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Digital Application of Intangible Cultural Heritage from the Perspective of Cultural Ecology

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Abstract

This paper explored the digital application of intangible cultural heritage from the perspective of cultural ecology. Through field investigations, combined with cultural ecology theory, an ontology-based semantic web technology was proposed, and Nanjing "Yunjin" brocade weaving technique was selected as the research object. The specific steps were as follows: First, based on the field surveys and cultural ecology theory, the intangible cultural ecological environment was divided into natural and social environments. Next, constructing the intangible cultural heritage ontology was constructed, including the collection and collation of Nanjing Yunjin weaving technique knowledge corpus, based on user needs analysis and corpus analysis, CIDOC CRM was used to create rules to build the ontology. Finally, based on the MediaWiki platform and Semantic MediaWiki, the semantic web model of the intangible cultural heritage was designed, and its semantic retrieval function was realized, thereby achieving the practical application of intangible cultural heritage digitization. Based on the perspective of cultural ecology, a set of intangible digital application models was proposed, which expanded the digital application of the cultural ecology theory, verified the application of this model in the sustainable development of cultural tourism, and provided reference for the sustainable development of cultural tourism.

1. Introduction

The integration of cultural heritage and tourism has been a hot topic in the field of tourism in recent years (Luo & Chen, 2016). Cultural tourism has gradually formed an emerging form of tourism, which has grown rapidly, accounting for over 39% of tourism arrivals (Richards, 2018). Cultural tourism is "the movement of people towards cultural attractions, somewhere other than their habitual place of residence, in order to obtain information and knowledge to fulfill their own cultural demands" (Jovicic, 2014; Richards, 1996). In recent years, the different definitions given by scholars are essentially similar to those of Richards (Richards, 2018). As mentioned above, the definition of cultural tourism is always associated with culture, which can be represented as tangible or intangible, physical or material (Smith, 2003). Currently, the position of cultural tourism has changed from a niche market to a mass market, leading to new challenges, such as overcrowding in key sites, while some sites have fewer tourists (García-Hernández, de la Calle-Vaquero, & Yubero, 2017). Thus, with the development of cultural tourism, the sustainability of tourism activities has also become the focus of attention. The World Tourism Organization (UNWTO) put forward that "tourist destinations should not only maintain cultural integrity and protect the ecological environment, but also meet the economic, social and aesthetic requirements of mankind in the development process." Among them, cultural integrity requires the protection of things themselves, together with their associated ecological environment and cultural environment, rather than artificially splitting it and destroying its systemic nature. This requirement is consistent with the theory of cultural ecology, emphasizing the

relationship between human culture and the surrounding environment. However, due to the late rise of China's cultural tourism industry, there have been some problems: Firstly, due to the lack of understanding of cultural integrity, there are more focuses on resource development, rather than resource protection (Zhao, 2019); excessive cultural integration (Zheng, 2019); insufficient depth of local cultural tourism excavation, which causes insufficient competitiveness, and other issues. Secondly, cultural resources, such as traditional handicrafts, provide tremendous tourism value; however, the solidified protection and static display not only consume a lot of human capital, but also cannot improve its own vitality. Finally, the lack of professional talent also hinders the organic integration of cultural and tourism industries, thereby affecting the sustainable development of cultural tourism. Therefore, how to protect the cultural integrity of intangible cultural heritage (hereinafter referred to as "ICH") and maintain the cultural ecosystem of ICH has become an important research topic.

Today, digital technologies continue to penetrate various industries in all regions of the world. Similarly, they have a greater and stronger impact on the tourism sector at all levels (Minghetti & Buhalis, 2010). Since they can provide different and convenient approaches, promoting the efficiency of information management and value development, they are considered an important link between tourism and cultural heritage (Roque & Forte, 2017). Thus, digitization in cultural tourism can contribute to the conservation and development of cultural resources without damaging the environment, improving promotional channels and reputation, and ultimately promoting the sustainable development of cultural tourism. There are

currently some studies on the digitalization of cultural heritage in the field of tourism, including digital storytelling (Kasemsarn & Nickpour, 2015, 2016), information and communication technologies (Maurer, 2015; Minghetti & Buhalis, 2010), and other technologies (Li, 2015; Tscheu & Buhalis, 2016). However, despite the current momentum of tourism informatization, many countries are still in their infancy when it comes to digital preservation of ICH, both in terms of theory and technical means (Liu, 2020). For example, in the digitalization of China's ICH, there are still many shortcomings in the information arrangement and organization of ICH. Based on the above background, this study poses the following research question:

Based on the perspective of cultural integrity, how can information/digital tools be used to address the problem of inadequate conservation and development of ICH?

In fact, the theory of cultural ecology emphasizes the systematization of cultural survival and development environment. As society enters the information age, the digitalization of ICH becomes a new kind of survival state, and maintains its cultural ecosystem together with its traditional survival state. However, there is limited research on the digitalization of cultural heritage based on cultural ecology theory at present (Jiang, Yang, Zhang, & Su, 2019; Liu, Li, & Destech Publicat, 2018; Mitsche & Strielkowski, 2016; Prada-Trigo, Lopez-Guzman, Pesantez, & Perez-Galvez, 2018; Taheri, Gannon, & Kesgin, 2019; Tian, 2017; Wang, Liu, & Liu, 2017; Xua, Zhang, Lu, & Zha, 2019; Zhang, 2018; Zhang, Wen, Liu, & Zhu, 2017). Actually, ontology technology can clarify the knowledge structure system in a certain field, which is suitable for the reuse and sharing of knowledge. Semantic Web is a good survival carrier of ICH digitization, which adds semantic information to the documents on the network based on the World Wide Web. A large number of ICH complex information, using ontology modeling technology, can effectively manage and solve the problem of information loss and redundancy caused by the lack of traditional protection, and organize ICH information in a systematic way. The Semantic Web allows the semantic retrieval of ICH information through the application of cultural tourism, as well as ICH related fields and platforms, and can promote the protection and inheritance of ICH resources, thereby contributing to the sustainable development of ICH. Therefore, this study analyzes the state of ICH in each environment based on the cultural ecology theory, then establishes the ontology of ICH from the perspective of holistic protection of ICH, and implements the ontology application through the semantic web technology, the contribution of which is: (1) The cultural ecology theory is incorporated into the digital research application of ICH, enriching the digital application scenario of the theory. (2) The semantic web for ICH is constructed based on ontologies, which provide a theoretical reference for the integration of ontology and semantic web technologies in the protection of intangible cultural heritage.

The rest of this paper is structured as follows: Based on the theoretical background and literature review, this paper describes the research design, including the introduction of the research object and the overall research process. And in the last part, through a field survey, the paper analyzes the composition of the ICH ecosystem, followed by the digital practice scheme with uses examples.

2. Literature Review

2.1 Sustainable Development and Cultural Tourism

Sustainable development, as an important global issue (Zhu & Wei, 2014), has been one of the research hotspots of cultural tourism in the global field in recent years. In 1972, the United Nations Conference on the Human Environment first proposed the concept of "sustainable development." Since then, the theory of sustainable development and the ways to achieve it have become the focus of various research fields. Tourism was one of the earliest industries to adopt the concept of sustainable development (Tiago, Gil, Stemberger, & Borges-Tiago, 2020). In the past few decades, cultural tourism has gradually emerged and become a popular form of tourism activities in recent years. However, with a growing number of tourists flocking to many heritage sites, which results in "overtourism," ICH has become another way for tourists to participate in new experiences, and its sustainability also has attracted more attention (Richards, 2018), such as how Lonardi, Martini, and Hull (2020) found through semi-structured interviews that when tourists show a genuine interest in minority languages, the indigenous people's national consciousness will be enhanced, thereby promoting language revitalization. When it comes to cultural heritage development, ICH is heavily dependent on the environment, due to changes in the environment and the shift of people's attention, where intangible cultures such as folk customs and traditions can easily disappear. Thus, the healthy maintenance of cultural ecosystems has at present become an important research topic for sustainable tourism.

