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Research on the Construction of Cultural Tourism Knowledge Graph in Liaoning Province

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Abstract: *With the advent of the digital era, promoting the digital and intelligent transformation of cultural tourism has become an inevitable trend. This paper constructs a characteristic model of cultural tourism in Liaoning Province through the three-level coding of grounded theory. On this basis, it completes the design of the logical architecture of the knowledge graph covering the schema layer and data layer, clarifies various entities, data attributes and object attributes, and finally builds a structured ontology model of cultural tourism in Liaoning Province. To verify the feasibility of the model, this paper takes the Liaoshen Campaign Memorial Hall as an empirical case and uses the Neo4j graph database to realize the visual storage and display of its knowledge graph. This lays a solid foundation for the intelligent development of cultural tourism in Liaoning Province and provides a reference paradigm for the digital construction of cultural tourism resources in other regions of the country.*

Keywords: *Liaoning Region; Digital Tourism; Grounded Theory; Knowledge Graph*

1. Introduction

Against the backdrop of the in-depth integration of digital humanities and intelligent tourism, the visual presentation of tourism resources is gradually evolving into a significant field that boasts both methodological innovation significance and academic research value. As a major resource-rich province endowed with abundant historical relics and profound cultural heritage, Liaoning Province, driven by the dual forces of practical exploration and theoretical research, has initially established a relatively sound cultural tourism development system. Various themed educational activities and culture-tourism integration projects are showing a trend of normalized and distinctive development.

However, with the rapid iteration of immersive technologies such as AR and V), coupled with the continuous upgrading of the public's demand for spiritual and cultural experiences, the in-depth development and innovative communication of Liaoning's tourism resources are facing multiple challenges, including insufficient technological adaptability, lack of immersive experience, and limited communication effectiveness. These restrictive factors not only affect the efficiency of activating and utilizing cultural tourism resources but also weaken their value communication effect in the new era.

Based on this, this study focuses on the innovative paths for the visual presentation of cultural tourism resources, aiming to break through the temporal and spatial limitations of traditional tourism through technological empowerment and content reconstruction. This exploration is not only an inevitable choice to conform to the trend of digital and intelligent transformation, but also bears important theoretical value and practical significance for promoting the transformation of Liaoning's cultural tourism resource advantages into high-quality development momentum.

2. Current Research Status at Home and Abroad

2.1 Research on Digital Tourism

Digital tourism is a new type of tourism model supported by technologies such as the Internet, mobile communication, big data, and virtual reality. It enables remote access to scenic spot information and efficient scenic area management through electronic tickets, intelligent tour guides, online bookings, and other means. At the practical level, scholars have focused on multimodal data fusion and the application

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of intelligent technologies. For example, Ronghui Xu[1] constructed a tourism destination risk assessment model by integrating text, image, and sensor data, providing decision support for disaster early warning and resource optimization; Chaohao Yuan[2] optimized the cultural heritage tourism recommendation system using AI technology to support cross-language interaction and intelligent tour guiding, which significantly enhanced tourists' experience. These studies have laid a technical foundation for data integration and intelligent services in the construction of the knowledge graph of cultural tourism in Liaoning Province.

2.2 Research on Ontology Engineering

Ontology engineering is a field in computer science that focuses on the construction, management and application of ontologies. It describes the concepts, attributes and relationships of specific domains through formal methods, laying a foundation for knowledge sharing and system integration. In the field of cultural tourism, the application of ontology engineering is particularly crucial. For example, Rongguang Ye[3] proposed an ontology engineering-driven intelligent recommendation system, which integrates multi-source data such as historical backgrounds and user preferences, optimizes itinerary planning combined with semantic reasoning, and provides personalized services for tourists. Xiaotang Wang[4] further constructed a dynamic knowledge graph model, which integrates social media and booking data to achieve real-time tourism demand forecasting, enhancing the resilience of destination management. These studies provide theoretical support for the standardized representation and dynamic updating of the cultural tourism knowledge graph of Liaoning Province.

