Structural Representation and Digital Narrative: Event Ontology-Driven Cultural Transcoding of Chinese Ancient Villages with Red Legacy

Tianjiao Qi [1,2], Xinyue Zhang [1], Yejing Yin [3]

[1] School of Information Resource Management, Renmin University of China, Beijing, China -zhangxinyue817@ruc.edu.cn
[2] Research Center of Digital Humanities, Renmin University of China, Beijing, China - qtjjoy@163.com
[3] Gaoling School of Artificial Intelligence, Renmin University of China, Beijing, China - 2022202096@ruc.edu.cn

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Abstract

This study pioneers an event ontology framework for Chinese Ancient Villages with Red Legacy to resolve cultural resource fragmentation and narrative discontinuity. Extending the CIDOC-CRM standard, this paper developed a multidimensional ontology integrating villages, events, figures, locations, time, and cultural resources through domain-specific semantic modeling. Utilizing Protégé and Neo4j tools, unstructured cultural resources from 754 nationally designated villages were transformed into structured linked data, exemplified by the Dawangmiao Village knowledge graph implementation. This framework enables multidimensional access to tangible/intangible heritage, dynamic reconstruction of revolutionary history via semantic relationships, and structural representation of spatiotemporal contexts. The ontology-driven approach significantly enhances scholarly research capabilities and dissemination efficacy, establishing a reusable digital infrastructure for transmedia storytelling. It provides methodological foundations for digital conservation of red legacy, directly supporting red-themed education and sustainable cultural tourism development through semantically enriched knowledge organization.

1. Introduction

1.1 Chinese Ancient Villages with Red Legacy

Traditional Chinese Villages refer to settlements formed in earlier times, possessing abundant traditional resources and historical, cultural, and multifaceted value (Ministry of Housing and Urban-Rural Development of the People's Republic of China [MHURD], 2012). They document the formation and evolution of China's traditional agrarian society, and are acclaimed as the "genetic repository" and "living fossils" of Chinese civilization (Ma LQ, 2023). Since 2012, China has comprehensively implemented the Ancient Village Conservation Project, with 8,155 villages included in the National List of Traditional Villages to date (MHURD, 2023). Based on their defining cultural characteristics, these villages are primarily categorized into three types: those featuring clusters of historic architecture, those embodying significant settlement planning culture, and those rich in intangible cultural heritage (Zhao H, 2013).

Examining the detailed historical and cultural contexts of ancient villages, particularly within the framework of modern Chinese revolutionary history, reveals a special type possessing composite cultural value: Ancient Villages with Red Legacy. Red Legacy refers to cultural heritage associated with the revolutionary history led by the Communist Party of China, including sites, artifacts, and oral traditions from the 1921-1949 revolutionary period. Ancient villages with Red Legacy are defined as organic territorial spatial entities rooted in specific rural settlement spaces, with revolutionary cultural DNA as their core informational unit. Their essence encompasses commemorative sites, landmarks established by the Chinese Communist Party (CCP) leading the people during the revolutionary war period (1921-1949), along with the resultant revolutionary history, events, and spirit that permeate the space(Yang YB and Deng Q,2022). Specifically, Ancient Villages with Red Legacy represent a subtype of Red Villages distinguished by their extended settlement histories and elevated historical-cultural significance. These villages embody the intersection between ancient villages and red villages, meeting dual compliance with criteria for both historical longevity and revolutionary cultural attributes. Their dual identities possess unique research value in the field of cultural heritage protection.

1.2 Systemic Challenges and Digital Transformation in Village Conservation

However, the conservation of ancient villages currently faces systemic challenges under the tide of modernization. Rapid urbanization-induced population loss leads to the absence of cultural transmission agents, while village hollowing-out accelerates the decay of physical fabric. Administratively driven conservation models have resulted in ambiguous property rights and imbalanced benefit distribution. Capital intervention in tourism development risks fragmenting cultural memory and reducing living heritage to commercialized consumption symbols, while the interplay of multiple stakeholders creates governance dilemmas (Tian FZ, 2023).

