



# GENERATIVE AI POSSIBILITIES

A WHITEPAPER ON USE CASES



# Table of Content

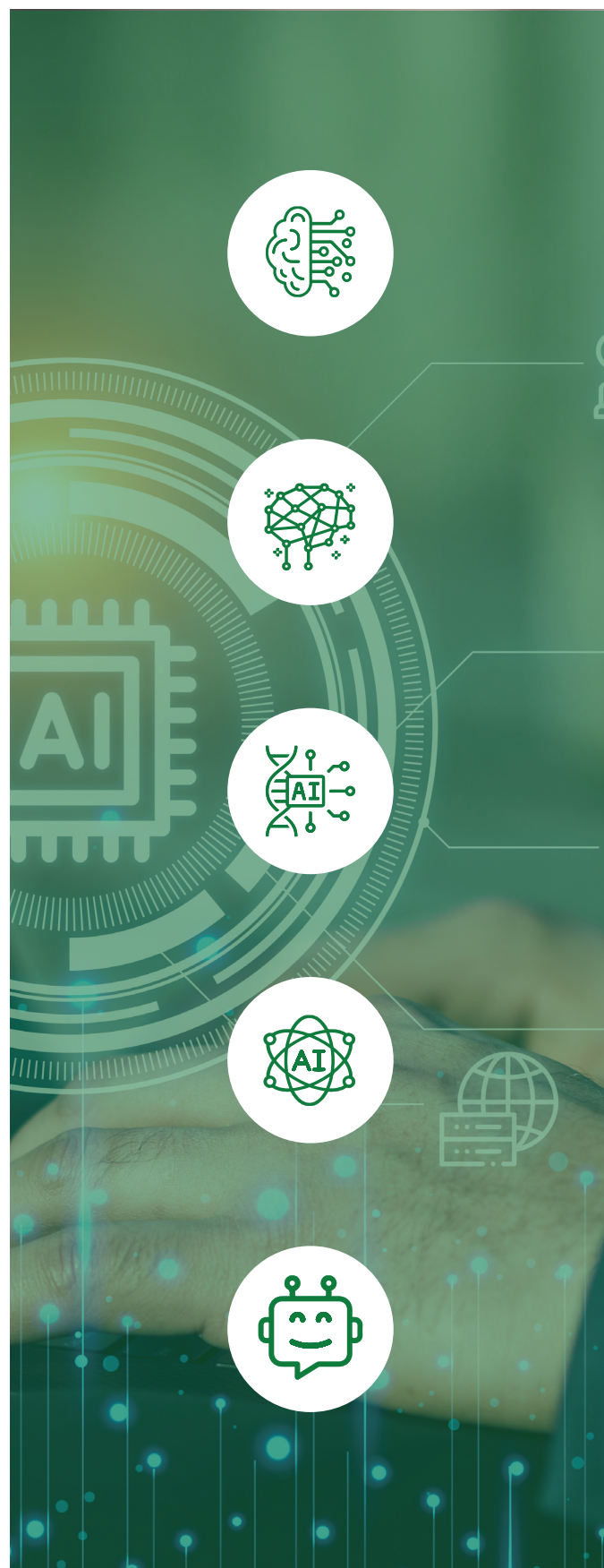
Chapter 1		
Generative AI Landscape	.....	4
Chapter 2		
Impact of Generative AI on Beginner-Level Tech Enthusiasts	.....	12
Chapter 3		
Exploring the Use of Generative AI in Optimizing Community Pharmacy Practice in Nigeria	.....	19
Chapter 4		
The Future of Pharmaceutical Information: A Case for Generative AI Over Pharmacopoeias and Medical Apps	.....	26
Chapter 5		
Filling the Protein Gap with Generative Artificial Intelligence	.....	33
Chapter 6		
Household Energy Management Using Generative AI	.....	43
Chapter 7		
Generative AI for Music Production and Distribution	.....	50
Chapter 8		
Harnessing Generative AI for a Personalized Self-Healthcare Evolution in the Healthcare Revolution	.....	55
Chapter 9		
Exploring the Pragmatic Ability of Large Language Models	.....	63
Bibliography	.....	68

# Definition of Terms



- **Algorithm:** A set of step-by-step instructions designed to solve a specific problem or perform a task.
- **API:** An application programming interface is a medium for two or more computer programs to communicate with each other. It is a type of software interface that offers a service to other pieces of software.
- **Artificial Intelligence (AI):** This refers to the capability of computers to think and perform tasks in a way similar to that of humans.
- **BERT:** BERT, which stands for Bidirectional Encoder Representations from Transformers, is based on Transformers, a deep learning model in which every output element is connected to every input element, and the weightings between them are dynamically calculated based upon their connection.
- **Bias:** These are systematic errors in data, algorithms, or models that can lead to incorrect results or unfair treatment of certain groups or outcomes.
- **Chatbot:** A chatbot is a software application or web interface that aims to mimic human conversation through text or voice interactions. Modern chatbots are online. They use artificial intelligence systems that can maintain a conversation with users in their natural language and mimic the way a human would behave in a conversation. Such technologies often utilize aspects of deep learning and natural language understanding, but more simplistic chatbots have been around for decades.
- **ChatGPT and DALL-E 2:** These are advanced artificial intelligence-powered applications using models developed by OpenAI.
- **Computer Vision:** This is a field of artificial intelligence that empowers computers and systems to derive meaningful information from digital images, videos, and other visual inputs and take actions or make recommendations based on that information.
- **Deep Learning:** This subset of artificial intelligence creates layers of neural networks to simulate the way humans acquire knowledge.
- **Generative AI (GAI):** This form of artificial intelligence can produce novel information. By training on extensive collections of pre-existing information, GAI can discern recurring themes. After this training phase, it can craft data that echoes its learning foundation.
- **Large Language Model (LLM):** This artificial intelligence model utilizes deep learning algorithms by harnessing a substantial dataset to understand, summarize, generate, and forecast new data.
- **Legacy code:** This is an existing software or programming code that has been in use for a significant period, often for several years. It is typically characterized by being outdated or written using older technologies, languages, or methodologies.
- **Machine learning (ML):** Machine learning is a type of artificial intelligence that enables computers to learn and improve from experience without being explicitly programmed.
- **Model:** A representation or framework used to simulate a system, process, or phenomenon, often used in predictive analysis.
- **Neural Network:** This consists of a series of algorithms trained to identify patterns in data, and functions like the neuron systems in a human brain.

- **Natural Language Processing (NLP):** Natural language processing is a branch of artificial intelligence that is responsible for computers' ability to comprehend, generate, and manipulate human language(s). Natural language processing can interrogate the data using natural language presented as text or voice input.
- **NVIDIA:** NVIDIA is a technology company renowned for designing and producing graphics processing units (GPUs) and other computing technologies.
- **Pharmaceutical information:** This refers to the comprehensive understanding of medications and how they are employed. It encompasses medications' characteristics, applications, potential adverse reactions, and how they interact with other medications.
- **Plugin:** A software designed to extend the functionality of LLMs, enabling them to access up-to-date information, run extended computations, use third party services etc.
- **Prompt:** A prompt is any form of information that communicates to a system what response you're looking for. It is like a post and get request. Depending on how you phrase the prompt, Generative AI could create varying responses. For example, a prompt could be "Write a one-paragraph article about Nigeria."
- **Python:** is a programming language used to give computers instructions via written code.
- **Query:** Often, queries are extracted from prompts. They are more specific than prompts when requesting information. Queries are often used to request information from a database by providing criteria the information must satisfy, such as "what are the five most popular cities in Nigeria?"
- **Synthetic data:** Synthetic data is artificially generated data created to mimic or resemble real-world data while not directly derived from actual observations.
- **Technophiles:** Technophiles are young, energetic people who are interested in learning about technology, such as enthusiasts, novices, and beginners.





1.

# Generative AI Landscape

by Patricia Ojonoka Idakwo

# Introduction

Generative artificial intelligence (GenAI) has been a trending topic in the field of computing and artificial intelligence since the launch of ChatGPT by OpenAI in November 2022 and later Bard by Google. GenAI has undergone several stages of research and development since its introduction in the 1960s<sup>36</sup>. The current buzz and heightened interest are a result of the evolution and recent advancements in GenAI leading to the development of advanced AI systems such as ChatGPT, a chatbot with a simple user interface. Individuals and organizations became more aware of the diverse possibilities of GenAI for improving their efficiency/productivity in the way people work, live and interact with technology. This paper gives an overview of the Generative AI landscape with a special focus on large language models (LLMs)

## 1.1 What is Generative AI?

GenAI is a branch of artificial intelligence which can be used to generate content (such as text, image, video, code, or sound and more)<sup>37</sup>. It differs from other artificial intelligence (AI) systems used for tasks such as clustering/grouping data, classification, and making choices of actions as it has the capability to learn from data and create content.

GenAI uses algorithms/models called foundational models which mimic or even out-do human intelligence and creativity. Input and output data types of foundational models are text, audio, image, video, 3D models, animation, molecule, DNA, protein, and even code. A single foundational model takes inputs as prompts and can be adapted to perform multiple tasks ranging from text generation, such as text-to-text) to audio/visual generation such as text-to-image. Figure 1 shows popular GenAI models/applications for various tasks.

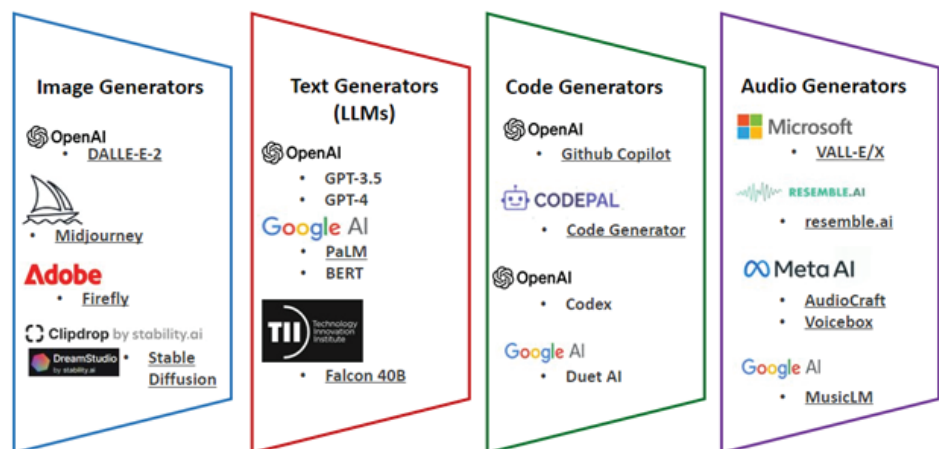


Figure 1: Generative AI Tasks and Popular Applications/Manufacturers

## 1.2 GenAI Application Areas

Gen AI application areas with their respective tasks, as shown in figure 2, gives an insight into the applications and tools of more interest to users in recent times. With emphasis on text processing and generation tasks, these application areas as follows:

- Text processing and generation:
  - text (text-to-text)
  - code (text-to-code)
- Text processing:
  - visual media (text-to-image): takes text input (a description of an image as a prompt) and generates images.
  - speech and audio (text-to-speech): takes text input (description of an image as a prompt) to generate speech/audio.

These text processing and text generation tasks fall within the range of tasks carried out by LLMs<sup>38</sup>. LLMs have ample business potentials and are now the focus of many GenAI investments.

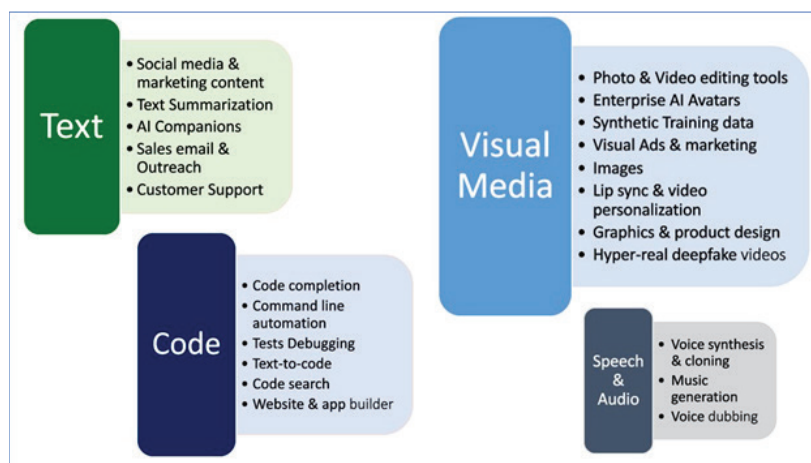


Figure 2: Generative AI Application Areas<sup>37</sup>

## 1.3 Benefits of Generative AI

GenAI provides diverse opportunities for individuals and organizations. The benefits are outlined in Figure 3.



Figure 3: Benefits of Generative AI



## 1.4 GenAI Start-ups

The benefits of GenAI have led to an exponential increase in investment in AI start-ups in the first half of 2023 by five times the cumulative amount in 2022<sup>39</sup>. Start-up companies with high investment funding in GenAI include:

- OpenAI: developers of ChatGPT
- Inflection AI: developers of chatbot Pi (an AI-based personal assistant)
- Anthropic: developers of Claude (an AI-based Chatbot)
- Adept: developers of ACT-1 (an AI that turns text to action by learning how to use software on users' machines); and
- Cohere AI: developers of Cohere (an AI-powered ecosystem for enterprise customer support and data privacy).

Some other recent GenAI start-ups include:

- Hugging Face: developers of a platform which hosts open-source AI models that enable developers build and deploy AI applications,
- You.com: an AI personal search assistant which safeguards individuals' private data,
- Imbue: a start-up developing AI agents; and
- AI21 Labs: provides enterprise text-based GenAI service.

The high investment in GenAI start-ups is an indication that generative AI is not over-hyped, as reported by the media,<sup>40</sup> but is transcending into real-life use cases in various domains.

## 1.5 Implementation of GenAI

GenAI implementation entails building a new model or customizing existing models for a business use case. Its components are:

- Infrastructure:
  - high computing systems including graphical processing units (on-site) or cloud tensor processing unit (cloud-based) for storage and high processing speed,
  - vector database technology: an emerging technology for vector databases. Vector databases are special databases used for applications with high-dimensional parameters requiring semantic search to understand underlying structures, relationships and patterns)<sup>41,42</sup>; and
  - application programming interfaces (APIs) and machine learning operations.
- AI/deep learning expertise (whether in-house or outside the organization),
- training data (in cases such as LLMs, very large datasets with billions to trillions of parameters), and
- a plan which leverages best practices and tools for the adoption of responsible AI principles in the organization.

Some GenAI models allow users and applications to access their APIs so they can be implemented as-is, become a customized standalone application, or are incorporated into an existing application. Others, called generative interfaces, are implemented with their own graphical user interfaces.

These generative interfaces employ graphical user interfaces such as web pages and mobile applications, which run on top of Generative AI models and are able to perform tasks in one or more GenAI application areas. They serve diverse purposes such as AI assistants and human machine interfaces, general search, as well as productivity and knowledge management applications.

## 1.6 What are LLMs?

Large language models are GenAI systems that focus primarily on processing and generating text<sup>38,43</sup>. They are transformer-based neural networks which use deep learning and NLP techniques to train on using very large amounts of text corpus, which have hundreds of millions to billions of parameters/dimensions, such as entire internet archives, books, web pages or articles<sup>37,44</sup>. They are able to understand language syntax, content, and grammatical structure; decipher the relationships and patterns between words; and interpret and generate text. LLMs are useful for language understanding, translation, and generation tasks such as entity recognition, text summarization, content generation, and answering questions. Some LLMs have interfaces built into them to perform tasks such as general search, AI assistants, and knowledge management. Examples are Bard, built on PaLM (Pathways Language Model) and ChatGPT-4, built on GPT-4 (Generative Pre-Trained Transformer 4).

## 1.7 Categories of LLMs

There are two categories of LLMs, generalist LLMs and domain-specific LLMs<sup>45</sup>.

### i. Generalist LLMs:

These are trained on publicly available general datasets taken from the web through web scraping, such as Wikipedia and books, among others. These LLMs are able to perform tasks such as generating content for sales pitches, essays on given topics, marketing emails/content, code, audio, and images; and they act as search assistants (eg. Google's BERT, BARD with PaLM, Bing Chat with GPT-4). These tasks are carried out as conversations using chatbots where users ask questions (as prompts) and the LLM provides responses. Although these LLMs have the capacity to demonstrate understanding and text generation on numerous topics, they still fall short where domain-specific, in-depth knowledge is needed. They are also prone to hallucinations—inaccurate/weird responses—and privacy issues if confidential datasets like patient data are fed into the model. As such, these LLMs usually provide access to their APIs so that individuals or businesses can easily customize them for domain-specific use cases and complex tasks.

### ii. Industry-Specific LLMs:

These LLMs have overcome the challenges of generalist LLMs. They are built using industry-specific datasets; therefore, they have an understanding of the nuances, terminologies, and topics in their specialized areas. In industries like medicine and finance, these domain-specific LLMs ensure data privacy as their training data are not open access and are only accessible to authorized individuals/groups.

LLMs in the medical domain include: Med-PaLM, which has the capability to generate long-form responses to customer health queries as well as accurate answers to medical questions (performing beyond the average pass mark on the US Medical License Exam-style questions); GPT-Neo; PubMedGPT; PubMedBERT; BioLinkBERT; DRAGON; and Galactica, among others.

Some of these example LLMs were built using access to APIs of generalist LLMs, eg. Med-PaLM from the PaLM API; GPT-Neo and PubMedGPT from GPT APIs; and PubMedBERT and BioLinkBERT from the BERT API.

iii. Text-to-Text Interactions Some LLMs:with Some LLMs:

Prompt: *Where can I get the best Asun in Abuja?*

- Bard

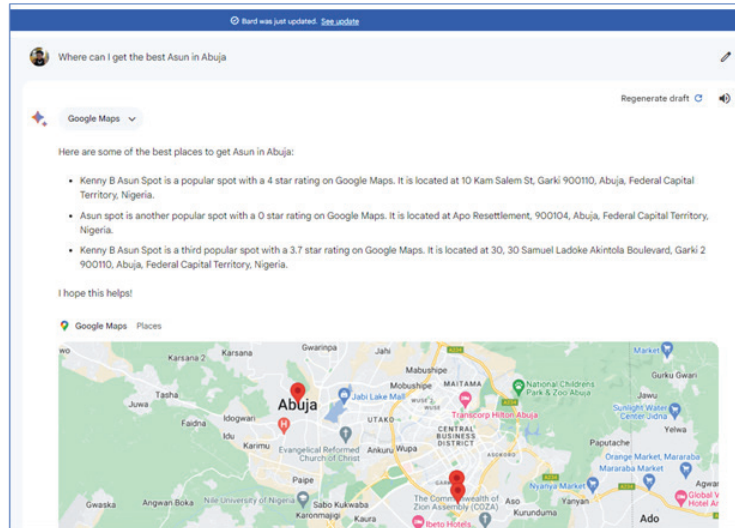


Figure 4: Bard’s answer to the prompt

The response from Bard shows a high level of intelligence and is capable of giving the output in text, audio and image formats (see the map)

- ChatGPT

ChatGPT did not provide a relevant response.

