Conceptual Definition of Smart Reading Services and Critical Review of Domestic Research: Post-print

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Abstract

[Purpose/Significance] To define the concept of smart reading services, systematically review relevant domestic research achievements from the past three years, and provide a reference for research development in this field. [Method/Process] Conduct a search on CNKI for domestic relevant research achievements since 2017, systematically review relevant research literature, analyze research hotspots, summarize an analytical framework for smart reading services, and provide an outlook for future research. [Results/Conclusion] Domestic smart reading service research achievements since 2017 mainly include smart reading service systems and platforms, users, service content and strategies, service evaluation, and service management. Among these, service content and strategies and users represent two research hotspot directions. The hot information technologies that have been studied more extensively include big data and artificial intelligence technology and virtual reality technology. Smart reading services will be a future research hotspot, and technology and users are the key directions for future research.

Full Text

Defining Smart Reading Services and Reviewing Related Domestic Research

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Abstract:
[Purpose/Significance] This paper defines the concept of smart reading services, reviews relevant domestic research achievements from the past three years, and provides references for the development of research in this field.

[Method/Process] Relevant domestic research achievements since 2017 were searched through CNKI, research literature was reviewed, research hotspots were analyzed, an analytical framework for smart reading services was summarized, and future research was prospected. [Result/Conclusion] Since 2017, domestic research on smart reading services has mainly included smart reading service systems and platforms, users, service content and strategies, service evaluation, and service management. Service content and strategies, and users are two key research hotspots, with big data and artificial intelligence technology, and virtual reality technology being the most studied information technologies. Smart reading services will be a future research hotspot, with technology and users being the key research directions.

Keywords: smart service; reading service; smart reading; intelligent reading; 5G reading; VR reading; digital reading

2. Concept of Smart Reading Services

Following IBM's introduction of the "Smart Earth" concept in November 2008, the notion of "smart" has gradually permeated various fields, giving rise to concepts such as smart cities, smart campuses, smart homes, and smart services. In the domain of reading services, related concepts include smart communication, smart publishing, smart education, and smart libraries. Understanding the concept of "smart" and clarifying its relationship with related concepts are fundamental theoretical issues that must be addressed to define smart reading services.

In the *Xinhua Dictionary*, "wisdom" (智慧) is defined as the ability to correctly understand things and solve problems, while the *Chinese Dictionary* explains it as the ability to analyze, judge, invent, and create. Based on these definitions, we understand "wisdom" as the relatively strong cognitive and behavioral capabilities possessed by humans or living organisms. As machines have become increasingly capable in information processing and control, the industry has proposed a series of concepts such as smart cities and smart campuses to express the application of new information technologies across society, aiming to achieve services with human-like machine intelligence. This machine-based human-like wisdom represents a narrow definition of "smart." Smart technologies encompass both existing and emerging information technologies, being downward compatible with current technologies that more or less assist in analysis, judgment, and problem-solving, while upwardly developing new technologies to continuously improve machines' cognitive and operational capabilities. Like humans, machines possess varying levels of wisdom (different forms and hierarchies), depending on the information technology employed. Moreover, the development of smart technologies is an ongoing process, from early IoT technologies like RFID to the current rise of artificial intelligence, with each wave of emerging information technology continuously advancing the level of smart services.

Human-machine collaborative wisdom is and will remain the norm for a considerable period. Under current technological conditions, machines primarily handle deterministic, basic, and routine information analysis, judgment, and operations, while humans mainly address uncertain and complex information analysis, judgment, and operations.

Smart reading services represent the fusion of reading services with human wisdom and machine intelligence. Reading services refer to services provided by publishers, schools, libraries, and other service organizations to support users' reading behaviors (processes), including reading literacy education, content supply, and reading assistance. Broadly defined, smart reading services are reading services supported by human-machine collaborative wisdom. However, current concepts of smart services in various fields emphasize machine intelligence. Consistent with this, our definition of smart reading services also refers to reading services based on machine information technologies with human-like intelligence—this is the narrow definition of smart reading services. Its connotation is that with the support of emerging information technologies such as digital, mobile/5G, Internet of Things, cloud computing, big data, artificial intelligence (AI), and virtual reality (VR/AR), machine systems can "see," "listen," "understand," "converse," and "analyze" reading materials and various reading service information in real time, make accurate judgments and decisions, and interact and integrate with humans (service personnel and users) to achieve fast, accurate, and personalized reading literacy education, content supply, and reading assistance services that better meet diverse user needs and enhance reading service effectiveness.

