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Abstract

[Purpose/Significance] The mobile application of ancient books databases represents a transition from online versions to mobile versions. Currently, mobile applications for ancient books databases are in the initial development stage, necessitating an investigation into their present status to provide recommendations for their growth and development. [Method/Process] This study selects two categories of ancient books databases—those based on the WeChat platform and those with mobile phone clients—analyzes their operational models and primary functions, summarizes existing problems, and proposes recommendations. [Results/Conclusion] Current mobile applications of ancient books databases exhibit issues such as limited resource scale, monotonous data formats and content, incomplete platform and functionality construction, and insufficient user attention. The development of mobile applications for ancient books databases should further enhance platform construction, diversify data formats and increase quantity, optimize relevant functions, and emphasize communication and interaction with users.

Full Text

Preamble

ChinaXiv Cooperative Journal: Academic Exploration

Current Status and Development Strategies of Mobile Application Services for Ancient Books Databases

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Abstract

[Purpose/Significance] The mobile application of ancient books databases represents a transition from online versions to mobile platforms. Currently in its initial development stage, it is necessary to investigate the present situation and provide recommendations for its growth. **[Method/Process]** This study selected two types of ancient books databases—those based on the WeChat platform and those with mobile phone clients—to analyze their operational models and primary functions, summarize existing problems, and propose suggestions. **[Result/Conclusion]** The research reveals that current mobile applications of ancient books databases suffer from issues including small resource scale, monotonous data forms and content, incomplete platform and function construction, and insufficient user attention. The development of mobile applications for ancient books databases should focus on improving platform construction, enriching data forms and quantities, optimizing relevant functions, and emphasizing communication and interaction with users.

Keywords: ancient books database, mobile platform, digitization, WeChat

Classification Number: G250

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Introduction

The digitization of ancient books is a process that aims to preserve and disseminate traditional culture as its fundamental purpose and to serve academic research through knowledge discovery as its highest goal. Based on the collation and organization of traditional paper ancient books, it utilizes computer technology to convert them into digital information that is readable, searchable, and capable of semantic association and knowledge reorganization [1]. Ancient books databases, formed on the basis of ancient books digitization, represent an effective means and important approach for developing and utilizing ancient books information resources. Ancient books databases are diverse in type, and can be mainly divided into three categories by platform: (1) Online databases. These databases contain the largest volume of data and possess comprehensive retrieval systems, generally suitable for universities, research institutes, libraries, and other scientific institutions. However, their use is often restricted by network IP, platform limitations, and high usage fees, making them extremely inconvenient for users outside institutions or beyond IP address ranges. (2) Mobile client-based ancient books databases. These databases have independent mobile apps, are convenient to use, and allow users to access relevant materials anytime through mobile phones, tablets, and other mobile devices. However, platform construction and maintenance require substantial technical and financial support, resulting in high operational costs. (3) Ancient books databases based on third-party platforms, such as those relying on the WeChat platform.

As an instant messaging platform, WeChat occupies a large user base and covers most smartphones with its convenient and diverse functions. In addition to online ancient books databases, the latter two types rely on mobile platforms and are more convenient to use compared to online databases.

The users of ancient books databases are generally university faculty and students in relevant majors, researchers, or other users interested in ancient books. However, current ancient books databases are primarily online databases, usually purchased by institutions, and therefore subject to IP restrictions. Users can only access them within certain IP ranges, creating difficulties for a broader range of users. Mobile applications of ancient books databases can solve this problem, enabling users to break through IP range restrictions and access databases anytime, anywhere through mobile platforms such as smartphones. Therefore, it is necessary to study the current development status of mobile applications for ancient books databases to promote their popularization.

This study selected two ancient books databases based on the WeChat platform and two based on mobile apps to analyze the current status of mobile applications for ancient books databases, identify existing problems, and explore improvement measures.

