the gap between architectural characteristics and historical contexts, contributing to a more nuanced understanding of regional cultural heritage (Changmai et al., 2022; O'Reilly, 2006; Higham, 2001).

The ontology development process adhered to established methodologies in knowledge organization and semantic web technologies (Manola & Miller, 2023; Uschold & King, 1995). The resulting framework catalogs architectural elements and interweaves historical narratives, providing a multidimensional perspective on these ancient structures (Bang et al., 2020). This approach aligns with contemporary trends in digital humanities, emphasizing the interconnectedness of cultural artifacts within their broader historical and geographical contexts (Chansanam et al., 2015).

A semantic search application was implemented to demonstrate the ontology's practical utility. This application showcases the ontology's capacity to facilitate complex queries, leveraging the intricate relationships among ontological classes. The evaluation process, conducted by a pivotal online tool in ontology evaluation, focused on assessing the ontology's capacity to represent Oral Traditions with fourteen classes; Performing Arts with six classes; Social Practices, Rituals, and Festive Events with twenty-four classes; Knowledge and Practices Concerning Nature and the Universe with twenty classes; and Skills to Produce Traditional Crafts with thirteen classes.

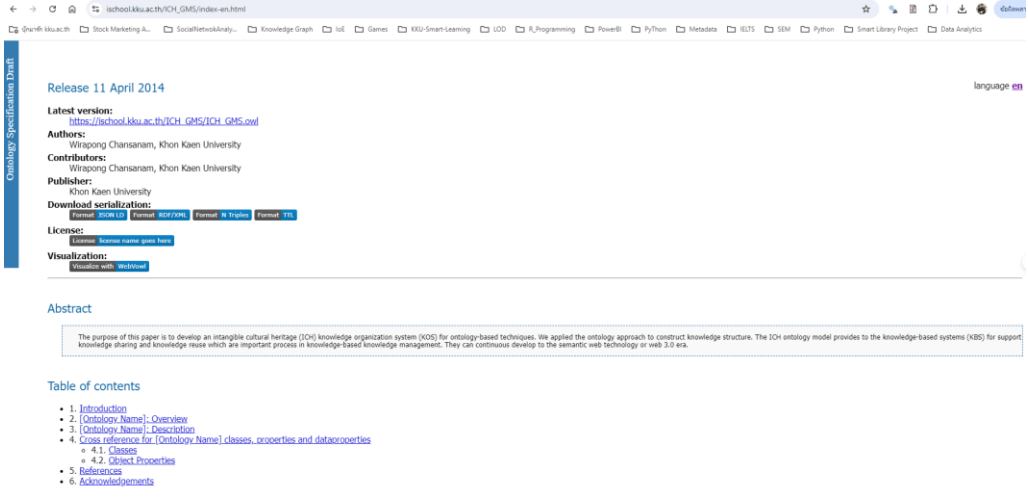

Figure 3. The ICH ontology by WIDOCO. Source: The authors.

3.3 Ontology evaluation

Oops! (Ontology Pitfall Scanner) is a pivotal online tool in ontology evaluation, meticulously designed to identify and rectify prevalent pitfalls that compromise ontology quality and efficacy. This tool performs a systematic analysis to detect missing or incorrect definitions, structural inconsistencies, and logical errors that often

elude manual inspection. By automating the evaluation process, Oops! enhances the accuracy and reliability of ontologies, foundational to semantic web technologies and knowledge representation. The tool's utility is underscored by its ability to provide detailed feedback and recommendations for improvement, thereby facilitating the development of robust and coherent ontological structures. The adoption of Oops! in ontology engineering streamlines the validation process. It aligns with best practices in knowledge organization, ensuring that ontologies can effectively support complex data integration and retrieval tasks. This contributes significantly to advancing fields that rely on high-quality ontological frameworks, such as bioinformatics, digital humanities, and artificial intelligence (Poveda-Villalón et al., 2014).

The analysis results obtained from OOPS! were manually revised in this subsection. The modeling error(s) are categorized into three degrees: critical, important, and minor. These specify the significance of the errors that occur. The first two degrees must be adjusted. Priority is given to the critical degree. The last degree is unnecessary because it is not a problem; however, doing so will improve the ontology's performance. Figure 4 shows the validation results for the ICH ontology. It attains no critical. The reparation recommendations are taken exactly (Poveda-Villalón, 2014). The advantages of consistency include evading modeling errors and improving the readability and simplicity of understanding the ontology.