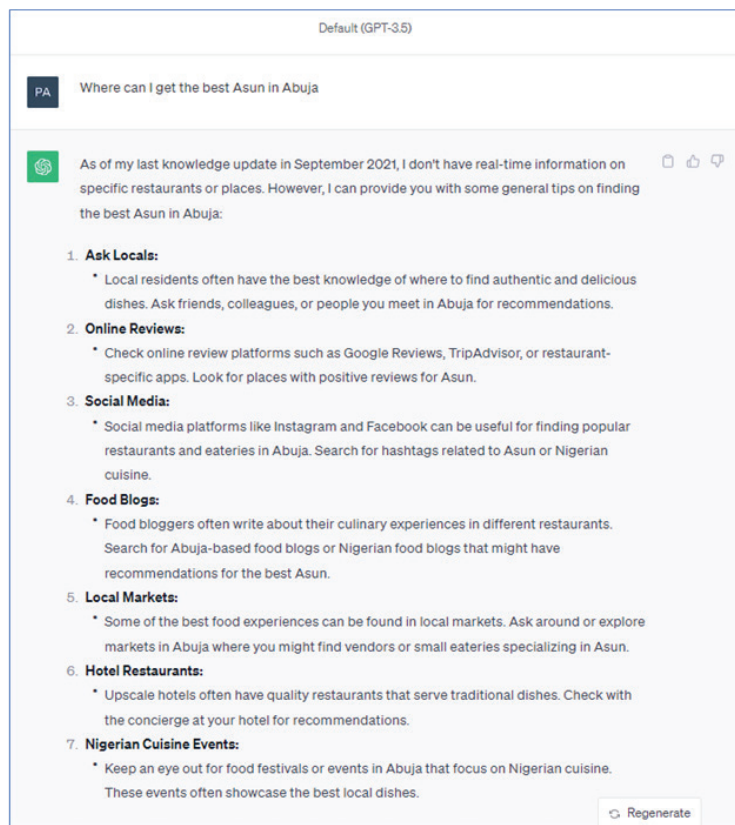


Figure 5: ChatGPT’s response to the prompt

iv. Text-to-Code

Prompt: Write a Python function to find the average of values in a list

- Bard's reply



Figure 6: Bard's response to the prompt for calculating an average

- ChatGPT

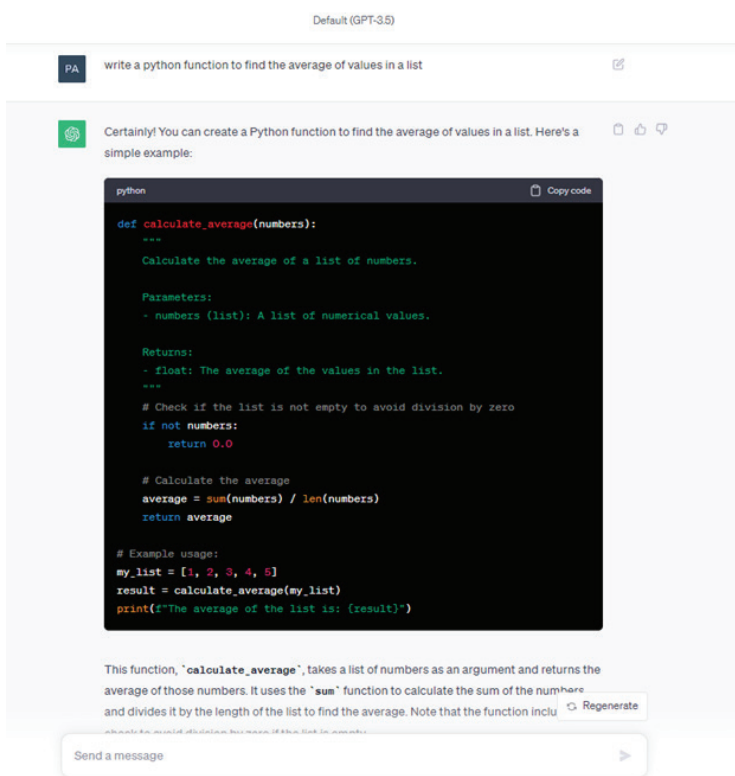


Figure 7: ChatGPT's response to the prompt for calculating an average

Both LLMs created useful code that completed the specified task.

### iii. Text-to-Image

*Prompt: A flying house with wings*

- Adobe Firefly

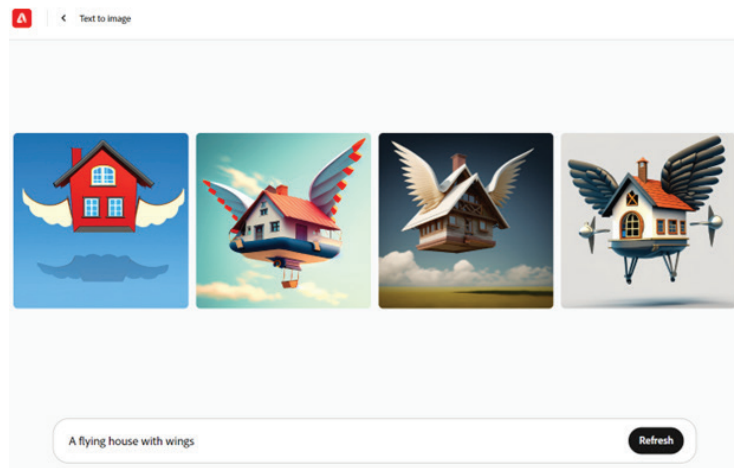


Figure 8: Adobe Firefly's response to the prompt for a house with wings

The excitement and buzz around GenAI as a result of the benefits to individuals and business organizations who sampled the creations from ChatGPT, BARD, BERT and others have not died down. The limelight is still on the potentials of GenAI and LLMs to revolutionize the way we live, work, and interact with technology. It is my belief that the increased focus on investments in GenAI will soon start yielding stable versions of GenAI applications and tools for use in production.

## Conclusion



The excitement and buzz around GenAI as a result of the benefits to individuals and business organizations who sampled the creations from ChatGPT, BARD, BERT and others have not died down. The limelight is still on the potentials of GenAI and LLMs to revolutionize the way we live, work, and interact with technology. It is my belief that the increased focus on investments in GenAI will soon start yielding stable versions of GenAI applications and tools for use in production.

2.

# Impact of Generative AI on Beginner-Level Tech Enthusiasts

by Honour-Jesus Bezaleel

# Introduction

Since the emergence of generative artificial intelligence (generative AI), humans using it have proven to be faster at their jobs and studies as they no longer need to spend much time on research. An architect could create a prompt for generative AI by using an abstract drawing as a prompt to be modeled into a building, and an appropriate generative AI will create pictures of the house.

In the ever-changing world of technology, generative AI, which is a branch of artificial intelligence (AI), has taken the world by surprise with its undeniably vast abilities, beginning a new era of how machines relate to humans. This pushes the limitations and boundaries of what machines have been known to do.

This white paper comprehensively explores the impact of generative AI on beginner-level tech enthusiasts, also known as technophiles. In the pages that follow, I explore the fundamental concepts of generative AI, investigate its content generation capabilities, anatomize the conflicts and challenges encountered by inexperienced users, suggest practical solutions, and offer a conclusion that considers the overall influence of this technology.

## 2.1 What is Generative AI?

Generative AI is a branch of artificial intelligence built on the principles of machine learning (ML), deep learning algorithms, and neural networks. These systems are trained on vast datasets to understand patterns and independently generate content on any topic. The first chatbot was built in 1960, it introduced generative AI, which was followed by the integration of generative adversarial networks (GANs) in 2014. The most recent advancement is the integration of Transformers and large language models (LLMs), which have optimized the generation of engaging text and realistic images<sup>36</sup>. A user can input a couple of images as prompts, and based on them, the generative AI can generate hundreds of images that are realistic and similar to the ones given in the prompts. Earlier versions needed application programming interfaces or special tools and written applications in programming languages such as Python. Now, there are better options for users that enable them to use plain human language as commands, and setting the tones and style in which the result should be generated.

The new generative AI technology has infiltrated the everyday lives of ordinary people; it has met the needs of humans by mimicking human interactions, generating all kinds of content (poetry, articles, reports, even movie scripts, images, and music), and speaks over 4,000 languages<sup>51</sup>. According to Statista, generative AI's capabilities have transformed sectors and led to a 40% increase in the efficiency of content creation and other forms of creativity; it also led to a 90% increase in the automation of many business workflows<sup>52</sup>. These abilities have made rich educational content available and accessible.



Figure 1. Evolution of Generative AI. Source: TechTarget<sup>53</sup>

## 2.2 Why Use Generative AI?

For beginners who have just moved from being mere enthusiasts to exploring the world of technology, this digital innovation has extensive implications. The concept of generative AI holds the promise of expediting the acquisition of technical skills and knowledge. It offers a shortcut to code generation, content creation, and problem-solving, potentially redefining the learning curve for technophiles at the novice level.



One of the most notable impacts of generative AI on beginner-level technophiles (or techies) is its capacity to effortlessly generate content based on the prompts or commands given to it. This can include generating code snippets, writing articles, or even designing basic applications that are indistinguishable from those produced by humans. For a beginner-level technophile, computer code can be explained and broken down into simple terms to improve understanding, and the code can be further modified into simpler codes; a problem statement can be given to generative AI as prompts, and it will provide a step-by-step guide for solving the problem and the necessary code needed in a matter of seconds<sup>54</sup>.

A beginner-level techie can use the help of generative AI to get an understanding of the mathematical equations and formulas used in many computer codes and theories. Generative AI, such as an AI-powered chatbot, can write code documentation for a beginner-level tech enthusiast. Also, generative AI offers fast and seamless reading and understanding of legal documentation for beginner-level techies who can't afford a lawyer<sup>55</sup>.

Generative AI can be leveraged to build applications of any type, a process that can be as easy as giving the model a flowchart; the model can generate the necessary code and guidelines for the end-to-end process. Generative AI also analyzes and synthesizes data for data generation. Generative AI has been implemented in websites, applications, code, and sandboxes of courses taken by technophiles. The technology can make suggestions, explain error messages, complete code as you work and learn, and suggest solutions that make debugging faster. Generative AI can help beginners with research and generating style guides for writers<sup>55</sup>.

Generative AI can also help to write proposals, applications for grants or financial aid for paid courses, suggest email replies, create engaging learning games with great visuals, and generate ideas for start-ups. It can summarize a whole course in a matter of seconds, give an overview of what to expect before taking a course, or simplify difficult concepts—by using the right prompts. Generative AI has been integrated into many learning platforms and better explains each exercise.

Generative AI's availability and accessibility will help technophiles get reliable results—although you must crosscheck for accuracy. Generative AI has several qualities that can be endlessly explored and is only limited by how the user prompts it<sup>55</sup>.

### 2.3 Which Types of Generative AI Are Useful to Beginner-Level Tech Enthusiasts?

**i. Text-to-Text:** These types are used for generating text-based content like articles, writing styles, code, and getting suggestions. Examples include<sup>56</sup>:

- **ChatGPT:** This is a dynamic tool from Open AI that can be used to generate many kinds of content in text form, generate codes, and explain codes. The GPT-4 version can generate audio, video, and Visual responses from image to text and text to image prompts. This is a useful tool for learning, interactions, and getting ideas for technophiles.
- **Scribe:** As a generative AI-powered writing tool, Scribe crafts reports, assists in summarizing articles, helps with research writing, and generates content in different styles and formats.
- **AlphaCode:** This generative AI-powered coding assistant fosters coding proficiency, curbs errors, assists in coding bug resolution, and increases developers' workflows by offering real-time coding suggestions.

- **GitHub Copilot:** As a generative AI-powered coding assistant, it offers code snippets, enables fast coding, facilitates learning, supports diverse programming languages, explains code, and gives context-based guidance.
- **Bard:** Bard is Google's powerful chatbot for content generation. It is built on the LaMDA transformer model.
- **Claude:** An AI assistant for researchers by Anthropic called Claude helps with task automation.

ii. **Text-to-Image:** these generative AIs are used to generate realistic visuals that can be used in articles or research.

- **DALL-E2:** A generative AI that creates images from text descriptions, it helps technophiles experience a new world of creativity as DALL-E2 can produce unique designs that fuel innovation.
- **Stable Diffusion:** Released in 2022, Stable Diffusion is an open-source neural network by Stability.ai that allows users to generate images based on text prompts. It creates stunning art in a short amount of time. This generative AI also assists in completing sketches and editing original images. Stable Diffusion relies on a diffusion model that generates images from random noise. It is trained to remove unnecessary parts from a sample image step-by-step, producing the result after a few stages of processing. This algorithm works by successively adding noise to the original image and gradually transforming it into photorealistic images or art.
- **Midjourney:** Another generative AI tool for image creation is the Midjourney neural network, created in 2022. It is powered by speech recognition algorithms and image-generating algorithms. Simply put, it can recognize printed text and convert it into images. It is a diffusion neural network that, like Stable Diffusion, creates images from noise. It is renowned for being amazingly easy to use to generate artistic ideas with many finely detailed features.
- **Synthesisia:** This generative AI-powered content creation tool, helps create life-like videos by using deep learning techniques.
- **Canva Free AI Image Generator:** It produces images based on the prompts given to it, and produces dynamic images that can be used in design through AI.

A few music-generating generative AI tools are MuseNet, AMper, Deep Dream, and Dadabots.

## 2.4 Concerns About Generative AI for Beginner-Level Techies

Although generative AI can be a powerful tool for beginners, as this technology becomes increasingly integrated into their lives it raises concerns about plagiarism, ethical usage, and the risk of dependency on AI-generated content. For those tech enthusiasts, relying on AI-generated solutions could stifle the development of the beginner techie's critical thinking, creativity, and problem-solving abilities, and the technology could potentially make them lazy, which could affect their output when they enter the job market.

Moreover, the ethical dimensions of generative AI cannot be ignored. Generative AI is a double-edged sword that can be used in unacceptable ways. Issues of giving credit appropriately, plagiarism, and responsible usage are very significant, particularly as novice techies wrestle with the temptation to leverage AI-generated content without fully understanding the implications. As of March 2023, AI Lab had to pause the production of anything more advanced than ChatGPT-4 after an open letter was signed by many CEOs, technologists, researchers, and academics. They stated that harm could be done as the AI could go out of control, and even its creators would not be able to predict its actions<sup>57</sup>.

As they start to understand the complexities of AI-generated material, beginners must learn to strike a delicate balance between harnessing the power of this technology and using it ethically and responsibly. Quality control is yet another concern. AI-generated content can differ greatly in terms of quality, accuracy, and relevance. Beginners, unfamiliar with the intricacies of AI systems, may find it difficult to differentiate between high-quality and inferior output. This could lead to prospective hindrances in their learning journeys; the beginners might have been learning and practicing with mediocre quality<sup>55</sup>. Generative AI has also been said to lack creativity; it does not think outside the box and it cannot think of new ideas only does what it is asked to do.

Generative AI is available round the clock, and newbies tend to rely on its results rather than reach out to teachers or mentors who have more domain knowledge and industry experience. This may give them a false impression that they no longer need the veterans in the field.

## 2.5 Resolving Concerns About Generative AI

One way to overcome the concerns expressed above could include implementing a learning environment that is guided by laws and standards. In this case, the result returned by generative AI would be referenced so beginning technophiles could actively engage in learning and creating. The learning environment should be guided and the generative AI would be restricted from answering certain questions if the answers could be life threatening or lead to physical harm.

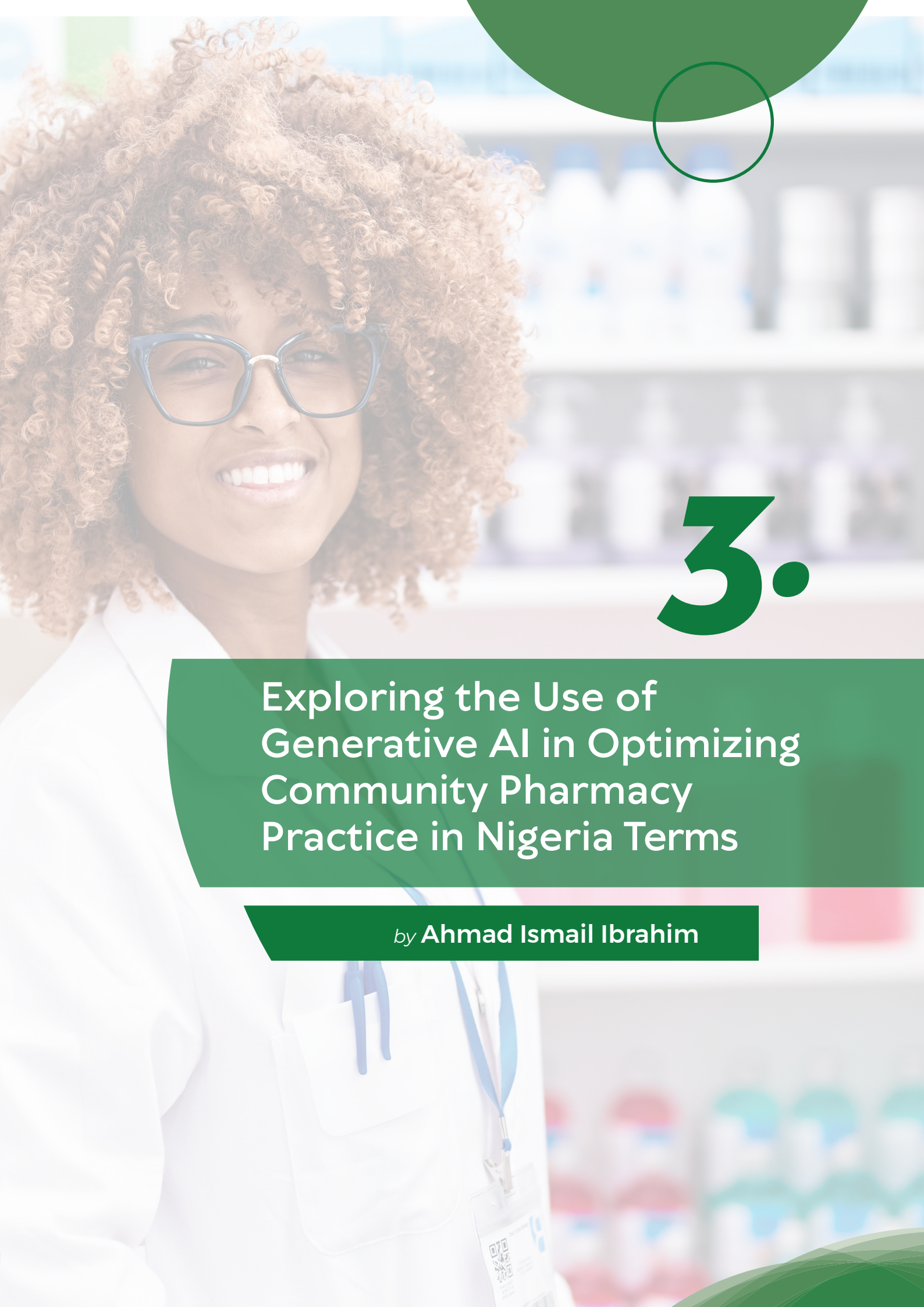
Education, awareness, and implementation of ethical guidelines for using generative AI could teach technophiles how to properly and ethically use the technology and understand the consequences of not using it ethically. This could include policies guiding the use of generative AI at work and setting limitations on its use.

Production of tools and methods could be developed to check the quality and accuracy of AI-generated content. This could help beginners learn to recognize high quality content and how to avoid plagiarism; some generative AI depends on data scraped from the internet. Among tech communities, awareness that most of the information generated is not 100% accurate and is not necessarily dependable or trustworthy could save beginning technophiles from overreliance on generative AI. Tech communities could also warn that relying strictly on generative AI could stunt the beginning technophiles' skill development.

## Conclusion

In the ever-changing world of technology, generative AI has provided new opportunities for beginner-level tech enthusiasts to learn, create, grow, and harness the technology's potential. As generative AI keeps growing, so will its impact. Ethical concerns should be resolved by policymakers, educators, and the tech communities at large. Soon, generative AI tools for learning will increase, and with the right governing principles in place, learning will become easy for tech novices.