1.1 Current Status of Academic Research

China's ancient books digitization started relatively late but has still achieved considerable accomplishments. Since the 1980s, various ancient books databases have continuously emerged, and research on ancient books digitization has remained a hot topic in academic circles. Currently, domestic research on ancient books databases primarily focuses on copyright issues [2], construction standards and evaluation [3], comparisons between different databases [4], database technologies [5], and literature reviews [6], with less involvement in research on mobile applications of ancient books databases. On April 20, 2017, the author conducted a subject search in three database platforms—CNKI, VIP, and Wanfang—using “ancient books database AND mobile” as search terms, obtaining 207 results. After removing duplicates and invalid results, 189 documents remained, covering multiple disciplines and including journal articles, dissertations, newspapers, and conference papers. Analysis of these 189 documents revealed that only 132 were directly related to ancient books. Among these 132 documents, most studied theoretical or technical issues related to ancient books digitization, with some addressing mobile media for ancient books digitization [7] or mobile reading of ancient books [8]. This demonstrates that research on mobile applications of ancient books databases is still in its initial stage.

1.2.1 WeChat Platform

Searching for public accounts on WeChat using “ancient books” as the keyword yielded 349 results. These public accounts mainly consist of industry-related ac-

counts (such as bookstores, publishers, libraries, and ancient books research institutes), ancient books reading accounts, and ancient books culture promotion accounts. Among these 349 public accounts, only two provide full-text retrieval and reading of ancient books: “Zhonghua Classic Ancient Books Database” and “Ancient Books Pavilion.”

1.2.2 Apple Store and Anzhi Market

iOS and Android are the two main operating systems for current smartphones and tablets, providing app downloads for iOS and Android systems respectively. Searching on these two platforms can reveal the development status of application software related to ancient books databases. Using “ancient books” as the search term on these platforms yielded 364 and 378 records respectively. These apps are primarily various ancient books reading apps that provide full-text reading of one or multiple ancient books without offering retrieval functions. Among the retrieved apps, only two have the nature of ancient books databases: “Traditional Chinese Medicine Ancient Books” app and “Shutongwen Ancient Books Database” app.

The above search results may have omissions, but they indicate that both academic research and software development of mobile applications for ancient books databases are in their initial stage.

2.1.1 Ancient Books Databases Based on WeChat Platform

(1) **Zhonghua Classic Ancient Books Database WeChat Version (hereinafter referred to as “Classic Ancient Books Database”).** The “Classic Ancient Books Database” is the first mobile Chinese ancient books database based on the WeChat client developed by Zhonghua Book Company, representing a pioneering initiative. The “Zhonghua Classic Ancient Books Database” originated from Zhonghua Book Company’s “Chinese Character Database Project” in 2003, marking the beginning of Zhonghua Book Company’s exploration into ancient books digitization [9]. The WeChat platform for the Zhonghua Classic Ancient Books Database developed on this basis is the first mobile Chinese ancient books database based on the WeChat client in China to date, representing a leapfrog attempt by Zhonghua Book Company to adapt to the major trend of mobile internet [9]. The database follows the classification standards of classics, history, masters, and collections, primarily collecting collated versions of classic ancient books published by Zhonghua Book Company over the years. Currently, 886 types of books are available for reading on the WeChat platform, and errors in the original books have been corrected during the digitization process, with quality and precision consistent with the mirror and online versions.

(2) **Ancient Books Pavilion Database (hereinafter referred to as “Ancient Books Pavilion”).** The construction of “Ancient Books Pavilion” references the 12th Five-Year Plan construction goals of Chinese libraries, aiming

to build a large-scale literature classics resource database that comprehensively reflects the circulation and preservation status of ancient Chinese documents, enabling one-stop retrieval. Its resources rely on various libraries nationwide. The entire project is expected to include more than 300,000 types of literature materials (different versions) published before 1949 (approximately 80 million images), totaling about 5 billion characters, to be completed in phases. Collected resources come from ancient books resources held by public, school, and research institution libraries and museums in Mainland China, Hong Kong, Macao, and Taiwan. The ancient books resources collected by “Ancient Books Pavilion” are rich and comprehensive, suitable for students majoring in history, Chinese language, classical literature, sociology, medicine, and ancient architecture engineering [10]. On this basis, the WeChat version of “Ancient Books Pavilion” was launched.

