SMART CARTOGRAPHY OF CULTURAL-CONTEXT MAPS: A CASE STUDY ON THE INTELLIGENT MAPPING OF JIANGNAN REGIONAL CULTURE

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Abstract
The cultural-context map represents a conceptual and technological innovation of digital cartography and cultural mapping research in AI era. In this paper, we propose an AI-driven framework coupling a spatio-temporal knowledge graph (SKG), cultural Big Data and an AI chatbot for smart cartography of cultural-context map. From a theoretical perspective, this paper defines the concept and characteristics of the cultural-context map, and puts forward new requirements for digital cartography. In terms of methodological approaches, technical means and empirical studies, taking the Jiangnan region (also Yangtze River Delta region) as the study area, which endowed with profound historical and cultural heritage and distinctive natural and humanistic landscapes, is one of the most brilliant regions in China and enjoys a high reputation internationally. this paper developed an ontology-based construction method in establishing a spatiotemporal knowledge graph of Jiangnan water towns. Secondly, it employs thematic knowledge discovery techniques to facilitate the thematic design and compilation of cultural-context maps. Finally, it develops an AI chatbot model to carry out the intelligent mapping practice of the cultural-context map of Jiangnan regional culture.

Keywords: *cultural-context map, digital cartography, spatial-temporal knowledge graph, Jiangnan regional culture, AI chatbot*

INTRODUCTION

Human society in the 21st century has fully entered a new era. Digital technologies represented by mobile internet, big data, and artificial intelligence are comprehensively transforming the way people work and live. Every academic field and industry are facing the tidal wave of digital and intelligent transformation, and maps and cartography in the era are no exception. On the one hand, as humanity's spatial language, maps are eternal. Chen(1988) pointed out: "As a cultural tool, maps will coexist and endure alongside language and art in the treasure house of human knowledge". Indeed, driven by digital technologies, maps have become increasingly diverse in many types (e.g., sound maps, video maps, AR maps, story maps, etc.), more widely applied, and more deeply integrated with the internet and new media. In particular, maps have seen growing interaction and exchange with the humanities (e.g., history, culture, art, language, archaeology, cultural creativity, mass media, etc.). On the other hand, driven by technological progress and evolving social demands, cartography is also ever-renewing, possessing the characteristic of advancing with the times.Wang (2022) systematically summarized the "three rises" of cartography through its historical development (ancient, modern, and contemporary). He argued that cartography is "a science full of vitality and vigor, continuously enriched and perfected through long-term evolution and development. It has now become a science with a complete theoretical system, a modern technological system, an applied service system, and a transdisciplinary nature spanning time and space, nature and humanities, technology and engineering." Furthermore, in light of the development of information technology, Wang (2022) pointed out that "spatio-temporal big data has become the core driving force for the development of cartography," and that "further development of cartography requires the guidance of dialectical thinking in cartography, the impetus of artificial intelligence technology, the solution to key problems in intelligent mapping through multidisciplinary integration, and, most importantly, the support of national development strategies."

How can we carry out innovative research in cartography in response to contemporary needs? The Chinese cartography research and professional communities have debated various doubts and differing opinions (e.g., "Where is cartography heading?" "Is the future of cartography scenography?" "Can maps be replaced?"). These debates (Wang, 2022) have

clarified the main confusions in the development of cartography in the information age, reached the "Lanzhou Consensus on Cartography," and provided a future outlook. The consensus proposed three directions for the development of cartography: (1) improve the theoretical system and leverage the disciplinary advantages of cross-fertilization and mutual learning between cartography and new technologies; (2) enrich cartographic techniques, open up new application scenarios, and expand the influence of the cartographic discipline; and (3) support national strategic needs, promote national economic and social development with the power of cartography, and solidify the discipline's strength (Guo et al., 2023).

Based on the above reflections and discussions, this paper analyzes and discusses the theoretical and technical issues encountered in the research project "Mapping the Cultural Context of the Yangtze River and Digital Communication." The main issues include: (1) the concept, connotation, and positioning of cultural-context maps; (2) the key technologies, characteristics, and innovations in compiling cultural-context maps; and (3) what new perspectives and thoughts can cultural-context maps, as an emerging thematic cultural mapping approach, bring to the innovation of cartographic theory and methods.

