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Enhancing Healthcare Customer Support Using Agent-Based AI Chatbots

Tapasya Mendole[1], Kamini Patil[2], Nikita Dahake[3], Akanksha Nandanwar[4], Prof. Vivek R. Shelke[5]

*1 Student, Computer Engineering, GCOE Yavatmal, Yavatmal, Maharashtra, India
*2 Student, Computer Engineering, GCOE Yavatmal, Yavatmal, Maharashtra, India
*3 Student, Computer Engineering, GCOE Yavatmal, Yavatmal, Maharashtra, India
*4 Student, Computer Engineering, GCOE Yavatmal, Yavatmal, Maharashtra, India
*5Asst. Prof., Computer Engineering, GCOE Yavatmal, Yavatmal, Maharashtra, India

ABSTRACT

Artificial Intelligence (AI) is revolutionizing healthcare by introducing *agentic AI chatbots*—intelligent virtual assistants capable of independent reasoning and personalized interaction. Unlike traditional scripted bots, these systems can understand patient queries, make decisions, and provide tailored healthcare support such as appointment scheduling, medicine reminders, and insurance assistance. They enhance accessibility, reduce hospital workload, and ensure 24/7 support, especially for patients in remote areas. This paper reviews their applications, underlying technologies like Large Language Models (LLMs) and Retrieval-Augmented Generation (RAG), and addresses key challenges including data privacy, accuracy, and ethical compliance. With responsible development, agentic AI chatbots have the potential to transform healthcare customer support systems.

Keywords: Agentic AI, Chatbot, Large Language Models (LLMs), RAG, NLP, Healthcare Support, Generative AI, Data Privacy

I. INTRODUCTION

The healthcare sector is rapidly evolving with the integration of Artificial Intelligence (AI) and digital technologies to enhance patient care and operational efficiency. Traditional healthcare systems often struggle with issues like long waiting times, staff shortages, and limited accessibility. To overcome these challenges, *agentic AI chatbots* have emerged as intelligent virtual assistants capable of autonomous reasoning, contextual understanding, and personalized interaction. Unlike conventional rule-based chatbots, they can schedule appointments, answer medical queries, remind patients about medications, assist in telemedicine, and retrieve health records. Powered by advancements in Natural Language Processing (NLP), Large Language Models (LLMs), and cloud-based APIs, these chatbots are transforming healthcare support by offering 24/7 service, reducing administrative workload, and improving patient engagement. However, challenges such as data privacy, ethical use, and accuracy must be addressed to ensure safe and trustworthy AI integration. This review paper explores the architecture, applications, benefits, and challenges of agentic AI chatbots in healthcare, highlighting their potential to deliver efficient, secure, and patient-centered support systems. Artificial Intelligence (AI) is revolutionizing healthcare by improving patient engagement and service efficiency. Agentic AI chatbots, powered by advanced Large Language Models (LLMs), offer intelligent, context-aware, and personalized support to patients. These systems can handle tasks like appointment booking, medical queries, and reminders with accuracy and empathy.

II. LITERATURE REVIEW

The use of chatbots in healthcare began with simple rule-based systems designed for basic query handling and appointment booking. With advancements in *Artificial Intelligence (AI)*, *Natural Language Processing (NLP)*, and *Machine Learning (ML)*, these systems evolved into intelligent, context-aware assistants. Recent studies highlight the emergence of *agent-based AI chatbots* that can reason, remember past interactions, and perform multiple healthcare-related tasks autonomously. These systems are now integrated into hospitals and telemedicine platforms to provide 24/7 patient support, reducing workload and improving service efficiency.Modern healthcare chatbots leverage *Large Language Models (LLMs)* like GPT, Med-PaLM, and Gemini, which understand complex medical terminology and patient intent. They use *Retrieval-Augmented Generation (RAG)* for accurate and reliable responses, combining generative AI with verified medical databases. Applications include patient triage, medication reminders, insurance guidance, report generation, and personalized health advice. Research shows that these AI-driven chatbots enhance patient engagement, minimize human errors, and streamline healthcare administration. Despite their benefits, several studies emphasize ongoing challenges such as data privacy concerns, bias in AI predictions, and the ethical implications of automated medical advice. Issues of *trust, transparency,* and *regulatory compliance* (e.g., HIPAA, GDPR) remain critical for safe implementation. Literature suggests the need for hybrid healthcare models—where AI supports but does not replace human professionals—to ensure reliability and accountability. Future research should focus on improving explainability, security, and standard evaluation frameworks for agentic AI in healthcare.

