

Postprint: Construction of a Spatio-temporal Data Model for Intangible Cultural Heritage Spaces

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Abstract

[Purpose/Significance] The generation, development, and inheritance of intangible cultural heritage (ICH) are all anchored in specific cultural spaces. By leveraging the spatiotemporal and attribute characteristics of tangible carriers within these cultural spaces, a spatiotemporal data model can be constructed to represent the entire evolutionary process of ICH, thereby enabling a holistic understanding of its development dynamics and patterns, and facilitating the protection and inheritance of ICH. [Method/Process] Based on the analysis of spatiotemporal features, carrier type classification, and spatiotemporal representation of ICH cultural spaces, this study proposes a spatiotemporal data model oriented toward ICH cultural spaces. Taking the inheritors of Xiaogan carved paper-cut as the analytical object, a spatiotemporal representation model for their inheritance information is established. [Results/Conclusion] The model is capable of representing changes in the spatiotemporal information of inheritors. The prototype system developed based on this model can dynamically trace and retrieve the spatiotemporal information of inheritors, and extract information that influences their development, thereby facilitating their own growth. Simultaneously, it provides a reference for the development of other ICH projects and holds certain theoretical and practical significance for the cultivation and protection of ICH inheritors.

Full Text

Preamble

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Construction of Spatio-temporal Data Model for Cultural Space of Intangible Cultural Heritage

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Abstract

[Purpose/Significance] The generation, development, and inheritance of intangible cultural heritage (ICH) all depend on specific cultural spaces. By leveraging the spatio-temporal and attribute characteristics of tangible carriers within these cultural spaces, we can construct a spatio-temporal data model to express the entire evolutionary process of ICH, thereby grasping its developmental dynamics and patterns holistically and promoting its protection and inheritance. **[Method/Process]** Based on spatio-temporal feature analysis, carrier type classification, and spatio-temporal representation of ICH cultural space, this paper proposes a spatio-temporal data model oriented toward ICH cultural space. Taking successors of Xiaogan carved paper-cut as the analytical object, we establish a spatio-temporal expression model of their inheritance information. **[Result/Conclusion]** The model can express changes in the spatio-temporal information of inheritors. The prototype system built upon this model can dynamically trace and retrieve the spatio-temporal information of inheritors and extract information that influences their development, thereby facilitating their own growth. Simultaneously, it provides a reference for the development of other ICH projects and holds theoretical and practical significance for the cultivation and protection of ICH inheritors.

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Intangible Cultural Heritage (hereinafter referred to as “ICH”) is a living art form that emerges in specific spatio-temporal contexts, relies on human carriers, and is passed down through generations. It represents the precious memory of traditional national culture, bearing rich historical information and national spirit while playing a vital role in building cultural confidence and enhancing cultural soft power. However, influenced by economic and social factors, ICH is constantly evolving and changing, innovating and recreating itself through interactions with nature, reality, and history. This “living nature” invisibly increases the complexity of ICH protection and makes it a hotspot and difficulty in digital preservation efforts.

In terms of digital protection, current information technologies such as virtual simulation and big data have focused primarily on the digital collection, storage, restoration, reproduction, display, and dissemination of ICH resources. However, research on ICH cultural space—such as the human environment and core

values—remains relatively scarce. Therefore, studying how to accurately describe the cultural space of ICH and establishing a data model that can express its spatio-temporal information to effectively analyze and display its evolutionary patterns has become urgent and significant for promoting ICH protection and inheritance.

2. Related Research

2.1 Spatio-temporal Research on ICH Projects

As a specialized term used by UNESCO in ICH protection, “cultural space” refers to “the concentrated expression of intangible cultural heritage with special value,” defined as “a place where popular and traditional cultural activities are concentrated, or a period of time when specific activities are regularly held. This time and natural space exist because of the presence of traditional cultural expression forms in the space” [1]. It constitutes an inseparable part of ICH. Although domestic academic circles still debate the definition of cultural space, there is consensus on viewing it as “the soil where ICH generates, survives, and develops” [2], “the most concentrated embodiment of ICH’s living nature,” and “the top priority in ICH protection” [3].

