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A meme-based approach for knowledge mining, organization, and presentation of traditional Chinese settlement culture

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Abstract

Traditional Chinese settlements are successful examples of harmonious coexistence between man and nature. Traditional Chinese settlement culture (TCSC) is the product of its inhabitants' adaptation to the natural and social environment and has national cultural originality and transmission. Core cultural elements of these being chosen to stay can be considered as memes. This study considers traditional Chinese settlement cultural memes (TCSCM) as a special kind of knowledge, and proposes a meme-based approach to mine, organize, and present traditional Chinese settlement cultural knowledge from a knowledge management perspective. This approach is composed of identifying memes, constructing the memes ontology, and the memes knowledge graph, mainly describing and establishing the memes identification index system, the ontology conceptual framework, and knowledge graph construction rules. In addition, the feasibility of the above work is verified by a case study of Jinggang Ancient town in Hunan province. This study provides new practical ideas for the authentic conservation and industrial construction of TCSC.

Keywords Traditional Chinese settlement culture (TCSC), Memes, Memes ontology, Memes knowledge graph

Introduction

"Traditional settlements", also known as historical and cultural settlements in China, refer to the formation of the historical period, retaining significant historical and cultural characteristics, and the history of relatively complete ancient towns, ancient cities, and ancient villages [1]. They are excellent examples of the harmonious coexistence between human beings and nature, and their profound culture bears witness to Chinese farming civilization and records China's long national history. Along with a series of policies such as "rural revitalization" [2] and "cultural confidence" [3], China attaches more importance to the protection and development of traditional Chinese settlement culture (TCSC). However, due to the lack of knowledge guidance of settlement culture, the development and construction process of traditional Chinese settlements not only easily destroy the original settlement cultural environment but also the homogenization phenomenon is more common. Therefore, excavating and utilizing the characteristic cultural information of the settlement has become an important issue in this context. At present, several research results have been published in TCSC conservation, involving regional culture [4, 5], cultural landscape [6–9], spatial forms [10–14], cultural resources [15], etc. Through the available literature, researchers have mostly focused on the preservation of the material forms of TCSC, while neglecting the knowledge mining of their culture.

The application of the "gene" to the study of settlements was first introduced as a biogenetic concept by Clark and Kroeber, who pointed out that cultural areas

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formed by different regions have a "genetic gene" similar to biology [14]. Richard Dawkins proposed the concept of cultural replication factors by analogy with biological replication factor genes and called such replication factors "memes" [16]. Kate Distin further elaborated on the evolutionary process of memes, arguing that memes are replicated and transmitted and that their hosts often reorganize or mutate the representation of information when they replicate and transmit them [17]. We consider that the "genes" of TCSC are memes, and the evolution and development of settlement culture are the results of the evolution of its memes.

From an information-theoretic perspective, memes are a semantic unit of information that can be copied, selected, disseminated, and exchanged for information processing or computation [18], and is a "knowledge-based" independent unit of meaning [19]. The memes of traditional Chinese settlements carry the semantic information of the settled culture, which is further refined, processed, and abstracted to obtain the knowledge of the settled culture and thus guide the practical activities that humans take on traditional Chinese settlements, such as tourism development, archaeological research, etc. In fact, to make knowledge accessible and usable (by human or technological agents), it has to be organized in some way [20]. The characteristics of knowledge organization proposed by Broughton et al. [21] and Hjørland [22] include two items: (1) knowledge organization process, such as abstracting, indexing, subject analysis, and classifying; and (2) knowledge organization systems, tools designed to achieve the above purposes. Referring to Hodge's classification [23] and ANSI/NISO Z39.19-2005 (National Information Standards Organization [NISO] 2005), knowledge organization systems can be divided into four categories in terms of structure and function from simple to complex: (1) term lists, such as pick lists; (2) metadata-like models, such as synonym rings and directories; (3) classification and categorization, such as subject headings, taxonomies, and categorization schemes, (4) relationship models, such as ontologies and knowledge graphs. Currently, knowledge organization technology has been widely used in the conservation and utilization of cultural heritage, such as many studies using ontologies, linked data, and knowledge graphs to construct the urban tourism cultural heritage ontology [24], the narrative ontology [25], the built cultural heritage ontology [26], the intangible heritage knowledge graph [27], and the cultural heritage knowledge graph [28] to reveal the knowledge structure of each type of cultural heritage. In addition, several studies have proposed innovative approaches to knowledge organization of cultural heritage, such as cultural heritage data aggregation based on linked data [29], geospatial linked data based on the geospatial semantic web [30], and mind maps, concept maps, cognitive maps, semantic grids, and other visualization techniques to reconstruct knowledge of architectural heritage [31]. Knowledge organization tools can help display cultural heritage knowledge better and enable communication cross-time and cross-space. Considering the above findings, we argue that knowledge organization tools can also provide technical support for knowledge organization and even knowledge mining and presentation of TCSC.

However, the field of traditional settlement research lacks the principles and methods of knowledge organization to explore the knowledge mining and utilization research of TCSC, especially from the meme perspective. This directly makes it difficult to ensure the authenticity of TCSC transmission and scientific protection. This study attempts to explore the methods of knowledge mining, organization, and presentation of TCSC from a meme perspective. We propose a knowledge management method framework for TCSC, explore the process of memes identification for it, and establish memes ontology (MO) and memes knowledge graph (MKG). Simultaneously, this work also explores the application of knowledge storage and presentation of TCSC through modeling MO and MKG. Therefore, this work aims to search for an approach used for the sustainable development of TCSC and to promote the knowledge utilization of TCSC through mainly memes knowledge organization.

Methodology

Overall framework

Our approach involves the identification of traditional Chinese settlement cultural memes (TCSCM), the construction of a MO, and a MKG, using a logical framework for knowledge mining, organization, and presentation (Fig. 1). Protégé and Neo4j knowledge organization software tools provide the experimental conditions for the digital storage and visualization of memes.

Knowledge mining: memes identification

Identification process

The synthesis of DNA in biological genetic engineering is first reverse-translated from the protein to the RNA and then catalyzed by reverse transcriptase using the RNA as a template. By analogy with this principle, we propose a general process framework for identifying TCSCM (Fig. 2): initially, collecting cultural element instances from traditional Chinese settlements and dividing them into element populations; subsequently, analyzing the functions, principles, and structures of element populations to extract cultural elements; finally, extracting memes from cultural elements based on gene identification principles, in which cultural