3.

## Exploring the Use of Generative AI in Optimizing Community Pharmacy Practice in Nigeria Terms

by Ahmad Ismail Ibrahim

# Introduction

Generative artificial intelligence (generative AI) is a technology that has been making waves and transforming approaches to solving traditional problems in some fields. It is a technology capable of producing texts, images, music, and other ways humans express their creativity in a way that could pass as human-made. This realism differentiates generative AI from other technologies made to help humans work better, such as autocomplete.

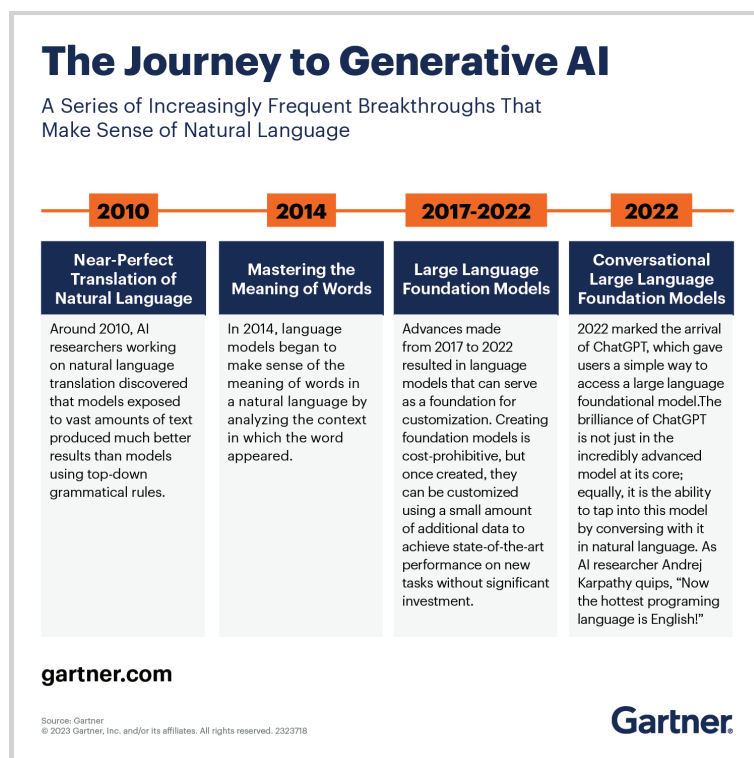


Figure 1. History of Generative AI  
Source: Gartner

The public first experienced this technology through OpenAI’s DALL-E 2 and ChatGPT<sup>1</sup>. DALL-E 2 is a model capable of generating images from textual descriptions input by users, which are called prompts, while ChatGPT is a chatbot that can simulate human-like, naturally coherent conversations. With ever-expanding and innovative applications of these and similar tools, many things previously thought to be impossible are now being achieved. As expected, the public availability of these tools has revolutionized many industries and fields of study. It has also changed the face of an old type of fear: the fear of intelligent machines taking over human jobs and positions in society. There are also discussions about the legality of the data used to train these models and the copyright and ownership of their outputs<sup>2</sup>.

### 3.1 How Generative AI Works

Generative AI achieves its realism by going beyond the utilization of traditional machine learning algorithms and detecting patterns and trends in a wide range of unstructured data, such as texts and audio data. Then, it generates free-form outputs as texts and images by using algorithms trained on a vast amount of data, called large language models (LLMs). LLMs like OpenAI's ChatGPT and Google's Bard analyze vast amounts of text-based data and calculate the likelihood that a word, or collection of words, will appear in a piece of text, given the presence of other linguistic patterns. The ability of LLMs to predict the words most likely to follow various prompts grew as technology advanced and allowed artificial intelligence researchers to train such models on progressively larger amounts of text. Thus, LLMs are similar to the auto-complete systems that have proliferated on search engines, smartphones, and other digital environments over the past decade, but on a far larger scale and with more advanced training methods<sup>1</sup>.

To a lesser degree, there have been parallel advancements in images and audio. In these cases, the algorithms create instant images using deep learning technology to create new images based on the co-occurrence of pixels in different sizes and colors learned from vast amounts of data. These images can range from artificial human faces and copies of famous works of art to surreal—and occasionally quite innovative—brand-new artistic mediums<sup>1</sup>.

According to NVIDIA<sup>3</sup>, there are three essential requirements for a successful generative AI model. These are:

1. High quality output, especially for applications that interact directly with users.
2. Diversity, to help reduce undesired biases in the trained models
3. High speeds: the fast generation of output to enhance users' experiences and enable workflow integration.

Generative AI models, responding to simple natural language prompts from users, can produce various outputs including texts, images, and audio. With regular improvements and updates to these models, they continue to expand and improve their capabilities.

### 3.2 Adoption of Generative AI

Following the public acknowledgment of Open AI's popular LLMs in 2022, ChatGPT reached 100 million distinct users in just two months<sup>4</sup>. Industries and businesses have dedicated resources to explore how they can adopt generative AI technology for their needs. A global survey by McKinsey explored the adoption of generative AI-powered tools less than a year after their introduction, and one-third of the respondents said that their organizations utilize these tools in at least one of their core functions<sup>5</sup>. These organizations use generative AI to optimize customer experience/retention, drive revenue growth, optimize cost, and ensure business continuity<sup>6</sup>. In a similar study conducted by ResumeBuilders.com, business leaders reported the use of ChatGPT in their organizations for a variety of reasons, including 66% for writing code, 58% for copywriting and content creation, 57% for customer support, and 52% for producing meeting summaries and other documents<sup>2</sup>.

Generative AI has the potential to be integrated into nearly any human activity, and there are some important domains where the technology has already been put to use. This is mainly facilitated by the availability of application programming interfaces that enable entrepreneurs to build the fundamentals of these models into niche products. These include creating images and text to make non-player characters in games<sup>7</sup> and generating texts to build on existing linguistic products such as Grammarly<sup>8</sup>.

Perhaps the activity most impacted by generative AI is content creation. From writing emails, school essays, and social media posts to official document reviews and even songs, generative AI has been used for various purposes relating to content creation. It has impacted industries like marketing, entertainment, design, and journalism. With its capacity to create texts and images of all kinds that are coherent and tailored to specific needs, generative AI has been used to automate the process of preparing articles, reports, and product descriptions. Writers also use it for tone manipulation and context simplification, enabling them to break down complex contents, create outlines, and write plans<sup>6</sup>.

Generative AI is also being utilized in some areas that may have long-term impacts. The use of generative AI in synthetic data creation is one such instance. Researchers are using generative AI to create entirely new datasets to counter the inadequacy of data, especially in low-resource regions<sup>6</sup>. Researchers at Data Science Nigeria used generative AI to generate a wholly new dataset for African fashion apparel; the previously existing dataset information was unavailable or inadequate<sup>9</sup>. While synthetic data generation is not entirely new—self-driving car technology has been utilizing virtual streets for training models—the public availability of generative AI makes data creation in our data-driven world easier, especially in settings where data is unavailable or sensitive, such as personal finance and medical records<sup>10</sup>. Generative AI has also led to the creation of companies that provide these services<sup>10</sup>, including Syntegra and Synthetic Data Vault.

Another area where generative AI may have long-term impacts is by proactively suggesting additional actions for users and providing them with information, acting as a sort of guide when users explore certain services<sup>6</sup>. The best example is Microsoft's services, in which OpenAI's ChatGPT is incorporated into applications as its Copilot<sup>11</sup> software. This has been so successful that OpenAI introduced a "browse with Bing" feature into ChatGPT<sup>12</sup>, and Microsoft integrated Copilot into its Microsoft Office Suite, Microsoft 365, and the Windows 11 operating system in the September 2023 updates<sup>13</sup>.

Generative AI has profoundly impacted programming and coding. LLMs can generate code from natural language descriptions; their accuracy rate is comparable to human programmers'. Coupling this with the models' ability to converse means that errors can be debugged, and the codes can be improved. This has revolutionized computing education and made programmers' workflow more efficient<sup>14</sup>. Similarly, generative AI is being used to modernize legacy codes, making them more efficient and easier to manage. IBM recently announced it is using generative AI to translate the legacy Common Business Oriented Language (commonly known as COBOL), which was created around 1959, to Java. This upgrade, without generative AI, is an expensive and painfully long process that cost the Commonwealth Bank of Australia around \$700 million and took around five years<sup>15</sup>.



### 3.3 Generative AI in Healthcare

Generative AI is being used for developing new drugs and diagnostics tools and has driven collaboration between the biotechnology and pharmaceutical industries. Generative AI has powered several research projects regarding diseases and healthcare management<sup>16</sup>. Generative AI is also used in medical imaging to generate synthetic medical images closely related to real ones, creating vast datasets to help medical imaging research progress. It is also used to enhance and reconstruct medical images, thus optimizing them for diagnostic use; and it detects subtle anomalies and segment interest points, thus helping to detect diseases such as tumors and lesions<sup>17</sup>.

In hospital settings, generative AI models are used to automate clinical documentation, support clinical administration, and facilitate multidisciplinary collaboration among healthcare teams. A study mentioned using ChatGPT to generate draft clinical notes swiftly and accurately and using Microsoft Copilot coupled with Microsoft Office to improve productivity during meetings<sup>18</sup>; generative AI tools also utilize speech recognition and offer real-time transcription, ensuring the preservation of critical information and providing recommendations for optimal patient care<sup>18</sup>.

Generative AI is transforming patient engagement by enabling patient-centered, empathetic communication and automating administrative tasks. Hippocratic AI, an LLM tailored for healthcare, prioritizes empathy, care, and compassion in its responses, and it has been shown to be preferred over physician responses<sup>19</sup>. GridSpace, an enterprise solution powered by generative AI, automates patient outreach by handling phone calls, answering questions, and performing administrative tasks, enabling scalable, cost-effective patient engagement and freeing healthcare professionals to focus on critical patient care tasks<sup>20</sup>.

### 3.4 Optimizing Community Pharmacy Practice with Generative AI in Nigeria

The community pharmacy is the first point of care for the populace. People go to the community pharmacy for medical and cosmetic supplies, leading to regular interaction with the community pharmacists<sup>21</sup>. Generative AI tools can help pharmacies manage this traffic and optimize healthcare while catering to the business's administrative and management needs. Some of the aspects where generative AI tools could improve operations include:

**i. Medication management:** In addition to assisting pharmacists in recommending appropriate medications and dosages based on provided patient information, generative AI can recommend dietary and nutritional supplements to improve patients' health outcomes. It can also ensure that the interactions of these drugs do not adversely affect the patient, enabling optimized outcomes. Generative AI can also be employed to automate prescription filling, reduce errors, ensure accuracy in medication dispensing, and track patients' use of their medications<sup>18</sup>.

**ii. Patient Education and Language Translation:** AI tools can help improve patients' understanding of their medications by fast generation of on-demand educational resources explaining how to use their drugs, bridging knowledge and language gaps. This is very important in a country like Nigeria, with its diverse languages and cultures. Prescription labels, dosage instructions, and other educational resources can be translated to cater to the different languages that patients use. Generative AI can also power tele-pharmacy platforms, thus extending services to underserved locations<sup>22</sup>.

**iii. Data management:** Data-driven activities in pharmacies, including inventory management and health record management, can be handled by generative AI tools. Although some applications are already available for these, such as the point-of-sale system most pharmacies use for sales and other electronic functions management, generative AI's speed in providing real-time insight is greatly superior. Generative AI can suggest ordering patterns based on variations, seasons, and sales, thus optimizing supply logistics and ensuring medications are always available. The accessibility to patient information, spanning personal and prescription history records, is quick and secure. This unified data management system can also be a great source of public health data for research, and to track and manage potential public health issues.

In addition to the major uses listed above, generative AI can also be employed in many other innovative ways to solve specific issues or optimize some processes in community pharmacies.

### 3.5 Issues and Limitations of Generative AI

The lifelong fear of AI and robots taking over people's jobs is becoming more realistic now. Researchers believe while AI is not outrightly taking over people's jobs, generative AI will significantly alter how some jobs are done, especially jobs that involve content creation. This is evident from how generative AI simplifies the generation of texts and images and the advancements made with music and video production. Workers in these roles will have to acclimatize, perhaps becoming editors of sorts, which may require different skill sets to their previous functions. This could lead to an increase in the workers' knowledge and productivity<sup>6</sup>. The exciting part of generative AI's effect on jobs is that generative AI creates new jobs and roles that were hitherto unknown, e.g., prompt engineers and AI legal practitioners.

Copyright and ownership issues and privacy concerns are also associated with the development and improvement of Generative AI. There have been numerous debates about the data used in training these AI models before they were launched for public use. Generative AI models such as DALL-E 2 and Bard can be prompted to generate content in certain styles and tones reminiscent of copyrighted materials, posing some currently unsettled copyright and intellectual property ownership questions. Similarly, privacy concerns led Italy to block access to ChatGPT in April 2023. Although access to ChatGPT is now restored, the block examined concerns about collecting and storing users' data to further train the model. This led OpenAI to introduce a feature that allows users to turn off their chat histories. Users can thus choose which conversations the company can use to train the models<sup>18</sup>. Healthcare and other sectors deal with relatively sensitive data that is usually obtained based on trust. While the impact of generative AI, which is still in its infancy, is already astounding, stakeholders and users must look to policymakers to protect their data and intellectual properties. There are now regular calls to regulate the development of AI and the creation of privacy laws, including the right to be forgotten and the ability to unlearn personal events<sup>18, 23, 24</sup>.

Perhaps the most critical issue related to clinical practice is the accuracy of the clinical output by Generative AI models. ChatGPT, the most popular of these models, is infamous for its unpredictability and wide variation in its outputs. This creates trust issues and thus hinders adoption. Generative AI models are also known for their hallucinations, which occur when the model quotes or cites non-existent research, essentially inventing facts. Although there are ways to combat this, it is enough reason to question clinical reliability and safety<sup>18</sup>. Medical and healthcare regulatory bodies are also introducing new regulatory frameworks and updating their existing ones to deal with AI being used as a medical adviser. However, medical AI algorithms will often continue to learn from new data after the initial regulatory approval and may require ongoing reapproval at regular intervals.

## Conclusion



Generative AI is a rapidly evolving technology with many potential applications. However, it also raises challenges that include trust, safety, reliability, privacy, copyrights, and ownership issues. These challenges are not yet fully settled, but they are gradually being addressed as the technology matures. Third-party developers can now easily build custom applications and solutions using application programming interfaces and plugins offered by leading generative AI providers. This is opening up new opportunities for innovation and improving user interfaces.

Researchers believe that generative AI will play an increasingly important role in medicine and healthcare as it further evolves and it becomes better tailored to the unique settings and requirements of the medical domain.



# 4.

## The Future of Pharmaceutical Information: A Case for Generative AI Over Pharmacopoeias and Medical Apps

by **Bashirudeen Ibrahim Opeyemi**

# Introduction

Over the past few years, artificial intelligence (AI) has undergone rapid transformations, initiating diverse changes across many sectors<sup>25</sup>. AI has emerged as a catalyst for redefining conventional practices in domains as diverse as healthcare and manufacturing. AI established an early foothold within the pharmaceutical sector, particularly in drug discovery and development<sup>26</sup>. This white paper delves into a specific facet of generative AI and its pivotal role in the pharmaceutical industry, especially in the future of how we access Pharmaceutical Information from reference materials.

## 4.1 Rationale

Pharmaceutical information is a vital source of knowledge regarding dosage forms, regimes, and formulations. This information serves as a guide when prescribing drugs for certain diseases. There are various sources of pharmaceutical information, some of which are in the form of official books such as the Pharmaceutical Codex (i.e., the British Pharmaceutical Codex), the pharmacopoeias (i.e., The British Pharmacopoeia, The U.S. Pharmacopoeia, The International Pharmacopoeia, etc.).

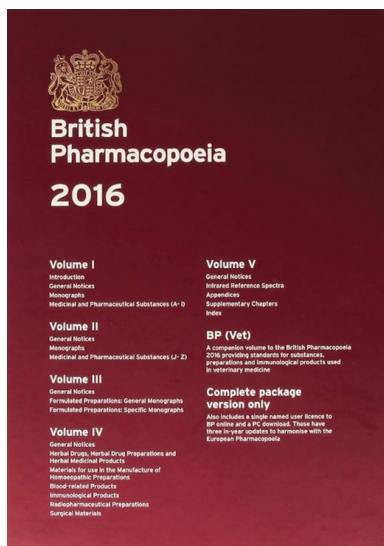


Figure 1. British Pharmacopoeia 2016 Edition.



Figure 2. British National Formulary

Pharmaceutical Information is essential for safe and effective medication use. The info helps healthcare professionals understand the use and risks of different drugs and make informed decisions about which medications to prescribe to their patients, enabling these professionals to avoid guesswork. In the contemporary digital era, bolstered by technological advancements, obtaining medical and pharmaceutical information has become remarkably accessible through the internet and mobile applications<sup>27</sup>. Platforms such as Medscape, EmDEX, WebMD, Epocrates, and Drugs.com are at the forefront of this

digital transition, providing a wealth of knowledge at the fingertips of individuals worldwide. Medscape, in particular, has garnered a global user base of healthcare professionals with over 5.6 million registered users and surpassing 4 million app downloads. Similarly, Epocrates enjoys robust user engagement with over 1 million active users and 600,000 app downloads, further exemplifying the digital shift in accessing pharmaceutical and medical information<sup>28</sup>.

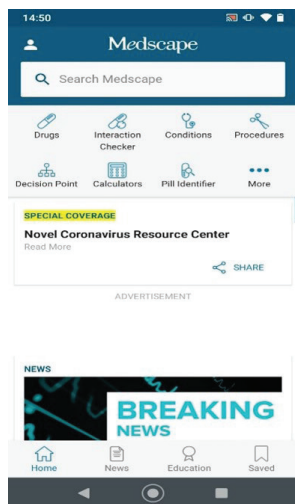


Figure 3. Medscape

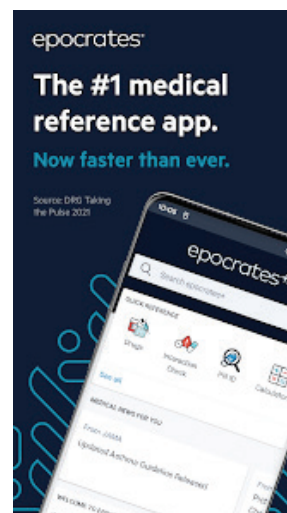


Figure 4. Epocrates

Traditional sources of pharmaceutical information, such as pharmacopoeias and medical apps, have several limitations. Pharmacopoeias are typically updated biennially or triennially, meaning they may not reflect the latest medical knowledge. Medical apps can be helpful for quick reference but are often limited in scope and depth.

Generative AI, a subset of machine learning, harnesses sophisticated algorithms to produce novel data resembling the input data it has been trained on and encompasses a wide array of inputs such as images, text, and chemical structures. This technology leverages neural networks to discern underlying patterns within the input data and subsequently generates new data that closely mirrors the original. In the context of the future of pharmaceutical information, generative AI serves as a transformative tool by deciphering complex pharmaceutical data, facilitating innovative discoveries, and advancing our understanding of crucial pharmaceutical insights.

Generative AI has the potential to revolutionize the way we access and use pharmaceutical information. It can generate new data, such as drug summaries, drug interactions, and adverse event profiles. It can also be used to personalize pharmaceutical information to the individual needs of patients.