In this context, digital conservation emerges as a necessary response: utilizing technologies like 3D scanning and virtual reality to preserve endangered built structures, mitigating the fragility of physical carriers; constructing cultural memory databases to revitalize intangible heritage and transcend spatiotemporal transmission constraints; leveraging data analysis to optimize conservation decisions and establish dynamic monitoring and response mechanisms. Digital technology disrupts traditional unidirectional conservation by reconstructing heritage value systems through event correlation and spatiotemporal visualization, establishing foundations for multi-stakeholder collaborative mechanisms in the digital era.

1.3 The Multifaceted Research value of Ancient Villages with Red Legacy

Ancient Villages with Red Legacy represent a type of exceptional value within China's cultural heritage system.Their

core feature lies in witnessing the historical memories and cultural practices of modern revolutionary wars, and forming a unique cultural complex.Their research significance manifests primarily in three dimensions:

First, as physical spaces of modern warfare relics, they preserve a wealth of revolutionary-era architectural remains, living environments, and military facilities, providing irreplaceable material historical sources for studying modern Chinese history. Second, war memories, transmitted through living mechanisms like oral traditions and commemorative rituals, continuously generate empirically valuable collective memory resources. These intangible cultural elements expand the analytical scope of revolutionary history research into the dimension of cultural influence, revealing the mechanisms of cultural agency in social transformation. Third, these villages exhibit a characteristic "spatiotemporal superimposition," reflecting a deep intertextuality between traditional spaces and revolutionary events, making them crucial samples for analyzing cultural transformation during China's revolutionary history.

1.4 Advancing Methodology: An Event-Driven Ontology Approach

Given the cultural specificity of Ancient Villages with Red Legacy, traditional static classification methods prove inadequate for capturing their dynamic historical trajectories. Adopting an Event-Driven Ontology Approach (EDOA) can overcome this limitation.

First, this method uses historical events as an organizational framework to systematically deconstruct the mutual constitution between revolutionary practices and traditional spaces, enabling quantitative analysis of the localization mechanisms of revolutionary culture dissemination. Secondly, by analyzing the dissemination mechanism of revolutionary culture, it models cultural practice as a discrete event chain and visualizes the spatial infiltration path of revolutionary culture. Practically, this framework supports dynamic knowledge updating and digital twin applications, accommodating the continuous discovery of new historical materials and bridging professional research with public understanding. Consequently, event-driven ontology research not only deepens comprehension of the generative logic behind the dual cultural identities within Ancient Villages with Red Legacy but also, through methodological innovation, highlights their unique academic value and practical significance in modern Chinese historical studies.

2. Literary review

2.1 Research Status in Ancient Village Studies

Current research on Chinese ancient villages has yielded substantial outcomes, primarily focusing on historical context, architectural typology, spatial configuration, landscape features, and associated conservation and development strategies. Existing studies demonstrate that spatial analysis techniques like GIS can effectively reveal the spatial distribution patterns of ancient villages and their influencing factors.(Zeng YL,2025) However, this field has long grappled with challenges stemming from relatively singular disciplinary perspectives and methodological limitations. A prominent issue is the predominance of static descriptions, with insufficient attention paid to the dynamic transmission mechanisms of living cultures, such as "village rituals" (cunli) and "clan rituals" (zuli). (Current Status and Reflections on Village Culture Research in China,2016)Concurrently, the lack of unified data collection standards and technological cost constraints have resulted in significantly fragmented data, hindering the construction of a comprehensive cultural resource system for ancient villages. This impedes the in-depth exploration and holistic presentation of their cultural value.(Zhang HJ et al.,2017)

2.2 Research Status in Revolutionary Cultures

Within the realm of revolutionary cultures research, scholarly achievements have primarily concentrated on the textual research and analysis of archival documents, revolutionary relics, and other historical records, forming a solid academic foundation. In recent years, Chinese academia has progressively strengthened its integrated understanding of rural culture and revolutionary cultures, affirming the positive influence of revolutionary cultures in rural revitalization—bolstering conviction, guiding industry, serving as communication vehicles, and acting as mnemonic bonds. (Li WF and Jiang JJ,2018)Nevertheless, key questions remain unresolved: What constitutes the specific connotation of revolutionary cultures within Chinese ancient villages? What cultural structure do they manifest? How were they incubated and formed within revolutionary history? And how do they influence the transmission and development of other cultural elements within ancient villages? Although recent studies have begun to explore the impact of revolutionary cultures factors on the spatial differentiation of villages,(Pan JB and Li XY,2024) the field of revolutionary cultures research overall exhibits a pronounced tendency towards prioritizing textual records over spatial analysis.