2.1.2 Ancient Books Databases Based on Mobile Apps

(1) Traditional Chinese Medicine Ancient Books. Since an app is often designed with different versions for different mobile operating systems, no distinction is made by system here. The Traditional Chinese Medicine Ancient Books app has processed traditional Chinese medicine ancient books through selection (selecting excellent book titles and versions), recognition (recognizing images and text in traditional Chinese medicine ancient books), collation (analyzing the catalogues and paragraphs of medical literature according to standards), indexing (conducting multi-level knowledge analysis and indexing of case content in medical literature), and thesaurus processing (final analysis, classification, merging, and editing of various diseases and attributes according to the scientific system structure of medicine classification, diseases, and symptoms), providing users with various retrieval methods including title search, full-text search, and author search. In addition to searching for traditional Chinese medicine ancient books, users can also search for traditional Chinese medicine cases and related prescriptions on the app, making it a practical single-discipline mobile database.

(2) Shutongwen Ancient Books Database. This database was developed by Beijing Shutongwen Digital Technology Co., Ltd. (hereinafter referred to as “Shutongwen Company”). Established on May 10, 2000, Shutongwen Company’s predecessor was Shutongwen Computer Technology Development Co., Ltd. and the Electronic Edition Engineering Center of the “Wenyuan Pavilion Siku Quanshu,” specializing in the digitalization of Chinese classic ancient books and historical documents, as well as the application research, production, and sales of Chinese character information technology processing [11]. The “Shutongwen Ancient Books Database” app is a mobile application developed by this company.

2.2 Operation Model

In daily use, the three ancient books databases “Traditional Chinese Medicine Ancient Books,” “Classic Ancient Books Database,” and “Ancient Books Pavilion” all adopt a “membership system,” where users pay a certain membership fee to purchase corresponding usage time and become database members, enjoying corresponding privileges and services such as different usage permissions and database usage duration. When “Ancient Books Database” and “Ancient Books Pavilion” were first launched, they both offered activities that granted free membership for a certain period by following relevant WeChat public accounts and introduced related preferential measures. Specific 收费标准见表 1 . “Shutongwen Ancient Books Database” adopts an application system, where users can select 5 out of 44 databases for trial after downloading the app, with a trial duration of 1 month.

Without purchasing corresponding membership, “Traditional Chinese Medicine Ancient Books,” “Classic Ancient Books Database,” and “Ancient Books Pavilion” all provide services at different levels. For example, the membership rights of “Classic Ancient Books Database” include: (1) unrestricted reading of all books in the “Zhonghua Classic Ancient Books Database”; (2) unlimited search results for effectively locating ancient books literature in the entire database; (3) convenient management of personal reading notes and reading history. Considering that many users with less intensive needs for ancient books are also following the “Classic Ancient Books Database,” only resources are restricted while other functions are currently freely available to non-members, including: (1) search—non-members can also retrieve all results and see the source and a relevant passage of the search results; (2) notes; (3) chronology conversion and dictionary. Paid members can read all books within the “Classic Ancient Books Database” during the validity period without word count limitations, and can also read full texts from search results and reading notes pages. Non-members can only read the first 300 characters of each book or the first 300 characters of each search result. This is currently the main difference between paid members and non-members.

2.3.1 Resource Retrieval

Retrieval is a basic function of databases. The four ancient books databases investigated in this study all provide retrieval services at different levels, as detailed in Table 2 . Different databases offer different retrieval pages and methods. For databases based on the WeChat platform, taking “Classic Ancient Books Database” as an example, there is a search box in the middle of the homepage where users can input retrieval content. Below the search box is a “Recent Hot Searches” section listing several keywords with high user search volumes; clicking on a keyword directly displays the search results. Retrieval methods mainly fall into three categories: (1) General retrieval, which includes full-text retrieval, book retrieval, and secondary retrieval. Full-text retrieval means the search results are all articles where the search term appears; book

retrieval means searching for books where the search term appears in the title; secondary retrieval means continuing the search within results, with results classified by full-text retrieval and book retrieval. (2) Advanced retrieval, which allows searching by article title, article content, book title, author, or publisher. (3) Ancient books library retrieval—clicking “Ancient Books Library” on the homepage enters the “Ancient Resources Classification” page, where searches can be conducted by five categories: “Classics, History, Masters, Collections, and Series.” For mobile app-type databases, taking “Traditional Chinese Medicine Ancient Books” as an example, as it is a specialized database containing a large amount of traditional Chinese medicine-related data, searching for “cold damage” in the search box can retrieve related ancient books, medical cases, prescriptions, and traditional Chinese medicine encyclopedia entries, demonstrating high practicality and specificity.