ICH, as a type of cultural heritage, has a relatively short history from being proposed to being recognized and protected compared to its own existence. To better grasp the occurrence and development characteristics of ICH from a holistic perspective, some scholars have adopted narrative descriptions to outline the formation and evolution patterns of specific ICH projects across temporal and spatial dimensions. For example, Tan Zhiman studied the spatio-temporal evolution of the Tujia “Sa’erhe” ritual from perspectives of spatial scope, organizational forms, traditional functions, and inheritance methods [4]. Dou Qing detailed the evolution of “Maojiao” opera from aspects of musical patterns, lyrics, artistic forms, and singing styles [5]. Tian Qing [6] and Tang Juan [7] respectively introduced the occurrence, development, and evolution of traditional festival cultures using the Dragon Boat Festival and Mid-Autumn Festival as examples. These descriptions, summaries, and analyses of specific ICH projects’ developmental histories help us understand their evolutionary processes in detail, though they still lack depth in revealing hidden information.

Meanwhile, with the deepening application of digital technology in recording, storing, retrieving, displaying, and disseminating ICH resources, visual analysis of ICH has become a research hotspot. This is manifested in two aspects: first, using visualization tools or software to conduct spatio-temporal visualization or analysis of ICH resource information, inheritor relationships, and evolution according to design schemes [8]. For instance, Chen Luyao et al. proposed an ICH information visualization scheme based on key event technology to intuitively display the spatio-temporal evolution of “Gezaixi” across the Taiwan Strait [9]. Second, establishing appropriate spatio-temporal models or digital analysis models to analyze the spatio-temporal characteristics and development trends

of specific ICH projects or regional ICH resources—such as temporal evolution and spatial distribution—by setting variable parameters and leveraging digital technologies primarily based on Geographic Information Systems (GIS) [10]. These visualization schemes or data models intuitively and clearly demonstrate the historical processes, spatio-temporal distribution characteristics, and future development trends of ICH, holding important reference value for studying the overall cultural survival status of specific regions or ethnic groups.

However, the above studies either do not involve or only minimally address the cultural space of ICH, and systematic expression and analysis are still lacking. Therefore, this paper takes the cultural space of ICH as its research object, establishes its spatio-temporal data model, and conducts application analysis with examples.

2.2 Related Research on Spatio-temporal Data Models

In the geoscience field, to express the spatio-temporal change process between previous and subsequent states of geographic objects and to reason about the causal relationships triggering such changes, researchers have proposed various spatio-temporal data models, such as event-based spatio-temporal models, object-oriented spatio-temporal models, and state-based spatio-temporal models for events or individual changes mentioned in literature [11-13]. Among them, event-based spatio-temporal models and their improved versions are most common, mainly falling into two categories: first, theoretical innovation of spatio-temporal data models based on events combined with empirical analysis, such as the event semantic model proposed by Xu Zhihong [14], the object-event-process model by Chen Xinbao [15], and the event-based spatio-temporal research method by WANG S [16]. Second, application innovation of event-based spatio-temporal data models in various fields according to the spatio-temporal characteristics of research objects, such as spatio-temporal models established by Wang Zhangang [17] for historical events, Hu Qizhou [18] for urban traffic congestion, and Gao Yunbing [19] for land resources. Although these research methods have different emphases and respective advantages and disadvantages, event-related spatio-temporal data models can clearly reveal the process mechanisms behind geographic phenomena's generation, development, and spatial distribution, and even enable historical state reconstruction, change tracking, and trend prediction of geographic objects when reasonably improved and combined. This provides reference and scientific theoretical support for establishing spatio-temporal data models of ICH cultural space.

