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MODERN CHATBOT TECHNOLOGY: CURRENT APPLICATIONS AND FUTURE DIRECTIONS

Abstract: This paper explores the transformative potential offered by chatbot tecŠology across industries, with a focus on its impact, challenges, and future directions. The study employs qualitative analysis of chatbot use cases, current applications, and advancements in natural language processing. Results indicate that chatbots are effective in automating repetitive tasks, providing personalized interactions, and improving accessibility to services. However, challenges such as limited natural language understanding, multilingual capabilities, and data dependence remain unsolved. Emerging solutions, including explainable artificial intelligence, context-aware designs, and integration with large language models, promise to address inherent limitations of chatbots, and enhance chatbot reliability and scalability to support innovation, revolutionize numerous industries, and finally become indispensable comprehensive tools in the digital economy.

Keywords: Chatbot, chatbot applications, natural language processing, large language models, context-aware chatbot.

INTRODUCTION

The advent of chatbot tecŠology has had a profound impact across a range of industries, altering the manner in which organisations engage with users, oversee operations and provide services. By capitalising on advances in natural language processing and artificial intelligence, chatbots are facilitating operational efficiency and enhanced user engagement across a range of sectors,

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including customer service, e-commerce, healthcare, banking and education. Despite the growing prevalence of chatbots, the adoption of these tecŠologies continues to face significant challenges. The limitations of natural language understanding, multilingual capabilities, and emotional intelligence impede the ability of chatbots to deliver consistent and reliable experiences and impact user trust and acceptance. This paper aims to provide an overview of the current applications, challenges and future opportunities of chatbot tecŠology, with the intention of offering a constructive contribution to the ongoing discussion on this topic. By examining use cases and developments in conversational artificial intelligence, this paper aims to demonstrate how modern chatbot tecŠology could potentially address some of the operational inefficiencies that have been identified. The study suggests that chatbots have the potential to drive innovation and reshape the global market.

WHAT INDUSTRIES BENEFIT MOST FROM CHATBOT DEVELOPMENT?

Chatbot tecŠology demonstrates significant potential across diverse industries, such as customer service and e-commerce, healthcare domain, finances, human resources, education and government services. The integration of chatbots enables businesses to efficiently handle high volumes of interactions. By automating routine tasks and offering personalisation at scale, chatbots have become indispensable tools for modern businesses looking to meet growing consumer expectations.

In the field of customer service, chatbots can be of great assistance by providing immediate, consistent, and 24/7 support. By effectively managing repetitive enquiries, they have the potential to significantly reduce response times while relieving human agents from repetitive tasks (Vasquez-Correa et. al., 2021). This balance between automation and human expertise aims to provide an enhanced customer experience and optimise workforce utilisation. The e-commerce sector uses chatbots to shape the concept of personalised shopping. They can assist customers with product recommendations, answer questions in real time and simplify transaction processes. These features facilitate smoother purchasing and increase customer satisfaction. Post-purchase chatbots provide personalized support, such as managing returns or tracking orders, which may further strengthen customer loyalty and engagement (Hu et. al., 2018).

Chatbot applications have the potential to transform healthcare by enhancing patient engagement. They can assist with a number of tasks, including patients'

triage, appointment scheduling, medication reminders, and providing analysis of symptoms, which may help to make healthcare more accessible for patients (Manik et. al., 2021). Through empathetic interactions, chatbots also have the potential to deliver mental health support and educational content, which could help patients better understand their conditions and treatment options (Hu et. al., 2018). In times of crisis, such as the pandemic, chatbots have proven to be an invaluable resource, disseminating accurate and timely information to large populations, and reducing the burden on healthcare professionals. Their ability to operate 24/7 ensures consistent support, while their efficiency in handling routine inquiries allows medical staff to focus on more critical cases.

Chatbots have become integral to modern banking and financial management. They improve banking services by managing a wide range of tasks, from handling account inquiries to detecting and alerting users about potential fraud (Hu et. al., 2018). Their ability to provide instant transactional support ensures a seamless customer experience, enhancing convenience and accessibility for users. Chatbots also play a big role in fraud detection, using advanced algorithms to monitor transactions in real time and notify users of suspicious activities. This proactive approach enhances user trust while improving the overall security of financial operations. Additionally, their continuous availability ensures that customers receive reliable assistance at any time, reducing dependency on traditional customer service channels.

In human resources departments, chatbots have revolutionized the recruitment process. They simulate interviewers by preliminary resume screening. They also realize initial candidate evaluation employing advanced features like active listening to assess candidates effectively (Xiao et. al., 2020). Additionally, chatbots facilitate better candidate experiences by providing instant responses to queries, scheduling interviews, and offering updates on application statuses. This automation allows HR teams to ensure that recruitment processes remain concise and fair. Chatbots have become essential tools for modern HR operations, bringing efficiency and improving overall candidate engagement.

