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Knowledge graph construction and dissemination analysis in folk culture space: a case study of Wuzhen Xiangshi

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Purpose/significance: In the era of network self-media, online communication plays a crucial role in promoting the development of folk tourism. The computational communication method is utilized to analyze and visualize the communication content of the spatial elements of folk culture space, which is helpful for the development of folk culture space and the dissemination of national culture.

Method/process: Initially, the technical methodology of the knowledge graph was introduced, and an ontology model of cultural space was developed from the perspective of folk tourism. Utilizing the CIDOC-CRM model, the entity classes, attributes, and relationships were modeled, the core elements of cultural space were extracted from the description of cultural space by natural language analysis, and a knowledge graph was constructed. Building on this foundation, the network communication content of each element was collected, cleaned, and aligned. Utilizing computational communication methods, a multidimensional analysis of the network communication content for each element was conducted, and its communication, friendliness, influence, and interaction were studied. The public's communication preferences and the emotional tendency of the spatial elements of folk culture space were explored. Finally, the communication content is embedded into the graph to form a communication-oriented knowledge graph of the spatial elements of the folk culture space oriented toward communication, and the systematic and structured representation of the knowledge graph is realized.

Result/conclusion: Taking Wuzhen Xiangshi, a cultural space in the ancient water town located in the south of the Yangtze River, as a case study, this research constructs a knowledge map of the elements of Wuzhen Xiangshi oriented to communication and analyzes its communication characteristics to provide reference and help for the organization and dissemination of folk culture space.

KEYWORDS

folk culture space, knowledge graph, computational propagation, Wuzhen Xiangshi, era of network communication

1 Introduction

Folklore tourism is an activity in which folklore matters as the main content, and folklore culture is the basis for the survival and development of folklore tourism. The development of folklore resources can promote the development of the folklore tourism economy and help to enhance the sense of belonging to the nation, construct the sense of

community of the Chinese nation, and realize the protection and preservation of folklore resources (Duan and Che, 2021). However, there are still many problems with the current development of folklore resources, including insufficient understanding of the user's experience to accurately grasp tourists' preferences, as well as the generalization of folklore tourism and the creation of "pseudo-folklore." With the age of self-publishing, Weibo, TikTok, RedNotes, and a host of other social media platforms have been widely loved by the public. People can not only share their own travel experiences by clocking in on their cell phones and shooting short videos but can also participate by retweeting, favoriting, and commenting, creating a new way of digital experience. Folklore tourism enables tourists to gain cultural experiences through the supply of folklore resources. What are the elements of complete folk culture? Which folklore resources do local areas preserve? Which elements are the most popular among tourists? What resources are in dire need of improvement? With the help of knowledge engineering technology, folklore resources can be sorted, and elements of folklore can be extracted to explore the rich cultural connotations of folklore activities. At the same time, through the collection and analysis of communication content, a composite knowledge network of folk tourism and network communication can be constructed, which can deeply excavate the public's preference for folk resources and folk elements and the strength of communication. Jiangnan Water Town is a unique regional culture in China, which has unique folk culture characteristics. Typical collective folklore activities in Jiangnan Water Town folklore belong to the cultural space, such as various temple fairs, festivals, etc., which have the dual attributes of "spatial and temporal" and "material culture and intangible culture," rich folklore elements, and many people participating in them. It has rich folklore elements, many participants, and considerable network dissemination strength. Research on this topic can provide more convenient knowledge tools for resource planning and scene design of folk tourism and provide a knowledge reference for the dissemination of folk culture.

2 Related work

2.1 Current status of folk smart tourism research

The 19th CPC National Congress Report outlined a rural revitalization strategy. Subsequently, the CPC Central Committee and State Council issued *The Strategic Plan for Rural Revitalization (2018–2022)*, which emphasized to *reshape the cultural ecology of the countryside, closely combine the construction of characteristic towns and beautiful villages, make in-depth excavation of cultural symbols of countryside characteristics, revitalize local and ethnic characteristics and cultural resources, and pursue a path of specialization and differentiated development*. In 2019, the General Office of the State Council released *Opinions on Further Stimulating the Consumption Potential of Culture and Tourism,* proposing to "promote the integration of culture, tourism, and modern technology." At the same time, the digitalization of culture is becoming increasingly important. In 2021, the State Council promulgated *"The Opinions on Further Strengthening the Protection of Intangible Cultural Heritage,"* which explicitly pointed out the strengthening of digitization, the use of modern scientific and technological means, and the strengthening of the integration and sharing of national intangible cultural heritage resources, as well as their wide dissemination and effective use. For example, Xia Shu proposes to build a smart tourism ecosystem by intelligently connecting the physical, social, personal, and temporal elements in the tourism context. Yan (2018) proposes that digital technology and smart tourism contribute to the organic integration of spiritual space and physical space, which will bring about a dramatic change in the way tourism value is created and tourists experience it.

2.2 State of the art in knowledge graph research

Compared with traditional digital recording and storage technologies, Knowledge Graph has powerful semantic processing and open interconnection capabilities and is an effective tool for describing massive entities, entity attributes, and inter-entity relationships. With the rapid development of the semantic web, many knowledge bases have appeared. These include Linked Open Data and YAGO (Wang et al., 2017). With the advent of the Digital Intelligence Era, semantic technologies such as ontologies, Linked Data, and Knowledge Graphs are beginning to be applied to the knowledge organization of cultural heritage digital project resources. Carriero et al. proposed using knowledge graph RDF technology to encode and classify Italian NRM resources and to query and retrieve the association relationship between each NRM in the SPARQL language, which helps cultural heritage to realize smarter preservation applications (Carriero et al., 2019). In China, scholars have also conducted research on the construction of knowledge graphs in the field of non-heritage. For example, through Cite Space, Ji and Guo (2021) conducted a knowledge mapping analysis of the themes and evolutionary trends of NRM research in Liaoning Province. Yao Zhan-lei et al. analyze the problems of NRL folklore dissemination and put forward suggestions by drawing the key points of folklore knowledge mapping and comparing the differences between official propaganda and self-media dissemination (Yao et al., 2019). Fan Qing et al. constructed a knowledge graph model of intangible cultural heritage to form a link with the region, culture, and intangible cultural heritage itself, and utilized knowledge graph-related technology to display different types of intangible cultural heritage in the region (Fan et al., 2021).