2.3.2 Resource Browsing

Among the four ancient books databases studied, “Traditional Chinese Medicine Ancient Books” and “Classic Ancient Books Database” provide text browsing interfaces for digitized ancient books, while “Ancient Books Pavilion” provides scanned images of ancient books without text reading. “Shutongwen Ancient Books Database” provides both resource forms, allowing users to choose between browsing scanned images of ancient books or digitized full texts according to their preferences. To enhance user reading experience, all four databases provide various personalized settings. For example, “Classic Ancient Books Database” allows users to select reading chapters through the table of contents during reading, choose font size to adjust text size anytime, and select day or night reading modes, making it more user-friendly. “Traditional Chinese Medicine Ancient Books” allows adjustment of reading progress, among other features. Additionally, “Ancient Books Pavilion” and “Classic Ancient Books Database” provide note-taking functions. For instance, the “Classic Ancient Books Database” homepage has a “My Notes” section where users can directly access previously made reading notes. When reading, users can select any content in the main text and click “Notes” in the lower right corner to make reading notes. A completed note page mainly consists of three parts: corresponding topic, original text content, and note content. The corresponding topic refers to the book title and chapter being read, the original text content refers to the content selected when making the note, and the note content is the reader’s own notes. After use, all four ancient books databases have history or browsing record sections that can save all search records and reading history since the user’s first use of the database. Users can directly select needed books for reading through history records or delete history records.

2.3.3 Other Functions

(1) Interactive Function. The WeChat platform itself has social attributes with instant chat functions; therefore, “Classic Ancient Books Database” and

“Ancient Books Pavilion” based on the WeChat platform both have real-time interactive functions with users. “Classic Ancient Books Database” is also specially equipped with customer service personnel “Xiao Ku” to answer user questions during use. Users can directly send messages to the ancient books customer service “Xiao Ku” on the public account homepage to consult questions.

(2) Online Dictionary. “Classic Ancient Books Database” provides a dictionary query function. Currently, the built-in online dictionary uses the Zhonghua Da Zidian and also provides search results for related characters [10]. Users can select text anytime during reading, click the three dots in the lower right corner to enter the online dictionary for queries, or directly access the online dictionary from the homepage. The online dictionary can query different meanings, sources, etc. of Chinese characters.

(3) Chronology Conversion. Since ancient times did not adopt the Gregorian calendar, this creates difficulties for user reading or research. Therefore, “Classic Ancient Books Database” provides a chronology conversion function, offering detailed chronological data from the Xia Dynasty to the late Qing Dynasty. Users can freely locate historical periods using keywords such as era names, Gregorian calendar years, or imperial temple names [9]. For example, using “Emperor Gaozu” as a search term, the search results will appear in table form, listing Gregorian calendar, sexagenary cycle, period, regime, imperial title, imperial name, era name, and year for user reference.

(4) Historical Message Query. As WeChat service accounts, “Classic Ancient Books Database” and “Ancient Books Pavilion” can push messages to users. Therefore, both have functions for querying historical messages. This function is named “Ancient Books Database Talk” in “Classic Ancient Books Database” and “Latest News” in “Ancient Books Pavilion.”

