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From bard to Gemini: An investigative exploration journey through Google's evolution in conversational AI and generative AI

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Abstract: The advent of artificial intelligence (AI) has significantly transformed various aspects of human life, particularly in information retrieval and assistance. This research presents a comprehensive evaluation of Gemini, previously known as Google Bard, a state-of-the-art AI chatbot developed by Google. Through a meticulous methodology encompassing both qualitative and quantitative approaches, this research aims to assess Gemini's performance, usability, integration capabilities, ethical implications. Primary data collection methods, including user surveys and interviews, were utilized to gather towards the qualitative feedback on user experiences with Gemini, supplemented by secondary data analysis using tools such as Google Analytics to capture quantitative metrics. Performance evaluation involved benchmarking against other AI chatbots and technical analysis of Gemini's architecture and training methods. User experience testing examined usability, engagement, and integration with Google Workspace and third-party services. Ethical considerations regarding data privacy, security, and biases in AI-generated content were also addressed, ensuring compliance with major regulations and promoting ethical AI practices. Acknowledging limitations and challenges inherent in the investigative exploration, data analysis was conducted using thematic and statistical methods to derive insights. The results and findings of this research offer valuable insights into the capabilities and limitations of Gemini, providing implications for future AI development, user interaction design, and ethical AI governance. By contributing to the ongoing discourse on AI advancements and their societal impact, this exploration facilitates informed decision-making and lays the groundwork for future research endeavors in the field of AI-driven conversational agents.

Keywords: artificial intelligence (AI); bard; ChatGPT; computer vision; deep learning (DL); Gemini; generative artificial intelligence (GAI); large language models (LLM); machine intelligence; machine learning (ML)

1. Introduction

In recent years, artificial intelligence (AI) has ushered in a paradigm shift in human interaction and problem-solving, notably through the proliferation of AI chatbots. These conversational agents, fueled by advanced language models, have become indispensable aids in a wide array of tasks, from answering inquiries to generating text and offering recommendations. Google's creation, initially named Bard and later rebranded as Gemini, stands as a prominent figure in this domain [1]. This research exploration embarks on an investigation into the evolutionary journey of AI chatbots, with a specific focus on Google's transformation from Bard to Gemini [2–6]. The transition from Bard to Gemini symbolizes a significant leap in AI technology, characterized by enhancements in functionality, user experience, and integration with various Google services. The inquiry aims to scrutinize the capabilities of Gemini, assessing its aptitude in furnishing users with precise and

pertinent information across diverse topics [7–9]. Additionally, it seeks to dissect the technological advancements and foundational AI models powering Gemini, juxtaposing them with other notable AI chatbots in the market. Moreover, the research endeavors to dissect the impact of Gemini on user interactions and information retrieval, contemplating its potential to supplant traditional search engines in select contexts [10–15]. Through the examination of user feedback, performance metrics, and real-world applications, the research endeavors to uncover insights into the efficacy and constraints of Gemini as an AI chatbot. This investigative exploration seeks to enrich the ongoing dialogue encompassing AI chatbots and their pivotal role in shaping the trajectory of human-computer interaction. By conducting a thorough analysis of Gemini’s evolution and capabilities, it aspires to illuminate the potential of AI chatbots in amplifying productivity, streamlining information retrieval, and revolutionizing user experiences across diverse domains.

2. Methods and experimental analysis

The methodology employed in this research encompasses a multifaceted approach aimed at thoroughly evaluating the performance, usability, and integration capabilities of Gemini, previously known as Google Bard. Data collection strategies were devised to incorporate both primary and secondary methods. Primary data were procured through user surveys and interviews, focusing on eliciting qualitative feedback regarding user experiences with Gemini. This qualitative analysis delved into aspects such as user satisfaction, perceived response accuracy, ease of use, and specific use cases. Secondary data were sourced from analytics tools like Google Analytics to collect quantitative metrics such as session duration, interaction frequency, popular queries, and geographical distribution of users. Performance evaluation of Gemini entailed standardized benchmarks and comparative analysis with other AI chatbots like ChatGPT and Microsoft Copilot. This evaluation assessed Gemini’s response accuracy, response time, and adaptability in handling diverse queries. Additionally, a technical analysis scrutinized the underlying architecture of Gemini, encompassing neural network models, algorithms for Natural Language Processing (NLP), and image generation techniques. This analysis also examined the training data and pre-processing methods utilized to refine Gemini’s language generation and image synthesis capabilities. User experience testing involved designing scenarios to evaluate Gemini’s usability and engagement, including tasks such as text or image generation requests, interactions with Google Workspace integrations, and exploration of features like Google Lens. User feedback was captured through observation, task completion rates, and qualitative assessments of satisfaction and usefulness.

The integration capabilities of Gemini with Google Workspace tools and third-party services were analyzed to assess seamless integration and the effectiveness of extensions. Ethical considerations regarding data privacy, security, and potential biases in AI-generated content were integrated throughout the research process. Compliance with regulations such as GDPR and CCPA was ensured in handling user data, with strategies devised to mitigate biases and promote ethical AI practices.

Acknowledgment of limitations and challenges inherent in the methodology, such as biases in user feedback and constraints in accessing proprietary data, were addressed. Data analysis encompassed thematic analysis of qualitative data and statistical analysis of quantitative data to generate insights and conclusions. Findings and analysis were presented comprehensively in a research report, utilizing visualizations such as charts, graphs, and diagrams to illustrate key findings and trends. Summarizing the methodology, results, and implications of the research, preparations were made for dissemination to academic audiences, industry professionals, and AI practitioners.