In summary, due to the relative scarcity of spatio-temporal evolution research and applications targeting ICH cultural space both domestically and internationally, and because traditional narrative descriptions and other visualization methods struggle to balance historical authenticity with intuitiveness, this paper proposes a spatio-temporal data model oriented toward ICH cultural space to express and analyze its spatio-temporal evolutionary process. Centering on driving events, change processes, and state information during the formation and

evolution of various objects in ICH cultural space, this model provides structural and coherent description, which can vividly display ICH development history, facilitate public dissemination of ICH information, and promote further ICH research. Additionally, establishing spatio-temporal data models for the formation and evolution of ICH cultural space can explore effective data organization and storage methods, provide research ideas for ICH visual analysis, and offer important guidance for the current and future development and inheritance of ICH.

3. Spatio-temporal Characteristics and Carriers of ICH Cultural Space

Influenced by natural environments and human activities, the generation and development of ICH cultural space often do not occur randomly but present special manifestations or patterns during spatio-temporal evolution. Whether material or immaterial, the carriers of these manifestations or patterns directly or indirectly bear the cultural connotations and core values of ICH, constituting the internal driving force for ICH dissemination and inheritance. Therefore, grasping the spatio-temporal characteristics of ICH cultural space, clarifying the types of its carriers, and conducting spatio-temporal representation are crucial for establishing its spatio-temporal data model.

3.1 Spatio-temporal Characteristics of ICH Cultural Space

Based on comprehensive domestic academic definitions and protection methods of “cultural space” [20-21], this paper summarizes the basic components of ICH cultural space as: specific space (place or location), periodic time, participants, ICH activities, symbolic signs, and core values.

(1) Temporal Characteristics. Human social development has historicity, and ICH forms and develops along with human society, closely related to people’s production and practice activities within certain periods. These production and practice activities lay the foundation for ICH cultural space, endowing it with temporal attributes and enabling its formation, development, and derivation in time. For example, folk festivals, celebrations, and folklore events occurring at specific times all exhibit typical temporal characteristics.

(2) Spatial Characteristics. Conceptually, “cultural space” is first a place where ICH depends, where popular and traditional cultural activities are concentrated. Its objects can be specific people, objects, groups, locations, or regions, containing multiple entities and their internal relationships, which can be defined as point, line, or area spatial types according to their attribute characteristics. Taking ICH-related events as examples, their occurrence locations or spatial coverage can be counties, villages, or specific sites (ancestral halls, squares, alleys), or several administrative regions. Under political and economic influences, these spatial objects undergo information changes including location and shape, exhibiting different evolutionary processes and development trends

such as diffusion, fusion, or inheritance. Additionally, due to ICH's diversity and living nature, as the soil for ICH survival, various objects and material carriers in ICH cultural space even possess data or variables with certain meanings. During digital processing, specific description methods are needed to highlight their essential characteristics. Therefore, according to the expression methods of geographic object attribute characteristics, ICH cultural space also has attribute characteristics, such as attribute features of material carriers like tools and works, and subsidiary information like variation and innovation during dissemination, inheritance, and preservation processes.

3.2 Carriers of ICH Cultural Space

In addition to geographic “cultural places” and other material carriers, ICH cultural space contains more abstract “metaphorical spaces.” These “intangible” information forms such as religion, emotion, craftsmanship, language, and art are difficult to express directly. They not only depend on human carriers but also require specific material carriers. Meanwhile, due to the diversity of ICH cultural space manifestations, carrier types are inevitably diversified. Therefore, any concrete, vivid, and sustainable thing bearing ICH cultural space content or core values can be regarded as its carrier, such as inheritors as core carriers, artworks, props, squares, and various materialized remains. Each carries specific cultural implications and spiritual values, expressing and demonstrating ICH cultural space connotations in perceivable forms.

According to the importance of carriers to ICH dissemination, inheritance, and cognition, ICH cultural space carriers can be divided into two categories: physical carriers and virtual carriers. Physical carriers include participants (including inheritors, cultural audiences, and protectors), places (activity venues like squares and ancestral halls, shops, cultural protection units), props or works with special symbolic meanings, and physical objects. Virtual carriers consist of new media, public cultural resource service platforms, television, radio, and the Internet. Since different ICH types may have varying quantities of carrier components, the objective status of ICH should be followed when constructing spatio-temporal data models to ensure model effectiveness.