THE CONCEPT AND SIGNIFICANCE OF CULTURAL-CONTEXT MAPS

Background of cultural-context mapping

Over the past two decades, alongside the rapid development of information technologies such as the internet and big data, China's economic and cultural development has entered an unprecedented new era, with the concepts of 'cultural big data' and 'cultural confidence' becoming deeply ingrained in the public consciousness. In 2022, China officially launched the construction of the Yangtze River National Cultural Park, a major cultural project designed to promote the flourishing development of culture in the new era. Its significance lies in the fact that: 'The construction of the Yangtze River National Cultural Park will fully activate the river's rich historical and cultural resources,systematically expound upon the spiritual essence of Yangtze culture, and deeply explore its contemporary value. This holds major and far-reaching significance for thoroughly implementing General Secretary Xi Jinping's series of important directives on the construction of national cultural parks, enriching and refining the national cultural park system, strengthening and expanding the key symbols of Chinese culture, preserving historical continuity, bolstering cultural confidence, further enhancing the reach and influence of Chinese cultural symbols, and presenting the splendid and diverse Chinese civilisation to the world"(Xinhua News Agency,2022) . In the same year, China comprehensively rolled out its national cultural digitisation strategy, calling for "strengthening the development of public digital cultural resources, coordinating the advancement of the national cultural big data system, the national smart library system and the public cultural cloud, enhancing the capacity to supply public cultural digital content, and raising the level of digitisation in public cultural services" (General Office of the CPC Central Committee & General Office of the State Council,2022). In accordance with the central government's requirements, Jiangsu has drawn up the 'Implementation Plan for the Construction of the Yangtze River National Cultural Park (Jiangsu Section)' and the 'Construction and Conservation Plan for the Yangtze River National Cultural Park (Jiangsu Section)', which will coordinate the eight cities along the river to form a construction layout for the Yangtze River National Cultural Park (Jiangsu Section) comprising 'one main axis, eight branches and four zones'(Xinhua News Agency reporter, 2023).

How to highlight Jiangsu's distinctive characteristics, utilise the art of digital mapping, and empower the creative transformation and dissemination of Yangtze River culture is a key issue for the high-quality advancement of the Yangtze River National Cultural Park (Jiangsu Section). It also provides a digital solution for shaping Yangtze River culture in the new era and showcasing the modern civilisation of the Chinese nation. In this research, the concept of the "Yangtze River cultural-context map" was proposed, a digital spatio-temporal framework for the Yangtze River was developed, a knowledge graph of Yangtze River culture was constructed, and a digital exhibition platform for the Yangtze River cultural-context map was established.In the first phase of the project, centred on the theme of "The Millennial Cultural Heritage of the Jiangnan Water Towns", we systematically integrated the distinctive cultural resources of the water towns in the riverside cities and prefectures of Nanjing, Zhenjiang, Yangzhou, Taizhou, Changzhou, Wuxi, Suzhou and Tongzhou. Utilising innovative mapping technologies, we compiled a digital map of Jiangnan water town culture, with plans to display it on a digital cloud platform, thereby providing pioneering exploration and a model for the development of new digital dissemination platforms for Yangtze River culture..

The concept and significance of cultural-context maps

A s a thematic map, the cultural-context map focuses on the spatio-temporal visualisation of historical and cultural themes. In this context, it is essential to understand and grasp the essence of 'cultural context'. Simply put, 'cultural context' refers to the 'fabric of culture' and the 'origins and development of culture'(Han, 1988). "Cultural lineage"is a buzzword currently used in China when discussing history, culture and cultural traditions. In the Chinese linguistic context, the term is closely associated with concepts such as "bloodline", "artery" and "meridians"; its original meaning

refers to the structure of a literary text, and it can vividly describe “the vitality, relevance and spirituality of culture”(Xu, 2024).In the modern academic context, the term ‘cultural lineage’ was adopted by Chinese academia in the 1980s as a translation of ‘context’ or ‘contexture’. It originally referred to ‘context’ or ‘contexture’ in linguistics and literature, and was subsequently extended to denote the relationship between things in time or space, particularly the continuity and innovation within culture. It has become a core term in the fields of architecture and design, giving rise to a research boom in ‘architectural lineage’and “urban context”, emphasising that the “past–present–future” flows like a river, with (architectural) forms evolving and developing through movement in time and space, a process that inevitably involves both inheritance and innovation (Ai, 1989).

At present, cultural development has become a vital force in Chinese-style modernisation, providing the cultural resources and spiritual impetus for the comprehensive construction of a modern socialist country. On the one hand, the advancement of Chinese-style modernisation is rooted in the fine traditions of Chinese culture; it requires the earnest exploration and systematisation of the origins and evolution of Chinese culture, the preservation and promotion of the Chinese cultural lineage, whilst simultaneously drawing upon the essence of traditional culture to develop an advanced socialist culture;on the other hand, strengthening cultural development is an intrinsic requirement of Chinese-style modernisation, and fostering cultural confidence and self-reliance serves as the spiritual driving force for advancing Chinese-style modernisation. The Report of the 20th National Congress of the Communist Party of China states: “Chinese-style modernisation is a modernisation in which material civilisation and spiritual civilisation are in harmony” and “We must vigorously develop advanced socialist culture and promote the comprehensive enrichment of material life and the all-round development of the people”(Xi, 2022).

In the new historical context, ‘cultural lineage’ has become a key term for characterising the cultural DNA and spiritual lifeblood of China. Serving the development of national cultural parks and conducting in-depth research into cultural lineage have emerged as new research priorities within the Chinese academic community. The proposal of ‘cultural lineage mapping’ has come at a most opportune moment, representing a new frontier for cartography in serving major national needs and pursuing academic exploration and innovation.

Drawing on the above perspectives, this paper argues that the ‘cultural-context map’ is a cartographic product of the information age. It focuses on cultural themes, utilising the language of cartography to illustrate the spatial structure and historical evolution of cultural heritage, with an emphasis on depicting the origins, transmission and development of culture, thereby highlighting the cultural essence and spirit of the times of a nation or region.

