Table of Contents

CHAPTER 1

INTRODUCTION

Before getting started to know more on how Generative AI platforms are considered a significant leap towards General Artificial Intelligence, it is important to know what Artificial Intelligence (AI for short, I will use this short form throughout this article) is and how it has come into existence and what is the history behind.

1.1 ARTIFICIAL INTELLIGENCE

Artificial Intelligence (AI) is a field of computer science that involves the development of intelligent machines that can perform tasks that typically require human intelligence. These tasks include things like understanding natural language, recognizing images, and making decisions based on complex data sets. The goal of AI is to create machines that can think, learn, and reason like humans, and in some cases, even surpass human intelligence. The field of AI is broad and encompasses a wide range of techniques and applications. One of the most important areas of AI is machine learning, which involves the use of algorithms that can learn from data and improve their performance over time. This allows machines to identify patterns and make predictions based on large and complex datasets. Another important area of AI is natural language processing (NLP), which involves the analysis and generation of human language. NLP is used in applications such as chatbots and voice assistants.

At its simplest form, artificial intelligence is a field, which combines computer science and robust datasets, to enable problem-solving. It also encompasses sub-fields of machine learning and deep learning, which are frequently mentioned in conjunction with artificial intelligence. These disciplines are AI algorithms which seek to create expert systems which make predictions or classifications based on input data. AI also includes the development of expert systems, which are computer programs that are designed to simulate the decision-making abilities of a human expert in a particular field. These systems use a knowledge base and a set of rules to make decisions and provide advice. Expert systems have been developed for a wide range of applications, including medical diagnosis, financial planning, and engineering design.

1.2 HISTORY OF AI

The concept of artificial intelligence has a rich and fascinating history that spans centuries. Ancient civilizations and mediaeval scholars had unique and imaginative ideas about creating intelligent machines that could replicate human thought and behaviour. One of the earliest recorded examples of artificial intelligence dates back to ancient Greece. The Greeks had tales of robots, and the Chinese and Egyptian engineers made automations. These “automaton” beings such as Talos would protect Crete from invaders. The philosopher Aristotle described a set of mechanical devices that could perform tasks autonomously. These devices, called automata, were operated by a system of weights and pulleys and were designed to perform simple tasks like pouring liquids or playing musical instruments. These early examples of AI were driven by the idea of mimicking human behaviour in machines, which was a central goal of early AI research.

AI has become a buzzword in today's world, with the rise of technologies such as machine learning, natural language processing, and robotics. However, the history of AI dates back to the mid-20th century when scientists first began exploring the possibility of creating machines that could think and learn like humans. The history of AI can be traced back to 1943 when Warren McCulloch and Walter Pitts proposed a model of artificial neurons. In 1950, Alan Turing published a paper titled "Computing Machinery and Intelligence," in which he proposed the Turing Test, a method of determining a machine's ability to exhibit human-like intelligence. The Turing Test involved a human evaluator communicating with a machine via a teletype and determining whether the responses were from a human or a machine. Turing believed that if a machine could fool a human evaluator into thinking it was human, it could be considered intelligent.

In the 1950s and 1960s, researchers began developing AI programs and systems that could perform specific tasks, such as playing chess, solving mathematical problems, and translating languages. The first AI program to play chess was developed by Claude Shannon in 1950. In 1956, John McCarthy, Marvin Minsky, Nathaniel Rochester, and Claude Shannon organised the Dartmouth Conference, which is considered the birth of AI as a field of study. At the conference, the researchers proposed that "every aspect of learning or any other feature of intelligence can, in principle, be so precisely described that a machine can be made to simulate it." In the 1960s and 1970s, researchers focused on developing AI programs and systems that could perform more complex tasks, such as

understanding natural language and recognizing visual patterns. In 1969, Shakey, the first mobile robot that could navigate its environment, was developed at Stanford Research Institute. In the early 1970s, the Lighthill Report, commissioned by the British government, criticised the progress of AI research and recommended a shift towards more practical applications of AI.

In the 1980s and 1990s, AI research focused on expert systems, which were designed to mimic the decision-making processes of human experts in specific domains. Expert systems were used in a variety of fields, including medicine, finance, and engineering. However, the limitations of expert systems soon became apparent, as they were only able to handle specific tasks and could not learn from new data. This led to a decline in AI research and funding in the 1990s. The late 1990s and early 2000s saw a resurgence of interest in AI, thanks to advances in machine learning and the availability of large amounts of data. In 1997, IBM's Deep Blue defeated world chess champion Garry Kasparov, demonstrating the power of machine learning in complex tasks. In 2011, IBM's Watson defeated human champions on the game show Jeopardy, demonstrating the ability of machine learning to understand natural language.

Today, AI is a rapidly growing field, with applications in a variety of industries, including healthcare, finance, and transportation. Machine learning, natural language processing, and robotics are some of the key areas of research in AI. AI is also being used to develop autonomous vehicles, improve cybersecurity, and enhance customer service.

1.3 TURING TEST

Alan Turing was a British computer scientist and mathematician who is considered one of the founding fathers of artificial intelligence. In 1950, he proposed a test called the Turing Test, which aimed to measure a machine's ability to exhibit intelligent behaviour that is indistinguishable from that of a human. The Turing Test involves a human evaluator who engages in a conversation with both a human and a machine, without knowing which is which. If the evaluator is unable to distinguish between the human and the machine based on their responses, then the machine is said to have passed the Turing Test. Turing believed that the ability to pass the Turing Test was a key indicator of intelligence. He argued that if a machine could exhibit intelligent

behaviour that is indistinguishable from that of a human, then it should be considered intelligent in the same way that humans are.

Turing's contributions to the field of artificial intelligence were influenced by his broader understanding of intelligence. He believed that intelligence was not limited to humans, and that any system that was capable of exhibiting intelligent behaviour should be considered intelligent. In his seminal paper [1], "Computing Machinery and Intelligence," Turing wrote: "We may hope that machines will eventually compete with men in all purely intellectual fields." He argued that machines could be designed to simulate human thought processes and solve complex problems, and that the field of artificial intelligence had the potential to revolutionise many areas of human endeavour. Today, the Turing Test remains an important concept in the field of artificial intelligence. While some researchers have criticised the test as being too simplistic or arbitrary, it continues to serve as a benchmark for measuring the progress of AI systems and their ability to exhibit human-like intelligence.

1.4 CHINESE ROOM ARGUMENT

The Chinese Room Argument is a famous thought experiment introduced by philosopher John Searle in 1980 that challenges the validity of the Turing Test. In the Chinese Room thought experiment [2] , Searle imagines a room where a person who does not understand Chinese is given a set of rules and a Chinese language text. The person is then asked to translate questions written in Chinese into English and provide appropriate responses in Chinese. Although the person is able to follow the rules and produce appropriate responses in Chinese, they do not actually understand the language. This is analogous to a computer system that can process information according to a set of rules without actually understanding the meaning of that information.

The Chinese Room Argument suggests that a computer program can pass the Turing Test by producing behaviour that is indistinguishable from that of a human, but without actually understanding the meaning of the information it is processing. This argument contradicts the Turing Test, which assumes that a machine that can produce intelligent behaviour that is indistinguishable from that of a human must possess human-like intelligence. The Chinese Room Argument also raises questions about the nature of consciousness and understanding. If a machine can produce intelligent behaviour without

understanding the meaning of that behaviour, then what does it mean to truly understand something? The argument suggests that there may be more to human intelligence and understanding than can be replicated by a machine. Despite the criticisms of the Chinese Room Argument, it has had a significant impact on the field of artificial intelligence and philosophy of mind. It has spurred ongoing debates about the nature of intelligence, understanding, and consciousness, and continues to challenge researchers to develop more advanced AI systems that can truly understand and interact with the world around them.

CHAPTER 2

THREE STAGES OF AI

AI is typically divided into three stages based on its level of intelligence:

2.1 ARTIFICIAL NARROW INTELLIGENCE

Artificial Narrow Intelligence (ANI) is a type of Artificial Intelligence (AI) that is designed to perform specific tasks or solve particular problems [3]. ANI is also known as Weak AI, as it is limited in its ability to learn and apply knowledge beyond its specific domain. ANI systems are built with a predefined set of rules and algorithms that enable them to complete specific tasks with high accuracy and efficiency. They are programmed to recognize patterns in data and make decisions based on predefined parameters. For instance, image recognition systems used in self-driving cars are designed to recognize objects, such as pedestrians, vehicles, and traffic lights, and respond accordingly. ANI is widely used in various industries, including healthcare, finance, and manufacturing, to automate repetitive and time-consuming tasks. Virtual assistants like Siri and Alexa are also examples of ANI, as they are designed to respond to specific voice commands and perform certain tasks like setting reminders and playing music. While ANI has shown significant progress in recent years, it has its limitations. ANI cannot learn from experiences outside of its programming or adapt to new situations, making it unsuitable for complex problem-solving or decision-making tasks.

2.2 ARTIFICIAL GENERAL INTELLIGENCE

Artificial General Intelligence (AGI) is a type of Artificial Intelligence (AI) that is designed to perform a wide range of intellectual tasks that are characteristic of human beings [3]. AGI is also known as Strong AI, as it is capable of reasoning, learning, and adapting to new situations beyond its pre-programmed capabilities. AGI systems are designed to learn and reason in a way that allows them to handle different types of tasks in different domains. Unlike Artificial Narrow Intelligence (ANI), which is limited to specific tasks, AGI is designed to perform various tasks and adapt to new situations with little to no human intervention. For instance, an AGI system could perform tasks such as language translation, problem-solving, and image recognition, among others. AGI has the potential to revolutionise various fields, including medicine, finance, and transportation.

It could help solve complex problems and make predictions based on data from different sources. However, AGI is still in its early stages of development, and creating a system that is capable of performing at the same level as humans remains a challenge.