Consequently, research on Ancient Villages with Red Legacy, these unique cultural spatial remnants bearing revolutionary history and spirit, remains relatively underdeveloped. Existing studies often focus on villages already developed into tourist attractions, paying insufficient attention to their integrity as comprehensive cultural spaces (integrating natural, historical, social, and cultural contexts). Furthermore, they have largely failed to establish a robust theoretical framework capable of explaining the dynamic coupling mechanism between "space and events." This leads to blind spots in comprehending the spatiotemporal integrity of revolutionary villages, making conservation practices susceptible to becoming isolated efforts or symbolic collages.

2.3 Ontology Modeling: Advancements and Event-Driven Innovation

Ontology modeling, as a key technology for formalizing domain knowledge expression and establishing semantic relationships, has gained significant traction in the digitalization of cultural heritage. The internationally recognized CIDOC CRM model (ICOM,2006)provides a systematic descriptive framework for core concepts in cultural heritage. Domestic research in China is also actively exploring the construction of ontologies with greater local specificity for intangible cultural heritage, covering areas like traditional festivals and architectural craftsmanship. Ontology models have been applied to build knowledge graphs and extract features for ancient villages, enhancing data organization and retrieval efficiency. However, while ontology research in cultural heritage has made progress in domains like museums, cultural relics, and specific intangible heritage, its application scope and model design exhibit limited adaptability

to complex, integrated cultural spaces like ancient villages. A particular deficiency is the lack of systematic representational capacity for **event** elements of core historical and spiritual significance, such as war events. This impedes the ability to model the deep space-event interconnections inherent in Ancient Villages with Red Legacy.

Event ontology, a significant branch of ontological research, centers on the event as its core unit. By describing elements such as actions, time, objects, locations, participants, and their complex interrelationships, it can more effectively capture dynamic processes and spatiotemporal interactions. Compared to traditional ontologies, which tend to atomize event concepts and staticize relationships, (Liu ZT et al.,2009) event ontology demonstrates distinct advantages in representing complex historical processes and cultural practices. It has already been applied within digital humanities for tasks like the storified narration of open historical archives and the construction of knowledge graphs for major historical events.(Li H et al.,2020) This offers new pathways for structuring revolutionary spiritual genealogies and establishing deep resource interconnections.

2.4 Knowledge Gaps and Event-Ontology Driven Solutions

Based on the limitations existing in the above-mentioned research, there is an urgent need to construct a Revolutionary Ancient Village ontology driven by event ontology. This research pathway aims to position revolutionary activity events as the central nexus, structurally integrating multidimensional elements of ancient villages—spatial entities, material relics, intangible culture, and historical context. By establishing precise mapping relationships between event elements (time, location, participants, actions, impacts) and village spaces/cultural representations, this approach can not only bridge the disconnect between traditional and revolutionary cultural records but also effectively interlink multi-source heterogeneous data. Crucially, it can strengthen the narrative cohesion afforded by core events, forming coherent and complete chains of revolutionary events and cultural maps. This methodology can overcome the constraints of traditional conservation models, enabling deep interpretation and dynamic transmission of the cultural value within Ancient Villages with Red Legacy. Furthermore, it provides an innovative technological pathway and a solid theoretical foundation for the contemporary revitalization and utilization of revolutionary cultural legacies, holding significant practical importance for advancing the systematic protection of cultural resources and the cultural revitalization of rural areas.

3. Methodological and Data Collection

3.1 Ontology Design and Core Framework

This study employs the internationally recognized Stanford Seven-Step Methodology(STEVENS R,2025) to construct an event-driven cultural ontology model for Ancient Villages with Red Legacy. This established methodology encompasses key stages: domain definition, ontology reuse, terminology extraction, class and hierarchy definition, property definition, constraint specification, and instance creation. It demonstrates high maturity and applicability within the field of cultural heritage ontology construction.