3. Background research and iterative exploration for available knowledge

Gemini, formerly known as Bard, emerged as Google's response to the popularity of OpenAI's ChatGPT. Google executives, alarmed by ChatGPT's potential threat to Google Search, mobilized their workforce and launched Bard in February 2023, initially powered by the LaMDA family of large language models (LLMs) [10,15]. The rapid development and rollout of Bard reflected Google's efforts to compete with ChatGPT, with the goal of integrating generative AI chatbots into Google's products and services. The launch of Bard was met with mixed responses. Despite the initial excitement, Bard faced criticism for its inaccuracies, rushed announcement, and perceived lack of readiness. Google executives pushed ahead with the launch despite internal concerns, emphasizing the need to keep up with competitors. Bard's rollout was marked by challenges, including technical errors during demonstrations and ethical concerns raised by Google employees [16].

In response to feedback and competition, Google announced updates and enhancements to Bard, including the integration of PaLM and Gemini, expansion to new countries and languages, and improvements in personalization and productivity features [17–22]. Despite these efforts, Bard continued to face scrutiny for its cautious responses and perceived limitations compared to ChatGPT [23–33]. Gemini, introduced in December 2023, represented a significant advancement in Google's AI capabilities. With Gemini, Google aimed to further enhance Bard's performance and expand its use across various platforms and devices. The integration of Bard and Duet AI under the Gemini brand signaled Google's commitment to advancing its generative AI technology [34–44]. The development and rollout of Bard and its subsequent evolution into Gemini reflect Google's efforts to innovate in the field of artificial intelligence and compete with other tech giants, particularly in the realm of conversational AI and virtual assistants. Despite facing challenges and criticism, Google continues to invest in and refine its AI technologies to meet the evolving needs of users and maintain its position in the competitive tech landscape [45–52]. Google has rebranded its artificial intelligence (AI) chatbot Bard as Gemini Advanced, reflecting the significant advancements in AI technology and capabilities. Gemini Advanced represents a major step forward in AI development, positioning itself as a direct competitor to OpenAI's GPT-4 [53–55]. Gemini Advanced is built on the PaLM 2 architecture and boasts improvements in efficiency, multimodal capabilities, and future-proofing for memory and planning.

It outperforms its competitors, including GPT-4, in standardized benchmarks and has even surpassed human experts in Massive Multitask Language Understanding (MMLU). One of Gemini Advanced's groundbreaking features is its multimodal capabilities, allowing it to understand and interpret text, video, audio, images, and code simultaneously.

This capability enables Gemini to provide nuanced responses and solutions to a wide range of tasks across various domains, including applied mathematics, physics, engineering, and coding. Gemini Advanced comes in three sizes: Nano, Pro, and Ultra, catering to different user needs and environments. It is designed to handle highly complex tasks and is future-proofed to accommodate newer technologies and innovations. Google's rebranding of Bard to Gemini Advanced signifies its commitment to advancing AI technology and providing users with cutting-edge AI experiences. The rollout of Gemini Advanced includes a dedicated Android app and subscription options, emphasizing Google's investment in AI assistants and agents. The subscription option, Gemini Ultra 1.0, offers access to Google's most powerful AI model and includes two terabytes of cloud storage. Google aims to integrate Gemini into various Google products and services, enhancing user experiences and productivity. Gemini Advanced is available in English in over 150 countries, with plans for international expansion and additional language support. The rebranding reflects Google's evolution in AI development and its vision for the future of AI assistants and agents [56–60].

4. Bard to Gemini: The vision information's

Google has rebranded its AI chatbot Bard as Gemini Advanced, representing a significant advancement in AI technology. Gemini Advanced introduces Ultra 1.0, the most capable state-of-the-art AI model, which excels in complex tasks like coding, logical reasoning, and creative collaboration. Gemini Advanced offers personalized learning experiences, advanced coding assistance, and creative content generation as illustrated within **Figure S1**.

Gemini Advanced is available in over 150 countries and territories in English, with plans to expand to more languages. It is part of the new Google One AI Premium Plan, priced at \$19.99/month, which includes 2TB of storage and access to Gemini in Google products like Gmail and Docs. Google prioritizes safety and responsibility in AI development, conducting extensive trust and safety checks and incorporating user feedback to refine the model.

Gemini Advanced is designed to be conversational, multimodal, and helpful, providing assistance via typing, talking, or image input. For Android users, Gemini is available as a new kind of assistant, accessible via the Gemini app or Google Assistant. It offers a seamless overlay experience and supports various voice features. On iOS, Gemini will be integrated into the Google app, offering similar functionalities for creative tasks and productivity. Gemini is rolling out in the U.S. in English initially and will expand to more locations and languages in the coming weeks. Users are encouraged to provide feedback to enhance their experience with Gemini Advanced.

5. Critical analysis for Gemini model: Hype or hope?

Google's Gemini AI represents a significant advancement in the field of artificial intelligence, particularly in multimodal language modeling. Developed by Google DeepMind, Gemini is designed to process and understand various types of data, including text, images, and audio, through its Transformer-based architecture. Gemini comes in three distinct models tailored for different purposes and performance levels: Ultra, Pro, and Nano. Each model offers unique strengths and is optimized for efficiency and scalability.

The key strengths of Gemini lie in its multimodal learning approach, enabled by its innovative transformer-based architecture. This allows Gemini to seamlessly integrate and analyze information from various sources, leading to improved context awareness and enhanced handling of complex relationships within data. Gemini's diverse capabilities have the potential to transform industries such as healthcare, finance, education, and entertainment. By automating complex tasks, assisting in decision-making, and unlocking new avenues for creativity and innovation, Gemini is poised to revolutionize the way we work, learn, and interact with technology.

As Gemini's development continues, future applications could include general-purpose AI, human-AI collaboration, and advancements in creativity across various fields. However, ethical considerations surrounding bias, transparency, and accountability are crucial to ensure responsible development and deployment of Gemini. Gemini represents a significant milestone in AI technology, with the potential to shape the future of AI and its impact on society in both beneficial and challenging ways.