The guarantee of tourist satisfaction is an important prerequisite in the realization of sustainable heritage tourism (Asmelash & Kumar, 2019). In recent years, the development of information technology has greatly changed the users' tourism experience (Xiang & Fesenmaier, 2017). At the same time, it has created a new development space for cultural tourism, and has gradually attracted more researchers' attention. Several studies on the sustainable development of cultural tourism have emerged from the perspective of digitalization. Beatrice Vilceanu et al. established a 3D model based on the sustainable development of cultural heritage (Vilceanu, Herban, & Grecea, 2015); Jinhua Dou et al. proposed a construction method of the ICH knowledge map based on domain ontology and natural language processing technology, resulting from the perspective of the inheritance and dissemination of ICH, to promote knowledge management, but not involving the final retrieval application (Dou, Qin, Jin, & Li, 2018). At present, numerous mature ontology models exist in the field of cultural heritage, such as CIDOC CRM, FRBR, ABC ontology, etc. (Zhou, Zhao, & Sun, 2017). The semantic technology can be used to conceptualize cultural heritage data, which can reveal the deep connections between concepts (Lodi et al., 2017). Currently, in China, the subject perspective for discussing the development of cultural heritage based on ontology or semantic web is mainly from the perspective of informatics, and rarely from the perspective of tourism (Liu, 2018; Tan, Hou, & Zhuang, 2017), and mostly stays at the level of theoretical and model text elaboration, with very little implementation at the application level.

2.2 Cultural Ecology Theory and Digitization of ICH

The related concepts of cultural ecology theory first appeared in the book "Theory of Culture Change: The Methodology of Multilinear Evolution" by Julian H. Steward in 1955. He thought that cultural ecology was different from "environmental determinism," and that culture and environment played different roles, which were interdependent (Steward, 1955). At this stage, its theoretical core lies in "cultural ecological adaptation" and "cultural core and its remains," where the former refers to "the adaptation process of the culture developed in history to be transformed in a special environment", while the latter refers to "the core part of culture and many aspects of the social structure and ritual behavior" (Cui, 2012). Later, Robert F. Murphy, an American cultural anthropologist, further pointed out that "the essence of cultural ecology theory refers to a dynamic and creative relationship between culture and environment, including technology, resources and labor", thereby extending the connotation of cultural ecology from the traditional natural environment to the social and human environment (Hu, 2018; Murphy, 1989), and preliminarily describing the state and

characteristics of this interactive relationship. After the 1980s, with the in-depth study of scholars, the theoretical construction of cultural ecology entered a maturity period. Firstly, system theory has been incorporated into cultural ecology, and scholars have begun to examine the relationship between cultural elements and elements within the overall system (Wang, 2016). Secondly, with the advent of the information age, the social environment especially the information environment has been included in the scope of the research (Zhang, 2014). Researchers from different disciplines have explored the interactive relationship between information environment and culture caused by information revolution from various perspectives. For example, Bo explored the ecological change of Huayao Yi costume art and culture based on digital background, and proposed that digital art technology should be applied to the inheritance practice of ICH (Bo, 2012).

ICH is the precious wealth of all nations in the world. As an important part of the excellent traditional culture of various countries, it carries the historical memory of various ethnic groups (Chen & Huang, 2018). Meanwhile, it is also a fresh blood and an important resource for cultural tourism, with great development and protection value. Since ICH relies on the cultural, social and ecological environment, its "living" inheritance requires the integrity of the cultural protection, including the overall protection of its inheritors, heritage sites, heritage ceremonies, etc. (Dai, 2016); in other words, to ensure the protection of its cultural ecosystem. At this point, it is particularly important to apply cultural ecology theory to the safeguarding of intangible cultural heritage: that is, appropriate safeguarding and transmission measures need to be taken in full consideration of the social environment in which the ICH is located, including the political, cultural and information environment. Current research related to cultural ecology theory in the field of tourism mainly involves intangible cultural heritage conservation and influencing factors research (Hu, Wang, & Song, 2020; Ren, 2015); tourism experience and satisfaction (Prada-Trigo et al., 2018; Taheri et al., 2019; Xua et al., 2019), integration and development mechanism (Liu et al., 2018; Tian, 2017; Wang et al., 2017; Zhang, 2018), ICH distribution pattern (Jiang et al., 2019; Zhang et al., 2017), tourism service innovation (Mitsche & Strielkowski, 2016), etc. Most of the above studies are at the level of theory and recommendations and do not provide practical solutions for application. Based on national policy support, a three-dimensional ICH protection space has been formed, which is constructed by using various media such as text, film and television, network, etc., and the information environment has begun to penetrate into the cultural ecosystem of ICH. So far, the use of information technology for the digital protection of ICH has achieved fruitful research and practical results. However, there are still a series of problems. For example, many studies have found that due to lack of publicity and long-term display platforms, geographical distribution and other conditional constraints, most ICH projects are facing problems such as a reduction in audience groups, generally low awareness among the younger generation of tourists (Qiu & Chen, 2017), inadequate publicity and development etc. Digital applications of ICH are still in the exploration stage (Song & Wang, 2015).

Ontology, which is a kind of knowledge organization system that takes system theory as an important theoretical basis, can systematically sort out the relevant knowledge and present the internal relationship between knowledge and its scalability characteristics, thereby enabling adaptation to the dynamic cultural ecosystem. In the meantime, due to the information explosion in the era of big data, tourists often need to visit multiple websites to find relevant tourist information. At this time, ordinary retrieval can no longer meet the needs of their information. Semantic Web can implement semantic retrieval functions by adding semantic tags to the content of web pages, and can be applied to related platforms to enable systematic display, as well as effective dissemination of knowledge and

information. When it is used in tourism OTA-related platforms, it can achieve the transformation of cultural economic benefits, so as to better maintain the cultural ecosystem. Therefore, based on the perspective of cultural ecology, this study will select the most representative Nanjing Yunjin weaving technique in traditional Chinese handicrafts, explore its cultural ecosystem through field survey, and conduct digital practice and case tests in combination with ontology and semantic web technology, so as to provide a theoretical reference for the establishment of intangible cultural ecological protection and inheritance models, and further promote the sustainable development of cultural tourism

3. Research Design

Based on the above discussion, this study selects Nanjing Yunjin weaving technique, the most representative traditional handicraft in China's ICH, as the research object, to investigate its cultural and ecological characteristics and systems through local interviews and surveys, and to conduct practical research in combination with digital technology.

3.1 Case Object

Nanjing Yunjin was gradually developed on the basis of inheriting the famous jinjin "gold brocade" of the Yuan Dynasty. So far, it has a history of 1580 years and was listed as the first batch of China's ICH by the State Council in 2006 and listed as the ICH of humanity in 2009, representing the highest achievement of China's brocade technology. Its knowledge depends on handicraft creators, craft works and a large number of documents. They are huge in size, complex in steps, scattered and fragmented in expression, and need to be standardized through a systematic approach, with clear elements and different levels of knowledge systems (Sun, 2014), and a reduction in the threshold of user query through semantic retrieval, so digital protection is an important path for future development. At present, there is no relevant research on Nanjing Yunjin weaving technique using semantic web technology. Therefore, this article takes Nanjing Yunjin weaving technique as the research object, examines its cultural and ecological characteristics, establishes the ontology of ICH, and aims to conduct a tentative study on the sustainable development of cultural tourism on the basis of previous studies.