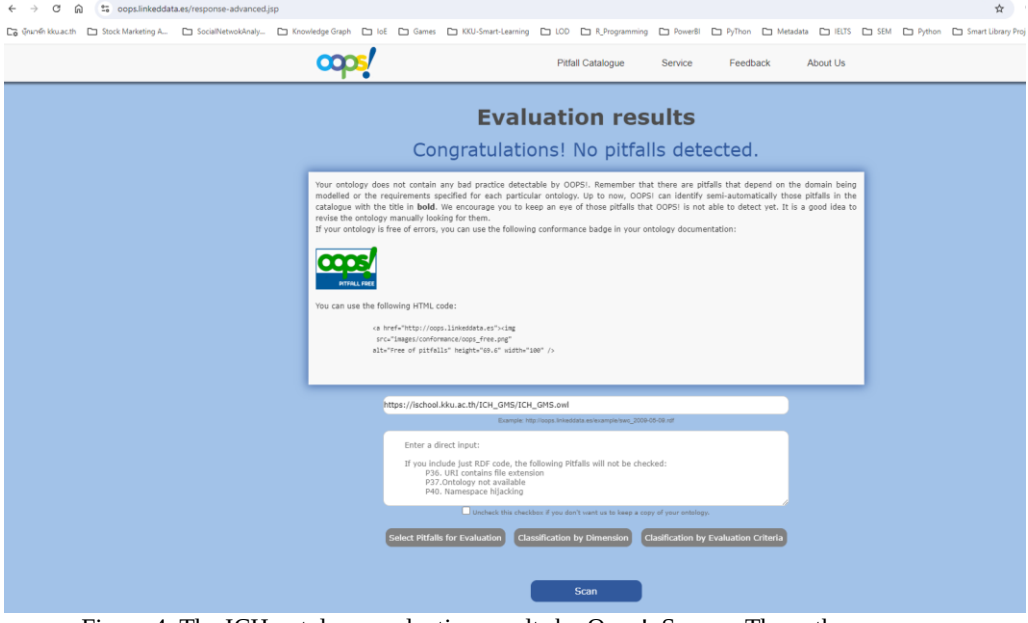

Figure 4. The ICH ontology evaluation results by Oops!. Source: The authors.

Discussion

Developing an ontology-based knowledge organization system for Intangible Cultural Heritage (ICH) represents a significant advancement in cultural informatics. This study's approach aligns with contemporary trends in digital humanities, emphasizing the

interconnectedness of cultural artifacts within their broader historical and geographical contexts (Chansanam et al., 2015). The systematic categorization of ICH knowledge into five sub-domains with seventy-seven classes provides a robust framework for organizing and retrieving complex cultural information.

Our methodology of using the HOZO ontology editor to develop the ICH ontology framework is consistent with best practices in ontology engineering. This approach facilitates the creation of a structured knowledge representation that can support advanced reasoning and knowledge management capabilities. The use of WIDOCO for ontology documentation and the Oops! (Ontology Pitfall Scanner) for evaluation aligns with the rigorous standards set by Poveda-Villalón et al. (2014), ensuring the quality and usability of the ontology.

The development of this ICH ontology addresses a crucial gap in cultural heritage informatics. While Hou et al. (2022) highlighted the need for advanced digitization techniques in ICH preservation, our study provides a concrete solution by offering a structured framework for knowledge organization. This ontology can serve as a foundation for various ICH management and research applications, similar to the semantic tools Smith and Zeng (2006) developed for scientific concepts in digital libraries.

Our approach to ICH knowledge organization resonates with the work of Fan et al. (2023), who emphasized the importance of spatiotemporal data visualization in ICH preservation. The hierarchical structure of our ontology, encompassing diverse aspects of ICH from oral traditions to traditional crafts, provides a comprehensive framework that could potentially integrate such spatiotemporal data, enhancing the contextual understanding of cultural heritage.

The semantic search application developed as part of this study demonstrates the ontology's practical utility, aligning with Huang and Xu's (2022) goals for enhancing ICH knowledge management through linked data technologies. This application showcases the ontology's capacity to handle complex queries, a crucial feature for researchers and practitioners in cultural heritage.

Our work also complements Liu et al.'s (2023) efforts to integrate digital technologies with traditional crafts. While their study focused on the practical aspects of digital making in ICH preservation, our ontology provides a theoretical framework that could support such initiatives by offering a structured knowledge base for various ICH elements, including traditional crafts.

The comprehensive nature of our ICH ontology, covering aspects from oral traditions to performing arts and traditional crafts, addresses ICH's multifaceted nature, as Chan and Cai (2023) described in their virtual museum project. Our ontology could serve as a knowledge backbone for such virtual exhibitions, providing a standardized structure for organizing and presenting diverse ICH elements.

The evaluation process of our ontology, focusing on its capacity to represent various aspects of ICH, aligns with the rigorous approach advocated by Adamou et al. (2023) in their study of Southern Chinese martial arts. While their work focused on detecting cultural influence, our ontology provides a broader framework that could potentially incorporate such specific cultural analyses within a larger ICH context.

However, it is important to note that our study primarily focused on ICH knowledge's structural and organizational aspects. Future work could benefit from incorporating more dynamic elements of ICH, such as the performative aspects highlighted by Chung (2023) in the context of Cantonese opera. Additionally, considering the tourist perception of ICH, as studied by Liu et al. (2024), could enhance the practical applications of our ontology in cultural tourism contexts.

In conclusion, this study contributes significantly to the field of ICH informatics by providing a comprehensive, ontology-based

knowledge organization system. This system enhances the understanding and preservation of ICH and supports advanced conceptual reasoning and semantic enrichment in the cultural domain. Future research could focus on further integrating this ontological framework with other digital humanities tools and methodologies to enhance ICH preservation and dissemination efforts.

Conclusion

This paper aimed to develop an ICH knowledge organization system using an ontology-based approach. By adopting knowledge structure concepts and ontology techniques, we successfully enhanced the ICH knowledge domain of this study. Our methodology involved analyzing, synthesizing, designing, and reorganizing ICH information. This approach effectively organizes knowledge from diverse sources, including websites, documents, and databases across various locations and languages. It supports knowledge sharing and reuse, which are crucial processes in knowledge management. The ICH knowledge structure can potentially improve the performance of semantic web technologies through the application of ontology schemes, offering significant advantages over traditional information systems. Developing knowledge-based systems using ontologies tailored to specific knowledge domains for future research remains a critical global issue. Careful consideration of appropriate content and methodology selection will be essential to advance this field.

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