The education sector benefits considerably from the introduction of chatbots. They contribute to offering personalised learning experiences and acting as virtual tutors. Adaptive tutoring platforms powered by chatbots have the potential to support learners with varying skill levels, providing personalized content and support to enhance individual learning outcomes (Finch et. al., 2023). In addition, chatbots can also be of help with administrative tasks, such as responding to queries about schedules, deadlines and course requirements, thus

facilitating communication between institutions and students. It seems fair to say that chatbots have become an indispensable part of modern online learning environments, making education more accessible and interactive.

In the government sector, chatbots are gradually transforming citizen engagement and service delivery by providing instant access to information. They can assist with a number of different tasks, including sharing updates, guiding users through form submissions and addressing common queries (Hu et. al., 2018). By making use of conversational artificial intelligence, government agencies are able to provide interactions that are accessible and user-friendly, which in turn allows citizens to navigate bureaucratic procedures with greater ease. These chatbots support transparency in public services. It is becoming increasingly clear that chatbots have the potential to play a significant role in modern governance, thanks to their ability to simplify complex processes and enhance communication disseminating administrative information.

Chatbots have also become versatile tools in industries like tourism, entertainment, and social care, enhancing user experiences. In the tourism industry, chatbots assist with personalized travel planning, offering recommendations, booking assistance, and real-time updates to ensure effortless journeys (Suryanto et. al., 2023). In the entertainment and gaming sectors, chatbots create engaging experiences by delivering conversational narratives and dynamic interactions (Hu et. al., 2018). They add depth to user engagement, transforming entertainment into immersive and interactive experiences. It is also worth noting that social robots with chatbot tecŠology can provide companionship, which could be particularly beneficial for the elderly, fostering social interaction in smart environments (McTear, 2020).

These applications demonstrate the potential for chatbots to enhance accessibility, interactivity and user satisfaction in a variety of fields. To provide a comprehensive overview, all discussed use cases are summarized, categorized by industry and their specific application, as presented in Table 1. The industries are ordered by the prevalence and recognition of chatbot tecŠology within them, offering a clear perspective on the versatility and impact of this tecŠology across various domains.

KEY CHALLENGES IN MODERN CHATBOT TECHNOLOGY

The deployment of chatbot tecŠology is subject to several tecŠical and operational challenges, which affect its overall performance and, in turn, limit its

usability and user satisfaction. One significant challenge is the ability to process natural language, which is an area that still requires further development. It has been proved that the varying sentence structures encountered by chatbots have an impact on the quality of user interactions (Finchi et. al., 2023). Another important operational challenge is the need for large, high-quality datasets, which presents certain difficulties in terms of scalability and data requirements. All these challenges are discussed subsequently below.

Table 1. Chatbot applications across industries

Industry	**Application use cases**
Customer service, e-commerce	Automating customer interactions, FAQs handling, resolving queries, reducing wait times, improving 24/7 service, order tracking, assisting in product recommendations, transaction facilitation, enhancing customer engagement
Healthcare	Patient interaction and support, symptom checking, mental health support, medical advice, appointment scheduling, diagnosis support, drug prescription support, administrative tasks support
Banking and finance	Providing financial information, assisting with transactions, automating customer inquiries, fraud detection
Human Resources	Conducting candidate interviews, screening, supporting employee onboarding
Education	Personalized learning, addressing student queries, facilitating remote education, supporting learning by acting as tutors, language practice
Government	Public service information dissemination, assistance in form submissions, citizen queries handling

Source: Own elaboration.

A critical issue is the complexity of natural language understanding, where ambiguities and insufficient training data slow down the chatbot's ability to accurately interpret user intents, particularly for morphologically complex languages (Kapočiūtė-Dzikienė, 2020; Manik et. al., 2021; Pawlik et. al., 2022). This challenge is compounded by the difficulty in maintaining tone and context awareness, as current systems often fail to generate responses that align with the emotional and contextual needs of users (Hu et. al., 2018). Moreover, chatbots often struggle with natural language complexities such as idioms, sarcasm, and ambiguous user inputs. This issue is particularly present in multilingual contexts where cultural and linguistic nuances vary significantly, therefore, Chakraborty (Chakraborty et. al., 2023) emphasizes the need for chatbots to address language comprehension biases.

Furthermore, many chatbots encounter limitations in their multilingual capabilities, where support for low-resource languages remains sparse, reducing the global applicability of chatbot systems (Kapočiūtė-Dzikienė, 2020). Moreover, out-of-scope intent detection remains a persistent issue, leading to difficulties in managing queries that fall outside predefined domains (Manik et. al., 2021; Schild et. al., 2022). This is further augmented by the lack of robust error handling and recovery mechanisms, which diminishes user trust when misclassifications occur (Finch et. al., 2023).

