A Survey and Analysis of Distant Reading Visualization of Cultural Heritage Images in Digital Humanities (Postprint)

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Abstract

[Purpose/Significance] Cultural heritage images serve as crucial resource carriers and manifestations of human cultural memory, constituting key research materials and significant objects of study in humanities disciplines. From the perspective of digital humanities, conducting systematic investigations into the distant reading visualization of cultural heritage images will facilitate a deeper understanding of the distant reading concept, advance digital humanities research and practice on massive collections of cultural heritage images, and enable the excavation of their value. [Method/Process] First, we analyze the foundational theories of distant reading visualization for cultural heritage images based on the distant reading concept in digital humanities; second, we propose a compositional framework for distant reading visualization of cultural heritage images, employing methods such as literature review, case analysis, and open coding to conduct a comprehensive analysis across dimensions including distant reading visualization tasks, visualization interaction, image visual features and attributes, users, and visual presentation; third, we explore the reading pathways and reading structures of distant reading visualization for cultural heritage images; finally, we summarize and synthesize the problems and challenges confronting distant reading visualization of cultural heritage images. [Results/Conclusion] Distant reading has already been applied to the analysis and exhibition of cultural heritage image resources, with concurrent emphasis on integrating distant reading and close reading. The reading of distant reading visualization for cultural heritage images can be categorized into two structural types: flat and progressive. Distant reading visualization of cultural heritage images remains strongly experimental in nature, facing numerous problems and challenges regarding theoretical guidance, application of intelligent technologies and methods, visualization interaction, and support for humanities research.

Full Text

Distant Reading Visualization of Cultural Heritage Images from the Perspective of Digital Humanities: An Investigation and Analysis

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Abstract: [Purpose/Significance] Cultural heritage images serve as crucial resource carriers and manifestations of human cultural memory, representing key research materials and important objects of study across humanities disciplines. From the perspective of digital humanities, systematic investigation of distant reading visualization for cultural heritage images will help further understand the concept of distant reading, promote digital humanities research and practice on massive cultural heritage image collections, and facilitate value mining. [Method/Process] First, this paper analyzes the fundamental theories of distant reading visualization for cultural heritage images based on the concept of distant reading in digital humanities. Second, it proposes a framework for distant reading visualization of cultural heritage images and comprehensively examines this domain across multiple dimensions—including distant reading visualization tasks, visualization interaction, image visual features and attributes, users, and visual presentation—using literature review, case analysis, and open coding methods. Third, the paper explores reading paths and structures for distant reading visualization of cultural heritage images. Finally, it summarizes the problems and challenges facing distant reading visualization of cultural heritage images. [Result/Conclusion] Distant reading has been applied to the analysis and display of cultural heritage image resources, with simultaneous emphasis on combining distant reading with close reading. The reading of distant reading visualization for cultural heritage images can be divided into two structures: flat and progressive. Distant reading visualization of cultural heritage images remains highly experimental, facing numerous problems and challenges in theoretical guidance, application of intelligent technologies and methods, visualization interaction, and support for humanities research.

Keywords: cultural heritage; image resources; distant reading; data visualization; digital humanities

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1. Introduction

Images, as visual media for disseminating information, knowledge, and ideas, can express complex information that text cannot convey. In recent years, with the advent of the "age of images" and the "pictorial turn," images have gradually become important research materials in numerous humanities fields such as history, archaeology, art studies, aesthetics, and cultural studies, complement-

ing and supplementing textual materials [1]. Cultural heritage images contain profound cultural connotations and represent the most common data type in cultural heritage digital resources. Particularly in the digital era, physical resources such as ancient books, manuscripts, maps, museum collections, and archives often exist and circulate in the form of digital images. Cultural memory institutions such as libraries, museums, and art galleries at home and abroad have built numerous image repositories and resource databases, providing open access to data [2]. Meanwhile, the establishment and widespread application of the International Image Interoperability Framework (IIIF) have enhanced the interoperability and accessibility of global image resources [3]. However, the effective organization of massive cultural heritage image resources remains a challenge, and discovering knowledge from large-scale images, excavating cultural connotations, and effectively communicating and displaying them to users is even more difficult. Currently, libraries, archives, and museums have launched distant reading visualization practices for images, attempting to provide new solutions to these challenges.

Distant reading visualization combines discrete data with visual elements to convey macro-level patterns, overall trends, and evolutionary laws inherent in large-scale datasets. It offers advantages such as enhanced comprehensibility, simplified complexity, and interactive visualization, providing a new interpretive perspective for analyzing and researching massive cultural heritage image resources [4]. With the development of digital technologies, massive digitized textual and image-based materials provide researchers with rich information. The combination of distant reading and visualization demonstrates enormous potential as tools for observation, analysis, interpretation, and presentation in cultural heritage image research. At present, numerous scholars at home and abroad have conducted systematic research on distant reading and visualization of large-scale texts from a digital humanities perspective, but research on distant reading and visualization based on large-scale digital images is still in its infancy, lacking in-depth theoretical investigation and analysis.

This paper adopts a digital humanities perspective, focusing on distant reading visualization of large-scale cultural heritage images. It primarily addresses three issues: the application practices and research status of distant reading concepts and methods in the domain of cultural heritage images; the dimensions, core components, and communication modes of distant reading visualization design for cultural heritage images; and the reading paths and structures of distant reading visualization for cultural heritage images. Through systematic investigation of distant reading visualization of cultural heritage images, this study seeks to further understand the concept and methods of distant reading and promote scientific research and value mining of cultural heritage images.