2.3 ARTIFICIAL SUPER INTELLIGENCE

Artificial Super Intelligence (ASI) is an advanced form of Artificial Intelligence (AI) that is beyond human intelligence in terms of its cognitive abilities. ASI surpasses the intelligence of any human being in every possible way, including creativity, problem-solving, and decision-making skills [3]. Unlike Artificial Narrow Intelligence (ANI) and Artificial General Intelligence (AGI), which are limited to specific tasks, ASI has the potential to handle any task that humans can perform, and even surpass them.ASI is a hypothetical form of AI that has been the subject of much discussion in the AI community, and there is still much debate on whether it can be achieved or not. Some researchers believe that ASI could be achieved in the future if we can create an AI system that is capable of improving itself through a process called recursive self-improvement. This means that an ASI system could improve itself continuously, leading to an exponential increase in its intelligence. However, achieving ASI also raises concerns about the impact that such a system could have on society. An ASI system could potentially replace human workers and even pose a threat to humanity. There is also the issue of control, as an ASI system could potentially be uncontrollable, leading to disastrous consequences.

While I was doing my research I found a lot of articles that stated that Artificial General Intelligence, Artificial Narrow Intelligence, and Artificial Super Intelligence are the different types of AI. To be more precise, these are three stages of Artificial Intelligence.

CHAPTER 3

LITERATURE SURVEY

Hernan Ceferino Vazquez in their paper [41] "Artificial Neuropsychology: Are Large Language Models Developing Executive Functions?" raises the question of whether Large Language Models (LLMs) like those of the Generative Pre-Trained Transformers (GPT) family are capable of developing Executive Functions (EFs) similar to those of humans as part of their learning. LLMs have been rapidly advancing and have demonstrated their ability to perform a wide range of cognitive tasks, including language processing, visual recognition, and decision-making. According to most authors in Neuropsychology, intelligent behavior depends on a number of overarching skills, or Executive Functions, which rely on the correct functioning of neural networks in the frontal lobes and have developed a series of tests to evaluate them. In this paper, the author evaluates the planning function and working memory of GPT using the popular Towers of Hanoi method, which is a standard neuropsychological test for measuring Efs.

To avoid the solutions being found in the LLM training data (data leakage), the author introduces a new variant of the classical Towers of Hanoi method. The preliminary results show that LLMs generate near-optimal solutions in Towers of Hanoi related tasks, adhere to task constraints, and exhibit rapid planning capabilities and efficient working memory usage, indicating a potential development of executive functions. However, the study concludes that these abilities are quite limited and worse than well-trained humans when the tasks are not known and are not part of the training data. The study provides valuable insights into the potential of LLMs in developing EFs and highlights their limitations. It raises important questions about the future of AI and its ability to develop human-like intelligence, particularly in the area of neuropsychology. The paper concludes that while LLMs exhibit promising results in certain cognitive tasks, they still have a long way to go before they can match human intelligence.

In their article titled "Governance of the AI, by the AI, and for the AI," Torrance and Tomlinson argue that the current state of artificial intelligence (AI) is ushering in profound changes to many sectors of society [42]. The authors contend that every new technology challenges the ability of humanity to govern it wisely, and the rapid evolution of AI makes it all the more necessary to analyze the interactions between AI and

governance. The authors discuss two main aspects of this relationship: the governance of AI by humanity and the governance of humanity by AI. The authors note that the arrival of powerful image generators like DALL-E2 and Midjourney, as well as text generators like GPT3.5 and BLOOM, have allowed individuals with access to easily create rich and complex art, compose detailed written descriptions, and generate code capable of myriad applications.

However, the authors caution that wise decisions must be made to maximize benefits and minimize costs. Torrance and Tomlinson's approach is informed by AI, as the article was written collaboratively by the authors and ChatGPT. The authors emphasize the need for thoughtful governance of AI, acknowledging that the technology will continue to evolve and improve at a rapid rate. By analyzing the interactions between AI and governance, the authors hope to contribute to a better understanding of how to effectively govern AI for the benefit of humanity.

In their paper titled "Unlocking Practical Applications in Legal Domain: Evaluation of GPT for Zero-Shot Semantic Annotation of Legal Texts", Jaromir Savelka evaluated the capacity of the GPT model for semantic annotation of short text snippets from various types of legal documents [43]. The authors noted that while discussions of the potential uses of large language models in the legal domain have intensified, there has not been a rigorous analysis of the GPT model's capacity in sentence-level semantic annotation of legal texts in zero-shot learning settings. The authors filled this gap by examining the model's ability to semantically annotate small batches of short text snippets based exclusively on concise definitions of the semantic types. The authors found that the GPT model performed surprisingly well in zero-shot settings on diverse types of documents, including court opinions, contracts, and statutes and regulations, with F1 scores of .73, .86, and .54, respectively. These findings have important implications for legal scholars and practicing lawyers who may benefit from the integration of large language models in their workflows involving semantic annotation of legal texts. Overall, this study offers valuable insights into the potential practical applications of GPT in the legal domain, and provides a foundation for future research in this area.

CHAPTER 4

GENERATIVE AI (GenAI)

Generative Artificial Intelligence (GenAI) is a type of Artificial Intelligence that can create a wide variety of data, such as images, videos, audio, text, and 3D models [4]. Unlike other types of AI systems that rely on pre-existing data to make predictions, Generative AI platforms can generate completely new content that has never been seen before. It does this by learning patterns from existing data, then using this knowledge to generate new and unique outputs. GenAI is capable of producing highly realistic and complex content that mimics human creativity, making it a valuable tool for many industries such as gaming, entertainment, and product design. Recent breakthroughs in the field, such as GPT (Generative Pre-trained Transformer) and Midjourney, have significantly advanced the capabilities of GenAI. These advancements have opened up new possibilities for using GenAI to solve complex problems, create art, and even assist in scientific research.

Generative AI has truly taken the world by storm, revolutionising the way we communicate, work, and innovate. ChatGPT, with its 100 million users, stands as a testament to the rapid adoption and widespread impact of this cutting-edge technology. Its stable diffusion and popularity on GitHub only reinforce its transformative potential. Even in its early stages, generative AI is already shaping the future across various domains, and its influence on our lives is set to grow exponentially. Embracing this powerful tech will open doors to unimaginable possibilities, ushering in a new era of creativity, efficiency, and progress. Let's dive deep into some applications:

A) TEXT GENERATION

Text Generation involves using machine learning models to generate new text based on patterns learned from existing text data. The models used for text generation can be Markov Chains, Recurrent Neural Networks (RNNs), and more recently, Transformers, which have revolutionised the field due to their extended attention span. Text generation has numerous applications in the realm of natural language processing, chatbots, and content creation.

B) IMAGE GENERATION

Image Generation is a process of using deep learning algorithms such as VAEs, GANs, and more recently Stable Diffusion, to create new images that are visually similar to real-world images. Image Generation can be used for data augmentation to improve the performance of machine learning models, as well as in creating art, generating product images, and more.

C) VIDEO AND SPEECH GENERATION

Video Generation involves deep learning methods such as GANs and Video Diffusion to generate new videos by predicting frames based on previous frames. Video Generation can be used in various fields, such as entertainment, sports analysis, and autonomous driving. Video Generation can be often seen in use with Speech Generation. The models used for speech generation can be powered by Transformers. Speech Generation can be used in text-to-speech conversion, virtual assistants, and voice cloning.

D) AND MUCH MORE

Generative AI has a diverse range of applications that go beyond text, video, image, speech generation, and data augmentation. For instance, it can be used for music generation, game development, healthcare, and more. In healthcare, generative AI can help generate synthetic medical data to train machine learning models, develop new drug candidates, and design clinical trials. These are just some examples of the many possibilities for generative AI, and as the technology advances, we can expect to see more applications emerge.

CHAPTER 5

CURRENT GENAI TOOLS

5.1 ChatGPT

Allow me to give you a brief introduction to OpenAI, an organisation dedicated to creating Artificial General Intelligence (AGI). The ultimate objective of AGI is to address problems beyond human capability, provided that the systems developed are safe, dependable, and beneficial to society.

5.1.1 OpenAI

OpenAI is a research laboratory made up of a group of researchers and engineers committed to the commission of building safe and beneficial AGI [5]. It was founded on December 11, 2015, by a group of high-profile tech executives, including Tesla CEO Elon Musk, SpaceX President Gwynne Shotwell, LinkedIn co-founder Reid Hoffman, and venture capitalists Peter Thiel and Sam Altman. In this subsection, I will talk about the early days of OpenAI, how it became a for-profit organisation, and its contributions to the field of AI. In the beginning, OpenAI was a non-profit organisation [6], and its research is centred on deep learning and reinforcement learning, natural language processing, robotics, and more.

The company quickly established a reputation for its cutting-edge research after publishing several influential papers and developing some of the most sophisticated AI models. However, to create AI technologies that could bring in money, OpenAI was reorganised as a for-profit company in 2019 [7]. Despite this, the company keeps developing ethical and secure AI alongside creating commercial applications for its technology. Additionally, OpenAI has worked with several top tech firms, including Microsoft, Amazon, and IBM. Microsoft revealed a new multiyear, multibillion-dollar venture with OpenAI earlier this year [8]. Though Microsoft did not give a precise sum of investment, Semafor claimed that Microsoft was in discussions to spend up to $10 billion. According to the Wall Street Journal, OpenAI is worth roughly $29 billion [9].

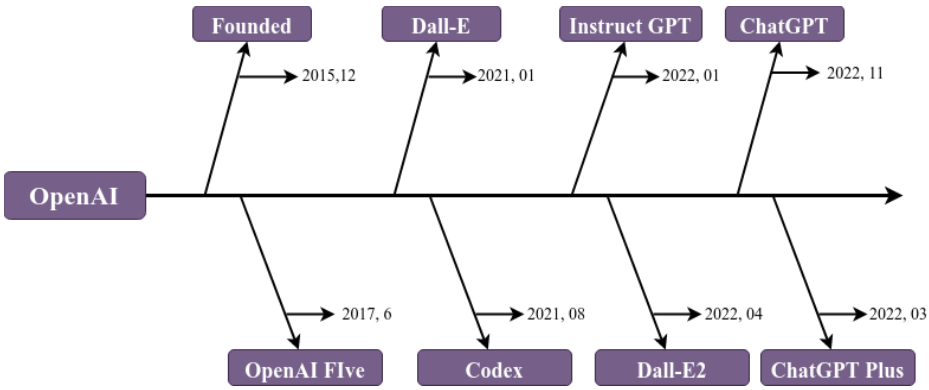

Figure 1: OpenAI products timeline.

