Technology framework and application scenarios on Digital Humanities research

Li Tianshuo[1][2] and Zhang Dongrong[1][2]

[1] National Science Library, Chinese Academy of Sciences，Beijing 100190, China
[2] Department of Information Resource Management, School of Economics and Management, University of Chinese Academy of Sciences，Beijing 100190，China
zhangdr@mail.las.ac.cn

Abstract. Digital technology is an important driving force for Digital Humanities （DH） research. Along with the iterative innovation of technology, more and more new technologies are being applied in DH projects. Based on the process of DH discipline and the use of technology in domestic DH projects, we sort out the framework of DH technology in China and combines it with typical cases to summarize the application scenarios of DH technology. We adopt the methods such as literature research, online research and analysis of typical cases to investigate the theoretical and practical achievements of DH technology classification at home and abroad, as well as the status of DH projects in China. We construct the framework of DH technology, and to discuss the use of DH technology in different application scenarios. Based on the disciplinary process of DH, a DH technology framework is constructed, which includes three types of DH technology, namely, Material Class, Analytical Class, and Presentation Class. Based on the service content realized by DH technology, it is classified into three types of application scenarios, namely, Infrastructure, Analysis and Research, and Interactive Presentation. The study further combines the practical experience of typical DH projects and platform construction practices in China to provide suggestions for improving the compatibility of technology and DH projects.

Keywords: Digital Humanities, Technology framework, Tools, Application scenarios, Compatibility.

1   Background of the study

The origins of Digital Humanities (DH) can be traced back to the computerized indexing of Thomas Aquinas's writings created by Jesuit Roberto Busa in collaboration with IBM in the late 1940s. Since then, archaeologists, historians, classical scholars, literary researchers, and others have also begun to use computers to automate searching, sorting, counting, and other tasks. The shift in terminology from "Humanities Computing" to " Digital Humanities " began with the anthology A Companion to Digital Humanities, edited by John Unsworth, Susan Schreibman, and Ray Siemens, which seeks to emphasize that the field is not "just digital" and proposes a new notion of " Digital Humanities ", which creates two overlapping fields, namely "the study of digital objects

through modern humanities methods" and "the study of digital objects through modern humanities methods". This creates two overlapping fields, namely "modern humanities approaches to the study of digital objects" and "information technology approaches to the study of traditional humanities issues" [1]. DH is a collection of new methods and tools for humanities research, i.e., a "methodological community", in which the basic materials on which traditional humanities research is based have changed drastically in form, as have the tools and means for handling them [2]. DH to digital technology and digital resources as the two starting points, digital technology is applied to DH from resource collection to analysis and processing, and then to the sharing of the presentation of the discipline process; digital resources cover the material, intangible and cultural memory and other types of DH resources, DH research can be understood as the evolution of the iterative innovation of digital technology, and DH resources to enrich the expansion of the process. However, the construction of digital resources also relies heavily on the processing capacity of digital technology. Taking textual resources as an example, from early image scanning to optical character recognition technology (OCR), to machine-readable based on ontology and Linked Data technology, the intrinsic information and knowledge of digital resources have been developed and utilized at a deeper level with the advancement of digital technology. At the same time, the progress of digital technology also enables more accurate and complete digital preservation of more complex humanities resources, such as 3D modelling of cultural relics and the construction of the "Digital Dunhuang" resource base. Therefore, DH technology is the fundamental driving force for DH to depart from the traditional humanities research paradigm.

With the flourishing development of DH globally, DH centers have been established in various countries and regions, and DH projects are thematically diverse and colorful. DH technology is increasingly beyond the application scene of academic research, and shines in social and cultural services. However, there is no systematic categorization of DH technology in China, and DH technology has not been considered in combination with its application scenarios. This study constructs a framework of DH technology in China, which is divided into three types of DH technology, namely, Material Class, Analytical Class, and Presentation Class, according to the disciplinary process of DH; and is divided into three types of application scenarios, namely, Infrastructure, Analysis and Research, and Interactive Presentation, according to the content of services realized by DH technology. Discussing the use of DH technologies in different application scenarios improves the adaptability of technologies and DH programs, which contributes to the high quality of DH programs and the enrichment and improvement of the disciplinary methodology system.

2   Conceptualization

2.1   DH Technology, Methods, and Tools

DH technology, method and tool all refer to the series of modern information technologies on which DH research is based, and all three essentially mean the same thing, but there are differences at the semantic level and in national academic contexts. DH

Technology focuses on the examination of technological innovations, how they are applied to DH research and their impact; DH Method focuses on macroscopic abstraction and generalization, aggregating digital technological routes of humanities research into a community, constituting the methodological system of DH; and DH Tool points to specific software programs or service platforms.