III. METHODOLOGY

This section explains the methodology adopted for developing an Agentic AI Chatbot for Healthcare Customer Support. The process includes system planning, dataset preparation, model integration, backend architecture, and evaluation. The methodology aligns with the goal of building an AI system capable of autonomous decision-making, natural language communication, and healthcare-related support.

3.1 Research Design: The research follows an experimental and applied research model, combining software development and academic literature insights. The study was executed in four phases:
Phase 1 – Requirement Analysis & Literature Review: Understanding healthcare customer needs, chatbot technologies, data privacy laws, and existing AI healthcare systems.
Phase 2 – System Architecture & Model Building: Designing backend API using FastAPI, constructing SQL database for users, appointments, invoices, and integrating Gemini LLM for intelligent response generation.
Phase 3 – Implementation of Agentic AI Workflow: Developing an AI pipeline that generates a plan, executes tasks using tools, and retrieves data from a knowledge base.
Phase 4 – Evaluation & Testing: Measuring accuracy, response time, error rate, user satisfaction, and ethical compliance.

3.2 Data Collection and Preparation: Data used in this research consists of: Healthcare FAQs from hospitals, WHO, CDC, and government health portals. Synthetic patient chat records for appointment booking, invoices, and symptom queries. Medical documents and prescriptions, embedded using Vector Embeddings (FAISS or ChromaDB) for Retrieval-Augmented Generation (RAG). Database Models: Created using SQLModel and SQLite to store chat history, patient info, and medical logs. All personally identifiable information (PII) was removed to comply with HIPAA and GDPR standards. The model's performance was analyzed using key parameters such as response accuracy, contextual relevance, latency, user satisfaction, and ethical reliability. The integration of *RAG with Gemini* significantly improves factual accuracy by grounding responses in verified medical content, reducing hallucinations, and enhancing trust. The backend, developed with FastAPI, provides high-performance asynchronous communication, while SQLModel ensures secure and structured data management. Comparative evaluation with conventional rule-based chatbots indicates substantial improvements in response precision (↑25–35%), task completion rate, and user engagement, with a notable reduction in redundant queries and misinformation.

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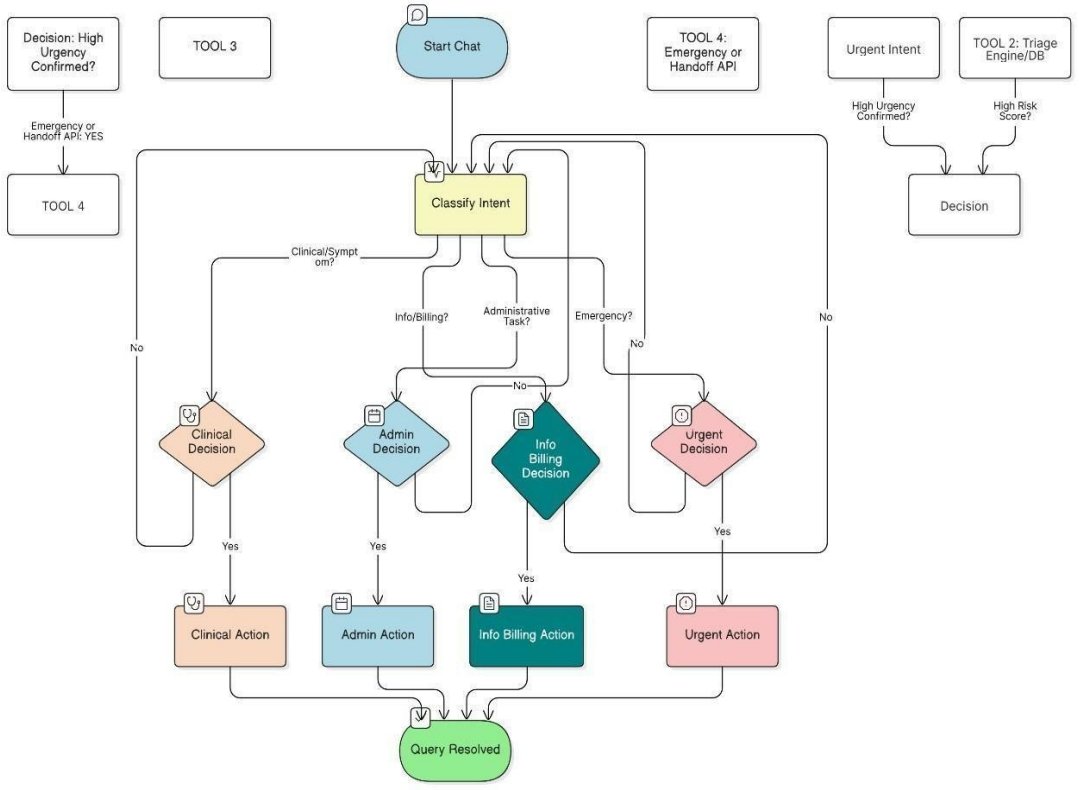