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2. Theoretical Foundations and Related Research

2.1 Theoretical Foundations

2.1.1 "Distant Reading" in Digital Humanities Research "Distant reading" was first proposed by Franco Moretti in his essay "Conjectures on World Literature," referring to the use of quantitative methods to study large-scale digital text corpora [4]. Subsequently, distant reading has been innovatively applied in literature, history, linguistics, cultural studies, and other fields, becoming an important theory in digital humanities. With the popularization of computer technology and the development of distant reading practices, distant reading is now considered a research method that uses computers to process digital textual information and presents computational analysis results through visualization, representing a new paradigm for humanities research in the era of big data [5]. In its extended sense, distant reading mostly targets research with large temporal spans or large quantities of materials, making it suitable for analyzing massive resources and opening new dimensions for digital humanities research [6].

As a paradigm for literary studies, distant reading primarily relies on digital means such as quantification and computation to discover stable patterns from large volumes of text through abstract modeling, thereby identifying overall trends, characteristics, and evolutionary patterns. Current distant reading research on large-scale texts mainly focuses on describing overall features of text collections and revealing internal structural characteristics of texts [7]. Increasingly, digital humanities visualizations combine distant reading with close reading, reflecting a reading perspective that integrates macro and micro views. This approach not only provides new solutions to traditional humanities questions but also helps identify new questions among numerous clues [8]. With the application of large-scale, data-driven, visual analysis, and computational research thinking in humanities disciplines, more scholars are focusing on how to conduct quantitative and computational analysis of large-scale images, and the ideas and methods of distant reading have begun to be applied to the analysis and research of image materials.

Distant reading visualization of images provides a macro-level, bird's-eye view of large-scale image collections, with significance lying in mining the macro-level patterns, trends, and relationships within massive image resources.

2.1.2 Data Visualization Distant reading is the cornerstone of digital humanities, and visualization is its most important presentation method [7]. The combination of visualization technology and humanities computing provides an effective means to identify knowledge, patterns, structures, relationships, and trends hidden within massive and complex cultural data, receiving widespread attention in digital humanities research. Visualization is a dynamic process of speculation and reinterpretation of disciplinary knowledge, a medium for interdisciplinary communication and collaboration, and an aesthetic stimulus that

triggers critical insights, speculation, and discussion [9].

Visualization technology provides new ideas for addressing the difficulties in organizing and analyzing massive cultural heritage image resources. Distant reading of cultural heritage images cannot be separated from visualization technology, which mines, transforms, and extracts structured information and knowledge from complex big data, presenting it in forms more easily understood by users through visualization techniques [10]. Data visualization in the cultural heritage domain can not only assist humanities scholars in analysis and interpretation but also enhance data context and details, enabling users to explore, interact with, and search cultural heritage data.

Furthermore, data visualization is also a storytelling tool and a medium for narrative and descriptive states. The interpretation and inheritance of cultural content, analysis and representation of cultural heritage images, and text mining can all be narrated through visualization. Through quantification, analysis, and computation of massive digital cultural resources, deep narrative meanings of different cultural contents can be excavated and extracted, revealing historical contexts, cultural connotations, and humanistic ideas [11]. Compared to data visualization, data storytelling combines three basic elements—data, visual effects, and narrative—placing greater emphasis on transforming data perception into data cognition [12]. The combination of data visualization technology and narrative can provide effective support for presenting cultural knowledge and enrich means of cultural communication and innovation.

2.2 Related Research Following Moretti's perspective on distant reading in literary studies, scholars at home and abroad have also paid attention to macro-level observation and analysis of massive visual materials like texts, proposing concepts and methods such as "distant viewing," "cultural analytics," and "deep watching" [13]. T. Arnold et al. proposed the method and theoretical framework of "distant viewing," referring to the use of computer technology for large-scale analysis of visual materials to automatically identify and extract "cultural code elements" [14]. K. Glinka et al. explored transformation modes between distant and close views for cultural heritage collections through cross-disciplinary case studies, advocating for dynamic, contextual, visually rich, and multidimensional interfaces for cultural heritage data visualization [15]. American scholar Lev Manovich developed visualization technologies directly oriented toward images to obtain macro-level observations of massive image collections, conducting a series of visual analysis and cultural analytics experiments on artists' works, museum collections, comics, and social media images [16].

Domestic scholars Xiang Fan and Zhu Shunshan developed an interactive visualization project "AwardPuzzle" for award-winning oil paintings in the National Art Exhibition, demonstrating the enormous potential of distant reading and visualization as tools for observation, interpretation, analysis, and presentation in art research [17]. In terms of visualization design, W. Florian et al. extensively surveyed the design space and visualization methods of data visualization

cases in the cultural heritage domain, finding that increasingly more interactive visualization methods are being applied to explore cultural heritage information spaces, forming a distinctive research field [18]. Additionally, numerous institutions such as museums and art galleries emphasize visualization and interactive experiences of digital collections, moving beyond simple keyword retrieval to provide rich views, multi-scale, and contextualized interfaces [19]. With the development of artificial intelligence technologies such as neural networks, image recognition, and visual analysis, intelligent analysis of massive images shows new potential.