After determining carrier types and quantities, another crucial step is spatio-temporal representation of carriers—semantic extraction of spatio-temporal information including specific spatial locations, occurrence times, scopes, processes, and changes. Table 1 lists representative material carriers of ICH cultural space and their spatio-temporal attributes. By materializing cultural space into specific carriers and conducting spatio-temporal representation, we can examine cultural space from multiple angles and scales through different cultural carriers' spatio-temporalization, while mining multiple spatio-temporal attributes of the same carrier can further broaden research perspectives, grasp cultural space characteristics in various ideologies, and discover more social, political, and economic meanings behind ICH cultural space. Taking a certain paper-cut cultural space carrier as an example, semantic extraction triggers driving events

for object changes, including time, spatial scope, and process information.

Table 2 shows that the “Inheritance Institute” experienced events of “renovation,” “relocation,” and “establishment of branch institutes,” undergoing changes of “inheritance,” “diffusion,” and “diffusion” respectively, with its state changing from “stable” to “developing.” In this transformation, the “Inheritance Institute” can be abstracted as a point, and its changing spatial scope can be either “line” type or “shape” change according to different granularity standards. Meanwhile, “Inheritor Li” not only experienced spatial displacement in his activity area but also caused changes in the spatial scope of artistic inheritance.

4. Spatio-temporal Data Model for ICH Cultural Space

ICH cultural space contains massive spatio-temporal information involving changes in time, space, and attributes of various objects. Moreover, these changes occur under the drive of certain events, aligning with the concept of event-based spatio-temporal data models. However, at specific scales, events provide insufficient granularity for spatio-temporal semantic description, unable to express change reasons and processes, and do not support expressing spatio-temporal evolution under continuous time. Therefore, drawing on object-oriented concepts [22] and event-based theories [23-24], this paper subdivides events during the evolution of cultural space core objects and their carriers into several processes, and combines these objects’ state information to construct an object-oriented spatio-temporal data model with event-process-state as the main thread to express the spatio-temporal evolution of ICH cultural space.

4.1 Main Components of the Model

One primary objective of this paper is to establish a spatio-temporal data model for core elements of ICH cultural space and their carrier objects. Here, objects are material carriers representable as points, lines, or areas, possessing temporal, spatial, and attribute features as the main body of the spatio-temporal data model, such as ICH inheritors, activity venues, special works, and props. These objects have basic relationships including temporal and spatial relationships, such as inheritance relationships and social networks among inheritors, as well as attribute change information under different events, states, or processes.

Generally, in digital processing, higher data granularity means smaller object granularity, while lower granularity means larger object granularity. Therefore, to better express the behavioral characteristics and change reasons of ICH cultural space objects, the “events” and “processes” discussed in this model are divided under specific scales. The core elements and their relationships are shown in Figure 1 [Figure 1: see original paper].

(1) Event. An event is a fact that has occurred, the direct cause of object state changes, and can also be viewed as a collection of processes that change object attributes. It directly drives object transitions between different states

on the temporal dimension, and its occurrence sequence reflects the object's spatio-temporal change process [25]. Events mainly include basic information such as type, occurrence time, location, participants, and causes. Every object's generation, development, and demise in ICH cultural space has direct or indirect causes, and any fact affecting changes in component attributes or states can be considered an event. According to different results, events can be classified into types such as attribute change events, displacement events, and deformation events. This paper defines the direct or indirect causes triggering state changes in ICH cultural space objects as events occurring to that object. A single event can be considered a simple event, while multiple interrelated simple events combine into a composite event corresponding to a more macroscopic object change and can include multiple sub-events.

(2) Process. Processes are typically used to describe events, mainly referring to series of operations between adjacent states during object evolution that ultimately cause quantitative to qualitative changes [26]. Changes in ICH cultural space objects themselves, such as alterations in participants' ideology and beliefs due to economic and cultural development, and planning and changes in ICH villages and towns, can all be regarded as evolution processes of related entities, with results directly reflected in object state changes.

