

The Conversational Agents and Natural Language Processing: Artificial Intelligence in Medicine

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Abstract

Background and Objective: The adoption of digital technology to enhance service delivery represents a significant advancement in the medical field. Digital Assistance Systems are gaining prominence, with Artificial Intelligence (AI) expected to play a pivotal role in transforming doctor-patient communication in the future. Advances in conversational agents equipped with natural language processing (NLP) capabilities are particularly compelling and are increasingly applied in diverse areas, including medical education. This review article explores these developments in detail, focusing on the integration of AI-driven conversational tools.

Materials and Methods: This review article outlines a structured methodology for conducting a literature review and critiquing the integration of artificial intelligence (AI) tools with conversational agents and natural language processing in educational contexts. The goal is to assess their potential in enhancing knowledge acquisition, skill development, and understanding of complex medical concepts.

Results: The integration of AI tools in learning has demonstrated significant potential in improving knowledge acquisition, skill development, and comprehension of medical concepts. These tools have been implemented in various forms, including 1) Medical information chatbots 2) Appointment scheduling chatbots 3) Medication management chatbots 4) Chatbots as mental health support 5) Post-discharge follow-up chatbots 6) Health Insurance guidance chatbots 7) Chronic disease management chatbots

Conclusion: Conversational agents and Natural Language Processing (NLP) are groundbreaking technologies revolutionizing the medical field. They enhance diagnostic processes, streamline healthcare delivery, and support the development of clinical skills. However, it is crucial to prioritize accuracy, reliability, and validity in their application. Moreover, safeguarding sensitive data through robust privacy and security measures is essential to ensure the ethical use of AI in healthcare.

Keywords: Conversational Agent; Natural Language Processing; Artificial Intelligence in Medicine

Introduction

Conversational AI and natural language processing (NLP) mark a transformative leap in human-computer interaction, empowering machines to comprehend and respond to natural language with unprecedented sophistication. As these technologies advance, they are driving innovation, streamlining processes, and enriching user experiences across a wide range of applications. Embracing the potential of conversational AI and NLP paves the way for a future where collaboration between humans and machines becomes seamless, intuitive, and remarkably effective.

The goal of using digital technology to modernize workflows is to provide services digitally and improve efficiency by ensuring fast and accurate information. This will enhance support, facilitation, and medical potential. Digital assistance systems are expected to play an important role in future communication between doctors and patients (Moldt et al., 2023). As technology advances, conversational agents can now engage in natural conversations, while ensuring accessibility as well. These agents allow people to access information easily via mobile phone interfaces (chatting). Moreover, conversational agents have become an attractive alternative for various applications, including medical education.