As a thematic map, the cultural-context map possesses significant characteristics such as the visualisation of culture, the preservation of historical traces, and the integration of time and space; it requires active exploration and innovation in line with contemporary needs and technological advancements.On the one hand, cultural-context maps differ from traditional thematic maps, which focus on the thematic surveying and mapping of physical and human geographical features. Sufficient foundational data has been accumulated in these areas, supported by mature cartographic experience and specialised technical expertise. Extensive practical applications have been implemented across various sectors—such as basic surveying, land resources, military affairs, the environment, planning, marine affairs and transport—resulting in the establishment of systematic and comprehensive cartographic standards and technical frameworks, which form a vital foundation for the modern surveying and mapping industry.Cultural context maps, however, represent a new product and application within modern cartography. Their content focuses on cultural, historical and other humanistic themes; map topics are increasingly diverse and complex; and cartographic data is derived more frequently from historical texts, cultural imagery (paintings, photographs),antique maps, historical aerial photographs, archaeological materials, literary works, film and television productions (video/audio), cultural imagery, social perceptions, and artistic designs, whilst primarily utilising multimedia materials (text, data, graphics, images, sound, animation, and video). This undoubtedly increases the complexity of cartographic data processing.At the same time, the research and compilation of context maps require multidisciplinary collaboration, particularly active cooperation with fields such as history, culture, art and media. They necessitate the support of humanities research and cultural reflection, which in turn inform map themes, content and design.At the theoretical and methodological level, cultural context mapping necessitates innovation in cartographic research, enhanced exchange and mutual learning with related disciplines, and the creation of a new cartographic language. By employing modern information technology, artistic techniques and media methods, it aims to produce cultural maps that blend science and art, interweave time and space, combine culture and communication, and balance innovation with creativity, whilst remaining accessible and appealing to the general public.

RESEARCH ON CULTURAL-CONTEXT MAPS OF THE JIANGNAN WATER TOWNS

The cultural-context maps of the Jiangnan water towns

Regarding the protection of the Yangtze River's cultural context and the development of the Yangtze River Economic Belt, Xi Jinping noted: "The Yangtze River has shaped a millennia-old cultural heritage stretching from the Ba Mountains and Shu waters to the water towns of Jiangnan; it is a representative symbol of the Chinese nation and an iconic emblem of Chinese civilisation, serving as a vital source for nurturing the core socialist values.We must protect, inherit and promote Yangtze River culture, continue the historical cultural heritage, and strengthen our cultural confidence"(Xi, 2020).

The Yangtze flows from the snow-capped mountains towards the East China Sea, leaving behind the imprint of China's ancient civilisation along its course. It serves as the enduring cultural vessel of the Chinese nation, and the section of the Yangtze in Jiangsu is a melting pot of cultures, having nurtured the profound cultural heritage of the Jiangnan water towns.Making full use of information technology to thoroughly explore the millennia-old cultural heritage of the Jiangnan water towns, and employing modern methods to advance innovative research, transformation and dissemination, in order to create distinctive and influential digital products, thereby providing new digital solutions for the inheritance and promotion of the Yangtze River's millennia-old cultural heritage, is a key task in the high-quality development of the Yangtze River National Cultural Park (Jiangsu Section). Among these, for the Su-Zhou section of the Yangtze River in Jiangsu, how to highlight the "millennia-old cultural heritage of the Jiangnan water towns" is the foremost research priority.Consequently, this paper undertakes research on the Yangtze cultural-context maps, taking 'Jiangnan Water Towns' as its central theme.

The geographical region and cultural characteristics of the Jiangnan water towns

'Jiangnan' is an integral and organic part of the Yangtze River basin, serving as a vital geographical region for the shaping of Chinese civilisation and the understanding of Chinese culture. At the same time, 'Jiangnan' is a geographical concept that has continuously evolved through history and time, encompassing multiple dimensions such as administrative geography, cultural geography, economic geography, political geography and social geography. Its concept and connotations are constantly changing, making it a product of its era.