Following domain scoping, the study first adopts the International Committee for Documentation Conceptual Reference Model (CIDOC-CRM) as its foundational framework. Developed by the International Council of Museums (ICOM), CIDOC-CRM's robust entity-attribute descriptive system effectively represents core elements within cultural heritage, such as actors (people), temporal dimensions (time), and spatial dimensions (place). However, CIDOC-CRM exhibits limitations in expressing the multi-dimensional semantics of dynamic events, making it difficult to satisfy the specific narrative requirements inherent to revolutionary historical events. To address this, the study integrates specialized event ontologies – including Event Ontology (EO)(Zhong Z et al.,2012), F-Event Model (F-Model)(Scherp A et al.,2009), and Simple Event Model (SEM)(Van Hage W R et al.,2011). Through conceptual restructuring and knowledge reorganization, it establishes an event knowledge model specifically tailored for Ancient Villages with Red Legacy.

During the construction phase, the study utilizes bibliometric methods to extract core concepts from historical archives, achieving conceptual alignment with reused ontologies through semantic mapping. It also references specialized research outcomes, such as the revolutionary archives ontology(Huang YQ et al.,2023) and the CCP historical events ontology, to semantically extend standard relationships. This includes verifying semantic compatibility (e.g., validating the compatibility between the relationship "Erqi Conference → held → Liangjia Ancestral Hall" and the CIDOC-CRM property crm:P8_took_place_on_or_within). After defining the base classes and hierarchies, 25 Ancient Villages with Red Legacy from the fifth batch were selected for instance validation. The ontological logical structure was refined through iterative optimization.

The final Revolutionary Ancient Village Cultural Ontology (AVRE) comprises 7 core classes, 43 data properties, and 134 object properties. The 7 top-level classes (including Event and Person) branch into 24 second-level classes and 19 third-level classes, forming a comprehensive knowledge system for revolutionary cultures.The fundamental framework of the event-driven cultural ontology for Ancient Villages with Red Legacy is illustrated in the ER diagram (see Figure 1), where Rectangles denote first-level core classes; Ellipses represent entities (S); Diamonds indicate inter-class relationships (G).

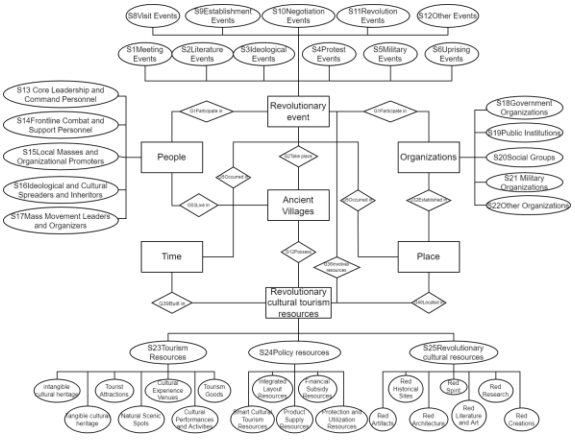

Figure 1. Event ontology of Ancient Villages with Red Legacy

3.2 Data Properties and Object Properties

Regarding property definition, the study innovatively adopts a **Five-Dimensional Elemen**t modeling approach. Using the framework **Time-Place-Person-Event-Resource**, it constructs

the data property system. Specifically, **the Revolutionary Event class** is assigned multi-dimensional properties such as name, brief description, and historical significance. **The Person class** includes properties ranging from basic information (name, gender) to social attributes (party affiliation, position). Notably, the model elevates **Time** and **Place** to independent class concepts. Their related attributes are expressed through associated object properties.

The object property system represents a key innovation of this research, comprising 134 relationships. These properties not only establish vertical connections between core classes and their subclasses but also create a cross-dimensional semantic network. Particularly for expressing relationships among revolutionary events, the study makes a breakthrough by designing dual-relationship properties encompassing both temporal sequence and logical connection. By constructing event chains, this effectively resolves the issue of fragmented revolutionary narratives, providing structured support for the systematic interpretation of revolutionary cultural resources.