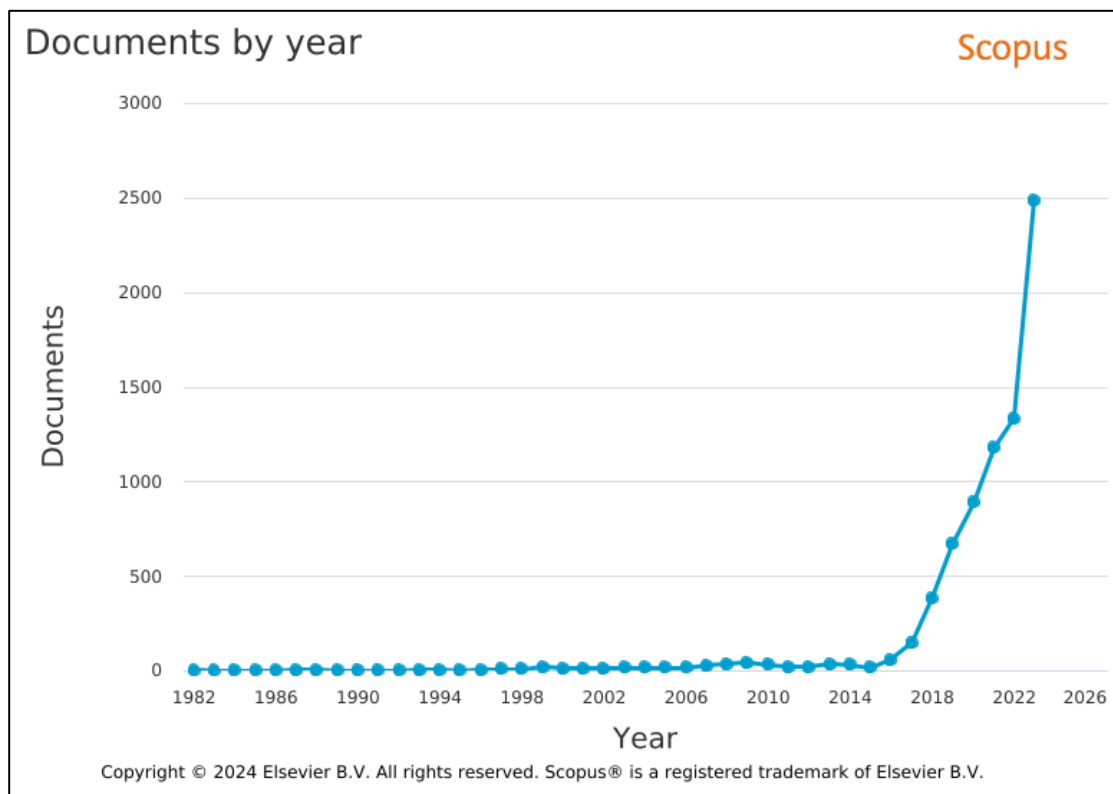


Figure 1: Search results in Scopus between 1982 and 2023 for the keywords ("chatbot" OR "conversation agent" OR "conversational interface")

Scopus searches conducted from 1982 to 2023, as illustrated in Figure 1, focused on the keywords "chatbot," "conversation agent," and "conversational interface." The data reveal a notable increase in the number of publications on these topics in recent years. Interest in the subject began to rise significantly after 2016, followed by a sharp surge in the volume of related research over the past decade.

Literature Review

Kamkankaew, P. (2024) described Artificial Intelligence (AI) as a significant advancement in various technologies, including machine learning and natural language processing (NLP). AI possesses the capability to rapidly analyze large volumes of data, identify patterns, and generate predictions based on historical information, driving transformative changes. It can learn from data, perform analysis, forecast trends, and make informed decisions. Looking ahead, the development of NLP systems for sentiment analysis on social media is anticipated to further expand AI's applications.

Kedthawon, S. (2024) describes Artificial Intelligence (AI) as the capability of machines to perform functions similar to those of humans, including perception, learning, data analysis, and reasoning. This enables AI to solve complex problems without relying on traditional command inputs or continuous instruction. By utilizing machine learning and natural language processing (NLP) techniques to analyze news text—such as data classification, similarity detection, and prediction-AI can accurately and swiftly identify and verify fake news, allowing the system to understand and process complex text in a manner akin to human cognition.

Kitthiwichayakul, B. (2023) describes Artificial Intelligence (AI) as the application of advanced techniques such as data analysis, prioritization, and heuristic computations to develop sophisticated decision-making models in crisis scenarios. These techniques enhance decision-making efficiency by providing structured and informed approaches. The implementation of AI in emergency management not only reduces costs but also significantly improves accuracy and response speed in critical situations.

Chitiyaphol, J. (2022) described Artificial Intelligence (AI) as the integration of AI within education and learning, facilitated by modern digital tools. This technology enhances the learning process through computer systems, with a focus on chatbot systems designed to deliver automated response services. These chatbots interact with users in real time via text or voice, analyzing questions and providing appropriate answers using artificial intelligence and natural language processing (NLP). The study specifically highlights the use of Dialogflow to develop a Chatbot on the LINE platform, enabling students to search for and review knowledge about computer network terminology. The system is designed to operate efficiently and swiftly, ensuring accessibility and usability at all times. Its primary function is to process user inquiries through the chatbot's Intent feature and deliver accurate and relevant responses. This capability ensures the system aligns with users' needs and supports effective engagement with learning content.

The full application of Artificial Intelligence (AI) in service development holds significant potential for advancing the medical field. This review article explores the role of AI in the future of patient-doctor communication. Progress is being made in enabling conversational agents to engage in natural language processing. The article aims to highlight the integration of AI technologies, demonstrating how AI can be applied in the context of education and learning through modern digital tools.

This article provides an analysis of The Conversational Agents and Natural Language Processing: Artificial Intelligence in Medicine, covering topics such as the definition and description of AI, its history, types of conversational agent chatbots, components of NLP, the relationship between NLP, NLU, and NLG, AI in medicine, the use of conversational agents in medical education (specifically ophthalmology), and concludes with insights into the transformative impact of Artificial Intelligence in medicine.