From large language models to open-source software, OpenAI has significantly advanced the field of AI. To begin with, OpenAI has developed some of the most potent language models to date, including GPT-3, which has gained widespread praise for its ability to produce cohesive and realistic text in numerous contexts. OpenAI also carries out research in reinforcement learning, a branch of artificial intelligence that aims to train robots to base their choices on rewards and punishments. Proximal Policy Optimization (PPO), Soft Actor-Critic (SAC), and Trust Area Policy Optimization (TRPO) are just a few of the reinforcement learning algorithms that OpenAI has created so far.

These algorithms have been employed to train agents for various tasks, including playing games and controlling robots. OpenAI has created many software tools up to this point to assist with its research endeavours, including the OpenAI Gym [5], a toolset for creating and contrasting reinforcement learning algorithms. In terms of hardware, OpenAI has invested in several high-performance processing systems, including the DGX-1 and DGX-2 systems from NVIDIA. These systems were created with deep learning in mind and are capable of offering the processing power needed to build sophisticated AI models. Except for ChatGPT, other popular tools developed by OpenAI include DALL-E and Whisper, Codex [5]. A summarization of the OpenAI product pipeline is shown in Figure1.

5.1.2 TECHNOLOGY PATH

BERT vs GPT

Traditional language models [10] mainly focused on a particular task and could not be transferred to other tasks. Transfer learning is a common approach for alleviating

this issue by pretraining a foundation model, which can then be finetuned on various downstream tasks. Based on the architecture, there are three classes: encoder-decoder, encoder-only, decoder-only [11]. Out of numerous large language models, encoder-only BERT [12] and decoder-only GPT [13] are arguably the two most popular ones. Both of them use attention-based Transformer with self-supervised learning to learn from textual datasets without labels. After pre-training, both BERT and GPT can be fine-tuned and show competitive performance in downstream tasks.

A core difference between BERT and GPT lies in their pre-training strategy: masked modelling and autoregressive modelling. With masked modelling, BERT predicts masked language tokens from unmasked ones. A major advantage of BERT is that it can utilise bidirectional text information, which makes it compatible with sentiment analysis tasks. Due to the discrepancy between the mask-then-predict pertaining task and downstream tasks, BERT is rarely used for the downstream task without fine tuning. By contrast, autoregressive modelling methods (represented by GPT) show competitive performance for few-shot or zero-shot text generation.

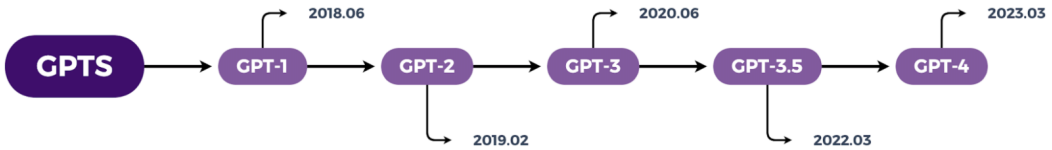

Figure 2: Timeline of GPT model families

GPT-1

With only the decoder, GPT-1 adopts a 12-layer Transformer and has 117M parameters. Trained on a massive Books Corpus dataset encompassing unique unpublished books, GPT-1 is capable of grasping long-range dependencies contexts. The general task-agnostic GPT model outperforms models trained for specific tasks in 9 of 12 tasks, including natural language inference, question answering, semantic similarity, and text classification [13]. The observation that GPT-1 performs well on various zero-shot tasks demonstrates a high level of generalisation. GPT-1 has evolved into a powerful model for various NLP tasks before the release of GPT-2.

GPT-2

As the successor to GPT-1, GPT-2 was launched by OpenAI in 2019 and focused on learning NLP tasks without explicit supervision. Similar to GPT-1, GPT-2 is based on the decoder-only Transformer model. However, the model architecture and implementation of GPT-2 have been developed, with 1.5 billion parameters and a trained dataset of 8 million web pages, which are more than 10 times compared to its predecessor GPT-1 [14]. With a zero-shot setting, GPT-2 achieved state-of-the-art results on 7 of 8 language modelling datasets tested, where the 7 datasets' tasks include performance recognition for different categories of words, the ability of the model to capture long-term dependencies, common sense reasoning, reading comprehension, summarization, and translation. However, GPT-2 still performs poorly on the task of question answering, demonstrating the capability of unsupervised model GPT-2 needs to be improved [14].

GPT-3

The foundation of GPT-3 is the Transformer architecture, specifically the GPT-2 architecture. Compared to GPT-2, which had 1.5 billion parameters, GPT-3 has 175 billion parameters, 96 attention layers, and a 3.2 M batch size, a significant increase in size [11]. GPT-3 was trained on a diverse range of online content, including novels, papers, and websites, using language modelling, a type of unsupervised learning where the model attempts to guess the next word in a phrase given the preceding word. After completion, GPT-3 can be fine-tuned on specific tasks using supervised learning, where task-specific smaller datasets are employed to train the model, such as text completion or language translation. Developers can use the GPT-3 model for numerous applications, including chatbots, language translation, and content production, thanks to OpenAI's API [15]. The API provides different access levels depending on the scale and intricacy of the tasks. Compared to other language models whose performance highly depends on fine-tuning, GPT-3 can perform many tasks (such as language translation) without any such fine-tuning, gradient, or parameter updates making this model task-agnostic.

GPT-3.5

GPT-3.5 is a variation of the widely popular GPT-3 and the ChatGPT is a fine-tuned version of GPT-3.5. On top of the GPT-3 model, GPT-3.5 has extra fine-tuning procedures: supervised finetuning and termed reinforcement learning with human feedback (RLHF) [16]. RLHF is used to overcome the limitations of traditional un-

supervised and supervised learning, which can only learn from unlabelled or labelled data. Human feedback can take different forms, including punishing or rewarding the model's behaviours, assigning labels to unlabelled data, or changing model parameters. By incorporating human feedback into the training process, GPT-3.5 has a significantly higher usability.

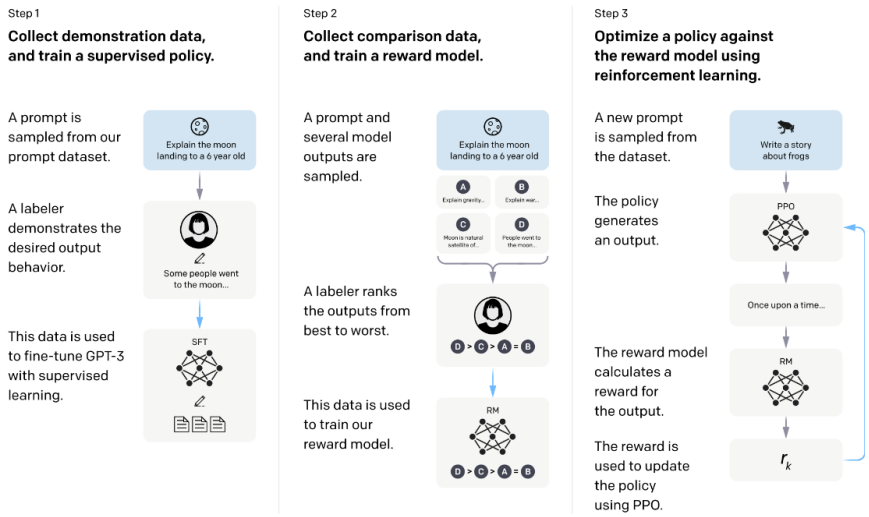

Figure 3: How GPT-3.5 is trained.

GPT-4

On March 14, 2023, OpenAI released GPT-4 [17], the fourth instalment in the GPT series. GPT-4 is a large multimodal model capable of taking text and images as inputs and generating text as output. The model delivers performance at a human level on several professional and career standards, but in real-world situations, it is still way less competent than humans. For example, the virtual bar exam result for GPT-4 is in the top 10% of test participants, as opposed to the score for GPT-3.5, which was in the lowest 10% [16]. The capacity of GPT-4 to follow human intention is significantly better than that of earlier versions. The answers by GPT-4 were favoured over the responses produced by GPT-3.5 on 70.2% of the 5,214 questions in the sample provided to ChatGPT and the OpenAI API. After the overwhelming majority of its pre-training data ends in September 2021, GPT-4 usually lacks awareness of what has happened and does not learn from its experiences. It occasionally exhibits basic logical mistakes that do not seem consistent with its skill in various areas, or it may be excessively trusting when

taking false claims from a user [17]. It may struggle with complex issues in the same way that people do, such as producing code that contains security flaws [17].

GPT Models	GPT-1	GPT-2	GPT-3	GPT-3.5	GPT-4
Parameters (10^9)	0.117	1.5	175	N.A.	N.A.
Dataset	BooksCorpus (over 40GB)	WebText (40TB)	Common Crawl (45TB)	N.A.	N.A.

5.2 Bard

Google has been at the forefront of NLP research for a long time, with several successful models such as BERT, GPT-2, and T5. The latest addition to the list is Bard, an NLP model specifically designed for dialogues. Google Bard's core is based on a neural network architecture technology called the Transformer. It produces a language model which can be trained on human-like sentence formations, words and their relations, and come up with a contextually correct sentence in response. One of these AI language models is LaMDA (Language Model for Dialogue Applications) which presents a free flowing natural language conversation interface. LaMDA presents a conversational AI service platform through which a free-flowing multi-topic and suggestion based discussion can be exchanged and this interface is optimistically called as Google Bard.

5.2.1 ARCHITECTURE

Bard is an extension of the existing Transformer-based encoder-decoder architecture used in models like GPT-2 and T5. However, it is specifically designed for dialogue generation tasks. The model consists of a multi-layered neural network, where each layer has multiple self-attention mechanisms that capture dependencies between different parts of a conversation. Additionally, the architecture also includes a bidirectional encoder that allows Bard to take into account the entire context of a conversation. The primary objective of Bard is to generate responses to open-ended questions in a dialogue setting based on the context provided. To achieve this, the model is pre-trained using a large corpus of conversational data, which spans different domains, languages, and styles of conversations.