DH Technology

China took the lead in discussing the construction of DH technology system. Liu Wei points out that the technical system of DH mainly includes six categories of Digital technology, Data Management Technology and Data Analysis Technology, Visualization Technology, VR/AR Technology, and Machine learning technology [3]; with the in-depth development of the practice of DH, Liu Wei examines DH technology at the micro level, including Text Analysis, Content Analysis and Mining, Spatial-temporal Analysis, Social Relationship Analysis, Entity Recognition and other specific technology applications [4, 5]. Foreign countries do not classify from the perspective of technology, but pay attention to the role of specific types of digital technology in humanities research, such as Giovanni Antonio Cignoni pointed out that virtual reality technology can simulate the establishment of virtual replicas for the future of the museum, three-dimensional visualization technology can make the audience more immersive in close contact [6]. The impact of digital technologies on the humanities is also discussed at a macro level, including the tension between data analysis and traditional humanities research, the advantages and disadvantages of online resources, and the unrealized potential of humanities software tools [7].

DH Method

The DH approach comes from foreign definitions of the concept of DH. Unsworth, the most recognized definition of DH in the academic world, proposed the conceptual framework of "academic fundamentals" in 2000, namely discovery, annotation, comparison, reference, sampling, description, and performance [8]. Unsworth's " academic fundamentals " considers the methods used in the DH as essential elements of humanities scholarship done digitally, DH is the methods traditionally used in humanities research presented in a form based on computer technology. Therefore, DH methods can also be understood as digital methods in humanities research. This conceptual definition of the discipline based on research methods has laid the foundation for the construction of the methodological system of DH at home and abroad. 2002, Harold Short and Willard McCarty of the Centre for Computing in the Humanities (CCH) at King's College London put the simulation of DH into practice. The process of humanities research has been articulated as a "Methodological Common" (see Figure 1) [9], which brings together cross-disciplinary disciplines and the applications they use to form a meta-framework for DH methods. On this basis, Liu Wei points out that methodology is the specific methodology for engaging in DH research, including Text Analysis, Content Analysis and Mining, Spatio-temporal Analysis, Social Relationship Analysis, Machine Learning and other technical methods [4].
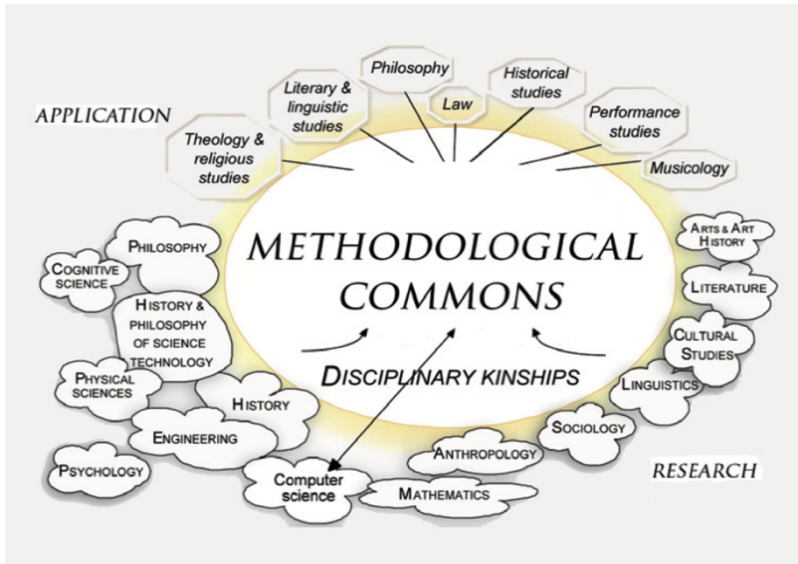
Fig. 1. Schematic diagram of the methodological commons[9].

DH Tools

The semantic pointing of DH tools is more micro, favoring specific software programs used in DH research. For example, Zhou Qianhao and Dai Zevanadium designed and implemented the inBooks DH tool based on the Shanghai Library's open data WeChat applet; Chih-Ming Chen and Szu-Yu Ho developed the Hierarchical Thematic Analysis Tool HTAT based on Hierarchical Latent Dirichlet Distribution (hLDA) to support DH research [10]; Tonguc Ibrahim Sezen and Digdem Sezen use Voyant, an open-source, web-based text analysis and visualization tool, to explore indicators of how players critically approach and discuss game narrative design [11]. There are also a few macro-theoretical comparisons and categorizations of DH tools, including John Bradley's categorization of tools into tools for making, tools for exploring, and tools for thinking, based on "how tools help us to deal with things in the world" [12], and Alan Liu's construction of a categorization index of DH Tools (see 3.3 for more details) [13].

