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A Comprehensive Survey of ChatGPT: Advancements, Applications, Prospects, and Challenges

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Abstract

Large Language Models (LLMs) especially when combined with Generative Pre-trained Transformers (GPT) represent a groundbreaking in natural language processing. In particular, ChatGPT, a state-of-the-art conversational language model with a user-friendly interface, has garnered substantial attention owing to its remarkable capability for generating human-like responses across a variety of conversational scenarios. This survey offers an overview of ChatGPT, delving into its inception, evolution, and key technology. We summarize the fundamental principles that underpin ChatGPT, encompassing its introduction in conjunction with GPT and LLMs. We also highlight the specific characteristics of GPT models with details of their impressive language understanding and generation capabilities. We then summarize applications of ChatGPT in a few representative domains. In parallel to the many advantages that ChatGPT can provide, we discuss the limitations and challenges along with potential mitigation strategies. Despite various controversial arguments and ethical concerns, ChatGPT has drawn significant attention from research industries and academia in a very short period. The survey concludes with an envision of promising avenues for future research in the field of ChatGPT. It is worth noting that knowing and addressing the challenges faced by ChatGPT will mount the way for more reliable and trustworthy conversational agents in the years to come.

Keywords

Large Language Models (LLMs); Generative Pre-trained Transformers (GPT); Natural Language Processing (NLP); Contextual Learning; Trustworthy Conversational Agents; Human-Computer Interaction; ChatGPT

1. Introduction

The groundbreaking development of artificial intelligence (AI) and natural language processing (NLP) has led to the evolution of progressively intelligent and skilled language models referred to as Large Language models (LLMs) [1]. Based on a specific class of AI (generative AI), the LLMs can create brand-new information founded on patterns and structures learned from existing data and enable machines to understand and generate human language [2]. Among the most influential LLMs, the Generative Pre-trained Transformer

(GPT) developed by OpenAI and its variant, ChatGPT, have emerged as a powerful tool for their language generation capabilities and a broad range of applications particularly in conversational contexts [3].

LLMs and ChatGPT represent the latest technological advancements in natural language processing (NLP), a field dedicated to machine-based human language understanding and generation [4]. Traditional NLP systems require large labeled datasets for each specific task, making it impractical and costly to develop models for every application. The basis of ChatGPT lies in the development of the transformer architecture by addressing the challenges of data scarcity and expensive supervised learning [5]. Pre-training, on the other hand, invests a huge quantity of raw, unlabeled text data to train a language model in an unsupervised mode. This procedure involves anticipating the next word in a sentence given the context of previous words, which allows the model to acquire rich representations of language and its inherent structures. One of the crucial works in Language Model Pre-training is the first appearance of Embedding from Language Models (ELM) [6]. ELM presents context-sensitive word embedding, providing important advancements in several NLP tasks.

The evolution of GPT was motivated by the goal of appointing a highly refined and skilled AI language model capable of assisting in diverse tasks, including data analysis, data translation, and text generation. The discovery came with the unveiling of the GPT model [7], which demonstrated the potency of Transformer-based pre-training for language and contextual tasks. It was planned to get over many of the limitations of former sequence-to-sequence models for natural language processing, such as convolutional neural networks (CNNs) and recurrent neural networks (RNNs) [8–11]. This groundbreaking advancement led to the creation of a powerful series of language models by OpenAI including GPT-1, GPT-2, GPT-3, and GPT-3.5 which served as a forerunner to ChatGPT [12–14] shown in Fig.1. Starting with GPT-1 as an original GPT demonstrated performance across a broad range of NLP standards and coherent text generation. Subsequently, GPT-2, an enhanced version of the model, was introduced [12], to further advance the edge of language generation and understanding. GPT-2 showed an unprecedented power to render consistent and contextually relevant text. GPT-3, introduced in 2020 [13], is the most progressive variant of the model and a true LLM containing 175 billion parameters. This model demonstrated impressive capabilities, showing competence in natural language understanding, translation, generation, and even solving complex reasoning tasks. GPT-3's skillfulness made it a transformative technology, leading to diverse functional applications and inspiring the beginning of specialized variants, including ChatGPT [15–22]. The ChatGPT, founded on the GPT-3.5 [14] architecture is explicitly designed for interactive and dynamic conversations as shown in Fig.1. It is an adapted version of the GPT-3 model released by OpenAI in 2020. GPT-3.5 is a smaller variant of GPT-3, with 6.7 billion parameters compared to GPT-3's parameters. Compared to earlier models, ChatGPT boasts several key improvements and innovations, including enhanced context understanding, reduced biases, and fine-tuning capabilities. While not flawless, this evolution underlines AI's journey towards more refined and contextually aware language generation models.

Stacked upon the transformer architecture proposed by Vaswani et al. (2017) [21], GPT invests self-attention mechanisms to model long-range dependencies within chronological sequence promptly. The GPT model's training process involves pre-training a multi-layer transformer decoder on a massive corpus of unlabeled text data using the language modeling objective as shown in Fig. 2. This enables the model to predict the next word in a sentence based on its context, leading to a deep contextual understanding of language. ChatGPT acquires the characteristics of the GPT architecture but is fine-tuned using Reinforcement Learning from Human Feedback (RLHF) [22] to stand out in creating human-like responses in conversational engineering. The fine-tuning procedure of ChatGPT is concerned with the exposure of the model to conversations, where human AI trainers play both the user and an AI assistant role. The AI trainers supply conversational prompts and quantitative ratings for the model's rendered responses, allowing it to acquire learning from feedback and iteratively generate human-like responses to user queries. With an effort to add improvements to model architecture, OpenAI releases the GPT-4, a multimodal [23] approach that can accept image and text inputs and produce text output. Although the precise architectures for ChatGPT and GPT-4 have not been released (source code is not available), While particular inside information about GPT-4's training continues unrevealed, it is a transformer-based multimodal model trained on diverse data sources, both public and licensed. GPT-4's reinforcement learning process based on RLHF involves training an initial policy model, followed by adversarial training to modify its defense against misleading inputs. Skilled evaluators from various domains evaluate them with reduced tendencies to provide harmful, evasive, or inaccurate responses, making them more reliable and secure in generating text [24].