During training, the model learns the patterns of human communication and how to generate coherent and contextually relevant responses. Once the model is trained, it can

generate responses to new questions given the context of the conversation. Google has developed several successful natural language processing models over the years, such as BERT, GPT-2, and T5. BERT was designed to learn the relationships between words in a sentence and improve performance on standard NLP tasks such as question answering, text classification, and named entity recognition.

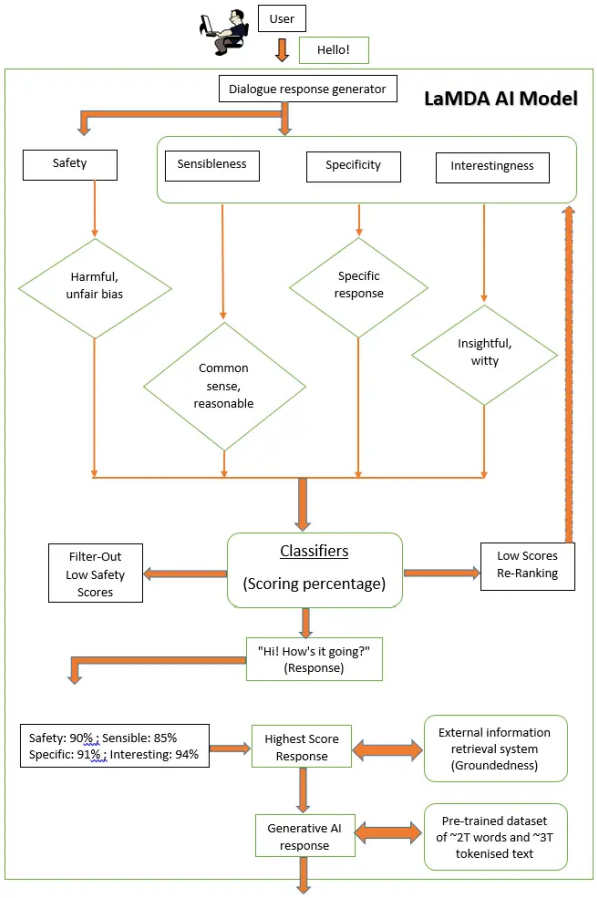

Figure 4: LaMDA AI Model Architecture

GPT-2, on the other hand, focused on generating coherent paragraphs of text. T5 was designed to perform various NLP tasks such as summarization, translation, and question answering. The key difference between Bard and other NLP models developed by Google is its focus on generating responses in a conversational setting. Unlike previous models that are trained on large corpora of text data, Bard is specifically designed to learn from conversational data. This allows the model to understand the context of a conversation and generate appropriate responses that are more human-like.

5.3 Text-to-Image Tools

Text-to-image generation is a technology that uses AI to understand text descriptions and convert them into unique images. Text-to-image models generally combine a language model, which transforms the input text into a latent representation, and a generative image model, which produces an image conditioned on that representation. The most effective models have generally been trained on massive amounts of image and text data scraped from the web.

A. DALL-E

One of the first text-to-image models to capture widespread public attention was OpenAI's DALL-E, a transformer system announced in January 2021. Named after the surrealist artist Salvador Dali and the Pixar character WALL-E, DALL-E represents a significant leap forward in the field of image generation. It can create unique and complex images that combine various objects, concepts, and scenes based on textual inputs provided by users. This means that users can describe an image they want to see and DALL-E will generate a unique image based on those inputs. The potential applications of DALL-E are vast and varied. In the world of art and design, it could be used for creating stunning visual artwork or helping designers quickly prototype new products. In advertising, it could be used to create compelling visuals that capture people's attention and drive sales. In medicine, it could be used to create visual aids for people with disabilities or to help doctors visualise complex medical concepts.

The technology behind DALL-E is based on Generative Adversarial Networks (GANs), a type of deep learning algorithm. GANs work by pitting two neural networks against each other. One network, the generator, creates images, while the other network, the discriminator, tries to distinguish between real and fake images. Over time, the generator becomes better at creating realistic images, and the discriminator becomes more adept at detecting fakes. DALL-E uses a variant of GANs called a BigGAN architecture, which allows it to generate images at a much higher resolution than previous image generation models. This means that DALL-E can create incredibly detailed, high-quality images that are almost indistinguishable from real photographs. A successor capable of generating more complex and realistic images, DALL-E 2, was unveiled in April 2022, followed by Stable Diffusion publicly released in August 2022.

B. Midjourney

Midjourney is a generative artificial intelligence program and service created and hosted by a San Francisco-based independent research lab Midjourney, Inc. Midjourney generates images from natural language descriptions, called "prompts", similar to OpenAI's DALL-E and Stable Diffusion [18][19]. Midjourney is currently only accessible through a Discord bot on their official Discord server, by directly messaging the bot, or by inviting the bot to a third party server. To generate images, users use the /imagine command and type in a prompt; the bot then returns a set of four images. Users may then choose which images they want to upscale. Midjourney is also working on a web interface [20]. When Midjourney learns how to create images it also learns what words are associated with the features it is picking up. This means that when it is fed a prompt with an artist's name it will generate an image with a "style" it has taught itself to associate with that name; the same applies to words which describe types of artwork.

5.4 Text-to-video Generation

Text-to-video generation is an emerging technology that allows the conversion of written text into video content through the use of artificial intelligence and machine learning algorithms. This innovative technology is poised to revolutionise the way video content is created, distributed and consumed. The technology behind Text-to-video generation involves combining natural language processing (NLP) and computer vision techniques to process written content and convert it into video form. Essentially, the algorithms analyse the text to determine its overall meaning, identify key ideas, and then generate visual content that corresponds to the text's message. The generated video may consist of a combination of animations, images, and audio elements that create an engaging and informative video.

The significance of Text-to-video generation lies in its ability to democratise the creation of video content. Historically, producing high-quality videos required significant resources, including specialised equipment, experienced staff, and a substantial budget. With Text-to-video generation, anyone with basic writing skills can produce engaging video content without incurring significant costs. This democratisation opens up new possibilities for companies, organisations, and individuals who previously did not have access to high-quality video production. Moreover, Text-to-video generation has the

potential to significantly impact various industries. For instance, in marketing, businesses can leverage this technology to create compelling explainer videos, product demos, and promotional content. In education, teachers can use Text-to-video generation to create interactive lessons and instructional videos that engage students and enhance their learning experience. In journalism, media organisations can use Text-to-video generation to quickly create news stories and reports, thus increasing their speed and efficiency in breaking news coverage.

A. Runway ML Gen-1

San Francisco-based startup Runway ML is on a mission to democratise artificial intelligence and make it accessible to creatives of all levels. Since its founding in 2018, the company has developed a range of AI-powered tools that enable designers to enhance and speed up their creative process. Runway ML is particularly focused on providing easy-to-use tools that can be used by anyone. The company places a strong emphasis on collaboration, working closely with industry leaders and academics to continue advancing the possibilities of AI. Runway ML's latest addition is their AI-powered text to video tool, which allows users to edit and generate videos using natural language descriptions. So far it's only been available by waitlist but is now accessible on Runway ML's website.

Its ability to import, edit, and even generate images based on text commands, making the process of creating a cinematic video more intuitive than before. In addition to text to video, Runway ML offers a range of other AI-powered tools for you to try out. For example, the backdrop remix feature enables users to quickly and easily change the background of an image. The online toolbox also entails a feature that increases image resolution while preserving detail. With the infinite image feature, designers can expand existing images with content-aware text-to-image generation. The research paper published by researchers at Runway ML [21], presents a new model that can generate videos based on structure and content information. To ensure that the videos are consistent in structure, the model is trained with depth estimates, while content is controlled using images or natural language. Additional temporal connections and joint image and video training are used to achieve stable results.

The model also allows users to control temporal consistency in the outputs. The researchers evaluated the model using quantitative methods and a user study, and found

that it was highly preferred over other approaches. The model can be customised by adjusting the level of structure preservation. The researchers caution against using the model for harmful purposes and suggest future work should focus on preventing abuse of generative models.

CHAPTER 6

APPLICATIONS OF GENAI

6.1 SCIENTIFIC WRITING

Generative AI tools such as ChatGPT is widely recognized for its powerful content generation capabilities, which have a significant impact on writing in the academic field. Many existing works have tested how these tools can be applied to scientific writing, including brainstorming, literature review, data analysis, direct content generation, grammar checking, and serving as an academic reviewer.

A. BRAINSTORMING

Brainstorming is an essential approach for obtaining initial ideas that are a prerequisite for high- quality scientific research. GenAI tools can play a variety of roles in brainstorming, ranging from stimulating creativity for new idea generation to providing suggestions for expanding existing ideas. These tools can assist users in divergent and creative thinking. In addition, some studies have explored ChatGPT's insights on future nursing research in a Q&A format, which can analyse the impact of future technological developments on nursing practice, and provide valuable insights for nurses, patients, and the healthcare system [22].

Moreover, these tools can also demonstrate the ability to "think" from multiple perspectives, it can analyse and reflect on the impact of excess deaths after the COVID-19 pandemic from multiple dimensions such as the medical system, social economy, and personal health behaviours. To evaluate whether GenAI tools for example ChatGPT generates useful suggestions for researchers in certain domains. The authors tested its ability on clinical decision support in and assessed its difference compared to human-generated suggestions. The test results have shown that, unlike human thinking, the suggestions generated by ChatGPT provide a unique perspective, and its generations are evaluated as highly understandable and relevant, which have significant value in scientific research.

B. LITERATURE REVIEW

A comprehensive literature review requires covering all relevant research, which can consume too much time and energy for researchers. For example, the Semantic

Scholar search engine, an AI-based scientific literature research tool, has indexed more than 200 million scholarly publications. As a result, finding relevant research papers and extracting key insights from them is almost like finding a needle in a haystack. Fortunately, Generative AI platforms have an AI-driven research reading tool, which can help us browse through a large number of papers and understand their content. In actual use, we can give a topic to these platforms, then they can help us find out the related literature. Before discussing the ability of ChatGPT in handling literature review, I will review a similar AI tool, SciSpace Copilot, which can help researchers quickly browse and understand papers [23]. Specifically, it can provide explanations for scientific texts and mathematics including follow-up questions with more detailed answers in multiple languages, facilitating better reading and understanding of the text.