In general, the commonality between technology, method and tool is greater than the difference, to buttress the domestic academic context, this paper unifies the three into the concept of DH technology.

2.2   Application Scenarios and Adaptability

The application scenario examines what kind of service content DH technology has achieved. From the definition of DH, as a basic element of humanities academics, DH has the functional attribute of serving humanities research; and from a more macroscopic sense humanities has the value function of promoting the development of human

body and mind and guiding the construction of culture [14], therefore, DH technology also has the task of serving humanities research and national cultural construction, and the application scenarios of DH technology are also enlarged from digital preservation of humanities materials, data analysis to visual presentation of our excellent traditional culture and interactive experience. The application scenes of DH technology have also expanded from digital preservation and data analysis of humanities materials to visual presentation and interactive experience of China's outstanding traditional culture.

However, the relationship between DH technology and its application scenes is not one-to-one correspondence, a DH technology may be applied to a variety of scenes, and an application scene can include a variety of types of DH technology, so it is necessary to discuss the suitability of technology and DH projects. Practice is the only standard to test the truth, this paper absorbs the experience of typical DH projects and platform construction in China and provides references for improving the adaptability of technology and DH projects from the aspects of resources, scale and users.

3   Theoretical and Practical Outcomes of DH Technology Classification

3.1   DH Technology System Construction

In 2016, Xiang Yang firstly proposed from the perspective of library DH construction paths that virtual reality, Linked Data and "Internet+" technologies are inherent boosts for library DH construction. Subsequently, domestic research has focused on the application of technologies including Mobile Visual Search [15], Application Programming Interface (API) [16], 3D Printing [17], Augmented Reality (AR) [18], Artificial Intelligence Text Generation (GPT) [19] Subject Modelling (LDA) [20], and so on, in DH research. Unlike the application research of a single technology, DH scholars in Shanghai libraries have taken the lead in discussing the technological system of DH and have achieved a series of theoretical results. In 2017, Liu Wei classified DH technologies into six categories [3] and refined, adjusted, and perfected them in the subsequent research [5] (see Table 1). Xia Cuijuan, Zhang Lei et al. aggregated DH technologies into three major categories of Knowledge Organization, Data Storage, and Knowledge Services from the perspective of library knowledge services and constructed a technical framework for DH projects in libraries [21]. From this, we can not only see the refinement and advancement of DH technology with the times, but also see the attempt to generalize and integrate DH technology, however, the current classification system has not yet cleaned and defined the classification hierarchy, and there are also unclear technical definitions and overlapping and intersecting problems to be further solved.

Table 1. A Series of Explorations on Building Digital Humanities Technology System in Shanghai Library.

Number	Author	First class

1	Liu Wei Ye Ying [3]	Digitization Technology Data Management Technology Data Analytics Visualization technologies VR/AR Technology Machine Learning Technologies
2	Liu Wei Liu Yue-Nan, etc. [5]	Text Statistics Content Analysis Natural Language Processing Image Analysis Social Relationship Analysis Visualization
3	Xia Cuijuan Zhang Lei He Chenzhi [21]	Knowledge Reorganization Data Storage Knowledge Services

3.2   Classifying Practices in DH Methods

Classification of Digital Methods in Humanities Research

In 2003, the ICT Methods Taxonomy was developed by the Arts and Humanities Data Service (AHDS) in the UK, which classifies digital resources as Text, Images, Audiovisual Data, Datasets or Structured Data, and DH processes as Acquisition, Structuring and Enhancement, Analysis, Publication, and Presentation [22].The Oxford University DH Programme refined it of a three-tiered structure: firstly, seven high-level categories: Communication and Collaboration, Data analysis, Data Capture, Data Publication and Dissemination, Data Structuring and Enhancement, Practice-orientation, and Data Dissemination. Each high-level category has several secondary and tertiary sub-levels, e.g. "data analysis" includes the following secondary levels: Audiovisual analysis, Statistical analysis, Textual analysis, Visualization, etc., with "textual analysis" comprising the following sub-levels Text Analysis" includes three levels: Collation, Assembling, Content Analysis, Indexing, Parsing, etc. [23]. Subsequently, the Digital Research Infrastructure for the Arts and Humanities (DARIAH) in Europe and its German branch and the Bamboo Digital Research Tools project in the USA (Bamboo Digital Research Tools wiki, BambooDiRT) have adopted the concept of methodological taxonomies, resulting in the *Taxonomy of Digital Research Activities in the Humanities* [24] (TaDiRAH), and the current level 1 of the Taxonomy categories are shown in Figure 2.