The applications of ChatGPT underscore its capability to adapt to diverse conversational styles and contexts, positioning it as a potentially versatile tool capable of reshaping human-machine interactions and providing substantial advantages across numerous real-world contexts [25–35]. Meanwhile, ChatGPT does exhibit certain limitations. It may sometimes produce plausible but incorrect outcomes, emphasizing the demand for achieving consistent and accurate interactions. In addition, like other LLMs, ChatGPT can exhibit biased behavior, highlighting the ethical concerns encompassing the use of such models. However, ethical considerations, potential biases, and accuracy challenges warrant further research to improve the model's performance and ensure responsible deployment [35–40]. We have presented the comparison of various LLMs in Table 1 and the comparison of GPT with ChatGPT in Table 2.

This survey paper serves as a summary of the current major applications of ChatGPT, its advantages, and limitations, and discusses potential future research directions to enhance and extend the capabilities of this revolutionary technology. As this is a rapidly evolving field, we must note that this survey cannot cover all aspects of current ChatGPT literature. In this survey paper, we present various contributions that can further guide researchers to better interpret ChatGPT. Some of the major contributions are listed below:

- We provided a comprehensive introduction to the background and the revolutionary process of ChatGPT creation for current real-world scenarios

and highlighted the generation pattern of ChatGPT with accompanying AI technologies.

- We elaborated detailed insights about various applications for which ChatGPT could be the most suitable AI model to serve.
- In parallel to the many prominent advantages, we highlighted key limitations, the existing challenges, ethical issues, controversies, and future direction.

To accumulate a comprehensive overview of ChatGPT's advancements, applications, prospects, and challenges, an extensive search strategy was implemented for this survey paper. The strategy focused on the latest publications from the past four years and used Google Scholar as the primary search engine. Keywords such as 'large language models' and 'ChatGPT variants' were employed to refer to relevant research papers. Additionally, the search explored future trends and potential applications of ChatGPT, particularly in the domains of recent technologies and medical imaging. This search approach aimed to gather a well-rounded body of literature encompassing the evolving viewpoint of ChatGPT, ensuring the survey's relevance and breadth.

2. Current Applications of ChatGPT

ChatGPT, a differentiated version of the GPT model, has tremendous use in almost every real-world scenario and its respective applications due to its significant language generation power some are presented in Table 3. We will discuss some of the possible applications where ChatGPT is aiding human efforts to advance the use of technologies and enlist the order of discussed points in Fig. 3.

2.1. Customer Support and Service

One of the most prominent applications of ChatGPT is in customer support and service. By investing its language understanding pre-trained knowledge, ChatGPT offers round-the-clock support as a virtual assistant, reducing the need for human intervention. Businesses have grasped ChatGPT as a representative to assist by conversationally engaging with customers to answer frequently asked questions, offering information about products and services, and resolving common issues [6]. The model's adaptability to various user queries allows for personalized responses, creating a more engaging customer experience that results in better customer satisfaction, improved response times, and overall user experience [12].

One of the key benefits of ChatGPT in customer support is to reduce functional costs for businesses [13] with its ability to reduce the workload of human representatives in customer service. Regular and repetitive queries can be expeditiously answered by ChatGPT, releasing manpower to focus on more analyzable content that involves human intervention. For smart work and quick response to manage the time limitations in sensitive scenarios, ChatGPT makes use of previous conversations and user data, and accordingly tailors its responses to individual customers, resulting in a more personalized customer experience. This strategy of personalization enables a sense of relation and commitment, driving customer satisfaction and ownership [14]. ChatGPT's scalability to handle a large number of queries makes it a valuable way to manage increased customer demands during marketing

campaigns during peak hours for businesses. Due to its multi-tasking nature, multiple users simultaneously interact with ChatGPT without long waiting times. Regardless of language preferences, businesses can extend their customer support services to users worldwide with the multilingual capabilities of ChatGPT. For global outreach, businesses can offer customer support in multiple languages to better cater to the diverse customer base leading to improved customer satisfaction [16]. ChatGPT receives valuable feedback and ratings on the quality of its responses by revealing the model to have conversations with AI trainers who play both the assistant and user roles. This feedback loop helps polish the model and boosts its ability to generate contextually befitting and accurate responses [17].

2.2. Personal Assistants

ChatGPT with its multifaceted role gained popularity as a virtual personal assistant, offering users a smooth way as they would with a human assistant to interact with smart devices and applications through natural language. Users can engage with ChatGPT to schedule appointments set reminders, read news, control smart home devices, and send messages. This near-to-natural physical phenomenon fosters a user-friendly experience for routine daily tasks [18,19] such as creating to-do lists, scheduling appointments, managing calendars, and sending emails streamlining users' schedules and reducing cognitive load [20].

As a knowledgeable assistant to share information, ChatGPT is a valuable resource to serve as a repository of vast information. ChatGPT can swiftly offer explanations on various topics, find answers to user queries, and provide timely access to relevant knowledge [21]. ChatGPT's reading and understanding abilities enable it to comprehend lengthy texts and briefly summarize their key points. For saving users time and effort in information consumption, ChatGPT with its distinguished feature, enables users to request for interpretation of documents, articles, or news updates and receive summaries [22]. Investing perception from former interactions with users and based on individual preferences ChatGPT can offer personalized recommendations to users for the relevant restaurants, books, movies, and other tailored choices providing a personalized touch to every user [24].

2.3. Content Generation

Another area where ChatGPT has made significant contributions is content generation. The model stands out in writing reports, drafting emails, generating marketing materials, and even managing social media posts. To save time and effort in the creative process, writers and marketers have embraced ChatGPT to streamline their workflows and improve productivity by having an assistant for an initial draft in generating ideas and refining their work from ChatGPT [26].