Large language models (LLMs) are pivotal to advancing generative AI by streamlining its creation and functionality. These models undergo rigorous training on vast textual datasets, enabling them to generate natural language outputs, discern intricate language patterns, and produce grammatically accurate and semantically coherent text. One prominent application of LLMs is the development of AI-powered chatbots, which can emulate human interactions by delivering authentic and contextually relevant responses to users.

## 4.2 Methodology

### 4.2.1 Data Collection and Integration

**Data Source:** When creating a Generative AI model for pharmaceutical information, the first step is gathering a diverse and expansive dataset from pharmaceutical journals, pharmacopoeias, pharmaceutical codex and databases from institutions such as the FDA or WHO.

**Data Integration:** This refers to combining data from different resources to provide a unified view or dataset. This will allow the model to draw insights from a broad spectrum of information sources, providing a holistic view.

### 4.2.2 Training the Generative AI model

**Initial Training:** Utilizing a selected portion of the compiled data, the generative AI model will be trained to recognize patterns and understand drug properties, potential side effects, and interactions.

**Validation and Iteration:** The generative AI model's generated content will be validated against known data to measure its accuracy. This iterative process helps refine the model's outputs and improve precision.

### 4.2.3 Query-Based Generation

Healthcare practitioners can interact with a specialized system to request precise pharmaceutical data. In response, the integrated generative AI, drawing from its comprehensive training, produces current and occasionally novel insights. This mechanism can be encapsulated within an interactive chatbot, offering professionals a more intuitive and human-like engagement with the advanced model<sup>29</sup>.

### 4.2.4 Feedback and Continuous Learning

**User Feedback Integration:** Healthcare professionals can provide feedback on the generated information, which can be used to refine the model further.

**Real-Time Updates:** As new pharmaceutical research emerges, the model can be updated and retrained, ensuring that the AI's generated content always reflects the latest knowledge.

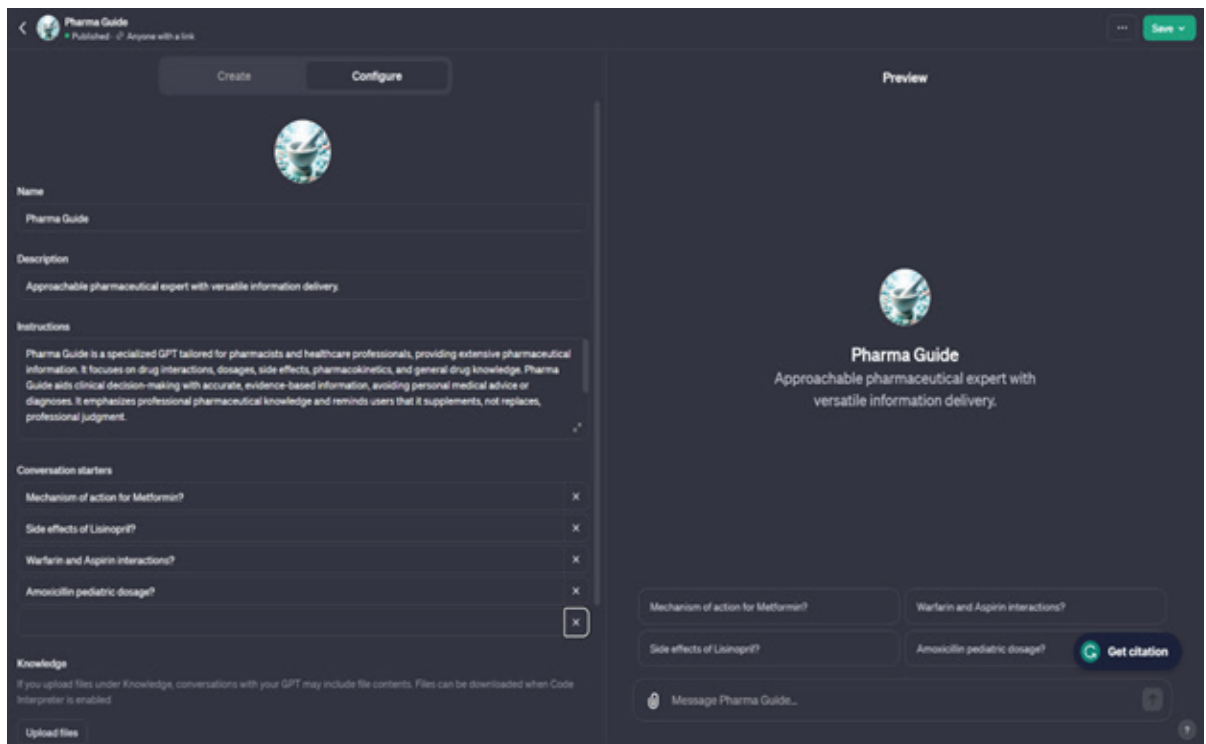


Figure 5. Chatbot "Pharm Guide" provides pharmaceutical information created with Custom GPT.

## 4.3 Conflicts and Resolutions

### 4.3.1 Data Privacy and Security

**Conflict:** As with any AI system that uses vast amounts of data, there is the inevitable concern regarding data privacy and security. With the inclusion of data from institutions like the FDA or WHO and potential real-time updates, ensuring the integrity and confidentiality of data becomes paramount.

**Resolution:** The system must include rigorous data encryption techniques, adhere strictly to global data privacy standards, and employ advanced cybersecurity measures to prevent unauthorized access. Additionally, it is essential to obtain permissions and licenses for any data sourced<sup>30</sup>.

### 4.3.2 Accuracy and Reliability of AI-Generated Information

**Conflict:** Relying on AI-generated information can pose concerns about the data's accuracy, especially in critical areas like pharmaceuticals.

**Resolution:** The model must undergo extensive validation and regular audits. By comparing the generated data with trusted sources, ensuring the system's output remains credible. Encourage regular feedback from healthcare professionals for continuous refinement.



### 4.3.3 Bias and Misrepresentation

**Conflict:** AI models, including generative AI, can perpetuate biases in the training data. This could lead to the AI system making biased predictions or misrepresenting certain drug information.

**Resolution:** Bias can be overcome by employing fairness-enhancing interventions during the training process. Using diverse datasets that cover a broad spectrum of information will help prevent the perpetuation of any specific biases. Also, regularly review and update the data sources to maintain a balanced representation.

### 4.3.4 Over-Reliance on AI-Generated Information

**Conflict:** With the convenience and advanced capabilities of the generative AI model, there is a danger that healthcare professionals might become overly dependent on it, potentially sidelining traditional information sources or the professionals' expertise.

**Resolution:** The AI system should be designed as a supplementary tool rather than a primary source of information. Regularly remind users of the importance of cross-referencing with other trusted resources and using their clinical judgment.

### 4.3.5 Technological Barriers and Adaptability

**Conflict:** While AI tools are advanced, they might not be accessible to or user-friendly for all healthcare professionals, especially those who are less technologically inclined.

**Resolution:** Prioritize user experience in the development phase of the chatbot or interface. Provide comprehensive training sessions, user manuals, and customer support to aid users in adapting to the new technology.

### 4.3.6 Ethical Implications

**Conflict:** The ability of generative AI to produce novel insights can sometimes tread on ethical boundaries, especially if it suggests untested or speculative drug interactions or uses.

**Resolution:** Always label generative AI-generated novel insights as theoretical and highlight that they have not been clinically verified. Encourage users to consider these insights as starting points for further research rather than conclusive facts<sup>26</sup>.

## Conclusion

In an era characterized by rapid technological advancements and transformative innovations, the intersection of artificial intelligence and the pharmaceutical sector represents a paradigm shift in how we access and interpret pharmaceutical information. Traditional methods, while foundational, have inherent limitations. In contrast, generative AI promises not only the accessibility of information and the potential for groundbreaking insights into drug interactions, effects, and personalized patient care. Current pharmaceutical information applications could benefit from incorporating generative AI-LLM chatbots. By doing so, the applications can enhance user interactivity, streamline access to drugs' details, and ensure the delivery of precise information for optimal pharmaceutical care.

However, with great potential comes great responsibility. As we tread this new path, we must address conflicts of data privacy issues, accuracy, potential biases, and the ethical implications of AI-generated insights. By adopting rigorous validation mechanisms, prioritizing data integrity, and emphasizing continuous feedback and learning, we can ensure that the adoption of generative AI is a boon to the healthcare community.

In the final analysis, generative AI does not seek to replace traditional methods but to augment them. It offers a dynamic tool that can work with established practices, thus providing healthcare professionals with a richer, more nuanced understanding of pharmaceutical information. As generative AI advances, it is our collective responsibility to use this technology judiciously, always prioritizing the well-being and safety of patients. In doing so, we open the doors to a future where technology and human expertise merge. Improving pharmaceutical care will lead to superior patient healthcare results.





5.

## Filling the Protein Gap with Generative Artificial Intelligence

*by* Flora Oladipupo

# Introduction

With recent advancements, particularly in artificial intelligence (AI), fields including engineering, education, finance and many more have benefitted from innovations. The field of life sciences is not exempt from AI innovations either, as they have facilitated major breakthroughs for scientific research. The process of carrying out scientific research has been a tedious process with many technicalities that can be time-consuming and unproductive results at the end of the process. These problems most often lead to losses in terms of resources, time, and finances that may not be recoverable. Still, the potential gains from carrying out such research outweighs the problems associated with the work, as it could yield results with greatly positive impacts on humanity<sup>31</sup>.

Bioinformaticians and researchers in computational biology are beneficiaries of the intersection between generative AI and scientific research, especially in the three “omics.” The most popular buzz words around generative AI have been large language model (LLM), which covers the Generative Pre-Trained Transformers (GPTs) that are useful for creating conversational content. There is also the protein language model (PLM), which is not used as an ordinary conversational language; it is more of a language model for proteins. That is, PLM is like a GPT for proteins. This model has been a major breakthrough in science considering the challenges and problems faced when trying to understand proteins and their sequences. Now, the gap of understanding between researchers and what is being researched can be bridged while also saving time and other resources needed to study proteins in the laboratory<sup>32</sup>.

## 5.1 What is Generative AI?

Generative AI encompasses algorithms capable of crafting diverse and novel content ranging from text, images, and audio to code, simulations, and videos. This subset of AI, exemplified by models such as ChatGPT, leverages advanced deep learning techniques to produce content of substantial quality, reflecting the patterns and nuances learned during the AI’s training phase. Recent innovations in generative AI hold the promise of revolutionizing content creation processes and offering new methodologies and approaches to synthesizing high-fidelity data and artifacts. The implications of these advancements extend across various domains, and thus could alter how we perceive and engage with artificially generated content.

## 5.2 Types of Generative AI

Generative AIs are being quickly developed and introduced, so there are different types of generative AI depending on their target use; they are not limited to the types mentioned in this paper<sup>33</sup>. By the time this paper is completed, there most likely will be new types of generative AI released for use.

### 5.2.1 Generative Adversarial Networks (GANs)

As the name implies, generative adversarial networks, or GANs, is a generator. Using this analogy, it can be likened to an art contest between two players: the artist who crafts pictures, and the judge who evaluates them. The artist (the generator) strives to create pictures so realistic that the judge (the discriminator) cannot tell if they were made by the artist or are real photographs. Meanwhile, the judge hones their skills in distinguishing real pictures from the ones made by the GAN. They are in a constant game, with the artist trying to create evermore convincing artworks and the judge learning to become more discerning. This playful competition allows GANs to create imagery, sounds, and other forms of content that are remarkably realistic, thus transforming how we generate and interact with digital creations.

### 5.2.2 Variational AutoEncoders (VAEs)

Variational autoencoders, or VAEs, can be visualized as creative translators. Imagine them as artists who study pictures, sounds, or words, then translate what they've learned into a special artistic language—a more condensed, essential form of the original. Afterward, the VAEs use this special language to recreate the original artworks, or even create new, unique pieces of art, blending the essences of what they studied. In essence, VAEs learn the essence of the data they are trained on, such as images or sounds, and use this understanding to create new, similar pieces, offering innovative ways to create and explore in the digital realm.

### 5.2.3 Transformer-Based Models

Transformer-based models are akin to highly intelligent and adaptable linguists in the realm of AI that specialize in understanding and generating human language responses. Imagine having a conversation with a multilingual friend who comprehends and responds in multiple languages and adapts their responses based on what they learned during previous conversations. That is what transformer-based models, like those in the GPT series, do in the digital world. They are designed to understand the nuances of languages, create human-like responses, and even generate coherent and relevant text in various styles. Whether they are answering questions, completing sentences, translating languages, summarizing texts, or crafting content, transformer-based models are revolutionizing the ways we interact with and utilize language-based AI technologies.

### 5.2.4 Autoregressive Models

Think of autoregressive models as storytellers who craft tales one word at a time, with each new word being influenced by the ones before it. They are like writers who, when penning a story, consider the preceding words to decide the next word, ensuring that the unfolding narrative makes sense and is engaging. In the world of AI, models like GPT are examples of such storytellers, creating coherent and contextually apt pieces of text.

These models are trained to generate sequences, whether it be text, music, or another form of data, by learning from the examples they are given, making them versatile tools in creating rich, meaningful, and diverse content in various domains.

### 5.2.5 WaveGAN

WaveGAN is a generative AI model for audios. Imagine WaveGAN as a talented musician in the realm of AI who can compose new, unheard pieces of music or sounds. Instead of using musical notes or instruments, WaveGAN creates these compositions by understanding and manipulating the basic building blocks of sound, namely audio waveforms. It is like a composer who has learned the essence of different musical genres and can create new melodies, harmonies, and rhythms that weren't part of its original learning material, thus expanding the realm of possible auditory experiences. WaveGAN does not just recreate the sounds it has learned; it innovates, synthesizing entirely new audio pieces, thus offering a fascinating approach to sound and music creation.

### 5.3 Applications of Generative AI

The types of generative AI mentioned above are based on the type of content generated. Nevertheless, here is a list of generative AI applications:

1. image generation and manipulation,
2. text generation and language modeling,
3. music and sound synthesis,
4. video synthesis and deepfakes.
5. drug discovery and development,
6. protein structure prediction and design, and
7. genomic data analysis.

### 5.4 Intersection of Generative AI and Biology

Biology is the bedrock of life, holding knowledge of our existence and nature itself. From this bedrock we find cures to diseases, how to preserve our health, facilitate conservation of the environment, and learn general aspects relating to our existence, as seen in some of the AI applications for biology mentioned in the application section of this article. The central dogma of life entails the three main aspects that makes up life: DNA, RNA and protein, which are the very basis of research in genomics, transcriptomics, and proteomics, respectively.

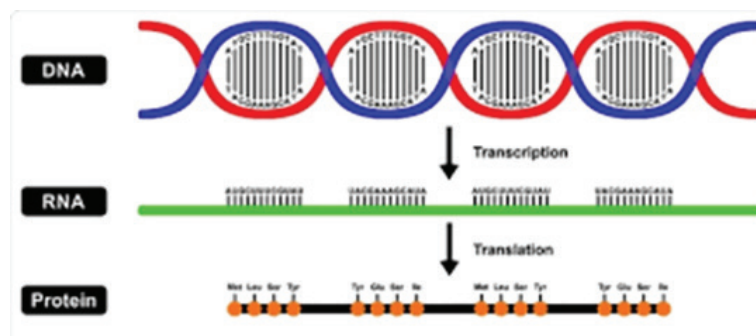


Figure 1. Transcriptions of DNA, RNA, and protein sequences by generative AI

One of the major breakthroughs in biology that AI has created is the development of language models for proteins<sup>34</sup>.

Proteomics involves the extensive examination of proteins, focusing primarily on their structures and functions. This field encompasses systematic identification and quantification of the protein content of a cell, tissue, or organism, and seeks to understand how proteins interact with each other and with other molecules. Through proteomics, scientists can explore how proteins are modified, how they are involved in metabolic pathways, and how their expression changes in response to various factors. This, in turn, helps in disease diagnosis, agricultural research, drug discovery and other applications that are being discovered daily.

AI, particularly through machine learning and language models, has helped address challenges in protein sequencing by enabling the efficient analysis and interpretation of massive protein sequence databases. This facilitates a better understanding of protein structures, functions, and evolutionary relationships, which were previously more time-consuming and resource-intensive to unravel. One of the ways AI has helped solve this problem is through the development of protein Language models<sup>32</sup>.

## 5.5 LLMs

Before delving into protein language models, we need to understand what LLMs are and how they work. This is where the intersection between generative AI and biology truly lies. LLMs are a subset of AI that use statistical analysis and artificial neural networks to process extensive data repositories for natural language processing (NLP) applications. By discerning patterns and relationships between words and phrases, LLMs mimic human intelligence to generate, understand, and manipulate natural language in manners akin to those of specific authors or genres, and enabling the creation of new content such as essays or articles. Through continuous learning from vast datasets, the LLMs enhance various NLP tasks, delivering more refined language-based services and solutions. At the time of writing this paper, there are two AI-powered chatbots that have grown in popularity among users, namely ChatGPT and Bard. These are examples of LLMs.

## 5.6 How LLMs Operate

LLMs are advanced AI systems employing transformer architectures to process and generate text. Through pre-training on extensive textual data, LLMs learn language structures and semantics. The core component, a transformer, comprises two segments: an encoder and a decoder. The encoder captures input data and converts it to vector representations, which the decoder interprets to generate text. The self-attention mechanism allows contextual understanding among words, enhancing the LLM's comprehension and output quality. Fine-tuning tailors LLMs to specific tasks, while human feedback helps refine their performance. Over time, LLMs like ChatGPT evolve, with increased parameters improving their ability to mimic human-like text generation, aiding various NLP applications<sup>31</sup>.

## 5.7 Protein Language Models (PLMs)

PLMs, as powerful machine-learning resources, have become instrumental in analyzing vast protein sequence databases. The models facilitate insights into protein evolution, structure, and functionality. The main application of protein language modelling is in protein folding, which can further expand to protein representation and protein design.

The intersection between LLMs and PLMs lies in treating protein sequences as sentences analogous to the polypeptide chain, with amino acids as words, to explore molecular biology sequence-structure-function paradigm.

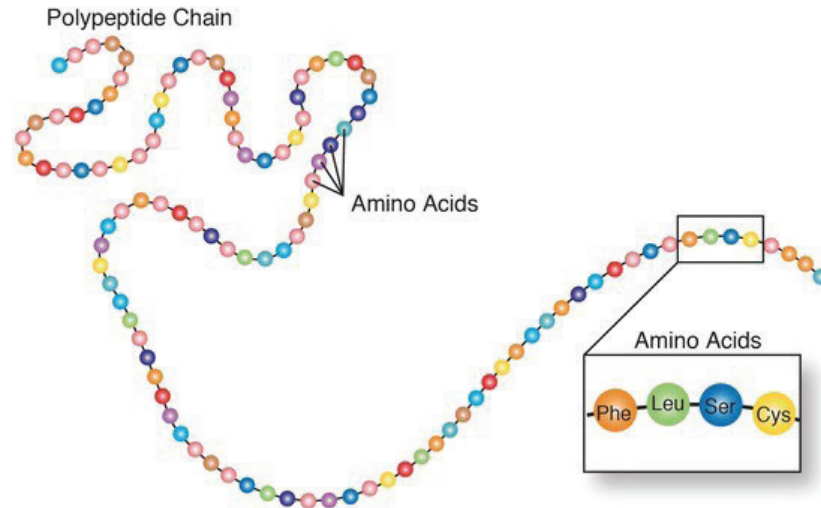


Figure 2. Polypeptide chain

Language models, borrowed from natural language processing, find applications in protein representation and design. Various deep learning models have emerged for protein representation, such as ProtVec, SeqVec, ProtBERT, and variants of T5, translating the advancements in NLP to protein science. This interdisciplinary approach aids in accurately predicting protein properties and understanding underlying biological mechanisms, thus bridging computational techniques with molecular biology.