By comparison, ChatGPT as a general language model not only has all the functions of SciSpace Copilot, but also can be widely used in various natural language processing scenarios [23]. A literature review is essential for summarising relevant work in the selected field. As an exploratory task, they chose the topic of “Digital Twin in Healthcare" and compiled abstracts of papers obtained from Google Scholar search results using the keywords “digital twin in healthcare" for the last three years (2020, 2021, and 2022). These abstracts are then paraphrased by ChatGPT, the generated results are promising. However, the application of ChatGPT in this task is still at the beginning. The authors in [24] ask ChatGPT to provide 10 groundbreaking academic articles with DOIs in the field of medical domains. Unfortunately, after conducting five tests, the results show that out of the 50 DOIs provided, only 8 of them exist and have been correctly published. Although ChatGPT’s abilities in literature review are still weak, I believe that in the near future, ChatGPT or any other GenAI platform will be widely used for literature review, further improving the efficiency of researchers and enabling them to focus their time on key research.

C. DATA ANALYSIS

Scientific data needs to be cleaned and organised before being analysed, often consuming days or even months of the researcher’s time, and most importantly, in some cases, having to learn to use a coding language such as Python or R. The use of these platforms for data processing can change the research landscape. For example, ChatGPT completes the task of data analysis for a simulated dataset of 100,000 healthcare workers

of varying ages and risk profiles to help determine the effectiveness of vaccines, which significantly speeds up the research process [25]. Another similar AI tool for data analysis is discussed in [23], where AI-based spreadsheet bots can convert natural language instructions into spreadsheet formulas. Furthermore, platforms like Olli can also visualise data, where users only need to simply describe the desired content, and then they can get AI-created line graphs, bar graphs, and scatter graphs. Considering that ChatGPT is the most powerful AI tool so far, I believe that these functions can also be implemented in ChatGPT in a more intelligent way.

D. CONTENT GENERATION

Numerous works have attempted to use Generative AI platforms for content generation for their articles [26]. For example, [26]employed ChatGPT to aid in writing reports in medical science about the pathogenesis of two diseases. Specifically, ChatGPT provides three aspects about the mechanism of homocystinuria-associated osteoporosis, all of which are proven true. However, when it comes to the references to the generated information, the papers mentioned by ChatGPT do not exist. Described a study on writing a catalysis review article using ChatGPT, with the topic set to CO2 hydrogenation to higher alcohols. The ChatGPT-generated content includes the required sections of the paper but lacks an introduction to the reaction mechanism, which is critical for the topic. The content of this article contains abundant useful information, but specific details are absent and certain errors exist.

In addition, many of these GenAI platforms can help prepare manuscripts, but the generated results have a large difference from actual published content. A possible reason is that the keywords of these platforms and human-generated text vary greatly, which requires users to further edit the generated content. ChatGPT has also been utilised to generate a review article in specific areas such as the health field [27], which indicates scholars can focus on core research while leaving the less creative part to AI tools. Nonetheless, Considering the style difference between human-generated content and GenAI-generated content, it is suggested in [27] to not fully rely on these tools. Utilise them as an assistant to help us to complete the writing rather than relying solely on them.

E. PROOFREADING

There are numerous tools for grammar checking. Some works have conducted tests on grammar and spelling correction, which shows that ChatGPT and other generative AI platforms provide a better user experience than pre-existing tools. For example, ChatGPT and Bard can be used to automatically fix any punctuation and grammar mistakes to improve the writing quality. In addition, the study investigates how these platforms can go beyond helping users check grammar and can further generate reports about document statistics, vocabulary statistics, etc, change the language of a piece to make it suitable for people of any age, and even adapt it into a story. Moreover, ChatGPT and Bard have been compared to other AI-based grammar checkers, including QuillBot, DeepL, DeepL Write, and Google Docs. The results show that these tools perform the best in terms of the number of errors detected. While ChatGPT has some usability issues when it comes to proofreading, such as being over 10 times slower than DeepL and lacking in the ability to highlight suggestions or provide alternative options for specific words or phrases, it should be noted that grammar-checking is just the tip of the iceberg. Generative AI platforms can also be valuable in improving language, restructuring text, and other aspects of writing.

F. ACADEMIC REVIEWER

Peer review of research papers is a crucial process for the dissemination of new ideas, with a significant impact on scientific progress. However, the sheer volume of research papers being produced has posed a challenge for human reviewers. The potential of generative AI platforms for literature review has been investigated in [28]. Specifically, ChatGPT is capable of analysing inputted academic papers, and then it can evaluate them based on several aspects, including the summary, strengths and weaknesses, clarity, quality, novelty, and reproducibility of the papers. Furthermore, the generated reviews of the papers are then inputted into ChatGPT for sentiment analysis. After this, a decision can be made on the acceptance of the reviewed paper.

6.2 EDUCATION FIELD

With the impressive capability to generate human-like responses, Text-to-text models have been studied by numerous works to investigate the impact they bring to the education field. Here, they are summarised from two perspectives: teaching/learning and subjects.

A. TEACHING AND LEARNING

In a typical classroom setting, the teachers are the source of knowledge, while the students play the role of knowledge receiver. Outside the classroom, the students are often required to complete the assignments designed by the teacher. How the teachers and students interact with each other can be significantly changed by these platforms[30]. Generative AI platforms can revolutionise the paradigm of teaching by providing a wealth of resources to aid in the creation of personalised tutoring, designing course material , assessment and evaluation [30]. Multiple works [29][30] have discussed how they can be used to create an adaptive learning platform to meet the needs and capabilities of students.

It has been shown in [30] that the teacher can exploit these platforms to guide students in interactive dialogues to help them learn a new language. These platforms have also been utilised to design course material in law curriculum, such as generating a syllabus and hand-outs for a class, as well as creating practice test questions. Moreover, a recent work [29] provides preliminary evidence that these Text-to-text models can be applied to assist law professors to help with scholarship duties. Specifically, this includes submitting a biography for a speaking engagement, writing opening remarks for a symposium, and developing a document for a law school committee. In addition, it is shown in [30], that these tools can be exploited as an assessment and evaluation assistant, including automated grading and performance and engagement analysis for students.

On the other hand, they also bring a significant impact on how students learn. A poll done by Study.com (an online course provider) reveals how ChatGPT is used among adult students. According to its findings, 89% of them utilised ChatGPT for homework, and 48% of them exploited it for an at-home test or quiz. Moreover, over half of them admitted to using ChatGPT to write essays, and 22% confessed to using ChatGPT to create a paper outline. Meanwhile, multiple works have investigated how ChatGPT might assist students in their studies. For example, [30] utilises ChatGPT to translate language, which helps students converse more effectively in academic issues and comprehend different language essays and papers. Moreover, ChatGPT or Bard can be used to propose suitable courses, programs, and publications to students based on their interests. In [29], ChatGPT helps students comprehend certain theories and concepts to assist in more effective problem-solving.

B. GENAI PLATFORMS FOR VARIOUS SUBJECTS IN EDUCATION

In modern education, there is a wide variety of subjects, including economics, law, physics, data science, mathematics, sports, psychology, engineering, and media education, etc. To facilitate the discussion, subjects are divided into STEM (Science, Technology, Engineering, Mathematics) and non-STEM (including economics, law, psychology, etc).

STEM subjects. Generative AI platforms have the potential to revolutionise the way STEM subjects are taught and learned. These platforms can offer personalised and interactive learning experiences for students, enabling them to learn at their own pace and level. Here are a few ways Generative AI platforms can be used in STEM subjects education:

- Personalised learning: Generative AI platforms can be programmed to personalise the learning experience based on individual students' strengths and weaknesses. The platforms can analyse students' performance data and provide tailored recommendations on what topics they need to focus on and how to improve.
- Interactive simulations: With Generative AI platforms, students can explore and interact with complex scientific simulations, which can be difficult or impossible to replicate in traditional classrooms. These simulations can help students develop a deeper understanding of scientific principles and phenomena.
- Adaptive assessments: Generative AI platforms can be used to create adaptive assessments that adjust the difficulty level based on the student's performance. These assessments can provide immediate feedback and help students identify areas where they need to improve.
- Natural language processing: Generative AI platforms can process natural language and provide answers to students' questions in real-time. This feature can help students clarify their doubts and deepen their understanding of complex concepts.
- Project-based learning: Generative AI platforms can be used to create project-based learning experiences for students. Students can work on projects that require them to apply their knowledge and skills to real-world problems, fostering creativity and innovation.

- Collaborative learning: Generative AI platforms can be used to facilitate collaborative learning among students. For example, a platform could be developed that uses machine learning algorithms to match students with similar interests and learning goals, and then assigns them to work together on a project. This type of collaborative learning can help students develop teamwork and communication skills.

Simultaneously, ChatGPT has sparked substantial interest in engineering education among both students and educators. As the work [31] suggests, the ChatGPT gives insights for many questions, such as discussing how to use ChatGPT in engineering education from the viewpoints of students and professors.

Non-STEM subjects. Beyond medical standardised tests, the investigation of GenAI platforms on their potential in economics and law exams have also been conducted. [32] evaluate the performance of ChatGPT for the Test of Understanding in College Economics (TUCE), which is an undergraduate-level economics test in the United States. The results demonstrate that ChatGPT properly answers 63.3% of the microeconomics questions and 86.7% of the macroeconomics questions, which performs better than the average level of performance of students. The research [33] conducted by Jonathan focused on the performance of ChatGPT on four genuine legal examinations at the University of Minnesota, the content of which includes 95 multiple-choice questions and 12 essay questions. The study reveals that ChatGPT passed all four courses and performed at the level of a C+ student. Moreover, this research mentions that the ChatGPT can be utilised to create essays with the capacity to comprehend essential legal norms and continuous solid arrangement. There are a few studies on the application of GenAI platforms in psychology. ChatGPT, as a strong text-generating chatbot, makes it easy to write essays about psychology. However, the ability of ChatGPT to handle emotional input is still unknowable.