ChatGPT's competence in rendering logical and contextually right material makes it a vital resource for content creators [27]. ChatGPT serves as a co-writer or creative collaborator with authors and writers to flash ideas and develop related opinions by providing creative prompts and expanding on user input [28]. In the marketing domain, ChatGPT's content generation capabilities enable them to focus on strategy and implementation while streamlining the creation of marketing materials. Regular and routine tasks such as creating

product descriptions, blog content, social media posts, and advertising have saved a lot of time and effort for marketers [29]. By adapting its responses based on user interactions, ChatGPT enriches the content discovery experience for users. It can suggest tailored content that resonates with individual users, leading to higher engagement and conversion rates [30] [31]. For businesses with global audiences, ChatGPT with its multilingual capabilities can create content in multiple languages enabling them to reach diverse markets with culturally relevant content [32]. By yielding imaginative content, ChatGPT enriches interactive narratives for storytelling experiences [33].

2.4. Language Translation

ChatGPT as a virtual translator demonstrated promising applications in language translation to help users translate specific contents or entire documents between various languages [33–35]. For breaking down language barriers and enabling global interactions, ChatGPT's multilingual capabilities facilitate smooth communication between individuals who communicate in different languages [36]. As an on-the-go language translation, ChatGPT enables users to have multilingual conversations in real-time, enhancing their understanding of various cultures [37]. ChatGPT's language generation capabilities enable it to produce translations with decent accuracy [38]. Language translation by ChatGPT bridges language gaps in several critical setups such as business meetings, political conversations, international conferences, and travel experiences [39]. ChatGPT is also discovered to be suitable for everyday language translation needs as it candidly handles informal language, including colloquial expressions and conversational language to assist users in translating informal messages, emails, and social media posts [40].

2.5. Education and Tutoring

In the field of education with its power to explain analyzable concepts in a user-friendly mode, ChatGPT has appeared as a valued virtual tutor [41–43]. As a study companion, ChatGPT assists students beyond conventional textbooks and materials in knowing hard topics and supplying them with additional explanations. Educational platforms and e-learning websites have integrated ChatGPT as a virtual tutor which can accommodate the learning pace and liking of individual students, making a more engaging and impressive learning environment. One of the primal advantages of ChatGPT in education is its competence in describing complicated concepts with step-by-step explanations to facilitate a better understanding of in-depth explanations and clarifications on difficult topics [44].

Being a virtual tutor, ChatGPT accommodates its instruction style and material to provide individual students' learning knowledge levels and preferences [43]. ChatGPT enhanced students' problem-solving skills and overall academic performance students by assisting them with assignments to provide quick guidance to suggest various approaches to solving problems [45]. Students can practice for conversations with ChatGPT using its multilingual capabilities to improve their grammar and vocabulary usage and have feedback for improvements [46]. ChatGPT has access to a vast repository of learning materials, hence incorporating ChatGPT into educational platforms can enable educational managers to recommend relevant books, articles, and resources to supplement students' learning journey and enrich their knowledge of various domains [47].

2.6. Creative Writing and Storytelling

Storytelling and creative writing are natural fits for ChatGPT's expertise. ChatGPT as a creative collaborative can generate brainstorming ideas for dramatic content, shape characters, and render plot lines for their tales [48–49]. ChatGPT's ability to generate imaginative content has also been used in interactive storytelling fields and games. By choosing adventure-style narratives, the user can participate in creating dynamic and personalized storytelling experiences, where the shape of the plot and characters are according to the user's taste and experiences [50]. ChatGPT excels in generating descriptive and immersive text in fiction and fan fiction writing [51–53]. Poets can use ChatGPT to enrich their poems with a realistic variety of word selections, emotions, and characters to enhance the gross reading experience of their contents [54]. ChatGPT can be used to assist with screenwriting, songwriting, and even novel writing by providing suggestions and ideas for plot development, character development, and story structure. By examining data on famous genres and plot structures, ChatGPT can enable writers with personalized recommendations that can aid them in creating compelling scripts, songs, and content [55].

2.7. Mental Health Support

Because of the empathetic conversation format, ChatGPT has been tested as a virtual counselor and mental health companion, offering a range of supportive services to users facing various mental health challenges. A human can be bored and can't be a continuous listener but ChatGPT can't. As a virtual listener, it provides emotional support and sympathetic replies to user's queries. ChatGPT can provide an outlet for users to represent their thoughts and emotions by analyzing user input and responding with non-judgmental solutions [56]. As a knowledgeable compassionate assistant, ChatGPT can provide resources related to coping mental health strategies, information on mental health conditions, and self-help techniques [57]. ChatGPT can help users in carrying off anxiety and stress by offering mindfulness exercises, relaxation techniques, positive affirmations, and self-reflection exercises [58]. ChatGPT's language generation capabilities enable it to deliver therapeutic interventions based on evidence-based techniques for users to explore their thoughts and behaviors, fostering self-awareness, and gaining insights into their mental well-being [59] By providing cognitive-behavioral therapy (CBT), it can help users challenge irrational beliefs, re-frame negative thought patterns, and work on cognitive restructuring [60].

2.8. Code Writing and Programming

ChatGPT has shown significant promise as a tool to generate code and assist programmers in the field of writing and debugging code for software development. Leveraging its advanced language generation capabilities[61–63]. ChatGPT can be engaged to create code snippets based on natural language prompts or existing code contexts. This practicality can aid developers in rapidly writing boilerplate code and automatize repetitive coding jobs [63]. ChatGPT's language perceptive capabilities enable it to assess code syntax and find potential errors as a result generate error-free codes for the relevant tasks. By supplying instructive responses to coding mistakes, ChatGPT can help developers distinguish and find errors in their code [64]. ChatGPT can play an important role in refactoring, modifying,

and optimizing existing code by advising betterment and expeditious implementations. It can examine code snippets and suggest secondary formulations to raise code performance and understandability [65]. ChatGPT allows developers to handle complex functionalities through simple language questions with its powers of interacting in natural language query interfaces for APIs and libraries [66]. ChatGPT can cater to debugging assistance by helping professional programmers find and fix bugs in their lengthy codes. It can examine error notifications and give ideas for troubleshooting the problem when explained with a background scenario of the error to streamline the coding workflows and enhance code quality [67]. ChatGPT can be used to render code comments and documentation, raising the comprehensibility and maintainability of code bases [68].