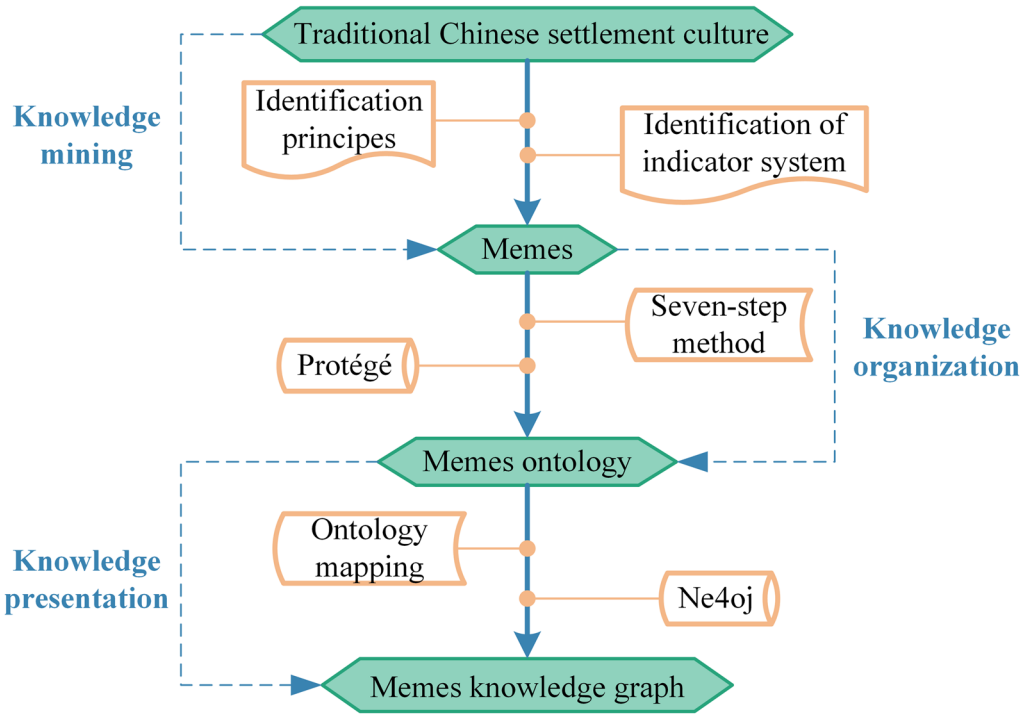

Fig. 1 Methodological framework

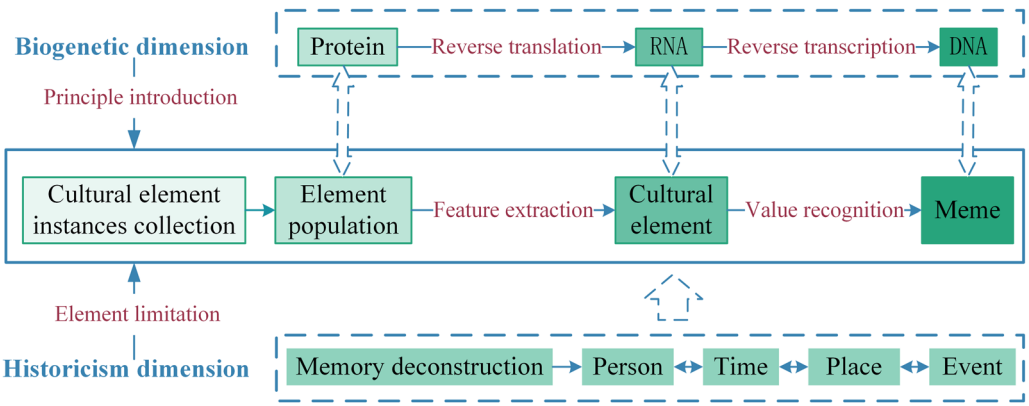

Fig. 2 General process framework of TCSCM identification

element populations, cultural elements, and memes correspond to proteins, RNAs, and DNAs in biological genetic engineering. Besides, we integrate the "natural and objective" approach employed in historical and humanistic research by classifying the collection of cultural elements according to four entities: time, place, people, and event. And memes are identified through the perspective of "restoring historical and cultural memory".

Identification steps

In Fig. 3, an overview of steps is shown, which will be discussed in the following subparts.

First, the collection of traditional settlement cultural element instances should adhere to the principles of comprehensiveness and scientific rigor. To achieve this, we adopt the methods of field research, historical materials, and research literature to conduct a preliminary categorization of traditional settlement cultural resources,

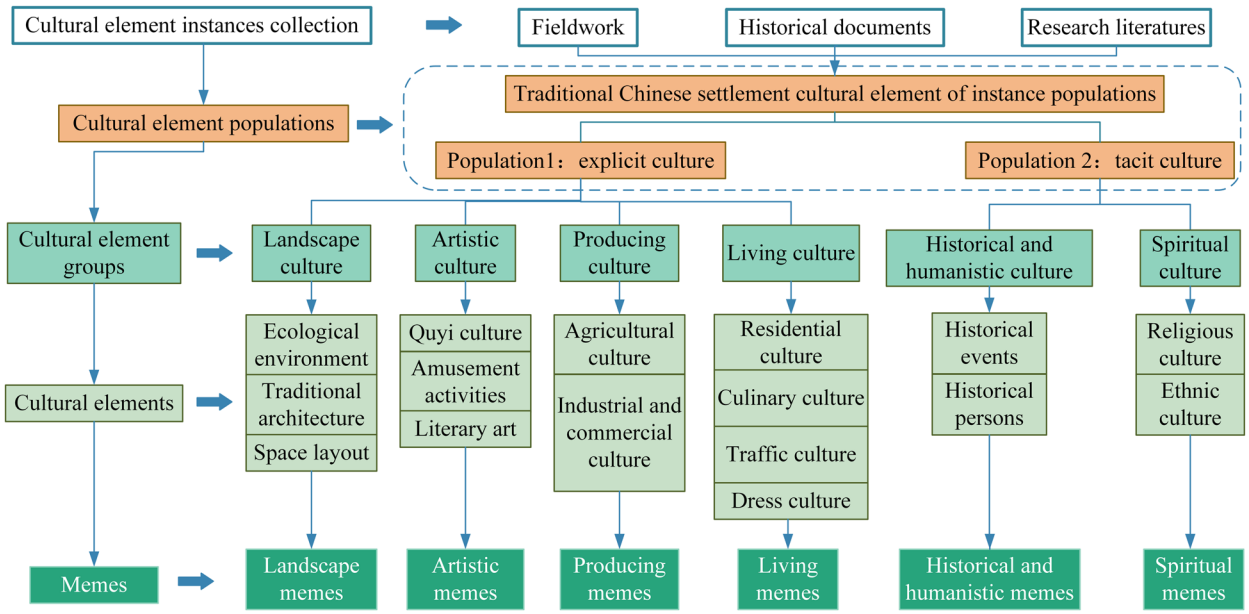

Fig. 3 Extraction general steps of TCSCM

primarily involving ecological and environmental culture, historical culture, folk life culture, and other resources.

Second, cultural elements can be categorized into two populations based on their manifestation: the dominant cultural element population exhibits outward material carriers, while the invisible cultural element population has no material carriers and remains internally implicit. Further division is made within these groups, with the former comprising four subgroups: landscape culture, art culture, production culture, and living culture; the latter includes two subgroups: historical humanities and spiritual culture.

Third, we analyze the cultural element groups from three aspects: function, principle, and structure, and extract the representative cultural elements among them (Table 1). Accordingly, TCSC includes 17 cultural elements, such as traditional architectures, spatial layouts, literature and arts, agricultural culture, clothing, foods, housing and transportation, historical persons, and religious culture.

Fourth, in the process of identifying memes, we refer to the four principles proposed by Liu Pei-Lin's team for extracting cultural landscape genes from traditional Chinese settlements [32] and employ diverse identification principles tailored to different groups of cultural elements (Table 2). After that, in constructing the TCSCM identification index system (Table 3) for specific memes excavation.

Knowledge organization: memes ontology construction

In this section, we will apply the knowledge organization approach to structure the extracted TCSCM using an ontology, which is a standardized framework extensively utilized for organizing knowledge concepts and their interrelationships across various domains. This study adopts an ontology to establish a semantic

Table 1 Analysis of the function, principle, and structure of cultural element groups

Cultural element groups	Function and principle	Structure
Landscape culture	The native environment and carrier of culture	The core structural layer is the architectural culture
Producing culture, living culture, Artistic culture	According to Maslow's hierarchy principle of needs is to satisfy the needs of physiology, socialization, security, and self-actualization	Food, residence, and production culture are the foundation, and art culture is the characteristic
History and Humanity	Historical level reflects the cultural origin of the settlement and the process of cultural transmission; the humanistic level is living in the settlement or the culture of people	The core of the historical structural level is spiritual; The human structure level consists of spirit, behavior, the institutional and material components
Spiritual culture	Reflects the important product of social production relations	The spiritual layer of culture

Table 2 Identification principles of TCSCM

Cultural element groups	Identification fundamental	Identification principles
Landscape culture	Extrinsic uniqueness	The uniqueness of the external landscape of the settlement
History and humanity, spiritual culture	Intrinsic uniqueness	The uniqueness of the intrinsic origin of the settlement
Producing culture, living culture	Local uniqueness	Local but key elements are unique
Artistic culture	Overall superiority	Other settlements have similar cultural elements, but this element is particularly prominent in this settlement

