

Research on the construction of revolutionary cultural heritage knowledge graph and the application of digital cultural innovation

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Abstract: This paper discusses the application of revolutionary cultural heritage in digital innovative design and proposes a method for constructing a knowledge graph of revolutionary cultural heritage. Revolutionary cultural heritage is not only a witness to historical periods but also serves as the objective carrier of Red Culture. The key focus of this study is to use digital technology to protect and inherit these cultural heritages by integrating scattered resource information through the construction of a knowledge graph, thereby enhancing the efficiency of cultural expression and inheritance. Methodologically, the article details the extraction of entity datasets, the construction of the knowledge graph, and the definition of relationship datasets, emphasizing their importance in digital innovation design. The construction of the knowledge graph includes extracting entity and relationship data from open-source data and establishing a multi-level relationship network to support design retrieval and application. In the design application section, it proposes integrating the knowledge graph into the digital cultural innovative design workflow to address the issues of designers' lack of understanding and difficulty in accessing information about revolutionary cultural heritages in the early stages of design. By applying the knowledge graph, designers can quickly obtain cultural heritage information related to the project, effectively enhancing the spiritual and aesthetic expression of the design outcomes. In summary, the establishment and application of the revolutionary cultural heritage knowledge graph not only strengthen the digital protection and innovative application of cultural heritage but also provide important reference resources and inspiration for digital cultural innovative design, promoting the modern design inheritance and development of Red Culture characteristics.

Keywords: Digital cultural innovation; Revolutionary cultural heritage; Meme; Knowledge graph

1. Introduction

Revolutionary cultural heritage is the witness of historical period as well as the objective carrier and physical basis of Red Culture^[1]. Different from the artistic and scientific values of traditional cultural heritages, the pivotal characteristic of revolutionary cultural heritage is the unique cultural genetic value given by the special historical context, which is also an important reason to distinguish them from other cultural heritages. With the construction of cultural big data and the development of modern innovative design, the digital protection and inheritance of revolutionary cultural heritages have received widespread attention and promotion.

In recent years, the development of information technology has driven a transformation in the innovation direction of cultural heritage (including tangible cultural heritage and intangible cultural heritage), shifting from a material level to digital innovation in virtual spaces^[2-4]. Scholars from various countries around the world have conducted extensive research on the digital processing, storage, application and promotion of cultural heritage (physical objects, photos, models, environments and textual materials, etc.) from multiple aspects^[5-8].

As a special category of cultural heritage, revolutionary cultural heritage has important reference value in the process of digital cultural innovative design. In addition to the development of extraction and storage technology and the improvement of protection methods, the research should focus on how to promote the transformation and application of cultural heritage characteristics and internal Red Culture in a way that is easily understood by the public, including the digital construction of Red Culture theme exhibition hall and Red Culture electronic database^[9-10]. Nevertheless, most studies either sorted out the Red Culture from the perspectives of history, sociology and education and discussed the development laws and dissemination paths as an ideology, or their research objects only carried out the collection and

integration of single piece/set of revolutionary cultural heritage in some areas, without developing effective methods for digital innovation and application of cultural resources ^[11-12].

2. Literature review

2.1. Meme

“Meme” was first raised by Richard Dawkins in “The Selfish Gene” in 1976 and was regarded as the basic unit of cultural inheritance in the research process of cultural evolution, spreading through non-genetic means such as imitation and replication ^[13]. The term “gene” originated from Darwin's theory of biological evolution and is an internal genetic code that determines the basic structure of an organism, having a mapping relation of control and encipherment with the representative traits of the organism. Memes are considered as genetic analogues with biologically similar genetic structures in some studies, serving as internal abstract genetic information that maps with external physical features. This mapping relation supports the translation between cultural heritage ontological attributes and memes, and establishes a mapping model for memes and ontological attributes.

As biological gene analogues, memes not only conform to the mapping characteristics of genetics, but also meet the consistency characteristics ^[14]. Like biological genes, if a certain ontological attribute of different revolutionary cultural heritage resource individuals is the same, it indicates that the memes contained within them also have consistency, thus forming a linkage relation. For example, if the time ontological attribute content of two individual cultural heritage resources is 1934, then consistency and relation are formed by these two pieces/sets of cultural heritage resources’ memes of “date”. The derivation of meme consistency is shown in Fig.1.

