Research Article

Research on Knowledge Management of Intangible Cultural Heritage Based on Linked Data

Zhaoyan Huang¹ and Tao Xu²

¹Guilin University of Technology at Nanning, Nanning 530001, Guangxi, China
²Zhejiang University of Science and Technology, Hangzhou 310023, China

Correspondence should be addressed to Tao Xu; 114032@zust.edu.cn

Received 28 June 2022; Revised 26 July 2022; Accepted 2 August 2022; Published 27 August 2022

Academic Editor: R. Mo

Copyright © 2022 Zhaoyan Huang and Tao Xu. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

At present, the protection of intangible cultural heritage has received more and more attention from all levels of society. Intangible cultural heritage is a treasure of national culture. It is an indispensable part of Chinese civilization, the crystallization of the wisdom of Chinese civilization, and represents the country’s soft power. The effective organization and management of intangible cultural heritage knowledge is the premise and foundation for the protection, dissemination, and inheritance of intangible cultural heritage. Ontology and linked data technology provide a new method and realization path for the organization and management of intangible cultural heritage knowledge. In this paper, the intangible cultural heritage knowledge is organized reasonably semantically based on the method of linked data, and the purpose is to use the structure of linked data to express the resource data of different structures in a structured manner. This paper first introduces the meaning and background of the research and analyzes the relevant research at home and abroad. Second, it introduces the related knowledge of linked data, analyzes and sorts out the elements and semantic relationship of knowledge in the field of intangible cultural heritage, and designs and constructs the ontology model of intangible cultural heritage knowledge. Finally, based on linked data technology, the process of intangible cultural heritage knowledge organization and linked data set construction is studied, including key steps such as entity to RDF, entity association, linked data storage, and publication. The application of linked data technology in the field of intangible cultural heritage knowledge organization and management can promote the standardization and standardization of intangible cultural heritage knowledge management and is of great significance to the protection and inheritance of my country’s intangible cultural heritage culture.

1. Introduction

With the development of society and the changes of the times, my country has made great achievements in both economic and technological development. In the long-term exchanges with countries around the world, the Chinese government has deeply realized the importance of cultural soft power in enhancing the overall national strength and has begun to strengthen the cultural identity of the Chinese people. As an important part of the excellent traditional culture of various ethnic groups, intangible cultural heritage shows the characteristics of the region, contains the wisdom of the group, and is a nonrenewable cultural wealth for every country. Intangible cultural heritage has various manifestations, covers a wide range of fields, and contains rich knowledge. Structural representation and semantic organization of knowledge in the field of intangible cultural heritage is an inevitable requirement for the protection of intangible cultural heritage and knowledge dissemination in the era of knowledge. However, in the management of intangible cultural heritage knowledge, the China Intangible Cultural Heritage website and the intangible cultural heritage dissemination platforms of various provinces and cities only display the information of intangible cultural heritage items and representative inheritors in the form of a list, lacking knowledge of projects and inheritors, projects and regions, and so on. The lack of effective organization and management of knowledge in the field of intangible cultural
the dissemination of intangible cultural heritage knowledge, which greatly limits the integrity and dissemination of knowledge. At the same time, there is a lack of professional knowledge-based linked data sets in the vertical field of intangible cultural heritage [1], and a mature intangible cultural heritage encyclopedic knowledge base has not yet been formed. Although some achievements have been made in the research of Chinese encyclopedia knowledge map in the general field, in the field of Chinese knowledge encyclopedia, there is a lack of large-scale encyclopedic knowledge data sets such as DBpedia and Freebase. Since the data in the field of intangible cultural heritage are still dominated by semi-structured data and basic databases, there are many fragmented data, and there is a lack of high-quality open data sets for intangible cultural heritage; the single linear organization of intangible cultural heritage knowledge cannot reflect the diversity of intangible cultural heritage culture. characteristics, which cannot meet the needs of multidimensional disclosure and knowledge retrieval. This limits scientific research on intangible cultural heritage as well as the dissemination of intangible cultural heritage knowledge and the inheritance of intangible cultural heritage.

Foreign research on linked data is early. In January 2007, the Open Linked Data Project was launched, and the research on linked data began. In May 2010, the World Wide Web Consortium (W3C) established the Linked Data Incubation Group in the field of libraries. The main purpose is to help libraries use their data information to establish linked data, realize the effective organization and utilization of resources, and provide users with more comprehensive information. Intelligent retrieval services improve the relevance and interoperability of digital resources among libraries. In 2008, the Swedish National Library actively participated in the development of linked data, organized the Swedish Union Catalogue (UBRIS), and released it in the form of linked data. During the publishing process, the existing vocabulary was reused, which contains vocabularies of library domains such as DC, FOAF, and SKOS [2]. With the development of the Semantic Web, some domestic researchers have introduced ontology and linked data theories and methods into the field of intangible cultural heritage knowledge organization and knowledge management and have carried out a lot of research on ontology construction, resource integration, and resource organization. In terms of knowledge structure analysis and ontology construction research in the field of intangible cultural heritage, Lu et al. analyzed various elements of intangible cultural heritage from the perspective of systems theory and constructed a series of intangible cultural heritage items, people, things, events, documents, and so on. The ontology conceptual model is composed of core concepts and formulated metadata standards and specifications for intangible cultural heritage resources [3]. Huang et al. analyzed the difficulties in the construction of intangible cultural heritage knowledge ontology and took folk dance as an example to design an intangible cultural heritage knowledge ontology construction system for text and multimedia data [4]. Zhou et al. took the ontology method as a research perspective and designed a framework for the organization and retrieval of intangible cultural heritage information resources from the perspectives of ontology representation, semantic organization, and semantic retrieval and realized the ontology of intangible cultural heritage information resources by taking drama intangible cultural heritage projects as an example [5]. Ou and Tang proposed to divide natural language questions into simple sentences involving one data set and complex sentences involving multiple data sets in the study of automatic question-answering in the face of multiple RDF data sets and convert them into structured questions. The SPARQL query, and then integrate the answer, through experiments prove that the answer is more accurate [6]. Li and Zhao proposed an intangible cultural heritage archives resource development model based on linked data [7]. Dong used linked data technology to organize intangible cultural heritage knowledge semantically and realized the semantic disclosure and organization of intangible cultural heritage resources and their relationships [8].