6. Gemini vs. GPT4: Exhaustive analysis, comparisons

Gemini, known for its advanced capabilities in specific domains, is designed to excel in tasks requiring deep domain knowledge and contextual understanding. It offers various types of assistance, especially in specialized programming languages or frameworks, providing tailored solutions and optimization tips. On the other hand, GPT-4, the latest iteration in the generative pre-trained transformer series by OpenAI, is renowned for its versatility across various tasks and programming languages. It can generate code snippets, debug, and provide solutions to common programming problems across different technologies.

The comparison visualized and achieved from **Table 1** mainly highlights that Gemini excels in specialized domains, offering in-depth knowledge and tailored solutions, making it potentially more suitable for niche applications. In contrast, GPT-4's strength lies in its versatility and broad knowledge base, making it ideal for a wide range of applications, including general coding assistance.

Ultimately, the choice between Gemini and GPT-4 for developers depends on the specific requirements of their project. For projects demanding deep expertise in a particular domain, Gemini might be preferred. However, for more general purposes and a broader range of tasks, GPT-4 would likely be more beneficial.

Table 1. A Comparison between the models of Gemini and GPT4.

Feature/aspect	Gemini	GPT-4
Knowledge base	Specialized in certain domains, offering in-depth insights.	Extensive and general, covering a wide range of topics.
Learning approach	Focused on deep learning within specific domains.	Utilizes unsupervised learning with a diverse dataset.
Language understanding	Highly contextual in its specialized fields.	Broad and nuanced understanding across multiple languages.
Coding assistance	Potentially more adept in specific programming languages or frameworks.	Versatile in offering coding assistance across various languages and frameworks.
Customization	May offer more tailored solutions in certain domains.	General-purpose with adaptable frameworks for different tasks.
Real-time learning	Could be more focused on real-time updates in its areas of expertise.	A broad range of tools and extensive community support.
Interactivity	Possibly more interactive in niche scenarios.	Highly interactive with a wide range of conversational abilities.
Error rate	Potentially lower in specialized tasks.	Generally low, but can vary depending on the task complexity.
Developer tools and support	Specific tools tailored to specialized domains.	Broad range of tools and extensive community support.
Use case specificity	High in its areas of expertise.	Broad and adaptable to numerous use cases.

7. Generative AI (GAI): The research landscape

The evolving landscape of large language models (LLMs) is characterized by significant innovations like Gemini and Q*, prompting numerous studies aimed at delineating future research paths. These studies showcase a dichotomy between established methods and early adoption, with a growing focus on multimodal capabilities and conversation-driven learning, as exemplified by Gemini.

However, the propagation of preprints, while expediting knowledge sharing, raises concerns about reduced academic scrutiny, inherent biases, and the risks of plagiarism and forgery. The academic community stands at a juncture, requiring a unified effort to refine research directions amidst the rapidly evolving field, which is partly traced through changing research keywords' popularity over time [56–60].

The release of generative models like GPT and the commercial success of ChatGPT have significantly influenced research trends, correlating with industry milestones like the release of the “Transformer” model and ChatGPT-3.5. Exploring the societal and economic impacts of AI advancements reveals how AI technologies reshape industries, alter employment landscapes, and influence socio-economic structures.

While AI drives innovation and economic growth, ethical implications and potential societal disruptions necessitate careful consideration. The exponential increase in preprints posted on platforms like arXiv underlines a paradigm shift in research dissemination within the AI community, facilitating rapid knowledge exchange but raising concerns about information validation. The evolution of LLMs from statistical approaches to deep learning techniques, culminating in models like GPT and BERT, has revolutionized Natural Language Processing (NLP). The advent of deep learning has led to the development of LLMs like ChatGPT, pushing the boundaries of language understanding and generation.

ChatGPT's success underscores a robust market demand for natural language AI, stimulating interdisciplinary research across various sectors like education, healthcare, and commerce. However, concerns about AI consciousness, safety, and ethical governance persist. Advancements within LLMs have highlighted the importance of fine-tuning, hallucination reduction, and alignment in enhancing functionality and reliability. The adoption of the Mixture of Experts (MoE) architecture in LLMs represents a critical evolution, offering significant scalability and specialization advantages. However, technical challenges like dynamic routing complexity and ethical alignment issues necessitate continued interdisciplinary research and governance to ensure the safety, ethical alignment, and transparency of these models.

The evolving landscape of LLMs, exemplified by innovations like Gemini and Q*, underscores the importance of interdisciplinary research, ethical considerations, and responsible governance to navigate the complex challenges and harness the transformative potential of AI for the benefit of humanity. Moving towards the emergence of multimodal AI, exemplified by innovations like Gemini, Q*, and speculative advancements in AI technology, heralds a transformative era in artificial intelligence development. Gemini, a pioneering multimodal conversational system, surpasses traditional text-based LLMs by integrating diverse data types such as text, images, audio, and video. Its architecture, characterized by a dual-encoder structure and cross-modal attention network, sets new benchmarks in AI by enabling sophisticated multimodal contextualization and compositional understanding of scenes. Despite these advancements, evaluating Gemini's real-world performance in complex reasoning tasks remains a challenge. The development of multimodal AI systems faces technical hurdles like creating robust datasets, managing scalability, and enhancing user trust and system interpretability. Challenges include data skew and bias, computational demands, and resolving conflicts between modalities. Addressing these challenges is vital for enabling seamless and intelligent interaction aligned with human expectations. Furthermore, the expansion of multimodal AI introduces ethical and social challenges beyond those faced by text-based AI. Concerns include DeepFake technology's ability to generate convincingly realistic media, privacy implications, and the propagation of biases and stereotypes. Ethical development and governance frameworks focusing on transparency, consent, and data handling protocols are essential to address these challenges. Speculative advances like Q* represent a significant leap forward, blending structured learning with creativity to surpass current multimodal capabilities. The integration of Q-learning, A* algorithms, and LLMs aims to create AI systems adept at structured problem-solving and complex human-like communication and reasoning. This potential advancement illustrates the dynamic and ever-evolving nature of AI research, opening up possibilities for more integrated AI applications with greater autonomy and sophistication. The emergence of multimodal AI, including advancements like Gemini and speculative projects like Q*, signifies a transformative era in AI development. Addressing technical challenges, ethical considerations, and realizing the potential of speculative advancements are crucial for leveraging multimodal AI's capabilities to benefit society and advance the field of artificial intelligence.