3. Domestic Research Progress Since 2017

The development of smart reading services is closely related to the maturity and popularization of information technology. While smart reading services are currently flourishing, they remain in their infancy and require both a transformation of service concepts and upgrades in relevant technologies. Chinese academic research on the informatization of reading services has largely kept pace with the application of various information technologies. Research on online reading and digital reading began around 2000, mobile reading around 2004, IoT reading and cloud reading around 2010, and research on big data reading, virtual reality (VR) reading, AI reading, and 5G reading began around 2012, 2014, 2017, and 2018, respectively.

We searched for relevant domestic research achievements since 2017 through the CNKI platform (search date: September 29, 2019) using search terms including digital reading, online reading, mobile reading, 5G reading, IoT reading, virtual reality (VR) reading, augmented reality (AR) reading, cloud reading, big data reading, intelligent (AI) reading, and smart reading. A total of 102 relevant documents were identified. Among them, library science research accounted for approximately 53%, publishing studies for 27%, and education for 11%. Theoretical research accounted for 49%, empirical (data, survey, experiment)

research for 38%, and technology development papers for 13%.

Since 2017, domestic research on smart reading services has included a few studies examining the theory and practice of smart reading services as a whole, such as investigations and analyses of the current state of digital reading services in Chinese university libraries, theoretical analyses of the impact of artificial intelligence on traditional and digital reading services, and suggestions for the development of Chinese intelligent reading. However, most research has approached the topic from segmented themes and specific smart technology perspectives, covering five main directions: smart reading service systems and platforms, users, service content and strategies, service evaluation, and service management.

3.1 Research on Smart Reading Service Systems and Platforms

The integration of new-generation information technology with reading services is first reflected in the design and development of reading service systems and platforms. Research in this area includes publishing and reading service systems as well as library reading service systems.

Regarding publishing and reading service systems, studies have examined an online printing and publishing cloud platform based on IoT and integrated with big data and cloud computing technologies [1], a new book recommendation system based on IoT [2], a mobile reading recommendation algorithm combining context and collaborative filtering [3], and the transformation and development of physical bookstores into smart spaces [4]. Library reading service system research has addressed the construction of digital library smart reading platforms [5], the development of library cloud reading service and promotion platforms [6-7], the construction of library big data application platforms [8], smart reading recommendation systems based on user profiles [9-10], a thematic diversity reading recommendation method based on user social network analysis [11], and personalized recommendation algorithms for digital journals [12].

3.2 Research on Smart Reading Service Users

Research on smart reading service users encompasses both user needs and user behavior. Studies on user reading needs have examined mobile reading needs among target users, potential users, and irrelevant users [13], reading needs in the context of AI technology [14], and audiobook platform users' needs for audio reading [15].

User reading behavior research has covered digital reading behavior, mobile reading behavior, cloud reading behavior, VR and AR reading behavior, AI reading behavior, and smart reading behavior, with relatively more research findings on mobile reading behavior and VR/AR reading behavior. Some scholars have analyzed complete and diverse digital reading behavior data obtained from authorized records, intuitively reflecting readers' "borrowing" and "reading" behavior data and exploring the reading behavior process after readers "borrow" digital materials—a relatively novel approach [16].

Mobile reading behavior research has addressed paid reading, deep reading, user stickiness, sharing behavior, and mobile reading among primary, secondary, and university students. With the rise of paid digital reading, corresponding research has emerged. Cheng Xiaoyu and Liu Kunfeng studied the influencing factors of mobile reading users' willingness to pay for reading [17]. Luo Xiaolan et al. used WeChat Moments "check-in" reading sharing activities as an example to investigate and analyze users' motivations for participating in paid reading activities, changes in reading behavior, reading sharing, reading effects, and activity evaluations [18]. Regarding whether mobile reading affects deep reading, Wu Dan and Lu Liuxing studied the impact of different mobile phone screen sizes and reading apps on university students' academic document reading efficiency [19], while Jia Jinxi analyzed the main factors causing the development dilemma of mobile "deep reading" and proposed countermeasures [20]. Zhu Jingwen et al. analyzed the impact of mobile reading immersion experience on user stickiness [21], and Liu Yuqing and Chang Guilin studied the influencing factors and mechanisms of knowledge sharing behavior among library mobile reading users [22].