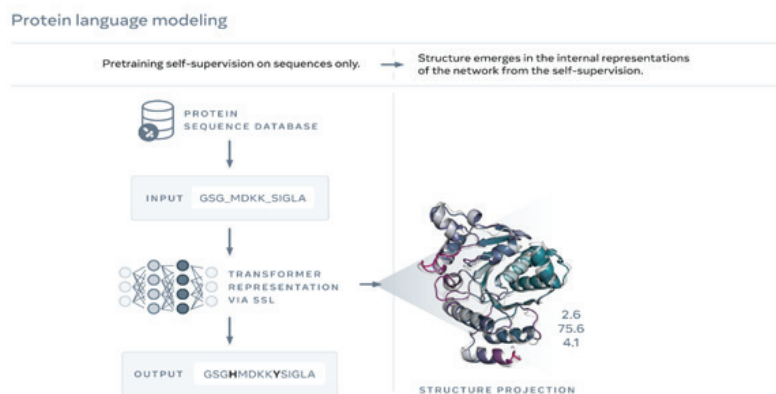


Figure 3. Protein language modeling

To really understand the impact of these deep learning models in protein modeling, we need to understand the concept of protein folding, which is what the breakthrough in protein language models cover. Protein folding refers to the process wherein a protein chain adopts its native three-dimensional structure, which is usually in a folded conformation, thus enabling the protein to attain biological functionality. This is the stage when the protein becomes useful and unlocks its full potential. Misfolding of proteins can occur when they fail to attain their typical native state, a process usually disrupted by mutations in the amino acid sequence or when external elements interfere with the normal folding pattern. This deviation from the expected order of folding represents an anomaly from the standard process. This misfolding can lead to degenerative disorder and cell death.



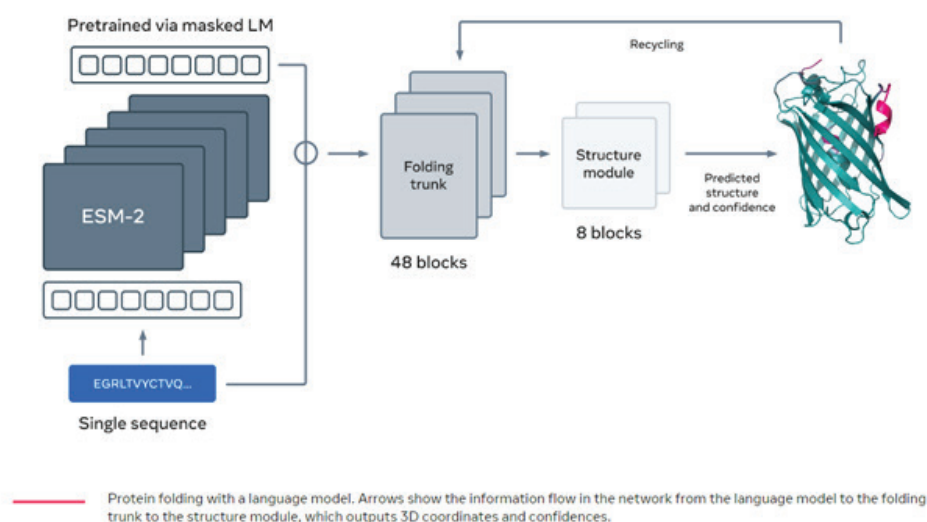


Figure 4. Protein folding with a language model

## 5.8 History of Protein Language Models

In late 2020, a groundbreaking moment in the fields of biology and computing occurred when AlphaFold, an AI system developed by Alphabet's DeepMind, successfully solved the longstanding protein folding problem. This achievement marked a watershed moment, as AlphaFold accurately predicted the three-dimensional shapes of proteins with an unprecedented level of precision, nearing the width of a single atom. It outperformed all previously devised human methods and left a profound impact on the scientific community<sup>32</sup>.

However, AlphaFold was merely the beginning of a new era in the intersection of AI and proteins. The concept of a protein language model traces back to the 2019 UniRep research from George Church's lab at Harvard, although it initially used long short-term memory networks (LSTMs) rather than state-of-the-art transformer models. In late 2022, Meta introduced ESM-2 and ESMFold, which are among the most extensive and sophisticated protein language models to date, and boast 15 billion parameters. ESM-2/ESMFold matches AlphaFold in predicting protein structures' three-dimensional shapes while possessing unique advantages.

Some early attempts at using deep learning for new protein designs, such as ProteinMPNN, originated from David Baker's renowned lab at the University of Washington. Unlike language models, ProteinMPNN relies heavily on protein structure data to generate novel proteins. The Baker lab later introduced RFdiffusion, a more advanced and generalized protein design model that utilizes diffusion models, the same AI technique powering text-to-image models like Midjourney and Stable Diffusion. RFdiffusion generates customizable protein backbones, or structural scaffolds, onto which sequences can be added.

While structure-focused models such as ProteinMPNN and RFdiffusion represent significant advancements in AI-based protein design, the field appears poised for a transformative leap forward, thanks to the capabilities of large language models.

The initial exploration of transformer-based language models for de novo protein design began with ProGen, introduced by Salesforce Research in 2020, with the original model featuring 1.2 billion parameters. Ali Madani, the lead researcher behind ProGen, subsequently founded Profluent Bio to advance and commercialize LLM-driven protein design. While Madani acknowledges the power of LLMs, he emphasizes the necessity of incorporating structural and functional data to maximize their potential in protein design. Another promising start-up in the early stages of applying LLMs to design novel protein therapeutics is Nabla Bio. Emerging from George Church's lab at Harvard and led by the UniRep team, Nabla focuses specifically on antibodies, a logical choice given that 60% of all protein therapeutics are antibodies, and the two top-selling drugs worldwide are antibody-based.

## 5.9 Tackling Protein Folding with Generative AI

Meta AI has introduced a novel method for protein folding, utilizing large language models, to offer an extensive insight into protein structures within one of the largest protein databases, the ESM Metagenomic Atlas, which has over 600 million proteins. The research revealed that using language models could hasten the prediction of atomic-level 3D structures by up to 60 times faster compared to prevailing protein structure prediction techniques. This significant advancement is set to accelerate a new era of structural understanding, potentially allowing for the comprehension of the structures of billions of proteins identified through gene-sequencing technology<sup>35</sup>. Additionally, API access is available for researchers to utilize in scientific studies.

### 5.9.1 ESM-2/ESMFold

ESM-2/ESMFold distinguishes itself by generating structures based on single protein sequences without requiring any structural information as inputs, making it up to 60 times faster than AlphaFold. This acceleration proves invaluable when researchers need to screen millions of protein sequences in protein engineering workflows. Moreover, ESMFold excels in producing more accurate structure predictions than AlphaFold for orphan proteins that lack close evolutionary analogues. ESM-2 can create entirely new protein sequences based on desired properties, diverging from natural sequences<sup>35</sup>.

The ESM Metagenomic Atlas, facilitated by computational approaches, offers a scalable solution to explore and analyze metagenomic protein structures, transcending the limitations of traditional laboratory techniques. This tool facilitates the examination of hundreds of millions of proteins, assisting researchers in uncovering structures that were previously uncharacterized, tracing evolutionary links, and discovering new proteins that could be valuable in medicine and various other fields.

This significantly accelerates the pace at which scientific understanding can advance in the realm of metagenomics, opening avenues for groundbreaking discoveries. This solves most of the major problems that occurs in research, including time and resource wastage.

Just as a complex puzzle is pieced together to reveal a coherent picture, protein sequences are meticulously arranged to fold into specific three-dimensional structures. The way each piece of a puzzle has a unique position and orientation to fit with others, and every amino acid in a protein sequence interacts with others to form a particular structure. By analyzing the co-evolution of amino acid positions, akin to understanding the matching patterns on puzzle pieces, ESM helps infer the structural interplay, revealing the complex picture of protein structures and functions.

In simpler terms, given a partial protein sequence like “A-GT--R” where the dashes represent missing amino acids, ESM could help predict the missing amino acids by analyzing patterns in known sequences and identifying likely amino acids that could fit in the gaps based on co-evolutionary information and other statistical patterns. This way, ESM helps in predicting the complete sequence, which in turn aids in understanding its potential three-dimensional structure and function.

ESM is not the only protein folding prediction tool, but it is currently the most advanced protein language model. There is also AlphaFold, developed by Google DeepMind, but it is not based on language models; instead, it is based on an older bioinformatics method called Multiple Sequence Alignment, which isn't as efficient as the protein language model.

There are other alternatives to ESM, including Uni-Fold by DP Technology, MEGA-Protein by Huawei, SCUBA by Haiyan Liu, RoseTTAFold Diffusion (RF Diffusion) by David Baker, Chroma by Generate Biomedicines, and Progen by Salesforce Research.

Each of these models has unique advantages and functionalities, catering to different needs in protein structure prediction and design.

### 5.9.2 Limitations of Other Models in Comparison to ESMFold

These factors explain why evolutionary scale modeling stands out from the other models and makes it a better option<sup>35</sup>:

- 1. Computational Intensity:** The Multiple Sequence Alignment (MSA) adopted in AlphaFold is computationally intensive because it requires referencing numerous protein sequences to determine the structure of a single protein. This process demands significant computational power and time. In contrast, ESM models, like ESM-2, are faster and can predict protein structures based on a single protein sequence, reducing computational demands considerably.
- 2. Dependency on Evolutionary Data:** MSA, AlphaFold and RoseTTAFold rely on the existence of evolutionarily and structurally similar proteins to make predictions. This dependency limits its effectiveness when dealing with orphan proteins, which have few or no closely related analogs. ESM models are more versatile and can provide accurate predictions for orphan proteins, thus expanding their utility in protein research.
- 3. Protein Sequence Space:** The article emphasizes the vastness of protein sequence space, with an estimated number of possible proteins that far exceeds the number of known proteins. Traditional methods like MSA struggle to explore this immense space efficiently. ESM models, powered by LLMs, offer a more systematic and comprehensive approach to explore and design proteins that do not exist in nature.
- 4. Innovative Protein Design:** ESM models, particularly when combined with structural and functional data, have the potential to revolutionize protein design. They enable the creation of entirely new proteins tailored for specific medical and industrial applications. In contrast, older models like ProteinMPNN and RFdiffusion may not harness the full power of large language models for this purpose.
- 5. Scaling Laws:** ESM models leverage the scaling laws observed in artificial intelligence, where increased model size, training data, and computational resources lead to significant improvements in performance. These scaling laws have been instrumental in the rapid progress of large language models. In contrast, traditional methods lack the scalability and emergent capabilities that ESM models offer.

In summary, ESM models, driven by large language models, represent a significant advancement in protein science compared to traditional methods. They offer speed, versatility, scalability, and the ability to explore the vast protein sequence space, paving the way for innovative protein design and transformative applications in various fields.

### 5.10 Future Advances

Generative AI has demonstrated its abilities to predict protein structures swiftly and accurately, even for orphan proteins lacking close analogs. The concept of inverting protein models, generating entirely novel protein sequences tailored to desired properties, presents an unprecedented opportunity. There is an immense potential for designing proteins that are purpose-built for various applications, including medicine, agriculture, materials science, and environmental remediation.

Despite these remarkable advancements, challenges remain. Incorporating structural and functional data into large language models is essential for further progress. Additionally, the commercialization and practical application of AI-designed proteins will require rigorous scientific, engineering, clinical, and business efforts, making it a long-term endeavor.

Looking ahead, the field of AI-powered protein design holds exceptional promise. It has the potential to revolutionize the treatment of human illnesses, drive advancements in gene editing, transform various industries, and address global environmental challenges. This transformative potential is underscored by the scaling laws observed in AI, in which increased model size, training data, and computational resources lead to remarkable breakthroughs.

Beyond protein design, large language models also have the potential to generate other biomolecules, such as nucleic acids, and contribute to the development of comprehensive foundation models for biology. These models could even extend their understanding from individual molecules to complex biological systems, including cellular interactions, tissues, organs, and entire organisms.

## Conclusion

The remarkable progress in protein modeling, driven by AI and large language models has opened up exciting possibilities for the future of biology and scientific discovery. ESM-2/ESMFold made a groundbreaking achievement by predicting protein structures with exceptional accuracy, and this marked a pivotal moment, demonstrating the power of AI in addressing complex scientific problems.

In essence, the twenty-first century is shaping up to be the century of biology, with generative AI, including large language models, at the forefront of unraveling its mysteries and unlocking its boundless possibilities. While the field of AI-powered protein design is still in its nascent stage, it represents a profound and exhilarating frontier in scientific exploration and innovation.



# 6.

## Generative AI for Music Production and Distribution

by **Olamide Shogbamu**

# Introduction

Music remains an integral part of the human lifestyle. It has the power to foster understanding and help people develop a strong sense of community and humanity, since we connect well with others who share similar music interests. Everyone knows that music is the breath of every party as it sets the mood and brings people together. The experience of having a group of people walk into a room and sing “Happy Birthday” on your birthday is priceless. It surpasses the gifts at that moment due to the awareness and connection it fosters. This paper focuses on the adoption and contributions of Generative artificial intelligence (generative AI) in music production and distribution, and clarifies what Generative AI is and how it can be optimized for music production and distribution. This paper also offers insights on how to strategically prepare and position yourself and your business for the future uncertain outcome of this technology through prediction and foresight.

## 6.1 What is Generative AI?

Artificial intelligence (AI) is a component of technology; it works to enable computer systems to perform tasks that would originally have required human intelligence. The part of this component that focuses on creating new data, such as text, sound, and visuals, is called generative AI. Generative AI learns to create new data by leveraging the ability of a computer to learn by recognizing patterns, information, and structure from a large dataset. ChatGPT, mentioned above, is a common example of generative AI.

Generative AI is a type of artificial intelligence made up of algorithms and models capable of generating new content. The new content it generates is usually in the form of text, images, audio, or video. Generative AI is trained on large datasets of existing content. It learns patterns, structures, and relationships from the content and uses that knowledge to generate new and novel content. Some common examples of Generative AI include ChatGPT, Bard, and DALL-E.

Generative AI can revolutionize the way we produce and distribute music. The type of content the AI generates is largely dependent on the type of content it learns from. For example, if the generative AI model learns from text data, it will produce text data. If it is trained with an audio data type, it will generate an audio file. The illustration below shows the different types of content a generative AI can produce.

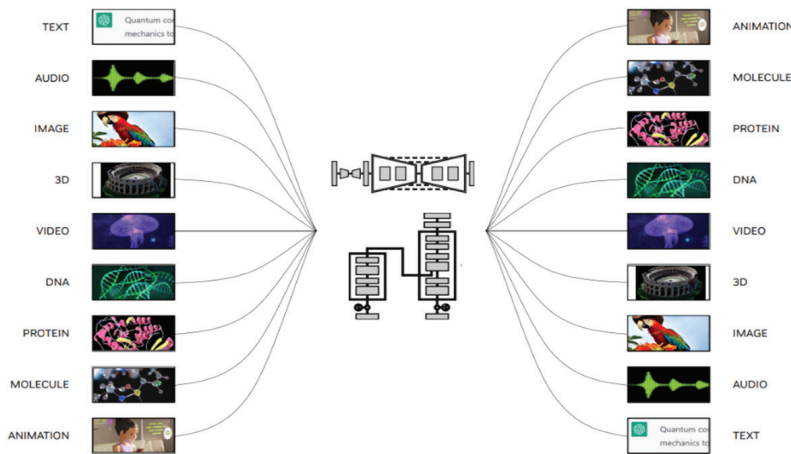


Figure 1: Types of content generative AI can produce.  
Source: NVIDIA Generative AI

One example of generative AI which you may be familiar with is ChatGPT. ChatGPT is an innovation that is breaking records. It recorded 100 million users in only two months; in comparison, YouTube, Facebook, and WhatsApp took years to do so. This rapid growth is an effect of the acceptance and impact ChatGPT has had on the everyday lives of its users. According to Goldman-Sachs Research, “The advancement and adoption of Generative Artificial Intelligence have the potential to bring about big changes to the global economy. As products using natural language processing advance, they could drive an almost \$7 trillion increase in global GDP and lift productivity growth by 1.5 percentage points over 10 years.”<sup>46</sup>

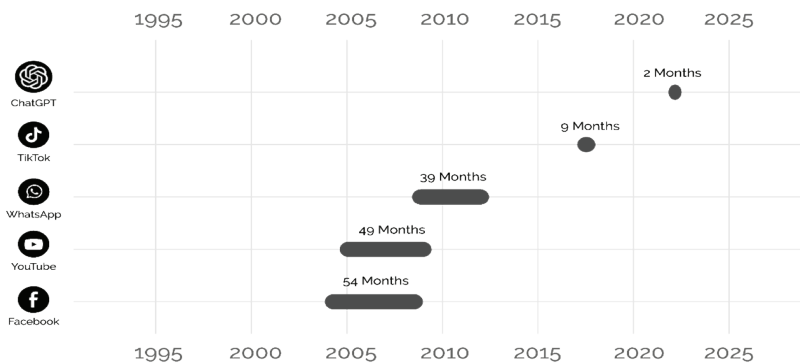


Figure 2: Time needed to reach 100 million users by ChatGPT and various apps/websites

The music industry is a different use case: it is creative, meaning that new music, new content, a new rhythm, a new listener’s choice, and new styles have to be created. These are the areas where we can adopt generative AI in music since its main function is to create new data. The large language model can be trained on existing music data, and the generative AI learns to create new and original music on its own. Although generative AI is still in its developmental stage, with proper investment it has the potential to modify the way we create, share, and consume music. Some instances where generative AI could be used in music production include:

- generating beats, rhythms, and melodies,
- generating custom music from specific user keywords,
- generating playlists and enjoyable music shuffles, and
- generating inspiration and lyrics.

Potential instances in music distribution include:

- recommending new music to listeners,
- detect copyright infringement,
- creating effective product advertisements, and
- functioning as an instant audience assistant and response line.

As developments and breakthroughs in generative AI begin to surface, acceptance and implementation will spread. Stakeholders will begin to worry about what this change will have on them and their organizations. How can they level up with this complex development and optimize it to stay relevant?

### 6.2 How Generative AI Works

Now that you understand what generative AI is, let's have a look at its components and how it works. A user interface or user medium is required for an individual to interact with a machine or software. First, a user enters a prompt or question into the system via the interface or medium. The system takes the input it received and finds important details. The system then compares those details to information in its knowledge source. More relevant information and context are obtained from the knowledge source. The prompt, the query, and the context are sent to a large language model (LLM) endpoint. The majority of the generating magic occurs at the LLM endpoint. The LLM creates new, comprehensive, and meaningful content, then sends it back to the user interface for the user to utilize.

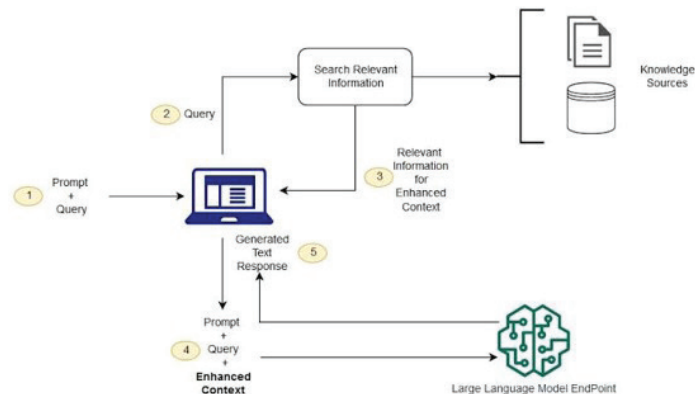


Figure 3. Conceptual Flowchart of information in a gGenerative AI model using an LLM  
 Source: AWS Machine Learning Blog

It is important to know that LLMs are not the only technique that can help generative AI create new content. The technique that helps generative AI create new content is called deep learning, which include LLMs, reinforcement learning, and generative adversarial networks (GANs).



