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# Generative Artificial Intelligence and GPT using Deep Learning: A Comprehensive Vision, Applications Trends and Challenges

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**Abstract**— Generative Artificial intelligence is a prominent and recently emerging subdomain in the field of artificial intelligence. It deals with question-answering based on natural language processing. This paper discusses recent methodologies adopted by researchers in this field. It also discusses GAI and machine learning techniques for multimodal applications like image, text and audio-based data generation. This meta-analysis and survey was done from prominent research up to 2023 from the Scopus Database consisting of reputed and authenticated research papers.The research contribution is twofold 1. To analyze the recent research and applications at the industry level 2. To identify techniques and associated limitations. This would further aid practitioners to address future challenges.

**Keywords**-artificial intelligence; GPT; GAN; GPT; Natural Language Understanding, OpenAI; machine learning

## I. INTRODUCTION

Currently, artificial intelligence has entered various aspects of digital lives, ranging from smartphone technology to autonomous-driving car features making its advancement virtually undetectable. However, the time factor is not accounted in these technologies. For instance, DeepMind's AI-based program Alpha Go defeated the world champion Go player in 2016, but the event quickly slipped from the public's memory. [1]

Generative Artificial Intelligence help researchers uncover hidden data patterns. Large Language Models (LLM) and new ML models have caused a "paradigm shift" in AI-based language analysis. LLMs are fairly complex AI systems that needs training on large textual datasets [2]

These language frameworks for artificial intelligence (AI) affect the community and technology in education. ChatGPT language models for instance are utilized by experts, analysts, and students to create essays, summarize literature, create rare draughts, enhance papers, find study issues and do analysis. This technology enables to design tests, write publications, and complete research.

As per the recent survey, 40% of directors use AI regardless of their company's capability and 62% of interviewees believe their organizations need the capabilities to adopt an AI strategy, whereas 4% are confident. [4]

## II. MOTIVATION

The relevance of GAI is increasing rapidly in various domains including entertainment, healthcare, computer vision, art and many more. The rapidity and ingenuity of Artificial Intelligence (AI) are set to remodel design research and content creation to facilitate the conversion, between programming languages thereby improving programmers' efficiency. Ultimately it will benefit in ensuring enterprise governance and safeguarding data security. [5] Another GAI Application includes 3D vehicle training for simulation and improving vehicle performance including efficiency and adaptability.

In the climate and temperature sector, GAI models can improve weather and natural catastrophe forecasts. These applications can render cities safer and help scientists forecast and prepare for natural disasters.

AI is challenging to implement for unstructured data for opinion mining [56] and further processing can aid in business intelligence [57]

Generative AI models could speed up content production in animation, video games, movies, virtual reality and world-building. Content Creators often apply generative models to improve their work.

## III. CONTRIBUTIONS

- In this paper, we explain categories of Generative Artificial Intelligence which are Autoregressive Models,

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Variational Autoencoders, Reinforcement Learning, Transformers, Recurrent Neural Networks, and Generative Adversarial Networks.

- The paper states the potential impact the various real-world applications of GAI have started to have on the world. Applications like Text Generators, Enhance Image Quality, Text to Speech Machines and Music Production are mentioned in the paper.
- It reviews various research papers on the topic of Generative AI and lists the method used, takeaways and the limitations of those papers.
- The paper analyzes critical challenges in GAI. This paper clears various confusion and myths regarding this new technology, which will help the public and researchers gain knowledge about GAI and also learn to use it responsibly.