Regarding the suitability of mobile reading for students, particularly primary and secondary students, some scholars have investigated students' ownership and use of smart media and its impact on their current extracurricular reading [23]. Jiang Hongwei and Wang Huifang conducted a sampling survey of fourth-grade children in four regions including Shanghai to understand their mobile terminal reading behaviors and habits [24]. Zhao Wenjun and Xie Shou explored the perceived value structure dimensions of university students' mobile reading using the Chaoxing mobile reading APP as a research platform, analyzing their impact on satisfaction and behavioral intention [25].

Research on VR or AR reading behavior has primarily explored the new experiences these technologies bring to users. "VR/AR books bring three major changes to reading methods: immersive reading experience, interactive reading scenarios, and imaginative reading thinking" [26]. "VR can truly achieve cross-temporal reading presentation and perspective, transforming 'static reading' into 'dynamic reading' and changing the 'distanced reading' between people and books into 'immersive reading' between people and environments" [27]. Virtual reality technology has both positive and negative impacts on human reading behavior. Positive impacts include immersion, interactivity, and cognition, while negative impacts include blurred reading motivation, weakened decoding of reading experience, defects in reading experience, and lack of reading ethics [28]. "Through AR technology, this information can be presented in a virtual form, enhancing people's perception of information in books and forming complete and in-depth information mastery. By programming various patterns in publications and installing designated reading software on mobile terminal devices, users can enjoy unprecedented interactive reading experiences through mobile screens" [29]. Han Feifei and Zhou Rongting elaborated on three elements through which augmented reality books influence public reading behavior—multi-sensory deep experience reading, multi-subject participatory in-

teractive reading, and hyper-realistic information integrated reading—and constructed a reshaping path of augmented reality books on public reading behavior from three levels: method, content, and platform [30].

"In the era of artificial intelligence, 'human-machine co-reading' will become a new paradigm, with personalized learning and personalized reading becoming mainstream" [31]. Wang Pengtao explored the revolutionary transformation of AI on reading methods [32], while Li Yingzhen analyzed the connotation of smart reading and discussed the construction of a smart reading system from both reader and media perspectives [33].

3.3 Research on Smart Reading Service Content and Strategies

Research on smart reading service content and strategies includes smart reading literacy education, smart content supply, smart reading assistance, and smart reading promotion, with relatively more research findings on smart content supply and smart reading promotion.

3.3.1 Smart Reading Literacy Education Reading literacy education primarily targets primary and secondary school students. Recent research has explored strategies for improving students' reading literacy through big data, AI, and smart technologies. Some scholars have investigated approaches to evaluating student reading literacy based on big data. Shang Chaowang et al. discussed the transformation of online learning evaluation from a big data perspective, analyzing the characteristics of process-based evaluation and designing a big data-based online learning process evaluation framework [34]. Cheng Xiaotang and Chen Pingping proposed a conception for an English reading ability cultivation and evaluation system based on big data [35]. Zhao Junyi explored mechanisms for introducing big data assistance into middle school Chinese reading instruction [36].

In terms of AI-assisted reading education, Zhao Zichun et al. discussed a new model of Chinese reading education for children combining AI and leveled reading [37], while Yao Yao analyzed the changing and unchanging roles of teachers in guiding children's extracurricular reading in the intelligent era [38]. Some scholars have explored strategies for promoting reading education based on various smart reading platforms. Zhang Tingting et al. [39] and Li Hailong [40] investigated strategies for promoting English reading instruction in primary and secondary schools based on smart classrooms, Chen Zhuoyi discussed the application of smart reading platforms in Chinese reading instruction [41], and Ouyang Ximin and Zhou Xueming explored practices for promoting students' extracurricular reading using the Internet+ "Reading Together" cloud platform [42].

3.3.2 Smart Content Supply Content supply is a major research focus. Studies on smart content supply include mobile content supply, VR and AR content supply, and intelligent supply.

Zhang Xiaoqing surveyed and analyzed the current state and existing problems of mobile services in "985 Project" university libraries, proposing to strengthen the construction of mobile reading digital resources and build a library digital resource system adapted to the mobile Internet environment [43].