6.3 MEDICAL FIELD

A. MEDICAL KNOWLEDGE ASSESSMENT

Generative AI platforms can be used in medical knowledge assessment in various ways. One of the most common applications is through the development of intelligent tutoring systems that can provide personalised learning experiences to medical students.

These systems use natural language processing algorithms to analyse a student's responses and provide targeted feedback based on their strengths and weaknesses. Another way in which generative AI platforms can be used in medical knowledge assessment is through the creation of virtual patient simulations. These simulations allow medical students to practise diagnosing and treating patients in a safe and controlled environment. By using generative AI platforms, these simulations can be made more realistic and personalised to the specific needs of each student.

Generative AI platforms can also be used to develop decision support systems for medical professionals. These systems can analyse large amounts of patient data to help doctors make more informed decisions about diagnosis and treatment. By using machine learning algorithms, these systems can learn from past cases and provide increasingly accurate recommendations over time. Finally, generative AI platforms can be used to develop chatbots and other conversational agents that can assist patients in navigating the healthcare system. These chatbots can answer common questions, schedule appointments, and provide reminders about medication and follow-up care. By using natural language processing and machine learning algorithms, these chatbots can provide personalised and accurate information to patients, improving their overall experience with the healthcare system.

The skills in answering questions regarding cirrhosis and hepatocellular carcinoma (HCC) have been evaluated in [22]. The results show that ChatGPT can answer some basic questions about diagnosis and prevention, and the accuracy rate for quality measurement questions is 76.9%, but there is still a lack of understanding of advanced questions such as treatment time and HCC screening criteria. In addition, ChatGPT is evaluated for its performance on the United States Medical Licensing Examination (USMLE) Step 1 and Step 2 exams in a study. Multiple choice questions from the USMLE Step 1 and Step 2 exams are employed, and the results reveal that the response from the ChatGPT is equal to that of a third-year medical student.

B. DISEASE DIAGNOSIS AND TREATMENT

Generative AI platforms have shown promising results in disease diagnosis and treatment. One of the ways Generative AI can be used is by analysing medical imaging data such as X-rays, CT scans, and MRIs to help in the detection of diseases and other health conditions. AI-based algorithms can be trained to identify patterns and anomalies

in medical images that may be difficult to detect by human clinicians. This can lead to earlier detection of diseases, more accurate diagnosis, and faster treatment. Another way Generative AI can be used in disease diagnosis and treatment is by analysing large sets of patient data to identify potential risk factors, genetic markers, and other indicators of diseases. On the other hand, in order to provide patients with more accurate diagnoses and better treatment outcomes, it is necessary to manage and analyse patient medical data effectively, perhaps leading to better healthcare ultimately.

Therefore, to achieve this, one possible approach is to utilise ChatGPT to summarise the huge and complex patient medical records and then extract important information, allowing doctors to quickly understand their patients and reduce the risk of human error in decision-making. With the ability to analyse large datasets, Generative AI can uncover hidden patterns and insights that can be used to inform clinical decision-making and treatment planning. This can lead to more personalised and effective treatment options for patients. Generative AI can also be used to develop new drugs and treatments by simulating molecular interactions and predicting the efficacy of various drugs. By analysing large amounts of medical data, Generative AI can help researchers identify new targets for drug development and optimise existing treatments.

For example, a study is conducted in [34] to identify appropriate imaging for patients requiring breast cancer screening and assessment for breast pain. They compare the responses of ChatGPT to the guidelines provided by the American College of Radiology (ACR) for breast pain and breast cancer screening by assessing whether the proposed imaging modality complies with ACR guidelines. The results are exciting, with the worst-performing set of metrics achieving an accuracy of 56.25%. In addition, the clinical decision support capability of ChatGPT in standardised clinical vignettes, which are a special type of clinical teaching case primarily used to measure trainees' knowledge and clinical reasoning abilities, is evaluated. The authors input all 36 published clinical cases from the Merck Sharpe & Dohme (MSD) clinical manual into ChatGPT, and compared the accuracy of ChatGPT in differential diagnosis, final diagnosis, etc., according to different classifications of patients. The results showed that ChatGPT achieved an overall accuracy of 71.7% across all the published clinical cases.

6.4 OTHER FIELDS

A. ASSISTED SOFTWARE DEVELOPMENT

Generative AI platforms can also be used in assisted software development, where they can help developers in various tasks such as code completion, debugging, and testing. With the help of generative models, developers can automate repetitive tasks, write more efficient and secure code, and reduce the overall development time. One way in which generative AI platforms can assist in software development is by providing code suggestions and auto-completion features. For example, platforms like OpenAI's Codex can generate code based on natural language descriptions of the task at hand. This can save developers time and effort, especially when working with complex codebases.

Generative AI can also assist in debugging and testing software. Specifically, ChatGPT can provide assistance in solving programming errors by offering debugging help, error prediction, and error explanation, but currently it is only suitable to analyse and understand code snippets. Platforms like DeepCode can analyse code and provide suggestions to fix bugs or improve code quality. Additionally, generative models can be used to generate test cases automatically, which can improve the overall testing process and reduce the chances of errors slipping through the cracks. Finally, generative AI platforms can be used to automate the process of writing documentation for software. With the help of natural language processing, platforms like TabNine can generate descriptions and explanations of code and API documentation. This can save developers a lot of time and effort, and ensure that the documentation is accurate and up-to-date. While it cannot currently replace programmers, it is capable of generating short computer programs with limited execution.

B. MANAGEMENT TOOL

Generative AI platforms have several characteristics that can be of help in management. One of the primary characteristics is their ability with advanced language understanding and generation capabilities to process large amounts of data in a short amount of time. This allows managers to quickly analyse data and make informed decisions. Additionally, Generative AI platforms can identify patterns and trends in data that may not be immediately apparent to humans, enabling managers to make more accurate predictions about the future. The construction industry requires a significant amount of repetitive and time-consuming tasks, such as the need for strict supervision and

management of construction progress. Another characteristic of Generative AI platforms is their ability to automate tasks. This can be especially useful in management, as it frees up managers to focus on higher-level tasks that require more critical thinking and decision-making skills. For example, Generative AI platforms can be used to automate repetitive tasks such as data entry, report generation, and analysis, allowing managers to focus on more strategic tasks.

Generative AI platforms can also be used as a tool for communication and collaboration. For example, Generative AI platforms can be used to analyse communication patterns within an organisation and identify areas where communication can be improved. Additionally, Generative AI platforms can be used to facilitate collaboration by identifying areas where different teams or departments can work together to achieve common goals. Finally, Generative AI platforms can be used to improve the overall efficiency and effectiveness of an organisation. By automating tasks, identifying patterns and trends, and facilitating communication and collaboration, Generative AI platforms can help organisations become more agile and responsive to changing market conditions.

These platforms can be integrated into almost every step of the product management process, such as getting early ideas on marketing, writing product requirements documents, designing the product, analysing the feedback from users and even creating a draft for go-to-market. Another example is that it has the potential to significantly impact traditional libraries as a library management tool. Given their ability to manage books and analyse data, customers can quickly obtain answers to their questions, enhancing the user experience. Furthermore, library staff can focus on more complex tasks and provide more efficient service to customers.

C. GENERATE ARTICLES FOR JOURNALISM AND MEDIA

The capabilities of Generative AI tools have also been demonstrated in [35] to generate articles for journalism and media. Generative AI platforms can be useful in journalism and media for generating articles quickly and efficiently. These platforms can assist journalists in creating articles on breaking news stories or other topics that require quick turnaround times. One example of a GenAI platform being used in media is the OpenAI language model GPT-3.5, which has the ability to generate coherent and contextually relevant text. In a recent experiment, The Guardian newspaper used GPT-3

to generate an article on the topic of why robots should pay taxes. Although the article was not published, the experiment demonstrated how GenAI platforms can assist journalists in generating content quickly. In addition to generating articles, GenAI platforms can also assist in the fact-checking process. The use of AI in detecting false or misleading information in news articles has been gaining attention in recent years, and GenAI platforms can be trained to recognize and flag such content.

D. MISCELLANEOUS APPLICATIONS

In addition to the fields indicated above, Generative AI platforms can be utilised in financial, legal advising, societal analysis, and accounting. Their potential for upgrading an existing NLP-based financial application is explored. The performance of using them as an expert legal advice lawyer is accessed [29]. ChatGPT, in particular, gives a deep and thought-provoking analysis of the Libor-rigging affair, as well as the implications of the current Connolly and Black case for Tom Hayes' conviction. Another application is in the creation of virtual assistants and chatbots. By leveraging natural language processing and machine learning techniques, Generative AI platforms can help develop virtual assistants that can interact with users in a more human-like way, understand user intent, and provide personalised recommendations or solutions.

In the field of design, Generative AI platforms can assist designers in creating new products, logos, and branding materials. These platforms can analyse existing design patterns and generate new ones that are both aesthetically pleasing and functional. Generative AI platforms can also be used in financial modelling and forecasting. By analysing large amounts of data, these platforms can provide insights into market trends, potential risks, and investment opportunities. Finally, Generative AI platforms can be used in the field of gaming to create more immersive and engaging experiences. By generating new game scenarios, characters, and challenges, these platforms can enhance the overall gameplay experience for users.

CHAPTER 7

CHALLENGES

As the field of Generative AI rapidly advances, there is no doubt that it holds significant potential in various domains, including but not limited to healthcare, journalism, education, and software development. However, like any other emerging technology, it also poses several challenges that need to be addressed. In this section, we will explore some of the significant challenges associated with Generative AI platforms, such as ethical concerns, bias, privacy, transparency, and more. We will discuss the potential impact of these challenges on the adoption and deployment of Generative AI platforms and strategies to mitigate these challenges.

7.1 TECHNICAL LIMITATIONS

A. INCORRECT

It is not accurate to describe Generative AI Platforms as inherently "incorrect" as they are simply tools that rely on algorithms and models that can be trained and fine-tuned to generate various outputs. These platforms are prone to sometimes generate wrong or meaningless answers that appear to be reasonable, which is like talking nonsense in a serious way. However, like any other tool, the results generated by Generative AI Platforms are not always perfect or completely accurate. For example, in language generation tasks, Generative AI Platforms may sometimes produce grammatically incorrect sentences or generate text that does not make sense in a given context. In image generation tasks, the resulting images may contain artefacts or be distorted in some way.