Figure 4. Venn representation on how types of AI can be used together



## 6.3 Generative AI for Music

Generative AI for music is also referred to as AI music. It uses artificial intelligence techniques to produce and consume music. Deep learning methods like LLM are trained on a large amount of existing music data to analyze patterns, structures, and relationships. Generative AI can then generate novel music using the melodies, rhythms, and styles it learned autonomously.

A generative AI algorithm can be trained using a specific musician's style to produce similar music. Generative AI aids the collaboration of music artists and can also produce and mix up multiple musical instruments into a perfect beat that is ready for production. This technology can also generate a user-tailored music experience for their mood or taste. Generative AI for music can help enhance music production and help music distribution regarding the way the music is consumed.

### 6.3.1 Generative AI for Music Production

One fantastic thing about generative AI is how easy it is to employ. A user only requires basic abilities in reading and writing; no technical knowledge is needed.

Have you tried the Android app called StarMaker? This is a perfect app for starting to use generative AI for music production. The application simply takes your voice and processes it into a studio-ready voice, although StarMaker does more fine-tuning of the audio. There are many generative AI tools that specialize in music production and generation. Some examples are:

1. **Google's Magenta Studio:** Google Magenta is an open-source project developed by Google that focuses on using machine learning to create art and music. It can be used as a plugin for Ableton Live. This serves as a cutting-edge machine learning app for generating music.
2. **MuseNet:** MuseNet is an OpenAI project that generates music, including rudimentary singing, as raw audio in a variety of genres and artist styles.
3. **AIVA:** AIVA, which stands for Artificial Intelligence Virtual Artist, is a music composer tool capable of writing emotional soundtrack music. It is powered by AI and designed to help composers and musicians.
4. **AudioCraft:** This is Meta's code base model for all generative audio needs, such as music, sound effects, and compression after training on raw audio signals.
5. **Boomy:** Boomy is an AI-powered music generation tool that creates fully produced songs following your directions, and even lets you monetize them.


### 6.3.2 Generative AI for Music Distribution

Just as the Xender mobile application revolutionized the way we share music, generative AI disrupts how people learn about new music and listen to it. File-sharing apps were very effective when people accessed music by downloading it. Nowadays, music is accessed via streaming. Music streaming platforms like Spotify and YouTube Music are employing generative AI in different ways to serve music to their subscribers and present new music to them. Here are some examples of how generative AI is used in music distribution.

1. **Spotify AI Discovery Weekly:** This is a playlist on the Spotify platform that uses AI to recommend music to listeners based on their personal listening history.
2. **YouTube Music Community:** YouTube uses AI to create a playlist named "From the Community." This creates a playlist that like-minded people (the community) are also listening to from a playlist.
3. **AI Radio:** Platforms like YouTube Music and Apple Music are using AI to create a radio station that is personalized to a user's preferences. This way, users can listen to an exhaustive list without listening to any song twice.
4. **Music Promotion:** Generative AI is used to make specific, target-driven advertisements based on the type of content the audience is interested in. Event campaigns and new music ads are served depending on what music a user prefers to listen to.
5. **Copyright Protection:** Generative AI is smart and intelligent enough to identify copyright infringement and potential copyright violations. This allows music investors to protect their intellectual and creative property.

## 6.4 Experiment

This experiment uses Bard - Google's Generative AI to generate a Music Lyrics for a song titled "African Queen". The output is then compared with the original African Queen song by 2Face Idibia.  
 Left: Google's Bard output | Right: 2Face Original song



*[Verse 1]*  
 She's an African queen, with a heart of gold  
 Her beauty shines bright, like a story untold  
 Her smile is so warm, her eyes so deep  
 She's the woman of my dreams, she's the one I keep

*[Chorus]*  
 Oh, African queen, you're my everything  
 You make my heart sing, you make my soul swing  
 I love you more than words can say  
 You're the light of my life, you're my guiding ray

*[Verse 2]*  
 She's strong and independent, she's always there  
 She's the one who loves me, for who I am, I swear  
 She's my best friend, my lover, my soulmate  
 She's the one who makes my life complete

*[Chorus]*  
 Oh, African queen, you're my everything  
 You make my heart sing, you make my soul swing  
 I love you more than words can say  
 You're the light of my life, you're my guiding ray

*[Bridge]*  
 I can't imagine my life without you  
 You're the best thing that ever happened to me  
 I'm so grateful to have you in my life  
 My African queen, my everything

*[Chorus]*  
 Oh, African queen, you're my everything  
 You make my heart sing, you make my soul swing  
 I love you more than words can say  
 You're the light of my life, you're my guiding ray

*[Outro]*  
 Oh, African queen, my everything  
 You're the light of my life, you're my guiding ray

We observe that the LLM (Bard) is able create a completely different song from the original song. However, it maintains the context and concept of the song which informs us that it has learned from it.

For an individual with music talent, it very easy to turn this lyrics into a nice sound. We can as well finish the work with AI by first generating a beat or instrumental sound for the song then pass the text lyrics into the model like Audio-Craft's MusicGen to convert it into Music.

*[Verse 1: 2Baba]*  
 Just like the sun lights up the Earth, you light up my life  
 The only one I've ever seen with a smile so bright  
 And just yesterday, you came around my way  
 And changed my whole scenery with your astonishing beauty  
 Ah, you coulda make a brother sing  
 You ordinary thing, a supernatural being  
 I know you are just brighter than the moon  
 Brighter than the star, I love you just the way you are

*[Chorus: 2Baba]*  
 And you are my African Queen, the girl of my dreams  
 You take me where I've never been  
 You make my heart go ting-a-ling-a-ling, oh ahh  
 You are my African Queen, the girl of my dreams  
 And you remind me of a thing  
 And that is the African beauty

*[Verse 2: 2Baba]*  
 Yahh ooooo you are my African Queen, oh Lord, ooh  
 Lord, hmm  
 Out of a million you stand as one, the outstanding one  
 I look into your eyes, girl, what I see is Paradise  
 Yeah, you captivated my soul, now every day I want you more  
 How can I deny this feeling I'm feeling inside?  
 Ey, oh no one can ever take your place, can never take your space  
 That's a fact I cannot erase  
 And you, you are the one that makes me smile  
 Make me float like a boat upon the Nile  
 Oooo ooooo yahhhh yahhh ooo

*[Bridge: 2Baba]*  
 You are my African Queen and I know that this means  
 That you're the only one that I will serve  
 I'll give you my heart, my love, my body and my money  
 Every other thing you think of  
 Who could think of anything better than you?  
 Who could think of ever hurting you?  
 Sacrifice my all, I'll give it all to you  
 'Cause you are my African Queen  
 For real

*[Outro: 2Baba]*  
 So black, so beautiful  
 I love you, I love you, I love you  
 Murayema, I love you, I love you, I love you  
 Murayema, I love you, I love you, ooooh yeah  
 My African Queen, I love you, I love you

Artificial Intelligence is a technology that will change the future; and contrary to how many people have perceived it, it will not displace humans. Instead, it will serve as a tool to enhance human creativity and productivity<sup>47</sup>. As a music lover or music investor, the next step is to embrace generative AI and harness its abilities for music production and distribution tasks by automating repetitive tasks, such as generating music ideas, transcribing music, writing lyrics, or automating the creation of fan communities and engaging with them via a chatbot. Just as the cover of this paper was generated using AI, you can also use generative AI to create music cover art. Collaborations can also be explored beyond borders as generative AI allows virtual co-creation. With its ability to translate languages, artists from any part of the world can come together and collaborate.

To get started, find a generative AI tool or platform that can service your need or task. It is important to cross-check the authenticity and quality of the platform. One advantage is that most generative AI platforms are very easy to use. If you have the basic abilities to read and write, you are well-equipped to use these platforms. After selecting a platform, read through the manual or documentation describing how to use it. Now, you are ready to make magic. If you are interested in building your own model for more custom output and to have control over the data, you can take a course on large language modelling or generative AI.

## 6.5 What are the Concerns?

“The AI Drake track is just the sign of a coming storm . . . the scale and inevitable variety could cut into the revenue collected by creators and rights-holders. The music business doesn’t need an umbrella – it needs a flood barrier.”

The statement above was made by Billboard after a music track that had been uploaded to the internet was found to be a copy of Drake’s and The Weeknd’s vocals. The track is titled “Heart on My Sleeve.” The song was later taken down by the record labels. This shows how easy it would be to scale without proper regulation and why there are concerns around the violations of personality and copyright laws<sup>48</sup>. Another thing to be worried about is the ownership rights and deciding who receives credit for the songwriting, vocals, and other contributions. These are confusing areas. Bias and reliance issues are other major concerns of using generative AI. Artificial intelligence is capable of reflecting bias, which is not inclusive and fair; it is not advisable to always fully rely on AI to do the work.

# Conclusion

When music streaming was first introduced, most music investors were against it until a profitable business model was built around music streaming. Now, music streaming is the way many people consume music. Generative AI exists now, and it is going to democratize the way music is created and accessed. Music investors need to start exploring ways to build a business model around it. This will help to create more employment, new roles, and regulate the spam of AI-generated music.



7.

## Household Energy Management Using Generative AI

*by* Richard Ugorji

# Introduction

The discovery of electricity changed the world and the way we live our lives; harnessing this new form of energy ushered in a new era of technology and industrialization in the world. In developing nations like Nigeria, access to electricity is a major driving force for innovation and increased economic activities, thereby reducing poverty levels.

In Nigeria, the power sector experiences many broad challenges related to electricity policy enforcement, gas supply, inconsistent billings, transmission system constraints, and more. The introduction of the electricity meter system has helped tackle some of these issues, such as inconsistent billing and policy enforcement.



Figure 1. Prepaid energy meter

The introduction of the prepaid metering system (shown in fig. 1) has made users more mindful of their power usage. It led them to find and try methods to reduce their power usage and thereby reduce the cost of their energy bills in a highly unstable market. In this market, there is a need for a more pragmatic and systemized approach to help homeowners monitor, analyze, and optimize their energy usage through a system that recommends power plans and provides information on approaches to minimize expenses and maximize usage.

## 7.1 Product concept

Looking at this problem shows the need for a solution that seems personalized to users and highlights solutions that cater to the users' needs. In designing our solution, we realized the need to integrate a "buddy-like" interface for users that is engaging and, more importantly, feels distinct to our users. Imagine that you have a personal assistant that monitors your electrical power expenses, analyzes your spending, and offers recommendations based on your current financial situation. This digital assistant also monitors your electricity usage at intervals you set, analyzes your energy use patterns. Also, it can also integrate with your financial information, gaining insights into your energy expenses and financial goals.

Using your data, the digital assistant would offer personalized recommendations tailored to your unique circumstances, such as helping you set a budget for electricity, suggesting energy-efficient upgrades, or alerting you to cost-saving opportunities. This personal assistant could become your trusted ally in making informed decisions that optimize your power consumption and enhance your financial well-being.



Figure 2. Sample chatbot for our energy assistant project

## 7.2 Methodology

According to McKinsey, “Generative artificial intelligence (AI) describes algorithms that can be used to create new content, including audio, code, images, text, simulations, and videos. Generative AI is capable of producing highly realistic and complex content that mimics human creativity, making it a valuable tool”<sup>49</sup>.

Large language models (LLMs) can be described a type of generative artificial intelligence (generative AI) that can create human-like text and perform various natural language processing tasks. The LLMs are trained on massive datasets of text, allowing them to learn the patterns and relationships that exist in language. In simpler terms, LLMs are a type of generative AI model that can understand and generate textual data. Common examples are OpenAI’s ChatGPT, Microsoft’s Bing and Google’s Bard.

Our product concept revolves around using state of the art (SOTA) models and a technique called transfer learning, which enables models to leverage pre-existing knowledge to solve problems more efficiently. In this setup, we use our sourced data to retrain the end layers of our SOTA models, such as OpenAI’s GPT 3.5, and then provide access to our model through a phone app interface for our end users.

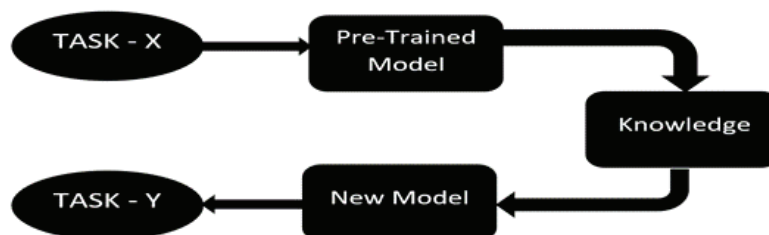


Figure 3. Flow chart for developing our SOTA model

### 7.3 Simple Transfer Learning Framework

Transfer learning will enable us to build a large language model specialized for our task using the intricacies and knowledge of recognized SOTA models. This helps us create a SOTA model for our tasks<sup>50</sup>.

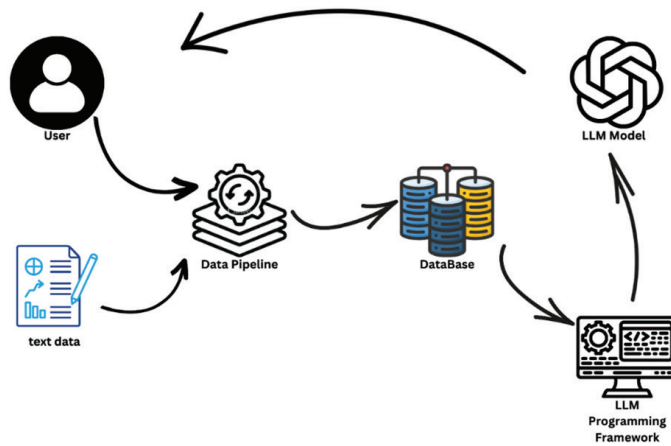


Figure 4. Proposed Project Concept Framework

A simplified version of the proposed network for our product concept is shown above (figure 4). The concept has four key components:

- Data Pipeline**  
 This component handles our Extract, Transform and Load process. It will acquire data from the user or from other learning sources, transform it, and load it into our system.
- Database**  
 This system stores data and their embeddings. Databases allow faster processing and reduce the amount of data processed during training and inference.
- LLM Programming Framework**  
 The LLM framework serves as a programmable interface between the LLM model and the system. It plays a crucial role in orchestrating various components, including the LLM model, embeddings, etc.
- LLM Model**  
 This is our SOTA model, which is fine-tuned after using the transfer learning technique. It is responsible for generating intelligent output for our end users.

### 7.4 Resolutions

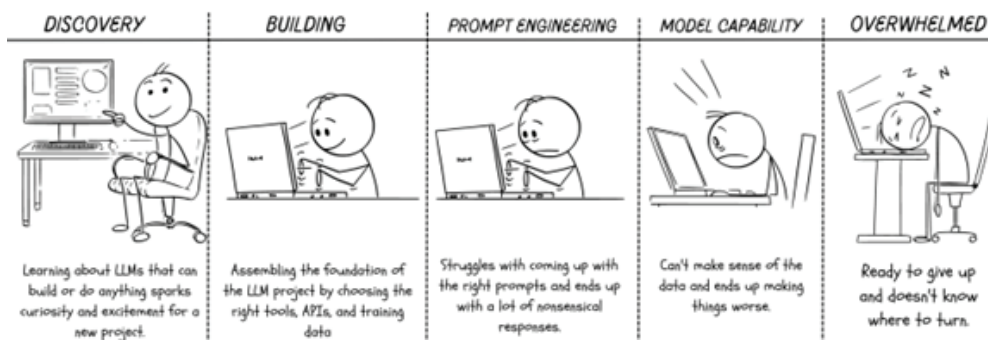


Figure 5. Model development challenges

While the product is indeed impressive, considering its infrastructure and alignment with our project objectives, it presents certain challenges and potential obstacles. Some of these issues, which I anticipate could be significant hurdles both during development and production phases, are:

- **Scalability**

While these models offer remarkable capabilities, their substantial computational requirements result in significant cloud costs that can strain budgets. Running LLMs at scale also entails substantial expenses for the computational resources and for their energy consumption, making them cost-prohibitive for organizations.

- **Maintenance**

LLMs are continuously evolving, and keeping models up-to-date, managing model versions, and dealing with software updates are ongoing tasks.

- **Data**

LLMs are highly data dependent, especially in the development phase. Although transfer learning reduces this, the need for data related to our task is still an obstacle we will need to overcome. Also, data privacy and security are essential. Ensuring that sensitive information is not inadvertently exposed is crucial.

- **Response Quality Control**

Monitoring and maintaining the quality of responses generated by LLMs is essential to prevent issues such as delivering incorrect information or misleading content.

## 7.5 Key Takeaways

- **User-Centric Approach:** The project emphasizes the need for user-centric solutions that feel personalized and engaging to individual users.
- **“Buddy-Like” Interface:** The concept introduces a “buddy” like interface, that will create a distinct and interactive experience for users.
- **Personalized Recommendations:** Using data analysis, the digital companion will offer personalized recommendations tailored to each user’s circumstances, including budgeting, energy-efficient upgrades, and cost-saving opportunities.
- **Tech-Enabled Sustainability:** The concept leverages technology to promote sustainable practices in energy consumption and financial management.

# Conclusion

Our product will be one of a kind, especially in the Nigerian market. Our project concept revolves around the creation of a user-centric, personalized digital assistant designed to revolutionize the way individuals manage their electrical power expenses. The goal is to create a “buddy-like” application interface that offers recommendations to our end users.





8.

Harnessing Generative AI for  
a Personalized Self-Healthcare  
Evolution in the Healthcare  
Revolution

by **Gideon George**

# Introduction

We live in an era of unprecedented technological advances that have solved problems in most industries. The healthcare sector has not been left out, as emerging technologies, including artificial intelligence (AI), stand as beacons of innovation. These technologies' vast potentials could create a paradigm shift toward personalized self-healthcare, especially by using generative AI, which is a sub-field of AI. By harnessing the power of generative AI, individuals could be equipped with the tools needed to take center stage in managing their well-being and become active participants in their health journeys. This white paper explores the potential to Generative AI to reshape the healthcare sector.

The healthcare industry is undergoing a revolution, driven by factors including rising healthcare costs, accessibility to healthcare services, the prevalence of chronic diseases, and technological advancements, among many others. Generative artificial intelligence (generative AI) could be harnessed to enable individuals to become better informed about their health statuses, gain insight for better health awareness, and receive personalized recommendations by providing basic information input to generative AI. These inputs would include each person's blood group, genotype, clinical test results, medical history, medical documents, medical images, and electronic medical records. This information would be processed, and the generative AI's output, or responses, would be generated in text, audio, video, or image format(s).

The rationale behind this proposed integration of medical information into digitized format is the need for continuous and proactive management of individuals' well-being and their ability to access personalized self-healthcare management advice. Shifting the healthcare system's focus from reactive to proactive healthcare would allow individuals to delve deeper into their health metrics and become equipped with the knowledge and the awareness needed to optimize their well-being, thus making it faster, more efficient, and economically viable to improve healthcare.

The implications, importance, and potential impact of embracing generative AI for personalized self-healthcare is immense, as using generative AI offers the potential to empower individuals with the knowledge and tools to be informed about and understand the state of their bodies and make informed decisions about their general health. This white paper explores the concept, conflicts, and potential resolutions of using generative AI in a proposed, personalized self-healthcare system.