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Research activities
1   Capture                 4   Analysis              7   Dissemination
    conversion                  content analysis          collaboration
    data recognition            network analysis          commenting
    discovering                 relational analysis       communicating
    gathering                   spatial analysis          crowdsourcing
    imaging                     structural analysis       publishing
    recording                   stylistic analysis        sharing
    transcription               visualization

2   Creation                5   Interpretation
    designing                   contextualizing
    programming                 modeling
    web development             theorizing
    writing

3   Enrichment              6   Storage
    annotating                  archiving
    cleanup                     identifying
    editing                     organizing
                                preservation
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Fig. 2. Level 1 categories of Taxonomy of Digital Research Activities in the Humanities[24].

The classification of DH technology from the perspective of digital methods for humanities research in foreign countries has achieved rich practical results, and in summary, it has the following two characteristics: firstly, it is classified according to the hierarchy, i.e., DH technologies with similar functions are aggregated into a high-level category, and the secondary and even tertiary categories under it cover a rich variety of specific technologies; Secondly, the advanced category of DH is generally divided according to the disciplinary process of DH from resource collection to structuring, and then to analyzing, processing and sharing and presenting, which provides valuable references for the construction of China's DH technology system.

Methodological classification of DH teaching materials

In recent years there has been a succession of textbooks in the DH that have enriched the field of technology not yet covered by earlier classifications of digital methods in humanities research. The *Research Methods for the Digital Humanities* [25] can be divided into four sections: 'Analysis' " introduces computational approaches to data for dealing with large amounts of text; "Ethnography" teaches the use of digital tools to get more and better data; "Representation" presents examples of typical technologies such as gamification, virtual reality, programming languages, etc. Archives" teaches techniques for preserving, sharing, and using digital resources. The *Digital Humanities Coursebook An Introduction to Digital Methods for Research and Scholarship* (hereinafter referred to as the "Handbook") [26] builds a framework of disciplinary connotations based on the linear continuum of disciplinary processes in the DH, which includes the concepts of material, processing, and presentation. "Material" is the conversion of original humanities resources into machine-readable and computationally processable data through scanning, restoration, modelling, and other activities, including

digitization and datafication techniques; "Processing" is the use of digital technologies, methods, or tools to analyze acquired data, including metadata, database design, and information visualization. data, database design, information visualization, data mining and analysis, and geographic information systems (GIS); and "Presentation", i.e. the presentation of DH research results through the web and other means to meet user needs, including 3D modelling, virtual reality, human-computer interaction interfaces, web presentation formats and online platforms, data sharing and intellectual property rights. The *Introduction to DH Enhancing Scholarship with the Use of Technology* [27] emphasizes that regardless of the type of resource, its treatment undergoes two main processes: digitization of materials and construction of datasets. Following on from the previous practice of classifying DH technologies, DH textbooks have developed a common DH technology system, which is divided into three categories of technologies: Resource Acquisition, Analysis and Processing, and Presentation, according to the DH process, and supplemented with case studies on the latest advances in DH technologies.

3.3   Classification Practices for DH Tools

One of the most significant contributions to the field of DH tool categorization has been the integration of the DH Tools website constructed by Alan Liu, who has grouped hundreds of DH tools into 23 categories of Visualization Tools, Thematic Modelling Tools, Textual Analysis Tools, Text Coding Tools, Social Network Analysis Tools, Video and Film Analysis Tools, and Crowdsourcing Tools, as well as providing links to the specific software or program that A wizard is provided for the selection and use of DH tools. Figure 3 illustrates the secondary categories and commonly used software programs under the broad category of Visualization Tools [13].

Table 2. Hierarchy of Digital Humanities Classification Visualization Tools, Alan Liu.

Visualization tools	General purpose or multi-purpose presentation tools	D3.js
		Gephi
	Chart and graphic tools Graphic tools	Pixlar
	Infographics tools	yED
	Web visualization tools	aiSee
	Text visualization tools	GIMP
	Timeline Tools	Pixlr
	Twitter Visualization Tools	Dorling
	General purpose or multi-purpose presentation tools	PinWords
	Chart and graphic tools	D3.js
	Graphic tools	Gephi
	Infographics tools Web visualization tools	Textexture
	Text visualization tools Timeline Tools	ChronoZoom

Twitter Visualization Tools	TAGSExplorer
	TweetsMap

This paper synthesizes the research results at home and abroad, adopts the expressions of Material Class, Analytical Class, and Presentation Class as the first-level categories of the DH technology framework, and supplements the second-level categories and even the specific tools according to the progress of the practice of China's DH projects, so as to construct China's DH technology framework.