4. Knowledge Graph Construction and Application

4.1 Formal Ontology Modeling with Protégé

This study employs an engineering approach to implement the AVRE ontology technically. During the formal modeling phase, Protégé 5.5 was selected as the development environment, and the ontological logic was expressed based on the OWL 2 language specification. Key technical implementations include:

4.1.1 Class Hierarchy Construction: Utilizing rdfs:subClassOf to establish the class hierarchy. Specifically, **the Revolutionary Event class** is defined as inheriting from the CIDOC-CRM base class E5_Event.

4.1.2 Object Property Definition: Defining 134 object properties using owl:ObjectProperty. Standard properties were semantically mapped to CIDOC-CRM (e.g., occurred at location ≡ P7_took_place_at). Custom properties had their domain and range strictly constrained (e.g., the property impacts ancient village is restricted to **the relationship Revolutionary Event → Ancient Village**).

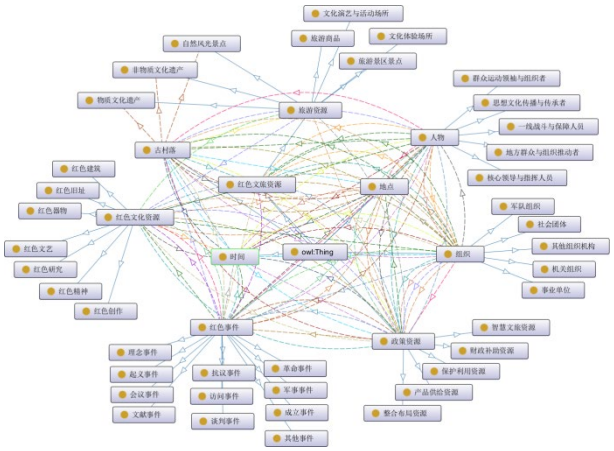

Figure 2. Event ontology of Ancient Villages with Red Legacy protege

4.2 Knowledge Graph Conversion and Application

To enable the practical application of the ontology, this study further constructed a knowledge graph conversion framework. Based on the Neo4j graph database, a systematic conversion scheme from the OWL ontology to a property graph was designed:

4.2.1 Node Modeling: Ontology classes were mapped to graph node labels.

4.2.2 Relationship Modeling: Object properties were transformed into graph relationship types.

4.2.3 Data Conversion: A custom ETL (Extract, Transform, Load) process was implemented to structure and import instance data.

Using village gazetteers from several ancient villages with revolutionary cultural historical backgrounds as data sources, a demonstrative knowledge graph was successfully built. This graph comprises 387 entity nodes and 621 relationships, validating the practical value of this model for digital narratology of revolutionary cultures. This case study fully demonstrates the end-to-end technical pathway, from ontology design to knowledge service delivery.

5. Structural Representation and Digital Narrative

5.1 Ontological Foundations for Cultural Connections

This study focuses on constructing an event-centric ontology for Ancient Villages with Red Legacy and exploring structured presentation and digital narratology methods based on this ontology. By deeply integrating historical documents, archival materials, and villager oral histories, and employing digital technologies, this research not only achieves the visualization of revolutionary cultural resources within these villages but, more crucially, uncovers the subtle, deep-seated humanistic connections within ancient villages. This powerfully corroborates the special value of ancient villages as dual complexes of natural space and humanistic space, as well as the significant value of the traditional cultures and revolutionary cultures they carry.

At the presentation level, this study established a revolutionary village website, leveraging structured presentation and digital narratology to provide the following advantages:

It enables multi-form presentation and interactive experiences.Through structured reorganization of knowledge and multi-dimensional associations, it renders revolutionary historical information more systematic and organized.Simultaneously, utilizing spatiotemporal superimposition analysis, it reveals the spatial memory mechanisms of revolutionary cultures, enhancing researchers' and the public's understanding of the connection between history and the spatial environment.

