Application and Exploration of AI Chatbots in Library Reference Services: A Case Study of ChatAI

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Abstract

[Purpose/Significance] Regarding the patterned interactive consultations characterized by repetitive and simplistic answers in domestic reference services, which substantially deplete reference librarians' energy, this study harnesses the ChatAI technological wave to introduce AI chatbots as virtual reference librarians for delivering novel reference services, thereby enhancing service efficiency while driving library reference work toward innovative development. [Method/Process] The author endeavors to commence with the general-purpose AI chatbot ChatAI, reconceptualizing the applicable scenarios for a rudimentary theoretical model—specifically, delineating the requisite entity frameworks for a professional ChatAI version within the reference service workflow. This study proposes employing the layered architecture commonly utilized in software engineering to construct a simplified ChatAI model tailored for library reference services. The implementation phase leverages the instant dialogue capabilities of a "Dialogue Manager" (DM) to mitigate issues such as information latency. [Results/Conclusion] Through preliminary verification, the current general-purpose version of the AI chatbot ChatAI has essentially satisfied the requirements of present-day simplified reference Q&A, establishing a foundation for its further advancement toward specialization.

Full Text

Application and Exploration of AI Chatbots in Library Reference Services: A Case Study of ChatAI

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Abstract

[**Objective/Significance**] Domestic reference consultation services suffer from repetitive, simplistic, and stereotyped interactive responses that consume substantial energy from reference librarians. Leveraging the technological wave of ChatAI, this study introduces AI chatbots as virtual reference consultants to deliver innovative reference services, thereby improving service efficiency while propelling library reference work toward more creative directions.

[**Method/Process**] Beginning with the general-purpose AI chatbot ChatAI, this study redesigns the application scenarios for a simplified theoretical model, specifically examining what entity frameworks a professional version of ChatAI should possess within the reference service workflow. The research proposes adopting the layered architecture common in software engineering to construct a streamlined ChatAI model suitable for library reference services. The implementation phase utilizes the real-time dialogue function of a "Dialogue Agent" (DM) to address issues such as information delays.

[**Result/Conclusion**] Preliminary verification indicates that the current general version of AI chatbot ChatAI already meets the needs of simplified reference Q&A, establishing a foundation for further specialization.

Keywords: ChatAI; Dialogue Agent; Reference Consultation
Classification Number: G251.2

A broad consensus has emerged in society that AI chatbots represent the most direct and efficient information transmission tools in digital environments. Reviewing the technological evolution of information transmission over the past two decades reveals that chat tool development has matured alongside smartphones, transforming user preferences from early PC-based QQ to mobile WeChat, with the latter delivering exponentially superior real-time communication experiences. Particularly in the current Industry 4.0 era, as artificial intelligence becomes the benchmark for emerging technologies, AI chatbots—leveraging their interactive capabilities and information transmission timeliness—have permeated daily life, especially in education, finance, and healthcare. Service institutions have begun recognizing and utilizing AI chatbots to support daily operations. This study therefore examines the prospects for AI chat technology in libraries, specifically within traditional reference services, and explores how it can enhance service quality to meet the information needs of today's university students.

The technological advantage of AI chat lies in enabling users to retrieve information through simple, clear natural language conversations with real-time satisfaction. Foreign libraries have accumulated substantial practical experience in this domain, as their users already widely employ Apple's Siri, Cortana, and Google's assistant chatbots. These libraries have integrated AI chatbots into daily services, particularly virtual reference consultations, yielding positive re-

sults. After extensive use, they have concluded that AI chatbots effectively create productive dialogue scenarios that facilitate high-efficiency information exchange and deliver satisfactory virtual service experiences.

The EU's High-Level Expert Group on Artificial Intelligence defines AI as "a scientifically sound understanding mechanism based on the concrete manifestation of human thinking and intelligent behavior in machines," noting that this storable intelligent behavior for machine comprehension is diversely defined. In the foreseeable future, more "human-like" machine intelligence will emerge, with AI chatbots representing conversational AI entities—so-called "conversational media."