2.3 State of the art in computational communication research

Along with the impact of the Internet and modern media technology on people's daily lives, an increasing number of scholars have begun to use online big data to explore hot social issues and analyze political communication phenomena (Liu, 2022). Overseas, computational communication has also been applied to news dissemination, computational advertising, and other fields. The choice of tourist destination depends on the level of awareness of the image of the destination, which is often influenced by tourist

information (Huang, 2018). YUAN Chao proposed that analyzing the demand characteristics of tourists from the perspective of perception can provide a useful basis for judging the level of tourism development (Yuan et al., 2020). Therefore, analyzing the content of online folklore tourism communication using computational communication methods can help understand and characterize the needs of tourists.

3 Domain ontology modeling of cultural spaces

3.1 Conceptual and domain ontology modeling of cultural spaces

Before constructing a knowledge map of cultural space, it is necessary to model the domain ontology of cultural space, which is a formal representation of conceptual classes and the relationships between them within a domain capable of describing information at the semantic and knowledge levels. The ontology of cultural space contains static environmental space and dynamic cultural activities with spatial, temporal, and cultural diversity. Therefore, cultural space needs to be analyzed from these three perspectives at a fine-grained level in terms of knowledge and resource elements.

3.2 Ontology modeling methodology for cultural spaces

The more extensive ontology construction methods include the Skeleton, TOVE, and Seven-Step methods, among which the Seven-Step method is the most versatile and applicable to the construction of ontologies in various domains. This study adopts a Seven-Step Ontology Construction Method to construct an ontology for a cultural space. After defining the cultural space ontology and conceptual classes and their attributes, the construction of instances related to the domain ontology can be accomplished by utilizing the collection and construction of datasets, thereby expanding the knowledge graph.

3.3 Analysis of the core elements of the cultural space knowledge meta

In 2001, for the first time, the six towns of Suzhou and Zhejiang proposed a joint bid for heritage. In the same year, it was inscribed on *"The Tentative List of World Cultural Heritage in China."* The project will be expanded to 15 ancient towns in Jiangsu, Zhejiang, and Shanghai by 2019 and written into *"The '14th Five-Year Plan' for Cultural Relics Protection and Scientific and Technological Innovation"* issued by the General Office of the State Council in 2021. This study centers on 15 ancient towns and analyzes the core elements of cultural space folklore from different dimensions, such as space, time, people, events, and things. Space refers to the physical space, place, or location where cultural space and folk activities are held, such as temple activities in the temple, which play a pivotal role in the cultural transition (Hui, 2024). Folklore is also organized at a time that is close to the time of the festival or because of the festival, which gives folklore special significance at the time level. The human element consists of the people involved in the organization of the event and commemorative figures, such as the Silkworm Flower Maiden. The event element refers to the traditional folklore activities that occur in the place where the rituals take place, such as parades and festivals, which are organized in accordance with the living habits of the people in the place, the rhythms of the year, and their beliefs (Zhan-qiong and Tian, 2023). The thing element, on the other hand, includes iconic physical objects in folklore activities, such as silkworm flowers, dragon heads, and shadow puppets, and includes intangible forms of non-folklore and online communication content, such as news reports and travel blogs.

3.4 Creation of core classes and attributes for cultural spatial knowledge metacategories

Before proceeding with ontology modeling, it is necessary to identify the metadata standards on which ontology semantic modeling is built. Metadata is the data of data, a structured description of information resources, which is used to organize, describe, discover, retrieve, index, integrate, browse, preserve, and manage information resources. If the description standard for folklore information is not unified, it is difficult to form an integrative and interactive nature of knowledge. By formulating a unified framework for metadata, rich folklore cultural information from different sources can be integrated, solving the problem that it is difficult to describe with standard cataloging rules and word lists, and facilitating the unified management and sharing of different data.

3.5 Modeling of cultural space ontology

After completing the definition of cultural space, NRM ontology classes, and hierarchical relationships, various types of entity attributes and data attributes need to be defined and described. Object attributes, i.e., relationship attributes, mainly express the relationship between entity classes and have definition and value domains corresponding to entities.

For example, "P70_is_doucumented_in" is a record relationship that indicates that the culture space "E2 Temporal Entity" is recorded in "E70 Thing," where "E2 Temporal Entity" is the definition field and "E70 Thing" is the value field.

The metadata structure standards related to the field of cultural heritage research are CIDOC-CRM, DC, CDWA, and VRA; the data content standards are CCO and DACS; and the data value standards are AAT and CONA. The CIDOC Conceptual Reference Model (CIDOC-CRM) is an international standard for cultural heritage information developed by the International Documentation Committee of ICOM. The International Standard for Cultural Heritage Information developed by ICOM (Yi-ru and Dong-hui, 2023) is also an ontology conceptual model with the highest generality and applicability in the field of non-heritage. The model has a wide coverage of non-heritage resources and, at the same time, has a strong openness. After determining the metadata structure, entity classes, attributes, and relationships were modeled based on the reuse of CIDOC-CRM. First, the top-level core concepts and attributes of the cultural space domain ontology were clarified. In order to clarify and

TABLE 1 Core categories of the cultural space of the ancient town of Jiangnan Water Town.

Top-level concepts	Secondary core concepts	Third core concepts	The structural hierarchy of concept terms
Cultural space category E1 CRM Entity	Jiangnan water town	Space E53 place	Region of organization, region of origin, region of prevalence
	Ancient town	Time E52 time-span	Time of organization, time of origin
	Cultural space	Person E21 person	Historical figures, inheritors, creators
	E2 temporal	Event E5 event	Event Ceremony, Public Information
	Entity	Thing E70 thing	Artifacts, Non-Heritage Items, Works, Documents, Videos

TABLE 2 Cultural space ontology object attributes (part).