2.3 Research on Knowledge Graphs

A knowledge graph is a structured semantic knowledge base that takes "entity-relationship-entity" triples and attribute-value pairs as its basic units, and is logically divided into a data layer and a schema layer. In specific domains such as cultural resources, the construction and application of knowledge graphs have attracted much attention. For example, Bian Haonan[5] systematically expounded on the paradigm shift in knowledge graph construction, emphasizing the innovation from rule-driven approaches to generative methods; Sergio Muíño Freire[6] explored the sustainable applications of knowledge graphs in digital tourism, such as risk assessment and post-disaster recovery, and improved the systematicness of cultural tourism management by integrating multi-source data through ontology engineering. These studies provide methodological guidance for the construction of the cultural tourism knowledge graph of Liaoning Province, and are particularly suitable for integrating Liaoning's cultural cultural resources and natural landscape data.

To sum up, as key technical pillars in the field of smart cultural tourism, digital tourism, ontology engineering, and knowledge graphs have gradually permeated from the theoretical research level to industrial practice. Against this backdrop, this paper takes the cultural and tourism resources of Liaoning Province as the research object. By constructing a knowledge graph system based on ontology engineering, it provides theoretical basis and practical paths for the structural optimization, service upgrading, and sustainable development of Liaoning’s cultural and tourism industry. This is of great significance for promoting Liaoning’s strategic transformation from a major province of cultural and tourism resources to a powerful province of cultural and tourism industry.

3. Grounded Theory Analysis of Influencing Factors for The High-Quality Development of cultural Tourism in Liaoning Province

3.1. Research Design and Data Collection

This paper adopts the interview method for data collection. Seven tourists, four experts and four scenic area managers were selected as interviewees, and differentiated interview outlines were designed for the three groups of respondents. After two weeks of interviews, a total of 15 text materials were obtained, numbered 01–15, with the original text amounting to 15,943 words, which were used for subsequent coding analysis.

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3.2. Three-Stage Coding Process

3.2.1 Open Coding

In this paper, the 15 interviewees were coded as a01, a02 ... a15. The original statements were subjected to initial conceptual coding, from which a total of 127 initial concepts were abstracted and named Z1, Z2 ... Z127. Then, the qualitative analysis software Nvivo was used to refine the selected 127 initial concepts into initial categories, resulting in 33 initial categories named A1, A2 ... A33. Taking A1-A3 as an example, the results of open coding are presented in Table 1:

Table 1: Open coding and original statements of A1-A3

Initial Category	Initial Concept	Partial Original Data
A1 Inheriting the cultural Gene	Z1 Inheriting Historical Culture	The core is to convey the cultural culture represented by the September 18th Incident—including the spirits of national awakening, tenacious resistance, patriotism and dedication—to tourists through various forms, so that they can remember history and inherit the cultural gene. a09
	Z2 Valuing Culture	When visiting cultural tourism attractions, I felt the emphasis and inheritance of cultural culture in the city of Shenyang. Culture elements can be seen in many places around the city, such as street sculptures and cultural walls. I hope this emphasis will be maintained forever. a01
	Z3 Understanding History	I think cultural tourism enables me to have a deeper understanding of revolutionary history and culture, thus cherishing the happy life we have now more. a06
	Z4 Sense of Identity	By visiting cultural attractions, tourists can learn about revolutionary history and culture, and enhance their sense of national identity and belonging. a10
A2 Laws and Regulations	Z5 Formulating Laws	We, Shenyang City, have formulated and improved laws and regulations for the protection of cultural heritage, clarifying the definition, classification, protection principles, protection measures and legal liabilities of cultural heritage, so as to provide legal safeguards for cultural heritage protection.a08
	Z6 Law Enforcement Intensity	We will intensify the law enforcement for cultural heritage protection, severely crack down on acts that damage cultural heritage, and ensure the integrity and authenticity of cultural heritage.a08
A3 Tourist Participation	Z7 Experience Diversity	In addition to visual and auditory experiences, multi-sensory elements such as touch and smell should be incorporated. For example, when presenting scenes depicting the harsh living conditions during the War of Resistance Against Japanese Aggression, visitors can be invited to touch replica homespun clothing, experience the shabby living environment, and even be exposed to scents simulating the gunpowder fumes of that wartime era, thus stimulating their senses in an all-round way.a14
	Z8 Experience Activities	We hope that scenic spots can add interactive experience projects, such as VR experiences and simulated battles, so that we can more immersive feel the charm of cultural.a05

3.2.2 Axial Coding

By analyzing the logical relationships and hierarchical affiliations among the initial concepts derived from the open coding phase, 12 main categories (B1–B12) were generalized and refined from the 33 initial categories. Taking B1-B3 as an example, the results of axial coding are presented in Table 2.