The traditional knowledge management method of intangible cultural heritage projects is mainly classified and filed according to the subject, region, and level, unable to fully express and reveal the relationship between knowledge elements. With the deepening of knowledge organization and knowledge management research, the management of knowledge in the field of intangible cultural heritage has developed into new organizational methods such as topic maps, knowledge maps, and semantic organization, and more emphasis has been placed on the multidimensional disclosure of the relationship between domain knowledge [9]. In particular, the ontology and linked data technology in the Semantic Web technology stack provide new solutions for the semantic organization of knowledge in the field of intangible cultural heritage. Linked data is regarded as a lightweight implementation of the Semantic Web, which aggregates heterogeneous information resources in the form of linked open data, which can improve the visibility, sharing, and openness of resources and knowledge. The organization and management of intangible cultural heritage knowledge based on linked data are to express the knowledge elements and their attributes in the field of intangible cultural heritage in a structured and formalized manner under the guidance of a standardized and unified domain ontology model and to build the semantic relationship between the knowledge elements, then achieve the purpose of knowledge semantics and order, and provide open data acquisition and knowledge services.

Based on this background, because of the effective management and knowledge association of intangible cultural heritage knowledge, this paper proposes a method system for intangible cultural heritage knowledge organization and intangible cultural heritage knowledge association database construction based on linked data, including the design of intangible cultural heritage knowledge ontology model to the construction of linked data, the whole process of storage and publishing; research the knowledge association between the internally linked data sets in the field of intangible cultural heritage and the external knowledge databases of DBpedia and Geo Names; and establish an intangible cultural heritage knowledge related database with
rich semantic relationships and knowledge interconnection and sharing, providing domain knowledge. Orderly organization and visualization of knowledge: It is helpful for the excavation and discovery of intangible cultural heritage knowledge as well as the international dissemination of my country’s intangible cultural heritage culture.

2. Research Methods

2.1. Concepts and Principles of Linked Data. The concept of linked data comes from the “Father of the Internet,” Tim Bemers Lee, who proposed the Web of Data when he analyzed the development and evolution of the Web in “Design Issues for the World Wide Web” published in 2006. In 2007, linked data was formally proposed in the Linked Open Data Project submitted by Chris Bizer and Richard Cyganiak to W3C. Different scholars have put forward their views on what is linked data. Tim Bemers Lee believes that linked data defines a URI specification that enables people to directly obtain digital information resources through HTTP and URI mechanisms. Wikipedia recommends linked data as a best practice for publishing, sharing, and linking all kinds of data, information, and knowledge on the Semantic Web using URI and RDF. It can be seen from this that linked data is a description specification, which describes data in the triple RDF format of “subject–predicate–object.” URI determines the uniqueness and relevancy of resources in the data. Link association builds a new data network to realize intelligent applications. Because linked data solves the problem of linking distributed and heterogeneous data in the form of semantic association, it is recommended by W3C as the “Best Practice of the Semantic Web.” Linked data has realized the extensive linking of data in different fields in the network and promoted the sharing and widespread use of various types of data. Users can quickly discover a lot of relevant data through data links. Figure 1 shows the situation of the Linking Open Data Cloud Diagram (LOD) as of March 2019. The data set already contains 1239 data sets and 16,147 links. Each node in the figure represents the data published by each data set. The lines between them represent the relationship between the data sets.

Tim Bemers Lee pointed out that the principles of linked data [10] mainly include four aspects: the first principle is to use URI as the name of the resource to identify things. All resources on the World Wide Web are assigned a unique URI as the resource identifier, which stipulates that everything in the World Wide Web uses a URI as a unique identifier, which is the primary condition of the Semantic Web. Using URI to standardize the name of things can avoid ambiguity and confusion; the second principle is to use HTTP URI to locate and find corresponding resources, that is, all URIs can be accessed and retrieved. It is stipulated to use HTTP URI as the link specification, which is conducive to discovering the required information resources according to the data link; the third principle is that when the URI of the resource is accessed, the information related to the resource is provided, and unified standard to represent this information, people can view data information and other classes and attributes through URI; the fourth principle is to provide relevant URI as much as possible to help people discover and obtain more information with potential use value and promote the sharing and utilization of information resources, truly realize the globalization of information.

These four principles are important indicators of the semantic association of digital information resources on the World Wide Web and are where linked data fully reflects its ability to solve the problem of distributed and heterogeneous digital information resources on the Semantic Web. If these four principles are not fully satisfied, they may also play a certain role in data association, but it will greatly reduce the potential of data association and reduce the value-added benefits of data aggregation.

2.2. Related Technologies of Linked Data. Linked data can reflect the objective entities such as data and concepts and the relationship between them, which is an important factor for it as an effective way to achieve semantic relationships on the Semantic Web.