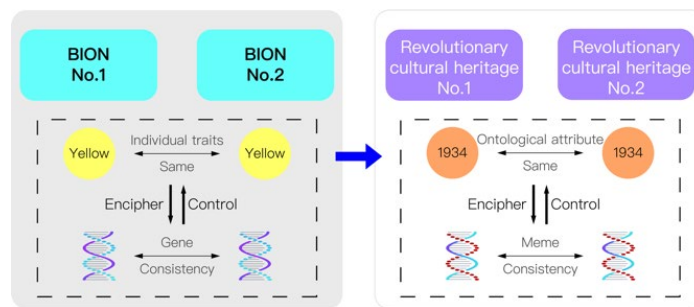


Figure 1: Derivation of Meme Consistency.

2.2. Knowledge Graph

The full text of the article must be typeset in single column. Knowledge graph is an emerging technology for smart correlation and search proposed by Google in 2012, which describes various entities and their relations in the real world in the form of accurate computer semantics and networked graphics, and improves knowledge retrieval capabilities by structured methods through effective knowledge association and management, thereby achieving the goal of displaying, reusing and inferring relevant domain knowledge information ^[15]. The knowledge graph is mainly composed of <head entity, relation, tail entity> as basic triple units. Among them, the head entity and tail entity come from the knowledge graph entity dataset and are represented by core structural points, and relation is the set of entity relation data, represented by directed line segments ^[16]. The necessary steps to form the triple content include entity extraction and relation extraction, providing the essential entity and relation information for constructing a knowledge graph, and expressing structured content through computer language.

2.3. Innovative Activation and Application

Against the backdrop of the growing contemporary digital economy, the development and innovation direction of cultural heritage protection, activation and application has shifted from traditional material protection and cultural creative design output to the intangible field of virtual digital culture ^[17]. As a newly emerging creative development space, the field of virtual culture can achieve the transformation from the real environment to the virtual environment, eliminate the limitations of communication channels caused by physical factors, form a wide range of cultural communication paths to shape a digital culture pattern that can infinitely disseminate and share, as well as meet the demand for flexible use of

resource data in practical innovation projects. Digital creative works belong to newly developing cutting-edge industries, and their product forms are not limited to traditional and single cultural creative products, which are in line with the development direction of contemporary cultural communication.

The digital innovative activation of revolutionary cultural heritages promote the deepening transformation, application and cultural dissemination of resource information. This requires taking revolutionary cultural heritages as the core, grasping the inheritance laws and genetic methods of memes in the digital era, and driving protection and dissemination through application, resulting in design works that can transmit cultural information content. By constructing an innovative activation and application model that coordinates digital technology and creative design, the objective form carried by revolutionary cultural heritages themselves is presented digitally, and targeted extraction for creative design is conducted, realizing the expression and inheritance of memes, and to deeply elaborating on the cultural attributes inherent in them^[18].

3. Method

3.1. Entity Extraction of Revolutionary Cultural Heritage

The entity extraction of revolutionary cultural heritage is one of the important steps in constructing a knowledge graph, and the extraction process is based on the semi-structured open-source archives of revolutionary cultural heritage that have already been formed. The task of entity extraction focuses on the characteristics of revolutionary cultural heritage and adapts to the semantic attributes of existing entity archives, in order to satisfy the original collecting, organizing and naming habits. To extract entities from revolutionary cultural heritage, it is first necessary to use a unified information resource identifier to identify the semi-structured text data of cultural heritage structurally and digitally, ensuring that the entity units have the same semantic structure in the input dataset of structured resource entities, allowing computers to understand and extract shared structured data and key information (Jin et al., 2020), thus the semantic transformation of revolutionary cultural heritage, "unstructured, semi-structured, structured" data, is fulfilled. Markdown syntax is applied to record the source data in the local database in plain text form during the extraction process.