To better understand the perspective in terms of relating to the matter **Figure 1** sheds light on the visualizations landscape ongoing within the Generative Artificial Intelligence (GAI).

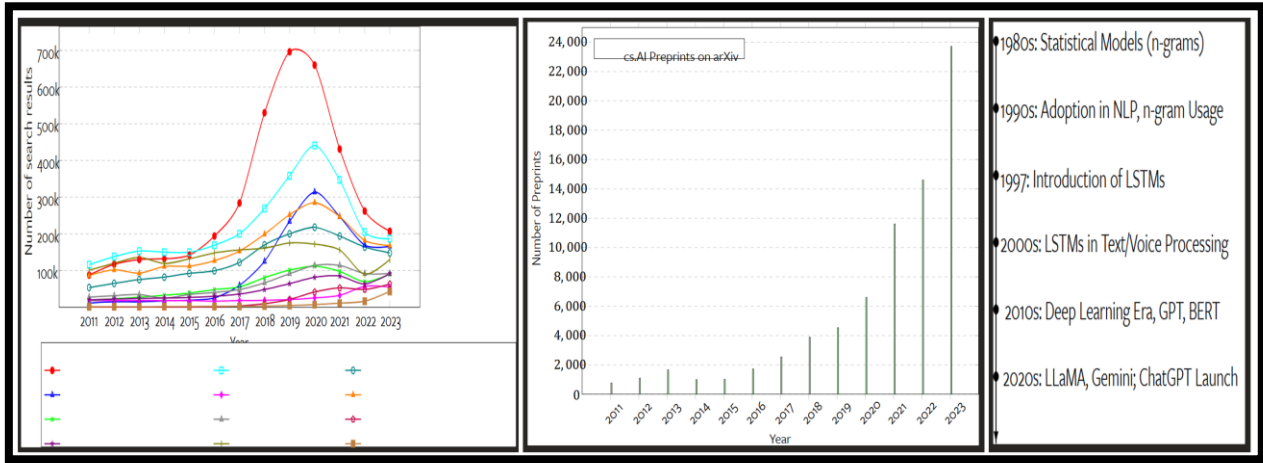


Figure 1. An illustration of the GAI Research Landscape.

8. Generative AI (GAI) research taxonomy: Breakdowns

The field of generative AI is experiencing rapid evolution, necessitating a comprehensive taxonomy to categorize its diverse areas of inquiry and innovation. This taxonomy, detailed in **Table 2**, encompasses model architectures, training techniques, application domains, compliance and ethical considerations, advanced learning, and emerging trends, providing a foundational framework to understand the current state and future directions of the field.

Table 2. Comprehensive taxonomy of current generative AI and LLM research.

Domain	Subdomain	Key focus	Description
Model architecture	Transformer models	Efficiency, scalability	Optimizing network structures for faster processing and larger datasets.
	Recurrent neural networks	Sequence processing	Handling sequences of data, like text, for improved contextual understanding.
	Mixture of experts	Specialization, efficiency	Leveraging multiple expert modules for enhanced efficiency and task-specific performance.
	Multimodal models	Sensory integration	Integrating text, vision, and audio inputs for comprehensive understanding.
Training techniques	Supervised learning	Data labeling, accuracy	Using labeled datasets to train models for precise predictions.
	Unsupervised learning	Pattern discovery	Finding patterns and structures from unlabeled data.
	Reinforcement learning	Adaptability, optimization	Training models through feedback mechanisms for optimal decision-making.
	Transfer learning	Versatility, generalization	Applying knowledge gained in one task to different but related tasks.
Application domains	Natural language understanding	Comprehension, contextualization	Enhancing the ability to understand and interpret human language in context.
	Natural language generation	Creativity, coherence	Generating coherent and contextually relevant text responses.

Table 2. (Continued).

Domain	Subdomain	Key focus	Description
	Conversational AI	Interaction, naturalness	Developing systems for natural and contextually relevant human-computer conversations.
	Creative AI	Innovation, artistic generation	Generating creative content, including text, art, and music.
Compliance and ethical considerations	Bias mitigation	Fairness, representation	Addressing and reducing biases in AI outputs.
	Data security	Data protection, confidentiality	Ensuring data confidentiality, integrity and availability security in AI models and outputs.
	AI ethics	Fairness, accountability	Addressing ethical issues such as bias, fairness, and accountability in AI systems.
	Privacy preservation	Privacy compliance, anonymization	Protecting data privacy in model training and outputs.
Advanced learning	Self-supervised learning	Autonomy, efficiency	Utilizing unlabeled data for model training, enhancing learning efficiency.
	Meta-learning	Rapid adaptation	Enabling AI models to quickly adapt to new tasks with minimal data.
	Fine tuning	Domain-specific tuning, personalization	Adapting models to specific domains or user preferences for enhanced relevance and accuracy.
	Human value alignment	Ethical integration, societal alignment	Aligning AI outputs with human ethics and societal norms, ensuring decisions are ethically and socially responsible.
Emerging trends	Multimodal learning	Integration with vision, audio	Combining language models with other sensory data types for richer understanding.
	Interactive and cooperative AI	Collaboration, human-AI interaction	Enhancing AI's ability to work alongside humans in collaborative tasks.
	AGI development	Holistic understanding	Pursuing the development of AI systems with comprehensive, human-like understanding.
	AGI containment	Safety protocols, control mechanisms	Developing methods to contain and control AGI systems to prevent unintended consequences.