It can be seen that the comprehensive application of distant reading concepts and visualization analysis technologies provides new approaches for large-scale visual corpus research. Based on existing research, scholars at home and abroad have conducted some research and practice in visual analysis of cultural heritage image resources, data visualization, and digital humanities, but there remains a lack of systematic review and research on distant reading visualization of cultural heritage images from the perspective of distant reading.

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3. Research Methods for Distant Reading Visualization of Cultural Heritage Images

3.1 Data Sources for Investigation The specific projects investigated in this paper include the International Digital Humanities Awards (DH Awards), IEEE VIS International Conference, International Digital Humanities Conference, and well-known museums or cultural institutions, covering relevant research literature and practical cases in digital humanities, data visualization, cultural analytics, museum studies, and digital art. Among them, the IEEE VIS conference established the VIS4DH workshop in 2016 to propose new research directions for visualization research in digital humanities and promote collaboration between visualization and digital humanities disciplines. The International Digital Humanities Awards, established in 2012, aim to increase public and researcher engagement in digital humanities. Through public voting, the awards select the best digital humanities resources annually, including a specific category for Best Data Visualization.

The specific projects surveyed include the 2015 runner-up for data visualization, Australian Prints + Printmaking, and the 2018 champion project COINS. Large-scale image visualization tools and platforms include PixPlot developed by Yale University's Digital Humanities Laboratory, the VIKUS Viewer platform developed by the University of Applied Sciences Potsdam for "visualizing cultural collections," and the PolyCube visualization tool. Library or museum collection visualization cases include the British Museum and the Amsterdam Museum. Additionally, the study includes cultural analytics research by Professor Lev Manovich on photographic collections from the Museum of Modern Art (MoMA). Finally, 16 representative cases of distant reading visualization of

cultural heritage images were identified, as shown in Table 1 , with some case interfaces shown in Figure 1 [Figure 1: see original paper].

Table 1. Survey Objects of Distant Reading Visualization of Cultural Heritage Images

No.	Case Name	Year	Source	Online Preview URL
1	VIKUS Viewer	2016	Library application case	https://vikusviewer.fh-potsdam.de/
2	PolyCube	2019	IEEE VIS 2019 and EuroVis 2019 conferences	https://danubevislab.github.io/polycube/cga2020/
3	PixPlot	2017	Yale University Digital Humanities Laboratory project	http://pixplot.yale.edu/v2/loc/
4	COINS-A Journey through a Rich Cultural Collection	2018	DH Award 2018 Data Visualization Champion	https://uclab.fh-potsdam.de/coins/
5	Museum of the Word	2016	Museum application case	https://britishmuseum.withgoogle.com/
6	Visualization of Rijkmuseum	2017	Museum application case, IEEE VIS 2017	http://vijks.com/
7	Drive into Color	2018	Museum application case	https://www.oliviavane.co.uk/dive-into-color
8	Aereo: State Library of NSW's Digital Collection	2019	Library application case	https://dxlab.sl.nsw.gov.au/aereo/

No.	Case Name	Year	Source	Online Preview URL
9	Australian Prints and Printmaking	2013	DH Award 2015 Data Visualization Runner-up	http://printsandprintmaking.gov.au/explore/
10	Raoul Hausmann	2017	Digital Humanities Conference 2019	https://uclab.fh-potsdam.de/hausmann
11	Close-Up Cloud	2017	Digital Humanities Conference 2019	https://uclab.fh-potsdam.de/coins/
12	Photogrammar	2020	VIS4DH 2020 conference paper	https://www.photogrammar.org
13	Google CURATOR TABLE	2017	Google Arts & Culture experiment case	https://artsexperiments.withgoogle.com/curatortable/
14	Codex Atlanticus	2017	Awwwards Honorable Mention, Webby Awards Best Data Visualization	https://codex-atlanticus.it/#/Overview
15	MoMA Photography Collection Visualization Case	2016	Cultural analytics by Lev Manovich	http://lab.culturalanalytics.info/2016/04/exploratory-visualizations-of-thomas.html
16	NYPL Visualization Project	2016	Library application case	http://publicdomain.nypl.org/pd-visualization/

3.2 Components and Framework of Image Distant Reading Visualization To investigate and evaluate the concepts and methods of distant reading visualization of cultural heritage images, it is first necessary to clarify the overall design architecture and elements. S. Miksch et al. proposed the “data-user-task”

design triangle methodology framework [27]. S. Latif et al. investigated the relationship between text and visualization in geographically data-driven narratives, dividing visualization into four main aspects: type, goal, exploration, and attributes [28]. F. Windhager et al. surveyed visualization of cultural heritage collection data from dimensions including data, users, tasks, granularity, interaction, temporal information visualization, and non-temporal information visualization [29].

Based on literature review of distant reading and visualization, this paper draws on information visualization reference models to propose the main components of distant reading visualization of cultural heritage images, including: visualization tasks, users and audiences, image visual features and attributes, visual presentation forms, visualization interaction methods, and visualization granularity. The logical relationships among these components are shown in Figure 2 [Figure 2: see original paper]. First, visualization tasks and target audience needs are the premise and foundation for designing image distant reading visualization. Second, the visual features of cultural heritage images and their metadata information constitute the fundamental data for distant reading visualization, with different attributes and data types determining the forms of visual presentation and communication. Therefore, understanding the data is a crucial step. Finally, users achieve visual interpretation and meaning construction through various visualization interactions, completing the visual decoding process to gain insights and make decisions.