5.2 Case Exemplar: Event-Driven Knowledge Integration

The core of this study lies in the construction of the event ontology and its revelation of deep-seated connections. Taking Dawangmiao Village in Henan Province, a third-batch nationally recognized ancient village, as an example, the research team constructed an ontology model centered around the key revolutionary event "Tantou Tragedy" (Tantou Can'an).

This construction was based on historical documents such as the Village Annals of Dawangmiao Village, Luanchuan County, Henan Province, archival materials, and villager oral histories.

This ontology integrates nodes related to the event, including **Person** (villagers, faculty and students of Henan University), **Place** (Dawangmiao Village, Tantou Town), **Time,** and **Revolutionary Cultural Resources** like *Chronicle of Henan University Faculty and Students' Bloodshed in Tantou Town During the Anti-Japanese War* (Kangzhan qijian Henan Daxue shisheng Tantou Zhen Diexue Ji), and *Record of the Establishment of the Henan University Tantou Memorial Monument* (Henan Daxue Tantou Jinianbei Jianbei Ji).

Its significant importance lies in transforming scattered documents into a structured knowledge network. For instance, by analyzing individual narratives such as "Villager Yan Huwa outwitted Japanese soldiers to protect faculty and students" and "Villager Sun Minghua assisted faculty and students in hiding teaching instruments", the study established triple relationships like **Villager - Rescued - Faculty/Student** at the ontological level. Concurrently, it linked the temporal sequences of events like "Henan University's Relocation for Operation", "Tantou Tragedy", and "Establishment of the Western Henan Base Area", forming a logical chain of **Mutual Aid in Education - Shared Suffering - Collaborative Resistance**. Serving as a bridge, this ontology model connects village cultural resources with digital narratology, laying the foundation for further interpretation of revolutionary cultural resources.

5.3 Three-Tier Knowledge Architecture and Multimodal Presentation

In terms of structured presentation and visualization, digital technology makes deep connections clearly visible. This study adopted a **Data Layer - Ontology Layer - Application Layer** three-tier architecture to build the knowledge base:

5.3.1 Data Layer: Integrates event texts, personnel archives, and geographic coordinates.

5.3.2 Ontology Layer: Based on the event model, defines core classes and their semantic relationships, connecting the logical chain between events.

5.3.3 Application Layer: Utilizes the Neo4j graph database to build an interactive knowledge graph webpage, dynamically presenting the multi-agent impact network of Dawangmiao Village and the Tantou Tragedy.

Visual analysis revealed the multi-dimensional humanistic bonds formed between Henan University faculty/students and villagers through knowledge dissemination, mutual aid and protection, and joint resistance against the Japanese. It intuitively displayed the trajectory of emotional sublimation in the university-community relations from **Mutual Aid in Education to Sharing the National Crisis,** exemplified by villagers shielding faculty/students, relocating teaching equipment, and the subsequent impact of being inspired by anti-Japanese propaganda to participate in base area construction. The multidimensional search and interactive narratology functions provided by this graph effectively support researchers and the public in autonomously exploring these deep connections.

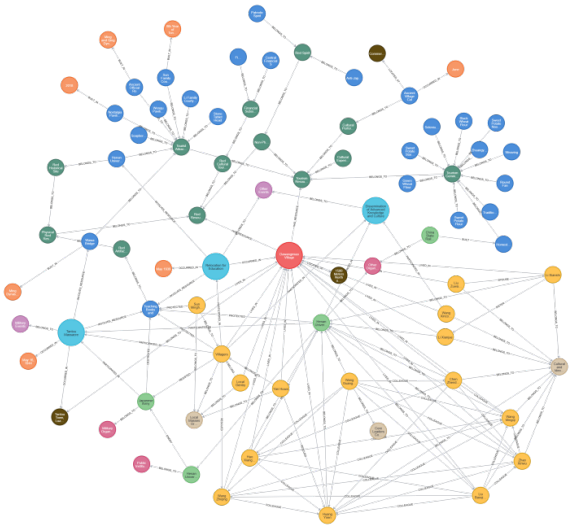

Figure 3. Knowledge graph for Dawangmiao Village

In exploring digital narratology methods, the visualization website for Ancient Villages with Red Legacy built by this study further enhances knowledge dissemination efficacy. The website combines GIS technology and distant reading methods to systematically analyze the spatiotemporal distribution patterns, composition of cultural resources, and spatial correlations of Ancient Villages with Red Legacy. It deepens the understanding of spatial memory through spatiotemporal superimposition mechanisms.