Through analysis and summarization of general cultural phenomenon development processes, the spatio-temporal change processes of ICH cultural space entity objects can be 归结为 the following operational forms: Appearance, Disappearance, Cessation, Merge, Split, Diffusion, Contraction, Mutation, Succession, and Reincarnation. These evolution processes can be considered discrete changes under specific temporal granularity standards. For example, appearance and disappearance can be viewed as sudden occurrences, while Succession represents the continuation of an object's certain state over a period—a relatively stable state. However, Succession may be natural (linear continuous change with slope $k=1$) or mutated inheritance after incorporating new elements (non-linear continuous change with slope $k \neq 1$).

(3) State. State expresses an object's relatively stable form at a certain moment or period, serving as an important marker for recording the evolution process of spatio-temporal objects. ICH is a product of specific environments that changes with its cultural space, continuously transitioning from one state to another and exhibiting a cause-effect relationship of state-event-state. Since not all object states change when events occur, data processing can store only changed parts based on historical base states without allocating new storage space.

Events, processes, and states are interrelated yet distinct. Events are facts that have occurred, driving the normal evolution of process sequences and serving as conditions for object state changes. After an event occurs, perhaps only one object undergoes one change, or one object experiences multiple changes. For example, when a paper-cut inheritor relocates from his living place, superficially only the inheritor's activity space undergoes displacement. However, as the carrier of paper-cut skills, this directly leads to the rise of paper-cut skills in

one place and decline in another, triggering multiple chain reactions. Additionally, multiple objects may undergo the same change, or multiple objects may experience multiple changes.

4.2 Construction of the Spatio-temporal Data Model

This model takes core elements of ICH cultural space as research objects and uses events, evolution processes, and states of objects as the main thread (see Figure 2 [Figure 2: see original paper]). According to each element's characteristics and roles in the spatio-temporal data model, common features and operational methods are abstracted into vector base classes, temporal base classes, and attribute base classes, mainly including object classes, event classes, process classes, state classes, and change classes. The Object Class inherits from the vector base class, primarily comprising core elements of ICH cultural space and their carriers associated with events or processes, such as inheritors, ICH works, and venues. The Event Class describes event attributes related to objects, including occurrence time, venue, and causes, aggregated from objects, event attributes, and time. The Process Class describes process types and spatial, attribute, and state information before and after changes, aggregated from objects and time. The State Class, aggregated from object snapshots and time, mainly expresses semantic information of object states, such as spatial and attribute information of objects in initial and final states. Additionally, there are Time Classes derived from moments and periods, and Change Classes involving various aspects of events, processes, states, and space.

Using the aforementioned paper-cut cultural space as an example (see Table 2), objects involve inheritance institutes, inheritors, paper-cut works, etc., with each object corresponding to several spatio-temporal changes. Among them, "Inheritor Li" under the "relocation" event "migrated from original residence to new location," with state updated from "residence" to "new location," inheritance space scope expanded accordingly, and attributes changed. This demonstrates that the spatio-temporal data model for ICH cultural space contains not only spatio-temporal objects, process types, and states but also retains temporal topological relationships in events, laying a foundation for retrieving and tracing ICH spatio-temporal information.

5. Spatio-temporal Data Model for Xiaogan Carved Paper-cut Cultural Space

5.1 Case Selection

Xiaogan carved paper-cut integrates northern and southern artistic strengths, possesses a long history and rich folk cultural connotations, features profound artistic language, and expresses itself through simple yet powerful forms with high aesthetic and artistic value, making it a treasure of Chinese traditional culture. With changing modern aesthetic habits, demand for paper-cut art is declining. Particularly under market economy impacts, traditional small-

scale, decentralized manual production models no longer suit today's large-scale production, forcing many artists to gradually withdraw from the creative stage due to small profits and high costs. More seriously, as former inheritors age and "materialism" influences make cultivating new generations more difficult, Xiaogan carved paper-cut faces the danger of talent gap and lack of successors, making its protection urgent, with the key lying in protecting its cultural space.