Model architectures: Generative AI model architectures have seen significant advancements across four key domains: Transformer Models, Recurrent Neural Networks (RNNs), Mixture of Experts (MoE), and Multimodal Models. These architectures enable enhanced contextual processing, sequence modeling, efficiency, and integration of diverse sensory inputs, revolutionizing tasks across Natural Language Processing (NLP), computer vision, and other domains.

Training techniques: Generative AI models leverage four key training techniques: supervised learning, unsupervised learning, reinforcement learning, and transfer learning. These techniques contribute uniquely to model training by using labeled data, uncovering patterns in unlabeled data, optimizing decision-making processes, and transferring knowledge across tasks, respectively.

Application domains: The application domains of generative AI are diverse and evolving, encompassing natural language understanding (NLU), natural language generation (NLG), conversational AI, and creative AI. These domains leverage advancements in AI technology to improve language comprehension, text generation, human-computer interactions, and creative content generation.

Compliance and ethical considerations: With the rapid integration of AI technologies into various sectors, ethical considerations and legal compliance have

become increasingly crucial. Bias mitigation, data security, AI ethics, and privacy preservation are essential aspects addressed through ethical AI frameworks, ensuring fairness, accountability, transparency, and privacy protection in AI development and deployment.

Advanced learning: Advanced learning techniques, including self-supervised learning, meta-learning, fine tuning, and human value alignment, enhance the autonomy, efficiency, and versatility of AI models. These techniques enable autonomous model training, rapid adaptation to new tasks, customization to specific domains, and alignment with human ethics and values.

Emerging trends: Emerging trends in generative AI research include multimodal learning, interactive and cooperative AI, AGI development, and AGI containment. These trends focus on achieving richer contextual awareness, enhancing collaboration between AI systems and humans, developing AI with human-like cognitive abilities, and ensuring the safety and ethical alignment of advanced AI systems, respectively.

The taxonomy of generative AI provides a comprehensive framework to navigate the complexities of the field, encompassing diverse areas of inquiry and innovation while addressing ethical considerations and emerging trends shaping the future of AI technology and human interaction.

9. Gemini era: Research challenges, effectiveness, performance, possibilities

The year 2023 marked the entry of Gemini, Google's groundbreaking AI solution, which surpassed GPT-4 in 30 out of 32 standard tests, showcasing its remarkable human-like versatility and "multimodality". Gemini's introduction has sparked excitement in the research community due to its potential to significantly enhance efficiency and productivity for researchers. Gemini offers several novel capabilities that can revolutionize the research process.

Interdisciplinary research: Gemini enables researchers to conduct research without the need to wait for expertise or resources. Its ability to engage in unscripted and open-ended conversations facilitates new discoveries and helps fill gaps in knowledge, particularly in basic research.

Organized and methodical approach: The AI organizes global data and presents it to researchers in a relevant and reliable manner, making it usable for research purposes. This organized approach streamlines the research process and enhances the quality of data analysis.

Deciphering research: Gemini has the capability to read through articles and determine their relevance based on prompts from the researcher. This feature simplifies the process of identifying relevant literature and extracting valuable insights from scientific papers.

Handling large datasets: Gemini excels in handling large datasets, quickly scanning data and generating figures and graphs within minutes to hours. This capability is particularly beneficial for fields such as genomics and other data-intensive areas like law and finance.

Multimodality: Gemini's standout feature is its ability to generate any kind of

output using any type of input. Whether it's generating code from various inputs or producing text and images, Gemini offers unparalleled flexibility and versatility.

Gemini's versatility and advanced capabilities make it a valuable tool for researchers across diverse fields. It facilitates interdisciplinary collaboration, aids in efficient data analysis, and accelerates the research process by handling large datasets effectively. Additionally, the increasing trend of international collaboration among researchers has become more prevalent in recent years, driven by evolving communication platforms like social media. Collaborations between researchers from different countries, disciplines, and sectors have led to a significant increase in co-authored research papers and international collaborations [60–66]. Despite the numerous benefits of research collaboration, it also presents challenges, including cultural and legal differences, conflicting working styles, and differences in communication habits.

Overcoming these challenges requires clear communication, systematic planning, and awareness of relevant laws and policies. Gemini represents a significant advancement in AI technology with the potential to revolutionize the research process by enhancing efficiency, facilitating interdisciplinary collaboration, and handling large datasets effectively. Embracing research collaboration, despite its challenges, offers immense opportunities for advancing knowledge and driving innovation in various fields.

10. Results, findings, directions

Google's AI creation, initially named Bard, faced criticism for its underwhelming performance, struggling to provide accurate information and maintain coherent conversations. However, Google made significant improvements to Bard, renaming it Gemini after its powerful language model, Gemini Pro. The revamped Gemini boasts capabilities that rival those of ChatGPT, including holding helpful conversations, generating images, and seamlessly integrating with Google Workspace. As mentioned previously, Gemini is a generative AI tool designed to assist users in various tasks, such as generating text for cover letters, homework, computer code, Excel formulas, question answers, and translations. Similar to ChatGPT, Gemini utilizes AI to provide human-like conversational responses to user prompts.

The Gemini chat window features a user-friendly interface with options like starting a new chat, entering prompts via text or microphone, uploading images for analysis, and listening to Gemini's responses. Users can interact with Gemini's responses by providing feedback, refreshing for new answers, selecting, copying, or reporting them. Additionally, Gemini offers extensions that enable it to connect with YouTube, Google Maps, Flights, and Hotel for richer responses. Users can customize their experience by adjusting themes, accessing their prompt history, seeking help and support, managing settings, and accessing Google Apps through their Google account. Gemini's ability to generate images adds another dimension to its capabilities, allowing users to request specific images for various purposes. Users can download generated images, regenerate them, or request different images as needed. The New Gemini represents a significant advancement in AI technology,

providing users with a powerful tool for generating text and images, conducting conversations, and enhancing productivity across various tasks.