3.1 Small Resource Scale

Currently, domestic ancient books digitization has achieved tremendous accomplishments, with diverse types of ancient books databases. Most online ancient books databases have organized various ancient books resources and possess relatively large resource scales. For example, the “China Basic Ancient Books Database” includes 10,000 types of classics from pre-Qin to the Republic of China, 170,000 volumes, 12,500 versions, 200,000 volumes, 1.7 billion characters in full text, 12 million pages of images, with a total data volume of approximately 320GB. “Hantang Diancang” contains about 10,190 types of documents from oracle bone inscriptions to modern literature, approximately 12 million images, and over 1.5 billion characters [12]. Compared with online databases, the data volume of the four investigated databases is relatively small, as detailed in Table 3. For instance, “Classic Ancient Books Database” currently contains 1,135 types of books (102 Classics, 319 History, 452 Masters, 262 Collections), with a total text volume exceeding 600 million characters, but still relatively small in quantity compared with other online ancient books databases. The resources

of the ancient books database mainly come from various collated ancient books published by Zhonghua Book Company. Naturally, the data volume expanded by a single publisher cannot compare with China's vast sea of ancient books. When the author searched for the book "Analects" in the database, five results were obtained: (Qing) Zhao Zaihan's "Seven Wefts (with Analects Prophecies)," (Liang) Huang Kan's "Analects Commentary," (Qing) Kang Youwei's "Analects Notes," (Qing) Liu Baonan's "Analects Justice," and Cheng Shude's "Analects Collected Explanations." The "Analects" is a Confucian classic, with numerous commentaries throughout history, yet "Classic Ancient Books Database" only contains five types, without the original text of the "Analects."

3.2 Single Data Form and Content

In terms of data form, among the four ancient books databases investigated, only "Shutongwen Ancient Books Database" provides scanned images of ancient books, while the other three databases only provide digitized texts. Although text databases enable full-text retrieval and facilitate reader reading and querying, and compared with other data forms such as audio and images, they occupy smaller storage space and reduce server pressure, the shortcomings of text data are also quite obvious. On the one hand, as Chinese characters have developed multiple fonts during their evolution, and there are various writing forms such as interchangeable characters, traditional characters, and variant characters, digitization is not only difficult but also prone to errors. On the other hand, digitized ancient books lose their original collation value. In other words, text ancient books databases provide users with a completely new form that is entirely different from the original appearance of ancient books. Users must consult original ancient books if they need to study format, printing, annotations, seals, and other information [13]. Moreover, with the development of multimedia technology and changes in user reading habits, single text databases cannot meet users' demands for diversified data types. In terms of database content, "Traditional Chinese Medicine Ancient Books" is a specialized database that only includes traditional Chinese medicine ancient books. "Classic Ancient Books Database," developed by Zhonghua Book Company, only includes collated ancient books from Zhonghua Book Company. "Shutongwen Database" contains multiple sub-databases, but users can only select 5 databases when applying, thus significantly reducing the data volume. Among the four ancient books databases, only "Ancient Books Pavilion" includes resources in multiple forms, as detailed in Table 3.

3.3.1 User Interface Needs Optimization

User Interface (UI) refers to the overall design of software's human-computer interaction, operational logic, and interface aesthetics. Good UI design not only makes software personalized and tasteful but also makes software operation comfortable, simple, and free, fully reflecting the software's positioning and characteristics [14]. The user interface of "Shutongwen Ancient Books Database" is

monotonous and oppressive, lacking appeal. The homepage of “Ancient Books Pavilion” lacks navigation. Except for “Classic Ancient Books Database,” the other three databases cannot adjust font size and brightness in the reading interface. These shortcomings reduce user experience.

3.3.2 Retrieval Results Cannot Achieve Semantic Association

In ancient books, not only do characters have multiple fonts or writing forms, but words and phrases also exhibit phenomena of “one meaning with multiple words” or “one word with multiple meanings,” creating difficulties for user retrieval and greatly reducing precision and recall rates. Although the four ancient books databases provide various retrieval methods, they cannot perform semantic analysis on search terms during retrieval and can only mechanically search the database for results matching the search terms. This is not only a problem that needs to be solved in the mobile application of ancient books databases but also a challenge that needs to be overcome in the development and improvement of ancient books databases.