3.2 Research Steps

In this study, field survey methods and experimental methods were used. One of the most important methods of fieldwork is participant observation. From August 7, 2017 to August 11, 2017, the research scope of the survey was the location of Nanjing Yunjin Brocade declaration unit (Nanjing Yunjin Research Institute) and related units (Nanjing Yunjin Museum). The main respondents were tourists and Nanjing Yunjin brocade related workers. The relevant workers mainly include docents and Yunjin apprentices. In this survey, unstructured interviews were conducted with three inheritors, an apprentice and a museum docent with knowledge of Nanjing Yunjin weaving techniques. The purpose of the interview was to understand the origin, development, current situation, and cultural connotations of Nanjing Yunjin inheritance, so as to lay a foundation for its cultural ecological characteristics and system construction.

Next, the cultural ecosystem of Nanjing Yunjin weaving techniques was analyzed based on the existing literature and data. On the basis of the construction of cultural ecosystem, relevant concepts in ontology are extracted from questionnaires, interview data and relevant literature manually, and the seven-step ontology construction method is followed to construct the ontology of ICH.

Current popular ontology construction methods mainly

include the IDEF-5 method, the skeleton method, and the seven-step method. Of these, the seven-step method is by far the most well-developed method. Proposed by the Stanford University Medical Intelligence Group, it is a domain ontology construction method based on the ontology construction tool, Protégé. The main idea behind this method was to abstract the main terms of the ontology into classes, define the properties of the class and create instances. Through seven steps, concept classification and ontology construction are completed. The process is detailed in Figure 1.
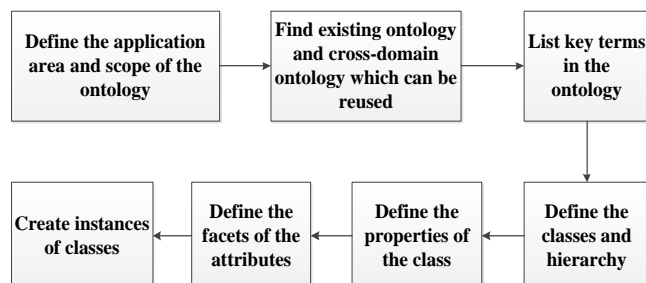

Fig. 1. Flow chart of Seven-Step Method

This paper constructs the ontology of the Nanjing Yunjin weaving technique on the basis of the seven-step method. The research process is as follows:

Step 1: Information collection and ontology design of ICH:
Initially, the information about ICH was collected in a comprehensive way, including a literature inquiry, web search, field investigation and interview research. Some relevant information is searched in "China National Knowledge Infrastructure" (CNKI), libraries, related forums, official websites and communities. The Nanjing Yunjin Research Institute and the Nanjing Yunjin Museum provided an opportunity for observation, inquiry, photography and interviews with experts and tourists. Finally, the corpus of the Yunjin ontology is constructed by integrating the collected amassed data, converting the multimedia information into text and removing the repeated text information.

Step 2: Based on the concepts, relationships, and instances contained in the ontology, the data extraction, ontology construction and visualization of Nanjing Yunjin are as follows:
1. Constructing an ICH knowledge system based on the analysis of problems in natural and social environment of the ICH and scope analysis;
2. Extracting knowledge from ICH by conducting content analysis based on the ICH knowledge system;
3. Defining the entities and properties of the ontology based on CIDOC CRM;
4. Creating ontology instances for specific ICH resources (Nanjing Yunjin);

Step 3: Semantic Web module design of ICH ontology:
The Semantic Web can effectively realize the semantic retrieval of the ICH data, which was conducive to the outward dissemination of ICH, so as to promote the cultural ecological balance of ICH. Therefore, at this stage, through the design of the semantic network module function, the research provided ideas for the development and management of ICH resources.

4. Practical Plan

4.1 Ecological Analysis of ICH

Based on the field surveys and literature reviews, it is found that Nanjing Yunjin is a cultural product formed in a certain natural and social environment. The natural conditions, stable and

prosperous political environment, inclusive and diverse cultural environment and high-speed development information environment, which are close to mountains and rivers and have suitable climate, interact with each other, and together constitute the cultural and ecological situation of Nanjing Yunjin weaving technique. Its cultural ecosystem is shown in Figure 2.
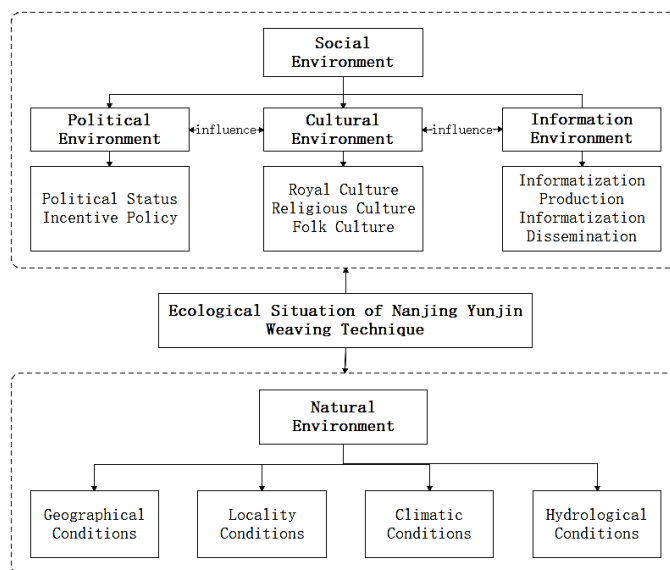

Fig. 2. Ecological situation of Nanjing Yunjin weaving technique

Based on the above summary, the problems faced by Nanjing Yunjin weaving technique are analyzed in terms of the natural and social environments respectively.

1) The scope of development is limited, and insufficient attention is paid to the "dynamic nature." In terms of the natural environment, Nanjing Yunjin weaving technique is clearly territorial, and the people who inherit them basically live in the relevant areas. Due to the maintenance of their authenticity, Nanjing Yunjin weaving technique is difficult to leave its relevant living environment, limiting the scope of development and influence. While it is important to maintain the authenticity of the ICH, equally important is its "dynamic nature," which means that it is not only inherited from generation to generation, but is also constantly recreated in the process of interaction with the natural and historical environment. The current conservation of Nanjing Yunjin weaving technique in the National Museum of China and other places is relatively static, that is, it only records cultural and historical information, but not the changes in its modernity, ignoring the dynamic nature of its living environment, which does not truly reflect the value of the ICH (Xu, 2018). Therefore, the digital recording of ICH information should not be a mechanical digital reproduction of books or archives, but rather an organic integration, systematic sorting and real-time expansion.

2) Insufficient social awareness and reduced social demands. Although the inheritance and development of traditional handicrafts is currently strongly supported by national policies, not many people really know about Nanjing Yunjin weaving technique, and even many local Nanjingers are unaware of it. Based on a survey, Cheng concluded that the most important problem currently facing Yunjin is publicity. Due to the lack of long-term and stable external publicity channels, most young groups do not have a deep understanding of it, and do not have a clear perception of its development, making external dissemination and development a significant problem (Cheng, 2015). Additionally, as Nanjing Yunjin weaving technique was used by the royalty during the feudal period, most people in modern society consider it expensive and impractical. Therefore, the development of Nanjin Yunjin needs to adapt to changing times and the needs of consumers, and there is more space and potential for the extension of its industrial chain (Zhou, 2019).

During this process, the use of technology is also indispensable, both in terms of demand acquisition and market development.

The above analysis shows that the development of Nanjing Yunjin weaving technique has so far suffered from deficiencies in propagation, inheritance and exploitation, and many scholars have argued that Nanjing Yunjin weaving technique needs to be protected and inherited from the perspective of information technology. As ontologies are extensible, through ontologization, the ontology of the ICH can be constantly replenished according to the results of its re-creation in the process of interaction with the environment, and the semantic web helps to promote systematic knowledge of ICH. The next part of this paper presents a concrete solution for the digitalization of Nanjing Yunjin weaving technique in practice, combining ontology and semantic web technologies.