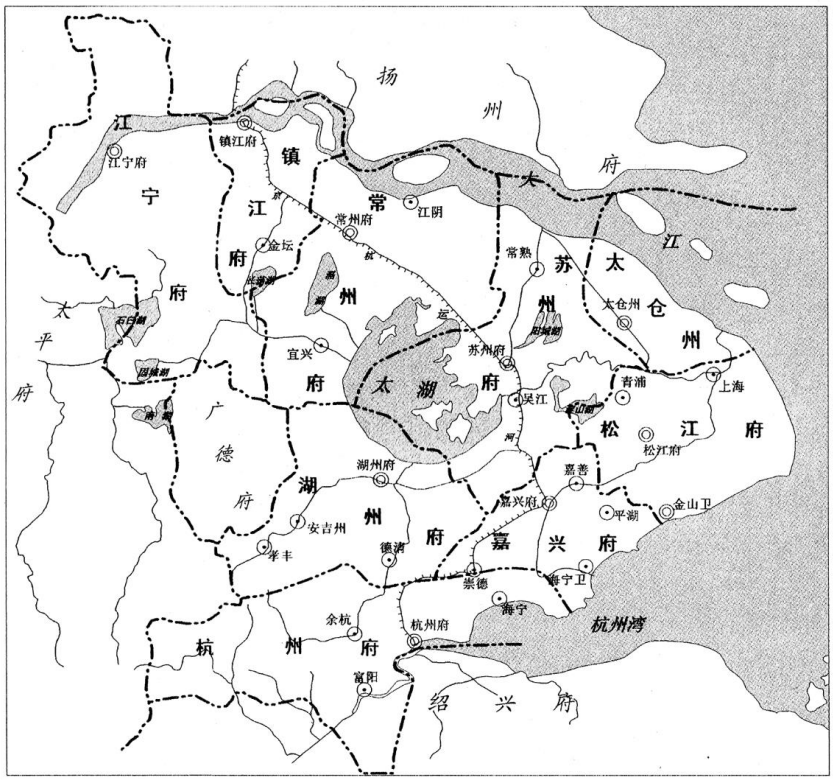


Figure 1. Schematic map of the "Eight Prefectures and One State" of Jiangnan during the Ming and Qing Dynasties
(Source: Chen, X. Y., & Bao, W. M. (2003). Jiangnan towns: A focus of traditional history and culture. Tongji University Press.)

Firstly, as a geographical concept, 'Jiangnan' represents a core region in the development of Chinese history and culture, yet the geographical scope it denotes has undergone constant shifts throughout history. From the Pre-Qin period through to the Wei, Jin, and Southern and Northern Dynasties, Jiangnan broadly referred to the southern regions of China, particularly the vast area south of the middle and lower reaches of the Yangtze River and north of Lingnan, whilst the lower reaches of the Yangtze were more commonly referred to as Jiangdong and Jiangxi, or Jiangzuo and Jiangyou.In the first year of the Zhenguan era of the Tang Dynasty (627 CE), the country was divided into ten circuits; among these, the Jiangnan Circuit encompassed the region south of the Yangtze River, stretching from the western part of present-day Hunan in the west to the sea in the east. This defined the geographical concept of Jiangnan from the perspective of administrative division.In the Song dynasty, the term 'Jiangnan' sometimes referred to the Jiangnan East Circuit (present-day north-eastern Jiangxi, southern Anhui and the Nanjing area of Jiangsu) and the Jiangnan West Circuit (most of present-day Jiangxi); at other times, it encompassed the Jiangnan East and West Circuits together with the Two Zhe Circuits (southern Jiangsu, Shanghai and the whole of Zhejiang), collectively known as 'Jiang-Zhe'; and on occasion, it also included the Fujian Circuit (present-day Fujian Province). Overall, the geographical scope of Jiangnan in the Song dynasty was not as extensive as that of the Tang dynasty.During the Ming and Qing dynasties, Jiangnan became the most prosperous region in China in terms of economy and culture, renowned throughout the land, whilst its geographical scope was further reduced (Chen, 2004). Based on the 'geomorphological-ecological region' theory, Li(2003) defined Jiangnan in the Ming and Qing dynasities as comprising 'Eight Prefectures and One State', namely 'including the Ming and Qing-era Su, Song, Chang, Zhen, Yingtian (Jiangning),Hang, Jia and Hu, as well as Taicang Prefecture, which was carved out of Suzhou Prefecture (Figure 1),1 roughly corresponding to the scope of the narrowly defined Yangtze River Delta region or the Taihu Lake basin, forming a cohesive whole in terms of geography, hydrology, ecology and economic ties (Li, 2003).

Secondly, Jiangnan is renowned not only for its economy but also for its culture, which forms its very soul; it represents the pinnacle of Yangtze River culture and has become a shining emblem of Chinese civilisation.In the late 1980s, Chinese scholars put forward a relatively comprehensive concept of 'Jiangnan culture', noting that its characteristics 'are inseparable from the natural geographical environment and economic development features of the Jiangnan region where it originated. … Its natural environment and the principal features of its economic development are directly linked to "water"'(Li, 1990). Consequently, from the perspective of cultural characteristics, Jiangnan culture takes 'water' as its backdrop, forming the distinctive theme of 'Jiangnan water town' culture.

The compilation of a cultural-context map centred on Jiangnan water town culture is significant not only for reconstructing the spatio-temporal context of traditional Jiangnan culture, but also for responding to and serving contemporary demands through cultural development—such as advancing the theory of Chinese-style modernisation, building the Yangtze River Delta integration region, and establishing a pilot demonstration zone for high-quality development in the Yangtze River Basin. Jiangnan culture serves as the intrinsic genetic code and spiritual bond that unites the integrated development of the Yangtze River Delta region. By tracing the natural foundations of Jiangnan since the Ming and Qing dynasties (the Jiangnan water network and the 'land of fish and rice'), urban development (Jiangnan towns and gardens), the growth of industry and commerce ("clothing the world"), to the region's role as a core industrial hub in modern China (modern Jiangnan industry), and the Yangtze River Delta region during the modernisation process, integrating the rich and diverse cultural resources of Jiangnan, distilling regional cultural memory and spatial identity, and mapping the spatio-temporal trajectory of Jiangnan culture, undoubtedly holds significant positive implications for advancing the construction of the Yangtze River Cultural National Park.

Preliminary compilation of cultural-context maps for Jiangnan water towns

The compilation of the cultural-context maps for Jiangnan water towns serves the national need for the development of the Yangtze River National Cultural Park. It focuses on the exploration and interpretation of the conceptual connotations of 'Jiangnan Watertown Culture', and combines the concepts of cultural big data and spatio-temporal knowledge graphs with relevant theories from cultural geography and landscape geography. Utilising modern cartographic theories and methods, it compiles a digital map of the Jiangnan Watertown cultural context, highlighting the unique watertown landscapes and cultural scenery of Jiangsu Province.