2.9. Healthcare and Medical Assistance by ChatGPT

As a versatile medical assistant, ChatGPT is serving as a promising source of medical information in healthcare and medical assistance by retrieving data from esteemed medical databases and literature. As a virtual medical assistant [69], ChatGPT has been explored to assist healthcare professionals, individuals seeking medical information, and patients in staying updated with the current medical research and guidance, as well as educating patients about treatment options and medical conditions [70]. ChatGPT can be instrumented as a symptom checker to engage users in conversations to assess their symptoms and provide appropriate recommendations as a solution therapy. It can aid patients in determining the importance of their indications and guide them toward finding proper medical care [71]. ChatGPT can resource patients in managing their medicine by providing dosage instructions, reminders, and information about possible side effects. It can also speak about questions related to dose interactions and contraindications [72]. In component to physical health, ChatGPT is substantially offering mental health support by supplying mindfulness exercises, stress management techniques, and self-care tips [73]. ChatGPT can sum up medical reports and electronic health records (EHRs) allowing healthcare professionals to rapidly critique relevant information and patient histories [74]. Ongoing research can lead to fine-tuning many sophisticated language models for specialized medical domains to better understand medical contexts.

2.10. Legal and Compliance Assistance

The multifaceted role of ChatGPT has been explored as a virtual legal supporter, offering assistance in legal advice to individuals and professionals [75–80]. ChatGPT can help judicial professionals in administrating legal research by acquiring relevant statutes, legal documents, and case laws from reputable legal databases [81–87]. Its language apprehension abilities allow it to examine legal texts and help in case analysis, distinguishing relevant preceding and legal arguments. ChatGPT can assist in contract writing by creating standardized construction and templates founded on user inputs and legal requirements [88]. It can also provide reassessment for contracts, flagging possible legal issues and suggesting rectifications. ChatGPT can cater to compliance assistance by offering counseling on applicable policies, regulations, and industry standards [89]. ChatGPT can assist in intellectual property issues to help organizations navigate complex legal demands and guarantee adherence to compliance protocols by providing information on trademark, patent, and copyright laws [90]. Based on user requirements, ChatGPT can generate legal forms and

documents such as wills, leases, and power of attorney documents, and enable individuals to interpret the basics of intellectual property protection laws and rules for the appropriate resources [91]. As a natural language interface for legal databases, ChatGPT streamlines the procedure of document formulation for individuals seeking specific legal [92].

2.11. Medical Imaging and Radiology

In recent years, the integration of ChatGPT into the field of medical imaging has aided various sectors of healthcare by expediting clinical decision-making processes, streamlining workflows, and enhancing diagnostic accuracy. Within the domain of medical imaging and radiology, the utilization of ChatGPT has facilitated the interpretation of complex visual data and augmented the capabilities of medical professionals across multiple levels of data complexity: from the patient level to population health [41]. Working as an intelligent virtual assistant ChatGPT employs advanced natural language processing capabilities to enable seamless communication between clinicians, medical imaging datasets, and radiologists. ChatGPT oversteps the conventional boundaries of human-computer interaction by providing a new means of extracting valued insights from complex imaging data with its power to comprehend and reply to human language. These advancements help to introduce an interactive approach to medical image analysis, allowing healthcare practitioners to engage in significant conversations with the AI model to build and polish background knowledge for diagnostic processes.

Another potential use of ChatGPT in medical care is to develop chat-bots that can help with patient triage [121, 122], serving the medical providers to regulate the urgency of a patient's condition and the suitable course of action [42]. By examining the patient data and related symptoms of the hands-on problem, ChatGPT can supply healthcare providers with a second opinion for the appropriate recommendations to polish the disease diagnosis and treatment. ChatGPT can be used to study a large sum of clinical data, distinguishing patterns and directions that can be used to evolve new treatments and interventions [187]. ChatGPT is being used to generate and simplify common questions about diseases and disorders related to lung cancer [43], screening recommendations, and appropriate preventive suggestions for breast cancer[44].

3. ChatGPT's Pros and Cons:

While ChatGPT has proven to be an invaluable tool in providing support in many applications, as with any technology, it also comes with its set of advantages and disadvantages. Here, in this section we will delve into an extensive consideration of the current ChatGPT, focusing on its pros, cons ethical considerations, and potential future developments [93–96]. The pros and cons of current ChatGPT lightness the possible usage and challenges of innovative language models in real-world applications. Its context retention, natural language understanding, and adaptability substantially offer unprecedented opportunities for conversational AI. Critical current research and improvements are required to unlock the full perspective of language models like ChatGPT in shaping the future of artificial intelligence. Below we listed the most prominent advantages and disadvantages of ChatGPT also represented in Fig. 4.

3.1. ChatGPT Pros:

- **Natural Language Understanding:** ChatGPT stands out in knowing and generating human-like text. Its power to grasp context and provide logical responses makes it a valued AI tool for several natural language processing projects [97].
- **Accessibility:** ChatGPT lets individuals communicate with AI systems in natural language, removing obstructions for users without specialized expertise to pursue advanced technologies [78].
- **Versatility:** ChatGPT can be applied to a broad scope of applications, considering medical and health care, legal services, customer support, education, content generation creative writing, and more, demonstrating its skillfulness as a language model [63].
- **Time-Saving:** ChatGPT can streamline content creation and reply to queries quicker than human operators, which results in a reduction of response times with accelerated productivity [84].
- **Continuous Learning:** ChatGPT can be fine-tuned for particular areas or tasks, allowing professional developers, content creators, and programmers to tailor the model to be fitted for specific applications [95].
- **Language Translation:** ChatGPT can alleviate cross-lingual connection by rendering real-time translation services, bridging language understanding problems in global interactions [6].
- **Innovation Catalyst:** ChatGPT inspires invention in natural language processing exploration pathways and motivates the evolution of more refined language models [98].
- **Enhanced Learning Experiences:** In the educational framework, ChatGPT can provide individualized tutoring experiences with adaptability to adjust its responses to cater to personal learning styles [8].
- **Creative Collaboration:** ChatGPT can work with writers and artists, enhancing the power of creativeness and offering new orientations in the inventive process [99].
- **Mental Health Support:** ChatGPT has the prospective to provide resources for stress management, and to offer emotional support for mental wellness [101].
- **Context Retention:** ChatGPT earns the advantages of the transformer architecture, enabling it to keep contextual information all over the long sequences. This contextual representation alleviates coherent and context-aware results.
- **Transfer Learning and Fine-tuning:** ChatGPT can be pre-trained on sizable corpora and then fine-tuned for circumstantial tasks. This transfer learning model intensifies skillfulness and reduces the need for large task-specific training data.