OWL: top object property	RDFs: comment	Domains	Ranges
crm:p59_is_located_on	Be situated at	Cultural spaces/architecture/people/events	Location
CRM:P164_is_temporally_specified_by	Date of occurrence	Cultural spaces/events	Time
CRM:P70_is_doucumented_in	Recorded in	Cultural spaces/events/people	Literature/web content dissemination
CRM:P5_has_preferred_identifier	Landmark	Cultural space	Artifacts/Non-projects
crm:12_occurred_in_the_presence_of	Occurrence	Cultural space	Ceremonial activities/news events

TABLE 3 Data attributes of ontology classes (partial).

Domains	OWL: top data property
Old town in southern Jiangsu province	Chinese name, alias, category, geographic location, level of attraction, area covered, climatic conditions, description of the old town
Cultural space	Chinese name, alias, type, geographic location, description of folklore, time of origin, time of organization
Person	Name, alias, gender, ethnicity, era of affiliation, character's place of origin, character's occupation, character's description
Thing	Incident type, incident name, incident location, incident time, incident description
Webcast content	Name, author, URL, date posted, number of visits, number of reviews, number of likes, number of retweets, introduction

qualify the scope of knowledge constructed by the knowledge map, this study takes the cultural space class as the top-level conceptual class (crm: E1_CRM Entity), the existing cultural space of 15 ancient towns of the Jiangnan Water Towns as the second-level concept (crm: E2_Temporal_Entity), and other conceptual elements revolve around the cultural space and constitute subcategories. The six core classes of space (crm: E53_Place), time (crm: E2 Temporal_Entity), person (crm: E21_Person), event (crm: E5_Event), and thing (crm: E70_Thing) constitute the subclasses of cultural space. The analysis obtained a structural hierarchy of the core concepts of the cultural space domain of the ancient Jiangnan Water Town, as shown in the following table (Tables 1, 2).

Data attributes are used to express the properties of the entity class. The definition field is the entity class, and the value field is a specific data type. Such as the number "dc: description" definition field is the cultural space "E2 Temporal Entity," and the value field is RDF plain text "RDF: Plain Literal" and "PlainLiteral." The data attributes adopt metadata standards, such as Dublin Core, Records in Context Conceptual Model (RiC-CM), and Friend-of-a-Friend (FOAF) vocabulary, which extend the XML/RDF. The value domain adopts OWL 2 Web Ontology Language. OWL2 provides classes, attributes, individuals, and data values for semantic web expression with a formal definition of meaning, and its standard prefixes include rdf:, rdfs:, owl:, and xsd:. For example, owl: Thing denotes the most generic class. RDF, RDFs, and OWL are ontology description languages recommended by the W3C, and they are also commonly used as storage formats for data in knowledge graphs. RDF, RDFS, and OWL are W3C-recommended ontology description languages and are also common storage formats for data in knowledge mapping, and they are all based on metadata written in XML (see Table 3).

4 Construction of cultural spatial knowledge mapping of Jiangnan Water Town based on ontology modeling

The construction process of the knowledge map is divided into pattern-and data-layer construction, as shown in Figure 1. The construction of the pattern layer determines the scope of the domain ontology and core knowledge elements for the construction of the knowledge map of the cultural space. Finally, the ontology model and ontology library of the cultural space were constructed. The construction of the pattern layer can provide a conceptual model and logical basis for the construction of a knowledge map, thus guiding and standardizing the construction of the data layer. The construction of the data layer is based on the definition and specification of the schema layer to realize the construction of ontology instances. Through data collection, knowledge extraction, knowledge fusion, knowledge processing, and knowledge updating from literature and Internet information, the knowledge map is constructed to form a

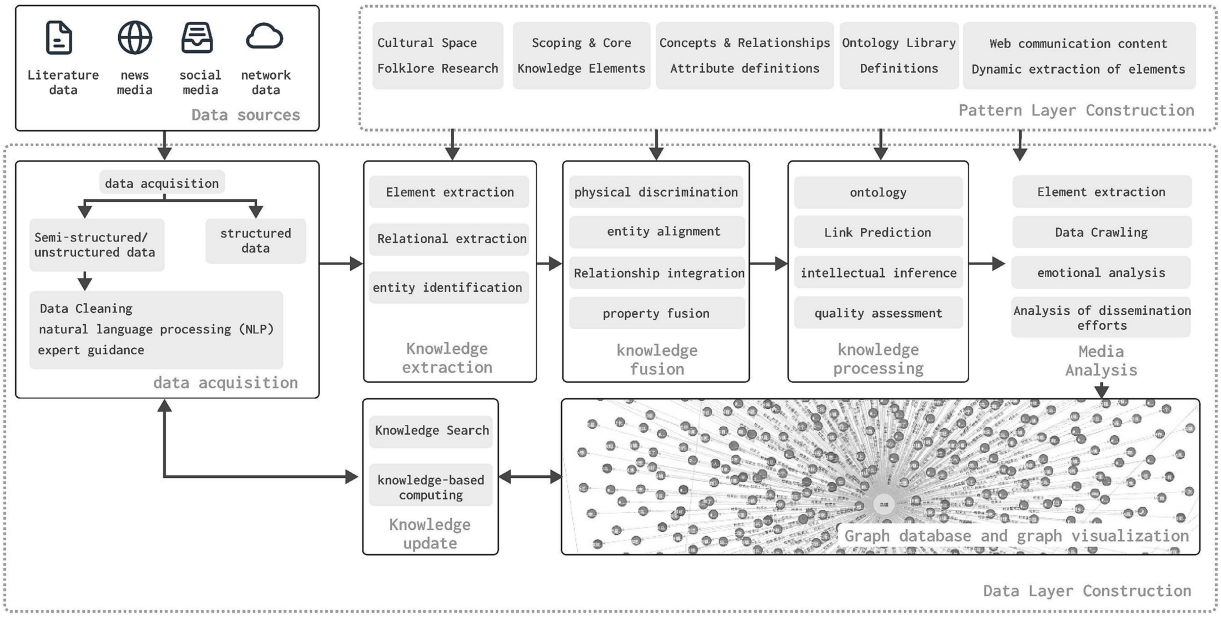


FIGURE 1
The process of building the knowledge graph of cultural space.

knowledge map and then visualized and displayed to support the application of knowledge.