Table 3 Identification index system of TCSCM

Memes categories	Identification factors	Identification indicators	Examples of indicators
Landscape memes	Ecological culture	Natural elements	Climate, soil
		Terrain	Mountains, rivers, topographic relief
		Characteristic species	Characteristic animals and plants
	Traditional architectures	Building materials	Wood, stone, bamboo, earth, green brick
		Architectural colors	Brown, white, red, gray
		Form of facades	Single-storey, multi-story on the front, eaves and gables on the side
		Hill Wall forms	Herringbone, wavy, horse-head, and earthen
		Roof forms	One-character, curved, concave, mouth-shaped
		Windows and doors	Stone frame door, solid door, frame door, partition door; Straight latticed windows, casement windows, flower windows
		Partial decorations	Carving, paintings
	Spatial layouts	Spatial patterns	Stripes, clumps, irregularities ('S' type 'W' type)
		Spatial levels	Type of settlement site (mountain facing water, mountain terrace, hilly interlocking), Settlement units (boundary space, center space)
		Spatial structures	Architectural group space, street space, nodal space (plaza space, ritual space, theater space, etc.)
Producing memes	Industrial and commercial productions	Commercial industries	Handicraft industry, service industry, finance industry
	Agricultural productions	Agriculture, fishing, forestry, and animal husbandry	Major crops, production customs, and rules
Living memes	Social life	Recreational activities	Temple fairs, temple plays, teahouses, card culture
		Transportations	Horse-drawn carriages, boats, hand-drawn carts
		Dialects	Regional communication language
		Festival activities	Worship the gods and ancestors, enjoy the moon and chant poetry, make festival foods
	Productive life	Characteristic clothes	Ethnic costumes, ethnic accessories
		Specialty cuisines	Flavorful snacks, specialty dishes
		Traditional crafts	Handicrafts
Artistic memes	Artistic activities	Folk songs and dances	Operas, dances, songs
		Folk amusement activities	Game competitions, sports
	Literature and arts	Stories and legends	Folk tales, myths, legends, and celebrity stories
		Literary works	Poems, essays, calligraphies, artworks
Historical and humanistic memes	Historical events	Historical evolution	Historical causes, historical processes
		Important activities	Famous wars, political activities
	Historical persons	Historical figures	Red celebrities, ancient writers, craftsmen
Spiritual memes	Religious culture	Religious beliefs	Confucianism, Taoism, Buddhism, Christianity
	Ethnic culture	National spirit and values	Genealogy, moral concepts, village regulation, and non-governmental agreement

framework that describes the concepts of TCSCM and their relationships, serving as a reference for tools and methods capable of outlining the knowledge structure of traditional Chinese settlement cultural resources and accessing essential knowledge. The MO employed in this research belongs to a domain ontology. hence, we implement Stanford University's "seven-step approach", which is commonly used for constructing such ontologies. The specific steps involved in this method encompass "determining domain knowledge, organizing conceptual knowledge, and implementing the system."

Domain knowledge determination

The ontological construction of TCSCM requires commencing with a compilation of pivotal terms and concepts within the domain to formulate a set of knowledge concepts pertaining to memes. This section deals with the classification of TCSCM in the realm of memes. First, adhering to the previous steps of extracting TCSCM, we classify them into six categories. Then, the conceptual organization draws upon Schlaile and Ehrenberger's three elements of memetics ("P-I-E") [33], establishing connections between the domains of TCSCM and these elements. They posit that memes can be divided into three categories: P-memes, which are generally the objects of Popper's World 3 and the products of human mental activities, including objective knowledge and works of art; I-memes, which represent memes possessing mental representations described as mental concepts, such as beliefs, attitudes, spirituality, etc.; E-memes, which refers to memes with environmental or physical representations. Finally, based on the concept of the "P-I-E" memes model while considering the characteristics of six types of TCSCM, their classification results under this conceptual model are:

- E-memes: landscape memes
- P-memes: living memes, producing memes, artistic memes, historical and humanistic memes
- I-memes: spiritual memes

Conceptual knowledge organization

In the ontology, a class, also referred to as a concept, represents a collection, concept, type of object, or thing. For example, if we consider a collection of historical figures as a class or concept, then a particular historical figure is an instance of a particular object in the class. The features, characteristics, and parameters that an object or class possesses are called the properties of a class; for example, properties of the historical person class may include gender, ethnicity, age, and date of birth. The first part is the top-down method to determine the hierarchical relationships of the TCSCM classes, concerning the concepts of TCSCM domains and memes identification index systems listed in the previous section. The first class is divided into P-memes, I-memes, and E-memes from the theoretical model of memes "P-I-E"; the second class includes six specific memes regarding the results of the TCSCM classification; the third class is the TCSCM identification index system of identification factors, including thirteen memes subclasses. Table 4 illustrates the hierarchical relationship among these defined "classes."

In the second part, the authors define the properties of the class, which are divided into two categories, object properties and data properties in the ontology. Object properties reflect class characteristics and can describe the relationship between classes or between instances in a class. Drawing on gene ontology property relationships in biology and biological gene principles, seven object properties based on TCSCM characteristics are proposed by the authors (Table 5).

Data properties generally describe numerical characteristics of classes or instances, with a focus on four elements of the historicist dimension of time, place, person, and thing when defining content for six types of TCSCM data properties (Table 6). Each data property has a different data type; in general, text corresponds to character type (string), numerical values are restricted to integer or floating point, etc.

System implementation

Many automated ontology editing tools are available, such as Apollo, Onto Edit, Protégé, Swoop, and others. Among them, Protégé (Stanford University School of Medicine) is a free and open-source platform, which is

Table 4 The class hierarchy of TCSCM ontology

Class I	Class II	Class III
E-memes	Landscape memes	Natural ecology
		Traditional architectures
		Space layouts
P-memes	Living memes	Productive life
		Social life
	Producing memes	Industrial and commercial productions
		Agricultural productions
	Artistic memes	Literary arts
		Artistic activities
	Historical and humanistic memes	Historical persons
		Historical events
I-memes	Spiritual memes	Ethnic culture
		Religious culture

Table 5 TCSCM ontology main object properties

Property sources	Property names	Property descriptors	Example of domain (object A)	Example of range (object B)
Ontological relationships: gene ontology	is a	B is a subclass of A	Yangtze River (an instance of natural ecology)	Xiang River (an instance of natural ecology)
Ontological relationships: gene ontology	has part	A always treats B as a part, B exists A does not necessarily exist	Cloth shoe industry (an instance of industrial and commercial productions)	Handmade cloth shoes(an instance of productive life)
Ontological relationships: gene ontology	regulate	A regulates B	Hakka ideology (an instance of ethnic culture)	Ancestor worship (an instance of social life)
Principle: subclasses of genes in a biological gene work together to express a gene	co-express	A and B are expressed simultaneously; there is functional synergy between A and B	Historical persons (class)	Historical events (class)
Ontological relationships: gene ontology	occurs in	B is present in A	Anti-japanese incident (an instance of historical events)	Anti-japanese spirit (an instance of ethnic culture)
Ontological relationships: gene ontology	part of	B exists in A. B is part of A. B exists that A must exist	Temple fair (an instance of social life)	Temple opera (an instance of social life)
Principle: subclasses of genes in biological genes are related to each other	associate	A is functionally linked to B	Production memes (class)	Life memes (class)

Table 6 TCSCM ontology data properties

Class names	Properties contents
Landscape memes	Formation time, category, heritage level, distribution area, temporal scope, preservation history
Living memes	Important places, type, historical duration, person, formation time
Producing memes	Type, person, important place, historical source, formation time
Artistic memes	Person, date of creation, history of preservation, type
Historical and humanistic memes	Person, time of the event, place of the event, description of the thing
Spiritual memes	Connotation, kind, historical source, person, historical duration

a Java-based extensible tool for building domain models and knowledge base applications with ontologies. It can be customized to provide user-friendly support for ontology creation, visualization, and manipulation in various representation formats. Therefore, the Protégé tool is selected for the semantic description of TCSCM, which facilitates machine recognition and processing to form a retrievable resource system.

In the Protégé software, we utilize OWL as the ontology description language for TCSCM, with the resource description framework(RDF) serving as its foundation. To ensure the logical integrity of the language expression, these knowledge elements need to be realized as components of the RDF triad for digital storage and knowledge representation of TCSCM resources.

Knowledge presentation: memes knowledge graph construction

The knowledge graph is a semantic network in graphs, consisting of entity-relationship-property triples. Graph databases, as the knowledge graph construction tool, provide Cypher query capabilities to enable knowledge queries and visual displays based on user requirements. Applying the knowledge graph approach to form the knowledge association network of TCSCM not only facilitates the machine to realize the functions of data analysis, intelligent search, and knowledge reasoning but also enhances users' ability to read, understand, and utilize. This study adopts the ontology mapping approach to construct the MKG, first parsing the ontology knowledge contents of TCSCM, and determining the mapping rules between ontologies and graph databases; then importing the TCSCM data into the graph database for storing and drawing the knowledge graph, and completing the visualization of the instances.