4.2 Ontology Construction Based on CIDOC CRM

4.2.1 Analysis of Scope and Corpus

The analysis of Nanjing Yunjin cultural ecosystem can serve as a reference for ideas on entity extraction and ontology construction from the perspective of ICH integrity conservation. Based on this, ontology construction is carried out by the seven-step method, in order to provide a reference for digital application in the information environment. The first step of the seven-step method is to determine the professional field and scope of the ontology. In the inheritance of traditional handicrafts, the most important argument is about successors. However, the craftsmanship is too difficult to make most young people avoid like a plague, finally, the apprenticeship numbers have gradually declined (Guo & Zhong, 2018). This has greatly increased the difficulty of inheritance. In addition, most ICHs have been inherited over many generations and the relevant information is sizable. Therefore, the purpose of the ICH ontology in this study is to preserve the intangibles in the form of ontology data and to associate the effective information about the ICH ontology through the form of the Semantic Web.

According to the characteristics of ICH and the analysis of its cultural ecosystem, this paper extracted the categories "actor" and "place" on the basis of Nanjing Yunjin Brocade products and its weaving skills, and combined the knowledge classification methods of scholars Hao (2011) and Hu (2016) to classify the knowledge categories of traditional crafts into "activity," "temporal," "actor," "place" and "thing."

• Activity refers to the activities related to ICH organized and participated in by individuals, including the production techniques, and exhibition activities and communication activities.

• Temporal signifies the time periods associated with ICH, including the origin and prosperity of ICH, important events in the development of ICH and the execution time of important processes during ICH activities.

• Actor refers to people and organizations closely related to the origin, development and inheritance of ICH, including its founders, the application and operation units of ICH, and the organizers and participants in ICH activities.

• Place represents the development, display and inheritance of ICH, including the origin of ICH, the location of ICH, the location of ICH activities, and the location of major events related to ICH.

• Thing signifies the tangible and intangible items closely related to ICH, including items required for its inheritance, the finished products, landmarks, and derivatives of ICH activities.

The information related to ICH obtained from the literature, the Internet, and the field work is particularly large and diverse making it particularly difficult to directly construct the ontology.

Therefore, the pictures, audio and other related information were converted into words firstly, and the duplicate and irrelevant information was removed. Thus, the corpus for the next analysis was organized. Based on the knowledge classification system discussed, the key information from the five categories was extracted to obtain a complete ICH knowledge system.

4.2.2 Select Concept and Property of the Domain

Entity extraction is the extraction of important concepts and information in the field of ICH. The entity is also called "class" in CIDOC CRM, which is usually a collection of one or more items with the same characteristics, so that items belonging to the class can be more easily identified by virtue of their differentiating and characterizing characteristics. In the work of entity defining, the first step is to identify the central entity and derive other entities accordingly. Through the corpus analysis, the knowledge of ICH was summarized into the five categories discussed in section 4.2.1 above. Combined with the knowledge concept of the CIDOC CRM top-level subject, the categories can correspond to "Temporal Entity," "Place," "Actor," "Time-Span," and "Thing" respectively. CIDOC CRM provided a scope note for all entities and specified the explicit properties available between different entities and logical inferences between super- and sub-classes between entities and properties. Figure 3 presents the structure of some entities and their levels, and Table 1 exhibits some of the properties.
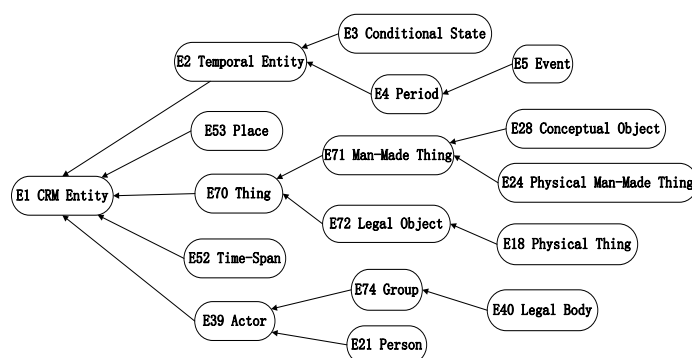

Fig. 3. Structure of some entities and their levels of ICH

Table 1. Some of the main properties used by the entity

Property ID	Property Name	Property ID	Property Name
P1	is identified by (identifies)	P33	used specific technique (was used by)
P2	has type(is type of)	P70	is documented in
P5/P9	consists of (forms part of)	P92	brought into existence (was brought into existence by)
P14	carried out by	P120	occurs before (occurs after)
P15	was influenced by (influenced)	P139	has alternative form
P20	had specific purpose (was purpose of)	P167	at (was place of)

4.2.3 Analysis of Nanjing Yunjin weaving technique corpus

Through the collection of knowledge information in the online and offline channels, the paper analyzed the corpus of Nanjing Yunjin weaving technique from five aspects: "activity," "temporal," "actor," "place" and "thing" to form a knowledge system of techniques, as illustrated in Figure 4.
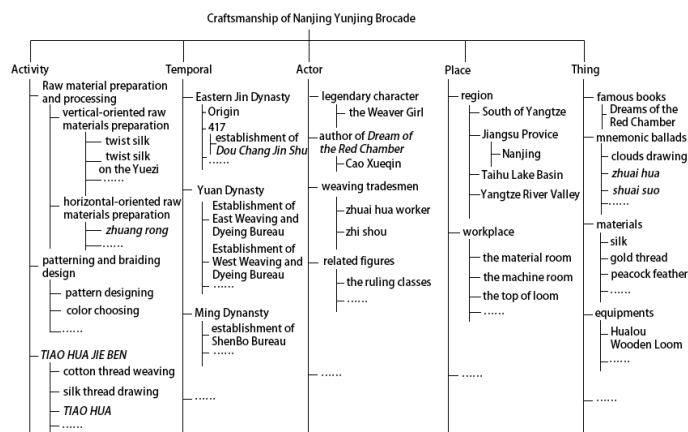
Fig. 4. The knowledge system of Nanjing Yunjin weaving technique

4.2.3.1 Activity

As the representative of the ancient silk weaving process, Nanjing Yunjin weaving technique flourished during the Yuan, Ming and Qing Dynasties, and represented the highest level in Chinese brocade technology at that time. As a kind of "Shu Zhi Ti hua Silk Fabric" (one kind of silk fabric which is dyed before woven), all the weaving processes need to be made by hand, which are exceptionally cumbersome. The steps are first processed through silking, dyeing, etc., and then weaved with gold and silver thread. The only remaining "wooden-loom Zhuang Hua with hand-woven technology" is the one that has been handed down. Its weaving process includes five steps: raw material preparation and processing, patterning and braiding design, TIAO HUA JIE BEN, the setup of looms and weaving. In every major process, there are many small intricate processes. It is only with the craftsmanship and sophisticated raw materials that the Nanjing Yunjin Brocade can be weaved with beautiful patterns.

4.2.3.2 Temporal

In the 417th year of the Eastern Jin Dynasty, the birth of the "Douchang brocade office" marked the Nanjing Yunjin Brocade as an independent silk fabric on the stage of history (Wang, 2012). During the Yuan, Ming and Qing periods, the Nanjing Yunjin was listed as a royal imperial product. In every period, different Nanjing Yunjin production facility were established. Some of the most striking and well-woven works have been handed down through the generations and are now housed in the Nanjing Yunjin Museum and other museums. With the demise of the Qing Dynasty and the advent of the industrial age, the Nanjing Yunjin weaving technique as a traditional handicraft went into decline. After New China was founded, the Nanjing Yunjin Research Institute was established in 1957, the techniques began to be rescued.