Themes and content of cultural-context maps for Jiangnan water towns

As mentioned earlier, the Jiangnan water towns constitute a distinctive geographical feature of the Jiangnan region throughout history. Water culture has nourished Jiangnan culture, giving rise to a cultural ethos characterised by both natural splendour and human ingenuity, as well as a harmonious blend of strength and grace.The Yangtze River and its tributaries form the backbone of the water network in the Jiangnan region. Here, rivers and lakes criss-cross the landscape, paddy fields stretch far and wide, towns and cities are densely clustered, the population is thriving, and cultural life is vibrant. Represented by the small towns of Jiangnan, where the rhythm of water serves as the fusion of

nature and culture, small bridges over flowing streams, pavilions and towers, and landscape gardens together form the beautiful scenery of the Jiangnan water towns.From the perspective of cultural landscapes, Jiangnan not only benefits from favourable natural conditions but also owes much to human initiative. The region places great importance on family traditions and reveres education, actively promoting traditional Chinese culture and advocating a social ethos of 'practical learning for the nation's prosperity' and 'striving for achievement'. This has fostered a positive interplay between the economy, culture and society. Throughout the ages, the region has produced a succession of distinguished figures and flourished culturally, giving rise to numerous distinguished cultural families and establishing itself as a central hub of China's economy and culture.All of these elements can serve as thematic elements for the mapping of the cultural context of the Jiangnan water towns.



Figure 2. Base map for the Compilation of the cultural-context maps for Jiangnan water towns (Schematic Diagram)
(The current geographical base map was produced based on the 'Yangtze River Delta Regional Map' (Approval No.: GS(2020)3189); historical administrative boundary data sourced from: CHGIS v6.0, https://dataverse.harvard.edu/dataverse/chgis_v6)

In terms of the mapping scope, taking into account the requirements for the construction of the Yangtze River Cultural National Park (Jiangsu section), the study primarily focuses on the eight cities along the Yangtze River in Jiangsu, whilst extending to surrounding areas such as Shanghai (Figure 2). Historical administrative boundary data utilises the 1820 administrative boundaries (data source: CHGIS v6.0).This scope encompasses the main regions of Jiangnan during the Ming and Qing dynasties (namely the five prefectures of Su, Song, Chang, Zhen and Ning, as well as Taicang Prefecture; Hangzhou, Jiaxing and Huzhou are not included for the time being), and includes the three cities along the Yangtze River in Jiangsu north of the river (Yangzhou, Taizhou and Tongzhou).From a cultural-geographical perspective, although these three locations belong to the region north of the Yangtze River, historically and culturally, due to the north-south connectivity and east-west exchange facilitated by the Grand Canal and the Yangtze River, the Yangzhou region (now the cities of Yangzhou and Taizhou) has been closely integrated with the south bank of the Yangtze River and the Taihu Lake basin in terms of economy and culture since the Tang and Song dynasties, making it a central area of cultural Jiangnan;Since modern times, the Nantong region has also become deeply integrated into the Jiangnan region due to its outstanding achievements in industrial, urban and cultural development, thereby contributing to the integrated development of the Yangtze River Delta. Based on the above considerations, this paper posits that the core of Jiangnan's water town culture is a distinctive regional culture centred on the eight cities along the Jiangsu section of the Yangtze River (Nanjing, Suzhou, Wuxi, Changzhou, Zhenjiang, Yangzhou, Taizhou and Nantong) and the surrounding area (Shanghai).

Currently, in line with research progress, three main themes have been planned and organised:

- **The Watery Charm of Jiangnan**: Based on the water network of Jiangnan (rivers, lakes, ponds and water transport networks), this theme encompasses cities (prefectural and county-level cities and above), towns (Jiangnan towns from the Ming and Qing dynasties), ports, mountain ranges and cultural landscapes (temples, tombs, bridges, pagodas, steles and other significant scenic spots and historical sites). It primarily employs traditional thematic mapping methods, combined with spatio-temporal knowledge graph technology, to provide an overview of the natural and cultural landscapes of the Jiangnan region.
- **Ancient Towns of Jiangnan:** Drawing upon the 'Tentative List of World Cultural Heritage Sites in China' published by the National Cultural Heritage Administration, this project focuses on the 15 ancient water towns of Jiangnan that have applied for World Heritage status (Luozhi, Zhouzhuang, Tongli, Qiandeng, Jinxi, Shaxi, Wuzhen, Xitang, Nanxun, Xinshi, Lili, Zhenze, Fenghuang,Xinchang, Huishan) as the subject of mapping. Employing artistic cartography techniques, a series of maps (or a composite map) will be produced. By integrating the historical and cultural spatiotemporal knowledge graph of these ancient towns, the unique cultural elements of each town will be explored. Through elements such as rivers, bridges, streets, houses and temples, the distinctive features and highlights of Jiangnan's ancient towns as potential World Heritage sites will be highlighted, thereby providing geographical visual products for tourism and cultural research.
- **Cultural Context of Jiangnan**: Centring on cultural figures of Jiangnan, construct a spatio-temporal knowledge graph to catalogue the cultural dynasties, major schools of thought, renowned scholars, distinguished civil service examination candidates, social networks, biographical trajectories (including former residences and places of residence), and principal works from the Ming and Qing dynasties to the modern era. Map the cultural landscape of Jiangnan to provide an overview of its spatio-temporal structure and developmental evolution since the Ming and Qing dynasties.