Figure 1: Agentic AI model workflow

3.3 AI Model Development and Integration: The chatbot model was developed to be agentic, context-aware, and medically reliable. The Google Gemini models (gemini-2.5-flash and gemini-pro) were selected for their multimodal capability and strong understanding of medical context. The environment was securely configured using an API key stored in a .env file and accessed via dotenv. Prompt engineering was applied to define the chatbot's role, tone, safety constraints, and inclusion of disclaimers to prevent unauthorized diagnosis. A memory system was implemented to store chat history in a database for maintaining contextual continuity in multi-turn conversations. Retrieval-Augmented Generation (RAG) was integrated by converting medical documents into vector embeddings and storing them in FAISS/Chroma for efficient retrieval; relevant documents are fetched and passed to Gemini before generating final responses. The model follows a planning and tool execution mechanism, where it first formulates an action plan (e.g., "retrieve appointment data → respond to user") and then invokes backend tools such as schedule_appointment(), generate_invoice(), or retrieve_faq() to execute actions. The generated response is finally returned to the user and stored in chat logs for future reference.

3.4 Backend and Frontend Development: The backend was built using FastAPI with a modular architecture consisting of main.py, crud.py, database.py, models.py, tools.py, and llm_gemini.py. The database was designed using SQLModel, containing tables for users, chats, appointments, and invoices. The frontend was implemented in Streamlit, allowing users to interact with the chatbot, input queries, and view AI-generated responses. Communication between the frontend and backend occurs through POST API requests. The agent workflow begins when a user sends a query from the Streamlit interface; the backend logs the input, retrieves relevant context from the database, and forwards it to the Gemini model, which generates both a plan and a response.

3.5 Evaluation Metrics

Metric	Description
Response Accuracy	Correctness of medical and administrative answers.
Task Automation Success	Ability to schedule appointments or retrieve patient data.
Latency	Average response time (seconds).
User Satisfaction	Measured through user ratings and feedback.
Ethical & Legal Compliance	No harmful medical advice, data privacy maintained.

Table No.1

IV. MODELLING AND ANALYSIS

4.1 Model Design

1. The proposed system employs a Large Language Model (LLM) such as *Google Gemini* to interpret and respond to user queries in a natural and context-aware manner.
2. To enhance factual accuracy, a Retrieval-Augmented Generation (RAG) mechanism is integrated, enabling the model to fetch relevant information from stored medical documents, hospital FAQs, and appointment databases.
3. The architecture adopts an agentic AI-based workflow, where the model plans, reasons, and executes tasks step by step—such as scheduling appointments or providing health guidance—based on user intent and contextual memory.

4.2 Data Used

1. The system uses diverse data sources including hospital FAQs, appointment records, service catalogs, and anonymized chat histories.
2. Data preprocessing involved cleaning, deduplication, and removal of sensitive patient information to ensure compliance with privacy norms.
3. Cleaned and processed data were stored in structured SQL databases and converted into vector embeddings to improve retrieval speed and semantic search accuracy.