3.3 Open Coding The purpose of using open coding on the text is to identify specific components and elements within distant reading visualization cases of cultural heritage images, achieving a comprehensive understanding of image distant reading visualization. To this end, six cases were first selected from the 16 cases as seed cases. Two coders observed and analyzed them, listing all elements constituting the image distant reading visualization system. Second, the coding results from both coders were compared, unified naming was established for all element concepts through merging similar codes and aligning conflicting codes. After repeated discussions among the authors and the two coders, an initial classification coding scheme for investigating distant reading visualization of cultural heritage images was obtained. Finally, based on the initial coding scheme, the remaining survey objects were coded—one coder performed the initial coding, and the other reviewed and refined it, supplementing and validating the classification coding scheme throughout the process.

The final classification coding scheme for investigating distant reading visualization of cultural heritage images includes six dimensions and 38 specific secondary categories: visualization tasks, visual presentation methods, image visual features and attributes, visualization interaction elements, visualization granularity, and users and audiences. The overall feature distribution and quantitative statistical results of the distant reading visualization cases for cultural heritage images are shown in Figure 3 [Figure 3: see original paper].

During the open coding process, the two coders collaboratively identified key pages and transition processes in the reading process of each distant reading visualization case, discussed and mapped out the distant reading visualization reading paths for each case, and on this basis, identified the reading structures of image distant reading visualization.

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4. Survey Results of Distant Reading Visualization of Cultural Heritage Images

4.1 Analysis of Components of Distant Reading Visualization of Cultural Heritage Images Based on the coding scheme for investigating distant reading visualization of cultural heritage images, the survey statistics are shown in Figure 3. This section analyzes each component.

4.1.1 Distant Reading Visualization Tasks Distant reading visualization has different types of goals and tasks, directly influencing the selection of visualization methods, visual presentation forms, and interaction methods. This investigation first seeks to identify its core tasks and objectives. This paper categorizes distant reading visualization tasks for cultural heritage images into three types: display and browsing, cultural analysis, and relational. Display and browsing types primarily aim at visual presentation and display of image resources or information, supporting users in exploratory browsing of image resources through various interaction methods. Relational visualization aims to discover important connections between objects or phenomena, including causal, spatial, temporal, and structural relationships, through relationship identification, comparative analysis, and network presentation to discover hidden associations and new knowledge. Cultural analysis types employ computational analysis and visualization technologies for systematic analysis of large-scale cultural datasets to interpret cultural phenomena or connotations.

The survey found that most cases focus on visualization display and browsing of large-scale image resources, followed by relational visualization. However, distant reading practices and applications in cultural analysis and narrative visualization are relatively few and require further research.

4.1.2 Image Visual Features and Attributes Image visual features and metadata information constitute the data foundation for distant reading visualization. Image semantic content is generally divided into three levels: feature level, object level, and semantic level. The feature level mainly includes visual features such as color, shape, and texture; the object level refers to objects in images and their spatial relationships; the semantic level includes scene semantics, behavior semantics, and emotional semantics. The survey found that color information is most frequently used among low-level visual features. Color is one of the most direct and attractive features, and what audiences perceive first is color, which is also an important part of visual presentation. Many online

museums and art galleries use color information as an important parameter for digital collection retrieval and navigation, such as the Library of Congress, Google Arts & Culture, Cooper Hewitt Museum, and Rijksmuseum [30].

From the perspective of image metadata, temporal information is most commonly used in distant reading visualization, followed by metadata such as image type, spatial information, tags, themes, and dimensions. Temporal information and timelines are widely applied in organizing and visualizing cultural data, playing an important role in determining relationships between cultural collections [22]. Image tags and themes enable richer semantic-level connections between images and are also commonly used in distant reading visualization design.

Additionally, with the application of artificial intelligence technologies such as visual analysis and convolutional neural networks, multidimensional semantic features of images can be automatically extracted. Through algorithms such as image visual similarity calculation, clustering, and dimensionality reduction, high-dimensional data can be visualized to discover macro-level patterns or regularities exhibited by massive images. However, current research on image distant reading visualization still rarely applies object-level and semantic-level information, including visual objects, image styles, emotions, and behaviors within images, making it difficult to establish associations at higher semantic levels and fully reveal the historical and cultural connotations and humanistic spirit embedded in cultural heritage images.

4.1.3 Visual Presentation Forms Visual presentation forms determine the efficient communication of massive and complex information, influencing users' information reception and reading experience. Through visual encoding and design, rich visualization forms can enhance the accuracy, effectiveness, and aesthetics of data presentation and visual communication. With the development of data visualization and human-computer interaction technologies, increasingly more visualization methods are being applied to distant reading visualization design for large-scale data.

Distant reading visualization presentation forms for cultural heritage images can be categorized into three major types: basic forms, spatial information encoding, and temporal information encoding. Basic forms mainly include representative classic chart types such as bar charts, lists, grids, mosaic plots, and treemaps, which remain the main visual presentation forms for distant reading visualization. Temporal information encoding mainly includes timelines, animations or dynamic effects, and spatiotemporal cubes. Spatial information encoding includes maps (spatial distribution maps, route maps, etc.), clustering, and network diagrams.