Throughout history, Xiaogan carved paper-cut has experienced stages of brewing, emergence, maturity, development, revival, and promotion (see Figure 3 [Figure 3: see original paper]). Its cultural space has undergone numerous changes under economic and social influences, with various carrier objects showing different evolutionary processes and development patterns. Moreover, during interactive integration, these objects inevitably have direct or indirect associations, such as inheritance factions, technological innovations, and relationships between work themes and historical backgrounds. This information enhances the feasibility of establishing spatio-temporal data models for ICH cultural space.

Since Xiaogan carved paper-cut belongs to the manual skills category of ICH, its development and dissemination mainly rely on numerous artists. Therefore, this paper selects "inheritors," one of the core carriers of Xiaogan carved paper-cut cultural space, as the object to establish a spatio-temporal expression model of inheritance information according to the above model's class relationships, demonstrating its spatio-temporal associations and evolution.

5.2 Spatio-temporal Description Model for Inheritance Information

Given the particularity of the "inheritor" carrier, in implementation, the events of the "inheritor" object mainly involve inheritance activities. Specific spatio-temporal dimension display contents include: (1) one-dimensional relationships of faction inheritance and social inheritance; (2) two-dimensional relationships of inheritance space, i.e., spatial distribution patterns based on inheritors' birthplaces and workplaces, describing inheritors' spatial dynamics in different development periods. The model is shown in Figure 4 [Figure 4: see original paper].

On this basis, we semantically extract the spatio-temporal information of Xiaogan carved paper-cut inheritors, i.e., extracting events related to inheritors (including occurrence time, scope, process, and changes), spatial locations, and states, and establish a spatio-temporal database. Accordingly, we establish associations among events, spatial locations, and states related to the "inheritor" object, such as constructing inheritance relationship matrices (see Table 3) or generating cross-cooperation event matrices among inheritors. This can display spatio-temporal trajectories of individual or groups of inheritors and 挖掘 out the development and dissemination characteristics of Xiaogan carved paper-cut.

5.3 Carrier Data Collection and Expression

Through literature review, records, field visits, and web information collection software, we compiled 161 pieces of resource information related to Xiaogan carved paper-cut. After removing duplicates and irrelevant content, 123 valid pieces remained, spanning from January 1, 1950, to December 31, 2017. The data covers main inheritors and their excellent paper-cut works, research institutes, associations, affiliated industrial companies, and inheritance bases. The data information built around inheritors is shown in Figure 5 [Figure 5: see original paper].

In the figure, A, B, a1, a2, b1, b2, etc., represent different paper-cut inheritors, while L, M, O, P, etc., represent the spatial locations of each inheritor during specific periods (such as birthplace, workplace, and visiting place). Since inheritors may experience spatial location state changes during different time stages, and under event influences, inheritors have master-apprentice or cooperative relationships with overlapping and interwoven spatio-temporal associations in mutual exchanges and learning, visualizing these complex spatio-temporal information can describe their change processes and more vividly demonstrate the inheritance and development characteristics of Xiaogan carved paper-cut.

5.4 Results and Implications

Extracting spatio-temporal data of some core inheritors from different periods from the inheritor spatio-temporal database and conducting visualization operations according to the inheritance information spatio-temporal model construction approach, we captured three time points with the following results:

(1) Inheritance Relationships: As shown in Figure 6 [Figure 6: see original paper], the mainstream inheritance method of Xiaogan carved paper-cut transitioned from faction inheritance to social inheritance. In the early stage (by 2000), inheritance mainly occurred within the same faction with relatively dispersed distribution. From the middle stage (by 2005), intra-faction inheritance gradually weakened, with some even showing discontinuity, and faction inheritance after the fourth generation began to decline. In the later stage (by 2015), social inheritance started to dominate.