3.2. Meme of Revolutionary Cultural Heritage

The mapping relation between ontological attributes and memes mainly reflects the mutual transformation pattern of resources from entity features to internal genetic codes. The scope of determining the ontological attributes of revolutionary cultural heritage has to meet the needs of digital innovation applications, and the text data of ontological attribute under 102 different information names obtained from the paper archives of cultural heritage collections should be screened. After removing special materials used for research and excluding valueless attributes components of revolutionary cultural heritage, as well as screening out attribute factors that are easy to express in creative design, then the scope of sifting ontological attribute is focused on: (1) emphasizing the objective description of revolutionary cultural heritage in digital innovation, and paying attention to the direct participation of resource attributes in creative design; (2) highlighting that the focal point of digital innovation applications returns to the inherent functions of cultural heritage, and mainly focuses on categories, cultural relic functions and information related to usage, exploring digital description methods of traditional behavior patterns; (3) describing the ontological attribute of spiritual characteristics when it comes to revolutionary cultural heritage, to enhance the cultural identity of revolutionary cultural heritage in digital innovation. Taking the three aspects above as the basic framework for extracting the ontological attribute of revolutionary cultural heritage, 22 ontological attributes of revolutionary cultural heritage for digital innovative activation and application are identified.

3.3. Meme Category of Revolutionary Cultural Heritage

As for revolutionary cultural heritage, the generalization of its coarse-grained entity and the differentiation of its fine-grained meme can easily lead to a decrease in the applicability and objectivity of the digital structure of revolutionary cultural heritage. Therefore, it is necessary to add a hierarchy of medium-grained meme category between fine-grained revolutionary cultural heritage meme and coarse-grained cultural heritage resource entity, forming the progressive connective organization and management hierarchy, in order to support the optimal path for design retrieval and application in the form of multiple structures and channels. By integrating the facet classification method, CDWA,

ontology model of cultural heritage and metadata extension model of cultural heritage information, conceptual analysis and vocabulary merging can be applied to the acquired memes from bottom to top. The final results are shown in Tab.1.

Table 1: Meme Category of Revolutionary Cultural Heritage.

Meme Category	Definition	Meme
A. Date	The meme collection related to time.	A1. Date; A2. Date Type
B. GEOGRAPHY	The meme collection related to geography.	B1. Region; B2. Region Type
C. HUMANITIES	The meme collection related to humanity.	C1. Humanities Type; C2. Humanities; C3. Profile
D. MATERIALITY	The meme collection related to physical characteristics.	D1. Physical Appearance; D2. Texture; D3. Measurement; D4. Volume; D5. Quality; D6. Color; D7. Luster; D8. Quantity
F. GENRE	The meme collection related to genre.	F1. Type; F2. Function Type; F3. Façture
G. LOGOTYPE	The meme collection related to logotype.	G1. Unique Mark; G2. Language; G3. Typeface; G4. Handwriting Color; G5. Inscription Situation

The characteristics of memes are the fundamental basis for category classification, and the coding of meme categories describes the relation and status between memes and meme categories in the hierarchical structure of classification. In order to further clarify the classification status of the concept of revolutionary cultural heritage entity, meme and meme category, a visual hierarchical model is used to identify and confirm the hierarchical structure among these three. According to the previous research, it can be seen that the revolutionary cultural heritage, as the fundamental core of protection work, is logically derived based on a specific relation among its entity, ontological attribute, meme and meme category, which provides the relation foundation and transformation conditions for the digital utilization of revolutionary cultural heritage in the later stage.

3.4. Revolutionary Cultural Heritage Knowledge Graph

The essence of constructing a knowledge graph of revolutionary cultural heritage is to integrate and associate discrete and fragmented resources, forming a composite network that includes individual information, memes, global networks, relation networks, etc., to assist users in developing a comprehensive understanding of resources during digital innovative activation and application design, and provide corresponding design references, retrieval paths and inspiration sources, thus promote the improvement of cultural expression and inheritance efficiency of revolutionary cultural heritages in modern society. Therefore, the construction of revolutionary cultural heritage knowledge graph needs to meet the following principles: (1) take the resource ontology as the structural core, and pay attention to the objectivity and integrity of revolutionary cultural heritage; (2) take memes as the relational basis, reflecting the cultural inheritance characteristics of revolutionary cultural heritage; (3) take flexible application as the organizational task to realize the innovative driving force of revolutionary cultural heritage.