Unlike the free version of ChatGPT, which has a knowledge cutoff in January 2022–2023, Gemini can provide up-to-date information from the web, making it versatile for a wide range of tasks such as giving recipes, assisting with code debugging, and answering factual questions. Users can interact with Gemini by asking questions or providing prompts, and the chatbot responds with AI-generated answers. Some examples of prompts users can ask include creating to-do lists, defining terms, writing poems, or developing plugins. While Gemini strives to provide accurate responses, it is an experimental AI tool that may occasionally make mistakes or provide inaccurate information. Google has made significant upgrades to Gemini's capabilities and user experience, integrating it with various Google services like Gmail, Maps, Lens, and more. Gemini does not save entire conversations but retains the prompts and questions asked by users. However, given Google's reputation as a major data tracker, users are advised to refrain from sharing personally identifiable or private information with the chatbot. Gemini uses Google's proprietary large language model (LLM) called Gemini Pro, rather than the GPT series used by other popular AI chatbots. While Gemini and similar AI chatbots have the potential to replace traditional search engines by providing conversational responses to user queries, they may not always deliver accurate information. Initially accessible through a waitlist, Gemini is now currently available to users in over 180 countries and territories without the need for waiting, as announced during Google's I/O event in May 2023. The introduction of the new Gemini, Google's latest and most capable AI model, marks a significant milestone in the evolution of artificial intelligence (AI). Demis Hassabis, CEO and Co-Founder of Google DeepMind, emphasizes the transformative potential of AI in advancing scientific discovery, accelerating human progress, and improving lives worldwide. The shift towards AI is predicted to be the most profound technological transition in recent history, offering unprecedented opportunities for innovation, economic growth, and societal advancement. Gemini represents a culmination of Google's efforts in AI research and development, aiming to create a versatile and intuitive AI model inspired by human cognition. Unlike previous models, Gemini is multimodal, meaning it can seamlessly understand and process various types of information, including text, code, audio, image, and video. This flexibility enables Gemini to excel in a wide range of tasks and applications, from natural language understanding to mathematical reasoning and code generation. The introduction of Gemini 1.0 brings state-of-the-art performance across multiple benchmarks, surpassing human experts in tasks such as massive multitask language understanding (MMLU) and multimodal reasoning. Its sophisticated capabilities enable it to extract insights from complex data sets, provide nuanced explanations, and generate high-quality code in multiple programming languages. Google has now also prioritized responsibility and safety in the development of Gemini, implementing safeguards to address potential risks associated with AI capabilities. Comprehensive safety evaluations, including bias and toxicity assessments, have been conducted to ensure ethical and inclusive AI deployment. Collaboration with external experts and the adoption of best-in-class adversarial testing techniques further enhance the model's safety and reliability. The

results, findings, visualizations are represented within **Figures 2** and **3** respectively to provide better understanding on the perspective.

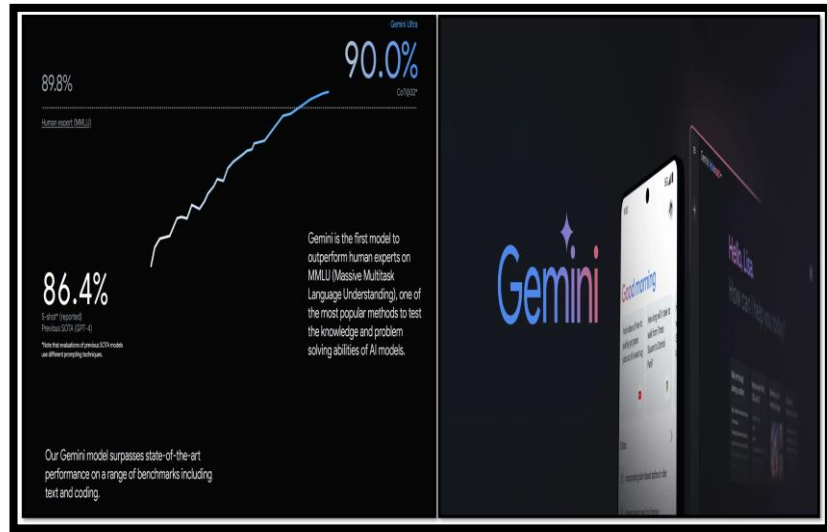


Figure 2. An overview visualization of the research findings 1.

TEXT				MULTIMODAL					
Capability	Benchmark	Description	Gemini Ultra	GPT-4	Capability	Benchmark	Description	Gemini	GPT-4V
General	MMLU	Representation of questions in 57 subjects (incl. STEM, humanities, and others)	90.0% 5-shot CoT@32*	86.4% 5-shot** (reported)	Image	MMMU	Multi-discipline college-level reasoning problems	59.4% 0-shot pass@1 Gemini Ultra (pixel only*)	56.8% 0-shot pass@1 GPT-4V
Reasoning	Big-Bench Hard	Diverse set of challenging tasks requiring multi-step reasoning	83.6% 3-shot	83.1% 3-shot (API)	Image	VQAv2	Natural image understanding	77.8% 0-shot Gemini Ultra (pixel only*)	77.2% 0-shot GPT-4V
	DROP	Reading comprehension (F1 Score)	82.4 Variable shots	80.9 3-shot (reported)	Image	TextVQA	OCR on natural images	82.3% 0-shot Gemini Ultra (pixel only*)	78.0% 0-shot GPT-4V
	HellaSwag	Commonsense reasoning for everyday tasks	87.8% 10-shot*	95.3% 10-shot* (reported)	Image	DocVQA	Document understanding	90.9% 0-shot Gemini Ultra (pixel only*)	88.4% 0-shot GPT-4V (pixel only)
Math	GSM8K	Basic arithmetic manipulations (incl. Grade School math problems)	94.4% maj@32	92.0% 5-shot CoT (reported)	Image	Infographic VQA	Infographic understanding	80.3% 0-shot Gemini Ultra (pixel only*)	75.1% 0-shot GPT-4V (pixel only)
	MATH	Challenging math problems (incl. algebra, geometry, pre-calculus, and others)	53.2% 4-shot	52.9% 4-shot (API)	Video	VATEX	English video captioning (CIDEr)	62.7 4-shot Gemini Ultra	56.0 4-shot DeepMind Flamingo
Code	HumanEval	Python code generation	74.4% 0-shot (IT)*	67.0% 0-shot* (reported)	Video	Perception Test MCQA	Video question answering	54.7% 0-shot Gemini Ultra	46.3% 0-shot SEViLA
	Natural2Code	Python code generation. New held out dataset HumanEval-like, not leaked on the web	74.9% 0-shot	73.9% 0-shot (API)	Audio	CoVoST 2 (21 languages)	Automatic speech translation (BLEU score)	40.1 Gemini Pro	29.1 Whisper v2
					Audio	FLEURS (62 languages)	Automatic speech recognition (Based on word error rate, lower is better)	7.6% Gemini Pro	17.6% Whisper v3