The survey found that half of the cases used more than three visualization presentation forms. The PolyCube tool uses the most visualization presentation forms, highly abstracting data and employing spatiotemporal cube forms to express complex information, comprehensively exploring multidimensional, dy-

namic, and relational features hidden in the data. Timelines are the most used visual presentation form in distant reading visualization of cultural heritage images. Timelines or time axes are the primary form for temporal sequence data visualization, emphasizing evolution and dynamic development based on time, intuitively presenting continuity and trends. Overall, current image distant reading visualization presentation forms remain relatively traditional and singular, lacking composite applications of multiple visualization representations and dynamic elements.

4.1.4 Distant Reading Visualization Interaction Elements Interaction is the foundation of data visualization. Users complete different information activities in the visualization interface through various interaction operations based on different needs and tasks, such as overview, filtering, querying, zooming, and detail viewing. On this basis, combined with methods such as observing changes, comparative analysis, and evidence finding, users can discover and analyze potential patterns and regularities to achieve problem-solving, knowledge creation, and meaning construction [31].

The interaction process between users and visualization systems is constituted by the interaction of various basic interactive elements. Professor B. Shneiderman distilled seven types of interaction tasks: overview, zoom, filter, details-on-demand, relate, history, and extract [32]. F. Windhager et al. distinguished six types of interaction activities, including object retrieval, overview and location, vertical immersion or abstraction, detail display, horizontal browsing and exploration, and curatorial path [18]. W. A. Pike et al. formulated high-level goals from the user perspective, including exploration, analysis, browsing, absorption, classification, evaluation, understanding, and comparison [33]. Through literature analysis and case surveys, this paper identifies eight specific and refined distant reading visualization interaction elements: overall overview, zooming, retrieval, filtering, detail display, browsing and exploration, comparison, and annotation.

The survey found that basic interaction elements for distant reading visualization of cultural heritage images mainly include browsing and exploration, providing macro or overall overviews, displaying object details, filtering, and zooming. To reflect distant reading of massive images, most cases provide overall overviews and macro views of data collections as core user interaction pages. Seventy-five percent of cases provide display of individual objects, about 70% provide object selection and filtering functions, and 37.5% support zooming from overall to individual as an interaction method combining distant and close reading. Notably, none of the surveyed cases provide explicit visualization reading paths, navigation structures, or narrative modes, mainly relying on users' free browsing and exploration, which is not conducive to understanding data and gaining insights from distant reading. Under the concept of data storytelling or data-driven visualization, designing narrative modes and structures for image distant reading visualization is a worthy new research topic. Additionally,

according to digital humanities primitives, compared to text distant reading visualization, image distant reading inadequately embodies functions for digital humanities research activities such as comparison, illustration, representation, and sharing. Currently, there is a lack of easy-to-use, comprehensive image visualization analysis tools like Voyant for text visualization analysis.

4.1.5 Distant Reading Visualization Granularity Due to the complexity of cultural heritage data, providing only single visualization views is insufficient; instead, multi-granularity, multi-perspective, and multi-dimensional visualization methods are needed to enable analysis and interpretation of the same data from different angles [34]. This paper adopts the granularity classification proposed by F. Windhager et al., dividing distant reading visualization granularity into four levels based on abstraction degree and visualization form: single-object view, multi-object view, discrete overview of the entire collection, and abstract overview of the entire collection. The latter two differ in abstraction degree; the former still maintains accessibility and visibility of individual objects.

Through survey and analysis of visualization granularity, although distant reading describes macro-level global features of data collections, most cases can obtain visualization and preview of single or multiple objects. Over 60% of cases provide discrete representation of the entire collection, such as abstracting individual objects into points or color blocks. Meanwhile, only a small portion of cases provide more macro-level abstract overviews of the entire dataset, such as abstracting the entire dataset into heatmaps or map distributions. Different levels of visualization granularity provide different perspectives for understanding image datasets.

Multi-granularity visualization is an important dimension of distant reading visualization and what distinguishes it from general visualization. Overall, current distant reading visualization of cultural heritage images mainly focuses on discrete representation at the macro level of the entire dataset while ensuring accessibility and close reading needs for individual objects.

4.1.6 Users and Audiences Users' data visualization literacy and information cognition levels vary, as do their purposes and methods for obtaining information. Based on audience members' knowledge backgrounds and cognition levels, users can be divided into general users and professional users. General users do not have particularly clear goals or tasks; their purposes are more about data exploration, browsing, and visual enjoyment, but they require guidance and direction. Providing clear reading paths and visual guidance is crucial. Professional users mainly include curators from museums and archives, as well as personnel in data visualization and digital humanities fields. These users have high requirements for visualization design, using visualization as an analytical method and tool. Particularly under the digital humanities research paradigm, distant reading visualization technology can assist humanities researchers in presenting research findings and grasping the dynamic development of matters from

both macro and micro perspectives, becoming an indispensable basic element [35].

Combining the goals, tasks, and intentions of image distant reading visualization cases, this paper conducts open coding and classification of their target users. The survey found that most image distant reading visualization cases target general users, with display and exploratory browsing applications being common. Distant reading visualization interfaces also mostly use images themselves or thumbnails for intuitive presentation. Only a few cases target professional users, and currently, they cannot meet the needs of humanities scholars for foundational digital humanities research such as large-scale studies, spatiotemporal analysis, and comparative analysis.