B. ILLOGICAL

As with any technology, there are limitations and potential drawbacks to the use of Generative AI platforms. One issue that can arise is illogical output, where the generated content does not make sense or is inconsistent with established knowledge. This can be especially problematic in fields such as medicine, where incorrect information could have serious consequences for patients. It is noted in [36] that ChatGPT’s logic reasoning capability for example still needs improvement. Since ChatGPT lacks rational human thinking, it can neither “think" nor “reason" and thus failed to pass the Turing test. In

addition, ChatGPT lacks a “world model" to perform spatial, temporal, or physical inferences, or to predict and explain human behaviours and psychological processes, and is also limited in mathematics and arithmetic, unable to solve difficult mathematical problems or riddles, or even possibly get inaccurate results in some simple computation tasks [36]. To address this issue, it is important to carefully curate and validate the training data used to develop the AI system. Additionally, the AI system should be designed to incorporate checks and balances that can identify and flag illogical output for review by human experts.

C. INCONSISTENT

Inconsistency can refer to a lack of coherence or conformity in a system, method, or logic. In the context of Generative AI platforms, inconsistency may occur when the output generated by the platform is not in line with the expected or desired results. These platforms can generate two different outputs when the model is fed with the same prompt input, which suggests that GenAI platforms have the limitation of being inconsistent. Moreover, they can be highly sensitive to the input prompt, which motivates further investigation in prompt engineering. A good prompt can improve the query efficiency for systematic review literature search. If the platform has not been trained on enough data or the quality of the data is poor, the generated output may contain errors or inconsistencies. Additionally, if the training data is biased or incomplete, the platform may not be able to generate accurate or reliable results. To address these issues, Generative AI platforms require careful development, training, and validation to ensure that they are consistent and reliable in their output. Regular testing and refinement can also help to identify and address any inconsistencies or errors in the platform's output.

D. UNCONSCIOUS

These platforms as of now do not possess self-awareness [36], although they can answer various questions and generate seemingly related and coherent text, image, video or other media, they do not have consciousness, self-awareness, emotions, or any subjective experience. For example, ChatGPT can understand and create humour, but it cannot experience emotions or subjective experiences. There is no widely accepted definition of self-awareness yet, nor reliable test methods. Some researchers suggest inferring self-awareness from certain behaviour or activity patterns, while others believe

it is a subjective experience that cannot be objectively measured [36]. It is still unclear whether machines truly possess or can only simulate self-awareness.

7.2 MISUSE CASES

The powerful capabilities of ChatGPT can be misused in numerous scenarios. Here, I will summarise its misuse cases, which are summarised as follows:

A. PLAGIARISM AND MISCONDUCT

Plagiarism and misconduct are major concerns in academia and research. While Generative AI Platforms offer many benefits to researchers and authors, they also bring some ethical concerns. One of the major concerns is the potential for plagiarism and misconduct when using Generative AI Platforms. Since Generative AI Platforms are trained on vast amounts of data, there is a risk that they may generate text that is similar or identical to previously published work. This can be unintentional, but it can also be deliberate, with the aim of passing off someone else's work as one's own. In addition, Generative AI Platforms may not always provide proper attribution for sources used in generated text, which can lead to unintentional plagiarism. Researchers may use the content generated by these platforms to submit papers and conceal the use of these tools.

To prevent plagiarism and misconduct, researchers and authors must ensure that they use Generative AI Platforms responsibly and ethically. This includes properly citing sources used in generated text, verifying the accuracy and originality of generated content, and using Generative AI Platforms as a supplement to, rather than a replacement for, original research and writing. It is also important for academic institutions and publishers to establish clear guidelines and policies for the use of Generative AI Platforms to promote responsible and ethical use. Many schools have already prohibited the use of ChatGPT, and the emergence of such tools is disruptive to the current education system and the criteria for evaluating student performance. If students use ChatGPT and hide it, it is unfair to those who do not use ChatGPT. This behaviour undermines the goals of higher education, undermines the school’s education of students, and may ultimately lead to the devaluation of degrees.

B. OVER RELIANCE

Over reliance on Generative AI platforms can lead to a false sense of accuracy and completeness, causing individuals to overlook or dismiss important nuances, details, or context that are not captured in the generated output. This is especially true when it comes to complex tasks such as medical diagnosis or legal analysis, where decisions made based on incomplete or inaccurate information can have serious consequences. The use of ChatGPT by students and researchers, or the use of Midjourney by artists to generate ideas or art might lead to more terrifying issues, that is, their over-dependence on the model and abandoning their independent thinking [19], which not only means the simple issue of writing plagiarism and copyright infringement, but a more serious one. Although ChatGPT can generate constructive answers according to the questions asked, just like search engines, but more powerfully. This effortless generation of ideas or guidance may gradually weaken the ability of critical thinking and independent thinking. Similarly over reliance on Midjourney or any Text-to-image and Text-to-video models may impact creativity among individuals. Therefore, while Generative AI platforms can provide a valuable resource for researchers, educators, and other professionals, it is important to use them in conjunction with other sources of information and to exercise caution when relying solely on generated output.

C. Improper content

Generative AI platforms, especially the ones trained on large datasets, may generate improper or offensive content. Since these platforms are designed to generate content based on the input data, they may replicate or amplify the biases, stereotypes, and offensive language present in the training data. This can lead to the generation of inappropriate or harmful content, including hate speech, racist or sexist remarks, and other offensive material. Moreover, these platforms may also generate inaccurate or misleading information that could be harmful to individuals or society at large. For instance, a generative AI platform that generates medical advice based on limited or unreliable data can potentially harm patients by providing inaccurate or even harmful recommendations. Similarly, a platform that generates fake news or misleading information can mislead the public and have a detrimental effect on society. For example, ChatGPT can be abused to generate pornographic, vulgar, and violent content, which can harm individuals and society. Hackers can use ChatGPT's programming capabilities to create malicious software [37], such as viruses or Trojans, for network attacks, data theft,

or attempts to control other computer systems, which can cause serious harm to other network users. Moreover, ChatGPT does not receive any human review when generating the content, which makes it difficult to hold someone accountable when inappropriate content appears in the output [19].

D. FALSE DISSEMINATION

False dissemination refers to the spread of false or misleading information through various channels, including digital media. Generative AI platforms can contribute to this problem by generating false or misleading content that is then disseminated through social media or other channels. For example, ChatGPT may be exploited to generate a large number of fabricated articles that appear on blogs, news, newspapers, or the internet that look indistinguishable from other articles but are actually false. Microsoft has added ChatGPT to its search engine Bing, which will accelerate the speed of wrong information spreading on the Internet. Disseminating such forgeries not only harms the public interest but also disrupts the network environment [37]. If not controlled, the rapid spread of wrong information on the Internet will have disastrous consequences for public information security. To prevent false dissemination, it is important to ensure that Generative AI platforms are only used for ethical purposes and are carefully monitored by human experts. One approach to addressing false dissemination is to develop algorithms that can detect and flag potentially misleading or false content generated by Generative AI platforms. This could involve using natural language processing techniques to identify patterns and anomalies in the generated text, or developing machine learning models that can distinguish between high-quality and low-quality content. Additionally, it is important to educate users and the public about the potential risks of Generative AI platforms and to encourage responsible use of these tools.

7.3 ETHICAL CONCERNS

With the wide use of ChatGPT, there is increasing attention to the underlying ethical concerns. Here, I will try to summarise the ethical concerns behind, which are summarised as follows:

A. BIAS

One of the major concerns with Generative AI platforms is the potential for bias. Since these platforms rely on large datasets to generate content, any biases in the data can be reflected in the output. For example, if the dataset used to train a language model is biased towards a particular group or viewpoint, the resulting text generated by the model may also be biased towards that group or viewpoint. For example, ChatGPT has a left-wing liberal ideological bias when reviewing the importance of political elections in democratic countries [37]. Bias can also be introduced if the training data is not diverse enough. If a model is trained on a narrow range of data, it may not be able to accurately generate content for topics outside of that range. This can lead to inaccuracies and misinformation in the generated content. Furthermore, there is a risk that bias could be introduced intentionally, either by the developers or by users of the technology. This could be done for political or social reasons, or for financial gain. Such biased data generated by these platforms can influence students during the process of education, thus magnifying the phenomenon of bias in society [19].

B. PRIVACY

Generative AI platforms may infringe on personal privacy in both its training process and user utilisation process. Coming to the training process, these platforms require large amounts of data to train their models and generate outputs, which often involves processing sensitive personal information. For example, a healthcare organisation using a generative AI platform to generate medical reports may need to provide access to sensitive patient information. This can create significant privacy risks if the data is not handled properly. Moreover, generative AI platforms may also generate outputs that include personal information, which could be shared or made public without proper consent or security measures. This could lead to potential breaches of privacy and expose individuals to risks such as identity theft, cyber attacks, and more. Additionally, there may be legal and ethical concerns related to data privacy, especially when the data is being processed across borders or by third-party service providers. The General Data Protection Regulation (GDPR) and other data protection laws set strict guidelines for handling personal data, and failure to comply with these regulations can result in significant penalties and reputational damage. During the user utilisation process [19], users may unintentionally disclose their own information to meet their own needs, such as

personal preferences, and chat records. Thus, such information may bring adverse effects to users if obtained by criminals.

C. FAIRNESS

Concern related to fairness is the potential gap in knowledge dissemination and academic publishing that could arise if Generative AI platforms are only available to those who can afford to pay for them. This could create an uneven playing field in terms of who has access to the latest research and information, and may result in those who can't afford these tools being left behind. This is particularly concerning in the field of academic publishing, where access to information is critical to the advancement of knowledge and innovation.

