



# International Journal of Multidisciplinary Research in Science, Engineering and Technology

*(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)*



**Impact Factor: 8.206**

**Volume 9, Issue 3, March 2026**



# Research Progress and Application Trends of Red Culture Knowledge Graphs: A Review

Yuexing WU<sup>1</sup>, Zihong WU<sup>2</sup>

School of Management, Hunan City University, Yiyang, Hunan 413000, China<sup>1</sup>

International Education College, Hunan City University, Yiyang Hunan 413000, China<sup>2</sup>

**ABSTRACT:** Against the backdrop of China's national cultural digitization strategy and the continuous advancement of digital humanities, research on knowledge graphs of red cultural resources has gradually shifted from single-resource digitization and organization toward multi-source heterogeneous data integration, semantic association modeling, and scenario-oriented intelligent services. Based on a corpus of 30 collected studies, this paper systematically reviews research on red culture knowledge graphs from four dimensions: research objects and resource types, construction methods and technical routes, application scenarios and service models, and research evaluation and development trends. The findings indicate that existing studies have formed a research landscape characterized by multiple types of entities, including historical figures, events, cultural relics, archival materials, revolutionary sites, and publishing resources. The technical pathways have evolved from ontology modeling and rule-based extraction to multimodal integration and large language model-assisted knowledge extraction. In terms of application, knowledge graphs have gradually expanded into diverse scenarios such as education, libraries, cultural tourism, rural revitalization, intelligent question answering, and spatiotemporal narrative visualization. However, several challenges remain, including the in-depth mining of regional revolutionary figure resources, the coordinated organization of multimodal data, sustainable knowledge updating mechanisms, and the development of visualization platforms for public-oriented communication. Overall, research on red culture knowledge graphs is transitioning from a stage of resource integration to a new phase emphasizing knowledge association and intelligent services.

**KEYWORDS:** red culture; revolutionary historical figures; knowledge graph; multimodality; visualization applications; digital humanities

## I. INTRODUCTION

Red cultural resources constitute an important carrier of China's revolutionary historical memory, spiritual lineage, and local social development. With the advancement of knowledge graphs, digital humanities, large language models, and visualization technologies, the organization of red cultural resources is gradually shifting from a "document-listing preservation" model to a "semantic network-based association" model. Existing studies generally suggest that knowledge graphs can not only improve the structuring, standardization, and interconnection of red cultural resources, but also provide new technological support for cultural dissemination, educational transformation, intelligent services, and the development of local culture [1–2]. In this context, the focus of red culture research is gradually moving from general resource digitization toward in-depth knowledge modeling oriented to specific regions, themes, and research objects.

From the perspective of existing studies, research on red culture knowledge graphs has gradually formed a relatively clear set of research concerns. First, red cultural resources are widely dispersed, lack unified standards, and show insufficient levels of resource sharing [3]. Second, the modes of resource presentation remain relatively limited, and the deeper cultural connotations embedded in these resources still require further exploration [4]. Third, current applications mainly focus on display and retrieval functions, while the level of intelligent knowledge services still needs improvement [5]. Therefore, conducting a systematic review of existing research achievements can not only help clarify the development trajectory of red culture knowledge graph studies, but also provide theoretical references for further research in related fields.



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### II. RESEARCH OBJECTS AND RESOURCE TYPES: FROM GENERAL RED RESOURCES TO THEMATIC, REGIONAL, AND FIGURE-CENTERED STUDIES

In terms of research objects, existing studies have gradually moved beyond the broad notion of “red cultural resources” and have formed a more refined research landscape focusing on specific regions, categories, and themes. Some studies take regional red cultural resources as their primary object of analysis. For example, research on the knowledge graph construction of red cultural resources in Liaoning Province [6] and studies on the red culture knowledge graph of Shanghai [7] mainly emphasize the integration of regional red resources and the promotion of local cultural communication. Other studies concentrate on specific revolutionary historical resources, such as the Northeast Anti-Japanese United Army resources [8], Long March red cultural resources [9], multimodal red cultural resources of the New Fourth Army [10], and revolutionary relic resources of the Dabie Mountains [11], demonstrating a clear trend toward thematic research.