4.2 Reading Structures of Distant Reading Visualization of Cultural Heritage Images Distant reading represents a new way of reading and understanding literature, making text comprehension and information mining more convenient and intelligent, and better adapting to readers' digital reading needs [36]. Distant reading visualization can be regarded as a multidimensional visualization reading space composed of data, visual elements, narrative elements, and interaction, allowing readers to read from different dimensions or paths, thereby completing information transmission and meaning construction to achieve the effects of distant reading visualization [37]. In image distant reading visualization design, navigation structure and reading paths are crucial elements. Visualization reading strategies and navigation design directly influence users' interaction behaviors, thereby affecting data interpretation and visualization, making them key to visual communication. Therefore, this section analyzes the reading paths of distant reading visualization cases for cultural heritage images.

Professor Ben Shneiderman of the University of Maryland proposed the "mantra" for visual information seeking: "Overview first, zoom and filter, then details-on-demand" [32]. Based on this principle, the general logic for reading distant reading visualization of cultural heritage images can be abstracted as a process from the homepage or overview page (A), through different intermediary pages (B), to the detail display page for individual objects (C). Intermediary pages (B) can be search result pages, selection and filtering pages, zoom pages, or other transitional pages, or different views. The individual object display page (C) may not exist in some cases.

This paper mapped out the reading paths and navigation structures of the surveyed cases, identifying two different reading structures based on their topological structures: flat and progressive, as shown in Figure 4 [Figure 4: see original paper].

Figure 4. Reading Structures of Distant Reading Visualization of Cultural Heritage Images

Figure 4 intuitively shows that flat visualization reading structures have fewer intermediary interfaces, often providing a single distant reading visualization

interface but allowing data filtering, sorting, and reorganization at the macro overview page level. This model can directly switch from distant reading to close reading of individual objects, generally using a top-down combination form. The flat reading structure can provide both overall overview and interaction while effectively avoiding information disorientation and overload caused by frequent switching between different pages and visualization granularities.

In contrast, progressive visualization reading structures have more complex and diverse reading paths, using different types of intermediary interfaces to achieve multidimensional organization and display of data. Intermediary pages can be summarized into three types: pages supporting data selection, filtering, or screening; search result display and interaction pages; and views or pages that re-layout data.

Combined with the above analysis of distant reading visualization interaction elements and methods, users primarily connect macro overviews and micro displays through interaction operations such as selection, search, filtering, and view switching during reading. Overall, visualization of large-scale cultural heritage image resources increasingly emphasizes mutual transformation between distant and close reading, combining bird's-eye views of large datasets with close-up views. However, the design of reading paths and structures for distant reading visualization of cultural heritage images remains highly exploratory, with insufficiently clear design of visualization reading structures, paths, and narrative strategies, and lacks systematic guiding principles and reference theoretical models.

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5. Challenges for Distant Reading Visualization of Cultural Heritage Images

Distant reading visualization of cultural heritage images is not merely about visual presentation of massive images; more importantly, it makes complex and vast data vividly displayed, enabling visualization and analysis to explain macro-level patterns, paradigms, evolutions, and models from broader perspectives, thereby providing strong support for decision analysis. Currently, distant reading visualization of cultural heritage images still faces numerous problems and challenges in terms of distant reading concepts, application of intelligent technologies and methods, and support for humanities research.

5.1 Incomplete Conceptualization of Distant Reading Visualization of Cultural Heritage Images As an academic research method, tool, and evidence, distant reading visualization is a crucial aspect of digital humanities research. Currently, distant reading visualization of cultural heritage images primarily relies on concepts and methodological systems from text visualization and text distant reading, lacking theoretical models specifically for distant reading of cultural heritage images. Although cultural heritage data visualization

forms are increasingly diverse, visualization is often uncritically applied directly to humanities fields, ignoring fundamental aspects of humanities research such as interpretation, ambiguity or uncertainty, and the specificity and contextual particularity of viewpoints [38]. Meanwhile, due to the numerous domains and themes involved in cultural heritage images, rich semantic content, and complex relationships, distant reading visualization of images faces many uncertainties [39].

In terms of types of distant reading visualization, current applications mainly target image resource display and exploration for the general public, with insufficient depth in reflecting and researching cultural analysis, relational discovery, and data storytelling. Distant reading visualization needs to further integrate with humanities computing, culturomics, and cultural analytics to explore patterns and models behind cultural heritage image data resources, enabling comprehensive and detailed observation and analysis of cultural phenomena across long time spans.

Although many digital humanities visualization projects can support both distant and close reading, research on the relationship between these two research methods and how to combine them remains insufficient. Given the complexity and uncertainty of cultural heritage data, the advantages and disadvantages of distant and close reading and their reasonable and effective application scopes need consideration. In digital humanities research, how to organically combine distant and close reading according to research needs and flexibly switch between them requires further study.

5.2 Insufficient Application of Intelligent Image Processing Technologies and Methods The rapid development of artificial intelligence technology provides strong support for recognizing image content and semantic understanding. Methods such as image recognition, object detection, and image semantic segmentation can intelligently extract multidimensional image features, obtaining more evidence to verify hypotheses and speculations. However, current distant reading visualization of cultural heritage images mainly focuses on basic image attributes and metadata information, without delving into deeper content and semantic levels, making it difficult to excavate and reveal important information, historical connotations, and cultural patterns behind cultural heritage images. Therefore, artificial intelligence technologies such as image analysis, machine learning, and deep learning are needed to achieve automated extraction and intelligent recognition of image content elements, while integrating images and texts through multimodal data fusion and unified knowledge representation to explore trends, patterns, and relationships in large-scale image resources at broader scopes and finer granularities.

