Pros and cons of AI-generated content

Artificial intelligence is growing rapidly in the tech sector and assisting with various tasks such as creating images and generating content. However, it cannot do everything.

is becoming popular, but many people wonder how to use it and if it truly sounds authentic.

AI is growing rapidly in the tech sector, including supply chain, food industry, chatbot, and content and image generation use cases. AI-generated images made the news when critics claimed that these AI art systems are stealing people's intellectual property on large models, such OpenAI's Dall-E. And people are wondering if AI will take the place of artists and illustrators.

OpenAI introduced a similar AI program for content known as ChatGPT. This bot serves a more general purpose and offers an open prompt for users to ask questions, give a command or ask for an observation. The bot answers both broad and specific questions. The system generated answers that professors and other educators said were extensive enough to receive a good grade. However, after further review, some sources -- such as Stack Overflow for coders and developers -- said the information was incorrect and temporarily banned answers using this system. Since there are no limits to answers that ChatGPT can give, a user was even allowed to search how to make explosives and shoplift, adding more controversy.

Businesses are looking at AI tools to help with content creation and copywriting. The same question is being posed as to whether AI will take the place of content writers. While AI-generated content might not be suitable for all copywriting, there are some great ways to use these tools.

What is AI-generated content?

AI-generated content includes copy such as blogs, marketing materials, articles and product descriptions written by a machine. The AI content creator generates the content after a person inputs information such as keywords, phrases and topics.

What are the pros of AI-generated content?

AI-generated content can be valuable in several ways. Here are some of the pros.

Efficiency and scalability

AI can create content much faster than people, which is probably the biggest benefit. An AI tool can produce an article in minutes. It would take a human writer much longer to do all the research and write it.

Multiply the quick turnaround by the number of articles, and an AI tool can produce a significant amount of content.

AI also helps with language localization for various geographic areas and can create social media, personalizing this content for various sites.

Cost-effectiveness

Hiring quality content writers typically costs a few hundred dollars per project, often depending on article length, the number of pieces and the needed technical knowledge. And this could prove to be money well spent if it results in high-quality, well-researched content.

Some AI writing tools are free, while others charge a monthly subscription rate. The pricing typically runs about $100 for tens of thousands of words.

Given these considerations, AI-generated content might be better suited for simpler content than articles needing expertise and authority.

Improved SEO

AI content generators scroll through thousands of online documents to absorb the information. In viewing all these documents, generators choose keywords to improve search engine optimization (SEO). The AI tool can suggest keywords for the content writer. By using these keyword suggestions throughout an article, the content appears higher in search engine rankings if it follows the rest of the guidelines of being authoritative and is written by a person.

Help with writer's block

Writer's block is a common hurdle for many people. At times, writers might have trouble creating authoritative content for a subject they know little about.

To help overcome this hurdle, AI tools can create detailed outlines and key points to help the writer determine what should be included in the article. These suggestions from AI tools can help the user overcome writer's block and spark the ideas needed to get started.

What are the cons of AI-generated content?

There are several considerations when it comes to using AI-generated content. Some content is best written by a human writer. Here are some cons of AI-generated content.

Quality concerns and possible plagiarism

AI relies on data and algorithms for content. AI tools can cover black-and white-areas of a topic, but gray areas are more subjective and the intended tone can get lost.

Search engines might also flag content because it is similar to published materials, as the AI pulls from the same sources. The AI tools piece content together from various sites and reword them. Without adding the proper flow, this process goes against Google's "stitching and combining content" guidelines. Content needs to be authoritative and informative, which can be hard to do when piecing information together from various sites without proper human review.

Algorithms devalue content

Google released its helpful content update in August 2022, which highlights "helpful content written by people, for people." It goes on to state that a search engine crawler looks for content from humans, providing a more cohesive and satisfying practice with SEO.

The update looks to punish content that is created for the purpose of ranking higher in search engine results. AI tools evaluate SEO results first without truly understanding the text, so the results often prioritize keywords over being informative to the reader.