Ontology parsing and mapping

We refer to relevant concepts and hierarchical relationships from MO when structuring MKG content. To address mismatches between ontological data structure and graph database representation, we parse MO into RDF triples and realize the mutual mapping between

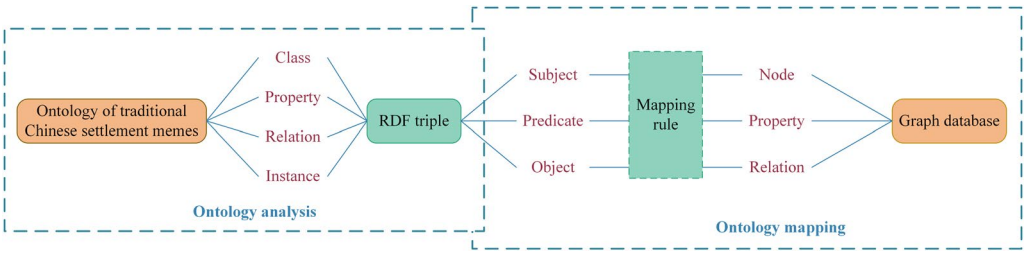

Fig. 4 Flow chart of ontologies to graph databases conversion

the ontology and the graph database through the correspondence between the elements of RDF triples and the graph database (Fig. 4).

(1) Parsing of the ontology

Ontology description languages are generally divided into two categories, one is based on predicate logic, and the other is based on Web, such as RDF, RDF Schema, OWL, OIL, etc. Among them, ontology storage based on OWL files or relational databases does not fit knowledge graph storage's node, relation, and property graph structure. In contrast, RDF utilizes a network identifier URI (Unified Resource Identifier) for resource identification and employs a triad comprising of subject, predicate, and object as the representation structure [34]. This allows for the description of resources and their properties and values based on the RDF directed graph schema, which is consistent with the graph structure storage utilized by graph databases. Therefore, we have chosen to implement mapping links between ontologies and graph databases using RDF triples and RDF graphs.

The main meta-structure of MO contains four main parts: class, relation, property, and instance; each having fixed phrase representations within derived RDF or OWL files. As an example, the RDF triad resolution rules are described below for the history and humanities class of MO:

- "Class" is generally used as the subject or object of an RDF triple. When a triple represents a class, denoted as (Class name, rdf: type, owl: class). For example, the RDF triple for the historical and humanistic class could be represented as (Historical and humanistic memes, rdf: type, owl: class).
- "Relation" generally corresponds to relationships in RDF triples. For example, an RDF triple of parent and subclasses is denoted as (Historical person, rdf: subclass of, Historical and humanistic memes), with the meaning that "Historical person" is a subclass of "Historical and humanistic class".
- "Property" RDF triples description is divided into two cases: object properties and data properties. For example, the object property "Co-expression" is represented by the RDF triple (Co-express, rdf: type, owl: Object Property), and (Historical person, Co-express, Historical events) indicates that historical persons and historical events have a co-expression relationship; The data property of events time is represented by the RDF triple (events time, rdf: type, owl: Data Property).
- "Instance" is a concrete case. The instance can inherit properties, relations, and other information from the class to which it belongs. For example, the instance "Mao Zedong" is populated under the historical person class. An RDF triplet represents the instance as (Mao Zedong, rdf: type, Historical person), and Mao Zedong is an instance of the Historical person class.

(2) Mapping of the ontology to the graph database

RDF graphs store RDF triples in a graph structure, where one node represents the subject, another node represents the object, and the directed link between them represents the predicate. The classes, relations, properties, and instances in the ontology can be decomposed into a series of directed graphs from the subject to the object within the RDF graph structure. We implement the mapping with the graph database based on the ontology resolution rules in the previous section.

The basic constituents of graph databases are nodes, relations, and properties, and a graph is a collection of nodes and other nodes associated with nodes and their properties. Some graph databases also support labels for grouping nodes that correspond to classes in ontologies; these nodes represent ontology instances. In Fig. 5, we show the minimum knowledge units of the ontology RDF graph format (left part) and the graph database (right part). To reveal in detail how ontology classes, class hierarchical relationships, data properties, and object properties are translated into knowledge representation

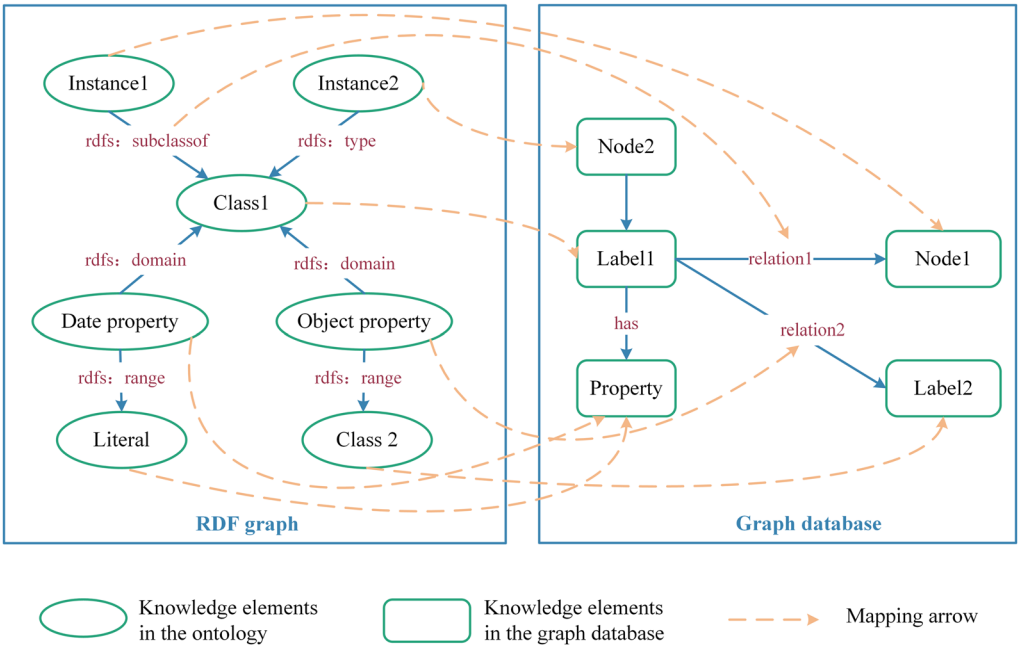

Fig. 5 Mapping rules for the ontology to the graph database

of nodes, relationships, properties, and labels in graph database.

Memes knowledge graph visualization

In our study, the MKG will be represented by applying the RDF graph schema for storing and plotting in non-relational databases. Graph databases are a mainstream tool for non-relational databases, which adopt a graph structure to store and query data patterns for easier knowledge storage and visualization, popular graph databases are Neo4j, Microsoft Azure Cosmos DB, Orient DB, Arango DB, etc. Among these options, Neo4j stands out as it offers scalability, dynamism, security, and data privacy features. It is currently recognized as the top-ranked and most extensively used graph database [35]. Therefore, we have chosen Neo4j as the tool for storing and mapping the MKG, and applied its browser tool for visual presentation.