## 8.1 Generative AI

Generative AI is a subfield of AI that can take input from a user, process it, and generate new content. The generated output can be text, audio, video, images, or computer programming code. The input and output can be in the same medium, such as text-to-text, or in a different medium, such as text-to-video, text-to-image, etc.<sup>57</sup>



Figure 1. Innovating generative AI tools shaking up major industries  
 Source: 25 Best Generative AI Tools: The Power and Pressure Game Is On! (Madhvani, Niyati. 2023)

## 8.2 Healthcare Revolution

Technology has dramatically improved the healthcare sector from when it was based solely on the culmination of human intelligence, judgment, and effort. This occurred due to the need for, and advancement of, the digital era. Revolutionizing healthcare delivery systems began by maximizing access to medical data from healthcare specialists, electronic health records, and different technologies<sup>58</sup>. In the Medicine and health fields, AI is used in prevention, diagnosis, novel drug designs, and after-care. Its positive outcomes are auspicious, such as equitable distribution of healthcare, reducing human error, reducing reliance on social services, and reducing medical costs<sup>59</sup>.

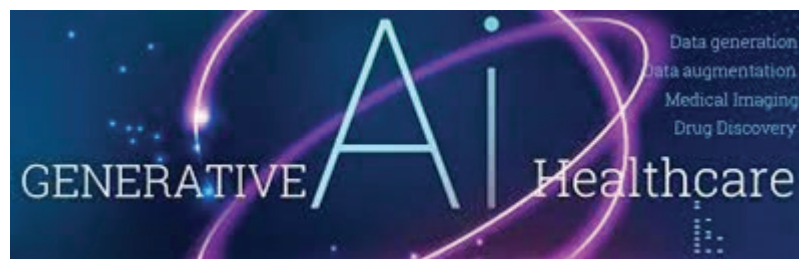


Figure 2: Generative AI in Healthcare: Revolutionizing Medical Discovery and Care  
 Source: 25 Best Generative AI Tools: The Power and Pressure Game Is On! (Syed Rayhan Zafar. 2023)

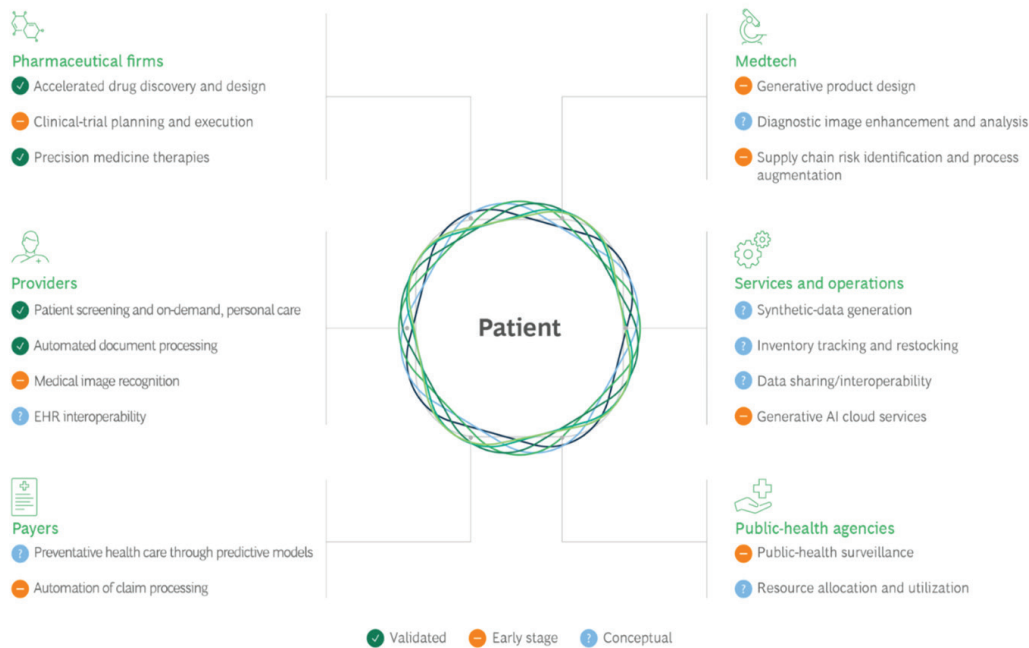
### 8.3 Personalized Self-Healthcare

This approach to healthcare would be tailored to each person’s unique needs, providing them with a personal health plan to maximize their health and minimize disease. It would focus on having individuals manage their health by using generative AI to offer insights, solutions, and recommendations customized to their health needs so healthcare is understood and managed better than it is now.

Harnessing generative AI in synergy with personalized self-healthcare would operate on the principle of deep learning to continuously adapt and evolve based on real-time data. This can be transformative on a large scale and help enable the shift from reactive to proactive health management strategies. Making knowledge about each person’s health fully available to them is not just a privilege but a fundamental right. Adopting personalized self-healthcare would foster a more equitable, informed, and healthy society. When information is easily accessible and personalized to each person’s special needs, and when individuals are not just patients but active stewards of their well-being, it will empower individuals, democratize healthcare knowledge, and redefine the essence of healthcare delivery, thereby shaping a future in which personal health management is not just a concept but a reality accessible to all.

“Generative AI algorithms can analyze large volumes of medical data and create new content. Technology can improve the quality of care, make it more accessible and affordable, reduce inequities in research and care delivery, and help companies unlock value in new ways. Moreover, generative AI overcomes some previous hurdles to AI adoption in healthcare. It requires less data, is more adaptable to unfamiliar situations, and can interface better with clinical staff. These features make generative AI more broadly applicable and transferable to different health care tasks.”<sup>60</sup>

### Generative AI Has Potential Use Cases Across All Health Care Segments



Source: BCG analysis.

Figure 2: Generative AI in Healthcare: Revolutionizing Medical Discovery and Care  
 Source: 25 Best Generative AI Tools: The Power and Pressure Game Is On! (Syed Rayhan Zafar, 2023)

Generative AI will grow faster in healthcare than any other industry, with an estimated annual growth rate of 85% until 2027.<sup>26</sup>

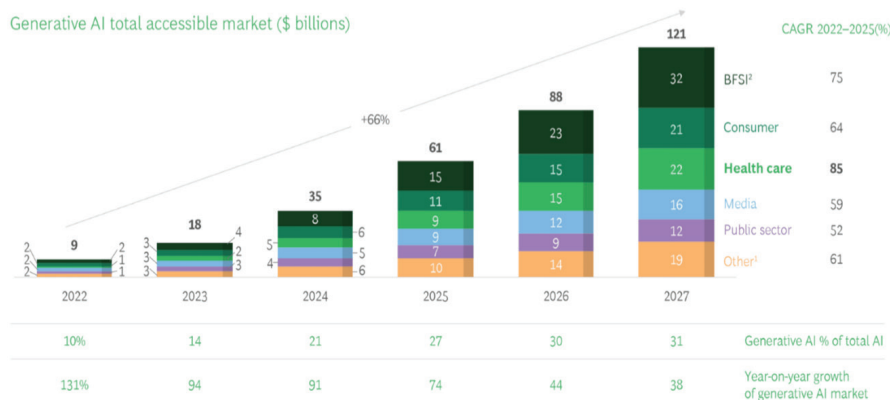


Figure 4: Growth of Generative AI in Healthcare  
 Source: The Accelerated Growth of Generative AI in Healthcare Compared to Other Industries (Schroer et al, 2023)

### 8.4 Benefits of Using Generative AI for Personalized Self-Healthcare

Generative AI offers several benefits for personalized self-healthcare, as listed below.

- i. **Accuracy:** An accurate and personalized insight into each person’s health can be generated with AI because it can be trained on large datasets, enabling it to identify and learn from patterns. These datasets would include health data, including genetic, lifestyle, and medical records.
- ii. **Scalability:** Generative AI can be used to personalize healthcare at scale. This is because generative AI models can be deployed on computers and mobile devices, making them accessible to everyone on the planet who has access to such devices and can use the internet.
- iii. **Affordability:** Generative AI can perform numerous tasks currently performed by healthcare professionals, thus making it more affordable.
- iv. **Mental health:** Generative AI can develop new tools for mental health assessment, prevention, and treatment, such as chatbot-based therapists that provide personalized aid to patients with mental health conditions.
- v. **Chronic disease management:** Generative AI can be used to develop new tools for managing chronic diseases. This would be highly beneficial to humanity.
- vi. **Disease Detection:** Generative AI can save lives by detecting diseases earlier and more accurately, which could lead to better outcomes. The importance of saving lives cannot be overemphasized.
- vii. **Improve Healthcare Delivery:** The automation of several tasks using generative AI can help to improve the efficiency of healthcare delivery. This can help healthcare providers to focus on patient care.

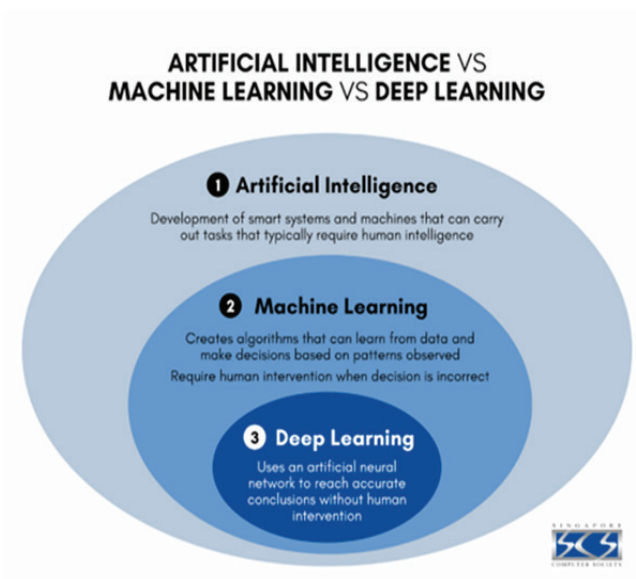


Figure 5. Basic building blocks  
 Source: Machine Learning vs. Deep Learning.  
 Adapted from Singapore Computer Society (n.d.).61(Schroer et al, 2023)

## 8.5 Fine-Tuning LLMs for Healthcare

Fine-tuning large language models for use in healthcare will require customizing this smart language expert for a specialized job in the medical domain. It will be like giving them additional training, specifically about health and medicine. So, they can assist medical practitioners by providing the desired information, generating reports, or suggesting treatment options tailored to the individual user.

### 8.5.1 Process for fine-tuning an LLM in the context of generative AI for personalized healthcare

The steps listed below explain what must be done, and when, for optimal results in the generative AI's functioning. The steps are:

1. **Healthcare Data Collection:** Gather a high-quality healthcare dataset containing medical records, patient data, and relevant health information.
2. **Data Preprocessing:** Clean, anonymize, and structure the healthcare data while preserving its quality and privacy.
3. **Base LLM Selection:** Choose a base large language model (such as BERT) as the foundation for fine-tuning.
4. **Dataset Splitting:** Divide the healthcare dataset into training, validation, and test sets.
5. **Fine-Tuning:** Train the base LLM on the healthcare dataset, adapting it to generate health-related content and recommendations.
6. **Validation and Tuning:** Continuously assess the fine-tuned model's performance on the validation set, fine-tuning the hyperparameters to optimize the results.
7. **Healthcare-Specific Metrics:** Evaluate the model using healthcare-specific metrics, such as accuracy of diagnoses, adherence to medical guidelines, and patient satisfaction.
8. **Deployment:** Deploy the fine-tuned model within a secure healthcare environment, ensuring compliance with the data privacy regulations.
9. **Optional Real-Time Data Integration:** Connect the model to real-time health data to provide personalized recommendations.
10. **Maintenance and Monitoring:** Implement monitoring systems to detect anomalies in health recommendations and provide ongoing model maintenance
11. **User Training:** Educate healthcare providers and users on effectively using the AI system for improved self-healthcare
12. **Feedback Loop:** Establish a feedback loop to collect input from healthcare professionals and users, thus guiding further model improvements.
13. **Ethical Considerations:** Ensure ethical use of the AI system, addressing concerns related to data privacy, bias, and transparency.
14. **Documentation:** Maintain comprehensive documentation of the fine-tuning process, model performance, and compliance efforts.

## 8.6 Use Cases for Generative AI in the Healthcare Industry

- Personalizing treatment plans
- Improving care
- Enhancing medical imaging
- Enabling early disease detection
- Accelerating drug discovery
- Stimulating medical research
- Empowering constant patient support
- Supporting clinical decision-making
- Boosting healthcare operations
- Empowering population health management.<sup>62,63</sup>

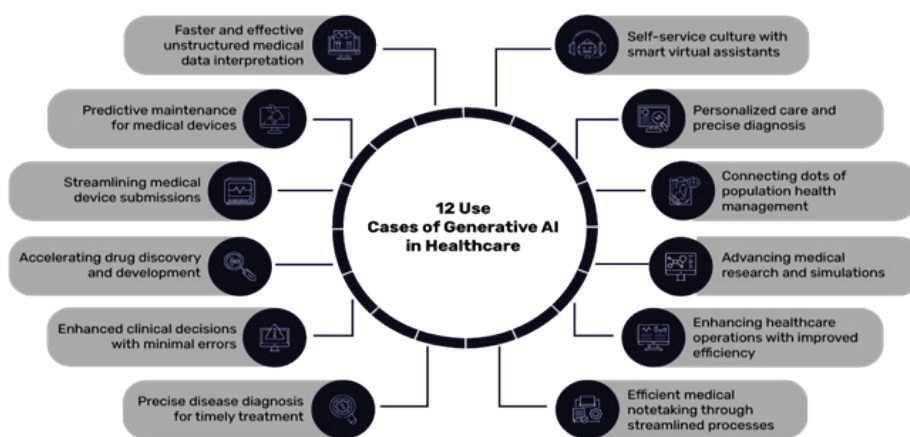


Figure 6: Other Use Cases of Generative AI in Healthcare  
 Source: Mindbrowser team (n.d.). 12 Use Cases of Generative AI in Healthcare

## 8.7 Conflict and Resolutions

	Conflict	Resolution
1.	Issues of data privacy	Implementation of data governance frameworks and stringent privacy regulations.
2.	Over-reliance on generated recommendations	Upholding the fundamental human elements in healthcare and educating individuals to critically assess health insights.
3.	Lack of transparency	Educating healthcare professionals about some essential features of AI models.
4.	Copyright infringements and intellectual property rights	Develop frameworks that address intellectual property and authorship rights for AI-generated content.
5.	Security risks and privacy	Stringent implementation of encryption, access controls, and ethical guidelines to safeguard patient data.
6.	Possibilities of false results	Continuous validation and testing of AI models while enabling clinical judgment by healthcare professionals.

7.	Issues of overreliance or misuse	Maintaining the human element in other supporting aspects while providing adequate training, education, and guidelines for responsible AI use.
8.	Challenges of data interoperability	Developing standard data formats and protocols for seamless data exchange between elements of healthcare systems.
9.	Inadequate resources in healthcare institutions	Better investment in AI infrastructure and training in healthcare organizations is necessary for the maximum utilization of the immense data that can be collected on a daily basis, as data is the new crude oil.
10.	Considerations of AI ethics during development	Integrating ethical AI uses and responses into development processes, conducting regular reviews and overly involving ethicists in AI projects.
11.	Informed consent awareness	Establish transparent consent processes for AI utilization that enable patients to understand how their data will be utilized.

## Conclusion

By harnessing the power of generative AI, personalized self-healthcare is set to become a revolutionary force in healthcare. It can help individuals gain previously unknown insights about their health statuses and receive recommendations tailored for their optimal well-being. To fully embrace generative AI's potential is to take a remarkable step toward a future where individuals are empowered to take control of their health and make informed decisions leading to healthier lives. However, it is essential for this transformation to be duly approached with caution and responsibility by ensuring that privacy is preserved and errors are minimized. Importantly, the human element in healthcare should not be diminished; instead, it should be augmented. To maximize its full potential, stakeholders from diverse domains need to collaborate and ensure that the evolution of healthcare is inclusive, equitable, and universally accessible. This white paper recommends fostering an ecosystem that encourages innovation while maintaining ethical standards. The integration of generative AI for personalizing self-healthcare is not just a technological advancement but a societal shift towards a future of healthcare as a realization of individual empowerment, autonomy, and fundamental human rights. This integration is indispensable, and the rewards could be profound and revolutionary.



A hand is visible in the bottom left corner, pointing towards the center. The background features a large green number '9' on the right side. The overall design includes a green circular shape at the top right, a white speech bubble icon in the center, and a white robot head icon on the left. The background is a light gray with a bokeh effect of small white and blue dots.

9.

# Exploring the Pragmatic Ability of Large Language Models Revolution

by **Oluwawemimo Folayan**

# Introduction

In simple terms, generative artificial intelligence (AI) is the creative AI. It is the ability of AI to generate entirely new and original content based on the vast amount of data it was trained on<sup>64</sup>. The content ranges from text to multimodal. These processes have revolutionized every aspect of artificial intelligence.

Language and language use is essentially a complex, intricate system of human expressions governed by grammatical rules<sup>65</sup>. Communication has been an integral part of human existence. One of the most successful aspects of human communication is language use. The arbitrariness of languages has become standardized to pass information.

Generative AI is built on the principles of language use, which is why it is the foundational part of natural language processing (NLP)<sup>66</sup>. Large language models' (LLMs') ability to process massive data sets allows them to potentially know and understand everything, including the entire history, context, nuance, and intent of a business and its products, markets, and customers<sup>64</sup>. The aim of this paper is to examine potential LLM and human similarities and distinctions in terms of pragmatic use of language; specifically, in the popular LLMs, their abilities to understand and communicate in literal meanings of utterances with pragmatic implications.

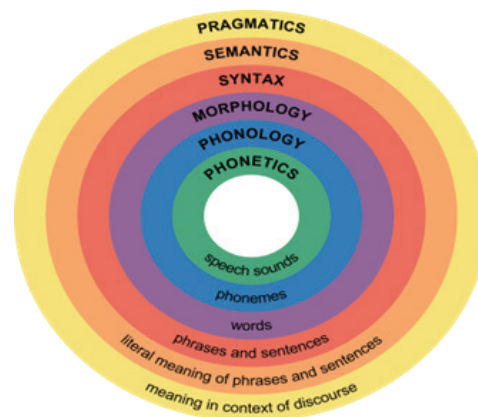


Figure 1. Aspects of language.

## 9.1 Generative AI and LLM

*"Generative AI is teaching us that the way you speak is actually code itself"*

*-Lisa Huang, Head of AI at Fidelity Investments*

The groundbreaking introduction of Transformers in NLP, and the success of pre-trained Transformers, led to significant rise of LLMs<sup>67</sup>. LLMs are a specific type of generative AI model that focuses on generating human-like text. Generative AI encompasses a broader range of models and algorithms that can generate content beyond text. LLMs are specifically designed for NLP tasks and generating coherent and contextually relevant text based on the input they receive. They use generative algorithms to predict and generate sequences

of words, allowing them to create new text that is not explicitly present in the training data. While LLMs are a prominent example of generative AI in the context of natural language processing, generative AI as a whole includes various other models and approaches that generate content in different domains and modalities.