4.1 Data source preprocessing

According to the content of the ontology model described in the previous section, the nodes, edges, node attributes, and temporal features in the knowledge graph to be constructed are described inductively, where the node type, i.e., the type of knowledge element, is equivalent to the ontology of space, time, organization, person, event, thing, etc., and the edges are the associative relationships between knowledge elements, including located, occurrence, occurrence time, participants, etc.

4.2 Knowledge extraction, integration, and processing

4.2.1 Knowledge extraction

After defining the conceptual classes and attributes of the ontology, the construction of core instances of cultural spaces needs to be completed first. In this study, we first used local records as core resources to organize the catalog lists of existing cultural spaces in 15 ancient water towns in Jiangnan. Then, based on the catalog, ontological instances, such as time, space, people, events, and things, were extracted from the textual corpus, such as the official website of the non-heritage site and the authoritative description of the cultural space in the town records of each ancient town. For example, taking the introduction of Wuzhen Xiangshi as an example, "Wuzhen Xiangshi is a unique folklore activity in the south of the Yangtze River, which has been passed down for a long time in Tongxiang Wuzhen. Folk activities during the Xiangshi are rich and colorful, and the Silkworm Flower Festival is the most common and important activity. Wuzhen Xiangshi is located in the square of past temples, such as the Pujing Temple, General Wu Temple, and Chenghuang Temple. On the night of the Qingming Festival, local people began to set up sacrifices, avoid the White Tiger, fast for the silkworm God, and do other activities during which they burned incense and prayed for silkworms, carrying a silkworm sedan chair out on patrol. Women and children along the way to worship incense, singing songs, gathered at the Pu Jing Temple, commonly known as the silkworm flower hill. In the silkworm flower meeting, rural women burn incense to the gods, and after burning incense, they also go to the land temple in front of the water pool to wash their hands, commonly known as washing silkworm flower hands. Natural language processing, such as word segmentation, lexical annotation, and named entities, is carried out by utilizing the Language Technology Platform (LTP) of Harvard University, which is combined with LLM semantic recognition classification, and the effect is shown in Figure 2.

4.2.2 Knowledge fusion

Knowledge fusion refers to the recognition of the equivalence of entities, relationships, and attributes through entity disambiguation, entity alignment, and relationship fusion. Entity disambiguation refers to the elimination of entity designation ambiguity, i.e., the name is the same, but the facts are different, and different entities can be distinguished by instance numbering. For example, "Shaxi Town" has both "Shaxi Town, Taicang City, Jiangsu Province" and "Shaxi Town, Zhongshan City, Guangdong Province," which need to be strictly differentiated in terms of knowledge fusion. Entity alignment refers to the discovery of entities with different but equivalent names, e.g., "Wuzhen" and "Wudun" represent the same entity, and "Walking the Ten Bridges" and "Avoiding Disasters and Seductions" in Wuzhen are the same entity. For example, "Wuzhen" and "Wudun" represent the

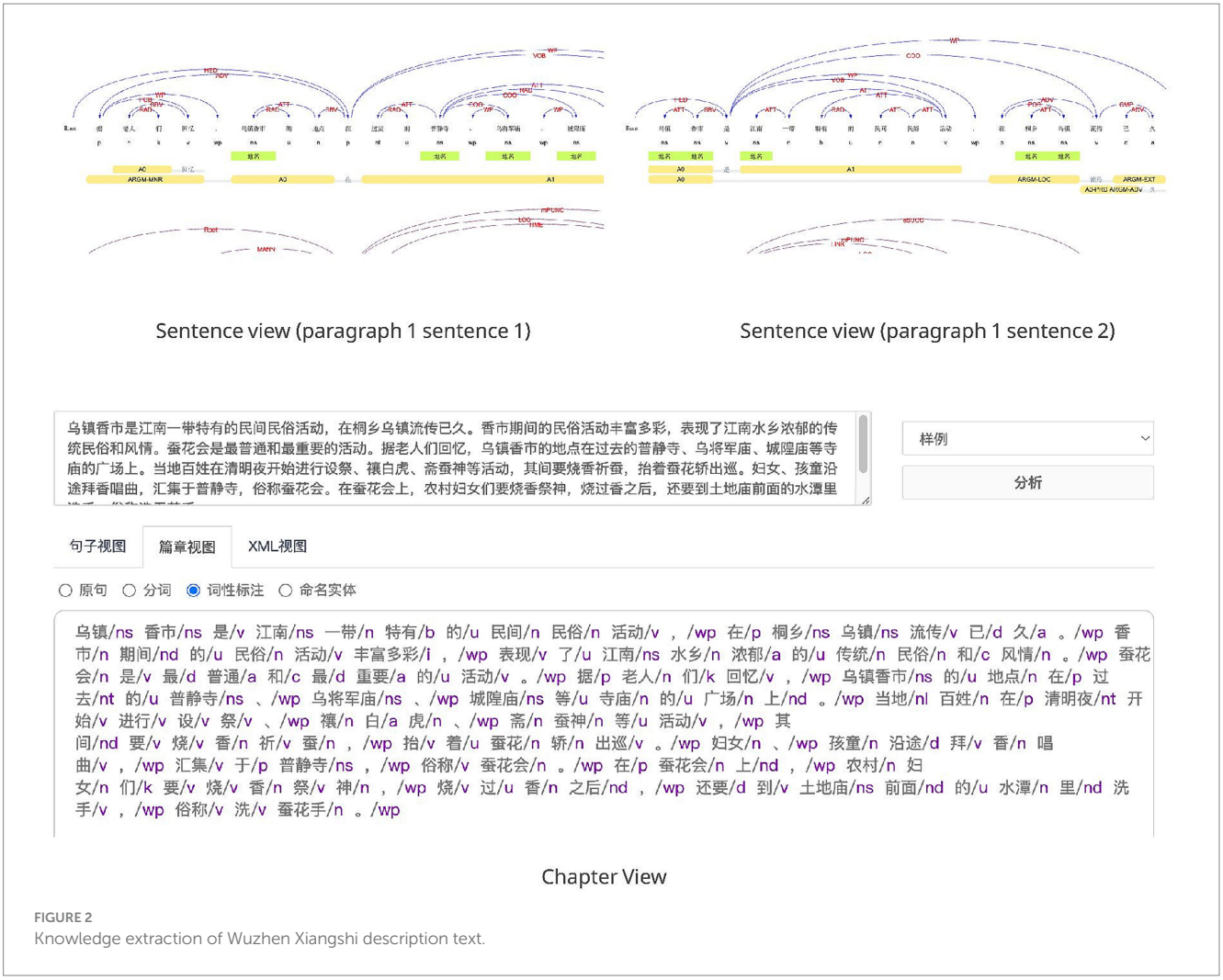


FIGURE 2
Knowledge extraction of Wuzhen Xiangshi description text.