## IV. TERMINOLOGY

- Open AI - Researchers and technologists at OpenAI work to construct secure and beneficial AGI. Research covers DL, image generation, NLP, chatbots, and more. The firm gained notoriety for its cutting-edge research. [47]

- Natural Language Understanding - Natural Language Understanding is defined as "the comprehension by computers of the structure and meaning of human language (e.g., English, Spanish, and Japanese), allowing users to interact with the computer using natural sentences"[8] Thus, NLU extracts utterance linguistic frame elements. Conversational agents, driverless car instruction, the Internet of Things, personal assistants, chatbots, robot training, and others require NLU. Semantic detection enhances user experience. Hence, this study field is essential and expanding.
- Chatbot - Chatbots are the most basic and common kind of intelligent Human-Computer Interaction (HCI). [9] Chatbots recount human speech to engage users, but that's not their primary function. They aid education, information retrieval, business, and e-commerce. Chatbots are popular because they aid clients and programmers. Most implementations are platform-independent and available without installation. Communication with the chatbot spreads over a user's social graph without giving up its native messaging app, which affirms identification. [10]

## V. APPLICATIONS

- Text Generator- GAI acts as a personal assistant that can create content on demand. For instance, a robot writer can write an article summary, product description, or an entire blog post. At the heart of text generation are language models, such as GPT (Generative Pretrained Transformer) and Google's Palm, which have been trained on enormous quantities of internet text data. These models utilize techniques of deep learning, and neural networks to comprehend the structure of sentences and generate coherent and context-appropriate text. [46]
- Enhance Image Quality- Multiple techniques used by GAI are used to generate multiple new images from existing image files.
- GAN – Using the generator and discriminator components, the data is created and verified. Super-resolution GANs may generate high-resolution reproductions of expensive-to-store medical documents and archives. [49]
- Text-to-Speech -Text-to-speech synthesis is used in marketing, education, podcasts, and advertising. For instance, audio file creations from class notes make them engaging. This method can educate blind or visually impaired individuals. Text-to-speech provides businesses with voice and language repertoire options as well as equipment savings. [48]
- Music Production- GAI is useful in generating original songs for creative projects. However, the usage of copyrighted material in exercise data can often result in copyright infringement and legal counsel can solve all issues. It is best to use generative AI to inspire your originality. [7]
- Autonomous vehicles can be trained with the help of synthetic data. Road testing of an autonomous vehicle in a realistic 3D world makes safety, efficiency and adaptability better. Transcription, medical coding, imaging and genetic testing tasks can be automated to support professionals in these fields.

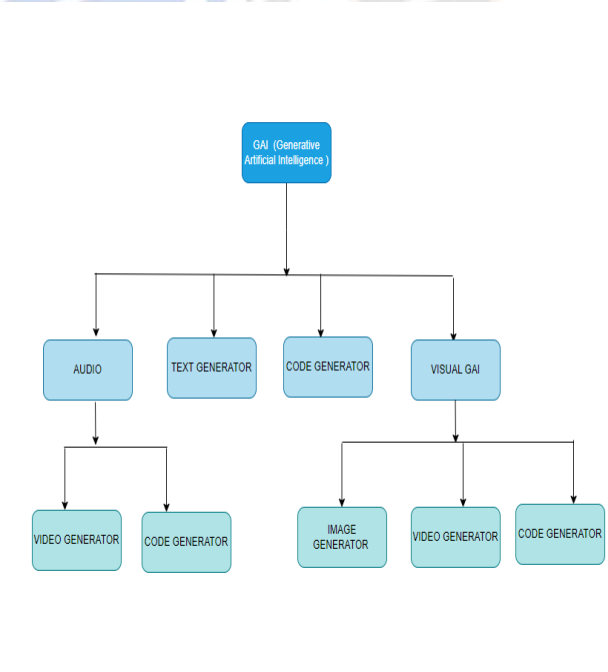


Figure 1. Categories of Generative Artificial Intelligence

Fig. 1 depicts the categorization of GAI based on audio , video and text based input provided to the AI model

## VI. LITERTAURE REVIEW

In this section a rigorous analysis of recent literature up to 2023 is provided along with in depth key challenges and takeaways for each paper explained in Table II