Case study on Jinggang Ancient Town

Study site and data sources

Jinggang Ancient Town is located in Wangcheng District, Changsha City, Hunan Province, China (Fig. 6). It is the second in Hunan Province and the first in Changsha City as a "Famous Chinese Historical and Cultural Town". The town is rich in cultural resources, and still retains the ancient architectural streets and alleys of the Ming and Qing dynasties, more than one hundred old stores and houses, and other monuments, which are of great research value. To better illustrate the value of cultural heritage in Jinggang, we draw on the universal value of cultural heritage in UNESCO's < Operational Guidelines for the Implementation of the World Heritage Convention > [36] to illustrate:

- Third point: bear a unique or at least exceptional testimony to a cultural tradition or to a civilization that is living or which has disappeared; Jinggang Ancient Town preserves the highly distinctive ruins of ancient Chinese teahouses, theaters, and brothels, a testament to prostitute industry and gambling entertainment culture of feudal China.
- Fourth point: be an outstanding example of a type of building, architectural or technological ensemble, or landscape which illustrates (a) significant stage(s) in human history; Jinggang Ancient Town has a spatial form of eight streets, four lanes, and seven wharves, which is characteristic of the layout of inland ports in southern China during the Ming and Qing dynasties.
- Fifth point: be an outstanding example of a traditional human settlement, land-use, or sea-use which is representative of a culture (or cultures), or human interaction with the environment especially when it has become vulnerable under the impact of irreversible change; Jinggang Ancient Town is situated at the mouth of the Wei river into the Xiangjiang river, which happens to be in a bend of the river. The entire street along the river can meet the convenience of

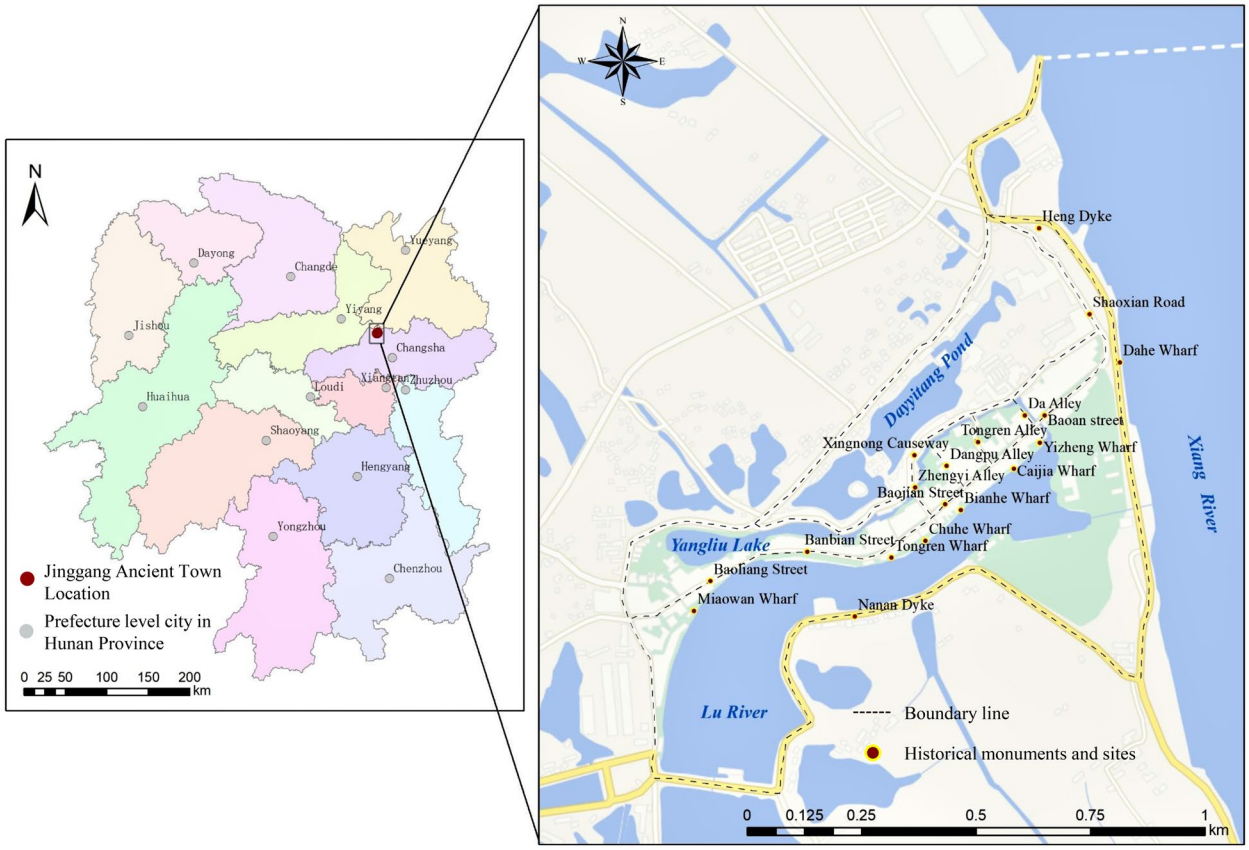

Fig. 6 Location map of Jinggang Ancient Town, Changsha City, Hunan Province

water transportation and domestic water, and is surrounded by the river to avoid river erosion and flooding disasters. Therefore, Jinggang has an ideal natural ecological environment, and its concept of "living by water" is a typical Chinese village and town location concept. Its spatial and temporal history of prosperity due to water transportation, decline due to water wars, and fading due to floods reflects the interaction between humans and the natural environment, but its characteristic inland water town environment has become extremely fragile because of the effects of urbanization and industrialization.

The author's process of collecting cultural resources in Jinggang Ancient Town, the research base data sources the following three parts:

- First-hand materials from field research and interviews with residents
- Literature from books such as "The History of Jinggang" and "Jinggang Ancient Town"
- Content materials from the relevant research literature

Memes value of Jinggang Ancient Town

Traditional Chinese settlements have been developing under the combined effect of "internal forces" and "external forces". Internal forces encompass the values, knowledge, and mindset of traditional settlement dwellers, while external forces include government planning policies, management measures, and the intervention of external capital. The internal forces alone may lead to the isolation and lagging of traditional Chinese settlements, while the external forces alone may lead to the phenomenon of "one look in a thousand settlements". In 2004, Jinggang was identified by the Hunan Provincial Government as a "Historical and cultural town in Changsha". In 2008, the protection and development of Jinggang were officially launched, and many ancient buildings, old shops, and famous workshops were put back on display after being protected and restored. In September of the same year, Jinggang was designated a "Famous Chinese Historical and Cultural Town" by the Chinese government, becoming the first famous historical and cultural town in Changsha, the provincial capital. Nevertheless, with the rise of tourism in Jinggang, the original features of the town and its historical and cultural heritage

have been destroyed. Additionally, compared to other renowned ancient towns in China, Jinggang Ancient Town lacks distinctive cultural products, and the unique cultural connotation of wharf culture also faces substitute threats and lacks its core competitiveness within the industry. Given the above issues, we think this results from a lack of local knowledge and an underestimation of knowledge management practices. Therefore, it is recommended that a comprehensive survey be conducted to investigate the historical formation and evolutionary processes of Jinggang Ancient Town, tap into its memes, and expose relevant personnel to its local knowledge to promote the cultural preservation of Jinggang Ancient Town as well as the formation and management of cultural products.

This paper identifies, organizes, and presents the memes of Jinggang Ancient Town, with the following values. First, by identifying its memes to excavate the iconic cultural elements in the culture of Jinggang Ancient Town; second, it classifies and organizes various memes and studies the relationships between them in the process of organizing the ontology and visualizing the knowledge graph aiming to explore the cultural connections between cultural elements in Jinggang Ancient Town and to restore each cultural scene. In addition, the ontology and knowledge graph constructed in the article can also provide structured data support for the cultural knowledge base and visualization system platform of Jinggang Ancient Town, which can be applied to the knowledge management of the cultural heritage of the town, the introduction of cultural knowledge graph of cultural tourist attractions, and the design of unique cultural products of the ancient town.

Knowledge presentation of Jinggang Ancient Town

Memes extraction from Jinggang Ancient Town

According to the identification steps of TCSCM, six types of memes of Jinggang Ancient Town are identified. In the specific memes extraction process, we use pattern, element, structure, and meaning extraction methods to identify them. In Fig. 7, a partial sample of the memes of Jinggang Ancient Town is illustrated.

Memes ontology construction of Jinggang Ancient Town

The construction of the MO of Jinggang Ancient Town is realized based on the ontological framework of TCSCM. In the instance addition stage, after field research, literature review, and internet data collection, a total of 230 representative memes instances are collected from Jinggang ancient town. After that, the class hierarchy, property relationships, and their instances are imported into the ontology modeling software Protégé to build the MO of Jinggang Ancient Town, and the OntoGraf plug-in included in the Protégé is used to visualize its knowledge content and interrelationships (Fig. 8). The solid lines in Fig. 8 show the relationship between parent and child classes, the dashed lines show the relationship between object properties, and the connecting lines of different colors show different types of property relations.

To better present the instance relationships of memes in Jinggang Ancient Town, partial instance data are selected for manual debugging visualization (Fig. 9). The instance labels in the figure show that the instances of commercially produced memes are related to instances of natural environments and spatial layouts. For example, the character Shuai Tielang manages the iron shop located on the side of Luhua River, Jin Peizhang manages the iron shop located on Half Street, and Yang Wanqin manages the Yang Guangxing line located on Baoan Street. In addition, the property characteristics of the instances can be described in detail, such as the category of Yang Guangxing line is a grain house, established in 1908; the iron store belongs to the iron industry, and the type of Luhua river is watery.