Another challenge that remains is the integration of text, voice and visual inputs, which is a complex task. There is room for improvement in these areas to enhance chatbot adaptability and ensure a more intuitive user experience (Chakraborty et. al., 2023). Seamless multimodal interaction is still underdeveloped in commercial chatbots.

The development of chatbots also requires extensive data resources, which can present challenges in terms of scalability and data requirements, particularly for domain-specific applications (Nuruzzaman & Hussain, 2018). Furthermore, there are logistical and tecŠical challenges involved in scaling chatbot solutions while maintaining their performance and updating them with new data or features. Niederer et. al. (Niederer et. al., 2023) and Suryanto (Suryanto et. al., 2023) highlight the difficulties in maintaining chatbots as they grow in complexity.

It is often challenging to apply personalisation efforts due to the limited integration of user-specific data, which makes it difficult to deliver tailored responses (Sidlauskiene et. al., 2023). Additionally, chatbots often lack dynamic and adaptive learning capabilities, preventing them from evolving with user needs over time (Finch et. al., 2023). Moreover, it is worth noting that maintaining context over long conversations and across multiple user interactions represents a persistent operational challenge. Finch, et. al. (Finch, et. al., 2023) as well as Suryanto (Suryanto et. al., 2023) have identified context-awareness as a critical factor for successful chatbot applications.

Security and privacy concerns are of major importance, given that chatbots handle sensitive user data. It is therefore necessary to implement stringent safeguards to prevent misuse or breaches (Hu et. al., 2018; Finch et. al., 2023). The lack of transparency in AI-driven decision-making processes also raises concerns about trust and transparency. Users are less likely to trust systems that operate in a manner of a “black box” that is opaque, as opacity is a significant barrier to trust (Vasquez-Correa et. al., 2021). Furthermore, ensuring user data privacy and secure handling of sensitive information represents a significant

challenge, particularly in industries such as healthcare and finance. Chakraborty (Chakraborty et. al., 2023) especially highlights the ethical concerns surrounding data usage in medical chatbots.

Addressing these presented challenges requires a combination of advanced tecŠological solutions, ethical considerations, and user-centred design approaches.

OPPORTUNITIES AND FUTURE TRENDS IN CHATBOT DEVELOPMENT

Several significant future trends emerge in chatbot tecŠology. These trends reflect advancements in natural language processing, deep learning architectures, and evolving user needs, offering a comprehensive roadmap for the development of conversational artificial intelligence.

Enhanced Context Awareness

Context-aware chatbots will evolve to understand not just the immediate conversation but the broader context of user interactions. This includes multi-turn dialogues and memory-augmented systems that provide continuity across interactions (Nuruzzaman & Hussain, 2018; Finch et. al., 2023; Niederer, Schloss & Christensen, 2023). Advances in natural language processing are enabling chatbots to deliver highly personalized interactions by adapting to individual user preferences, behaviours, and histories. This trend aligns with broader shifts toward user-centric design in artificial intelligence systems (Sidlauskiene et. al. 2023).

Emotionally Aware Chatbots

Emotional intelligence in chatbots is anticipated to be a key area of innovation. These systems will be designed to understand and respond to users' emotions, leading to more empathetic and engaging interactions. This advancement is especially promising in fields like mental health and customer support (Chakraborty et. al., 2023; Pawlik et. al., 2022; Su & Xie, 2022). Future chatbots will prioritize personalization and emotional awareness to enhance user engagement and satisfaction. Chatbots will combine advanced natural language processing tecŠiques and sentiment analysis to understand and respond to users' emotional states effectively. This includes the integration of tone-awareness and

empathetic responses, as explored by Hu (Hu et. al., 2018) in tone-aware systems for customer care.

Multilingual and Cross-Cultural Competence

It is anticipated that the development of multilingual chatbots capable of handling morphologically diverse languages will facilitate communication across linguistic barriers. These systems will incorporate advanced models like Bidirectional Encoder Representations from Transformers (BERT) and convolutional neural networks (CNN) for intent detection in complex linguistic contexts (Kapočiūtė-Dzikienė, 2020; Su & Xie, 2022). Future developments will likely include enhanced multilingual capabilities, enabling chatbots to supply to a global user base effectively.

Integration with Large Language Models

The adoption of generative language models, such as generative pre-trained transformer (GPT) variants, will further enhance chatbots' ability to produce creative and contextually relevant responses. The utilization of large language models (LLMs) like ChatGPT for dialogue behaviour detection and understanding conversational nuances will expand. Such integration will allow chatbots to handle a broader range of queries and provide more nuanced responses, moving closer to human-level dialogue capabilities (Finch et. al., 2023; Finch et. al., 2023). This trend is particularly impactful in education, content creation, and marketing.