4   Construction of DH Technology Framework and Analysis of Application Scenarios

Currently, the DH projects carried out by domestic universities and libraries have the highest degree of completion, but at the same time, experimental DH research published as academic papers is also enriching and expanding the DH technology system. This paper firstly researches the resources, technology usage and service contents of 28 typical DH projects of 28 DH projects of 7 institutions, including the National Library of China, Shanghai Library, Digital Humanities Research Centre of Peking University, Digital Humanities Research Centre of Wuhan University, etc., and applies the typical case study method to select the DH projects with different technical structures, service contents and development institutions based on the principles of diversity, difference and representativeness. Using the typical case analysis method, and based on the principles of diversity, difference, and representativeness, we focus on selecting DH projects with different technical structures, service contents and development institutions for case analysis, and then summarize the three types of application scenarios of DH technology, and on this basis, we construct a DH technology system of our China with the DH technology exploration results of the academic papers as a supplement.

4.1   Application Scenario

Through literature research and network research, it is not difficult to find that the number of DH technologies are numerous and varied, but no matter what kind of technology will eventually be put into certain application scenarios, and the use of technology under the same application scenarios generally has commonality, which provides a useful starting point for carrying out the classification of DH technologies. Therefore, it may be worthwhile to firstly look at the differences in the use of DH technologies under different application scenarios, which will help to construct the DH technology framework in a more comprehensive and complete way. Based on the case study of domestic DH projects, this paper divides three types of DH technology application scenarios, namely, Infrastructure, Analysis and Research, and Interactive Presentation, in accordance with the service content realized by DH technology. It is worth noting that to better meet the needs of users, a DH project may include a variety of application scenarios at the same time, and the typical cases selected below are all analyzed in terms of their core functional application scenarios.

Infrastructure

Infrastructure, i.e. the scene where DH technology is applied to the preservation, organization, retrieval and presentation of humanities resources, which is the basis for DH projects to further carry out analysis and research and even interactive presentation, is the service content achieved by most of DH projects in China at present, among which the "Chinese Ancient Books Resource Bank" developed by the National Library of China is the representative. Among them, the Chinese Ancient Books Resource Bank developed by the National Library of China is the representative. The resources of the Chinese ancient books resource base are diversified and large in scale, but the application of technology shows a simple linear structure around the resources, including Resource Digitization, Structural Database Construction and Digital Resource Presentation of four types of technology (see Table 3 for details) [28]. Other DH projects dominated by such application scenarios include "Yongle Grand Dictionary (the first series)" [29], "Dunhuang mural paintings thematic thesaurus" [30], "Song and Yuan academic case knowledge map "[31], "Humanities Data Platform of Fudan University" [32], etc., and at the technical level, it also includes digital resource organization techniques such as Linked Data and Knowledge Mapping.

Analysis

Analytical research is the scenario in which DH technology is applied to the analysis of humanities resources. If DH is regarded as humanities research in the digital environment, then the analysis and research category is transformed from the traditional humanities using the human brain's judgement and discernment to the application of computer algorithms for statistical analysis. Shanghai Library's "History and Humanities Big Data Platform-Text Analysis Toolkit" (hereinafter referred to as "Shangtu" DH Toolkit) provides more comprehensive analysis services. The "Shangtu DH Toolkit" covers eight text analysis research techniques: Text Comparison, Entity Relationship Display, Context Analysis, Automatic Summary, Style Analysis, Word Frequency Analysis, Sentiment Analysis, and Topic Model (see Table 3 for details) [33]. Currently, there are other DH projects focusing on such application scenarios, such as "Wuyudian Intelligent Processing System for Ancient Books " (hereinafter referred to as " Wuyudian " system) [34], "East China Normal University DH Research Support Platform" [35] and so on. Because most of the current analysis and research application scenarios are in the form of open-source analysis toolsets, the results of the use of DH technology lack of practical verification, and the experimental DH research results published in academic papers precisely to make up for the gaps in this regard, such as Ouyang Jian using mathematical statistics to quantitatively analyze historical data, and the study of Song-Liao, Song-Jin relations as an example, through the self-constructed ancient books real-time By using the word frequency analysis tool of the independently constructed real-time statistical analysis platform for ancient books, he quantitatively analyzed the words "war" and "peace" in the literature of the Song Dynasty and came to the conclusion that peace was the main topic of discussion [36], which verified the effectiveness of DH technology in serving humanities research.