Memes knowledge graph visualization of Jinggang Ancient Town

The visualization of the MKG of the Jinggang Ancient Town is achieved by its ontology mapping, which consists of three main steps: The first step is the implementation of the transformation from the ontology OWL language to the RDF format. The MO of the Jinggang Ancient Town built by Protégé is saved and exported as an OWL file, and then the Java program "rdf2rdf-1.0.1-2.3.1" is mobilized to convert the OWL file into an RDF file. The second step is to convert RDF files to graph database representation format triples. The "rdflib" library in Python is called to complete the triple conversion according to the ontology to graph database mapping rules developed in the previous section. The third step is to import the triple data into the Neo4j database for knowledge graph visualization. Call the "py2neo" program in Python to load the CSV format file of the triple, and then it can automatically import the Neo4j database. Following the above steps to draw the MKG of Jinggang Ancient Town, a total of 393 nodes (including 230 instance nodes, 110 data property nodes, 41 class nodes, and 12 object property nodes) and 590 pairs of relationships are obtained, and the visualization is shown in Fig. 10. The MKG of Jinggang Ancient Town provides better data support for effectively disseminating and utilizing its meme knowledge. On the one hand, users can more flexibly query the desired information through the visualization interface and discover new nodes and relationships as well as unanticipated details in addition to the target search