- **Massive Scale Data Processing:** ChatGPT's training procedure can assist large-scale distributed computing resources to process large datasets, enabling it to acquire from immense amounts of text [102].
- **Multilingual Capabilities:** With multilingual pre-training and fine-tuning, ChatGPT demonstrates the potential to support diverse languages, fostering global accessibility.
- **Human-like Interactions:** ChatGPT's natural language understanding and generation capabilities make up the illusion of human-like communications, making it an attractive tool for conversational AI applications.
- **Adaptability to Domains:** For domain-specific data with fine-tuning, ChatGPT can accommodate specific tasks and supply custom-made responses, offering versatility in various areas.
- **Zero-shot and Few-shot Learning:** ChatGPT displays few-shot and zero-shot learning capabilities, empowering it to execute tasks without specific training, and showcasing its abstraction abilities [103].

3.2. ChatGPT Cons:

- **Limited Context Understanding:** In lengthy conversations, ChatGPT might struggle to grasp intricate contexts or maintain coherence, leading to occasional absurd or irrelevant outcomes [101].
- **Biased Outputs:** From the training data, language models like ChatGPT can acquire biases, possibly directing to biased responses or reinforcing existing social biases [104].
- **Misinformation Propagation:** ChatGPT may render results that come out to be plausible but are factually fallacious, unknowingly disseminating misinformation [105].
- **Lack of Real Understanding:** ChatGPT can sometimes mimic understanding while missing genuine comprehension, which might inadvertently result in misleading interactions with users [14].
- **Ethical Concerns:** The use of ChatGPT for deceptive purposes, like generating fake reviews or misinformation, raises ethical concerns [106].
- **Security Vulnerabilities:** Malevolent users may use ChatGPT's capabilities to yield harmful content or pursue social engineering attacks [16].
- **Privacy Risks:** Communication and information sharing with ChatGPT may record sensitive user information, leading to a latent privacy gap if not adequately handled [107].
- **Dependency on Training Data:** The choice and diverseness of training data can significantly affect ChatGPT's performance. Like other language models, ChatGPT can unknowingly preserve biases present in the training data, posing challenges to producing objective and unbiased responses [108].

- **Limited Contextual Understanding:** While ChatGPT can acquire contextual information, it may attempt to hold complex or multi-level, multi-turn conversations, leading to unpredictable consequent results that demand coherence [109].
- **Over-Reliance on Training Data:** Over-reliance on the quality and variety of training data significantly impacts ChatGPT's performance which leads to undesirable outputs [111].
- **Inability to Reason Causally:** ChatGPT's outcomes are founded on patterns learned from training data which may lack true causative reasoning, leading to potentially misleading outputs.
- **Dependency on Prompt Phrasing:** The preparation of user prompts can importantly determine ChatGPT's responses, making it delicate to tenuous variations in input phraseology [112].

Present-day ChatGPT implementations offer amazing capabilities and expose the potential for transformative applications. However, they are also contingent on associated challenges affiliated with contextual understanding, explainability, biases, and sensitivity to input formulation. Acknowledging these strengths and limitations is indispensable for the responsible and effectual deployment of ChatGPT, paving the way for further progress in natural language processing and conversational AI.

4. Ethical Considerations of Current ChatGPT

The widespread applications of language models like ChatGPT increase several ethical considerations that need to be cautiously sorted. As these frameworks become progressively sophisticated and are incorporated into diverse applications, it is necessary to measure their potential implications on individuals, society, and the overall AI ecosystem. This section investigates some of the fundamental ethical considerations connected with underway implementations of ChatGPT. The structure and order of the discussed points are shown in Fig. 5

- **Bias and Fairness:** One of the firsthand concerns with language models is the possibility of showing biased behavior in their responses. ChatGPT acquires its knowledge and intelligence from the huge quantity of data available on the internet, which may incorporate biases present in the original material. These biases can be evident in the model's outcomes and impart to unequal treatment or confirmation of stereotypes. Research investigation should focus on developing techniques to observe, find, and rationalize biases in ChatGPT's outputs, ensuring that it provides fair and evenhanded responses to all users, irrespective of their backgrounds [113].
- **Misinformation and Harmful Content:** As an AI language model, ChatGPT can render text as an output based on input received from users. This susceptibility instant the risk of generating misinformation, harmful advice, or malicious content. Steps should be taken to preclude the model from creating and spreading false information or engaging in noxious behavior. Applying

moderation and content filtering mechanisms can help trim the likeliness of improper responses and defend users from potentially harmful materials [114].