Interactive Presentation

Interactive Presentation is the use of DH techniques in the presentation of research findings. In the previous case study, it is not difficult to find that "Presentation" is a DH technology widely used in any application scenario. Whether it is digital resource access, or digital resource analysis, only by presenting the resources and the results of the analysis, can we further obtain valuable conclusions and achieve the content of user services. However, this "Presentation" is a simple correspondence, such as a resource or a data table corresponds to a form of visual presentation, which is one-dimensional or two-dimensional; while the Interactive Presentation on the one hand, will be time, space, events, quantities, character relationships, and other information in more than two dimensions, "interactive" in the same plane; on the other hand, it also attaches importance to the "interaction" of multidimensional information with the user's visual and auditory perceptions. In the interactive presentation of multidimensional information, "Zhu Zi Annals Visualization System" is representative, the system has been Zhu Xi Annals of the long series of knowledge reconstruction as the goal, the time, space, characters and events of the four dimensions of the information integrated in a map presented (see Table 3) [37]; in the multidimensional user perception, the Shanghai Library East Museum of Art In terms of multidimensional user perception, the " Spiritual Realm and Stone Language - Stele and Poster Architecture VR Immersive Experience Exhibition Project" of Shanghai Library's East Building has a pioneering nature, which is an exploratory attempt to combine multidimensional historical information with users' real experience [38].

Table 3. Digital Humanities Technology Application Scenarios Typical Case Study Form.

Application Scenario	Project	Resource	Technology Utilization	Service Content
Infrastructure	National Digital Library of China: Chinese Ancient Books Resource Bank	The National Library has a collection of good books and ordinary ancient books, oracle bones, Dunhuang documents, tablets and posters with topographies, Xixia documents, Zhao Cheng Jin Collection, local chronicles, genealogies, annual paintings, old photographs, etc., as well as a total of about	Digitization of resources	Readers can view full-text images, support single library search and multi-library search, basic search, and advanced search, support fuzzy search, compatible with both PC and mobile. And it can realize page-by-page reading of digital resources.
			Structural Database Construction	
			Resource Browsing	

		100,000 resources collected from outside the library and overseas.		
Analysis	Shangtu DH Toolkit	Open source, users can import digital resources that meet the system format specification for analysis according to research needs.	Text Comparison	The Shanghai Library Digital Humanities Toolkit aims to support humanities researchers to conveniently use a variety of tools serving digital humanities research to extract, analyze, compute, and visualize knowledge content, and to facilitate digital humanities research in multiple disciplines such as linguistics, history, and literature.
			Entity Relationship Display	
			Contextual Analysis	
			Automatic summarization	
			Text Style Analysis	
			Word Frequency Analysis	
			Sentiment Analysis	
			Topic Modeling	
Interactive Presentation	Digital Humanities Research Centre of Peking University -Zhu Zi Annals Visualization System	The Annals of Zhu Zi, written by Yuan Zhongxi in the Song Dynasty, consists of one volume	Digitization of resources	In the context of the digital era, to facilitate readers to quickly sort out the logic of the genealogy of events, this project on Zhu Xi's annals of the knowledge reconstruction, the use of GIS technology on the genealogy of the events of the spatial and temporal visualization of the presentation, the realization of the "chronicle" and the "system of the land" co-exist.
			Structural Database Construction	
			Geographic Information System (GIS)	
	Shanghai Library: Spiritual Realm and Stone	Jucheng Palace Liquan Inscription, City God Temple Stele,	Digitization of resources	The story of the inscription is restored to a virtual scene in the style of Chinese

	Language - Stele and Poster Architecture VR Immersive Experience Exhibition Project	Longzang Temple Stele, three works of calligraphy and posters	Virtual reality	green and blue landscapes, telling the story of the "spring", "seeking rain" and "pointing colors" related to the three inscriptions.

From the three types of DH technology application scenarios can be summed up the following conclusions: first of all, no matter which application scenarios are inseparable from the resource digitization technology, at present China's infrastructure DH projects account for the majority of the project, which lays a good foundation for the subsequent analysis and research; secondly, different application scenarios under the application of the technology use of obvious differences, which will help to comprehensively review the application of DH technology; finally, the organic combination of DH resources, technology and services constitute the DH project as a whole.