3.3.3 Some Functions Need Enhancement

For example, the online dictionary of “Classic Ancient Books Database” can only query single characters and cannot query multi-character words such as personal names, place names, proper nouns, or fixed phrases. Due to differences between classical Chinese and modern vernacular Chinese, readers encounter not only obstacles in recognizing simplified and traditional characters but also difficulties in understanding words and phrases when reading, which creates obstacles for users reading and understanding ancient books. Single-character queries are insufficient to help readers completely overcome such reading obstacles. Additionally, during the author’s use of the four ancient books databases, issues such as lagging, crashing, and unresponsive navigation were encountered, requiring each database to improve software and hardware levels according to their specific situations and continuously optimize platforms to enhance user experience.

3.3.4 Interaction Response Efficiency Needs Improvement

During the investigation, the author asked questions to “Classic Ancient Books Database” and “Ancient Books Pavilion,” but replies were slow. For example, when the author encountered a crash issue while using the “Notes” function and consulted “Xiao Ku,” although an answer was provided, the response time was long. The author sent consultation questions twice, and both times “Xiao Ku” replied after more than 10 hours. The response time for “Ancient Books Pavilion” was as long as 22 hours. This shows that although based on the WeChat platform, these two ancient books databases have not effectively utilized WeChat’s instant chat function to timely answer user questions. When consulting the online customer service of “Shutongwen Ancient Books Database,”

no reply was received for a long time.

3.4 Insufficient User Attention

Although “Traditional Chinese Medicine Ancient Books” and “Shutongwen Database” are independent mobile apps, both have opened related WeChat public accounts. WeChat public accounts are divided into subscription accounts and service accounts. “Traditional Chinese Medicine Ancient Books” and “Shutongwen Database” have opened subscription accounts that can send one message daily, displayed in the subscription account folder. “Classic Ancient Books Database” and “Ancient Books Pavilion,” relying on the WeChat public platform, have opened service accounts. WeChat public service accounts can send group messages four times per month and are directly displayed in users’ chat lists. Since the opening times of each ancient books database public account vary and their types differ, the data collection period for public accounts was limited to May 1, 2016, to April 30, 2017, to 统计最近 12 个月数据情况, with specific results shown in Table 4 .

From the perspective of opening time, “Shutongwen Ancient Books Database” and “Ancient Books Pavilion” opened earliest, while “Classic Ancient Books Database” was launched on April 23, 2016, with the first WeChat message released on April 27, 2016, making it relatively late. Pushing articles through WeChat public accounts is, on the one hand, a means for accounts to enhance their exposure, and on the other hand, can reflect user attention to some extent. After 统计一年的发文量, it was found that although “Classic Ancient Books Database” had the shortest opening time, it had the highest frequency of pushing messages within the allowed range, basically maintaining at least three messages per month. In contrast, “Ancient Books Pavilion,” with a similar nature, pushed less than one-third the number of messages, with only 12 articles in a year. Within one year, “Traditional Chinese Medicine Ancient Books” pushed messages almost daily, while “Shutongwen Ancient Books Database” only pushed 42 times, showing low publishing efficiency.

The number of reads of the first article can roughly reveal the preliminary publicity results of a public account. According to Hong Tao, Deputy General Manager of Gulian Digital Media Technology Co., Ltd., on the day of the launch of the WeChat version of “Classic Ancient Books Database” on April 23, there were more than 6,000 registered users, which increased to more than 12,000 registered users after about 10 days [15]. This shows that the actual number of users following the Classic Ancient Books Database WeChat public account is far greater than the number of article readers, indicating good preliminary publicity results.

To analyze the current user attention of each public account, the author selected articles from January 1, 2017, to April 30, 2017, and obtained article read counts, as shown in Table 5 . “Shutongwen Ancient Books Database” had the lowest read volume. “Classic Ancient Books Database” and “Ancient

Books Pavilion” had relatively high read volumes, with “Classic Ancient Books Database” showing smaller fluctuations in article read counts. Among the many articles, the announcement about the launch of the WeChat version pushed by “Ancient Books Pavilion” had the highest read count of 12,991. Analyzing the specific reasons, on the one hand, it may be that ancient books databases do not promote themselves enough, leading to low public awareness; on the other hand, it may be that the pushed articles fail to arouse sufficient interest among readers.