* See the technical report for details on performance with other methodologies
** GPT-4 scores 87.2% with CoT@32 - see the technical report for full comparison

* Gemini image benchmarks are pixel only - no assistance from OCR systems

Figure 3. An overview visualization of the research findings 2.

Gemini is optimized for scalability and efficiency, leveraging Google’s in-house designed Tensor Processing Units (TPUs) for accelerated training and deployment. The introduction of Cloud TPU v5p, the most powerful TPU system to date, is poised to accelerate Gemini’s development and facilitate the training of large-scale generative AI models. The new Gemini represents an advancement in terms of AI technology, offering transformative capabilities that have the potential to

drive innovation and societal progress across diverse fields and applications. Google remains committed to advancing responsible and ethical AI development, prioritizing safety and collaboration with stakeholders to ensure the beneficial and inclusive deployment of AI technologies.

Gemini 1.0, Google's latest and most advanced AI model, is being rolled out across various products and platforms, heralding a new era in AI development as for the time of this research exploration. This release brings significant upgrades to existing Google products and introduces new features powered by Gemini's capabilities. Gemini Pro, the fine-tuned version of the model, will enhance the performance of Google's existing products like Bard, which will now incorporate advanced reasoning, planning, and understanding functionalities.

This upgrade will initially be available in English in over 170 countries and territories, with plans for expansion to support new languages and modalities in the near future. Additionally, Pixel 8 Pro will be the first smartphone to run Gemini Nano, enabling new features such as Summarize in the Recorder app and Smart Reply in messaging apps like WhatsApp, Line, and KakaoTalk. Developers and enterprise customers will have access to Gemini Pro through the Gemini API in Google AI Studio or Google Cloud Vertex AI.

Google AI Studio provides a free, web-based developer tool for quick prototyping and app launch, while Vertex AI offers a fully-managed AI platform with customization options and additional features for enterprise security, privacy, and compliance. Gemini Ultra, the most advanced model, is undergoing extensive trust and safety checks before its broad availability.

Early access will be provided to select customers, developers, and partners for experimentation and feedback, with plans to launch Bard Advanced, a new AI experience featuring Gemini Ultra, in the near future. Google aims to continue innovating and expanding Gemini's capabilities, with plans for future versions to include advancements in planning, memory, and processing capabilities. The company envisions a future where AI responsibly empowers innovation, creativity, knowledge extension, and societal transformation on a global scale.

11. Discussions and future directions

The emergence of Gemini in the field of AI signifies a significant milestone, prompting a reflection on the future landscape of artificial intelligence. This pivotal moment elicits a mix of excitement and cautious optimism, considering the revolutionary capabilities it promises across various domains. However, alongside the immense potential lies a need to address the accompanying challenges and ethical considerations inherent in wielding such powerful technology.

Collaboration and partnerships are deemed essential for the responsible development and deployment of AI models like Gemini. This entails fostering alliances between tech giants, research institutions, and industry leaders to leverage collective resources and expertise. Such collaborations can accelerate progress in AI while ensuring that its benefits are harnessed for the betterment of society, guided by ethical principles. Gemini's success is anticipated to catalyze increased investment in AI research and development, driving the creation of even more advanced AI

models. This surge in funding will facilitate the exploration of new frontiers in AI, leading to technological breakthroughs and discoveries that were previously unimaginable.

The rapid pace of development exemplified by Gemini underscores the likelihood of a continuous cycle of innovation, resulting in the emergence of new AI models with unique capabilities and applications. With the integration of AI into various aspects of daily life, governance and regulations become imperative to establish ethical frameworks and guidelines for AI development and deployment. Collaborative efforts between governments, industry stakeholders, and civil society are crucial to ensure transparency, accountability, and fairness in the use of AI, safeguarding against potential risks and biases. Maintaining human oversight and control over AI decision-making processes is paramount. While AI models like Gemini exhibit impressive capabilities, they are ultimately tools designed to be used by humans. Sustaining human control ensures that AI remains aligned with human values and ethical principles, necessitating ongoing monitoring, evaluation, and refinement to mitigate potential risks and biases. The increasing automation driven by AI may lead to job displacement in certain sectors, emphasizing the importance of reskilling and upskilling the workforce. Governments and educational institutions play a pivotal role in providing retraining programs and resources to facilitate a smooth transition for individuals affected by automation, thereby ensuring inclusivity and adaptability in the changing technological landscape. Addressing algorithmic bias is a critical challenge in AI development, as training data sets may inadvertently reflect societal biases, resulting in discriminatory outcomes. Mitigating bias in training data and algorithms is essential to promote fairness and inclusivity in AI applications, emphasizing the need for continuous efforts to enhance algorithmic transparency and accountability. Public engagement and education are vital in fostering understanding, trust, and responsible use of AI technology. Educating the public about AI capabilities and limitations promotes informed discourse and ethical decision-making regarding its development and deployment. International cooperation is indispensable in addressing global challenges and opportunities presented by AI, including issues related to data privacy, security, and ethics. Collaborative efforts on a global scale are essential to ensure responsible development and deployment of AI, facilitating the establishment of international standards and protocols for ethical AI governance. In terms of navigating the future landscape of AI with Gemini on the horizon, foresight, collaboration, and a commitment to ethical development are paramount. By harnessing the power of AI responsibly and thoughtfully, we can create a future where technology serves the collective good of humanity, ensuring that AI remains a tool wielded for the betterment of society.