- **Privacy and Data Security:** Language models like ChatGPT often interact with individuals who require personal information to complete the query to be asked which may involve the exchange of highly sensitive information. It is critical to order user privacy and data security during these communications. Standards like data anonymization, end-to-end encryption, and differential privacy should be incorporated to protect user personal data and forbid latent data breaches or misuse [115].
- **Transparency and Explainability:** The lack of clarity and explainability in AI models is a momentous ethical concern regarding trust in conversational models. As ChatGPT becomes more omnipotent and surefooted in rendering complex responses, individuals may effort to understand how the model comes to its conclusions. Research directions should be developed to provide meaningful explanations for the model's responses enhancing transparency and user reliance in the AI system [116].
- **Human Displacement:** The combination of language models like ChatGPT into various routine task repetitive applications such as content generation, customer support, and other applications has the prospective to force out human workers. While AI can modify skillfulness and scale services, it may also lead to the track where job displacement and economic repercussions can be alarming issues for societies to handle. Ethical considerations should concern guaranteeing a proportion between human involvement in AI, advancing AI-human cooperation, and providing chances for upskilling and grooming for affected individuals [117].
- **Accountability and Responsibility:** Nowadays determining responsibility and accountability in the context of AI language models is a critical demand. As AI frameworks are trained on huge datasets and their conduct is influenced by user involvement through interactions, it becomes indispensable to set up responsibility for their actions. Research should focus on developing frameworks to construct accountability for the model's outcomes and finding distinct guidelines for professionals and users concerning the system's capabilities and limitations [118].
- **Consent and User Awareness:** Individuals interacting with ChatGPT may not always be aware of the fact that they are communicating with an AI system, particularly when incorporated into chat interfaces or client assistance platforms. Supplying broad disclosures about the use of AI and acquiring informed consent from users can assist in fostering clarity and ethical use of ChatGPT [119].
- **Cultural Sensitivity and Exclusivity:** Contrasting cultures and communities may have particular norms, sensitivities, and values that should be respected by language models, as they need to be culturally sensitive and comprehensive in their responses. Integrating cultural consciousness into the model's training

and evolution can assist in confronting unknowingly generating offending or insensitive content.

- **Dual-Use and Ethical Dilemmas:** Language models like ChatGPT have different potential applications such as cyberbullying or disinformation campaigns which can increase ethical dilemmas. Research proceedings should investigate ways to code this dual-use premise and lessen the potential antagonistic impact of AI-generated content [120].

Ethical considerations are of predominant value in the improvement and advancement of current ChatGPT systems. By proactively addressing and acknowledging these ethical concerns, developers researchers, and policymakers can seek to create AI systems that are not only compelling and efficient but also accountable, reliable, and aligned with human values.

5. Future Research Directions with ChatGPT

The uninterrupted progress of language models, exemplified by ChatGPT, has opened up future horizons for research and development in the field of conversational AI. This section delves into respective technical prospects and unique directions that can lead to further improvements in ChatGPT's abilities, suggest solutions for its current limitations, and drive the development of conversational AI systems.

- **Contextual Understanding and Dialogue Management:** Improvements in ChatGPT's contextual understanding and dialogue management are fundamental areas for forthcoming research. While ChatGPT has made substantial strides in generating coherent responses [19–21], there is an opportunity for upgrading in handling extended conversations and preserving context across multiple turns on multiple levels. Methods such as reinforcement learning [22] and memory-augmented architectures can be discovered to empower the model to retain and apply long-term context effectually. Furthermore, progressing conversational context entrenching and memory mechanisms can support in better understanding of user aims and producing more contextually appropriate responses.
- **Dynamic Prompting and Interactive Learning:** Uniting dynamic prompting and collaborative learning methods can enable users to keenly contribute to managing ChatGPT's responses. At present, users have restricted control over the model's production. By supporting dynamic prompting, users can affect the model's behavior in real-time, enabling communications more interactive and personalized. User feedback mechanisms along with adaptive prompts [130] can be explored to polish the model's replies and expand its performance over time through cooperating learning.
- **Multi-modal Integration:** A promising future direction is to mount ChatGPT's competencies far from text to include multi-modal inputs such as audio and images. Assimilating language with auditory and visual indications can lead to supplementary completeness and expressive interactions. This will empower

ChatGPT to comprehend and produce replies grounded not only on text but also on complementary graphical or audio information, making it more adaptable in real-world applications such as computer-generated assistants and content generation.

- **Transfer Learning for Low-Resource Languages:** While ChatGPT has established inspiring performance in English and other famous languages, there is a prospect to expand its efficacy in low-resource languages. Transfer learning practices can be leveraged to pre-train the model on resource-rich languages and then fine-tune it on restricted data from low-resource languages. This method can lead to improved simplification and variation for languages with incomplete training data, making ChatGPT available to a wider variety of language groups.
- **Responsible AI with Bias Detection and Fairness:** Ensuring fairness and mitigating biases in ChatGPT's responses is a critical ethical consideration. Future research should focus on advancing bias detection and fairness-aware training techniques to reduce biased outputs across different user groups. Additionally, implementing interpretability methods can provide insights into the model's decision-making process, enabling users and developers to understand and address potential biases effectively.
- **Controllable Language Generation:** Processing controllable language generation methods is primarily for permitting users to influence the style, specificity, or sentiment of ChatGPT's outcomes. Fine-grained abstraction over the model's responses can be attained through conditional decoding strategies or reinforcement learning. This will enable individuals to delineate the wanted characteristics of the generated content, making ChatGPT more skilled for several applications, including personalized content generation and creative writing.
- **Contextual Pruning and Memory Efficiency:** Optimizing the computational efficiency and memory of ChatGPT is critical for real-time and resource-constrained applications. Future research can explore techniques such as parameter sharing, contextual pruning, and model compression to cut down the model's size and enhance inference speed without compromising its performance.
- **Domain Adaptation and Specialization:** Investigating domain adaptation in specialized domains such as healthcare [123–130], finance, or legal services and specialized fine-tuning techniques can advantage can enhance the model's knowledge and relevance.
- **Privacy-Preserving AI:** As conversational AI models like ChatGPT deal with sensitive user data, assuring privacy becomes progressively crucial. Research should give advanced solutions for privacy-preserving techniques, such as differential privacy, to maintain confidentiality and protect user data during communications with the AI model [107, 115].