4.2   Technical framework

Based on the results of the classification of DH technology and the domestic DH practice, this paper constructs a framework of DH technology based on disciplinary process. Looking back to the DH concept of "traditional humanities research using methods presented in the form of computer-based technology", DH research with the support of digital technology successively includes the collection, analysis, and presentation of digital resources. This framework integrates domestic and international research results, and divides DH technology into Material Class, Analytical Class, and Presentation Class at the highest level; the three categories of technology include several subcategories, and the following typical technologies within each category are selected as explanatory notes (see Table 4).

Table 4. Technical framework for digital humanities.

categorization	technical level			Tools/systems/platforms
Material Class	Digitization Technology	Digitization of Resources	Graphic Scanning	Photo Scan[39]
			3D Laser Scanning	VIUscan[39]
			3D Modeling	3ds Max 、Untiy3D、MicroStation[39, 40]
			Audio/Video Digitizing	

		Textualization of resources	Optical Character Recognition		Baidu OCR[41] 、 "Shangtu" DH Toolkit
	Dativization technology	Structural database construction			Structural Databases
					Metadata retrieval/navigation
		Relational database construction	Cleaning	Automatic Word Segmentation	Jieba[42]、 Shangtu DH Toolkit
				Automatic sentence reading	
				Entity Recognition	
				Entity relationship annotation	
			Modeling		Protégé[43]
			Storing	RDF databases	RDF4J[44]
				graph database	Neo4j[45]、JanusGraph[46]
			Retrieving		semantic retrieval
Analytical Class	data analysis				pandas、numpy[47]
	text analysis	Word Frequency Analysis			"Shangtu" DH Toolkit、Literature traceability analysis platform [48]
		Sentence reuse analysis			
		Book/Catalog Analysis			
		Text Comparison			
		Discourse Analysis			Wmatrix、CLAWS、USAS[49]
		Sentiment Analysis			SnowNLP[42]
		Theme Analysis			LDA[42]HATA[10]
	spatio-temporal analysis	Geographic Information Systems (GIS)			Google Maps、Gephi、Palladio 、ArcGIS[50, 51]
	relationship analysis	Character Analysis Network			Pajek[52]
		Character Relationship Network			ERGM[53]
		Text Association Network			stylometric R package stylo[51]Voyant[11]
		Cultural Theme Network			EDA[47]
Presentation Class	Resource Presentation	Resource Browsing			PDF
		Interactive Experience			QuickTime[40]
	analyze and present	Data Visualization			D3.js、Echarts、Pyvis[35]
		Spatio-Temporal Visualization			Google Maps、Gephi、Palladio 、ArcGIS[50, 51]

		Relationship Visualization	"Shangtu" DH Toolkit

Material Class

Material technology is the technology used in the process of collecting and preserving DH resources, which can be firstly divided into two categories: digital technology and data technology. Digital technology transforms humanities resources from their original form into digital pictures, audio and video, three-dimensional models, etc., for long-term preservation and sharing and communication, which is the origin of DH research. However, even if the DH resources are converted into textual information through optical character recognition, it is still a conversion of the media form of humanities resources. With the iteration and innovation of information technology, computers can dig deeper into the intrinsic knowledge of humanities resources and realize the semantic correlation of the resources. Humanities resources that are only converted into digital form can be preserved and retrieved through structural databases; while relational databases that can reveal the intrinsic knowledge of the resources need to be constructed by four types of DH tools: data cleaning, modelling, storage and retrieval.

Analytical Class

The Analytical Class is the technology of analyzing DH resources, that is, relying on the computer's "big" data processing ability, using quantitative research methods to discover and corroborate the phenomena and conclusions that have not yet been fully revealed by previous humanities research, and it is the backbone of DH research technology. Analytical Class technologies can be divided into four categories: Data Analysis, Text Analysis, Spatio-temporal Analysis, and Relational Analysis. Data analysis is the most basic, i.e. measuring and counting the information in the structural database; text analysis is based on the textual DH resources collected by material technology, and based on machine learning and natural language processing technology, automatic word division and entity recognition are carried out in turn, and then measuring and counting are carried out on the words and sentences in the text, and with the help of data visualization technology, the "big" text which is difficult to be noticed by the reading of the human brain is revealed. Spatio-temporal and relational analyses are also built based on entity annotation of DH resources, and are closely combined with the presentation technology, so that textual information, spatio-temporal information, entity-relationship information, and quantitative information of DH resources are aggregated and analyzed in the same plane.