4.1.1 Optimize User Interface

The user interface is users’ first impression of ancient books databases. If the user interface design lacks humanization, it will greatly reduce user experience. Therefore, when applying ancient books databases on mobile devices, more attention should be paid to the portable characteristics of mobile devices and user preferences. User interface construction can be strengthened in the following two aspects: (1) Pay attention to color matching and style selection. A concise and beautiful user interface will improve users’ first impression of the database. For example, the user interfaces of “Classic Ancient Books Database” and “Ancient Books Pavilion” both use light brown tones with Chinese-style gradient backgrounds, creating soft colors and an antique atmosphere that matches the connotation of ancient books databases. (2) Pay attention to layout design. General website homepage layout adopts a “T-shaped” structure, with the website name, logo, and advertising banner placed at the top, a column below the top introducing product categories, services, and navigation, content classification on the left, login boxes and search on the right, and auxiliary website information placed at the bottom [16]. However, the application of ancient books databases on mobile devices must consider the capacity of mobile devices, eliminating unnecessary columns to make the entire page more organized and clear at a glance for users.

4.1.2 Develop Mobile Client

With the current rise of smartphones, various mobile application software have emerged, and various industries are relying on mobile clients to provide more convenient services for users, such as the China University MOOC client and Superstar Mobile Library. Although two of the four ancient books databases investigated in this study are apps, compared with other mobile clients, ancient books database apps still have many shortcomings. For example, “Traditional Chinese Medicine Ancient Books” only collects traditional Chinese medicine specialized ancient books with small coverage. “Shutongwen Database” has relatively poor user experience. In contrast, “Classic Ancient Books Database” and “Ancient Books Pavilion” based on the WeChat platform have relatively high overall user experience. However, relying on the WeChat platform also has shortcomings, as the services provided by ancient books databases are limited by WeChat service account interfaces. Therefore, in addition to relying on the

WeChat platform, mobile clients for ancient books databases can be developed. On the one hand, starting from their own resource conditions and combining user needs, pages and functions that meet user habits can be designed with greater autonomy in the development process, and database functions can be improved and increased to enhance user experience. On the other hand, readers can enjoy the services of mobile applications of ancient books databases through mobile terminals without being restricted to WeChat.

4.2.1 Optimize Presentation Forms

Currently, online databases already have image full-text databases, image-plus-text databases, etc. Therefore, the development of mobile applications for ancient books databases should also introduce multiple data forms. Scanned images of rare ancient books are conducive for readers to appreciate the marks of original ancient books, such as annotations, famous collectors' seals, and formats, and also help avoid errors in words and sentences during the digitization of ancient books. In full-text databases, scanned images of ancient books can be added, enabling free conversion between the two. During reading, readers can choose appropriate data formats according to their preferences. Additionally, audio or video data forms can be considered. Ancient books often contain many rare characters and variant characters that readers may have difficulty reading and pronouncing. Adding audio formats can alleviate such difficulties. Currently, open online classes are very popular, and many experts and scholars have offered related courses based on ancient books on the China University MOOC platform, such as Professor Wan Xianchu's open course "‘Shuowen Jiezi’ and Ancient Society" from Wuhan University. Therefore, in the construction of mobile applications for ancient books databases, relevant video open classes can be introduced. On the one hand, this can enrich data forms and meet readers' needs for multimedia reading carriers. On the other hand, it can also help readers deepen their understanding of ancient books.

4.2.2 Expand Data Scale

Currently, mobile applications of ancient books databases are in the initial stage of development. As analyzed above, the data volume included is relatively small compared with online ancient books databases. Therefore, in the next development process, expanding data volume is essential, and construction can be strengthened from the following two aspects: (1) Strengthen institutional cooperation. The account subject of the "Classic Ancient Books Database" public account is Gulian (Beijing) Digital Media Technology Co., Ltd. (hereinafter referred to as "Gulian"). Gulian Company is a wholly-owned subsidiary of Zhonghua Book Company, mainly responsible for ancient books digitization and publishing. The power of a single publisher like Zhonghua Book Company is difficult to cover the vast number of ancient books. Therefore, Gulian has currently obtained authorization from Phoenix Publishing House, Tianjin Ancient Books Publishing House, Qilu Book Society, Bashu Book Society, and East

China Normal University Press to include their collated ancient books resources in the database [15]. Additionally, cooperation can be conducted with libraries, database providers, and data companies to expand the data volume on the platform. (2) Increase the conversion of data between different platforms. Although mobile applications of ancient books databases provide relatively small data volumes, the data volume of online versions is already considerable. Therefore, the conversion between these two should be intensified, using existing online database resources as a basis to convert them into resources in mobile applications.