A URI is a string used to identify a resource, allowing users to interact with any resource through a specific protocol. Linked data is based on Web technology, mainly involving HTTP, HTML, and URI. HTTP is a hypertext transfer protocol, which is a standard for client and server requests and responses. HTML is a hypertext markup language, which is stored on the server. Web page files: HTML uses markup symbols to identify and standardize various parts of web page content; URI is a uniform resource locator, which realizes the unified positioning of network resources at the access address; and associated data further define and expand these three technologies, using URI at the same time. To solve the problem of naming and positioning [11], at the same time, the biggest feature of URI is that the identification is stable, the resource path is regarded as a part of the resource name, and it is not allowed to change at will so that the resource does not have information dislocation due to the change of the attribute, which is helpful to Stable Links to Achieve Semantic Associations in Dynamically Changing Network Environments. URI is the most critical technology for linked data. Using URI, anything in the World Wide Web can be given a unique identification name, and “anything” is different, mainly divided into information resources and noninformation resources. Information resources refer to the information resources on the Internet. Digital resources that can be found, such as pictures, videos, web pages, audio, and so on, exist in various physical objects outside the network, including nature, human society, and human meaning, such as mountains, rivers, people, and so on. The fourth principle of linked data refers to the use of relevant URI as much as possible to realize the RDF description of resources. It can be seen that URI can also be used for URI reuse while ensuring the uniqueness of resource identifiers. That is if a resource has been identified by authoritative URI and other data creators, the URI identifier of the resource can be used to ensure the uniqueness of the resource identifier. At present, institutions such as the Library of Congress and W3C provide terminology services and representative use cases based on linked data. At the same time, authoritative vocabulary sets such as
DBpedia and FOAF also provide conceptual terms and associations for linked data. Therefore, the use of URI can effectively and uniformly identify resources, which not only has a clear indication function for resources but also ensures effective management of resources, which is conducive to identifying distributed and heterogeneous related resources in data association and realizing the spanning of linked data.

Purpose of development: URI simply creates a unique identification name and ensures the stability of identification, thus enabling information resources to form a stable associative aggregation in the World Wide Web [12].

RDF is a resource description framework, which provides a way to flexibly describe diverse network resources. It is a markup language used to describe resources on the Web. It is a basic semantic format that can be understood by machines. RDF data can realize data are exchanged between computers with different types of operating systems and application languages so that each data in the network can be shared and utilized to the greatest extent. RDF is to describe resources by using the triple pattern of the “subject–predicate–object” structure under the condition of strictly following the network structure, in which the resource is the subject, the attribute of the resource is the predicate, and the attribute value is the object. The resource is defined by URI, and the predicate represents the relationship between subject and object, which is also represented by URI. Data can be clearly and accurately described through RDF. The resources in RDF contain links identified by URI, which can link to other related resources. At the same time, these links contain semantic relationships, indicating the relationship between resources. Data can be composed of many pieces of RDF, described by a resource identified by URI. The object of RDF can be a numerical attribute or an object attribute, that is, the resource identified by URI; the predicate between the subject and the object indicates the relationship between subject and object and can also be mark with URI. These URIs can come from normative vocabularies, such as FOAF, DC, SKOS, and so on.

SPARQL is a query language and data acquisition protocol especially developed for RDF. Using SPARQL, all information resources represented by RDF can be retrieved.
and queried on the network. The ultimate goal of SPARQL is to retrieve the Semantic Web in the same way that SQL retrieves relational databases. SPARQL can query RDF data between different data sources. The data source can be the data in the RDF format of the entity, or it can be the data in the virtual RDF format through the middleware. The SPARQL language can query based on graphs, and its query results can also be returned in the form of RDF graphs or data sets. An SPARQL query statement can be composed of five parts: statement, query form and result set, data set, graph schema, and result decoration. The relevant query statements are shown in Table 1.

2.3. Technical Feasibility Analysis. The core of linked data is to name data resources with URIs under the premise of following the HTTP protocol and organize and standardize data resources into the RDF format of the "subject–predicate–object" relationship to reflect the relationship between attributes and attribute values, and finally use HTTP URI to locate and query each data resource. The application development of linked data has promoted the generation of tools for constructing and publishing linked data, which mainly include three types.

2.3.1. Relational Database RDF Conversion Tool. The database is the main place for storing resources. The database is a data collection that organizes, stores, and manages data according to a certain data structure. The independence of data is conducive to the centralized control of data, provides convenience for massive resource storage, and promotes the combination of linked data and resources. Databases can be divided into hierarchical databases, network databases, and relational databases. The relational database is based on a relational model that reflects the relationship between entities and entities, which meets the requirements of relational data mining for associations between data resources. At present, the commonly used relational database management system is MySQL, which saves data in different data tables instead of storing all data in one database. Each data table has a primary key attribute that is not a null value. Both the key attribute and the primary key have a certain limited association relationship. Each data table associates the data attribute values in different data tables through the invocation of the primary key and the foreign key. Using MySQL can easily call the data of each database; even if each database is updated, it will not affect the values of other databases. Based on determining the relationship between data resources, data resources need to be processed, including the creation and publication of RDF [13]. D2R is a tool for publishing relational databases into linked data. It mainly includes three parts: D2RQ Mapping language, D2RQ Engine, and D2R Server. The main function of the D2RQ Mapping language is to convert relational data into mapping rules in RDF format. D2RQ Engine uses the D2RQ mapping file to convert the data in the relational database into RDF format. It does not convert the relational database into real RDF data but maps it into a virtual RDF format. This file is used to access the relational database. When generating data, the query language SPARQL of RDF data is converted into SQL language, and the SQL query result is converted into RDF format or SPARQL query result. D2R Server provides a query access interface for RDF data, which is convenient for SPARQL clients and traditional HTML browsers. The operation flow of D2R is shown in Figure 2.

2.3.2. Linked Data Tools That Directly Generate RDF Data. Such tools mainly include Virtuoso Universal Server and Sparq Plug. Virtuoso Universal Server is a commercial-grade linked data tool that enables XML, Web server, and network. The ideal carrier between them can use the SPARQL side to convert the data into RDF format. Sparq Plug uses SPARQL query language and HTML DOM to convert traditional HTML data into RDF form.