Within library contexts, AI can assume various service roles. This study focuses on AI chatbot applications in reference services and explores possibilities for human-machine collaboration. According to Rubin et al. (2010), human-computer interaction can serve libraries through four functions: educational, informational, auxiliary, and interactive. AI chatbots are computer applications that simulate intelligent conversation scenarios through text, voice data, or concrete representations, functioning as digital assistants or virtual intelligent media. They provide real-time feedback to various queries with clear content orientation and typical problem characteristics within human-understandable parameters. Gujral et al. (2019) observed that AI chatbots can ensure 24-hour physical-time service independent of library operating hours while maintaining answer continuity and content practicality. However, they also argued that we cannot rely on AI chatbots to achieve innovative transformations of human wisdom or existing knowledge, though these systems possess sufficient potential for effective feedback on clearly defined queries and precise guidance on library service usage. AI chatbots should serve as digital reference assistants aimed at improving feedback efficiency and service quality rather than completely replacing or eliminating human librarians.

AI chatbots offer several advantages when applied to reference consultation:

(1) Delegating typical reference queries to AI chatbots liberates reference librarians from low-value, highly repetitive work, allowing them to devote more time to professionally demanding inquiries and meet user information needs through more creative and constructive expert responses. Simultaneously, if AI chatbots better integrate natural semantic interaction patterns, they can better assist librarians in handling complex user inquiries.

(2) AI chatbots can simultaneously provide conversational services to multiple users, ensuring immediate and continuous feedback.

(3) AI chatbots respond to valueless questions without emotional coloring, thereby ensuring a comfortable experience for users with genuine needs.

(4) AI chatbots indirectly promote library resources and services, as users become familiar with facilities and learn to better utilize available resources

through dialogue.

(5) They can serve as library "bulletin boards," providing personalized service announcements to each user, making service dissemination more targeted and efficient.

(6) AI chatbots possess the potential to engage users in extended conversations with continuity over longer durations, as exemplified by the successful Facebook Messenger chatbot.

(7) They feature self-learning capabilities; when "fed" sufficient inferential dialogue corpora exhibiting human language patterns, they can continuously adjust based on previous user conversations to complete automatic learning and develop the potential to anticipate user needs and propose constructive solutions to typical inquiries.

(8) Today's university students have widely adopted AI chat in daily life and established a certain dependency, quietly transforming their information acquisition channels to AI chatbots on mobile web browsers (such as ChatAI) as an indirect medium for obtaining needed information.

(9) AI chatbots ensure uninterrupted physical-time service regardless of library closure status.

According to industry expert assessments, current AI chatbots remain heavily dependent on corpora and linked knowledge bases, unable to answer inquiries beyond these resources. They are also limited by natural language processing capabilities, particularly evident in cross-language and cross-cultural inquiries where responses likely deviate from intended meanings. Their ability to handle multiple simultaneous user queries requires improvement, and they still have considerable distance before users perceive them as "human" rather than "machine."

2. Literature Review

Using "AI," "library," and "reference consultation" as title search terms in the CNKI database revealed that domestic research in this field remains relatively nascent. The study therefore examined foreign literature databases, where over 40 relevant articles were identified, as AI chatbots have been widely adopted by government and corporate sectors requiring customer interaction over the past decade. This review consequently focuses on foreign research.

Regarding development and introduction of general-domain AI chatbot products, Liao et al. (2016) designed a multimodal AI fashion chat system with comprehensive fashion knowledge to assist customers in locating precisely matching style products, conducting a SWOT analysis of the technology. Ko et al. (2018) introduced a "business card recognition" bot for workplace and business scenarios, featuring built-in OCR modules for business card identification and daily management. In medical institutions, Madhu et al. (2017) proposed design

concepts for AI chatbots to assist medical treatment, providing patients with medication lists and corresponding treatment plans. Villegas et al. (2019) explored how to better utilize AI chatbots' immediate reply functions to meet student information needs in smart campus contexts.

Regarding AI's role transformation in serving university students through libraries, Gupta et al. (2020) elaborated on AI applications across library operations, defining four primary scenarios: educational, informational, auxiliary, and social attributes, while describing impacts and future prospects. According to Vincze (2017), libraries adopting AI for reference consultation is feasible, emphasizing that AI chatbots can maximally simplify traditional reference service workflows and achieve efficiency optimization. Mckie and Narayan (2019) stressed the importance of collaboration between reference librarians and technology developers in creating reference service chatbots, arguing that only through such cooperation can current university students' information service needs in innovative learning environments be maximally satisfied.