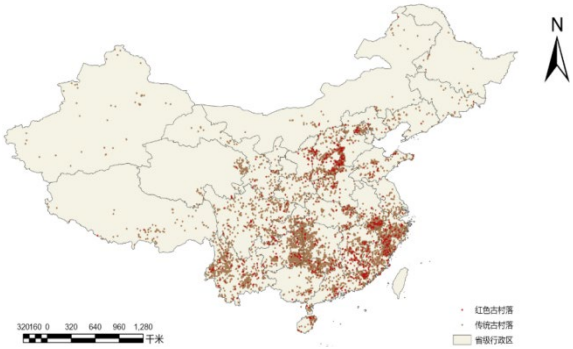

Figure 4. Distribution map of Ancient Villages with Red Legacy among the six batches of national traditional villages

Simultaneously, focusing on 209 villages in Shandong Province characterized by revolutionary cultures, it constructed the **Qilu Database of Characteristic Revolutionary Cultural Villages** around information such as historical background, cultural tourism resources, and policy funding. This achieves structured reorganization of knowledge and cross-dimensional associations, forming an integrated retrieval platform for provincial-level revolutionary village information. This multi-form presentation significantly enhances the accessibility and utilizability of cultural resources.

Figure 5. Qilu Database of Characteristic Revolutionary Cultural Villages

In summary, through the combined application of event ontology construction, structured presentation, and digital narratology tools, this study enables the vivid reproduction of revolutionary history and humanistic elements in digital space. The structured translation of knowledge not only promotes the in-depth exploration and dissemination of revolutionary cultures but also, by establishing event logic chains and spatiotemporal memory mechanisms, opens new pathways for revolutionary education, tourism, and cultural transmission.

6. Outcomes and Impacts

As tangible carriers of the Chinese national heritage and outstanding traditional cultures, Chinese ancient villages bear profound historical, cultural, scientific, artistic, social, and economic value . Ancient Villages with Red Legacy, serving as convergence points for both traditional cultures and revolutionary cultures, possess significant value for cultural exploration and transmission. However, they currently face challenges such as inadequate integration of cultural resources, fragmented narratives, and lagging technical methods. These issues lead to a disconnection between traditional and revolutionary cultures and a lack of data interlinkages(Notice on Conducting the Survey and Recommendation Work for the Sixth Batch of Traditional Chinese Villages,2023).

The event-driven ontology model for Ancient Villages with Red Legacy systematically constructed in this study achieves a structural leap in representing revolutionary cultural resources, transforming them from discrete remnants into a systematized knowledge network. Serving as the core hub, the event ontology deeply interconnects revolutionary events, Person, Place, and cultural symbols, effectively addressing the core dilemma of cultural disconnect and fragmented narratives between traditional and revolutionary cultures within the context of rural revitalization. Through the innovative integration of the event ontology framework and digital narratology techniques, this research realizes the transformation of revolutionary cultural resources from fragmented remnants into a structured knowledge system. This ontology model profoundly integrates the dual cultural legacy of material remains and spiritual representations, successfully establishing a dynamic association mechanism between historical event chains and the spatial fabric.

The research outcomes not only provide a comprehensive conservation solution for revolutionary cultural heritage encompassing **digital twinning—spatiotemporal reconstruction—memory** transference but also, through the visualization and narratology platform, activate the contemporary vitality of revolutionary history.

Through this structured translation and digital narratology, the event ontology not only becomes a bridge connecting revolutionary cultural resources with contemporary dissemination but also, at a methodological level, provides a new pathway for the revitalization of revolutionary resources within rural revitalization. This methodological breakthrough not only expands the theoretical boundaries of cultural heritage digitization but also opens new avenues for the living transmission of revolutionary legacy under the rural revitalization strategy. It promotes the paradigm shift of ancient villages from static historical fossils to dynamic spiritual homes.

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