2.3.3. Other Linked Data Tools That Publish RDF Data. Pubby is a front-end linked data for SPARQL that provides a linked data interface for resources in RDF format. Pubby is used to connect the linked data interface and the SPARQL side. It can provide a linked data interface to connect to a local or remote SPARQL protocol server. At the same time, it can also provide simple HTML calls to the database to display available resources. Its working principle is shown in Figure 3.

In RDF, resources are identified by URI, but in most SPARQL data sets, URI cannot be directly referenced, that is, they cannot be accessed directly in a web browser. At this time, by establishing a Pubby server on the SPARQL side, the method of URI mapping is adopted to obtain the original URI information by connecting to the SPARQL terminal and returning the result to the client so that the user can obtain the URI information that can be used directly.

2.4. Design and Construction of Intangible Cultural Heritage Knowledge Ontology Model. Ontology is regarded as a clear formal specification of shared conceptual models. In the field of information science and computer, ontology can be regarded as a model, which is a formal expression of objectively existing objects or concepts, their attributes, and related relationships. For the effective organization and management of knowledge in the field of intangible cultural heritage, it is first necessary to clarify the structure of intangible cultural heritage knowledge, its constituent elements, and internal relationships. Then, based on referring to the international general ontology model, a knowledge ontology model in the field of intangible cultural heritage is established according to the knowledge characteristics in the field of intangible cultural heritage. Intangible cultural heritage knowledge ontology is a formal conceptual model formed by a highly abstract summary of the intangible cultural heritage connotation and its constituent elements [14]. Based on ontology theory and existing research results, according to the ideas and steps of domain ontology design and construction, and by analyzing the knowledge structure and constituent elements of intangible cultural heritage projects, this paper constructs an intangible cultural heritage
knowledge ontology model. Description and knowledge association provide a unified and standardized knowledge representation model and data model. At present, for the protection and inheritance of intangible cultural heritage culture in my country, a four-level intangible cultural heritage protection system of “national–province–city–county” has been formulated. Therefore, the basic knowledge about intangible cultural heritage can be regarded as composed of intangible cultural heritage items, inheritors, relevant institutions, project types, geographical locations, and other elements. Intangible cultural heritage project (ICH Project) is an abstraction of intangible cultural heritage projects, and its example refers to each specific project in the four-level list of intangible cultural heritage protection established by my country. An instance of an intangible cultural heritage item is a composite object, which not only has its connotative attributes but also includes related entities such as inheritors and regions.

Based on analyzing the basic structure and relationship of intangible cultural heritage knowledge, the ontology model of intangible cultural heritage knowledge designed and constructed in this paper is shown in Figure 4. The ontology model reference draws on the ontology models such as CIDOC CRM, FOAF, Geo Names, person relationship vocabulary (Relationship), and the Dublin Core (DC) metadata standard [16]. According to the core elements of knowledge in the field of intangible cultural heritage, the knowledge ontology in the field of intangible cultural heritage is abstracted into four core categories: intangible cultural heritage project (ICH project), representative inheritor (Person), geographic location (Place), and project type (Category). Each core class defines corresponding data properties, and the relationship between entities is described and revealed through Object Properties. The intangible cultural heritage knowledge ontology model provides a macrounderstanding of knowledge concepts and their relationships in the field of intangible cultural heritage.
standardizes and unifies basic terms and relationships in the field of intangible cultural heritage, and accurately describes the internal relationship between knowledge concepts.

Item type category (Category) is used to construct the classification system of intangible cultural heritage items; by using the object attributes (skos: broader, skos: narrower, etc.) that represent the relationship between the upper and lower levels of the concept, a multiperspective, multilevel, scalable intangible cultural heritage item classification system. Representative inheritors of intangible cultural heritage are an important part of intangible cultural heritage. The definition of the agent class (Agent) in the ontology model defined in this paper reuses the FOAF ontology model, and the agent class can be divided into two subcategories: “inheritance individual” and “organization and institution”; “individual” mainly refers to certified national. The representative inheritors at the provincial and municipal levels are individuals, and “organizations and institutions” refer to the declaration unit of some intangible cultural heritage items. For example, the declaration unit of the 24 solar terms in the lunar calendar is the China Agricultural Museum. For the representative inheritor of an intangible cultural heritage item, its attributes include the inheritor’s number, name, gender, title, ethnicity, date of birth, place of origin, and other basic information, as well as the skills and skills they have acquired. In addition, the attributes in the relationship vocabulary (Relationship) are reused to better express the intricate inheritance relationship and inheritance lineage between inheritors. The geographic location class is defined in the ontology model. On the one hand, it expresses the geographical space of the distribution and circulation of intangible cultural heritage items, and on the other hand, it records information such as the place of residence and place of origin of the inheritor. And the geographic location class is given the data attributes of the administrative level of provinces, cities, counties, villages, and towns, which corresponds to the administrative divisions of our country. At the same time, associate each geographic location instance with the geographic database Geo Names to obtain information such as geographic location introduction, latitude, and longitude. Combined with geographic information system (GIS) technology, not only the spatial distribution of intangible cultural heritage can be expressed in the form of intuitive visualization of the spatial distribution of maps but also the hidden information of the spatial dimension in intangible cultural heritage can be excavated from a deep level. Using GIS spatial analysis techniques to analyze the spatial structure, evolution, and characteristics of intangible cultural heritage is of great significance for understanding the connotation of intangible cultural heritage [17].