4.3.1 Improve Retrieval Function

Whether general retrieval or advanced retrieval, both use character matching to complete the retrieval process and present retrieval results. However, Chinese meanings in ancient books are complex, and simple character matching affects precision and recall rates. Therefore, adopting knowledge retrieval to improve retrieval efficiency can better meet readers' diverse retrieval needs. Knowledge retrieval is no longer based on literal mechanical matching but can reveal the intrinsic meaning of articles from semantics and concepts.

4.3.2 Improve Reading Experience

Compared with computers, mobile devices are limited by screen size, hardware conditions, and input speed. Therefore, when providing services to users, mobile applications of ancient books databases can start from font size adjustment, reading mode selection (adjusting screen brightness, day reading mode and night reading mode), content layout selection (horizontal or vertical layout), simplified/traditional Chinese selection, bookmark collection, and ancient books version comparison, with special attention to users' reading experience.

4.3.3 Add Tool Functions

- (1) Strengthen dictionary functions. For example, "Classic Ancient Books Database" can add queries for multi-character words and proper nouns (such as personal names, place names, etc.) based on its current dictionary function. Additionally, online query functions can be added to compensate for dictionary deficiencies. For some rare characters, pronunciation and pinyin rules can be added to the dictionary, enabling readers to understand needed Chinese characters from three aspects: pronunciation, form, and meaning.
- (2) Chronology conversion. The chronology methods used in ancient books differ from today, and adding chronology conversion can help readers clarify timelines.
- (3) Add encyclopedia entries to help users gain deeper understanding of ancient books-related knowledge.

4.4 Focus on Communication and Interaction with Users

Communication channels between ancient books digitization product providers and end users, as well as between users, are limited. Although some databases have simple interactive modules such as error correction, feedback is slow after readers submit these errors. Interactive modules, social network services, and user opinion sections can be added to increase user participation enthusiasm [16]. On the one hand, user feedback and opinions can provide good guidance for the construction of mobile ancient books databases. On the other hand, strengthening communication with users can also expand platform influence through user word-of-mouth. Strengthening communication with users can be achieved through the following: (1) Improve response efficiency by leveraging WeChat platform's natural advantages to timely reply to user questions. (2) Open subscription accounts. WeChat subscription accounts have more freedom in pushing message quantity compared with service accounts, allowing one message daily, although messages are not displayed in users' chat lists but in the subscription account folder. WeChat service accounts and subscription accounts each have their advantages. Therefore, service accounts can be used to provide services related to mobile applications of ancient books databases, while subscription accounts can be used to push database-related information to increase user attention to ancient books databases. When pushing articles, attention should be paid to article types and styles. For example, article types pushed by "Classic Ancient Books Database" include information, historical knowledge, essays, and academic papers. Analyzing specific content reveals that articles related to "Classic Ancient Books Database" itself, ancient books collation, or historical knowledge receive higher user attention, while information articles receive relatively lower attention. Therefore, the types and content styles of pushed articles deserve further exploration to better conform to readers' reading habits. (3) Provide member discussion communities. Providing member discussion communities can enhance user cohesion and sense of belonging, increase user stickiness, and also create discussion atmospheres to promote cultural exchange. Currently, on mainstream social media, WeChat public accounts and Weibo accounts can be found for "Traditional Chinese Medicine Ancient Books," "Classic Ancient Books Database," "Ancient Books Pavilion," and "Shutongwen Ancient Books Database," but this is slightly insufficient for current diversified social platforms. It is recommended to use current social platforms to establish corresponding member discussion communities, such as Baidu Tieba, Douban groups, Zhihu topics, and Tianya forums.

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Author Contributions

Yang Siluo: Proposed research ideas, revision suggestions, and finalized the manuscript;

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