same entity, and "Walking Ten Bridges," "Avoiding Disasters and Sapience," and "Removing Hundreds of Diseases" in Wuzhen represent the same entity, so we need to merge them in the knowledge fusion, and we have constructed the list of names and aliases of the entities to align the entities for this purpose. Relationship fusion refers to determining whether different texts represent the same relationship, such as the need to be "located in," "situated in," and "addressed in" the content of these textual entities, consistent with the determination of the "located in" relationship (see Figure 3).

4.2.3 Knowledge processing

Knowledge processing is the further processing and specification of facts to form a structured knowledge system and the unified management of knowledge to achieve a high-quality knowledge supply. Knowledge processing includes ontology construction, knowledge reasoning, and quality assessment. The most important knowledge reasoning is to excavate or infer unknown implicit semantic relations in response to the incompleteness of existing facts and relations.

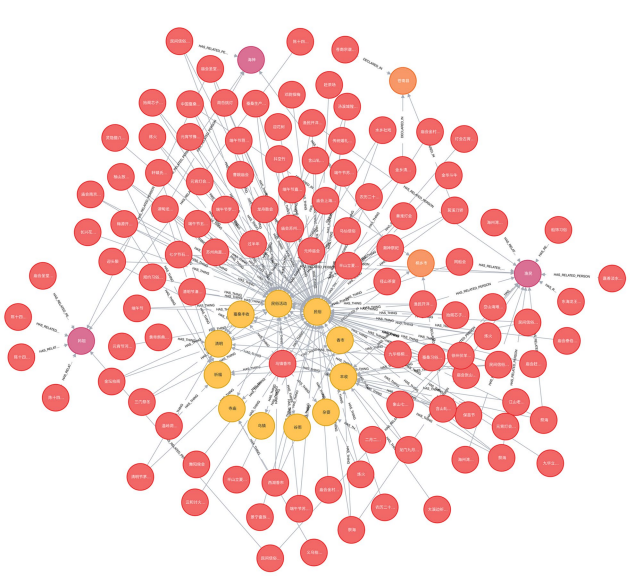
Through the above steps, a cultural spatial knowledge graph of the ancient town of Jiangnan Water Town was constructed, including the node information required for the ontology, such as the place name, person name, time, and activity name.

4.3 Knowledge graph construction, storage, and visualization

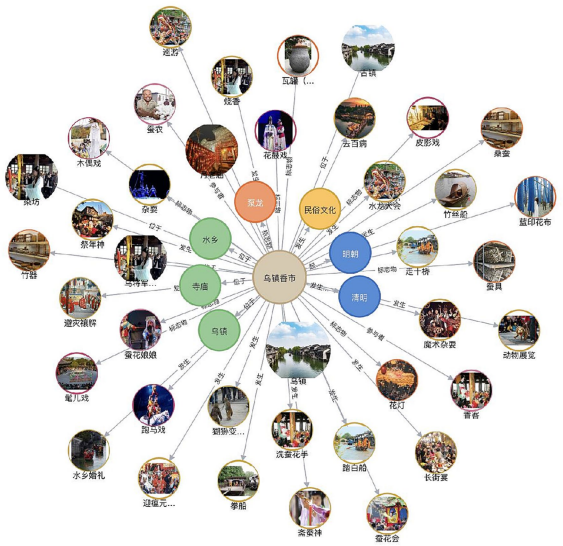
Python was used to link the Neo4j database. In the knowledge extraction and fusion phase, a table-structured knowledge store is used for natural language processing and entity parsing of the text. After completing the knowledge fusion and knowledge processing, a complete OWL description is formed by combining the ontology schema definition of the ontology repository. Then, the RDF data are imported into Neo4j through the Neo semantics plugin so that the instances in the ontology are converted into node labels in Neo4j, and the object attributes and data attributes are converted into relationship types and node attribute values in Neo4j. In addition, the color and size of the node shape are not used to represent the different attribute categories of the nodes.

5 Analysis of the elements of cultural space based on computational communication

In today's digital era, online media has become one of the most important channels for the dissemination of folk culture, especially on



Core elements of Wuzhen Xiangshi



Extension Elements of Wuzhen Xiangshi

FIGURE 3
Core elements/extended elements of the knowledge map of Wuzhen Xiangshi.

social platforms, and short videos have become the main means of self-expression for the public. However, most of the current cultural and tourism applications are based on the user's evaluation of attractions and merchants to recommend resources and lack deep excavation and analysis of folk culture. By combining knowledge mapping and social media communication analysis, we can analyze the folk elements of folk tourism on the one hand and mine and understand the relationship between each element and user preferences on the other hand at a fine-grained level. First, by analyzing the data on browsing, sharing, liking, and commenting on network communication content, we can intuitively calculate the heat degree of each element in folklore tourism and understand its influence and popularity in the public mind. Second, sentiment analysis of the communication content text is used to determine the positive and negative emotions of users toward the element to provide more accurate positioning and planning for the organization of folklore activities. Finally, through the analysis of the time of the heat of the web content, we can determine which folklore elements are gradually fading and which ones are gradually emerging to analyze the evolution trend of folklore elements.