The relationship between entities connects independent knowledge elements to form an intangible cultural heritage knowledge network, changing the single-clue model of traditional knowledge organization. In addition, based on these associations, by defining rules and relational reasoning, invisible knowledge can be inferred and discovered. Focusing on the organization and management of knowledge related to intangible cultural heritage projects, this article refers to the international common ontology models such as CIDOC CRM, FOAF, Relationship, and so on, and carries out the reuse and custom extension of an ontology according to the characteristics of intangible cultural heritage knowledge. The intangible cultural heritage knowledge ontology model is oriented to the organization and management of intangible cultural heritage knowledge, providing a formal representation of knowledge in the field of intangible cultural heritage, and meeting the knowledge management needs in the process of declaration and certification of intangible cultural heritage projects. The main function of building an ontology model of intangible cultural heritage is to standardize the description and formal expression of intangible cultural heritage knowledge, while the semantic transformation of data and the structured representation and storage of knowledge need to be implemented with the help of linked data technology.
## 3. Results and Discussion

### 3.1. Construction of Intangible Cultural Heritage Knowledge Association Data Set

The construction of the intangible cultural heritage knowledge association data set is a huge and systematic project. First, clarify the research scope and sort out the knowledge objects in the field of intangible cultural heritage; second, extract the domain entities, clarify the various attributes of the entities, build the domain ontology model, and form thesaurus and glossary; third, according to the ontology model, the entities are RDF attribute description, establish entity links, including entity links between internal entities and external open data; finally, select an appropriate data storage and publishing platform to provide access and data interfaces for humans and machines. Following the basic principles of linked data, the construction of a knowledge-linked database in the field of intangible cultural heritage can be divided into five key steps, namely data modeling, entity naming, entity RDFization, entity association, and entity publishing [18]. Among them, the data modeling process is the construction process of the knowledge ontology model in the field of intangible cultural heritage. This paper takes the Hubei Province intangible cultural heritage project as an example to explore the construction steps and specific implementation methods of the intangible cultural heritage knowledge association data set. The technical framework of the intangible cultural heritage knowledge association data set construction is shown in Figure 5.

### 3.2. Entity to RDF

Due to a large number of intangible cultural heritage projects in my country, and the dynamic changes in the identification of intangible cultural heritage projects and inheritors, the construction process of the entire knowledge base in the field of intangible cultural heritage needs to be carried out in layers and batches. There are two main sources of data. One is the data of intangible cultural heritage project declaration and representative inheritor certification application. The collected data are preprocessed such as data cleaning and stored in the database. Many traditional intangible cultural heritage information systems mainly use relational databases for data storage. This paper chooses to perform data semantic mapping based on D2RQ to convert the content in relational databases into linked data. Semantic mapping of data is to convert the two-dimensional table structure into associated data that is better at dealing with complex relationships and richer in semantic information; it specifically includes data table-to-class mapping, column-to-attribute mapping in data tables, and table-to-association mapping. In the mapping language, d2rq: Class Map is used to define the classes of the ontology model, which corresponds to the mapping of the data table, and d2rq: Property Bridge is used to define the attributes in the ontology model, which corresponds to the mapping of the columns and relational tables in the data table. The mapping of data in the relational database to RDF should follow the classes and attributes defined in the ontology model [19]. The five main data tables in the relational database are mapped to four core classes and their attributes, intangible cultural heritage item, inheritor, classification, and geographic location. The relational table is mapped to the “has Inheritor” object attribute, as shown in Figure 6. The fields of each data table are mapped to corresponding properties.

Finally, according to the data mapping file, use the dump-rdf tool of the D2RQ platform to convert the data in the relational database to generate an RDF/XML format file for use by other databases or third-party applications. Although D2RQ can also publish linked data, it is not flexible enough to update and manage data and has limited support for complex relationships and massive data. Therefore, this paper uses D2RQ to semantically transform the data into RDF/XML format files. Then, the data are stored in a special Triplestore database, and the server is configured to realize the associated publishing of the data and the data open interface. Table 2 corresponds to the mapping framework, which is the core statement for semantically mapping the item table, the inheritor, and the inheritance relationship table.

### 3.3. Entity Association

Entity association is based on the RDF description of entities, uses RDF links to describe the semantic relationship between different entity objects, and establishes associations with external data as much as possible to build a linked data network. Linking data to other open RDF data sets and vocabularies is a key step in enriching the semantics of linked data. Entity linking should more semantically link internal data with external open data sets and realize knowledge discovery through knowledge aggregation across domains, disciplines, and databases. In the Semantic Web environment, with the help of the standardization and open interconnectivity of linked data and the integration of multiple knowledge bases, the richness and breadth of knowledge in the field of intangible cultural heritage can be improved, providing scientific research and knowledge dissemination of intangible cultural heritage culture. Data Foundation and Knowledge Services [20]: To enrich the knowledge in the field of intangible cultural heritage, this paper chooses to match and associate data with DBpedia and Geo Names linked data projects. Through the association with DBpedia and its data source Wikipedia, the Chinese and English entries corresponding to the intangible cultural heritage items are obtained; through the association with the global geographic database (Geo Names), more information about the regions involved in the intangible cultural heritage field can be obtained. Use the OWL built-in attribute owl: sameAs to associate the internal knowledge entity with the entity in the external data set, indicating that the two linked entity objects are the same thing.