Artificial intelligence

Artificial intelligence (AI) is a field of technology and science that studies develops, and simulates intelligence in non-living things. It enables machines and computers to use algorithms and statistical tools to create intelligent software that can mimic complex human abilities, such as recognition, reasoning, decision-making, prediction, and communication. In some cases, AI can even learn autonomously. According to Chusri P. et al., (2019) there are 7 types of AI capabilities.

1. Machine Learning (ML): A system that enables machines to automatically learn from data and continually improve their decision-making processes. Machine learning works by analyzing computer data and can be categorized into three types:

- Supervised learning (Type 1): In this type, functions are created to link input data to desired outcomes.

- Unsupervised learning (Type 2): This type involves modeling data without labeled outcomes.

- Reinforcement learning (Type 3): This type determines action by observing the response of the environment to the action.

2. Natural language processing abilities

Natural language processing (NLP) is a technique that allows computers to understand human language.

3. Automated planning, scheduling, and optimization

Automated planning, scheduling, and optimization, involve empowering machines to make decisions and select actions that achieve specific goals.

4. Expert systems

Expert systems are techniques designed to mimic human decision-making abilities.

5. Speech recognition

Speech recognition is a technique that enables machines to recognize and analyze human speech, language patterns, and structures and to extract information from sound.

6. Computer vision

Computer vision is a technique that allows machines to interpret and understand image structures to analyze data from visual inputs.

7. Robotics

Robotics is a field of study that focuses on developing engines with various shapes and movements for specific purposes.

History

AI is transforming how we approach tasks by designing and evaluating advanced applications, known as intelligent agents that can perform various functions. Chatbots are AI programs that use NLP and sentiment to communicate in human-like language using text or speech.

Weizenbaum developed ELIZA, the first chatbot, in 1966. ELIZA is documented as a pioneering chatbot that used NLP. It was also one of the first AI programs to break through the barriers of conversational AI and successfully passed the Turing Test (Turing, 1950). ELIZA laid the foundation for subsequent chatbots like PARRY (Colby et al., 1971) and its successor, A.L.I.C.E. (Wallace, 2009). These chatbots served as the prototypes for current advancements in AI-driven chatbot technology such as Siri, Watson, Google, Microsoft, and Amazon's AI assistants.

In 1950 Alan Turing	> Introduced the concept of the Turing test, which became a foundational idea in the creation of chatbots.
1966 Joseph Weizenbaum	> ELIZA
1972 Kenneth Colby	> PARRY
1995 Richard Wallace	> A.L.I.C.E

Types of Conversational Agent Chatbots

Chatbots can be classified into two types based on their development approach: pattern-matching and machine learning.

1. Pattern-matching approach

Rules-based chatbots, such as prototypes ELIZA, and A.L.I.C.E., belong to the first category of conversational AI. These chatbots rely on pre-defined rules and patterns to generate responses using pattern-matching algorithms.

2. Machine learning approach

The new generation of chatbots uses NLP, a subset of AI defined as “machine learning”. With the introduction of NLP, traditional chatbots have transitioned into conversational agents. These conversational agents are characterized by their ability to engage in more natural human-like conversations. (Ramkumar, 2023).

A conversational agent is a software system designed to interact with users through instant messaging. It delivers knowledge and services to end users through NLP.

The importance of NLP

Chatbots are software applications that simulate conversations with users in natural language using NLP. They interact with users through messaging applications, websites, or mobile applications. (Saraswat et al., 2021).

“Natural language” refers to languages humans use to communicate, such as Thai, Japanese, and English. In computer science, “language” refers to “programming languages”, such as C and Java.

NLP combines computer science and linguistics. The application of computer or mathematical techniques to the study and understanding of human language is called Computational Linguistics (CL). This field has led to the development of systems that can respond to human communication, with some aspects of NLP utilizing machine learning and

deep learning techniques. NLP is crucial for enabling machines, such as computers, to process language, making it essential for the development of chatbot systems. When developing NLP technology, it is important to consider the complexities of language, including word diversity, language levels, grammatical structures, and ambiguity. Each language presents its unique linguistic challenges.

NLP also refers to the processing of information that enables computers to understand and communicate in human-like language. This involves converting unstructured data into a structured form, such as a database, data warehouse, or knowledge base. While humans can perform, this task, it is time-consuming and may result in varying quality. Therefore, NLP techniques are used to automate and streamline the process.

Components of NLP

1) Natural Language Understanding (NLU) focuses on enabling computers to read and comprehend human language. This requires knowledge of vocabulary, sentence structure, and semantics.

2) Natural Language Generation (NLG) involves generating text by converting structured data into text or speech. This process requires extracting context from a knowledge base, selecting appropriate words, generating phrases, and constructing sentences.