5.1 Web dissemination data collection

The sources of online communication data collection were mainly Baidu News, Ctrip Travel, and microblogging content, and the collection fields were article content, release time, AND number of likes, comments, and retweets. Unlike other common studies that only retrieve the communication content of the subject, this study utilizes the cultural space directory to conduct the first step of the search, such as "Wuzhen Fragrance Market." Then it further expands the retrieval content by utilizing the already extracted cultural spatial elements and geographic regions in the knowledge graph, such as "Wuzhen 斋蚕神 (A ritual at the Xiangshi temple fair in Wuzhen)." At the same time, word frequency analysis is performed on the collected network communication content to classify and identify words with high word frequency, such as the words that belong to the cultural spatial element but are not covered in the original knowledge map, such as "Drama Festival," "Marshal Wen," "Silkworm Flower Maiden," and other elements, which will be added to the knowledge map, and at the same time again, with the element geographic area for secondary search, supplementing the element's network dissemination content. The identification of these added elements not only increases the data support for the network communication content of the cultural space but also enriches the element system of the cultural space so that the final knowledge map can more accurately reflect the communication ecology of the cultural space.

5.2 Analysis of the effectiveness of network communication

The content posted on the network by tourists participating in folkloric tourism often contains personal emotional expression and experience feedback, while viewers' behavior of reading, commenting, and liking the content expresses users' concerns and preferences. The network communication content of the cultural space elements of Wuzhen Xiangshi was analyzed using the communication calculation method in four dimensions: dissemination, influence, interaction, and friendliness.

The degree of dissemination is closely related to the number of articles and retweets and the number of articles and retweets of the dissemination content associated with different elements accumulated by year. The annual changes in the top ten elements of the total are shown in Figure 4. Changes in the degree of dissemination are often closely related to major events or news reports, especially under the

coverage of official media; social attention will rise sharply, which is exceptionally obvious in the dissemination of Wuzhen Xiangshi. For example, in 2018, the Xinhua News Agency reported on Wuzhen Xiangshi, so at the node of 2018, the dissemination degree of various elements for Wuzhen Xiangshi increased significantly. This phenomenon can be explained by "genesis setting theory," which suggests that the media, through their choice of content, can significantly influence the public's attention to a particular event or culture-influencing phenomenon (Mccombs and Shaw, 1972).

The number of likes reflects the degree of influence, with a higher number indicating a higher degree of content recognition. The number of likes for different element-associated communication contents was accumulated by year, and the yearly changes in the top ten are shown in Figure 5. From the figure, the degree of influence of certain element-associated online communication content, such as parades, dyeing workshops, and moon temples, sometimes exceeds that of the communication content of the Xiangshi itself.

The number of comments expresses the degree of communication interaction and the number of comments on communication content associated with different elements accumulated by year. The top ten annual changes are shown in Figure 6. On social media platforms, the degree of interactivity is closely related to the sense of audience participation, and more interactive content tends to inspire more user participation and feedback, further enhancing the communication effects of cultural activities (Baoill and Jenkins, 2006). For example, the openness and interactivity of the elements of the "Long Street Feast" (a ritual at the Xiangshi temple fair in Wuzhen) and the "Parade" enhance the interactivity of the Xiangshi, increase the interest of the public, and lead to the wide dissemination of the relevant content. This shows that interactivity has become a key factor in attracting the attention of audiences to folklore activities.

Friendliness is expressed through sentiment analysis of the communication content, which is calculated by two factors: the positive prob. sentiment score and the sentiment polarity of the collected elemental network communication content text. The results of some samples are shown in Table 4, which estimates the sentiment polarity of the communication content through the probability of the positive category, self-confidence, and the probability of the negative category, with 0 being negative, 1 being neutral, and 2 being positive. The results of the sentiment analysis show the dominance of positive sentiments in the communication content.

Finally, the collected communication content is linked to the corresponding elements of the knowledge graph, as shown in Figure 7. The smaller nodes with distinct clusters are all news reports and hot posts on the Internet, and the results of the sentiment analysis are visualized with color distinctions. Green nodes indicate positive content, blue nodes indicate neutral content, and red nodes indicate negative content. As can be seen from the figure, different elements of the user emotional experience tour differences, such as "water town wedding (a ritual at the Xiangshi temple fair in Wuzhen)" and communication content for more positive emotions, and are easy to trigger a strong positive emotional expression of the topic. Combined with the theory of "sentiment analysis," the performance of emotionally charged content is more likely to resonate with and promote wider dissemination of the message (Pang and Lee, 2008). This has helped increase the dissemination of the cultural space and its elements and has led to more