The DBpedia project is a large-scale knowledge data set based on linked data and established by extracting data from Wikipedia. It is the core of the linked open data cloud graph. The DBpedia data set contains a large amount of information about my country’s intangible cultural heritage described in Chinese and English, and entity association with it can
enrich the knowledge in the field of intangible cultural heritage and improve the visibility and generality of intangible cultural heritage knowledge [21]. This paper adopts a combination of automatic retrieval and manual inspection. First, the resource items related to intangible cultural heritage items in DBpedia are retrieved online through SPARQL language, and then the retrieval results are screened and checked by manual inspection, and finally the retrieved resources are retrieved. The URI is associated with the internal intangible cultural heritage item entity through the owl: sameAs attribute. In the DBpedia ontology model, the db: abstract attribute represents the abstract of the resource, and the foaf: is Primary Topic of attribute links the Wikipedia page corresponding to the resource. The SPARQL Endpoint site of DBpedia is called online, and the related concepts of the intangible cultural heritage items are retrieved by constructing SPARQL sentences to retrieve the resource items containing the keyword. Due to the imperfections of DBpedia, for example, some intangible cultural heritage items lack entries, the Chinese information provided by DBpedia is incomplete, the resource entries related to intangible cultural heritage in Wikipedia are not included in DBpedia, and because the titles of intangible cultural heritage items are not uniform, through the above methods, some entries are not correctly matched, and some are not fully matched. Therefore, based on automatic retrieval and manual inspection, this paper associates as many internal intangible cultural heritage project entities with DBpedia-related resources as possible. In the end, about 1/3 of the intangible cultural heritage items are physically associated with DBpedia or Wikipedia, which also highlights the necessity of establishing an encyclopedic database of intangible cultural heritage in my country.

The Geo Names geographic database contains more than 10 million geographic names around the world and provides information such as geographic name alternatives, latitude and longitude, population, and Wikipedia. It adopts the principle of linked data to organize, defines a unique resource URI for each geographic name, and publishes the geospatial semantic information to the Internet. To obtain more information about geographic location, enrich domain knowledge, and provide a data basis for spatial analysis of intangible cultural heritage based on geographic information, this paper combines entities related to geographic location, such as intangible cultural heritage project application areas and inheritor’s residence, with Geo Names database for the association. The Geo Names data can be obtained by calling its official API or by using the SPARQL endpoint provided by a third party [22]. To ensure the consistency with the DBpedia data association, this paper uses the SPARQL endpoint of the Factforge website to obtain Geo Names data. The core SPARQL query statements related to data matching and association are shown in Table 3.

The query sentence uses "Dark Biography" as the keyword to perform a full-text search on the Chinese tags of DBpedia and obtain the abstract information of the resource and the corresponding Wikipedia page. It is linked to the intangible cultural heritage item entities in the internal data set.
Retrieve the resource entry corresponding to “Enshi Prefecture” in the Geo Names database and limit the search scope to China (coded as CN) and the resource type to country and region (coded as A). The retrieval result will return the URI of the geolocation object, <http://sws.geonames.org/1811624/>, and you can further obtain information such as the latitude and longitude of the geographic location and the Wikipedia link. In the case of the same geographic names, disambiguation can be achieved by judging the municipal and provincial geographic names (parent ADM2, parent ADM1). In the above way, the association to the geographic location entity achieves a 100% match. Finally, based on constructing internal intangible cultural heritage domain knowledge-linked data, multiple categories of entities such as intangible cultural heritage items, people, and geographic locations are associated with external databases such as DBpedia and Geo Names. The number of entities and triples in the finally constructed intangible cultural heritage domain knowledge association database are shown in Table 4. Among them, there are more than 10,050 triples, involving multiple categories of objects such as intangible cultural heritage items, inheritors, institutions, geography, and types. There are 505 entities associated with DBpedia and 295 entities associated with Geo Names. By linking DBpedia, it can be more convenient to associate with Wikipedia, WIKIDATA, YAGO, and other resources. Moreover, the constructed intangible cultural heritage knowledge-linked data are completely open according to the W3C standard, and data services can be obtained through online retrieval, SPARQL Endpoint, and other data cabling methods.

3.4. Storage and Release of Intangible Cultural Heritage Knowledge-Related Data. After converting all kinds of data and knowledge in the field of intangible cultural heritage into the form of linked data, it needs to be persistently stored and published. The storage and publishing of linked data directly affect the sharing and reuse of data [23]. There are many ways to store and publish linked data. This article adopts the native method for storage, configures the server for linked data publishing, and provides open data services and knowledge services. Open Link Virtuoso is used as the storage and management database of RDF data, and Lod View is used for users to provide data browsing of the intangible cultural heritage knowledge base and use Lod Live to provide a visual representation of the intangible cultural heritage knowledge association graph.

The storage scheme of linked data is roughly divided into relational data-based storage, NoSQL database storage, and Triplestore database storage. Among them, the Triplestore database is specially developed for the characteristics of the RDF data structure and has efficient data storage, query, and reasoning mechanisms; at the same time, because it adopts a unified data model, it can achieve efficient interaction between data. Considering the expansion of knowledge in the field of intangible cultural heritage and the growth of data in the future, this paper chooses Open Link Virtuoso, which is
The Virtuoso database is a cross-platform scalable high-performance database management software that provides SQL, XML, RDF database management functions and supports the storage and management of billions of scale triples. The Virtuoso database provides multiple mechanisms such as WEB pages or ISQL commands for data import. The original data related to intangible cultural heritage is semantically described or semantically mapped to generate RDF format data and then imported into the Virtuoso data storage, and the IRI (Internationalized Resource Identifiers) of the named graph to which the data belong is specified.