Technical approach to the compilation of cultural-context maps for Jiangnan water towns

This study proposes a technical approach to the compilation of cultural-context maps driven by spatio-temporal knowledge graphs (detailed below).

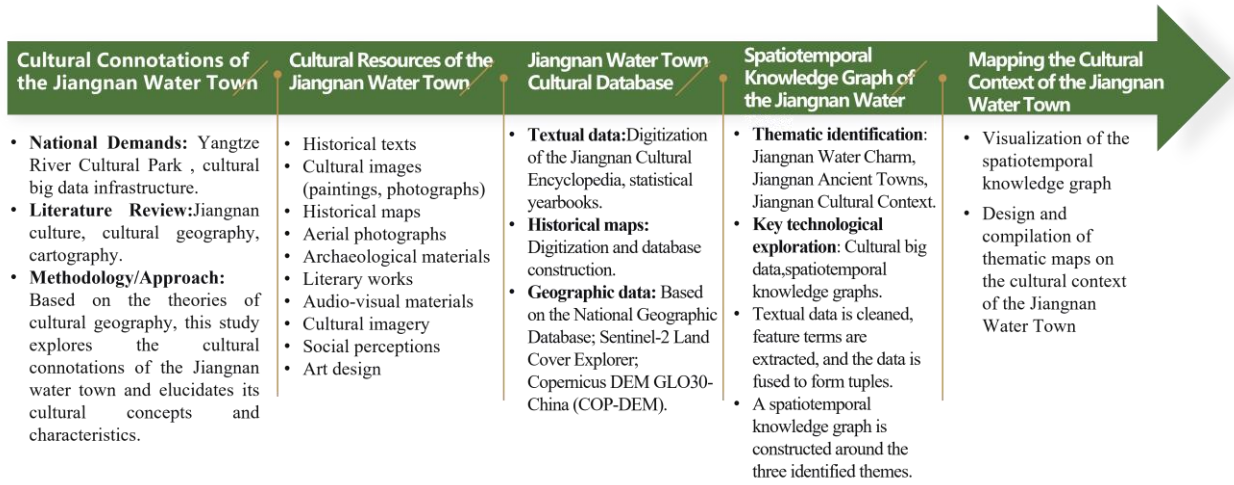


Figure 3. schematic diagram for Compiling the cultural-context maps for Jiangnan water towns.

Key technology for compiling the cultural-context maps for Jiangnan water towns: spatio-temporal knowledge graphs

Spatio-temporal knowledge graphs, also known as geographical knowledge graphs, represent a new application of knowledge graph technology in the organisation and representation of geographical information, and have become a research hotspot in the field of geographical information science in recent years. In 2012, Google introduced the concept of the 'Knowledge Graph' as part of improvements to its search engine algorithms (Liu et al., 2016).A knowledge graph is, in essence, a semantic web technology designed to describe concepts, entities and their interrelationships in the objective world(van den Berg et al., 1992). Zhang et al.(2020) argue that a geographical knowledge graph is a knowledge system that utilises semantic networks to provide a formalised description of geographical concepts, entities and their interrelationships, and possesses immense application potential in areas such as

the understanding of geographical knowledge, the resolution of geoscientific problems, and spatio-temporal forecasting and decision-making. In addition to sharing the connotations and characteristics of general knowledge, geographical knowledge also possesses specific spatio-temporal features and geoscientific mechanisms (Zhang et al., 2020).

This paper argues that spatiotemporal knowledge graphs, as a new type of surveying and geographic information technology, integrate geographic big data, semantic networks of geographic knowledge and visualisation techniques. Based on a GIS platform, they can facilitate the development of cultural spatiotemporal big data, support the intelligent mapping of cultural context maps, and empower the preservation and promotion of the cultural context of the Jiangnan water towns.Taking the Jiangnan region during the Ming and Qing dynasties as the study area, this paper proposes an ontology-based method for constructing a geographical knowledge graph and develops a spatiotemporal knowledge graph of the Jiangnan water towns; furthermore, it utilises thematic knowledge discovery techniques to assist in the design and compilation of cultural context maps.

In the field of data visualisation, knowledge graphs also break through the limitations of traditional structured data storage by adopting an unstructured graph format to store data, thereby facilitating new knowledge and discoveries. They are utilised to address issues such as intelligent question-answering and decision support within the field of artificial intelligence.In the field of cartography, knowledge graphs serve as a knowledge architecture framework, functioning as a method for organising geographical data or a visualisation technique(Peng et al.,2022; Li et al., 2022), and are also beginning to be applied to the design of cultural narrative maps (Zhong et al.,2021).