4.2.3.3 Actor

As a traditional handicraft in China, Nanjing Yunjin has long been associated with legendary figures and historical culture in the process of development. One of the most famous was a Zhinu, who was called "Yunjin Niangniang" (goddess of brocade weaving) by the Nanjing people. The industrious and simple Jiankang girl was able to weave the Nanjing Yunjin which appears like gorgeous clouds, because of the craftsmanship taught by the Weaver Girl and the Cowherd (husband of Weaver Girl). Besides, the word "Yunjin" has appeared frequently in the novels of the Six Dynasties and achieved the peak of literature and art in the Dream of Red Mansions by Cao Xueqin during the Qing Dynasty,

whose three generations worked in Jiangning Weaving Bureau, which established a very deep relationship with Nanjing Yunjin.

In the Nanjing Yunjin weaving process, the weaving tradesmen has two roles: One man who sitting on the top of the textile machine and responsible for the operation of the jacquard program, called "zhuai hua worker"; The second man who sitting under the textile machine and responsible for weaving of patterns and colors according to the warp opening lifted by the former, called "weaving hand" (Wang, 2012).

4.2.3.4 Place

In the past, the brocade's main production base was concentrated in the South of Yangtze, and now only Nanjing retains its production process, hence its name, "Nanjing Yunjin." During the Yuan, Ming and Qing Dynasties, the production facilities of the Nanjing Yunjin were divided into the material and machine rooms. The material room was predominantly used for raw material preparation and processing while the machine room was used for Brocade weaving. The main production tool of Nanjing Yunjin is "Hualou wooden loom," which can be divided into "large Hualou wooden jacquard loom" and "small Hualou wooden jacquard loom," the former contains 1,924 parts. The complexity of the loom is evident.

4.2.3.5 Thing

Nanjing Yunjin is made of processed silk as raw material, peacock feather line, gold and silver thread and color line. It is mainly divided into four varieties, but only one of them has been handed down, which is "wooden-loom Zhuang Hua with hand-woven technology" that was listed in the first batch of the National Intangible Cultural Heritage. In addition, in the development of Nanjing Yunjin, a wide-ranging art form has also formed among the weavers, such as mnemonic ballads that remind them of the techniques and the "White Bureau" tunes with "Jiangnan" characteristics (a kind of style of culture or folk in south of the Yangtze River).

4.2.4 Ontology Construction of Nanjing Yunjin weaving technique

According to the extracted knowledge system of Craftsmanship of Nanjing Yunjin, this study defined a total of 556 entities and properties based on the ontology definition rules of CIDOC CRM, as presented in Table 2.

According to the entities and properties defined by CIDOC CRM, the ontological relationship network formed is displayed in Figure 5[1]. The Nanjing Yunjin weaving technique (E1 CRM Entity) is a (P2 has type) traditional handicraft (E55 Type), used to weave (P20 had specific purpose) Nanjing Yunjin (E71 Man Made Thing). Nanjing Yunjin hailed from (P92 brought into existence) Eastern Jin Dynasty (E67 Birth). The weaving process includes (P9 consists of) raw material preparation and processing (E7 Activity), patterning and braiding design (E7 Activity), TIAO HUA JIE BEN (E7 Activity), the setup of looms (E7 Activity) and weaving (E7 Activity). Among them, the raw materials (E18 Physical Object) used for (P16 used specific object) raw material preparation and processing, include silk (E1 CRM Entity), peacock feather (E1 CRM Entity) and gold thread (E1 CRM Entity). The alternative form (P139 has alternative form) of TIAO HUA JIE BEN is Tongjing Duanwei (E41 Appellation). The setup of looms is used to make (P20 had specific purpose) Hualou wooden loom (E71 Man Made Thing). The brocade is required to use (P16 used specific object) a weave knife (E18 Physical Thing),

[1] The ontology data of Nanjing weaving technique is available at: https://figshare.com/articles/dataset/Ontology_data_of_Nanjing_weaving_technique_556_records_/14251688.

which is mainly made of (P45 consists of) hardwood (E57 material) and has a knife length (E54 Dimension) of (E90 has value) 110 (E60 Number) centimeters (E58 Measurement Unit).

Table 2. Some entities and properties of the Nanjing Yunjin weaving technique

Property ID	Property Name	Entity-Domain	Entity-Range
P2	has type (is type of)	E1 CRM Entity Nanjing Yunjin weaving technique	E55 Type Chinese Traditional Craftsmanship
P20	had specific purpose (was purpose of)	E7 Activity Nanjing Yunjin weaving technique	E71 Man Made Thing Nanjing Yunjin Brocade
P9	consists of (forms part of)	E1 CRM Entity Nanjing Yunjin weaving technique	E7 Activity the setup of looms
P1	is identified by (identifies)	E1 CRM Entity the setup of looms	E41 Appellation "Zao Ji"
P20	had specific purpose (was purpose of)	E7 Activity "Zao Ji"	E71 Man Made Thing Hualou wooden loom
P139	has alternative form	E41 Appellation Hualou wooden loom	E41 Appellation TiHua Loom
P33	used specific technique (was used by)	E7 Activity "Zao Ji"	E29 Design or Procedure "Da Fan Zi"
……	……	……	……

4.3 Semantic Web Query Construction Based on MediaWiki

Semantic Web is an extension of the World Wide Web. In 2000, the concept was first formally proposed by Tim Berners-Lee, the father of the World Wide Web. The core of the concept is to add semantic meta-data to documents on the World Wide Web (such as HTML and XML documents). This makes the network sufficiently intelligent to enable the computer to understand semantics and the words and concepts and the logical relationship between them, making the entire Internet a universal medium of information exchange. In this way, the Semantic Web adds some semantic information that can be understood by the computer on the basis of the World Wide Web. It not only facilitates the user to read and use, but also realizes the interaction and cooperation between computers.

Based on the Semantic Web technology, the research steps in this stage were as follows: (1) the design of the Semantic Web page based on the MediaWiki platform and Semantic MediaWiki extension; (2) the creation of the ontology entities and properties and their hierarchy and (3) an example of semantic query function and examples of application.

4.3.1 Design of Semantic Web Page

Originally designed to write Wikipedia, MediaWiki (MW) was designed by students at the University of Cologne and Magnus Manske program developers. It runs in the PHP+MySQL environment and is currently the world's most famous open source wiki. It is the system software of Wikipedia and the platform of choice for building wiki websites. In China, systems such as Grey Fox are currently using this system. Taking Wikipedia, the world's largest wiki project, as an example, MW has the advantages of having rich features and multi-language support. MW also has many features in the creation of web pages, including open editing, allowing the use of templates and a self-selecting system appearance that makes it convenient for users to support the classification, internationalization, etc.