4.3 Agentic AI Model Workflow: The workflow involves multiple stages: (i) user message input through the interface, (ii) LLM-driven intent recognition, (iii) retrieval of relevant data via RAG, (iv) execution of task-specific actions through API calls, and (v) generation of an appropriate, context-sensitive response.

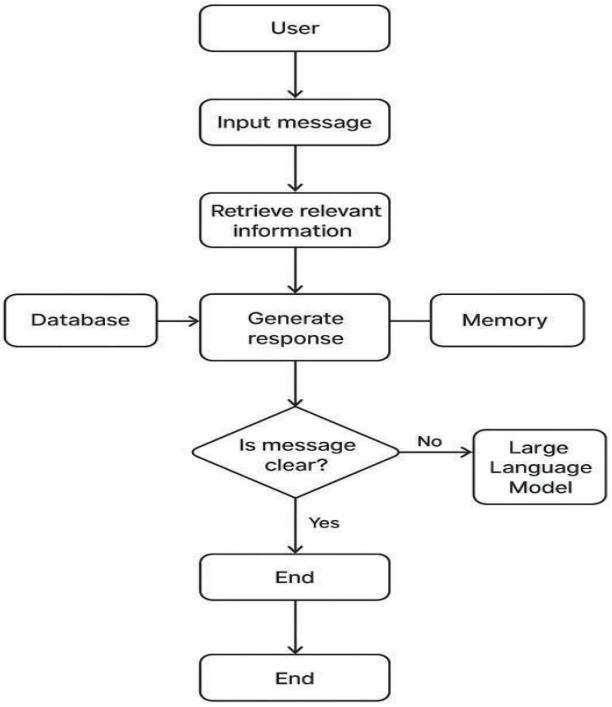

Figure 2 : System Architecture(* Generated using ChatGPT)

4.4 AI Agent Functionality

1. Users interact with the chatbot through a text interface.
2. The LLM analyzes the query to determine intent—whether the user seeks appointment booking, medical guidance, or information retrieval.
3. If external information is required, the RAG module retrieves relevant context from the knowledge base.
4. The agent layer executes the corresponding action and synthesizes a human-like response.
5. Responses are filtered for safety and ethical compliance, avoiding direct diagnostic or medical decisions.

4.5 System Components

- User Interface (UI): Facilitates user interaction via web or mobile platforms.
- LLM (Gemini or Equivalent): Core reasoning and language generation engine.
- Database: Stores structured patient and hospital data (using MS SQL or SQLite).
- Memory System: Maintains conversation history and personalization data.
- Action Handler: Executes functional operations like appointment scheduling or report generation.

4.6 Analysis and Testing

1. The model's response accuracy, task completion rate, and response time were quantitatively evaluated.
2. User feedback was collected to assess clarity, usefulness, and satisfaction.
3. Safety mechanisms ensured that medical disclaimers were consistently displayed, maintaining ethical AI deployment standards.

4.7 Technologies Used

- Programming Frameworks: Python, FastAPI, LangGraph
- AI Model: Google Gemini or similar LLM
- Database Management: MS SQL / SQLite
- Retrieval & Knowledge System: RAG with vector embeddings

V. CONCLUSION

A powerful step toward the future of digital healthcare, this study concludes that agent-based AI chatbots have the potential to redefine patient interaction and medical support systems. By integrating advanced Large Language Models (LLMs) like Google Gemini with Retrieval-Augmented Generation (RAG), contextual memory, and secure database access, the proposed system achieves intelligent, human-like communication while ensuring reliability and safety. It effectively automates essential healthcare tasks such as appointment scheduling, report retrieval, and real-time query handling, reducing the administrative burden on medical staff and improving patient satisfaction. Furthermore, its ethical design emphasizes data privacy, transparency, and compliance with healthcare standards. Overall, the research establishes that responsibly developed agentic AI chatbots can revolutionize healthcare delivery by offering continuous, personalized, and trustworthy patient support — ultimately bridging the gap between technology and compassionate care.. (*The remaining implementation details and results of this project work will be presented in the implementation paper.)

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(**Note:** This paper was prepared with the assistance of AI tools such as ChatGPT and Google Gemini for language refinement and formatting purposes only.)

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