Regarding AI chatbot model construction and deployment in libraries, Tubachi (2017) noted that library service and facility announcements can be delivered through AI chatbot simple or extended dialogues, as well as through video conferences, email, FAQs, tours, librarian inquiries, and library websites, with AI chatbots offering the advantage of round-the-clock information dissemination. He also pointed out that virtual reference consultation, currently the most important service sector, can be most simply, directly, and effectively extended by embedding AI chatbots directly into library websites. Ali (2019) shared experiences with a "concept explanation" AI chatbot, proposing that development should focus on user experience and multi-party collaboration for system efficiency improvement. Allison (2012) concluded through research that most user inquiries are direct and fact-based. McNeal et al. (2013) noted that "virtual reference consultation services" represent an emerging library service aligned with current university students' information acquisition preferences, and that libraries can independently develop AI chatbots meeting their specific reference service needs through assembling available code packages, specifically using Artificial Intelligence Markup Language (AIML) such as Python AIML and chatbot scripts to build chatbot models as viable current approaches.

This systematic literature review reveals that research directly related to this study's theme remains extremely limited, indicating the research is at a relatively innovative stage, which conversely validates its value.

3. Design Approach for Library AI Reference Consultation System Model

3.1 Overall Model Framework

Focusing on AI chatbot applications in university library reference services, this study redesigns application scenarios for a simplified theoretical model begin-

ning with the general-purpose AI chatbot ChatAI, specifically examining what entity frameworks a professional ChatAI version should possess within reference service workflows. The core entities divide into three components: user dialogue interface, natural language processing program, and natural language generation module. The user dialogue interface sends and receives text through the natural language processing program, which reads, transforms, and understands user inquiries through text data processing to form answer index information, then retrieves answers from the knowledge base and, after natural language generation processing, completes responses to even highly complex knowledge queries.

Based on this design approach, a simplified ChatAI model for library reference services was constructed using a typical layered architecture, as illustrated below. The model comprises five layers from top to bottom: input layer, application layer (user dialogue interface), corpus layer (natural language processing layer), data layer (linked knowledge base), and content generation layer.

The model focuses on three key aspects: ChatAI problem-handling capability, reference consultation service platforms suitable for ChatAI deployment, and server reliability for ensuring daily ChatAI operation. The following sections elaborate on functional details of each layer in conjunction with service workflows.

```
User Demand Instruction (Typical Question)
    ↓
User Dialogue Interface
    ↓
Natural Language Processing $\rightarrow$ Natural Language Understanding $\rightarrow$ Natu
    ↓
Content Generation Layer
    ↓
Large Language Model
```

[Figure 1: see original paper] Layered Architecture ChatAI Model for Library Reference Services

When a user initiates an inquiry, the first layer activates the second-layer user dialogue interface to complete system input. This user dialogue interface is directly embedded in the service window for daily library-patron communication, with recommended deployment using mature, widely-adopted chat tools such as WeChat or Facebook Messenger. The second-layer user interface, supported by the third-layer corpus layer, implements text information transmission and reception. The third-layer corpus layer contains three core functional components: natural language processing unit, natural language understanding unit, and decision engine, which collectively ensure information accuracy throughout the AI chatbot system and maximize prevention of information misinterpretation. The natural language processing unit performs preprocessing on user text input data through sentence recognition, word segmentation, lemmatization

(reducing different word forms to their base form), part-of-speech tagging, dependency parsing (analyzing dependency relationships between words), named entity recognition, and semantic role labeling (determining semantic roles such as agent and patient). The natural language processing unit generates three key terms from user question input: "why," "how," and "what." The natural language understanding unit detects the user's true intent and categorizes it into a predefined set of purpose categories. The decision engine defines the knowledge domain from user input data processed by natural language processing to assist system answer generation. The fourth layer represents the AI chatbot's core component: its linked knowledge base. The interface (API) between the knowledge base and corpus layer requires substantial data "feeding" to systematically train more human-comprehensible language patterns. This interface serves as a critical component determining overall AI chatbot intelligence—it depends on linked knowledge base data quality on one hand, while representing a crucial link for semantic "mutual recognition" at the human-computer interaction level on the other, effectively assisting AI chatbots in accurately and rapidly understanding retrieved data information from the knowledge base to prepare for subsequent effective user feedback. The fifth layer is the content generation layer, transforming abstract data expressions from the fourth layer into natural language closest to universal human discourse comprehension and directly feeding back to the second-layer user dialogue interface.