Released in 2005, Semantic MediaWiki (SMW) is a free and open source MW extension founded the Voikel scholars at the University of Karlsruhe, Germany and designed to address MW's content consistency, knowledge access control, knowledge reuse, etc. SMW enables computers to understand the meaning of structured content by adding semantics to the content and structuring it, thus, enhancing SMW's search and navigation functions. The specific operation is to mark the knowledge content by a set of semantic mark-up rules, and the format is [[property:: property value]]. When searching, all the pages containing the marked content can be displayed in the form of a list.
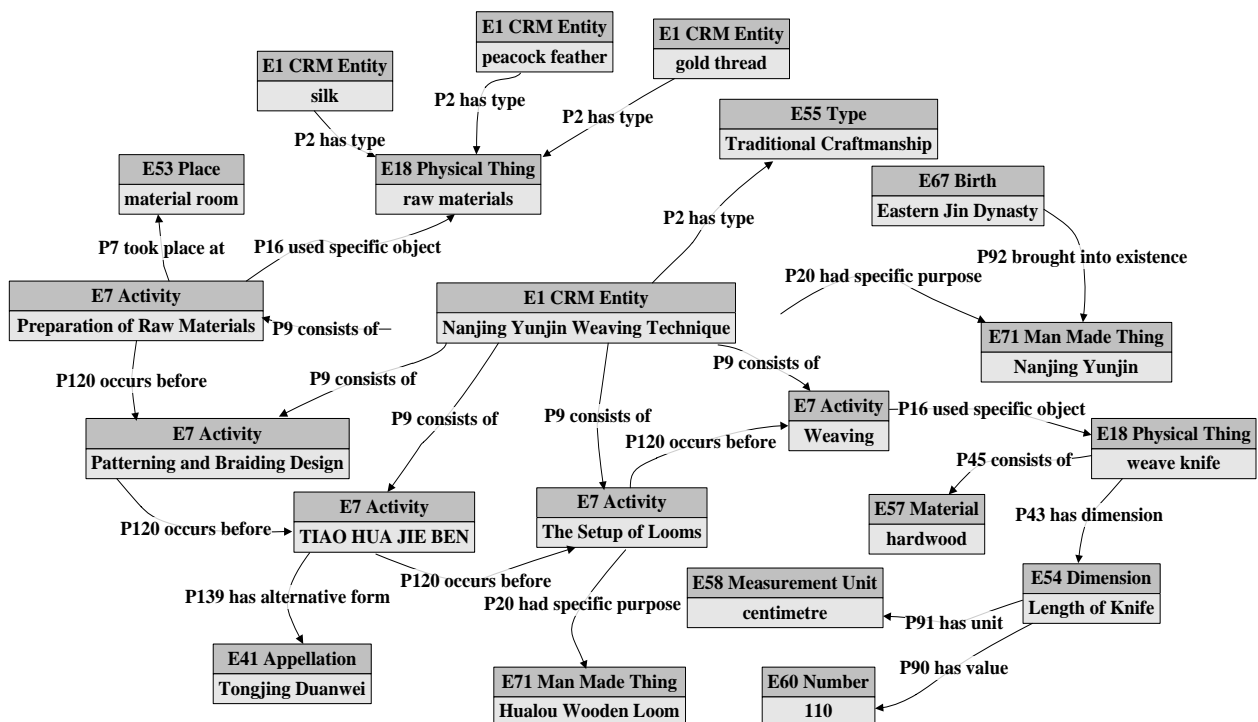

Fig. 5. Partial ontological relationship network diagram of the Nanjing Yunjin weaving technique

This study used the MW system to build an ICH ontology semantic web platform for two reasons: On the one hand, MW was more user-friendly, and the use of MW to build web pages was simple and easy to popularize, which can effectively reduce the cost of tools in constructing the Semantic Web. On the other hand, MW provided the SMW extension to facilitate semantic query functionality. Based on the basic framework and editing rules provided by MW, the homepage of the Semantic Web was designed. As displayed in Figure 6, under the default skin of the website, the user interface design was simple and clear, the style was unified, the color was predominantly white, the picture was rich, and the design was user-friendly.
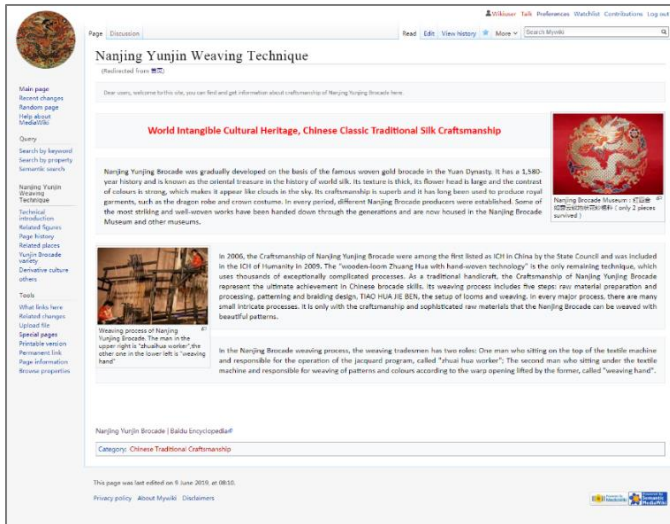
Fig. 6. Homepage design of Semantic Web of Nanjing Yunjin weaving technique

The main design work was as follows:

(1) The website icon was replaced with a very representative Yunjin Brocade from the "Wanli" period of the Ming dynasty. It was copied by the Nanjing Yunjin Research Institute. The homepage name was set to "Nanjing Yunjin weaving technique."

(2) To facilitate user retrieval, three search functions were added in the navigation bar on the left of the screen. At the same time, to enable user access and understanding, the relevant content of Nanjing Yunjin weaving technique in the navigation bar was divided into seven categories: "technical introduction," "related figures," "history," "related places," "Yunjin variety," "derivative culture" and a final category named "others."

(3) An overview of Nanjing Yunjin and its weaving techniques were added in the main body of the page while two representative images were added to enrich the form of the page content.

(4) A Baidu Encyclopedia external link to the Nanjing Yunjin Brocade was added at the bottom of the page to allow users to acquire greater understanding of the topic.

4.3.2 Creation of Entity and Property Hierarchy

Based on the ontology knowledge system that was constructed, a hierarchy of entities and properties had to be created. The grammar "[[Category:Name]]" provided by MW was used to build the entity in a hierarchical order. At the bottom of the classification page, the framework was automatically generated to display the parent entity. At the same time, the index on the classification page was generated at the bottom of the parent page. The purpose of this operation was to provide the reader with a list of topics for easy retrieval and review.

As presented in Figure 7, since "TIAO HUA JIE BEN" was a process in the "Nanjing Yunjin weaving technique," "Category:

TIAO HUA JIE BEN" was entered after "index.php" in the address bar to create page for the category (category page). At the same time, "[[Category: Nanjing Yunjin weaving technique]]" was entered in the text editing area. After clicking "Save Page," the index of "Classification: Nanjing Yunjin weaving technique" appeared at the bottom of the category page, TIAO HUA JIE BEN. Similarly, a category page entitled "TIAO HUA" was created, "TIAO HUA" was a sub-process of "TIAO HUA JIE BEN," "[[Category: TIAO HUA JIE BEN]]" was entered in the text editing area of page "TIAO HUA." Hence, the "TIAO HUA JIE BEN" category page contained the links to parent page, "Nanjing Yunjin weaving technique" and sub-category page, "TIAO HUA." The default sorting basis of the subclass link was the first word or letter of the page name, as shown in Figure 8.
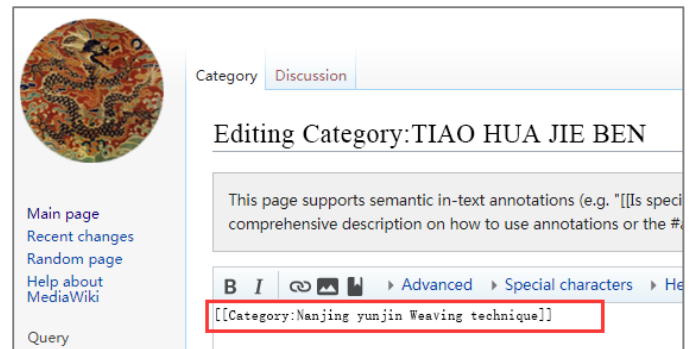

Fig. 7. The creation process of the entity hierarchy

Fig. 8. Display interface of the entity hierarchy

After creating the entity hierarchy, the entity was described in text and multimedia form on the entity classification page, followed by a description and the hierarchical construction of properties.