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TABLE I. RELATED GAI RECENT RESEARCH WORK

| Ref | Method | Limitation | Takeaway |
|---|---|---|---|
| [11] | Multi-Task Learning | The authors' preexisting ideas about multitask Natural Language Understanding was the main restriction. The suggested framework is in design, and observed validation is beyond this SLR . | The results indicate that the hybrid model, which combines strategies like active learning, is given much more regard, the reason being its effectiveness in addressing textual tasks for NLU. To build a multi-task NLU combination model is a promising prospect. |
| [12] | GANs is used to create artificial fundus images | The paper does not focus on investigating various biomedical images datasets and domain adaptation tasks | CycleGAN framework achieves high accuracy and the artificial visuals of medical imaging appear realistic. |
| [13] | Experimental Evidence | The tasks were self-contained, shorter, and also as mentioned by author, job satisfaction and self-efficacy is restricted. | In the experiment, it is seen that ChatGPT essentially substitutes for worker effort and it leads to a decrease in demand for workers, with adverse distributional effects . |
| [14] | A theoretical foundation for AI | A lack of technical detail may limit the paper's practicality.<br>It seldom discusses Generative AI implementation issues and limitations in real-world design contexts. | The paper took into consideration the interplay of internalizing and externalizing design knowledge and the variations and selection the core aspects of the augmented designer. |
| [15] | Examined ChatGPT's capabilities on 25 diverse analytical NLP tasks | The prompts needed to be more precise, and prompt construction had quite an effect on the quality of the model's performance. Quite a few times, ChatGPT gave ambiguous replies and suggested to provide more information. | SOTA methods are always better compared to ChatGPT and GPT4 by 4% to over 70% |
| [16] | Structured Common Sense | The proposed solution, in the paper does not effectively tackle the issue of unclear natural language requirements, which could potentially affect the accuracy of the model. | The article rates good formalization performance with an F1 Score of 86.55%. Additionally, it verified three automotive engineering service provider products. |
| [17] | Considering XAI-driven ideas and issues in diverse scenarios | The investigation based on user's needs for software engineering jobs have been very less | Eleven groups of explainabilty needs were identified in the context Generative AI for code. |
| [18] | To perform blind test technique on 117 people to measure and compare between Generative AI's musical experts vs human musical experts | Musical expertise formed utilizing Transformer and neural network architecture had the highest receptivity in the testing population, exceeding human compositions. | An imbalanced sample size and limited<br>Musical genre used in the blind test. |
| [19] | Large scale pre training for Generative AI like Gopher | Studies examine large speech samples rather than multiple audio, video, or GAI samples. Models may have problems | According to the study, large Generative models perform better on a variety of tasks and are reshaping the landscape of AI development, causing more actors to construct them. |
| [20] | Practical application of the 4PADAFE instructional design matrix for GAI in education | Qualitative data were not considered to better comprehend the effects and applications of generative artificial intelligence technologies in education. | The paper provided a comprehensive and practical understanding of how virtual classrooms and enhance the learning technologies |
| [21] | Evaluate paintings on four dimensions | Methodological precautions and the robustness of the outcomes, which reflect significant advances in HCI and computational creativity, disclose a negative perceptual bias against artificial intelligence (AI). | Methodological precautions and the robustness of the outcomes, which reflect significant advances in HCI and computational creativity, disclose a negative perceptual bias against artificial intelligence (AI). |
| **[22]** | Cycle-GAN framework | A specific dataset was chosen in the paper, and it might not represent all demographics. | Paper presents CycleGan medical imaging framework for artery picture creation and segmentation. The outcome was 98.19% precise. |
| **[23]** | Arranges social-relational perspective on rights of robots and also uses StyleGAN2 to generate images, which looks like modern art paintings | Did not clearly mention how participants ascribe moral status to an AI system that is described as a moral patient | Machine creation has less value than human creativity, especially when AI systems lack humanness and consciousness. |