12. Potential limitations and future explorations

While the research aims to comprehensively evaluate Gemini, a cutting-edge AI chatbot developed by Google, it is essential to acknowledge potential limitations and review points that may arise from this research investigative exploration. By addressing these points of perspective, researchers and developers can fully

strengthen the validity and reliability of their research findings, fostering a more nuanced understanding of Gemini's capabilities and limitations. Incorporating diverse samples, employing robust research designs, considering a broader range of evaluation criteria, and ensuring transparency and independence in research processes are vital steps toward enhancing the validity and reliability of findings in the evaluation of AI chatbots like Gemini. Overcoming the limitations identified requires careful consideration and strategic planning. Here are some suggestions on how these limitations can be addressed and potential routes for future research in these domains.

Generalizability of findings: Future research could focus on conducting comparative studies involving multiple AI chatbots developed by different companies or researchers. This approach would enable researchers to draw more generalizable conclusions about the performance, usability, and integration capabilities of AI chatbots across diverse contexts. Implementing standardized evaluation protocols and benchmarks could facilitate comparisons between different AI chatbots, enhancing the reliability and generalizability of findings.

Research bias: Employing more rigorous sampling techniques, such as random sampling or stratified sampling, could help mitigate biases in participant selection and improve the representativeness of the sample. Implementing diverse recruitment strategies, including reaching out to users from various demographic backgrounds and user segments, could enhance the diversity of participants and reduce potential biases in user feedback.

Overemphasis on technical analysis: Future research could adopt a more balanced approach that integrates technical analysis with qualitative assessments of user experience, cultural considerations, and societal impacts. This holistic approach would provide a comprehensive understanding of the strengths and limitations of AI chatbots like Gemini. Exploring innovative methodologies, such as user-centered design principles and participatory design approaches, could facilitate the integration of diverse perspectives into the evaluation process.

Ethical implications and bias mitigation: Continuously monitoring and evaluating ethical considerations throughout the development and deployment of AI chatbots is crucial. Future research could focus on developing and implementing robust frameworks for ethical AI development, including guidelines for data privacy, security, and bias mitigation. Collaborating with interdisciplinary teams comprising ethicists, sociologists, and legal experts could provide valuable insights into the ethical implications of AI technologies and support the development of effective mitigation strategies.

Commercial interests and transparency: Enhancing transparency and accountability in AI research and development processes is essential. Future research could advocate for greater transparency and openness in disclosing potential conflicts of interest and funding sources. Promoting collaboration between academia, industry, and regulatory bodies could foster transparency and facilitate independent evaluations of AI technologies like Gemini. Establishing clear guidelines and standards for transparency in AI research and development could help mitigate the influence of commercial interests. Addressing the identified limitations requires a multifaceted approach that integrates diverse perspectives, rigorous methodologies,

and ethical considerations. Future research in these domains should prioritize collaboration, transparency, and accountability to advance our understanding of AI chatbots and their impacts on society.

13. Conclusions

The introduction of Gemini signifies a pivotal moment in the advancement of artificial intelligence (AI), heralding a future teeming with exciting possibilities alongside notable challenges. To steer this future towards benefiting all of humanity, a concerted effort towards collaboration and responsibility is imperative. Collaboration among tech giants, research institutions, and industry leaders is paramount for expediting the responsible development and deployment of AI. This collaborative approach ensures a diverse pool of expertise and resources, facilitating comprehensive solutions and ethical considerations throughout the AI landscape. Increased investment in AI research is crucial for fostering innovation and understanding the potential implications of this rapidly evolving technology. Coupled with robust governance and regulations, this investment ensures that AI applications are developed and utilized in a manner that upholds ethical standards and promotes equity. Human oversight and control remain central in navigating the ethical complexities of AI. Reskilling and upskilling the workforce are essential to adapt to the evolving technological landscape and mitigate potential job displacement resulting from automation. Addressing algorithmic bias and promoting transparency are critical components of building trust in AI systems. By actively mitigating bias in algorithms and promoting transparency in decision-making processes, stakeholders can foster trust and ensure fairness in AI applications. Public engagement and international cooperation are indispensable in shaping a future where AI serves humanity positively. Engaging the public in discussions about AI's impact and fostering international collaboration on ethical standards and regulations are essential for guiding the responsible development and deployment of AI globally.

The future landscape of AI with Gemini and other advanced models requires a steadfast commitment to collaboration, ethical considerations, and responsible development. By embracing these principles, stakeholders can harness the unparalleled potential of AI to create a brighter and more inclusive future for all.

Supplementary materials: The new Gemini (Android) in action is represented within **Figure S1** for a better overview concerning the matter.

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from a wide variety of GOOGLE service domains. All the data sources and various domains from which data has been included and (accessed on for this research are identified, mentioned and referenced where appropriate. However, various original data models and datasets of which are not all publicly available, because they contain private information. The available platform provided datasets and data models that support the research findings and information of the research investigations are also referenced where appropriate.

Availability of data and materials: The various original data models and datasets of which are not all publicly available, because they contain private information. The available platform provided datasets and data models that support the findings and information of the research investigations are referenced where appropriate.

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