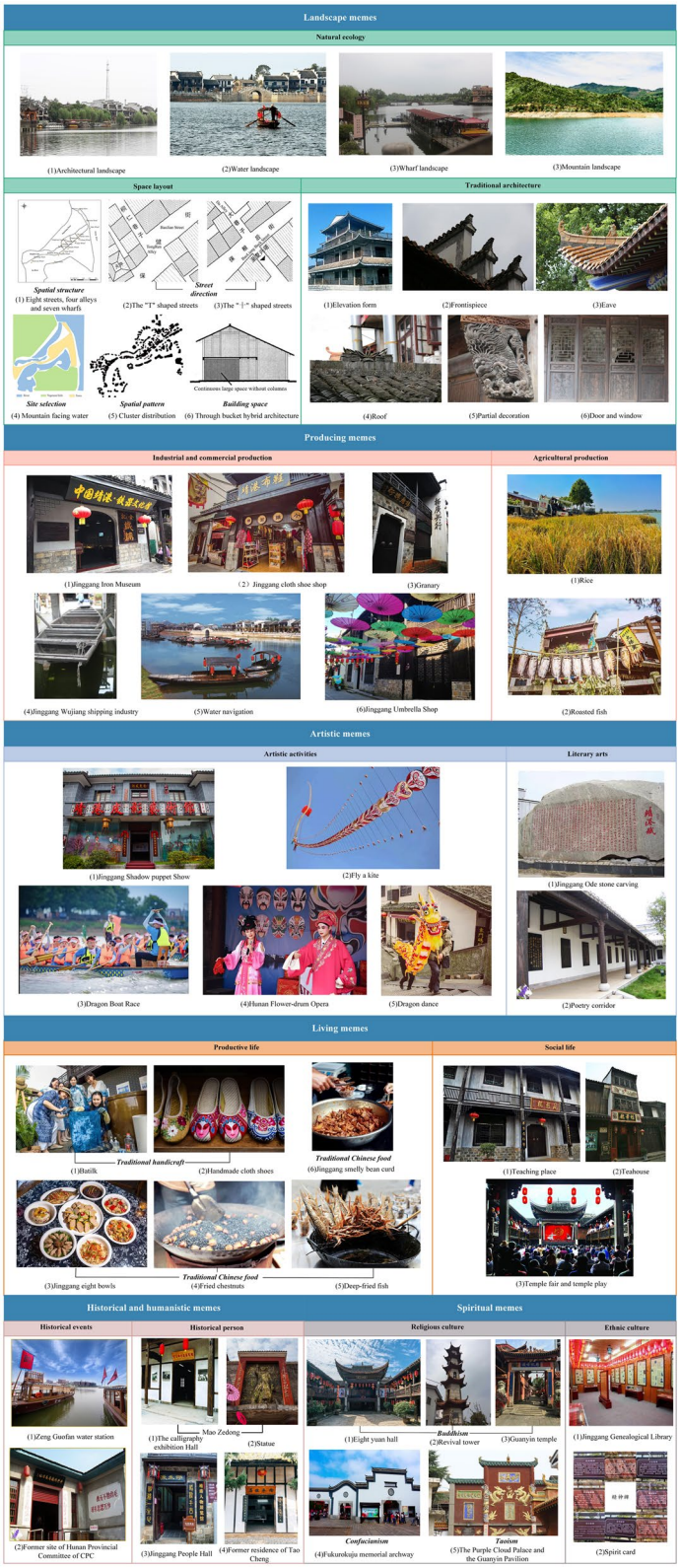

Fig. 7 Sample results of memes identification of Jinggang Ancient Town

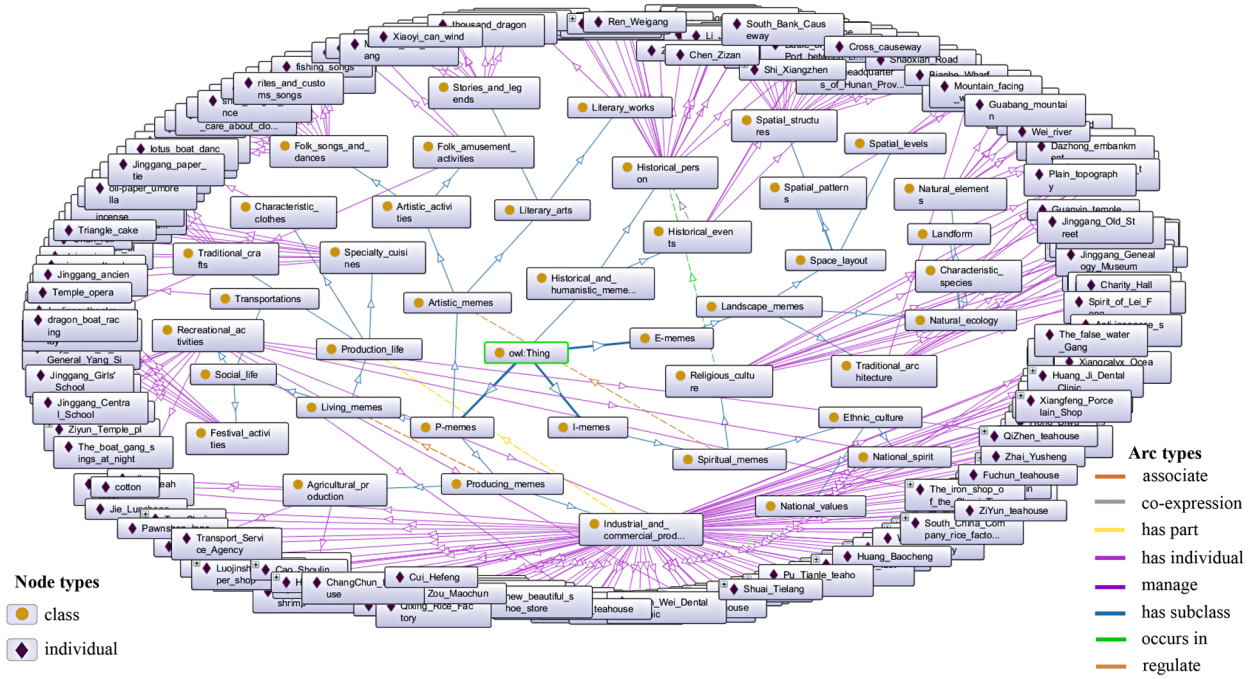

Fig. 8 Visualization of the MO software of Jinggang Ancient Town

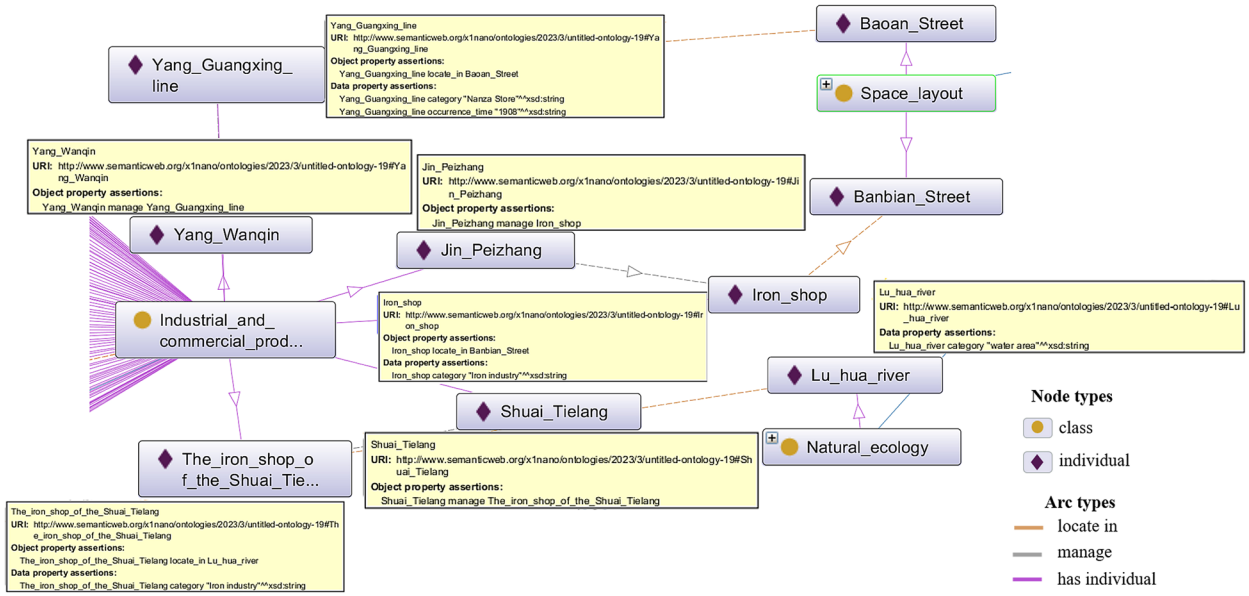

Fig. 9 Partial relationships of the MO of Jinggang Ancient Town

results; on the other hand, the visualization interface intuitively displays the structure and content of memes, making it easier for users to understand and analyze, and can be applied in the electronic presentation of each cultural resource.

Discussion

The article adopts the meme theory for the study of TCSC originated from the cultural landscape gene theory. Cultural landscape gene theory was developed by Chinese scholars to study traditional settlement landscapes in the context of Chinese culture [37], and it focuses on the

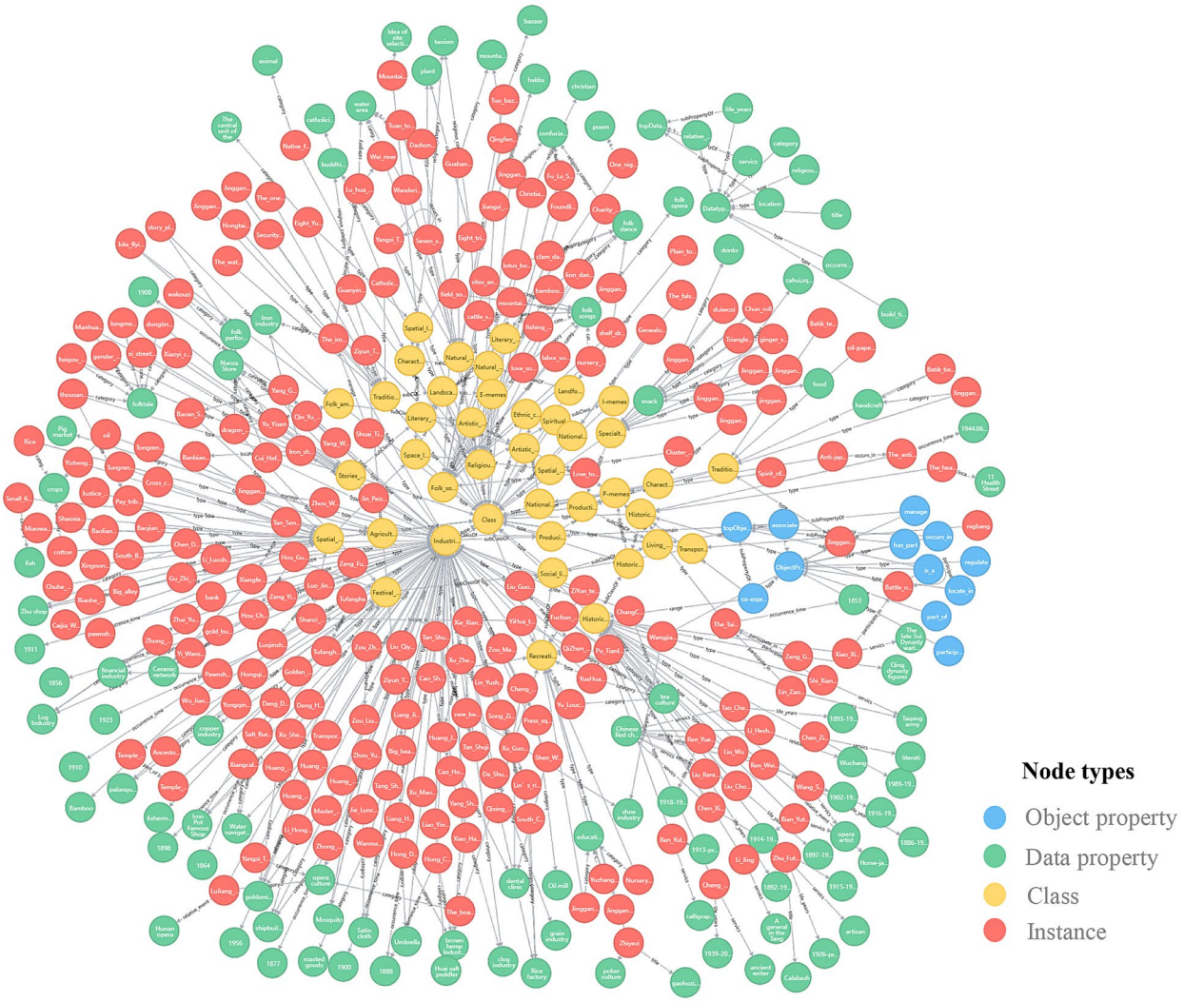

Fig. 10 Visualization of the MKG of Jinggang Ancient Town

geographic characteristics of traditional Chinese settlement cultural landscapes. Compared with the cultural landscape gene theory, meme theory provides a more comprehensive approach to analyzing the cultural information of traditional Chinese settlements. Because it not only includes the landscape culture of traditional Chinese settlements but also covers other cultures, such as production and living culture, spiritual culture, etc.

This study approaches the knowledge mining, organization, and presentation of TCSC from a knowledge management perspective, noting the premise that we consider the TCSCM to be equivalent to its knowledge. We propose a memes identification step of TCSC and use ontology and knowledge graph tools to organize and present its memes, which is a new exploration in the field of TCSC research. In this work, the MO and MKG of TCSC can visualize the relationship between people, historical events, cultural heritage, spatiotemporal geography, and other elements related to traditional Chinese settlement cultural resources, and provide data materials for the salvage protection and living utilization of traditional Chinese settlement cultural resources.

From the work, the model of MO and MKG of TCSC is very promising in many application areas. For example, at the governmental level, the structured knowledge in the MO and the MKG can help people develop work programs for protecting traditional settlements and maintaining cultural heritage. At the same time, the industries engaged in preserving traditional settlements or tourism can also benefit from this work. For example, for a given region, people can use the memes identification method in this study to identify iconic regional cultures in traditional settlements and apply the MO and MKG to achieve digital storage and visualization of cultural information.

As another example, the cultural relics of the Jinggang Ancient Town Museum can visualize their information by applying the Jinggang Ancient Town MKG.

In summary, meme theory provides an analytical framework for the composition of culture at multiple levels of TCSC, but its related theories and methods need to be further developed, especially the identification of the concept of TCSCM, and its categorization and organization relationship are not yet perfect.