Table 2: Axial coding results of B1-B3

Main Category	Initial Category	Category Connotation
B1 Cultural Inheritance	A1 Inheriting the cultural Gene	Through cultural tourism in Liaoning Province, the public can gain a profound understanding of revolutionary history and culture, cultivate patriotic feelings, and strengthen the national spirit.
	A2 Brand Construction	By exploring the connotation of culture, cultural tourism in Liaoning Province has built cultural tourism brands with local characteristics,and enhanced Liaoning's popularity and reputation.
	A3 Cultural Exchange and Integration	Developing cultural tourism in Liaoning can promote the exchange and integration of culture with diverse cultures.
B2 Cultural Protection	A4 Protection of Cultural Heritage	The renovation and protection of cultural heritage by scenic areas
	A5 Laws and Regulations	The legislative protection of cultural heritage by the government
	A6 Donation Activities	The collection of private cultural relics by scenic areas
B3 Tourist Feedback	A7 Tourist Satisfaction	To what extent can the resources and tour services provided by cultural scenic areas in Liaoning meet the specific practical needs of tourists
	A8 Tourist Participation	How can the products launched by cultural scenic areas in Liaoning improve tourists' experience

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3.2.3 Selective Coding

By further analyzing the conceptual connotations of the main categories derived from axial coding, the 12 main categories were collated and divided into four dimensions: culture, consumption, economy, and society. Taking culture and consumption as examples, their relational structure is shown in Table 3.

Table 3: Selective coding status of "Culture" and "Consumption"

Main Category	Category Relationship	Category Connotation
C1 Culture	B1 Cultural Inheritance	cultural inheritance refers to the process of protecting, disseminating and promoting culture.
	B2 Cultural Protection	Cultural protection refers to the process of preserving, maintaining and inheriting cultural heritage.
C2 Consumption	B3 Tourist Feedback	Tourist feedback refers to the evaluations, opinions or suggestions given by tourists on various aspects involved in the travel process after they complete the cultural tourism experience.
	B4 Travel Considerations	Travel considerations mainly refer to various factors and conditions that tourists focus on when planning and making travel decisions, such as budget, time and destination.

3.3. Saturation Test

To verify whether the data in this study has reached a state of saturation, on the basis of the existing interview materials, an additional three interviewees were selected and a batch of new qualitative materials were introduced to conduct a saturation test. Through the step-by-step coding and systematic comparison of the newly added materials, it was found that no new concepts or structural relationships emerged. This indicates that the existing theoretical framework has good integrity and theoretical saturation, and the data collection has reached a saturated state.

4. Design and Empirical Research on The Knowledge Graph of Cultural Tourism in Liaoning Province

Based on the characteristic model of cultural tourism in Liaoning Province and relevant scenic spot data, a knowledge graph in this field was constructed. The specific work consists of two core parts: first, in accordance with the cultural tourism characteristic model of Liaoning Province and by reusing existing ontologies, the schema layer of the knowledge graph was built in Protégé with the seven-step method; second, Python was adopted for data collection, and the data layer was constructed with the help of the Neo4j graph database. Thus, a complete knowledge graph architecture from the schema layer to the data layer was ultimately established, and the specific process is shown in Figure 1.

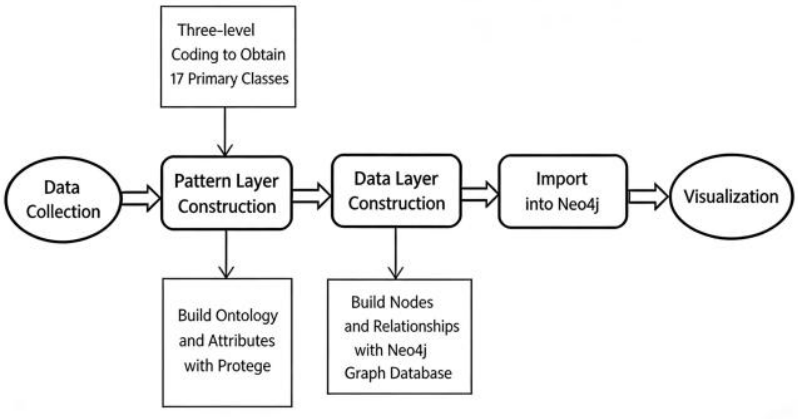

Figure 1: Ontology Framework of Cultural Tourism Knowledge Graph of Liaoning Province Based on Cultural Dimensions

4.1 Data Acquisition

Relevant data and information about cultural tourism attractions in Liaoning Province were collected

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through multiple channels, and then screened and processed to obtain data materials that meet the research requirements.