The relationship between NLP, NLU, NLG

In short, NLP converts unstructured data into a structured form, allowing software to understand the given input and respond appropriately. Meanwhile, NLU aims to understand the meaning of a sentence while NLG focuses on generating accurate and coherent sentences with correct intent in a specific language based on the dataset.

AI in medicine

1. Medical information chatbots

Vasileiou & Maglogiannis, (2022) developed health chatbots for telemedicine that utilize an intelligent interactive system for remote support. These chatbots use NLP and speech recognition algorithms for data analysis and classification, along with ML training to build AI models that can accurately predict diseases. The health bot also supports the field of telemedicine by using NLP and speech recognition to predict diseases such as Covid-19 and heart conditions. The accuracy of the health bot for predicting COVID-19 model is 98.3%, while the heart disease model has an accuracy of 82%. Practical implications: These chatbots can improve patient interactions, and accurately predict diseases, acting as virtual agents for medical assessments, appointments, and health monitoring.

Desai & Erulan, (2023) developed a medical chatbot using machine learning and NLP algorithms. These medical chatbots utilize machine learning to offer personalized healthcare assistance and provide affordable and tailored healthcare services. By improving patient engagement, these chatbots have the potential to reduce healthcare costs.

Anjum et al., (2023) developed a text-to-text NLP-enabled AI chatbot named MedBot, designed to provide personalized diagnoses based on presented symptoms. MedBot uses NLP and AI to offer healthcare assistance, promote a healthy lifestyle, and provide tailored medical recommendations. This article proposes the use of MedBot as a tool to reduce healthcare costs and improve accessibility by offering personalized advice before consulting a doctor. MedBot also aims to enhance patient care while reducing the need for immediate medical consultation.

2. Appointment scheduling chatbots

Srivastava et al., (2023) developed a chatbot that automates the scheduling process, making it easier for patients to find available times and book appointments. These chatbots can also send automated reminders to ensure appointments are not missed. The study explores the use of machine learning models for chatbots integrated with healthcare appointment systems. Medical appointment software that integrates with chatbots allows easy access to specialists recommended by the medical chatbot and coordination of an agreeable time for both the doctor and the patient. Such appointment systems have inherent advantages, such as reducing patient wait times. Patients can choose appointment times based on their preferences and book appointments through an efficient graphical user interface.

3. Medication management chatbots

Colombo et al., (2023) conducted a study on PharmaBulaBot, a chatbot designed to answer questions about drugs using information from drug labels. Most drug users struggle to read and understand drug labeling. PharmaBulaBot addresses this issue by extracting knowledge from drug labels using NLP techniques. Users can access information by asking questions and interacting with an intelligent interface that aims to respond with human-like quality in a fast, interactive, and efficient manner. The chatbot's formulation and evaluation were carried out through experimentation, using both quantitative and qualitative approaches. Out of a total of 3,147 human-generated questions, PharmaBulaBot successfully answered 2,959 questions (94.03% of the total) using sentence similarity. Local grammar was also used in the experiment to enhance the quality of responses to questions. PharmaBulaBot is capable of providing responses to questions with quality comparable to that of doctors and can integrate and interact with health information systems in public pharmacy units.

4. Chatbots as mental health support

Gupta et al., (2023) developed a mental health chatbot to provide accessible and confidential mental health support. The chatbot compares user inputs related to mental health questions to predefined responses, ensuring effective interaction. The study analyzed NLP techniques used in the Mental Ease mobile app, including word embeddings, sentiment analysis, sequential modeling, and attention mechanisms. The results indicate that these NLP techniques can be used to create an effective mental health chatbot that offers accessible and confidential support.

5. Post-discharge follow-up chatbots

Tang & Dai, (2023) studied the effects of follow-up and continuity of care among discharged patients with Colles' fractures. A total of 96 patients with Colles' fractures were randomly assigned to two groups. The control group received follow-up and guidance through traditional methods. In contrast, the intervention group used WeChat for continuous follow-up, incorporating, regular check-ins, and enhanced communication. The study found that integrating WeChat into the follow-up process improved the follow-up rate, patient satisfaction, and continuity of care. For patients discharged from hospitals with Colles'

fractures, the WeChat-based follow-up systems offer a beneficial approach that should be promoted for effective communication between patients and doctors and better clinical outcomes.