The intangible cultural heritage domain knowledge RDF data constructed above needs to be published through linked data to realize the utilization and sharing of data; the commonly used publishing methods of linked data are based on static RDF/XML files, based on relational data, and based on RDF data repository, using RDFa formula and other ways. Based on the Virtuoso database platform, this paper follows W3C’s four principles of linked data publishing, configures a linked data publishing server, and provides services such as RDF data management, linked data browsing, and SPARQL endpoints and content negotiation. To fully and comprehensively display the attributes and relationships of each entity in the intangible cultural heritage-related data set, the Lod View tool is used to provide users with a browse of the intangible cultural heritage-related data. Lod View is a Web application developed based on Jena and Spring framework. It supports the parsing of International Resource Identifiers (IRI) conforming to the W3C standard and is a tool for converting RDF data format to HTML; configuring Lod View’s SPARQL site and multimedia display and Attributes such as latitude and longitude; and returning the correct RDF data and web page description according to the content negotiation mechanism. The entities of the intangible cultural heritage knowledge association data set are distinguished according to the types of entities, including intangible cultural heritage items, inheritors, place names, and project types. The URI format of entity naming is http://base URI[/entity Type Name][/entity ID], where [entity Type Name] corresponds to the class in the ontology model; such as http://localhost:

### Table 2: Statements of data semantic mapping (part).

| Category | Check for phrases |
|----------|------------------|
| Intangible cultural heritage project table/mapping to ich: ICHProject class | map: project a d2rq: class map; d2rq: data storage map: database; d2rq: uri pattern "project/@project.ID@@"; d2rq: class ich: ICHProject; d2rq: class definition label "project"; |
| Inheritor information table/mapping to foaf: Person class | map: inheritor a d2rq: class map; d2rq: data Storage map: database; d2rq: uri pattern "inheritor/@inheritor.id@@"; d2rq: Class foaf: person; d2rq: class definition label"inheritor"; |
| The relationship table between inheritors and intangible cultural heritage items/mapping to ich: has inheritor object attributes | map: pro_inh_link a d2rq: property bridge; d2rq: Belongs to class map map: project; d2rq: property ich: has inheritor; d2rq: Refers to class map map: inheritor; d2rq: join "pro_inh . Inheritorid => inheritor . urlcode"; d2rq: join "pro_inh . Projectid => project . urlcode"; |

### Table 3: Data matching and associated core SPARQL query statements.

| Category | Check for phrases |
|----------|------------------|
| Intangible cultural heritage item class entities are matched against DBpedia | PREFIX rdfs:<http://www.w3.org/2000/01/rdf-schema#> PREFIX dbo: < . Org/ontology/" title = "http://dbpedia . Org/ontology/ " >http://dbpedia . Org/ontology/> SELECT ? res ? title ? Wikipedia ? abstract FROM <http://dbpedia . Org> Where{? Res rdfs: label? Title . ? title bif: contains"Dark biography." ? res foaf: is primary topic of ? Wikipedia . ? res dbo: abstract ? abstract.filter(lang( ? abstract) = "zh").} |
| Geolocation entities are matched against Geo names | PREFIX gn: <http://www . Geonames.org/ontology#> SELECT ? gnfeature WHERE {? gnfeature gn: country Code'CN '. ? gnfeature gn: alternate Name'Enshi Tujia and Miao Autonomous Prefecture'@ zh . ? gnfeature gn: feature Classgn: A . } LIMIT100 |
Table 4: Statistics of knowledge-related data in the field of intangible cultural heritage.

| Category                                      | Number |
|-----------------------------------------------|--------|
| Triad                                         | 10050  |
| entity                                        | 1200   |
| Intangible cultural heritage project entity   | 580    |
| Heir entity                                   | 530    |
| Associate with DBpedia                       | 505    |
| Associate with Geo names                     | 295    |

Figure 7: Intangible cultural heritage item object page.

8890/resource/ichproject/359 represents the instance of “Intangible Cultural Heritage Project Class” “Dark Biography”; the page that uses the LodView tool to display the details of this instance is shown in Figure 7.

This page shows all the properties of the “Dark Biography” instance of the intangible cultural heritage item. The upper part of the page is a multimedia display part, which visually displays multimedia resources such as pictures and videos related to it. The page lists the representative inheritors, types, distribution areas and other related objects of the project. For example, link the representative inheritor of the project through the ich: has inheritor attribute and click the hyperlink to jump to the detailed page of the inheritor object. When the user accesses, it provides an intuitive HTML page; when the application accesses, it returns the data in the corresponding format such as RDF/XML, RDF/Turtle, JSON, and so on, according to different content requests. In the intangible cultural heritage knowledge association data set, geographic location objects are associated with Geo Names. When the user accesses the information page of the instance of the geographic location class “Shennongjia Forest Area,” the location in the map is displayed according to the latitude and longitude information in the form of an online map. The middle of the page displays the specific attributes of the geographic location class and is associated with DBpedia, Geo Names and Wikipedia; at the bottom of the page, through the inversion of the ich: has Place attribute, the intangible cultural heritage items, and inheritor objects owned in the region are retrieved in reverse.

4. Conclusions

The development of the Semantic Web and linked data has provided new ideas and methods for the organization and sharing of knowledge in the field of intangible cultural heritage and has changed the representation and expression of intangible cultural heritage knowledge. To realize the effective
organization and management of intangible cultural heritage knowledge, based on processing and sorting out the knowledge in the field of intangible cultural heritage, this paper sorts out the elements and semantic relations of intangible cultural heritage knowledge and constructs the ontology model of intangible cultural heritage knowledge to reveal the field of intangible cultural heritage. A wealth of knowledge and the interconnectedness of knowledge: the intangible cultural heritage knowledge linked data set constructed based on linked data technology provides data consumption and sharing in the form of linked open data and provides knowledge services such as domain knowledge related to display and knowledge visualization based on linked data sets. The ideas and technologies of ontology and linked data have great advantages in the organization of knowledge in the field of intangible cultural heritage. Using linked data technology to build a knowledge base in the field of intangible cultural heritage in my country and physically linking it with international open data sets can improve knowledge in the field of intangible cultural heritage, relevance, sharing and openness, and influence.