4.2 Construction of the Model Layer

The model layer occupies a core position in the knowledge graph architecture. Based on the four main categories obtained by grounded theory and combined with the current situation of cultural tourism in Liaoning Province, this study designs the ontology framework of the cultural tourism knowledge graph in Liaoning Province.

The design idea is as follows: the main categories are established as top-level classes, and specific knowledge graph classes and attributes are designed under each first-level class to ensure full coverage of the connotation of each category. Taking the main category of culture as an example, details are presented in Figure 2.

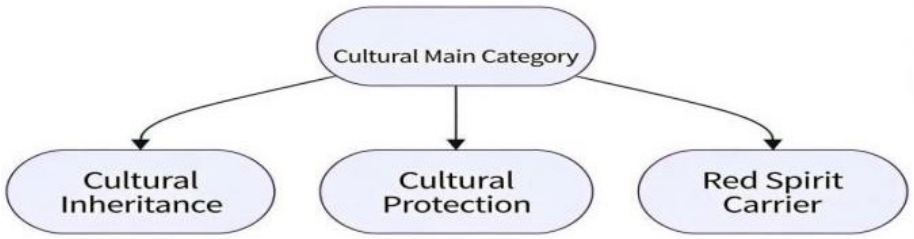

Figure 2: Ontological Framework of Liaoning cultural Tourism Knowledge Graph Based on Cultural Dimensions

Based on the above design ideas and ontology reuse, this study finally defines 17 first-level classes, including: Historical Events, Historical Figures, Movable Cultural Relics, cultural Tourism Attractions, Geographic Service Nodes, Cultural Inheritance, Cultural Protection, Carriers of cultural Spirit, Tourist Feedback, Product Innovation, Travel Considerations, Marketing, Economic Benefits, Development Prospects, Scenic Area Management, Social Education, and Social Collaboration.

4.3 Construction of the Data Layer

After constructing the ontological framework and its attributes using the Protégé tool in the preceding sections, this study further converts these ontologies and attributes into a visual relational network with the help of the Neo4j graph database. Taking Historical Events as an example, the detailed information on the formed node categories and the association relationships between nodes is presented in Table4.

Table 4. Node types and relationships of historical

Source Node	Relationship	Target Node
Cultural Inheritance	Activity Name	Specific name of the inheritance activity
	Activity Type	e.g., Lectures, Performances, Study Tours, Commemorative Ceremonies
	Holding Frequency	e.g., Once a year, Every Saturday
	Lecturer/Organizer	Person in charge or organizing unit of the activity

4.4 Data Visualization

Drawing on the constructed knowledge graph of cultural tourism in Liaoning Province, this paper takes the Liaoshen Campaign Memorial Hall as a case to carry out the instantiated construction of the knowledge graph. To enhance the clarity and interpretability of the visualization effect, a sampling display strategy was finally adopted. By executing the Cypher query statement MATCH (n) RETURN n LIMIT 300, a subgraph containing 300 nodes and their associated relationships was extracted from the full - scale data for visual presentation, which served as the entry point and example for subsequent analysis.

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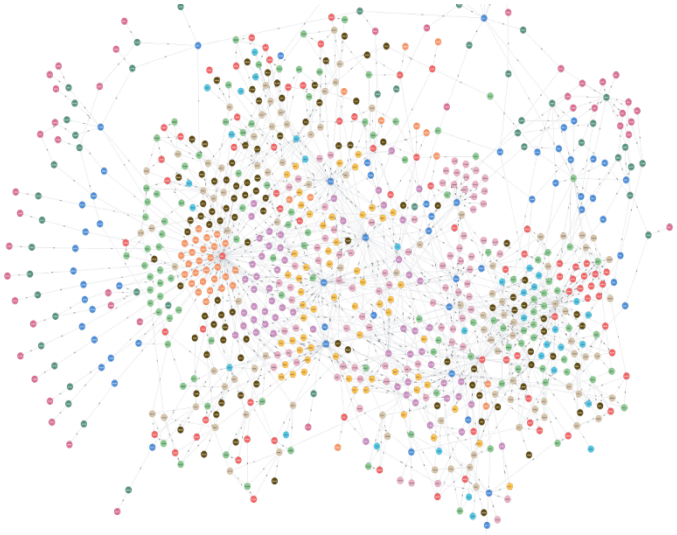