Presentation Class

The last Presentation Class is the technology that shows the results of DH projects and serves the needs of users, including the presentation of resources and the presentation of analyses. Resource presentation technology is the DH resources to serve user needs in an intuitive, easy to access way, which includes most of the word library has been achieved by the online reading of literature resources such as resource browsing technology, but also with the help of virtual reality and other technologies to achieve

the interactive experience of technology, Mao Yinghao, Sun Zhenjia et al. on the storytelling of the open collection of resources to achieve the process of a detailed description of the [54]. In the analysis of the presentation, as mentioned earlier, the presentation technology is often integrated with the processing technology, such as geographic information system tools, including Google Maps, ArcGIS, "Shangtu" DH Toolkit, " Wuyudian" system have the function of presenting the analysis results. This reflects the trend of integration of DH technologies.

4.3   DH Technology Compatibility Options

Based on the DH technology framework and service scenarios constructed above, it is not difficult to find that a technology may be applied to many scenarios, and an application scenario can also include many types of technologies, so it is necessary to discuss the adaptability of DH technology and its application scenarios. Based on the typical DH projects and platform construction cases in China, drawing on the practical experience of typical cases, we provide reference from the perspective of resources, scale and users to improve the adaptability of DH technology and its application scenes.

Firstly, it is the principle of resource adaptability. DH resources can be divided into cultural heritage (cultural relics), intangible cultural heritage (oral literature, customs, rituals, etc.), and cultural memory (ancient books, photographs, paintings, etc.) from the macroscopic level; and the return to the original form of humanities resources can be divided into textual, cultural relics, and intangible categories. The number of DH projects with textual resources as the research object is the most right and mature, and the relatively basic textual research generally corresponds to the textualisation of resources, textual analysis and data visualisation in the three stages of the technological process, such as the high-definition image database of the "Yongle Grand Dictionary (the first series)"; further textual research will extract and visualize the spatial-temporal and relational information within the text, such as the "Song and Yuan academic case knowledge map". In contrast, at present, China's cultural relics, non-material resources of DH research projects are less, cultural relics category to Digital Dunhuang as a representative of the list of the theme of the word, the current technological process of the material category, including remote sensing and mapping and the construction of the relational database, in the presentation of the aspect of the online browsing and virtual reality technology, the lack of analysis of the technical practice; and the intangible resources of the DH project is almost a blank, yet to be Practical verification.

The second is the principle of scale appropriateness. In the technical framework, there are simple tools and platforms such as the"Shangtu" DH Toolkit, " Wuyudian" system, which are quick to get started, and include scanning and mapping, virtual reality, related database construction and other technologies that require large-scale manpower inputs and have a high threshold. Correspondingly, the scale of DH projects includes both large-scale DH service platforms built by libraries or DH centers in universities, as well as small-scale experimental DH research results published in academic papers. Therefore, the appropriate DH technology should be selected according to the scale of the research, including financial, human, and technical capabilities.

Finally, is the principle of user suitability. Regardless of the application scenario of DH projects, they should ultimately aim at serving users. Therefore, before carrying out a DH project, we should first focus on the needs of users. Scripture Palm - Chinese Dynasties Catalogue Analysis System follows the user-centered design idea and summarizes the two layers of needs of scholars' ancient book catalogue research through many exchanges with expert users [55]. With the economic and social development of China, the spiritual and cultural needs of the people are increasing day by day, and the DH project also pays more attention to the needs of the people while serving humanities research. Chinese genealogy knowledge service platform in the realization of genealogical literature bibliographic control of the basic functions, but also to meet the user from the limited known information based on the roots of the ancestors, and ultimately practice based on user-contributed content of the evolution of knowledge and other needs [56]. In such a context, the technology selection of DH projects should focus on the expected user needs of the project; projects serving humanities research should focus on the depth of user needs; projects invested in public cultural services should focus on the breadth and participation of users.

5   Conclusion

Based on literature research, network research and typical case analysis, this paper constructs the technical framework of DH and summarizes the application scenarios of DH technology and concludes the three suggestions to improve the adaptability of DH technology and DH projects. Although today's digital technology is changing rapidly, such as meta-universe, GPT and other technologies are not yet covered by the current technical framework, but based on the DH from resource collection to analysis and research, and then to the sharing and presentation of the discipline process of the division of the material class, processing class and presentation pattern is still stable, new DH technology will continue to be integrated into the framework. All in all, resources, technology, and services constitute the basic elements of a DH project, and DH technology is the core force, but only by integrating all three can we create a good project that inherits cultural resources, supports humanities research and meets public needs.

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