Regarding resource types, research objects have expanded from traditional textual historical materials to a variety of cultural carriers, including red archives, revolutionary relics, revolutionary sites, artistic works, and publishing resources. For instance, studies on the narrative development of red archives [12], aggregation services for red literature resources [13], knowledge organization of Party-history-themed artworks [14], ontology model construction for revolutionary sites knowledge graphs [15], and knowledge graph construction for red publishing resources [16] indicate that red culture research is gradually moving beyond a single literature-centered paradigm toward the collaborative organization of cross-media and multi-form resources.

Meanwhile, research on historical figures has increasingly become an important direction in red cultural knowledge graph studies. Existing research has explored topics such as knowledge service systems for founding generals from Anhui Province [17], knowledge-based question-answering services for red historical figures [5], and the construction of knowledge graphs for figures associated with the Northeast Anti-Japanese United Army [18]. These studies demonstrate that red historical figures play a crucial role in connecting revolutionary events, historical locations, organizational relations, and spiritual lineages. Compared with general resource knowledge graphs, figure-centered knowledge graphs are more conducive to conducting relational network analysis, representing historical trajectories of individuals, and reconstructing historical narratives, thereby enhancing the narrative quality and readability of red cultural communication.

### III. CONSTRUCTION METHODS AND TECHNICAL ROUTES: FROM ONTOLOGY MODELING TO MULTIMODAL INTEGRATION AND LARGE-MODEL ASSISTANCE

From the perspective of technical pathways, existing studies have gradually formed a relatively complete workflow for constructing red culture knowledge graphs. Early research mainly emphasized the overall architecture involving the data layer, ontology layer, knowledge extraction layer, graph layer, and application layer. For example, research oriented toward knowledge services proposed a general framework consisting of a “digital resource layer–semantic description layer–knowledge graph layer–application service layer” [2]. Meanwhile, studies on the construction paths of red culture resource knowledge graphs further summarized key stages including data layer construction, ontology modeling, knowledge extraction, knowledge fusion, and visualization applications [4]. These studies provide a relatively mature methodological foundation for subsequent thematic practices.

In terms of data acquisition, the collection of multi-source heterogeneous data has become a common consensus in current research. Studies on the “Red Memory” knowledge graph suggest that red cultural resources should be collected through multiple channels, with entity, attribute, and relationship identification conducted for data from different sources and structures [19]. Research on Long March red cultural resources integrates web crawlers, OCR recognition, and named entity recognition technologies to achieve data aggregation [9]. Similarly, studies on the Shanghai red culture knowledge graph extract structured data from sources such as local thematic websites and red culture maps [7]. These practices indicate that the construction of red culture knowledge graphs is shifting from a single-database model toward a multi-source data integration model.

In terms of knowledge modeling, the combination of the Protégé ontology modeling tool and the Neo4j graph database has become a commonly used technical solution [9,14]. In addition, research that constructs ontology models of revolutionary heritage sites based on CIDOC-CRM [15] demonstrates that red culture knowledge graphs have begun to



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adopt mature ontology standards from the cultural heritage domain to enhance semantic expressiveness and cross-platform interoperability.

Meanwhile, multimodal knowledge modeling is emerging as a new research trend. For instance, research on the multimodal red cultural resources of the New Fourth Army incorporates textual, image, audio, and video resources into a unified modeling system [10]. Studies on the English translation of red historical materials in northern Guangdong also propose the use of multimodal knowledge graphs to address issues such as fragmented terminology and weak associations among historical materials [20]. These findings indicate that the organization of red cultural knowledge is shifting from a text-centered approach toward multimodal collaborative representation.

In recent years, the application of large language models has further promoted the development of knowledge graph construction methods. For example, a study using the Menglianggu Campaign as a case employed the ChatGLM model for entity and relation extraction [21]. Research on figures of the Northeast Anti-Japanese United Army combined models such as Qwen, DeepSeek, GLM, and Llama with LoRA fine-tuning to achieve efficient information extraction in low-resource environments [18]. Related studies have also proposed a red resource knowledge mining framework centered on large language models [22]. These studies suggest that the construction of red culture knowledge graphs is gradually shifting from a traditional rule-driven paradigm toward a new stage integrating ontology constraints, model-assisted extraction, and manual verification.