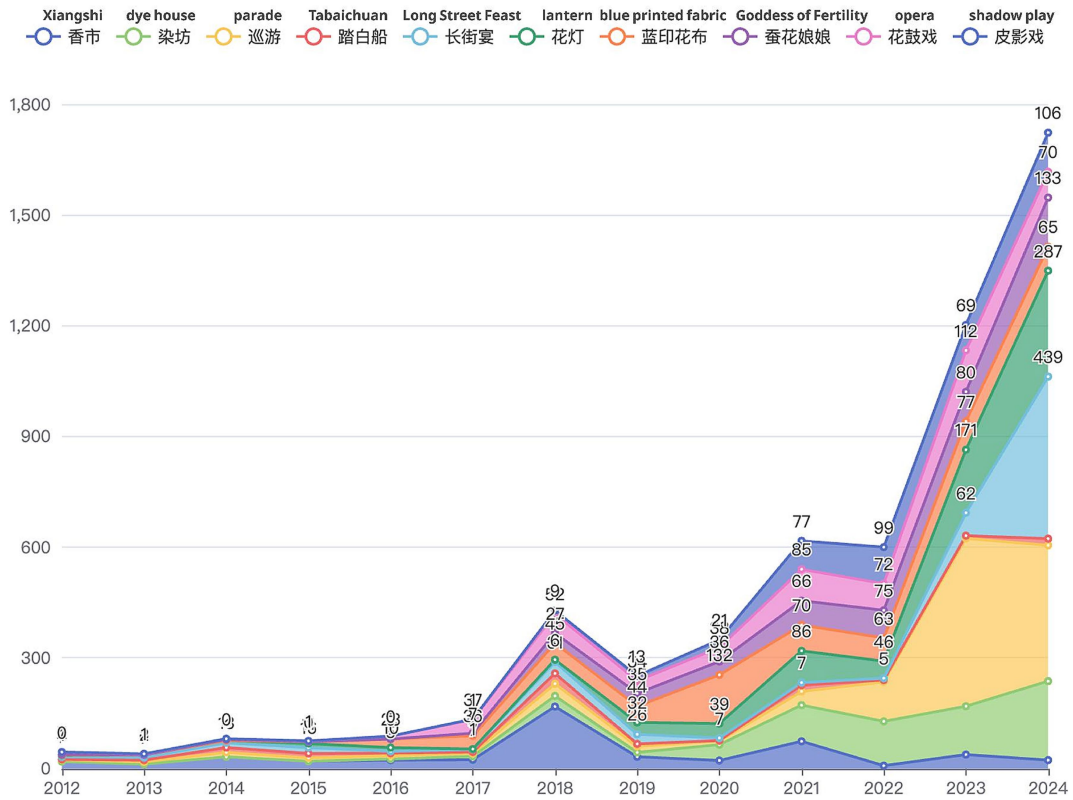


FIGURE 4
Analysis of the spread of the top ten key elements of Wuzhen Xiangshi from 2012 to 2024.

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FIGURE 5
Analysis of the influence of the top ten key elements in Wuzhen Xiangshi from 2012 to 2024.

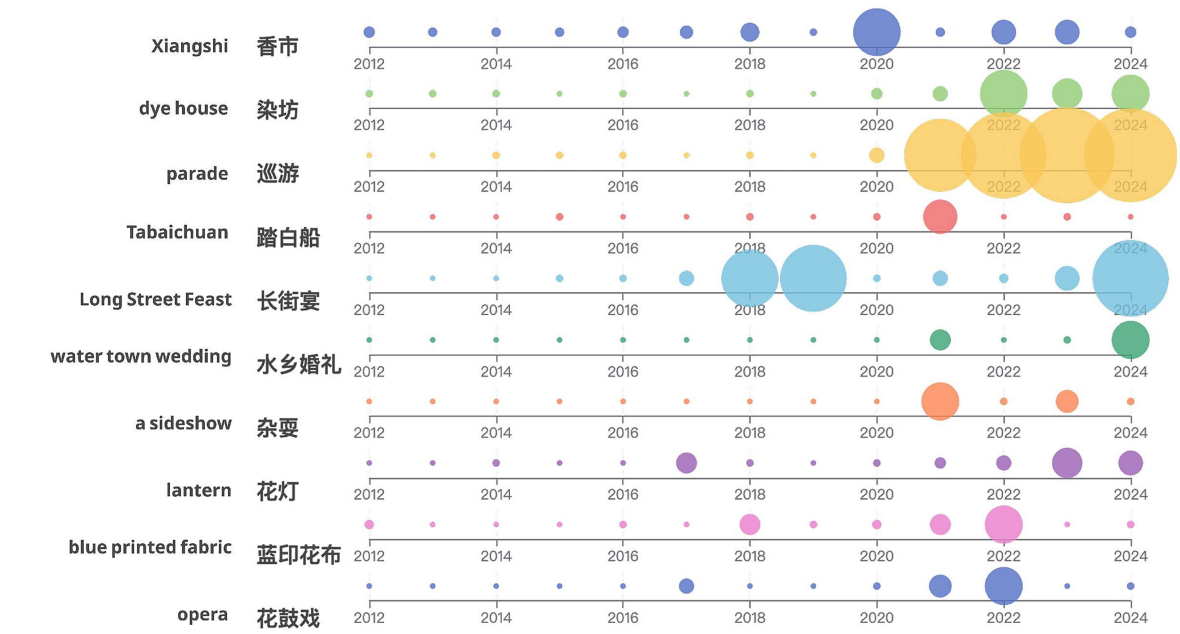

FIGURE 6
Analysis of the interaction of the top ten key elements of Wuzhen Xiangshi from 2012 to 2024.

TABLE 4 Partial sentiment analysis results of the content of web communication of the Wuzhen Xiangshi elements.

Text	Positive_prob	Confidence	Negative_prob	Sentiment
【#乌镇香市…	0.996765	0.992811	0.00323509	2
#乌镇微攻略…	0.927233	0.838295	0.0727672	2
“佳伯的马”…	0.130348	0.710339	0.869652	0
濮院进不去改道…	0.159089	0.64647	0.840911	0
以前因为乌镇戏…	0.45116	0.0231993	0.54884	1