GIMLET is citation-tracking software; after each inquiry completion, the system automatically records relevant data to "feed" the interface between natural language processing and the linked knowledge base, improving overall AI chatbot system intelligence through repeated language training. User inquiries through the dialogue interface form an inquiry data stream, sequentially input into the system according to system time for corresponding answer output.

3.2.1 Dialogue Interface Construction—Dialogue Agent

In essence, the design model proposed in 3.1 derives from currently mature FAQ systems, operating rule-based input-search-response mechanisms that leverage predefined rule libraries or linked knowledge bases plus learning functions. Through "training" by university student users completing training sets, as foreign scholar McNeal described: "Current AI chatbots cannot yet replace complex human dialogue, only applying to relatively typical inquiries aimed at saving communication labor time costs and guiding user services." Therefore, they currently only suit simple, short-text inquiries. The underlying programming language uses open-source O language and Artificial Intelligence Markup Language. AIML features strong extensibility and compatibility for complex composite systems. Meanwhile, these language files can obtain generated and shareable source files from online open-source technical communities without requiring coding from scratch. However, these open-source language files suit general-purpose dialogue; substantial modifications for library reference service scenarios are necessary to develop library-context "dialogue agents."

```
Context
    ↓
Dialogue Agent
    ↓
Updated Context
```

[Figure 2: see original paper] Dialogue Agent Decision Flow in Library Application Scenarios

As illustrated, the dialogue agent's inputs are user semantic expressions (or user behaviors, representing natural language understanding output) and current dialogue state, while outputs are next system actions and updated dialogue state.

If this model can achieve instant dialogue services, it can resolve many user problems plaguing previous reference services, such as information delays and communication psychological barriers for introverted users facing human customer service. Since instant dialogue services are "machines," conversations require no identity verification, IP address tracking, physical location positioning, or identity binding, maximizing communication barrier removal and comfort enhancement. For libraries, inquiry desk workloads will substantially decrease; simple, highly repetitive user questions such as restroom or copier locations can be resolved through AI chatbot instant messaging, allowing librarians to invest limited time in more creative work.

3.2.2 Backend Database Construction and Maintenance

The service backend database is built using the mature database language MySQL, dragging dialogue script files from the O language runtime environment directly into this online database system to implement user dialogue history backtracking and continuous system usage tracking while generating formatted data including dates, times, and response frequencies. AI chatbot system construction and daily maintenance updates can be collaboratively completed by library technical departments and specialized reference librarians. Specifically, technical departments handle server installation, ensuring servers can operate O language environments, deploy AI chatbot visual user dialogue interfaces, and build MySQL databases, while specialized reference librarians handle AI chatbot system updates and timely backup of backend operational data. Once the backend database is constructed and the AI chatbot launched, the system automatically performs daily chat script file backtracking, requiring approximately 5-6 hours of system time weekly to complete chat script backtracking and updated script file uploading. Such timely backup and updating effectively improves server performance to save system time for subsequent task completion.

4. Key Model Component—Dialogue Agent

4.1 Dialogue Agent Content Generation Mechanism

According to DeeAnn's 2012 proposition: "All concepts generated through human natural language interaction can serve as AI chatbot script files. The natural language interaction process divides user input questions into word or phrase forms, such as mapping parts of speech (nouns, verbs, adverbs) to 'why,' 'how,' and 'what' to enable more precise system understanding of user intent and more question-aligned feedback." After users pose questions to AI chatbots, the system searches all existing question-related answers, ranking them by relevance from high to low and returning the top-ranked answer to users. This question-generation mechanism currently faces bottlenecks requiring breakthroughs. On one hand, current library reference service content exhibits professional complexity; on the other hand, user questioning methods may cause system misinterpretation, such as polysemy phenomena, creating deviations in system understanding and causing returned answers to likely diverge from user intent, thereby affecting user experience comfort. Consequently, continuous script file version updates and necessary recoding are essential to reduce system "misreading" probability.

The AI chatbot system collects script file data through all inputs in the user dialogue interface. After identifying and deleting user identity information (such as ID numbers) and other privacy-related data, the system ensures information entering the corpus does not infringe user privacy and can be freely shared. This corpus data collection serves two purposes: first, to better train AI robots to align with user needs; second, to accumulate research materials for comparative effectiveness analysis with traditional human-based reference consultation and email-based reference services.