#### IV. APPLICATION SCENARIOS AND SERVICE MODELS: FROM KNOWLEDGE PRESENTATION TO NARRATIVE COMMUNICATION, EDUCATIONAL TRANSFORMATION, AND INTELLIGENT SERVICES

At the application level, research on red culture knowledge graphs has gradually shifted from “building graphs” to “using graphs.” First, in the field of education, studies on the integration of red cultural resources with ideological and political education have become increasingly active. Relevant research indicates that, under the background of educational digitalization and artificial intelligence, digital platforms, immersive learning environments, and dynamic evaluation systems can be utilized to integrate red cultural resources into ideological and political education in universities [23–24]. Meanwhile, studies from a digital humanities perspective on the development of red historical materials suggest that a multi-level educational application system can be constructed through curriculum transformation, classroom innovation, and the reconstruction of social memory [25].

In the fields of public cultural services and libraries, knowledge graph technologies have also demonstrated significant value. For instance, knowledge graphs of revolutionary wars have been applied to the digital construction of public library resources and intelligent retrieval services [21]. The thematic research project “Shanghai Supporting the Whole Nation” has promoted the construction of red memory through the development of library collections and the establishment of knowledge graphs [26]. In addition, research on the aggregation of red literature resources from the perspective of the metaverse explores integrating digital twin and virtual reality technologies into service systems for red cultural resources [13].

Knowledge graph technology also plays an important role in knowledge question-answering, spatiotemporal visualization, and narrative communication. Research on knowledge-based question answering for red historical figures has developed a complete technical framework including knowledge extraction, knowledge fusion, and KBQA systems [5]. Studies on founding generals from Anhui Province have utilized GIS technology to visualize the trajectories of historical figures [17]. The knowledge graph of the Northeast Anti-Japanese United Army enables spatiotemporal narrative presentation of revolutionary history through a mobile application [8]. Research on red archives in the Dabie Mountains further promotes integrated media dissemination by applying narrative theory [12]. Moreover, studies on digital memory engineering propose transforming fragmented historical memories into immersive digital cultural spaces through processes such as aggregation, reconstruction, and narrative structuring [27].

In addition, some studies have attempted to combine red culture knowledge graphs with broader social practices, including rural revitalization [1], cultural resource preservation [28], archival value development [29], and digital museum exhibitions [30]. These explorations demonstrate that knowledge graphs are not only an information technology tool but are gradually becoming a key infrastructure for promoting the digital dissemination and social transformation of red culture.



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### V. RESEARCH REVIEW AND FUTURE DIRECTIONS

Overall, research on red culture knowledge graphs has achieved notable progress. First, in terms of research objects, studies have gradually shifted from macro-level resource integration toward more regional, thematic, and person-centered research orientations. Second, regarding technical approaches, research has expanded from ontology modeling and rule-based extraction to multi-source heterogeneous data integration, multimodal knowledge representation, and large language model-assisted information extraction. Third, at the application level, research has extended from basic data organization to diverse application scenarios, including education, cultural communication, knowledge question answering, and public services.

However, several limitations remain in the existing studies. First, although many studies focus on regional resources, systematic knowledge modeling centered on groups of revolutionary figures remains relatively limited. Second, although multimodal research has begun to emerge, most studies still rely primarily on textual data, while the collaborative modeling of images, audio, video, and oral historical materials requires further development. Third, although various application models—such as question-answering systems, spatiotemporal maps, and digital storytelling—have been proposed, public-oriented visualization platforms with sustainable updating mechanisms are still relatively scarce. Fourth, some studies place greater emphasis on technical procedures, while in-depth exploration of the narrative structure of red culture and the system of historical memory remains insufficient.

Future research may be further advanced in several directions. First, red historical figures can be taken as core nodes to construct multi-dimensional relational networks among people, events, locations, and organizations. Second, greater attention should be given to the integration and representation of multimodal resources, including texts, images, audiovisual materials, and archival records. Third, the integration of large language models with knowledge graph technologies can be employed to improve the efficiency of information extraction and knowledge updating. Fourth, further efforts should be made to strengthen the visualization applications of knowledge graphs in spatiotemporal narratives, cultural communication, and public cultural services.

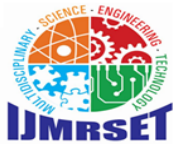
In general, research on red culture knowledge graphs is currently undergoing an important transformation from resource integration toward knowledge association and intelligent services. With the continuous development of digital technologies, multimodal knowledge organization and intelligent cultural services will become key directions for future research in this field.

### VI. FUNDING

This work was supported by the Hunan Provincial Social Science Foundation Project (Grant No. 25ZDBQ008).

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