5.3 Interaction Experience of Distant Reading Visualization Needs Optimization The collaborative interaction between distant reading visualization tools and humans is insufficient. On one hand, existing visualization rep-

resentations are far from supporting the complexity of cultural heritage images and the task requirements of scholars from different fields. On the other hand, visualization interaction modes are relatively singular and lack dynamic interaction. Therefore, multi-view linkage technologies, multi-scale and multi-faceted interaction technologies, dynamic visualization technologies, and zoomable interfaces need to be developed, with strengthened integration of various interaction technologies. Additionally, interaction methods such as voice interaction, multi-touch, and eye tracking should be added to increase user engagement and experience, helping people understand and comprehend information and knowledge conveyed by visualization more intuitively and efficiently.

Moreover, distant reading visualization design for cultural heritage images lacks clear visual narrative modes and reading paths, as well as contextualized and interactive storytelling capabilities. Strengthening the application of visualization storytelling and data storytelling in distant reading visualization design for cultural heritage images to form multi-dimensional, immersive data storytelling environments will help users gain data insights, trends, or potential patterns.

5.4 Capability to Support Humanities Research Needs Enhancement

As a research method and paradigm, how to transform user needs into corresponding distant reading visualization problems for general research methods in digital humanities such as discovery, comparison, reference, illustration, and representation is an indispensable aspect of distant reading. Currently, research and practice on distant reading visualization of cultural heritage images 偏向大众传播和展示展览，缺少辅助人文学者开展学术研究的分析工具和平台。同时，不同学科学者对远读可视化的需求不尽相同，要兼顾需求的差异性和可视化技术的适用性，对远读可视化提出了更高的挑战。因此，需要加强不同领域学者的跨学科研究，数字人文研究者提供数据、问题和任务，可视化设计师或专家提供算法和可视化与分析技术。通过跨界交流与合作，找到人文学科与可视化有效结合的方式。同时，完善远读可视化的标准规范与评价体系，对其合理性、有用性和有效性等方面进行评估与用户体验研究，是未来远读可视化发展的重要研究方向。

References

[1] Wang Jiahua. Making Images "Speak": The Possibility, Path, and Limitations of Using Images in Historical Research[J]. Historical Theory Research, 2021(3): 62-75, 158-159.

[2] Yang Min, Xia Cuijuan, Yan Jia. Current Status Analysis and Future Trends of Image Database Construction from the Perspective of Digital Humanities[J]. Library Journal, 2021, 40(4): 90-99.

[3] Chen Tao, Liu Wei, Sun Xun, et al. New Modalities of Cultural Heritage Application Research under the Influence of IIIF and AI[J]. Journal of Library Science in China, 2021, 47(2): 67-78.

[4] Su Zhen, Luo Lan, Yin Qian. Race and Distant Reading[J]. Digital Humanities, 2020(3): 36-45.

[5] Du Lanlan. On Moretti's Distant Reading and Its Influence[J]. Comparative Literature in China, 2020(3): 179-193.

[6] Wang Xiaoguang, Chen Jing. Digital Humanities Opens New Cultural Horizons (Path to the Peak)[N]. People's Daily, 2020-02-25(20).

[7] Wang Jun. From Humanities Computing to Visualization—Tracing the Development of Digital Humanities[J]. Literary Theory and Criticism, 2020(2): 18-23.

[8] Gu Xueqiang. Digital Humanities Research in the Age of Mediatization: Intellectual Lineage, Theoretical Connotations, and Research Paradigms[J]. Journalism and Mass Communication, 2021(1): 84-94.

[9] Hinrichs U, Forlini S, Moynihan B. In Defense of Sandcastles: Research Thinking Through Visualization in Digital Humanities[J]. Digital Scholarship in the Humanities, 2019, 34(S1): i80-i89.

[10] Sun Yuanbo, Wen Zhiyi, Xu Ruige, et al. A Review of COVID-19 Data Visualization Design[J]. Packaging Engineering, 2020, 41(8): 51-62.

[11] Zhu Mengze, Zhao Haiying. A Survey of Narrative Visualization[J]. Journal of Computer-Aided Design & Computer Graphics, 2019, 31(10): 1719-1727.

[12] Chao Lemen, Zhang Chen. Data Storytelling: From Data Perception to Data Cognition[J]. Journal of Library Science in China, 2019, 45(5): 61-78.

[13] Bermeitinger B, Gassner S, Handschuh S, et al. Deep Watching—Towards New Methods of Analyzing Visual Media in Cultural Studies[EB/OL]. [2021-11-26]. https://dev.clariah.nl/files/dh2019/boa/0335.html.

[14] Arnold T, Tilton L. Distant Viewing: Analyzing Large Visual Corpora[J]. Digital Scholarship in the Humanities, 2019, 34(S1): i3-i16.

[15] Glinka K, Pietsch C, Dork M. Past Visions and Reconciling Views: Visualizing Time, Texture, and Themes in Cultural Collections[J]. Digital Humanities Quarterly, 2017, 11(2)[2021-11-26]. http://www.digitalhumanities.org/dhq/vol/11/2/000290/000290.html.

[16] Xiang Fan. Visual Art Research from the Perspective of Visualization Design[J]. Literary Theory and Criticism, 2020(2): 46-53.