Research on VR content supply has addressed general publications, children's books, ancient texts, and bookstores. Studies on general VR publications have focused on changes in publications and their supply brought about by VR technology [44]. As noted, "Through smart devices such as mobile phones, books can be transformed from single text-image carriers into multimedia carriers, allowing readers to conveniently access video, audio, and interactive web content while reading text, thereby broadening the content and style of book publishing" [45]. "In addition to VR-guided reading services, libraries can also use VR for immersive reading activities such as VR reading experience exchanges and VR reading clubs" [46]. Yu Huilan analyzed the application of virtual interactive experience design in children's reading products [47], while Nie Jinglei analyzed the application status, problems, and countermeasures of virtual reality and augmented reality technologies in professional and children's books [48]. Zhang Ning et al. analyzed the distinctive advantages of "VR ancient texts" [49], and Zhang Weidi analyzed the enabling role of VR technology in physical bookstores based on application cases [50].

Research on AR content supply has addressed general publications and children's books. Liao Yufeng elaborated on the application of augmented reality (AR) technology in library personalized reading guidance and lending [51], while Wang Hui [52] and Lü Xin [53] focused on the innovative value and application of augmented reality publications. Zhou Rongting and Cao Yahui proposed AR book design recommendations based on embodied cognition theory [54]. Zhou Rongting and Gu Fei analyzed the implementation path of anthropomorphic techniques in AR children's books [55], while Lei Ming [56] and Li Xin [57] discussed the current status and problems of augmented reality children's publications and proposed development suggestions.

Research findings on intelligent supply have focused on using big data technology and artificial intelligence technology to provide personalized push and sales services. Tan Dingping [58] and Liu Jia [59] discussed strategies for libraries to carry out personalized content supply based on big data technology. Xu Fang analyzed that the rapid development of artificial intelligence technology and big data has brought disruptive revolutions to the publishing industry, including reader-centered sales, on-demand push, provision of personalized book displays and recommendation lists, and realization of timely, accurate, and targeted push to achieve personalized and dynamic content services [60]. Guo Rengui studied and analyzed the impact of artificial intelligence technology on the publishing industry chain from a process chain perspective, including personalized production and real-time accurate delivery of publishing content [61]. Liu Binjie proposed that the new smart publishing industry must be based on big data technology and big data publishing [62]. Zhang Han and Lu Jiajie proposed suggestions for

building smart book cities, including AI book recommendation, virtual reality reading, open online production, and knowledge system construction [63].

3.3.3 Smart Reading Assistance With the penetration of smart technologies, how to use various smart technologies to assist reading and improve reading efficiency has gradually become a focus of academic attention. Yan Zhiyong proposed strategies for using artificial intelligence to improve book reading efficiency, offering several assistance measures for three stages: material selection before reading, information processing during reading, and knowledge utilization after reading. These include recommending reading materials to readers based on knowledge graphs, context, and reader big data; prompting readers to review relevant notes before reading to extract relevant schemas from long-term memory to working memory; assisting readers in taking reading notes during reading; and analyzing reading notes after reading to form readers' reading maps for facilitating the next round of reading material recommendation and comprehension [64]. Zhou Jianshe et al. proposed a quantitative model for intelligent assisted reading based on logical image theory [65].

3.3.4 Smart Reading Promotion Reading promotion refers to marketing, communication, and educational activities aimed at encouraging more users to utilize reading services—an active service strategy. Since 2017, domestic academic circles have paid considerable attention to reading promotion, covering digital reading promotion, mobile reading promotion, cloud reading promotion, VR reading promotion, big data reading promotion, and AI and smart reading promotion, with relatively more research on digital reading promotion and smart reading promotion.