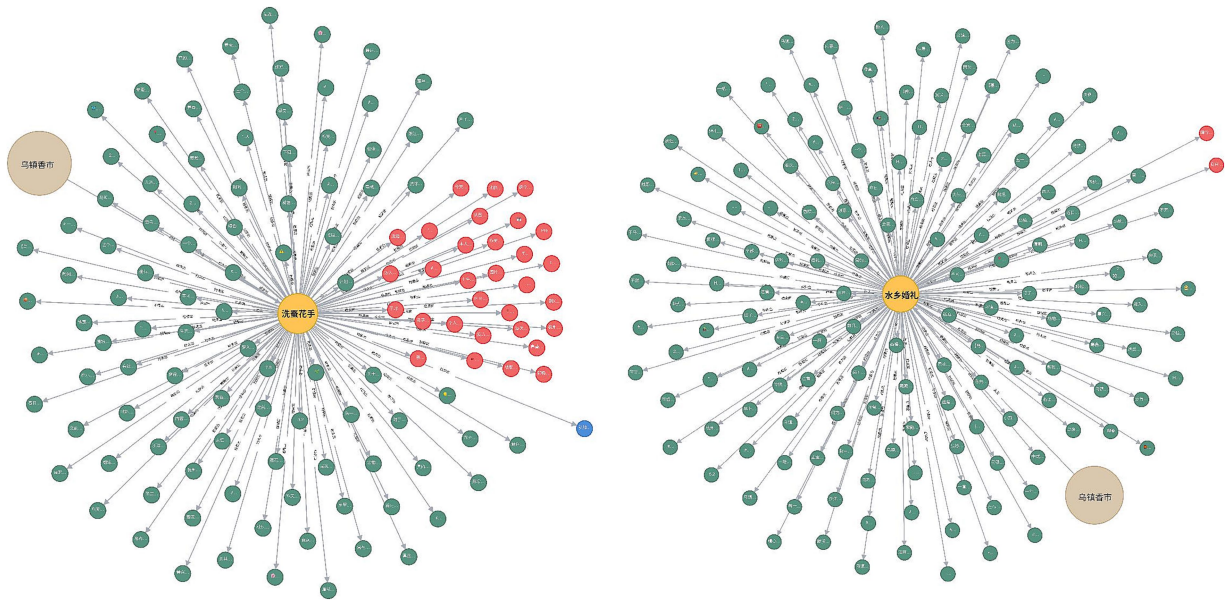

FIGURE 7
Knowledge map of emotional distribution of social media content dissemination of "Silkworm Flower Washing Hands"/"Water Village Wedding" elements.

people engaging in the conversation. Therefore, the use of knowledge graphs and emotion visualization allows for a quick preview of the results of a user's emotional experience of cultural-spatial elements.

5.3 Construction of a knowledge map for the dissemination of cultural spatial elements

By linking the communication content to the element nodes and adding them to the knowledge graph in the knowledge graph, the graph is expanded into a communication-oriented element knowledge graph. Figure 8A shows the knowledge graph of the cultural space elements of Wuzhen Xiangshi, with the spatial element nodes set in rosy red, activity element nodes in yellow, and time element nodes in blue. Figure 8B shows communication-oriented cultural space element mapping of Wuzhen Xiangshi. The green node represents the communication content, and the scale of the green node shows how much the element is associated with the amount of communication content. Communication content is associated with multiple elements, which form a complex cross-connection between the communication content nodes and element nodes, showing the multidimensional association structure of the elements. Figure 8C shows the communication content mapping of "Tabaichuan (A ritual at the Xiangshi temple fair in Wuzhen)," in which the nodes of the communication content with higher dissemination, influence, and interaction degrees are larger and closer to the element. Figure 8D shows the attributes of a single dissemination of a content node. Click on the dissemination content node to view the node attributes, such as text-specific information, release time, release account, release link, emotional value, number of likes, and number of comments. The element node can also be directly associated with the element's dissemination of content analysis (Figure 8E), showing the element's interaction, dissemination, and other changes to the element for multidimensional comparison and analysis.

Through the construction of the knowledge map of cultural space elements, it can intuitively display the elemental composition of the folk culture, and through the node cluster form of the element's network communication content, intuitively observe the element's degree of dissemination, influence, interactivity, and friendliness, and further understand the element's dissemination trend over time, so as to help organizers to explore the more influential elements of folk tourism and launch more targeted communication and publicity. This will help organizers explore more influential elements of folk tourism and launch more targeted communication and publicity. Meanwhile, as one of the folk cultures, cultural space is highly related to various types of non-heritage, and joint mention of multiple elements in the communication content can often achieve better communication effects. Promoting niche elements through popular elements can effectively promote exposure to niche elements and help their protection and dissemination.

6 Conclusion

This study focuses on the cultural space of the ancient towns in the Jiangnan Water Towns in the context of digitization and explores the mining of folklore elements in the network communication content using knowledge engineering techniques. The extraction method and knowledge map construction scheme of cultural space elements are proposed, the definition and extraction of multidimensional elements are realized, and the network communication contents of the elements are collected using computational communication methods. A communication-oriented knowledge map of cultural space in the ancient town of Jiangnan Water Town is constructed, analyzed, and displayed in a visualized form to provide credible knowledge services for the positioning, holding, researching, and dissemination of folklore activities.

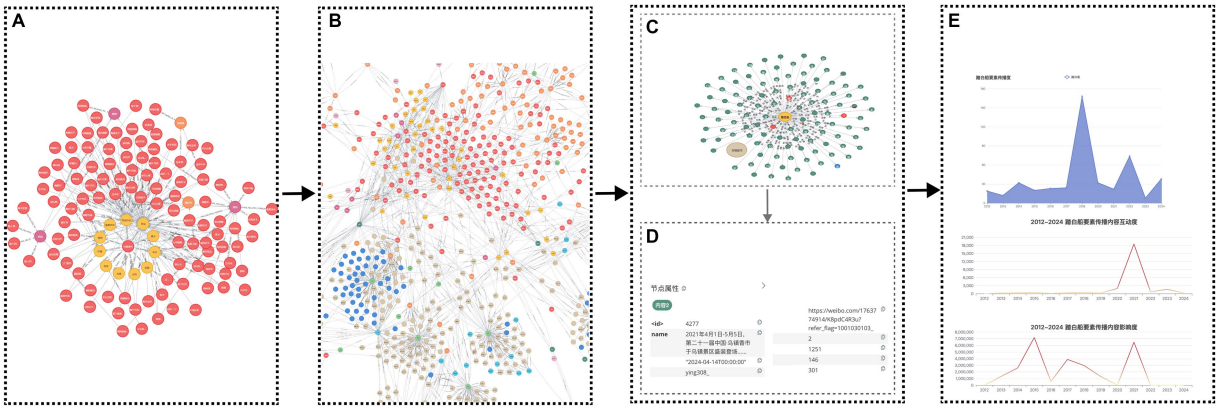

FIGURE 8
Visualization and node properties of different levels of the knowledge graph of cultural space elements in Wuzhen Xiangshi. **(A)** Knowledge mapping of cultural spatial elements in Wuzhen Xiangshi. **(B)** Knowledge mapping of communication content in the cultural space of Wuzhen Xiangshi. **(C)** "Tabaichuan" Dissemination of content knowledge mapping. **(D)** "Tabaichuan" dissemination of content attributes. **(E)** Analysis of the content mapping of "Tabaichuan communications.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

HaiZ: Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. JX: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Writing – original draft, Writing – review & editing. HaoZ: Methodology, Software, Writing – original draft, Writing – review & editing.

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The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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