The hierarchy of property was created in the same way. First, "Property: property name" after the "index.php" was entered in the home page address to create a page for the property and its inverse property (property page). Subsequently, the syntax format "[[Subproperty of::Property: the parent property name]]" was used to perform the hierarchical construction of the property. Thus, the index of the child property page was generated on the parent property page and the sub-property page also created an index pointing to the parent property page.

As shown in Figure 9, the entity "color choosing," as a process of "patterning and braiding design," required the use of "color system" -related knowledge. The process was represented by the property, "used specific object." At the same time, because the "color choosing" process was affected by the "mnemonic ballads of color" process, it was represented by the property: "was influenced by." CIDOC CRM specified that the property "P16 used specific object" was a sub-property of the property "P15 was influenced by." Therefore, after creating the page, "Property: used specific object," "[[Subproperty of::Property:was influenced by]]" was edited in the page and the creation of a property hierarchy was complete.
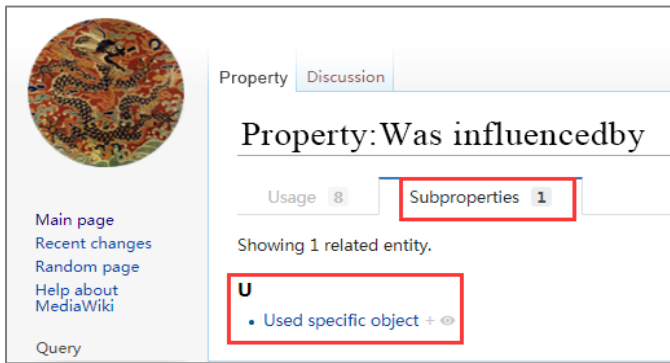
Fig. 9. User interface of the hierarchical of properties

The process of creating pages, adding property descriptions and building hierarchy for all properties was as described above. It is noteworthy that the property description syntax format was: "[[Property description:: description content]]." After the completion of that process, properties could be used on the entity pages. This step was implemented by the grammar, "[[property name:: entity name]]," and the index of the corresponding marked entity was directly displayed on the page.

As shown in Figure10, since the "patterning and braiding design" included steps, such as the "pattern designing," "color choosing," "organization designing," "specification designing" and "jacquard cards creating," the property "consists of" needed to be marked accordingly on the page "patterning and braiding design" while the reverse property "[[forms part of:: pattern designing]" was marked on these sub-operation pages to generate an index of the marked object on the respective pages.
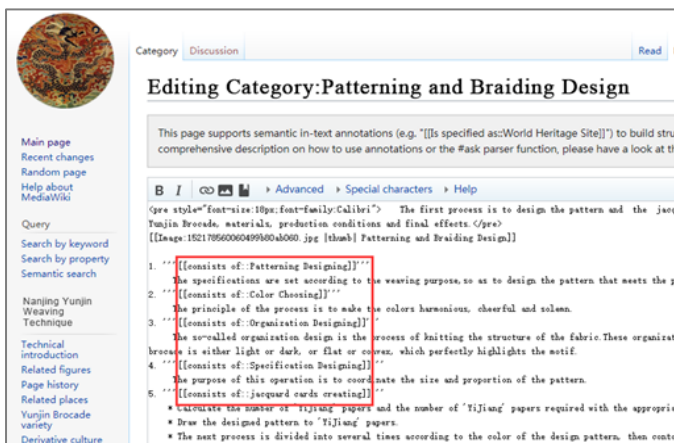

Fig. 10. Property definition in the entity page

4.3.3 Instance Test of Semantic Query Function

The ultimate goal of Semantic Web construction is to implement the semantic query function. There are three ways to implement the query function on the platform, including the function of "Search by Keyword" in MediaWiki and "Search by Property" and "Semantic Search" provided by SMW extension. Only the final one can implement inference queries and compound queries.

4.3.3.1 Search by Keyword

"Search by Keyword" means that the user inputs keywords in the search box at the top right of the MW. As shown in Figure11, if an individual wanted to search for content related to "Yunjin brocade," they enter that word in the search box. There were two types of search results, including pages matching by page title and page content.
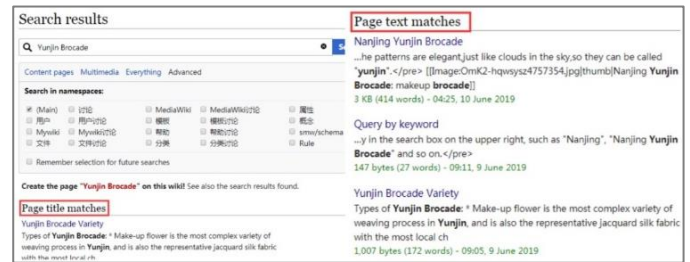

Fig. 11. Example of a keyword query

4.3.3.2 Search by Property

As shown in Figure12, the SMW extension provided the function to search by property, enabling property retrieval of the ICH content.
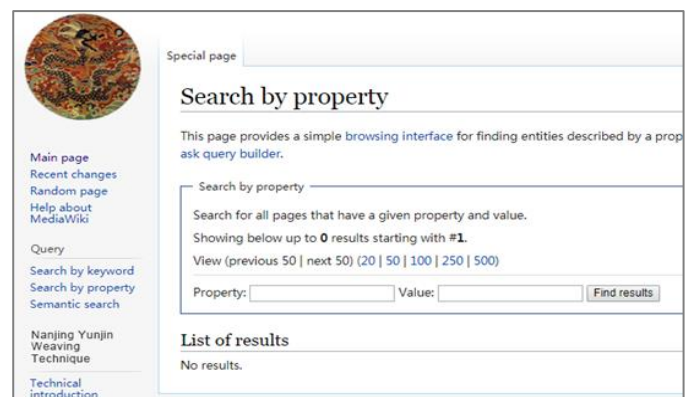

Fig. 12. "Search by property" page provided by SMW

On this page, the properties and the corresponding value fields were entered. When the "Find Results" button was chosen, the results list was displayed for all pages containing the properties corresponding to this value. As presented in Figure13, if one required another name for the process, "Zhuai Hua" (a sub-process of weaving, also known as "La Hua," "Pan Hua," "Ti Hua," "Wan Hua"), the property "has alternative form" could be entered in the property box. If one entered "Zhuai Hua" in the value box, a link to the corresponding page was displayed in the result list.

4.3.3.3 Semantic Search

The "Semantic Search" function was also provided by the SMW extension. Unlike "Search by Property," this feature enabled more search needs, such as category and subcategory inferential, property and sub-property inferential and compound conditional searches.