Generally speaking, the cartographic data for thematic maps (in the traditional surveying and mapping field) primarily derives from spatial numerical data, with a lack of cartographic methods and empirical cases for creating cultural maps using text as the data source (which is the primary data source for cultural mapping).This paper takes spatio-temporal knowledge graph technology as its starting point. By utilising the clustering characteristics of cultural figures in the Jiangnan region, and using cultural schools and cultural figures as connecting links, it organically associates works, events and locations to form the foundation for constructing a Jiangnan cultural spatio-temporal knowledge graph. It further proposes a technical approach for designing contextual maps through the construction of a knowledge graph of interpersonal relationships, as illustrated in Figure 4.

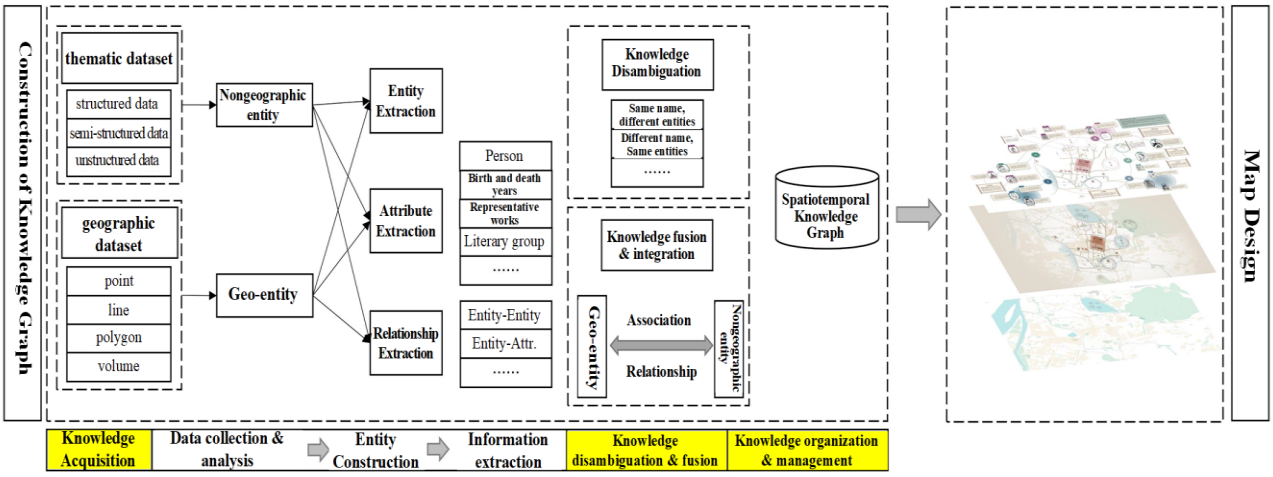


Figure 4. Technical approach for the creation of contextual maps supported by spatio-temporal knowledge graphs

Similar to the methods for constructing general knowledge graphs, the construction of spatio-temporal knowledge graphs is generally divided into two approaches: top-down and bottom-up. Top-down construction of knowledge graphs involves, based on the target problem theme, utilising existing thematic data—such as Baidu Baike and relevant texts—to construct an ontology from high-quality data, extract entity attributes and relationship information, and incorporate these into the knowledge base.Bottom-up construction of a spatiotemporal knowledge graph involves utilising specific technical means, such as natural language processing, to extract relevant resources from vast open datasets, filter out information with a high degree of confidence, and incorporate it into the knowledge base.The concept of spatio-temporal knowledge graphs applied in this paper can be understood as an extension of knowledge graph technology into the field of cultural geography. The research content can be categorised into two types: one treats spatio-temporal knowledge graphs as visualisation tools for the results of cultural data analysis, employing a top-down approach to construct such graphs; this approach is currently widely applied in studies of the social relationships of cultural figures and biographies of prominent figures (Huang et al.,2020; Wang et al.,2022); the other utilises textual information to

construct thematic knowledge graphs, employing techniques such as natural language processing to build knowledge graphs from the bottom up, such as those based on classical Chinese literary texts (Yang & Gu, 2021). The top-down construction of knowledge graphs primarily comprises three main steps: knowledge acquisition, abstraction and representation, and organisation and management.Knowledge acquisition involves deriving the fundamental content of an ontology from a dataset using relevant technical methods or manual processes. Knowledge abstraction and representation primarily involve converting the target content into a form that is comprehensible to map readers or recognisable and processable by computers, thereby effectively integrating thematic data with maps.

Textual data extracted from historical literature is combined with multimedia data and integrated with the basic geographic data from the National Platform for Common Geospatial Information Services, ‘ Tianditu ’ (https://www.tianditu.gov.cn/) to construct geographic big data. Furthermore, when extracting entity information from multi-source data, entities can be categorised into geographic entities and other entities; geographic entities represent spatial data, whilst other entities represent thematic data and similar information.New entities and knowledge constructed within the knowledge graph must be integrated to resolve contradictions and ambiguities. For instance, a single entity may be expressed in multiple ways, or a single expression may correspond to several different entities; these require manual verification. Furthermore, the key to data fusion lies in uncovering the relationships between geographic entities and other entities—that is, establishing ‘geographic entity–other entity’ associations—to ultimately achieve spatiotemporal data fusion.Knowledge organisation and management primarily involve storing knowledge using tabular or graph structures. Current mainstream graph data models include graph databases and resource description frameworks. This paper selects the Neo4j graph database as the tool for knowledge organisation and management. The ‘admin import’ tool in the Neo4j database allows CSV files containing knowledge graph nodes and relationships to be imported into the database and visualised in a straightforward manner.