The process of constructing the revolutionary cultural heritage knowledge graph first needs to clarify the entity dataset and relation dataset that make up the triple. The structure obtains the range of entity datasets required for the head entity (H) and tail entity (T) from open source data through steps of entity extraction, including the composite structure of the coarse-grained revolutionary cultural heritage entity (E) acquired from entity extraction results as the core, as well as the medium grained meme category (MC) as the second level and fine-grained meme (M) as the third level derived from entity ontological attribute mapping. The entity dataset model can fully reflect the entity information of revolutionary cultural heritage in the real world and the meme information contained in cultural heritage entities, thus completing the construction of knowledge graph entity datasets.

The purpose of the task of extracting relations between revolutionary cultural heritages is to associate entities from multiple heterogeneous data sources through the similarity principle between defined memes, thus establishing the semantic relations between different revolutionary cultural heritage entities. Accordingly, based on the similarity between memes and biological genes, the relation extraction rule of revolutionary cultural heritage that meets the needs is constructed through the relation consistency

between memes. The relation extraction of revolutionary cultural heritage knowledge graph not only focuses on the coarse-grained individual relations formed by the consistency of memes (M) under macro conditions, but also needs to fully utilize the granularity structure model of revolutionary cultural heritage to construct a multi-hierarchy relation network, increase the presentation form of relation information at the medium granularity hierarchy, provide logical links between vertical logical hierarchies, and ensure the comprehensiveness of relation construction.

By analyzing the entity dataset and relation construction rules that constitute the triple structure of revolutionary cultural heritage knowledge graph, it can be seen that the network structure based on meme consistency includes a multidimensional and multi-layer logical space formed by hierarchies of entity E, meme category MC and meme M. This method can decompose the relation network of knowledge graph into vertical hierarchical (coarse-grained, medium-grained and fine-grained) relation networks, thus achieving structured, multi-hierarchy and multi-granularity knowledge organizing and relation representing, which can not only associate real entities with knowledge data in archival texts in a network manner, but also provide supports for downstream digital innovation activation and application tasks.

4. Design Application of Revolutionary Cultural Heritage Knowledge Graph

Digital cultural innovative design is an important approach to inherit revolutionary cultural heritages. The main function of revolutionary cultural heritages during the inheriting process is to provide relevant references for designers in the early stage of design, so that the output scheme finally echoes with the selected references. Designers, however, usually face the problem of insufficient understanding of revolutionary cultural heritages and the difficulty of acquiring information rapidly from numerous unstructured revolutionary cultural heritages as design references. To solve this problem, it is proposed to establish a digital cultural innovative design model of revolutionary cultural heritage through bringing the construction of revolutionary cultural heritage knowledge graph, as the basis, into the design workflow of digital cultural innovation. Through the application of revolutionary cultural heritage knowledge graph in digital cultural innovation. Then, the design factor is reused, modified and preserved according to requirements of the project, and the design outcome of digital cultural innovation is accomplished eventually. As the structural cluster of exclusive domains, revolutionary cultural heritage knowledge graph is helpful to assist design professionals to get revolutionary cultural heritage information related to the project quickly from the perspective of meme, promote the design outcome to inherit and propagate the spiritual and cultural connotation of the Chinese revolutionary period in a more modern aesthetic way as well as effectively improve the application efficiency of revolutionary cultural heritages in digital cultural innovative design.

5. Conclusion

In the process of digital cultural innovative design, revolutionary cultural heritage, as a pivotal resource, provides an effective information source for designers in the early stage of the project. Nevertheless, designers still face the problem of obtaining and retrieving the information integrity of revolutionary cultural heritage. In order to solve this problem, the method of constructing the conceptual model of revolutionary cultural heritage knowledge graph is raised and applied to design workflow as well as the digital cultural innovative design model of revolutionary cultural heritage is accomplished. Under the guidance of this model, an overall relation network of revolutionary cultural heritage and retrieval paths in different hierarchies can be acquired to provide design reference for digital cultural innovative design projects. Meanwhile, design factors are extracted in accordance with the mapping relation between memes and ontological attributes to increase the stickiness between design outcomes and revolutionary cultural heritages and assist the inheritance and continuation of Red Memes with the means of modern design.

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