(2) Inheritance Space: Overall, it showed a “dispersion-convergence-dispersion” pattern. In the early stage (see Figure 7 [Figure 7: see original paper]), inheritance space diffused in small ranges centered on different faction origins, demonstrating faction-centered spatial distribution characteristics such as “Hu Faction” and “Guan Faction.” In the middle stage (see Figure 8 [Figure 8: see original paper]), an inheritance space centered on Xiaonan District gradually formed. In the later stage (see Figure 9 [Figure 9: see original paper]), social inheritance bases further expanded the inheritance space.

Combined with key events and time nodes in Xiaogan carved paper-cut development, we can see that macro-level ICH protection policies and micro-level core

inheritors jointly maintain its development. Formulating reasonable ICH protection policies and strengthening inheritor protection and cultivation are crucial for the healthy and sustainable development of Xiaogan carved paper-cut.

Finally, using Adobe Flex Builder 4.6 as the front-end development tool, we implemented the display of spatio-temporal processes related to Xiaogan carved paper-cut inheritors. Experimental results show that the system structured by this data model can dynamically trace and retrieve inheritors' spatio-temporal information. By querying time points or names, it can display related event sets and state information (see Figure 10 [Figure 10: see original paper]).

Through the above case analysis and experimental results, we obtain the following insights: First, core figures and important events in ICH inheritance processes play crucial roles in ICH inheritance, prosperity, and development. Using spatio-temporal data models and related development platforms can establish connections among inheritors' temporal, spatial, and attribute information, thereby reproducing ICH spatio-temporal development processes. Second, the current state of ICH is the result of multiple developmental changes, and its spatio-temporal change information can also be dynamically described through spatial displacement or diffusion processes of core objects and other carriers. For example, this paper could establish an information table of inheritors' activity ranges including workplaces, visiting places, competition venues, and main circulation places of works, combined with ArcGIS Server geographic data, to express the spatial diffusion and dissemination characteristics of Xiaogan carved paper-cut in different periods. Third, secondary data mining and analysis based on Xiaogan carved paper-cut inheritors' spatio-temporal information can yield conclusions about its development trends, more targetedly guiding us to address existing problems.

The regional, living, and fluid characteristics of ICH determine that its protection cannot be "frozen" static preservation but requires viewing traditional culture's evolution and even variation from a dynamic perspective of occurrence and development. Only by grasping the inheritance and evolution during ICH's spatio-temporal dynamic change process can we conduct comprehensive, authentic, and systematic documentation. This paper extracts core elements of ICH cultural space, classifies its carriers, and conducts spatio-temporal representation. Drawing on object-oriented methods and geographic event concepts, it proposes a spatio-temporal data model for ICH cultural space that optimizes data structure around change information such as events, processes, and states occurring to objects, effectively organizing ICH cultural information.

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Author Contributions

Tan Guoxin: Proposed research ideas and modification suggestions;
Zhang Lilong: Collected materials, wrote the initial draft, and revised the final

version.

The Construction of Spatio-temporal Data Model for Cultural Space of Intangible Cultural Heritage

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Abstract: [Purpose/significance] The generation, development and inheritance of ICH all depend on specific cultural space. Based on the spatio-temporal and attribute characteristics of tangible carriers in cultural space, a spatio-temporal data model can be constructed to express the entire evolutionary process of ICH, so as to grasp the development dynamics and laws of ICH holistically and promote its protection and inheritance. [Method/process] Based on the spatio-temporal feature analysis, carrier type classification and spatio-temporal representation of ICH cultural space, this paper proposes a spatio-temporal data model for ICH cultural space, and selects successors of Xiaogan carved paper-cut as the analysis object to establish a spatio-temporal expression model of their inheritance information. [Result/conclusion] The model can express changes in the spatio-temporal information of inheritors. The prototype system based on this model can dynamically trace and retrieve the spatio-temporal information of inheritors and extract information that influences their development, which is conducive to promoting their own development. At the same time, it provides reference for the development of other ICH projects and has important theoretical and practical significance for the cultivation and protection of ICH inheritors.

Keywords: intangible cultural heritage; cultural space; spatio-temporal data model

Note: Figure translations are in progress. See original paper for figures.

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