The construction of high-quality intangible cultural heritage knowledge open data sets and knowledge service platforms, on the one hand, provides a scientific data set for deeper analysis and research on intangible cultural heritage culture and on the other hand promotes intangible cultural heritage knowledge to play a greater role. The dissemination and inheritance of intangible cultural heritage are of great significance. The intangible cultural heritage contains a wealth of knowledge. This article only studies and sorts out the basic knowledge elements such as intangible cultural heritage items, inheritors, regions, and inheritance relationships. The granularity of knowledge organization needs to be further refined. Intangible cultural heritage knowledge ontology model still needs to be further expanded and enriched according to actual needs. The follow-up research will expand the data sources and research objects. In the big data environment, the organization and management of the massive heterogeneous knowledge of the intangible cultural heritage will be studied.

Data Availability

The experimental data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest to report regarding the present study.

Acknowledgments

This study was supported by Education Sciences Planning 13th Five-Year Key topics of the Ministry of Education in 2020 “Research on the practice mode and performance evaluation system of vocational education supporting the industrialization of intangible cultural heritage poverty alleviation” (Item No: DIA200312); Guangxi Philosophy and Social Sciences Planning Research Project in 2021 “Collection and research of oral archives of intangible cultural heritage inheritors of traditional skills in Guangxi” (Item No: 21BMZ011); Special Topic of Guangxi Ethnic Education Research in 2019 in the 13th Five Year Plan of Guangxi Educational Science “Research on Guangxi Zhuang cultural inheritance and education under the guidance of socialist core values” (Item No: 2019JY085) Phaseed research results; and Philosophy and Social Science Planning Project in Inner Mongolia Autonomous Region in 2021: Research on the Protection and Inheritance of Intangible Cultural Heritage “Wushen Horse Race” (project no. 2021NDYB165).

References

[1] Q. Jia and P. Wang, "Research on the aggregation of historical archives resources based on linked data," Library and Information Work, vol. 65, no. 10, pp. 105–112, 2021.
[2] S. Jong-Soo and I. J. Chung, "Dynamic FOAF management method for social networks in the social web environment," The Journal of Supercomputing, vol. 66, no. 2, pp. 633–648, 2013.
[3] C. Liu, Y. Xiong, and C. Liu, "Construction of Knowledge Organization System of Intangible Cultural Heritage Resources Based on Ontology and Metadata," Library Theory and Practice, no. 3, pp. 39–43, 2016.
[4] Y. Huang, W. Lu, Q. Cheng, and S. Deng, "The design and implementation of intangible cultural heritage knowledge ontology construction system—taking tibet’s “guozhuang” and “duixie” as examples," Journal of Tibet University for Nationalities (Philosophy Social Science Edition), vol. 37, no. 1, pp. 20–26+154, 2016.
[5] Y. Zhou, Y. Zhao, and J. Sun, "The research path of intangible cultural heritage information resources organization and retrieval—inspection and design based on ontology method," Journal of Information, vol. 36, no. 8, pp. 166–174, 2017.
[6] S. Ou and Z. Tang, "Research on automatic question answering technology for library linked data," Chinese Library Journal, vol. 41, no. 6, pp. 44–60, 2015.
[7] S. Li and Y. Zhao, "Development of intangible cultural heritage archive resources based on linked data," China Archives, no. 6, pp. 71–73, 2016.
[8] K. Dong, "Research on semantic organization of intangible cultural heritage based on linked data," Modern Information, vol. 35, no. 2, pp. 12–17, 2015.
[9] Y. Chen, Z. Chen, and Y. Qiu, "Research on the development strategy of enterprise archives informatization based on knowledge management," Management and Technology of Small and Medium Enterprises, no. 2, pp. 10–12, 2022.
[10] Y. Lu, "Research on Digital Archives Resource Sharing Based on Linked Data," Central China Normal University, Wuhan, China, Master, 2017.
[11] M. Huang, "Design of teaching resource library system based on java web technology," Electronic Technology and Software Engineering, no. 1, pp. 229–232, 2022.
[12] Y. Cao, Z. Gong, D. Chen, and Y. Kang, "Linked data technology and its research status," Library Theory and Practice, no. 11, pp. 42–45, 2014.
[13] W. Liu, "Linked data: concept, technology and application prospects," Journal of University Libraries, vol. 29, no. 2, pp. 5–12, 2011.
[14] Q. Nian, L. Li, S. Zhao, and H. Wu, "Knowledge modeling in the field of ontology intangible cultural heritage," Journal of
[15] S. Ye and L. Pan, "The formation, expression and transformation of the inheritance and development of intangible cultural heritage: based on the perspective of cultural capital," Jinyang Journal, no. 3, pp. 109–114, 2022.

[16] M. Fan, F. Zhu, and Y. Wu, "A web data sharing technology based on metadata," Journal of Mianyang Normal University, vol. 23, no. 2, pp. 34–40, 2004.

[17] X. Zhang, "Research on the distribution characteristics of rare tree species in Pingnan County based on GIS spatial analysis," Fujian Forestry, no. 6, pp. 42–45, 2021.

[18] P. Akeem, P. Anhtuan, N. P. Thanh, and P. H. Chien, "Data-driven construction safety information sharing system based on linked data, ontologies, and knowledge graph technologies," International Journal of Environmental Research and Public Health, vol. 19, no. 2, 2022.

[19] J. Lu and Y. Li, "Mapping method of object relational database to RDF(S)," Computer Science, vol. 48, no. 10, pp. 145–151, 2021.

[20] H. Gao, "Research on ontology mapping based on similarity calculation in semantic web," Network Security Technology and Application, no. 2, pp. 41-42, 2022.

[21] J. Shi, "Research on Entity Linking Technology Based on DBpedia Knowledge Base," Southeast University, Dhaka, Bangladesh, Master, 2018.

[22] W. He, "SPARQL Join Query and its Application," Dalian Maritime University, Dalian, China, 2014.

[23] X. Zhu and R. Wang, "Research on ontology construction of intangible cultural heritage image semantic information and its associated data storage and release," Modern Intelligence, vol. 41, no. 6, pp. 54–63, 2021.