[17] Xiang Fan. Visualization Design of Visual Documents—Design Exploration of the Visualization Tool AwardPuzzle for National Art Exhibition Award-Winning Oil Paintings[J]. Art & Design, 2016(7): 92-94.

[18] Windhager F, Federico P, Schroeder G, et al. Visualization of Cultural Heritage Collection Data: State of the Art and Future Challenges[J]. IEEE Transactions on Visualization and Computer Graphics, 2018, 25(6): 2311-2330.

[19] Whitelaw M. Generous Interfaces for Digital Cultural Collections[J/OL]. Digital Humanities Quarterly, 2015, 9(1)[2021-11-26]. http://www.digitalhumanities.org/dhq/vol/9/1/000205/

[20] Windhager F, Salisu S, Leitner A, et al. Many Views Are Not Enough: Designing for Synoptic Insights in Cultural Collections[J]. Digital Humanities Quarterly, 2017, 11(2)[2021-11-26]. http://www.digitalhumanities.org/dhq/vol/11/2/000290/000290.html.

[21] Gortana F, Vontemps P, Guhlmann D, et al. Off the Grid: Visualizing a Numismatic Collection as Dynamic Piles and Streams[J]. Open Library of Humanities, 2018, 4(2): 30.

[22] Vane O. Timeline Design for Visualising Cultural Heritage Data[D]. London: Royal College of Art, 2020.

[23] Bludau J, Dork M, Heidmann F. Relational Perspectives as Situated Visualizations of Art Collections[EB/OL]. [2021-06-20]. https://dev.clariah.nl/files/dh2019/boa/0445.html.

[24] Jünginger P, Ostendorf D, Vissirini B A, et al. The Close-Up Cloud: Visualizing Details of Image Collections in Dynamic Overviews[J]. International Journal for Digital Art History, 2020(5): 6.2-6.13.

[25] Arnold T, Ayers N, Madron J, et al. Visualizing a Large Spatiotemporal Collection of Historic Photography with a Generous Interface[C]//2020 IEEE 5th Workshop on Visualization for the Digital Humanities. Salt Lake City: IEEE, 2020: 30-35.

[26] Hochman M, Manovich L. A View from Above: Exploratory Visualizations of the Thomas Walther Collection[EB/OL]. [2021-05-12]. https://www.moma.org/interactives/objectphoto/assets/essays/Manovich_{Hochman}.pdf.

[27] Miksch S, Aigner W. A Matter of Time: Applying a Data-Users-Tasks Design Triangle to Visual Analytics of Time-Oriented Data[J]. Computers & Graphics, 2014, 38: 286-290.

[28] Latif S, Chen S, Bech F. A Deeper Understanding of Visualization-Text Interplay in Geographic Data-Driven Stories[J]. Computer Graphics Forum, 2021, 40(3): 311-322.

[29] Windhager F, Federico P, Schroeder G, et al. Visualization of Cultural Heritage Collection Data: State of the Art and Future Challenges[J]. IEEE Transactions on Visualization and Computer Graphics, 2018, 25(6): 2311-2330.

[30] Hinchcliffe G, Whitelaw M. Colouring Digital Collections: Challenges and Opportunities for the Use of Colour Metadata in Digital Collections[C]//Museums and the Web in Asia 2015. Melbourne: Museums and the Web LLC, 2015: 1-8.

[31] Ren Lei, Du Yi, Ma Shuai, et al. A Survey of Big Data Visual Analytics[J]. Journal of Software, 2014, 25(9): 1909-1936.

[32] Shneiderman B. The Eyes Have It: A Task by Data Type Taxonomy for Information Visualizations[C]//Proceedings of the 1996 IEEE Symposium on

Visual Languages. IEEE, 1996: 336-343.

[33] Pike W A, Stasko J, Chang R, et al. The Science of Interaction[J]. Information Visualization, 2009, 8(4): 263-274.

[34] Dork M, Pietsch C, Credico G. One View Is Not Enough: High-Level Visualizations of a Large Cultural Collection[J]. Information Design Journal, 2017, 23(1): 39-47.

[35] Qiu Weiyun. On the Meaning and Value of Visualized Data in Digital Humanities Research—Taking Digital Conceptual History Research as an Example[J]. Literary Theory and Criticism, 2020(2): 23-30.

[36] Hu Yuerong, Ma Qing, Liu Jiapai, et al. Analysis of "Distant Visual Reading" in the Context of Digital Humanities[J]. Library Tribune, 2017, 37(2): 1-9.

[37] Wang Haizhi. Research on the Application of Visualized Narrative in Data Journalism[J]. Media, 2021(1): 39-41.

[38] Bludau J, Dork M, Heidmann F. Relational Perspectives as Situated Visualizations of Art Collections[J]. Digital Scholarship in the Humanities, 2021, 36(S2): ii17-ii29.

[39] Windhager F, Salisu S, Schroeder G, et al. Uncertainty of What and for Whom—and Does Anyone Care? Propositions for Cultural Collection Visualization[C]//2019 IEEE 4th Workshop on Visualization for the Digital Humanities. Vancouver: IEEE, 2019: 1-5.

Author Contributions

Hou Xilong: Conceived the research idea, designed the survey scheme, and wrote the paper.
Wang Xiaoguang: Proposed the research questions and provided theoretical guidance.
Duan Qingyu: Conducted case investigations and revised the paper.

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