Conclusion

This study provides a way to advance the digital conservation of TCSC using meme theory and knowledge management methods, which will allow us to access the knowledge value of traditional Chinese settlement cultural resources and apply them to their cultural transmission and industrial revitalization guidance. We designed an ontology framework and knowledge graph construction method applicable to the TCSCM. Taking Jinggang ancient town as a case study, we used the ontology and knowledge graph software to construct a MO and MKG of Jinggang ancient town, which can realize the retrieval and presentation of detailed information of the memes instances and the relationship between the instances in Jinggang ancient town.

Note that there are still some important issues which should be resolved in the follow-up study. First, a more scientific and detailed index system for identifying the TCSCM needs to be revised. Furthermore, the ontology and knowledge graph constructed in this study are still in the preliminary stage of development, which can only satisfy the user retrieval and information display functions, and cannot be used for knowledge inference and knowledge discovery due to the lack of multi-dimensional and multi-quantity meme data of Jinggang Ancient Town. Therefore, future research can increase the participation of domain experts, use scientific and diverse methods to determine the memes identification index system, and expand the data of research subjects to promote the constructed ontology and knowledge graph to serve the local project practice.

Abbreviations

TCSC	Traditional Chinese settlement culture
TCSCM	Traditional Chinese settlement cultural memes
MO	Memes ontology
MKG	Memes knowledge graph
OWL	Web ontology language
RDF	Resource description framework
CSV	Comma-separated values
URI	Unified resource identifier

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Author contributions

YSM, YLN: Wrote this article; GH, LY: Reviewed the whole paper and put forward suggestions for improvement. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Competing interests

The author(s) declared no potential interest with respect to the research, authorship, or publication of this article.

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References

1. Liu PL. On Construction and Utilization of Chinese Traditional Settlements Landscape's Genetic Map. PHD thesis, Peking University, Beijing of China; 2011.
2. Liu Y, Zang Y, Yang Y. China's rural revitalization and development: Theory, technology and management. J Geogr Sci. 2020;30(12):1923–42.
3. Chen H. Introduction to cultural self-confidence. Int J Arts Commer. 2016;5(9):75–80.
4. He Y, Chen CP, Chou RJ, Luo HF, Hou JS. Exploring the transformation in the 'spirit of place' by considering the changed and unchanged defensive spaces of settlements: a case study of the Wugoushui Hakka settlement. Land. 2021;10(5):490.
5. Zhao F, Zhang S, Du Q, Ding JY, Luan G, Xie Z. Assessment of the sustainable development of rural minority settlements based on multidimensional data and geographical detector method: a case study in Dehong. China Socio-Economic Planning Sciences. 2021;78:101066.
6. Sun Y, Ou Q. Research on the traditional zoning, evolution, and integrated conservation of village cultural landscapes based on "production-living-ecology spaces"—a case study of villages in Meicheng, Guangdong. China Open Geosci. 2021;13(1):1303–17. https://doi.org/10.1515/geo-2020-0279/html.
7. Hu Z, Strobl J, Min Q, Tan M, Chen FL. Visualizing the cultural landscape gene of traditional settlements in China: a semiotic perspective. Herit Sci. 2021;9(1):128. https://doi.org/10.1186/s40494-021-00589-y.
8. Dang A, Wang F. Information technology methods for locality preservation and inheritance of settlement cultural landscape. Indoor Built Environ. 2021;30(4):437–41.
9. Li G, Hu W. A network-based approach for landscape integration of traditional settlements: a case study in the Wuling Mountain area, southwestern China. Land Use Policy. 2019;83:105–12.
10. Hu X, Li H, Zhang X, Chen XH, Yuan Y. Multi-dimensionality and the totality of rural spatial restructuring from the perspective of the rural space system: A case study of traditional villages in the ancient Huizhou region. China Habitat International. 2019;94:102062.
11. Ye C, Ma X, Gao Y, Johnson L. The lost countryside: spatial production of rural culture in Tangwan village in Shanghai. Habitat Int. 2020;98:102137.
12. Fu J, Zhou J, Deng Y. Heritage values of ancient vernacular residences in traditional villages in Western Hunan, China: spatial patterns and influencing factors. Building and Environment. 2021;188:107473.
13. Chen X, Xie W, Li H. The spatial evolution process, characteristics and driving factors of traditional villages from the perspective of the cultural ecosystem: a case study of Chengkan village. Habitat International. 2020;104:102250.

14. Xiang H, Qin Y, Xie M, Zhou B. Study on the "space gene" diversity of traditional dong villages in the southwest Hunan province of China. Sustainability. 2022;14(21):14306.
15. Lin L, Xue D, Yu Y. Reconfiguration of cultural resources for tourism in urban villages—a case study of huangpu ancient village in guangzhou. Land. 2022;11(4):563.
16. Dawkins R. The selfish gene. Oxford: Oxford University Press; 1976. p. 189.
17. Distin K. The selfish meme: a critical reassessment. Cambridge: Cambridge University Press; 2005.
18. Liu CY, Li QM. The Meme's-Eye on Cultural Evolution and Its Philosophical Implications. Philos Anal. 2022;13(1):154–64.
19. Shepherd J, McKelvey B. An empirical investigation of organizational memetic variation. Journal of Bioeconomics. 2009;11:135–64.
20. Soergel Dagobert. Digital libraries and knowledge organization. In: Kruk SR, McDaniel B, editors. Semantic digital libraries. Berlin: Springer; 2009. p. 9–39.
21. Broughton V, Hansson J, Hjørland B, López-Huertas MJ. Knowledge organization. Copenhagen: Royal School of Information Science; 2005. p. 133–48.
22. Hjørland B. What Is knowledge organization (KO)? Knowl Organ. 2008;35:86–102.
23. Hodge Gail. Systems of knowledge organization for digital libraries: beyond traditional authority files. Washington: The Digital Library Federation Council on Library and Information Resources; 2000.
24. Pinto A, Cardinale Y, Dongo I, Ticona-Herrera R. An ontology for modeling cultural heritage knowledge in urban tourism. IEEE Access. 2022;10:61820–42.
25. Meghini C, Bartalesi V, Metilli D. Representing narratives in digital libraries: the narrative ontology. Semantic Web. 2021;12(2):241–64.
26. Noor S, Shah L, Adil M, Gohar N, Saman GE, Jamil S, Qayum F. Modeling and representation of built cultural heritage data using semantic web technologies and building information model. Comput Math Organ Theory. 2019;25:247–70. https://doi.org/10.1007/s10588-018-09285-y.
27. Fan T, Wang H. Research of Chinese intangible cultural heritage knowledge graph construction and attribute value extraction with graph attention network. Inf Process Manag. 2022;59(1):102753.
28. Carriero VA, Gangemi A, Mancinelli ML, Nuzzolese AG, Presutti V, Veninata C. Pattern-based design applied to cultural heritage knowledge graphs. Semant Web. 2021;12(2):313–57.
29. Freire N, Voorburg R, Cornelissen R, Valk S, Meijers E, Isaac A. Aggregation of linked data in the cultural heritage domain: a case study in the Europeana network. Information. 2019;10(8):252.
30. Nishanbaev I, Champion E, McMeekin DA. A comparative evaluation of geospatial semantic web frameworks for cultural heritage. Heritage. 2020;3(3):875–90.
31. Zhang X, Zhi Y, Xu JQ, Han LX. Digital protection and utilization of architectural heritage using knowledge visualization. Buildings. 2022;12(10):1604.
32. Liu PL, Liu CL, Deng YY, Shen XY, Hu Z, Li BH. Study on the identification of Hakka traditional village's landscape genes and analysis in the perspective of geography. Hum Geogr. 2009;24(6):40–3.
33. Schlaile MP, Ehrenberger M. Complexity, cultural evolution, and the discovery and creation of social entrepreneurial opportunities: exploring a memetic approach. In: Berger ESC, Kuckertz A, editors. Complexity in entrepreneurship, innovation and technology research. Berlin: Springer; 2016.
34. RDF rules. W3school. https://www.w3school.com.cn/rdf/rdf_rules.asp. Accessed 21 May 2023.
35. Graph database ranking. https://db-engines.com/en/ranking_trend/graph+dbms. Accessed 21 May 2023.
36. Operational Guidelines for the Implementation of the World Heritage. UNESCO. https://www.docin.com/p-648962971.html. Accessed 22 May 2023.
37. Liu PL, Zeng C, Liu R. Environmental adaptation of traditional Chinese settlement patterns and its landscape gene mapping. Habitat Int. 2023;135:102808.

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