Integration with Internet of Things

The integration of chatbots with Internet of Things (IoT) devices is a growing trend. Chatbots are being integrated into IoT ecosystems, enabling conversational interfaces for smart homes, healthcare wearable devices, and other IoT applications. This expansion facilitates interactions across interconnected devices (McTear, 2020). Chatbots will act as intermediaries between users and their smart environments, allowing control over IoT systems through natural language commands (Suryanto et. al., 2023). Chatbots are expected to transition from static tools to dynamic collaborators capable of real-time problem-solving (Chakraborty et. al., 2023), and their integration into IoT ecosystems

further extends their utility, enabling natural language voice control over smart environments.

Knowledge-Driven Chatbots

The incorporation of knowledge graphs and ontologies (structured representations of data that show relationships between entities along with defined categories, properties, and rules of these relationships) to create knowledge-based chatbots will enable chatbots to provide factually accurate and context-aware responses (Manik et. al., 2021). Chatbots will increasingly incorporate voice recognition and multimodal interaction capabilities, such as combining voice, text, and visual interfaces. This evolution is expected to enhance accessibility and usability across different user demographics (Schild et. al., 2022; Niederer et. al., 2023). The integration of knowledge graphs and external databases into chatbots is expected to improve their ability to answer complex queries and provide contextually relevant responses, enhancing their utility in specialized domains.

CONCLUSIONS

The future of chatbot tecŠology lies at the intersection of addressing current challenges and seizing transformative opportunities. Resolving limitations such as context awareness, emotional intelligence, and privacy concerns will enhance chatbot reliability and user trust. Simultaneously, leveraging large language models and domain-specific optimizations will unlock new applications and contribute to innovation across industries. This approach establishes modern chatbot tecŠology as a fundamental component of contemporary digital interactions.

Advancements in natural language processing and large language models are enabling chatbots to handle complex conversations and operate across multilingual contexts. However, rapid adoption of these tecŠologies brings significant challenges. Natural language understanding remains an important limitation, particularly in handling ambiguous or complex inputs and maintaining context over multi-turn conversations. Privacy and security concerns also require adherence to regulatory frameworks, such as GDPR and CCPA. Ethical issues, including biases in training data and a lack of transparency, risk undermining user trust and credibility.

Innovations are yet constantly addressing these challenges. Emotionally intelligent chatbots are enhancing empathy in interactions, while explainable artificial intelligence (XAI) approaches improve transparency and accountability. XAI ensures chatbot decisions and responses are interpretable, focusing on user trust and regulatory compliance. Hybrid architectures combining rule-based systems with AI-driven adaptability are improving reliability and flexibility. Additionally, advancements in intent detection and context awareness are improving chatbot accuracy and coherence across diverse applications.

Chatbots demonstrate transformative potential by adapting across industries, revolutionizing customer interactions, operational management, and service delivery. Addressing current limitations through research establishes them as indispensable tools in the digital age, reshaping industries and driving innovation in the worldwide market.

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TECHNOLOGIA NOWOCZESNYCH CHATBOTÓW: OBECNE ZASTOSOWANIA I KIERUNKI ROZWOJU

Streszczenie: W niniejszym artykule zbadano potencjał transformacyjny oferowany przez tecŠologię nowoczesnych chatbotów ze szczególnym uwzględnieniem jej wpływu, wyzwań i przyszłych kierunków rozwoju w różnych branżach. W badaniu wykorzystano jakościową analizę przypadków użycia chatbotów, bieżących zastosowań i postępów w przetwarzaniu języka naturalnego. Wyniki wskazują, że chatboty są skuteczne w automatyzowaniu powtarzalnych zadań, zapewnianiu spersonalizowanych interakcji i poprawianiu dostępności usług. Jednak wyzwania, takie jak ograniczone rozumienie języka naturalnego, biegłość wielojęzyczna i zależność od danych, pozostają nierozwiązane. Nowe idee, takie jak wyjaśnialna sztuczna inteligencja, architektury uwzględniające kontekst i integracja z dużymi modelami językowymi, obiecują rozwiązanie wewnętrznych ograniczeń chatbotów i zwiększenie ich niezawodności i skalowalności w celu wsparcia innowacji, zrewolucjonizowania wielu branż i ostatecznie stania się niezbędnymi wszechstronnymi narzędziami w gospodarce cyfrowej.

Słowa kluczowe: Chatbot, zastosowania chatbotów, przetwarzanie języka naturalnego, duże modele językowe, świadomość kontekstowa chatbota.