4.2 User Question Content Analysis

To date, substantial research exists evaluating traditional manual-mode reference consultation and online instant messaging-mode reference consultation services, yet studies on "dialogue mechanisms and content analysis" remain scarce. Introducing the "dialogue agent" mechanism into reference consultation AI chatbots requires primary attention to generated dialogue content quality and user-side text language composition across dialogue rounds, as these determine chat script file content quality. As Houlson proposed: "Quantitative analysis of chatbot script files will provide referential detailed materials for virtual service effectiveness evaluation." This raises several considerations: (1) How should users effectively question AI chatbots during initial deployment (before training adjustments)? (2) How can AI chatbots gradually understand users' real research bottlenecks through the "dialogue agent" mechanism based on user input? (3) How can AI chatbots be recoded and adjusted based on deep understanding of user inquiry content through dialogue agents to provide more precise dialogue services?

The table below presents a typical "human-machine dialogue" example approximating human-to-human conversation patterns.

Dialogue Round	User/System
1	Hello, welcome to ××× Library Reference Consultation Dialogue System
2	hello()
3	Hello, I want to borrow a book
4	What specific type of book?
5	I like reading "The Three-Body Problem"
6	Confirm "Three-Body Problem"?
7	Inform(venue="library")
8	request(book)
9	Inform(book="Three-Body Problem")
10	confirm(book="Three-Body Problem")
11	affirm()

In reality, "human-machine dialogue" achieved through "dialogue agent" instant chat functions still faces numerous technical bottlenecks. From the user perspective, human-to-human dialogue can simply capture true meaning through colloquial or formal written statements, while traditional email methods provide ample semantic expression and mutual understanding space without word limits. Conversely, instant chat systems restrict users' expression space, while current AI chatbots remain incapable of handling complex language processing where a single word change in complex contexts completely overturns entire utterance meanings. Backtracking relevant chat script files reveals that most users habitually ignore system prompts for brief inquiries when using "instant chat" functions, instead adopting colloquial, long-paragraph approaches to initiate "human-machine dialogue," creating substantial pressure on AI chatbot backends for sentence segmentation and answer matching and severely affecting answer output quality.

5. Current ChatAI Application Experience and Future Specialization Prospects

[Figure 3: see original paper] ChatAI Chat Interface 1 & ChatAI Chat Interface 2

As the author works at Zhaoqing Library and understands relevant service conditions, Interfaces 1 and 2 clearly "borrow" generic information content from

other libraries. While response timeliness is high and reply patterns are fixed, accuracy remains low—especially Interface 1's responses significantly deviate from Zhaoqing Library's actual conditions, indicating failure to achieve targeted precise content discovery and remaining far from personalized service needs. However, for simple, highly repetitive Q&A, substantial advantages exist in reducing human service costs.

The author understands that the industry has already launched relevant professional products for trial use. For instance, the "Library AI Reference Consultation System," a module within the "Library ChatLibrary Service Platform," has achieved the following functions: (1) Intelligent communication through natural language interactive Q&A with precise question and intent understanding; (2) Precise result discovery based on semantic understanding that breaks language barriers and matches optimal results; (3) AI intelligent reference consultation services that meet users' personalized learning needs beyond traditional FAQ Q&A; (4) Construction of efficient, flexible intelligent learning and research spaces for users through cross-modal associated knowledge. In summary, this product outlines an ideal blueprint for future AI chatbot-assisted reference consultation services, validating to some extent the possibility of AI chatbots providing professional disciplinary services.

Library reference consultation services are crucial for optimizing collection development and facility utilization. Traditionally, these services have relied on reference librarians conducting interactive text-based consultations through consultation platforms. Interactive dialogue-based AI chatbots, with their powerful processing advantages for repetitive and simplistic questions, will substantially liberate professional librarians' workload and provide sufficient development space for innovative work once applied to reference consultation services. With ChatAI's rapid intelligent development, its application space in library reference consultation professional fields further expands. Leveraging libraries' long-accumulated chat scripts and linkable knowledge bases, AI chatbots serving as virtual reference librarians ensure uninterrupted round-the-clock service and enable synchronous, sustainable knowledge Q&A for multiple users through "dialogue agents." The industry has already developed relevant products such as the "Library AI Reference Consultation System" within the "ChatLibrary Service Platform." Due to access limitations, its application effectiveness can only be further explored through subsequent research.

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