Figure 3: Visualization of the cultural Tourism Resources Knowledge Graph of the Liaoshen Campaign Memorial Hall

In the knowledge graph illustrated in Figure 3, node colors are assigned a clear function of type identification, where different color values correspond to distinct entity categories. The connecting edges between nodes fully express the semantic associations among various entities of the cultural tourism resources of the Liaoshen Campaign Memorial Hall. This visualized "node-relation-node" structure directly embodies the semantic organization mode of "entity-relation-entity", and clearly presents the topological structure of the association network formed by the interconnection of heterogeneous nodes. The graph structure boasts favorable scalability; as domain-specific data continues to accumulate, dynamic supplementation of nodes and relations can be flexibly achieved via the Cypher query language, as illustrated in Figure 4. This extensible architecture lays a fundamental foundation for the realization of advanced knowledge services such as intelligent Q&A, relational reasoning, and personalized recommendation in the future, and significantly improves the organizational level and intelligent application capability of the knowledge graph.

```
        through
        zhucong1 = Relationship(cong18, 'through', nodeList4[0])
        zhucong2 = Relationship(cong13, 'through', nodeList4[8])
        graph.create(zhucong1)
        graph.create(zhucong2)
        graph.create(zhucong3)

    else:
        cong14 = Node('marketing channel', name=data1[i][14])
        graph.create(cong14)
        zhucong1 = Relationship(cong18, 'through', cong14)
        zhucong2 = Relationship(cong5, 'through', cong14)
        zhucong3 = Relationship(cong13, 'through', cong14)
        graph.create(zhucong1)
        graph.create(zhucong2)
        graph.create(zhucong3)
    if len(nodeList5) > 0:
```

Figure 4: Node - Related Information

4.5 Data Retrieval

By using Cypher statements, precise retrieval of nodes or relationships can be achieved. Taking "cultural attractions" as the retrieval target, a statement can be written to search for "the Liaoshen Campaign Memorial Hall", enabling accurate positioning of the corresponding cultural attraction node. Clicking on this node allows for a clear view of all other corresponding relationships it bears and connects to, with the visualized results shown in Figure 5.

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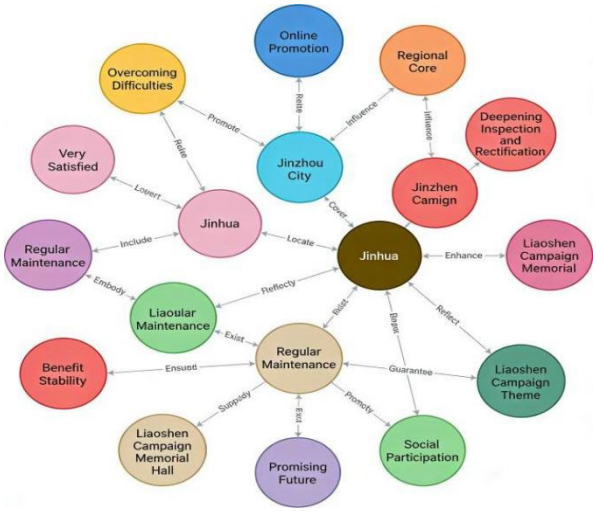

Figure 5: Knowledge Graph Display of the Liaoshen Campaign Memorial Hall

5. Conclusions and Limitations

5.1 Research Conclusions

This research, by constructing and applying the knowledge graph of cultural tourism in Liaoning Province, not only achieved the systematic integration and visual presentation of cultural resources, but also provided methodological support and data foundation for intelligent tourism services, cultural communication innovation and industry management upgrading. It has positive significance for promoting the high-quality development of cultural tourism and the contemporary inheritance of culture in Liaoning Province.

5.2 Limitations

This study has initially completed the construction and application exploration of the cultural tourism knowledge graph of Liaoning Province, yet there remains room for improvement in theoretical depth, technical precision and application breadth.

The currently constructed ontology model still has scope for refinement in terms of entity coverage and relationship granularity. Future research will introduce ontology reuse and model evaluation mechanisms, and refer to more mature upper-level ontologies to enhance the theoretical consistency and domain adaptability of the model.

The data sources and knowledge fusion precision of this study are still constrained by technical methods and tools. In the next step, more advanced natural language processing (NLP) tools and deep learning algorithms will be adopted to improve the accuracy of knowledge extraction from unstructured texts.

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