Generative AI is a subfield of AI that can take input from a user, process it, and generate new content. The generated output can be text, audio, video, images, or computer programming code. The input and output can be in the same medium, such as text-to-text, or in a different medium, such as text-to-video, text-to-image, etc.<sup>57</sup>

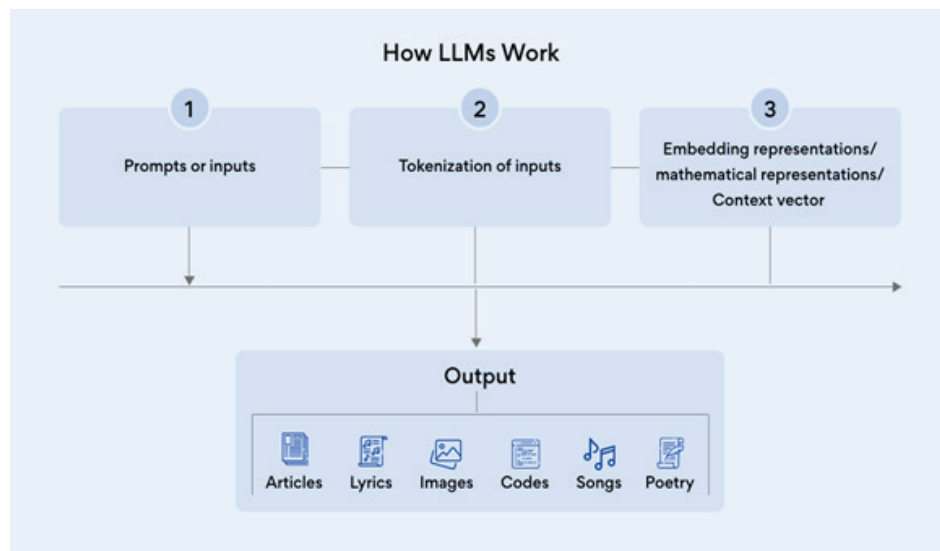


Figure 2. How LLMs work

## 9.2 Pragmatics and Language Use

One of humankind's most significant creations is Llanguage. More than any other development, this attribute separates our species from all other life forms on the earth. It permits contemplating concepts beyond tangible realities to envision alternative possibilities through simulation of hypothetical scenarios<sup>65,68</sup>. It also facilitates the dissemination of such speculation between members of our society and the refinement of ideas across eras and locations over many years. Practically no aspect of modern civilization could exist in its current state without language use.

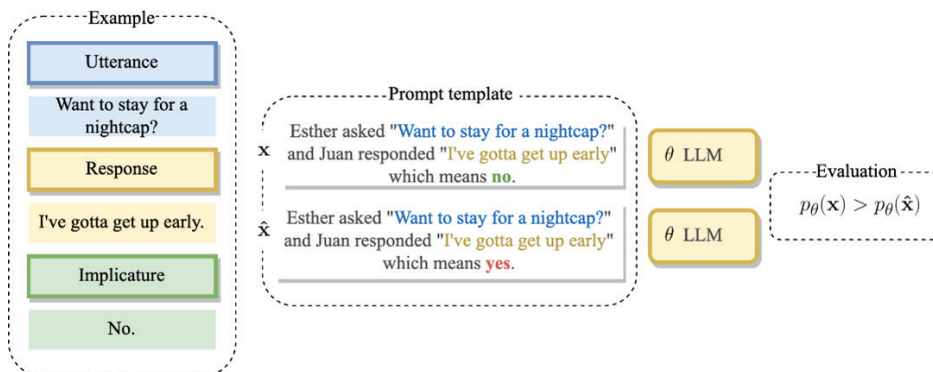
Communication is the catalyst for creation and change. Through human expression and exchange, innovation is sparked. Whether in applications, digital environments, written works, correspondence, visual or auditory mediums, language fuels discovery and progress<sup>65</sup>. Interactions and information, in all forms, can give birth to novel ideas, refining and reimagining them when leveraged with purpose.

Pragmatics refers to the contextual and sociocultural aspects of language beyond the literal meaning of words. It deals with how language is used in real communication. Pragmatics examines language as it is used in real communication rather than as an isolated set of grammatical rules. It explores how speakers and listeners make sense of utterances by taking into account various contextual factors, such as the speaker's intentions, the audience's expectations, the discourse situation, the cultural norms, and the communicative functions of the speech act. Pragmatics focuses on how speakers and listeners make sense of utterances by taking into account the social, cultural, and communicative factors that influence their interpretation.

### 9.3 Understanding Pragmatics in LLMs

Advances in automated language processing provide entirely new possibilities for generating value. As technologies progress in their abilities to understand, generate and interact with human speech and text at scale, they open up opportunities that have never existed before to transform countless domains and activities through their enhanced communication abilities<sup>65,67</sup>. The automation of language processing holds great potential for driving innovation, productivity, access to information and overall benefit. LLMs are able to understand contextual meaning through statistical learning from large conversational corpora, and are trained on real dialogue to provide statistical patterns that help with very common pragmatic inferences like implications, politeness, and presuppositions<sup>66</sup>. These models are trained on sufficient examples to infer or understand context about speakers, relationships, settings, and sequence of events<sup>69</sup>. Therefore, LLMs can make reasonable guesses about unstated presuppositions and inferences from conversations.

Using the rules guiding socio-cultural relationships helps the models understand common contextual conventions and dialogue templates that reflect pragmatic expectations. Also, feedback from humans helps the LLMs understand correlations between language, context, and appropriateness<sup>67</sup>.



### 9.4 Limitations

LLMs are predominantly trained on large text corpora, which provides exposure to different language usages and contexts. However, this data doesn't fully capture the richness of human pragmatics. Without a true understanding of the world, LLMs still struggle with pragmatic phenomena including implications, presupposition, cultural norms/expectations, politeness, deixis, and ambiguity resolution based on shared assumptions between people. For example, the word "Transformer" connotes and denotes different meanings depending on the context. The model is, therefore, limited by the context of the conversation and the meaning it was trained on.

## Conclusion

Continued learning from diverse, real-world dialogue data involving pragmatic inferences could help LLMs better understand and approximate the nuances of human communication. Explicitly modeling and fine-tuning the LLMs' interpretations of speakers, relationships, settings, and goals may also help LLMs address complex pragmatic phenomena. LLMs have shown promise in various language tasks. However, addressing the challenges specific to pragmatics and enhancing the models' pragmatic competence will be crucial for unlocking their full potential to generate contextually appropriate and communicatively effective language.



# Bibliography

1. Bail, C. Can Generative AI Improve Social Science Research? [1] Chris Bail Duke University [www.chrisbail.net](http://www.chrisbail.net). 1–23.
2. Garon, J. M. A Practical Introduction to Generative AI, Synthetic Media, and the Messages Found in the Latest Medium. SSRN Electron. J. (2023) doi:10.2139/ssrn.4388437.
3. Nvidia. Generative AI. glossary <https://www.nvidia.com/en-us/glossary/data-science/generative-ai/> (2023).
4. Milno, D. ChatGPT reaches 100 million users two months after launch. The Guardian <https://www.theguardian.com/technology/2023/feb/02/chatgpt-100-million-users-open-ai-fastest-growing-app> (2023).
5. Chui, M., Yee, L., Hall, B., Singla, A. & Sukharevsky, A. The state of AI in 2023: Generative AI's breakout year. 1–21 (2023).
6. Gartner Inc. Generative AI: What Is It, Tools, Models, Applications and Use Cases. <https://www.gartner.com/en/topics/generative-ai> (2023).
7. Bradshaw, T. Gaming industry puts generative AI to the test. Financial Times (2023).
8. Grammarly. GrammarlyGO. <https://www.grammarly.com/ai> (2023).
9. Oyewusi, W. F. et al. AFRIFASHION1600: A contemporary african fashion dataset for computer vision. IEEE Comput. Soc. Conf. Comput. Vis. Pattern Recognit. Work. 3963–3967 (2021) doi:10.1109/CVPRW53098.2021.00446.
10. Douglass, W. H. Synthetic data for AI. MIT Technology Review <https://www.technologyreview.com/2022/02/23/1044965/ai-synthetic-data-2/> (2023).
11. Clayton, J. Microsoft unveils new Bing with ChatGPT powers. BBC - Technology (2023).
12. Arunasalam, S. ChatGPT users can now browse internet, OpenAI says. Reuters <https://www.reuters.com/technology/openai-says-chatgpt-can-now-browse-internet-2023-09-27/> (2023).
13. Mehdi, Y. Announcing Microsoft Copilot, your everyday AI companion. Microsoft Official Blog <https://blogs.microsoft.com/blog/2023/09/21/announcing-microsoft-copilot-your-everyday-ai-companion/> (2023).
14. Denny, P. et al. Computing Education in the Era of Generative AI. (2023).
15. Wiggers, K. IBM taps AI to translate COBOL code to Java. Tech Crunch <https://techcrunch.com/2023/08/22/ibm-taps-ai-to-translate-cobol-code-to-java/> (2023).
16. Hasselgren, C. & Oprea, T. I. Artificial Intelligence for Drug Discovery: Are We There Yet? Annu. Rev. Pharmacol. Toxicol. Accept. Annu. Rev. Pharmacol. Toxicol. 64, 2024 (2024).
17. Sharma, S. Generative AI: Revolutionizing Medical Imaging and Diagnosis. <https://www.linkedin.com/pulse/generative-ai-revolutionizing-medical-imaging-diagnosis-sharma/> (2023).
18. Zhang, P. & Kamel Boulos, M. N. Generative AI in Medicine and Healthcare: Promises, Opportunities and Challenges. *Futur. Internet* 15, 286 (2023).
19. Ayers, J. W. et al. Comparing physician and artificial intelligence chatbot responses to patient questions posted to a public social media forum. *JAMA Intern. Med.* (2023).

## Bibliography

20. Gridspace. Explore Ways to Build a Better Customer Experience with Conversational AI. <https://resources.gridspace.com/> (2023).
21. Ekpenyong, A., Udoh, A., Kpokiri, E. & Bates, I. An analysis of pharmacy workforce capacity in Nigeria. *J. Pharm. Policy Pract.* 11, 20 (2018).
22. Raza, M. A. et al. Artificial Intelligence (AI) in Pharmacy: An Overview of Innovations. *Inov. Pharm.* 13, 13 (2022).
23. Karanasios, S., Kokshagina, O. & Reinecke, P. C. Calls to regulate AI are growing louder. But how exactly do you regulate a technology like this? *The Conversation* <https://theconversation.com/calls-to-regulate-ai-are-growing-louder-but-how-exactly-do-you-regulate-a-technology-like-this-203050> (2023).
24. Blair, L. & Larry, D. Who Is Going to Regulate AI? *Harvard Business Review* <https://hbr.org/2023/05/who-is-going-to-regulate-ai> (2023).
25. Lucas, M. What are LLMs, and how are they used in generative AI? *ComputerWorld* <https://www.computerworld.com/article/3697649/what-are-large-language-models-and-how-are-they-used-in-generative-ai.html> (2023).
26. Daniel, S., Steffen, S. & Gunnar, T. Medtech's Generative AI Opportunity. Boston Consulting Group <https://www.bcg.com/publications/2023/generative-ai-in-medtech> (2023).
27. *Pharmaceutical Data Mining*. (Wiley, 2009). doi:10.1002/9780470567623.
28. FDA. FDA Data Standards Advisory Board. FDA <https://www.fda.gov/industry/fda-data-standards-advisory-board> (2023).
29. Press, T. M. I. T. Ian Goodfellow, Yoshua Bengio, and Aaron Courville: Deep learning. *Genet. Program. Evolvable Mach.* 19, 305–307 (2018).
30. Kathy, B. & Yoav, S. Managing the Risks of Generative AI. *Harvard Business Review* <https://hbr.org/2023/06/managing-the-risks-of-generative-ai> (2023).
31. Mike, P. Large Language Models explained. *boost.ai* <https://www.boost.ai/blog/llms-large-language-models> (2023).
32. Huang, T. & Li, Y. Current progress, challenges, and future perspectives of language models for protein representation and protein design. *Innov.* 4, 100446 (2023).
33. Alexis, P. Unveiling 6 Types of Generative AI. *BigID* <https://bigid.com/blog/unveiling-6-types-of-generative-ai> (2023).
34. Madani, A. et al. Large language models generate functional protein sequences across diverse families. *Nat. Biotechnol.* 41, 1099–1106 (2023).
35. Meta AI. ESM Metagenomic Atlas: The first view of the 'dark matter' of the protein universe. Meta AI <https://ai.meta.com/blog/protein-folding-esmfold-metagenomics/> (2022).
36. George, L. What is generative AI? Everything you need to know. *Tech Accelerator* <https://www.techtarget.com/searchenterpriseai/definition/generative-AI> (2023).
37. Editorial Team - Folio3 AI. Are Generative AI And Large Language Models The Same Thing? Folio3 <https://www.folio3.ai/blog/generative-ai-and-large-language-models/> (2023).
38. Dilmegani, C. Large Language Models: Complete Guide in 2023. *AI Multiple* <https://research.aimultiple.com/large-language-models/> (2023).
39. CBInsights. The state of generative AI in 7 charts. <https://www.cbinsights.com/research/generative-ai-funding-top-startups-investors/> (2023).

40. Kabir, O. 5 reasons why generative AI hype might be exaggerated. CTech Analysis <https://www.calcalistech.com/ctechnews/article/rk88g8ovn> (2023).
41. KX. Vector Based Data. <https://kx.com/kdb-vector-databases-lp/> (2023).
42. Microsoft Learn. What is a vector database? Microsoft Official Blog <https://learn.microsoft.com/en-us/semantic-kernel/memories/vector-db> (2023).
43. Ajitesh, K. Large Language Models (LLMs): Types, Examples, Use Cases. Vital Flux <https://vitalflux.com/large-language-models-concepts-examples/> (2023).
44. Juraska, J. & Walker, M. Attention Is Indeed All You Need: Semantically Attention-Guided Decoding for Data-to-Text NLG. in Proceedings of the 14th International Conference on Natural Language Generation 416–431 (Association for Computational Linguistics, 2021). doi:10.18653/v1/2021.inlg-1.45.
45. Kundu, D. Unleashing the Potential of Domain-Specific LLMs. Analytics Vidhya [https://www.analyticsvidhya.com/blog/2023/08/domain-specific-llms/?utm\\_source=related\\_WP&utm\\_medium=https://www.analyticsvidhya.com/blog/2023/07/build-your-own-large-language-models/](https://www.analyticsvidhya.com/blog/2023/08/domain-specific-llms/?utm_source=related_WP&utm_medium=https://www.analyticsvidhya.com/blog/2023/07/build-your-own-large-language-models/) (2023).
46. GoldmanSachs. Generative AI could raise global GDP by 7%. GoldmanSachs <https://www.goldmansachs.com/intelligence/pages/generative-ai-could-raise-global-gdp-by-7-percent.html> (2023).
47. Soundful. THE ULTIMATE GUIDE TO GENERATIVE AI IN MUSIC PRODUCTION. Soundful <https://soundful.com/ultimate-guide-to-generative-ai-music-production/> (2023).
48. Paul, D. How AI Will Change The Music Industry - What To Expect In The World Of AI Music. The Generator <https://medium.com/the-generator/how-ai-will-change-the-music-industry-37cd4305c68e> (2023).
49. McKinsey & Company. What is generative AI? <https://www.mckinsey.com/featured-insights/mckinsey-explainers/what-is-generative-ai> (2023).
50. JavaTPoint. Introduction to Transfer Learning in ML. Machine Learning <https://www.javatpoint.com/transfer-learning-in-machine-learning> (2023).
51. Kezia, N. What is Generative AI? Learn Everything You Need to Know! Gleematic AI <https://gleematic.com/what-is-generative-ai-learn-everything-you-need-to-know/> (2023).
52. Paul, D. AI, automation could kill your job sooner than thought. How COVID sped things up. USA Today <https://www.usatoday.com/story/money/2023/07/26/automation-destroy-jobs-faster-pandemic/70464006007/> (2023).
53. Ben, L. BERT language model. Tech Target [https://www.techtarget.com/searchenterpriseai/definition/BERT-language-model#:~:text=BERT%2C which stands for Bidirectional,calculated based upon their connection](https://www.techtarget.com/searchenterpriseai/definition/BERT-language-model#:~:text=BERT%2C%20which%20stands%20for%20Bidirectional,calculated%20based%20upon%20their%20connection) (2020).
54. Schools, W. Generative AI Prompt Writing Introduction. W3 Schools [https://www.w3schools.com/gen\\_ai/gen\\_ai\\_prompt\\_intro.php#:~:text=AI Prompt Writing \(or Engineering,an AI to do something.](https://www.w3schools.com/gen_ai/gen_ai_prompt_intro.php#:~:text=AI%20Prompt%20Writing%20(or%20Engineering,an%20AI%20to%20do%20something)
55. Mary, K. P. Top advantages and disadvantages of AI. Tech Accelerator <https://www.techtarget.com/searchenterpriseai/tip/Top-advantages-and-disadvantages-of-AI> (2023).
56. Aditya, S. 11 Best Generative AI Tools and Platforms. Turing <https://www.turing.com/resources/generative-ai-tools> (2023).



57. Elysse, B. Generative AI: How It Works, History, and Pros and Cons. Investopedia - Business <https://www.investopedia.com/generative-ai-7497939> (2023).
58. Saranya, S. & Priya, S. Healthcare Revolution and Integration of Artificial Intelligence. in 67–79 (2023). doi:10.1007/978-3-031-27700-9\_5.
59. Stypińska, J. & Franke, A. AI revolution in healthcare and medicine and the (re-)emergence of inequalities and disadvantages for ageing population. *Front. Sociol.* 7, (2023).
60. Matthew, H., Josh, K., Krishna, Srikumar Krishna, D. & Daniel, M. Generative AI Will Transform Health Care Sooner Than You Think. Boston Consulting Group <https://www.bcg.com/publications/2023/how-generative-ai-is-transforming-health-care-sooner-than-expected> (2023).
61. Singapore Computer Society. SIMPLIFYING THE DIFFERENCE: MACHINE LEARNING VS DEEP LEARNING. SCS Blog <https://www.scs.org.sg/articles/machine-learning-vs-deep-learning> (2020).
62. Shankar, J. Explore The Use Cases of Generative AI Across Top Industries. EmizenTech <https://www.emizentech.com/blog/use-cases-of-generative-ai.html> (2023).
63. Manisha, K. 12 Use Cases of Generative AI in Healthcare. Mind Bowser <https://www.mindbowser.com/generative-ai-healthcare-use-cases/> (2023).
64. Accenture. A new era of generative AI for everyone Contents. Accenture (2023).
65. Rob, T. The Biggest Opportunity In Generative AI Is Language, Not Images. Forbes <https://www.forbes.com/sites/robtoews/2022/11/06/the-biggest-opportunity-in-generative-ai-is-language-not-images/?sh=141760ce789d> (2022).
66. Lipkin, B., Wong, L., Grand, G., Tenenbaum, J. B. & Csail, M. I. T. Evaluating statistical language models as pragmatic reasoners.
67. Chiara, B. di S. Pietro, Federico, F., Veronica, M. & Valentina, B. The pragmatic profile of ChatGPT: assessing the communicative skills of a conversational agent. *Sist. Intelligenti* 1–16 (2023).
68. Betti, M. J. Pragmatics in Linguistics. (2021) doi:10.13140/RG.2.2.29145.85606.
69. Pandia, L., Cong, Y. & Ettinger, A. Pragmatic competence of pre-trained language models through the lens of discourse connectives. 367–379 (2021).





---

**Address:** AI Hub, 33 Queens Street, Yaba, Lagos

📞 Call | 📱 Whatsapp : +234 814 000 0853

✉️ info@datasciencenigeria.org

🌐 www.datasciencenigeria.org

**Social media handles;**

🐦 dsn\_ai\_network    🔗 datascientistsnetwork

📺 @dsn\_ai\_network    📘 @dsnailive    📺 @dsnai

🗣️ @techhub.social/@dsnai    📺 @dsn\_ai\_network