- **AI-Human Collaboration and Hybrid Models:** Encouraging AI with human cooperation and processing hybrid models that pool AI language models with human supervision can lead to much more reliable and risk-free outcomes. Human-in-the-loop frameworks permit humans to interact and guide the model's responses, especially in critical or sensitive situations, ensuring the prime quality and accuracy of responses [17, 22, 46].
- **Long-Range Dependency Handling:** Elevating long-range dependency management in language models is primary for better understanding complex sentences and conversational dialogues. Future research should investigate groundbreaking methods to address this challenge, enabling ChatGPT to keep a link and relevancy connection across lengthy conversations.
- **Federated Learning for Decentralized AI:** Following federated learning can alleviate decentralized AI while conserving data privacy and security. By training ChatGPT on data from various points without centralizing the data, the model can showcase increased performance through aggregated knowledge while regarding individual data privacy [96, 97].
- **Addressing Model Overconfidence:** Investigating approaches to sort out model overconfidence is critical to trim down the risk of rendering erroneous or misleading responses. Methods that promote uncertainty approximation and certainty calibration can amend ChatGPT's robustness and reliability.
- **Model Compression for Scalability:** One promising future avenue is the integration of model compression techniques for users employing resource-constrained devices or platforms to enhance efficiency and accessibility. Prospective research endeavors [131,132] could be dedicated to current ChatGPT's model compression approaches to strategically reduce the model's computational demands and size. These techniques can serve as a fundamental tool in refining the inference speed and memory necessities to facilitate the deployment of ChatGPT across a broader range of devices, ensuring smoother interactions and accessibility for users facing resource constraints.

The future research directions for ChatGPT span a range of technological challenges and possibilities. By following these research directions, developers can propel ChatGPT towards becoming a more skilled, efficient, and ethically accountable language model, with wide applications and impact in various domains.

Conclusion

As the landscape of conversational AI continues to evolve, the advancements in ChatGPT and similar models have significantly transformed human-computer interactions. ChatGPT has already made momentous contributions to progressing scientific research and has the latent potential to advance the technologies in the future. In this survey, we have explored the background, applications, advantages, limitations, ethical concerns, and future directions of ChatGPT. With an in-depth investigation, we have provided valued insights into the significance of LLMs, the transformative power of GPT models, and the distinctive

characteristics of ChatGPT in the area of conversational AI. The survey started by laying the basis with an introduction to LLMs, highlighting their crucial role in shaping the field of natural language processing. We explain the inherent principles of GPT models, focusing on their transformer-based architecture and the importance of contextual learning during pre-training, which gives ChatGPT its extraordinary language understanding and generation capabilities.

Furthermore, we analyze some of the present-day applications of ChatGPT, showcasing its skillfulness in diverse domains. While admitting the many benefits of ChatGPT, the survey also candidly addressed its limitations and respective challenges. We underscore the importance of promising research directions for forthcoming research to address the identified limitations and challenges. By addressing the demand and ethical concerns connected with its use, researchers can employ the abilities of AI responsibly to push the limits of human understanding and knowledge. Finally, this survey paper contributes to a deeper understanding of ChatGPT and provides a foundation for future research tasks. With continuous refinements and advancements in the capabilities of ChatGPT, we can approach to pave the way for a better future where conversational AI models like ChatGPT can improve human experiences and foster seamless human-machine collaboration.

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Figure:1.
Timeline for LLMs (2018–2023)

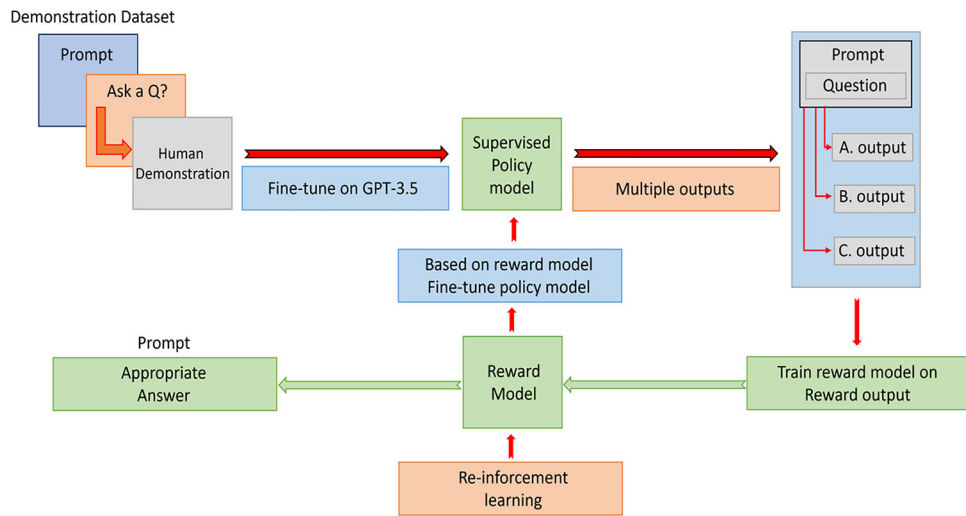


Figure 2:
Methodological work flow for the ChatGPT model

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Figure 3:
List of the current possible applications of ChatGPT