Map design refers to the process of designing the various elements of map layers—such as layout, content, colour schemes and symbol systems—based on cartographic data and thematic focus. Given that contextual maps must bridge past and present and integrate time and space, their design requires significant consideration and refinement compared to conventional thematic maps.Currently, case maps are designed by generally following the hierarchical structure of the Visual Perception Pyramid model (Weng et al., 2021). Through the superimposition of layers, historical and modern spaces are mutually corroborated, and the spatio-temporal mapping illustrates the spatial changes of the Jiangnan city (Nanjing) (Figure 5). This design approach has already been applied in the compilation and research of the Jiangnan Watertown Contextual Map, yielding preliminary results.

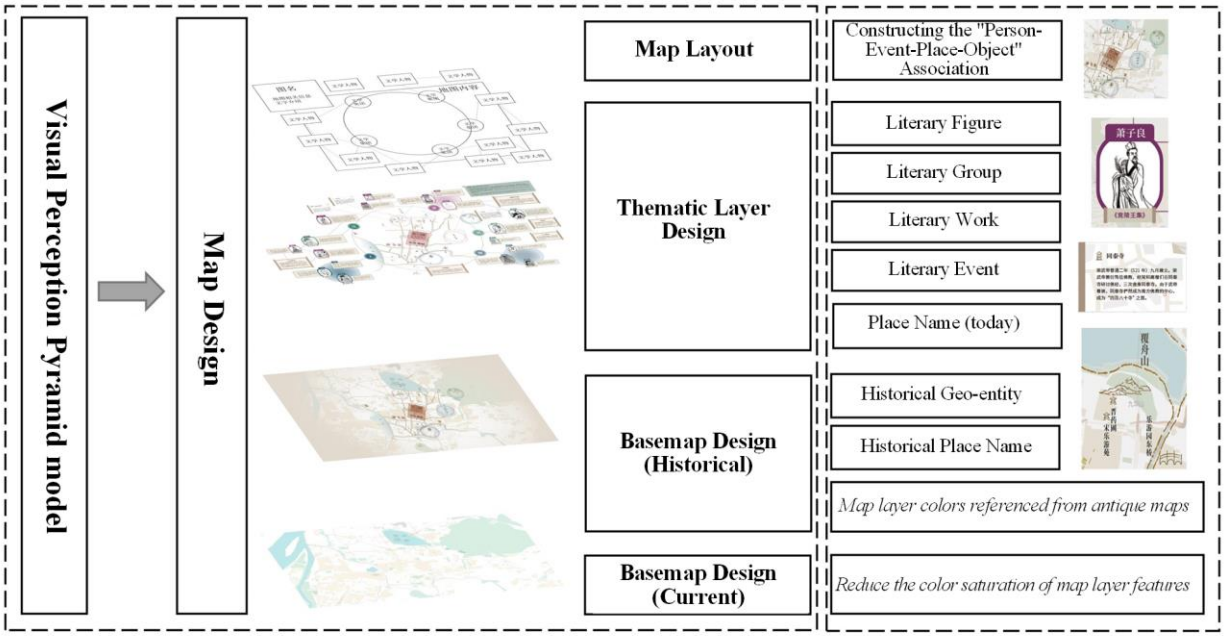


Figure 5. Design framework for a cultural-context map (using the compilation of the Nanjing Literary Map (interim results) as an example)

CONCLUSION

As Chen (1988) pointed out, "Cartography is closely integrated with the needs of social production, continuously introducing new academic ideas, geographical knowledge, and technical means to explore new application fields. This makes maps, as a cultural tool for human production and daily life, evolve rapidly."

The new cultural mission of building a culturally strong country and advancing modern Chinese civilization demands exploration and innovation in cartographic theory, methodology, and empirical research. Jiangnan culture is a significant representative of the Yangtze River culture. In the construction of the Yangtze River Cultural Park, it is the honorable mission of Chinese cartographers to conduct research on cultural context maps and preserve Jiangnan culture.

This paper argues that the spatiotemporal knowledge graph, as a new type of surveying, mapping, and geoinformation technology, as it may be called "Intelligent Cartography", integrates geospatial big data, semantic networks of geographic knowledge, and visualization techniques. Based on the National Platform for Common Geospatial Information Services, "Tianditu," it can construct cultural spatiotemporal big data, serve the intelligent mapping of cultural context maps, and empower the inheritance and promotion of Jiangnan water town culture. Focusing on the Jiangnan region during the Ming and Qing dynasties, this paper preliminarily proposes an approach based on spatiotemporal knowledge graph technology for the design and compilation of cultural context maps of Jiangnan water towns.

Future work includes: conducting in-depth research on the compilation of Jiangnan water town cultural context maps; integrating disciplinary knowledge from spatiotemporal big data, cultural geography, and cartography; actively applying advanced technologies such as spatiotemporal knowledge graphs and artificial intelligence; systematically organizing the spatiotemporal context of Jiangnan water town culture; mining cultural stories; and supporting the design and compilation of Yangtze River cultural context maps. Furthermore, in response to new contemporary demands for cultural maps (cultural context maps), this paper will consider the development and innovation of cartographic theory, methodology, and practice in the era of big data.

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