D. TRANSPARENCY

Transparency is a key issue in the development and deployment of generative AI platforms. In order to build trust with users and stakeholders, it is important that these platforms are transparent in their operation and decision-making processes. This means that the algorithms and models used by the platforms should be open to scrutiny and evaluation, and the data used to train them should be publicly available. This can help to address concerns around bias, accuracy, and accountability. So far, how large language models like GPTs work to generate the relevant responses is still unclear. The lack of transparency makes it difficult for the user to have fine-grained control of the generated content, and is especially problematic when the generated content is toxic. More worrisome is that the company OpenAI has deviated from its original non-profit goal to pursue a business interest, which makes it less reluctant to reveal the underlying technical details of its recent progress. For example, the recently released GPT-4 technical report [17] mainly demonstrates its superiority over the previous model families, while providing no technical details on how these are achieved.

7.4 REGULATION POLICY

Numerous scholars have discussed how to make regulations on the capabilities and impacts of GenAI, and the most frequently discussed topics are listed in the following paragraphs.

A. MISUSE PREVENTION

A major concern for the misuse of generative platforms is that it might damage academic integrity. Directly prohibiting the use of these tools in academic institutions is not recommended. To this end, some propose to cancel assignments based on article writing and seek alternative test forms to stop students from misusing these platforms. It is also possible to enrich student courses, such as adding thinking exercises courses, or teaching students how to use these platforms correctly. Another approach is to develop AI content detectors. Detecting whether a particular platform has generated a piece of content or not is an arduous task, even for professionals with master's or PhD backgrounds who are unable to correctly identify whether the content is generated by ChatGPT. Many developers use software to detect whether the content is AI-generated. ChatGPT is used to detect whether the content is generated by itself, and it has been proven to perform better than traditional plagiarism detection tools [38].

B. CO-AUTHORSHIP

Recently, multiple articles have listed ChatGPT as co-authors, sparking debate on whether ChatGPT can be listed as a co-author among journal editors, researchers, and publishers [36]. Those who believe that ChatGPT should not be listed as an author argue that it does not meet the four criteria for authorship set by the International Committee of Medical Journal Editors (ICMJE). Moreover, it is highlighted that ChatGPT is not creative or responsible, and its text may involve plagiarism and ethical issues, which might break the standards of content originality and quality. However, some argue that AI tools such as ChatGPT have the capacity or will have the capacity to meet the ICMJE authorship criteria and thus ChatGPT is qualified to be a co-author. Regarding this issue, Nature has clearly stated that large language models like ChatGPT do not meet the criteria for authorship and require authors to explicitly state how ChatGPT was used in the writing. An interesting point has been made that the debate over whether AI can be considered a "co-author" is unnecessary because the role of authors in traditional academic writing might have already changed when the debate arises.

C. COPYRIGHT

Copyright is an important legal consideration in the development and use of Generative AI platforms. These platforms are designed to generate new content, which can raise questions about who owns the rights to that content. According to the rules of

the US Copyright Office, only human creations can be protected by copyright. If there is no creative input or interference from a human author, a machine or mechanical program that runs randomly or automatically is not protected by copyright [37]. In some cases, the content generated by these platforms may be considered derivative works or may infringe on existing copyright protections. To avoid copyright issues, Generative AI platforms should be designed to comply with copyright laws and best practices.

Developers should take care to ensure that the platform does not generate content that infringes on the intellectual property rights of others. This may involve incorporating filters or other tools that help to identify copyrighted material and prevent it from being used in the platform's output. It is also important to consider issues of fair use when developing Generative AI platforms. Fair use allows for limited use of copyrighted material without obtaining permission from the copyright holder. Generative AI platforms may be able to make use of fair use exceptions in certain cases, but developers must be careful to ensure that their use of copyrighted material is truly fair and not likely to result in infringement.

CHAPTER 8

OUTLOOK TOWARDS AGI

8.1 TECHNOLOGY ASPECT

In this booming generative AI era, there are numerous AIGC tools for various generative tasks, including text-to- text, text-to-image, image captioning, text-to-speech, speech recognition, video generation, 3D generation, etc. Despite its impressive capabilities, it is noted in that ChatGPT is not all you need for generative AI. From the input and output perspective, ChatGPT mainly excels at text-to-text tasks. With the underlying language model evolving from GPT-3.5 to GPT-4, ChatGPT in its plus version increases its modality on the input side. Specifically, it can optionally take an image as the input, however, it can still not handle video or other data modalities. On the output side, GPT-4 is still limited to generating text, which makes it far from a general-purpose AIGC tool. Many people are wondering about what next-generation GPT might achieve [9].

A highly likely scenario is that ChatGPT might take a path toward general-purpose AIGC, which will be a significant milestone to realise artificial general intelligence (AGI). A naive way to realise such a general-purpose AIGC is to integrate various AIGC tools into a shared agent in a parallel manner. A major drawback of this naive approach is that there is no interaction among different AIGC tasks. After reviewing numerous articles, I speculate that there might be two road-maps for bridging and pushing ChatGPT toward AGI. As such, I will advocate a common landscape to achieve the interconnection between diversified AIGC models.

A) ROAD-MAP 1: COMBINING CHATGPT WITH OTHER AIGC TOOLS.

As discussed above, current ChatGPT mainly excels in text-to-text tasks. A possible road map for bridging the gap with general-purpose AIGC is to combine ChatGPT with other AIGC tools. Let’s take text-to-image tasks as an example: the current chatGPT (GPT-3) cannot be directly used to generate images. Existing text-to-image tools, like DALL-E 2 or stable diffusion, mainly focus on the mapping from a text description to a plausible image, while lacking the capability to understand complex instruction. By contrast, ChatGPT is an expert in instruction understanding. Therefore,

combining ChatGPT with existing text-to-image AIGC tools can help generate images with delicate details.

B) ROAD-MAP 2: ALL-IN-ONE STRATEGY.

The above road map renders ChatGPT mainly as a master of language understanding by exploiting the downstream AIGC tools as slaves. Such a combination strategy leverages advantages from both sides but with the information flow mainly from ChatGPT to the downstream AIGC tools. Moreover, there is still no interaction between different AIGC tasks. To this end, another road map might come to solve all AIGC tasks within the ChatGPT and exclude the dependence on the downstream AIGC tools. Similarly, I consider music generation as an everyday use case. For example, a user can instruct the ChatGPT with prompts like “Can you generate a music clip to match the input image", and ChatGPT is supposed to synthesise such a desired music clip. Such an input image is optional, depending on the task.

For example, a simple corresponding instruction prompt is sufficient if the task requires generating music beneficial for sleep. Such an all-in-one strategy might make model training a challenging task. Moreover, the inference speed might be another hurdle, for which pathways [39] might be a solution. Another evolving path might lie between road maps #1 and #2. In other words, road map #1 might be a more applicable solution in the early stages. With the technology advancing, ChatGPT is expected to master more and more AIGC tasks, excluding the dependence on external tools gradually.

8.2 BEYOND TECHNOLOGY

In the above section, I presented an outlook on the technology path that ChatGPT and other existing AGI Platforms might take towards the ultimate goal of AGI. Here, I further discuss its potential impact on mankind from the perspective of how AGI might compete with mankind. Specifically, I will focus on two aspects: job and consciousness.

A) CAN AGI REPLACE HIGH-WAGE JOBS?

Multiple works have performed a comprehensive analysis of the influence of ChatGPT on the job market [40]. According to the statistics in [40], 32.8% of jobs are fully affected and 36.5% may be partially affected. Meanwhile, it points out that the jobs that will be fully impacted are those that involve doing routine tasks, while the jobs that

will be partially affected are those that can be partially replaced by AI technologies [40]. OpenAI has also investigated large language models like GPTs that might affect occupations [5]. Their findings show that at least 10% of tasks for 80% of the US workforce and at least 50% of tasks for 19% of workers will be impacted. It is worth noting that the advent of new technology will inevitably replace some types of jobs.

However, what makes AGI different is its potentially greater influence on high-end jobs than on low-end ones. This outlook is partially supported by the findings in [5] [40] that high-wage jobs tend to have a higher risk of being replaced by AGI, for which lawyer is a representative occupation. The reason that AGI poses a higher threat to high-wage jobs is that most current high-wage jobs typically require professional expertise or creative output, which conventional AI cannot replace.

B) CAN AGI HAVE ITS OWN INTENTION AND HARM MANKIND?

In numerous fiction movies, an AI agent can have its own consciousness with its own intention. Such a human-level AI agent used to be far from reality, and a major reason is that other AI agents cannot make inferences. There is evidence that ChatGPT has developed such a capability, the reason for which is not fully clear, as acknowledged by Altman (founder of OpenAI) in his recent interview with Lex Fridman. Moreover, Altman also mentioned the possibility of AI harming mankind. Due to such concerns, very recently, Future of Life Institute has called on all AI labs to pause giant AI experiments on the training of AI systems more powerful than GPT-4. And the number of people signing this public letter has exceeded a thousand, including Yoshua Bengio, Stuart Russel, Elon Musk, etc. It is highlighted at the beginning of the letter that (we quote) “AI systems with human-competitive intelligence can pose profound risks to society and humanity", which shows deep concerns about the advent of AGI.

The deepest concern lies in the risk that AGI might outsmart and eventually replace us as well as destroy mankind’s civilization. However, not everyone agrees with its premise. For example, Yan Lecun is one of those who publicly disclose their attitude. It remains unclear how such a controversial movement might affect the future of pushing ChatGPT (or other products with similar functions) towards AGI. I do hope my seminar helps raise awareness of the concerns surrounding AGI.

CHAPTER 9

CONCLUSION

Generative AI platforms such as ChatGPT and Google Bard represent significant advancements in the field of natural language processing and conversational AI. These technologies have the potential to transform how we interact with machines, and could pave the way for the development of true artificial general intelligence in the future. However, there are still many challenges and limitations associated with these technologies, including issues around data privacy, security, and bias. As we continue to develop and refine these platforms, it will be important to address these challenges and ensure that they are used in an ethical and responsible manner. The development of Generative AI platforms is a fascinating and rapidly evolving field, with exciting possibilities for the future. As computer science students, it is important for us to stay up-to-date with the latest trends and developments in this area, and to continue pushing the boundaries of what is possible with this technology. By doing so, we can help to shape a future where machines are capable of truly understanding and engaging with human language, and where the possibilities for innovation and discovery are limitless.

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