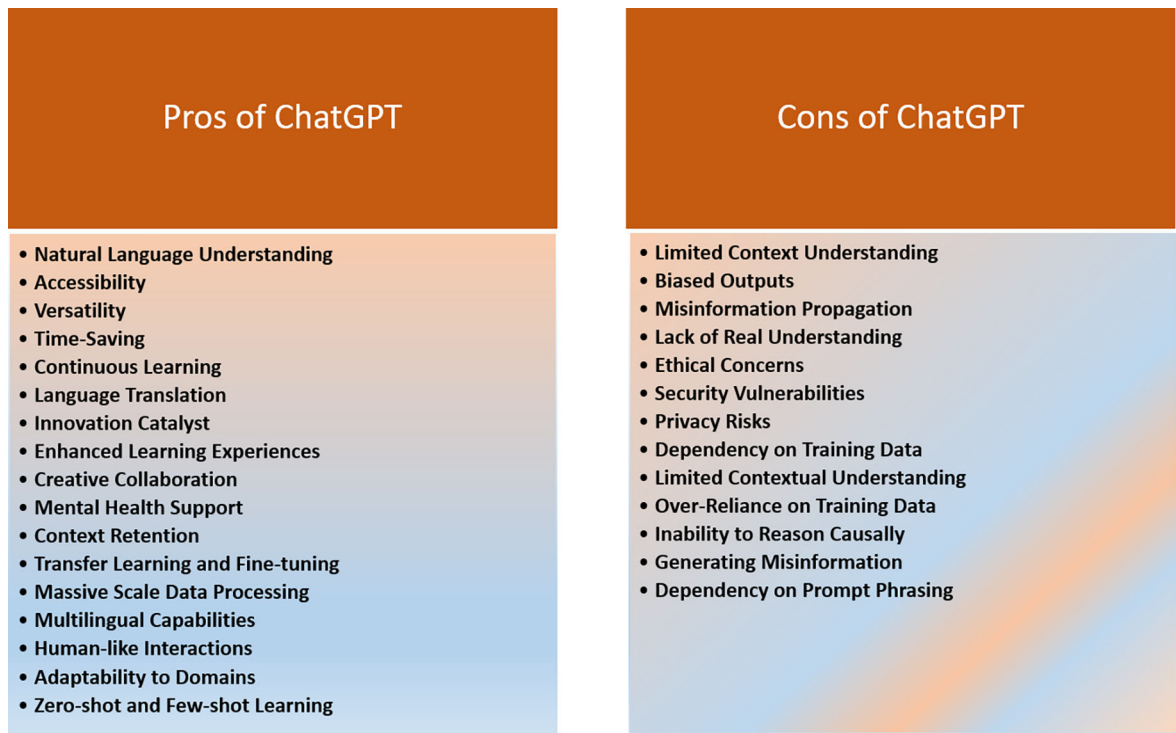


Figure 4:
Structure overview of the possible pros and cons of ChatGPT



Figure 5:
Structure overview of ethical considerations and future directions for ChatGPT

Table 1:

Comparison of famous LLMs 2018–2023

Model	Architecture	Parameters	Pretraining Data	Notable Features
GPT (2018)	large-scale Transformer model	110 million	Web text	large-scale Transformer model introduced as the first
GPT-2 (2019)	Transformer	1.5 billion	Web text	Improved Transformer model
GPT-3 (2020)	Transformer	175 billion	Web text, Books, Wikipedia	one of the largest models, capable of few-shot learning
GPT-J (2021)	Transformer	6 billion	Web text, Stack Exchange, ArXiv, PubMed, EuroParl, Books, Wikipedia, Common Crawl, Open Subtitles, Freebase	Released as a more accessible alternative to other large language models such as GPT-3,
GPT-Neo (2021)	Transformer	2.7 billion – 2.8 trillion	Web text, Books, Wikipedia, Common Crawl, Reddit, Pile	Open-source alternative to GPT
GPT-3 10x (2022)	Transformer	1.75 trillion	Web Common Crawl, Pile, text, Books, Wikipedia	A scaled-up version of GPT-3
BLOOM (2022)	Transformer	176 billion	13 programming languages, 46 natural languages	GPT-3 based multi-lingual corpus
ChatGPT-4 (2023)	Transformer	1.76 trillion	Supervised learning on a large dataset, then reinforcement learning using both human and AI feedback	More reliable, creative, and able to handle much more nuanced instructions than GPT-3.5

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Table 2:

Comparison of GPT and ChatGPT

Model	Architecture	Format of interaction	Applications
GPT (2018)	AI model with general mode for accessibility	Accessible through an API for providing on-demand intelligence	Implement semantic text understanding, Information search, and extraction, Used for extensive varieties of application developments, Making smart applications, Building co-pilot applications,
ChatGPT (2022)	A Chat-bot with Dialogue and conversation style accessibility	Interact with application users and perform tasks	Answers general questions, Provides assistance in code generation, Translation of languages, Language augmentation for higher reasoning, Productive applications, Idealization for content creation, Code debugging provisioning, speed and conciseness

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Table 3:

Comparison of achievements of ChatGPT w.r.t other tools

Field and testing year	Achievement	Tool with paper link
Jurisprudence/legal rulings,2023	ChatGPT helps a judge with a verdict (Colombia).	ChatGPT [103]
MBA,2023	ChatGPT would pass an MBA degree exam at Wharton (UPenn)	ChatGPT [105]
Japan: National Medical Licensure Examination (2023)	Bing Chat would achieve 78% [above the cut-off grade of 70%], ChatGPT would achieve 38%	Bing Chat [100]
Politic,2023	ChatGPT writes several Bills (USA).	ChatGPT [104]
Spanish medical examination (MIR),2023	Bing Chat would achieve 93%, and ChatGPT would achieve 70%, both above cut-off grade	Bing Chat [101]
Cover of TIME magazine,2023	ChatGPT made the 27/Feb/2023 cover of TIME magazine.	ChatGPT [102]
Accounting,2023	GPT-3.5 would pass the US CPA exam.	text-davinci003 [106]
Legal,2022	GPT-3.5 would pass the bar in the US	text-davinci003 [107]
IQ (Binet-Simon Scale, verbal only)	GPT-3 scores in 99.9th %.	Davinci [114]
IQ (fluid/aptitude), 2022	ChatGPT outperforms college students on the Raven's Progressive Matrices aptitude test	text-davinci003 [109]
Medical,2022	ChatGPT would pass the United States Medical Licensing Exam (USMLE)	ChatGPT [108]
SAT exam	ChatGPT scores 1020/1600 on SAT exam.	ChatGPT [112]
AWS certificate, 2022	ChatGPT would pass the AWS Certified Cloud Practitioner exam	ChatGPT [110]
IQ (verbal only), 2022	ChatGPT scores IQ = 147, 99.9th %	ChatGPT [111]
Reasoning	GPT-3 would pass the SAT Analogies subsection.	Davinci [116]
General knowledge	GPT-3 would beat IBM Watson on Jeopardy questions.	Davinci [113]
General knowledge	GPT-3 outperforms average humans on trivia.	Davinci [115]