In digital reading promotion, Ye Yu argued that new media reading in the mobile Internet era should return to value-based reading [66], while Sun Peng and Wang Zhenwei discussed the main approaches to digital reading promotion service innovation from five aspects: multi-space reconstruction, carrier form innovation, service model deepening, reading method expansion, and marketing channel extension [67]. More studies have investigated and analyzed the current state of digital reading promotion, such as the "Intelligent Bus Digital Reading Promotion Project" [68], Shanghai Library's practice in promoting digital reading promotion services [69], the "Scan Code to Read, Hundred Cities Read Together" activity organized by the Reading Promotion Committee of the Chinese Library Association [70], the digital reading promotion cooperation between Chongqing University Library and JD Reading [71], and Shanghai Library's children's digital reading promotion practice based on the OverDrive platform [72]. Peng Aidong et al. investigated the development status of digital reading promotion in domestic libraries [73], concluding that digital reading promotion in Chinese libraries is developing rapidly, with models including activities, publications, interpersonal communication, advertising, courses, navigation, and recommendation, but development is uneven, dominated by activity and recommendation models, leaving considerable room for development. Liu Yindi introduced sev-

eral digital reading promotion activities conducted in Western countries [74], while Yan Lingyan and Hu Bo surveyed digital reading platform functions and children's digital reading promotion practices in 45 U.S. public libraries [75].

Yu Shu et al. demonstrated a library mobile reading promotion model based on SICAS [76], Li Yi discussed the innovation of digital reading promotion models based on cloud platforms [77], and Tan Bo explored the basic paths and implementation strategies for libraries to carry out "VR+Reading Promotion" [78]. Some scholars have explored precision reading promotion paths based on reader behavior big data [79]. Gao Yujun argued that the key to carrying out AI reading promotion lies in the construction and realization of reading promotion scenarios [80]. Some scholars have conducted theoretical explorations of smart reading promotion as a whole. Zhang Luyue analyzed the connotation, components, service processes, and implementation approaches of smart reading promotion [81]. Wang Dazhuang analyzed the challenges that smart library transformation poses to reading promotion, constructed a smart library reading promotion service system, and proposed innovative strategies for smart library reading promotion services [82]. Zhao Fazhen et al. constructed a reading promotion model framework supported by smart library systems [83].

3.4 Research on Smart Reading Service Evaluation

Research on smart reading service evaluation includes mobile reading service evaluation and reading promotion evaluation based on big data.

Research on mobile reading service evaluation has primarily been theoretical. Cheng Xiufeng et al. discussed the influencing factors of mobile reading service quality in university libraries, proposing a multi-dimensional evaluation system for university library mobile reading service quality from four aspects: service resources, service technology, service management, and service feedback [84]. Wang Boya and Deng Zhonghua constructed a mobile reading service quality evaluation system based on the ANP-fuzzy comprehensive evaluation method [85]. Chen Hanzhang used the "Rural Book House" mobile reading platform as a case study to analyze the usage effects of digital rural book houses and their role in rural reading through reading data [86]. Zhao Fei et al. proposed constructing a holistic evaluation system and process mechanism for university library reading promotion activities based on reader behavior big data [87]. Zhang Luyue proposed ideas for evaluating smart library reading promotion through user feedback, user reading process and effect data [81].

3.5 Research on Smart Reading Service Management

In terms of smart reading service management research, Lai Aihua discussed the regular work mechanism of digital resource promotion using the Guangdong Provincial Library as an example [88]. Wang Yong'an and Liang Jun, based on experience from Xi'an's "Scholarly City" construction, proposed constructing an urban smart reading ecosystem that fully utilizes Internet and AI technologies

to connect information flow and logistics across the city's physical bookstores, breaking down barriers between public libraries and bookstores to serve nationwide reading [89].

3.6 Brief Analysis of Related Research

Based on the above review, it is evident that domestic academic circles have produced abundant research achievements on smart reading services since 2017. Among these, research on smart reading service content and strategies accounts for the largest number, followed by research on users. Key research hotspots include smart reading user behavior, smart reading promotion, smart content supply, VR/AR content supply, digital reading promotion, AI reading promotion, smart reading literacy education, mobile reading behavior, VR/AR reading behavior, and intelligent content supply. From the perspective of smart information technology, domestic research since 2017 has covered digital reading services, mobile reading services, IoT reading services, cloud reading services, VR/AR reading services, big data reading services, and intelligent reading services. The most studied hot information technologies are big data and artificial intelligence technology, followed by virtual reality (VR) or augmented reality (AR) technology, and then digital and mobile technologies.

However, existing research also has some shortcomings, including: lack of systematic theoretical research on smart reading services; insufficient attention to changes in user reading behavior under the influence of new-generation information technologies such as AI; inadequate research on user reading comprehension behavior processes and characteristics; absence of research on adult reading literacy re-education; insufficient research on assisted reading services; relatively few studies on smart reading service evaluation and management; and insufficient interdisciplinary exchange and collaboration.