| | | | |
|---|---|---|---|
| **[24]** | Technology is trained based on large language models | Only two public transit aspects are examined, which may not cover all difficulties. | The GAI Tools can boost research productivity, and many ideas may inspire future studies. |
| **[25]** | Survey on impact of AI on education | Scope of the research is limited and only for international students' education | AI can help improve international students' education as AI will bring new creative educational approaches. |
| **[26]** | Large Language Models(LLMs) in Healthcare | The paper does not discuss about the viewpoints of the developers and healthcare professionals who might have different opinions on Large Language models | Paper claims that Large Language Models differ from classical methods of deep learning with respect to the complexity, scale and adaptation. |
| **[27]** | Review on how AI can impact through applications | The paper does not talk about the perspective of other stakeholders and also does not produce enough evidence to prove its claims. | To succeed, generative AI must prioritize human-centeredness, empathy, transparency, explainability, ethics, governance, and change through AI literacy and intelligent arguments. |
| **[28]** | To determine the optimal combinations of human and generative AI for different kinds of tasks | The report did not discuss nations where universities have banned ChatGPT or provide a view. | This article discusses Generative conversation AI technologies like Bard and ChatGPT from a multidisciplinary approach. The paper also claims it can boost productivity in numerous fields. |
| **[29]** | The general method to update a traditional GAN into an interpretable GAN | The research does not compare the suggested technique to other Generative Adversarial Network interpretable feature recognition algorithms. | People can change the look of a visual notion on created photographs using the method. |
| **[30]** | Gathering opinion from experts | ChatGPT boosts intellect. GAI tools raise practical, moral, ethical, and policy issues. | Only 43 contributor's opinion were considered in the paper which is less and need more unbiased opinion to conduct research. |
| **[31]** | describe machine learning approaches which create functional music | The paper did not consider how technology may be used in therapeutic environments. | The Generative music technology can create limitless soundtracks matching a listener's bio-signals and neurofeedback loop. |
| **[32]** | unsupervised deep learning networks | Article does not evaluate the extent to which semantic relevance influences the accuracy of results. | The research shows that DF-GAN is the most optimal model for text-to-image synthesis and also generates high-quality facial images from text descriptions. |
| **[33]** | interviews of interdisciplinary designers were conducted | Due to small sample size of the interviewers, the findings of the research might be restricted. | Generative design tools affect how designers detect the design challenge and iterate through the design to meet quantitative and qualitative criteria |
| **[34]** | A Deep Convolutional Generative Adversarial Network generates skin lesion pictures. | This study verified results based on visual similarity between genuine and produced pictures, not on revolutionary GAN architectures for medical HS images. | Paper has proven the synthetic data and real images to be comparable by using ResNet18. |
| **[35]** | The legal aspects such as data protection, direct regulation, policy ideas , and content moderation | The research ignores key social and ethical considerations associated to LGAIMs' climate change and energy consumption effects. | The study claims the EU law is unsuitable for LGAIM risks and possibilities. |
| **[36]** | Creative making with text-to-image generative AI with the help of the hands-on workshop | The paper relies on one case study with a limited sample size, reducing its validity. Paper also does not compare GAI with other tools supporting craft education. | Text-to-image generative models that generate visual pictures from word prompts are examined in this research on AI in craft education. |
| **[37]** | Exploratory Research- through design study | SRT features were not used in the prototype, which may alter tool experience. | Research indicates that granular data visualizations and color-based communication effectively convey energy use. |
| **[38]** | Conduct research with participants who individually brainstorm with AI | The number of participants is less in number which reduces the generalizability of the outcomes. | The report says the AI system can stimulate new ideas for humans, but it also risks free riding as some people rely on the AI and decrease their own efforts. |

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|---|---|---|---|
| **[39]** | Review of existing and probable risks that GAI poses for journalism | No empirical evidence is provided to evaluate the likelihood of risks | The report gives real-world examples of each threat and proposes mitigation methods. |