6. Health Insurance guidance chatbots

Kirchhoff et al., (2022) conducted a pilot intervention to improve health insurance literacy rates and reduce financial toxicity among adolescents and young adults. This population often expresses concerns about costs and feels underinformed about insurance, which can hinder their ability to navigate the healthcare system and manage expenses. The study employed a randomized controlled trial to evaluate a virtual health insurance navigation intervention using a chatbot named CHAT. The chatbot aimed to enhance health insurance literacy and knowledge, increase awareness of insurance coverage, and reduce financial stress. The content included information on understanding insurance, navigating insurance plans, relevant insurance laws, and managing care costs. Eligible participants had access to a wireless device for the intervention. The study assessed the feasibility and effectiveness of CHAT compared to usual care, measuring outcomes like insurance confidence, insurance knowledge, and copayments. At follow-up, CHAT participants demonstrated improvements in insurance requirements compared to those receiving usual care. However, while CHAT improved outcomes more than usual care, it did not significantly affect costs.

7. Chronic disease management chatbots

Chaix et al., (2020) developed a chatbot named Vik to help patients with chronic disease. Vik is an easy-to-use chatbot that simulates human conversation via text or voice on a smartphone or computer. In terms of health, it can improve patient information, follow-up, or treatment adherence. Dedicated to disease tracking and patient support, Vik provides guidance on managing chronic diseases and offers a secure platform for cancer patients and their relatives through private messaging. By using NLP models, Vik interacts with patients to provide support and information. In conclusion, chatbots like Vik can help patients with minor health problems without the need for an actual doctor's visit.

Conversational agents in medical education (ophthalmology)

SiOph_chatbot was developed to provide initial consultation to new medical graduates and practicing physicians on the basic care of ophthalmology patients before referring them to an ophthalmologist. It serves as a knowledge management tool, consolidating various pieces of scattered medical knowledge. In this context, tacit knowledge is transformed into explicit knowledge and stored in a wisdom repository. (Srikong et al., 2023) By integrating AI into medical education, the chatbot management system supports practicing physicians using NLP. The conversation history between the chatbot and the medical practitioner is recorded through text input. The system simulates human-like communication to train the AI chatbot, enhancing its ability to understand and connect information by matching the intent of the messages according to the symptoms presented. This intelligent automation system helps the AI learn and improve over time. AI technology is a valuable tool for accessing knowledge, and making processes more efficient, convenient, and faster, while supporting continuous learning throughout life (life-long learning).

Conclusion

Conversational agents and NLP are transformative technologies revolutionizing the medical field. They improve the diagnostic process and increase the efficiency of healthcare delivery. Improving clinical skills through these technologies can lead to better healthcare learning outcomes, preparing professionals for future challenges. Future developments in conversational agents and NLP may include integration with virtual reality (VR) and augmented reality (AR), combining AI-powered conversational agents with immersive technologies to create realistic simulations and experiential learning environments. While these technologies offer significant benefits in the medical field, their accuracy, reliability, and validity must be carefully considered. Additionally, privacy and security concerns should be addressed to protect sensitive data and ensure the ethical use of AI.

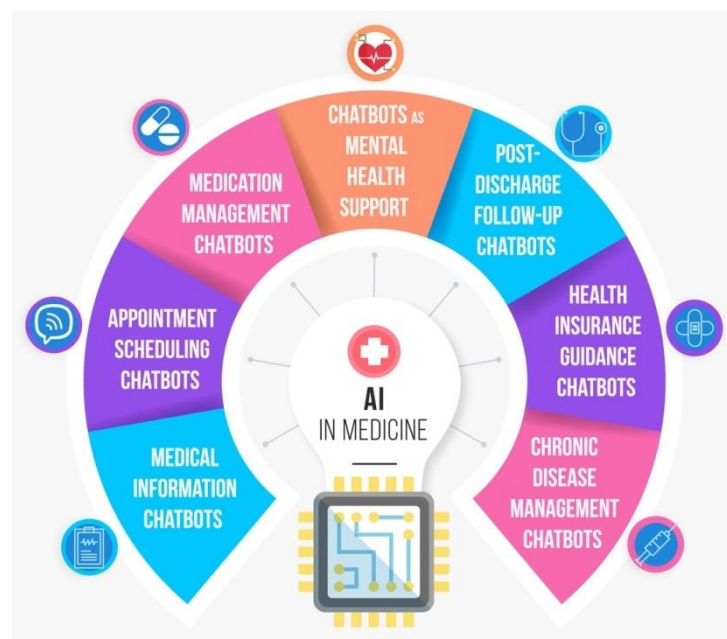


Figure 2: Applications of AI in medical concepts

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