4. Analytical Framework for Smart Reading Services

Examining domestic research on smart reading services, scholars have conducted studies from multiple levels and perspectives. Based on a synthesis of their research paths, ideas, and content, combined with our definition of smart reading services, we have constructed an analytical framework for smart reading services (see Figure 1 [Figure 1: see original paper]) to serve as a "roadmap" for observing and forecasting future research.

Reading services can be decomposed into two levels: reading service operation and reading service management. Reading service operation is a development process driven by the interaction of components including reading service subjects, service content, service systems, service strategies, users, and service evaluation. Reading service management involves decision-making, planning, command, coordination, and control of business, organization, and personnel in the reading service operation process. The research perspective of smart reading services is the changes brought by continuously iterative information technology to

reading service systems, users, service content and strategies, service evaluation, and service management. Its research tasks include promoting the application of various new smart technologies and optimizing already deployed technology applications. As shown in Figure 1, smart reading services consist of service subjects (publishing institutions, media organizations, schools, libraries, social organizations, individuals, etc.), service content (reading literacy education, content supply, reading assistance, etc.), service systems (on-site service systems, online service platforms), service strategies (personalized services, social services, reading promotion, micro-services, integrated services, etc.), users, service evaluation (process evaluation, effect evaluation, etc.), and service management. The deep integration of continuously updated information technologies such as digital, mobile, IoT, cloud computing, big data, artificial intelligence (AI), and virtual reality (VR/AR) with reading services will promote corresponding transformations in all elements of the reading service system. First, reading service systems will be upgraded, subsequently driving changes in service content and strategies and user reading behavior, leading to corresponding transformations in service evaluation and service management, thereby pushing reading services from digitalization and networking to intelligent development, and ultimately continuously improving reading service capabilities and effectiveness.

5. Future Research Outlook

Reading services are a research area of common concern across library science, editing and publishing, and education. Information technology is a major driving force for reading service innovation. As information technology development continues to enhance machine intelligence, smart reading services will become a future research hotspot. In the future, research on smart reading services in library science, editing and publishing, and education will each have different emphases while conducting interdisciplinary exchanges and collaboration to jointly promote the development of smart reading services.

For a given smart reading service subject, technology and users are the most important variables and the key directions for future research. Research on the application of smart information technology in reading services should focus on the implementation of new technologies and the optimization of existing applications. Among new-generation information technologies, artificial intelligence is the core, and its application in reading services will be a future research hotspot. Research on user needs and behavior in smart reading service environments should focus on the impact of smart technologies on user behavior and intelligent user profiling. Through big data, AI, and other technologies, research should conduct precise analyses of users' reading literacy, needs and behaviors when facing new technology applications, and behaviors and experiences in existing smart technology applications, particularly based on user behavior data (including content acquisition behavior data and post-acquisition reading behavior data). This will be an important future research direction.

In terms of smart reading service content and strategies, smart content sup-

ply is not only a current but also a future research hotspot, focusing primarily on image and voice information organization and retrieval, natural language retrieval, automatic document translation, big data intelligent analysis, knowledge organization and analysis, personalized recommendation, and intelligent consultation. Whether for student reading literacy education or adult reading literacy re-education, using smart technologies and tools to improve the efficiency and effectiveness of reading literacy education will also be a research focus. As breakthroughs occur in machine reading comprehension, processing, and analysis technologies, intelligent reading assistance will receive increasing attention. Reading promotion will maintain its current research popularity, with reading promotion based on smart technologies receiving more attention.

Research on smart reading service evaluation will 致力于 establishing a multi-indicator system oriented toward reading service processes and effectiveness, exploring evaluation systems such as big data evaluation, real-time evaluation, and tracking evaluation. Smart reading service management research will explore the datafication, intelligence, and normalization of business management, as well as the transformation and construction of reading service teams and collaboration between institutions.

In terms of research methods, future academic research should strengthen theoretical research on smart reading services, including basic theories, operation and management mechanisms, and models, with emphasis on originality and systematicity. Empirical research (interviews, questionnaires, data, experiments, etc.) should also be strengthened, particularly research based on data and experiments.

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