## VII. TECHNIQUES

- Variational Autoencoders (VAEs)-VAE consists of 2 neural networks, encoder and decoder, to map the input data into a latent space and rebuild it back to its original domain. VAE is commonly used in anomaly detection and generating text, images, and videos. Recently VAE has also been utilized in the biomedical informatics and pharmaceutical industry [40]
- Autoregressive Models - Autoregressive models assume past values impact the present, these models are valuable for studying nature, economics, and other time-varying systems. The next element is based on the previous elements and samples to produce new data. [41]
- Recurrent Neural Networks: They are employed to handle sequential data like natural language phrases and time-series information. They can also forecast the next element given the preceding elements for generative tasks, [42]
- Reinforcement Learning- Computer-based reinforcement learning automates goal-directed learning and decision-making. The Markov Decision Process (MDP) is a flexible approach to reinforcement learning. [43]
- Transformer-based - Transformers were developed to improve language translation and are well suited to process information in a different order than given and to scale up large models using unlabeled data. They are generally used for chatbots, language translations, text summarizations, and Sentiment analysis.
  They are not cost-effective in terms of training and need large datasets. [44]
- GAN- In Generative Adversarial Networks (GANs) the generator and discriminator neural networks engage in a game interaction. The generator produces data using noise while the discriminator evaluates real and fake

data. Generative Adversarial Networks (GANs) are capable of generating content in image synthesis, video generation and art creation. [45]
Table II describes GAI tools and related description [50]

TABLE II. GAI TOOLS AVAILABLE

| Sr | Tool name | Reference | Use Case | Pros |
|---|---|---|---|---|
| **1** | GPT 3.5 | [51] | Content Generation , optimized for human speech | Free and accessible<br>Can be integrated with other apps through APIs |
| **2** | Github Copilot | [52] | Wide range code generation | MultiLine function suggestion<br>GitHub Copilot gives coding suggestions in various different languages based on the prompts given by user |
| **3** | DALL-E 2 | [53] | Image and Art Generation | Improve the safety and appropriateness, as they removed explicit content from the training data.<br>Natural language inputs for image and art outputs. Several variations of original images can be made |
| **4.** | Bard | [54] | Content Generation , optimized for human speech | Information is pulled from the internet<br>Capable of software development tasks |
| **5.** | Claude | [55] | Large Language Model | -The operations and potential in business applications of Companies are revolutionized by the help of Claude<br>-Takes over many basic blog writing tasks<br>-Easy-to-use API |

## VIII. CHALLENGES

- It was quite difficult to detect and address bias in GPT. Reinforcing and amplifications of biases were considered but was not up to the mark. The challenge is to make sure that positive use cases are enabled while lowering the risk
- GAI is creating potential bias in generating synthetic data in prediction. They have advanced, resulting in massive ML models with astonishing capabilities. These models excel in analyzing large datasets and performing complicated tasks. These concepts have the potential to change almost every sector.
- Some issues are inappropriate Chabot-based language models that could negatively impact research quality, transparency, and autonomy. ChatGPT and other AIs can misinform with appealing but sometimes inaccurate content. [3]
- As generative AI models are latest technology, the long tail effect of it is yet to be seen. This means that employing them has known and unknown hazards.
- Although GAI models usually produce compelling results which are planned, the data they create needs to be corrected, it may be used to promote dishonest or criminal activities due to its gender attribute, ethnicity attribute and race attribute. ChatGPT will not demonstrate how to hotwire a car. Generative AI models

should consider the reputational and legal consequences of erroneously posting biased, offensive, or copyrighted information.

- Researchers need to select the initial data needed to train these algorithms with appropriate experimentation to avoid harmful or biased material. Next, organizations might use smaller, specialized generative AI models instead of off-the-shelf ones. More resourced organizations might build a broad model based on their data to reduce biases. Additionally, organizations should avoid using generative AI models for important decisions that involve major resources or human well-being and maintain a person in the loop. This will ensure a genuine human evaluates the result before releasing or utilizing it. [6]

## IX. Conclusions

In this paper, we explored the most recent research from the authentic and well established Scopus Database. Generative Artificial Intelligence is a recent technology and generative model has become a fundamental requirement for the researchers due to the growing dependency on AI. This paper dealt with categories, applications and recent methods adopted by researchers. Additionally, we have also identified techniques and their limitations of Generative AI.GAI is still in its inceptive stage and researchers need to work on challenges mentioned in previous section for further enhancement in this upcoming field.

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