(1) Category and Subcategory Inferential Search

If the user wanted to search the relevant page of the Nanjing Yunjin weaving technique and the page of its sub-category, they entered "[[Category: Nanjing Yunjin weaving technique]]" in the condition search box, as shown in Figure14, the results list included "weaving," "raw material preparation and processing," "Da Wei," etc. Taking "Da Wei" (a sub-process of weaving) as an example, although the "Da Wei" page was not marked as a sub-category of "Nanjing Yunjin weaving technique," "Da Wei" was marked as a sub-category of "weaving," which belongs to one of the five main processes of "Nanjing Yunjin weaving technique," Therefore, "Da Wei" was also recognized as one of the categories of "Nanjing Yunjin weaving technique," thus realizing the search function of categories and sub-categories.
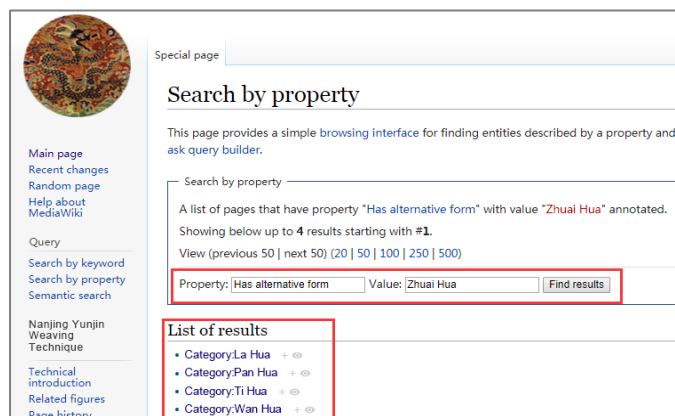
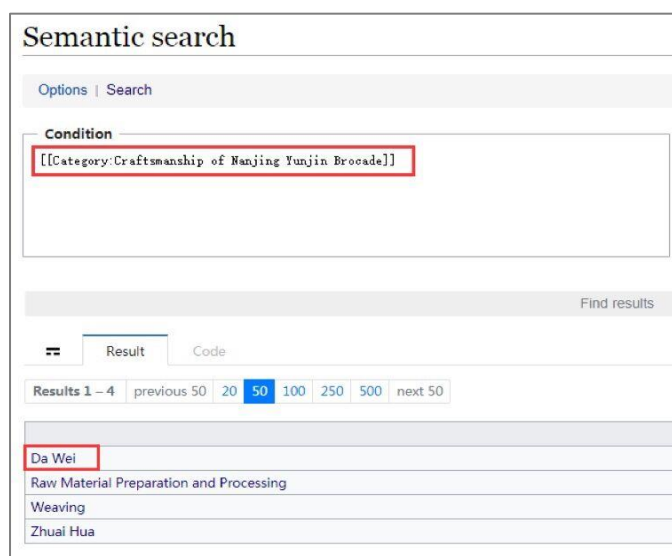**Fig. 13.** Example of searching by property

Fig. 14. Example of inferential search for categories and subcategories

(2) Property and Sub-Property Inferential Search

The property and sub-property inference search function was primarily reflected in the fact that if one entered "[[property name:: property value]]" in the condition search box, the result list would not only show the category page of the properties corresponding to the value, but also the page of their sub-properties, whose property value also correspond to the same value.

As shown in Figure15, in the property page "has current location," the property was set to be a sub-property of "has former or current location," that is, "[[Subproperty of::Property:has former or current location]]." The property "[[has former or current location:: The Palace Museum]]" was defined in the page of the "Nanjing Yunjin Brocade" and the property "[[has current location:: The Palace Museum]]" was defined in the page of the "Moon-white Woven Peony Pattern Zhuang Hua Silk" (a kind of Nanjing Yunjin currently stored in The Palace Museum). If the user wanted to inquire about the works of the ICH that were currently or previously stored in the Forbidden City Museum in Beijing, they entered "[[has former or current location::Beijing Forbidden City Museum]]" in the search box. Two pages discussed above would appear. In this case, the property and sub-property inferential search functions were implemented when performing search work.
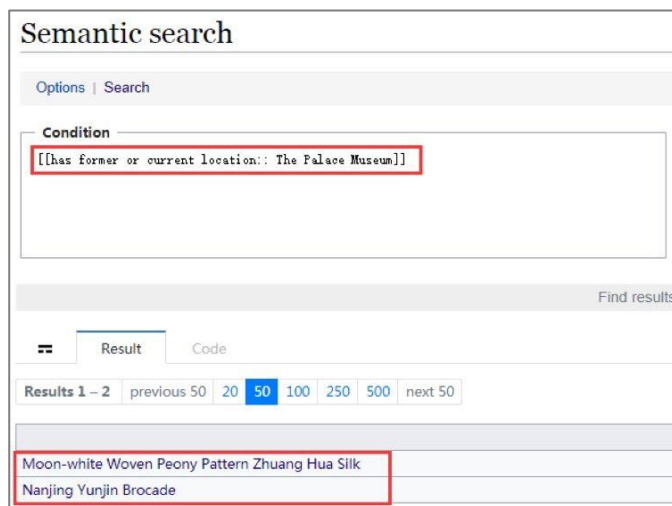

Fig. 15. Example of property and sub-property inferential search

(3) Search based on Compound Conditions

If the user wanted to find the sub-process which is been after the "Pan Zhi" in the main process "Weaving" and before the "Songjing and Juanqu," they entered the three conditions of "[[Category: Weaving]]," "[[occurs after::Pan Zhi]]" and "[[occurs before::Songjing and Juanqu]]" in the conditional search box. As shown in Figure16, the "Da Wei" process appeared in the results list.

Figure 16. Example of Search based on Compound Conditions

5. Conclusions

This study selected Nanjing Yunjin weaving technique as the main research object. Firstly, Based on the cultural ecology theory, the cultural ecosystem of Nanjing Yunjin weaving technique was analysed, so as to consider the environmental factors in the development process of the technique, and to summarise the problems in the natural and social environment, on the basis of which the ontology knowledge system was constructed. Specifically, combining its natural environment, political environment, cultural environment and information environment, based on the existing literature, it extracts the two categories of "person" and "place," and divides its knowledge system into "activity," "time," "actors," "place" and "goods"; among them, "actors" include persons and organizations that are closely related to the origin, development and inheritance of ICH, including founders, inheritors, etc.; while "place" includes the area of ICH development, display and inheritance. Based on this,

the cultural knowledge of Nanjing Yunjin was systematically sorted and stored. Later, based on the existing problems of insufficient publicity of the ICH, the semantic web was constructed to make full use of the existing information environment to spread its knowledge and culture. In the theoretical sense, many scholars have studied ICH from the perspective of cultural ecology theory, and put forward the digital needs of ICH, but only end up with theories and strategies (Hu, Li, & Zhou, 2018; Xue, 2020). Therefore, this paper makes an attempt to enrich the digital application scenarios of the cultural ecology theory based on the digital application of the theory. In a practical sense, this model can be used as a reference for ICH related websites, such as local ICH official website and museum website, as well as tourism information platforms. Examples of applications are as follows:

(1) Exhibition and dissemination of ICH knowledge

The construction of Semantic Web based on the complete and constantly perfected ontology knowledge system allows for the systematic display of ICH related knowledge, and thus the role of ICH knowledge storage, protection, and display. Meanwhile, the storage mode in the form of multimedia is conducive to skill teaching and inheritance, which can be applied internally to the internal teaching platform, and can be applied externally to the exhibition and dissemination of ICH related websites, local resource websites and tourist information platforms, so as to bring ICH knowledge to the masses (Wan, 2015).

In addition, the platform can be integrated into the teaching system, such as entering the second classroom in primary and secondary schools, opening classes of interest in ICH, etc., and conducting ICH education for primary and secondary school students through text, pictures, videos and other media (Guo, 2019), which cannot only broaden the vision of students, but also popularize the knowledge of ICH, and cultivate the younger generation's awareness and interest in ICH.

(2) Related applications of tourism information platform

In recent years, ICH tourism has become a hot topic in the tourism market. As the best tourism resource, culture can be integrated with tourism by means of information technology, which helps to better spread traditional Chinese culture and maintain the normal operation of the cultural ecosystem. In this study, the construction of Semantic Web can be applied to tourism information platforms to achieve an organic integration with the six major elements of tourism: food, accommodation, transportation, travel, shopping, and entertainment. For example, taking the research object of this article as an example, the page "Nanjing Yunjin store recommendation" can be established, and internal links in the "Nanjing Yunjin" were added to other entity pages, so as to make Nanjing Yunjin more market-oriented and commercialized; at the same time, a page of food and accommodation recommendations can be established, and add internal links to "relevant places" and other pages, so as to facilitate tourists to making travel itineraries.

The disadvantage of this study is that it only chooses Nanjing Yunjin weaving technique, a representative traditional handicraft, as the research object, while other types of handicraft and ICH are not considered, thus having certain limitations in universality.

Declaration of competing interests

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