Lack of creativity and personalization

Creative content makes articles more engaging. People tend to share articles they feel a connection to, but AI does not have the emotional intelligence to create a story. Its focus is generally directed toward adding facts to an outline.

AI relies on existing web content and data to develop wording. AI does not understand user intent for queries and still lacks the common sense of human behavior.

Human editing still required

People still need to read through AI-generated content. Although AI might save time, humans must continue to be involved to review articles for quality.

AI tools combine information from several websites into one piece. There might be some mix-ups to fix, such as product descriptions with textures and colors. This is generally because AI tools do not understand adjective meanings.

Can't generate new ideas

AI tools use existing data for content, so this means they cannot come up with fresh ideas. AI tools make it hard to come up with new content covering the latest trending ideas and topics.

Ways to use AI-generated content

AI-generated content is best used as a writing assistant instead of a way to rely strictly on the technology. Here are some ways to use AI tools for assistance with content:

- **Research.** For writers having issues organizing a topic or coming up with ideas, AI-generated content can help them get started. Some tools give ideas about what to include for broader topics to help narrow down the research process.
- **Proofread current material.** To make sure a drafted article is optimized, writers can run it through AI tools for a grade. The tool can also highlight keywords and phrases that should be used. AI tools can further assist with checking grammar and correcting spelling mistakes.
- **Write short content.** AI tools can produce a lot of content in a short amount of time, so they are a great way to reduce boredom with repetitive tasks. While some communications require more of an emotional side, some short descriptions do not. Product descriptions, metatags, ad copy and social media posts are examples of short text suitable for content generators.
- **Translate language.** For written material to appeal to all audiences, AI generators can help translate content into different languages.
- **Create templates.** AI tools can help create emails or other templates. Some AI tools offer different types of ready-made templates for users to plug in customized information.

Example of AI-generated content

There are many AI content generators available. Here is an example of how content generation works using a program called CopyAI:

1. Select style of writing from the left side.
2. Answer topic.
3. Add main points.
4. Select tone.

A couple options pop up for text. Here is the AI-generated content from the information entered. This was the first option meant to imitate the information in this article:

AI is an amazing technology that has the potential to change our world and how we live in it. But like any new technology, there are pros and cons to AI-generated content -- and businesses need to be aware of both before deciding whether or not to use it.

First, the pros:

1) AI-generated content saves time and money for businesses by allowing them to produce more content with fewer resources.

2) It allows businesses to create highly personalized content for each customer, which leads to happier customers.

3) AI-generated content makes sure that all information is correct, which helps prevent expensive lawsuits or bad press if something goes wrong with your business's operations (e.g., if you send out an email with incorrect information).

Now, let's talk about some of the cons:

1) AI-generated content can sound unnatural (like it was written by a robot), which can make customers feel uncomfortable or distrustful of your business. It doesn't matter how much effort you put into making sure that everything is correct if the end result sounds robotic!

2) If someone finds out that they've been reading an AI-generated piece of content instead.

Much of the information included in this TechTarget article is outlined in the AI-generated content above. However, the AI content is not particularly comprehensive or conversational -- even when selecting a friendly tone. This TechTarget article goes into greater detail for explanations and provides examples. The AI-generated content seems to be more of an outline and needs additional information to flow like a human-written article.

How to detect AI-generated content

There is a larger concern with AI-generated content: students using these tools to cheat. Several professors and teachers stated that the AI-generated content on ChatGPT created convincing essays.

To help distinguish between human and AI text, OpenAI launched a new AI text classifier on Jan. 31, 2023. However, in July 2023, OpenAI pulled the text classifier due to low accuracy. There are other online tools to help detect AI-generated content by classifying how likely it was written by a person versus AI. These resources include Originality.ai, Writing.com and Copyleaks.

OpenAI is also working on creating a watermark for longer AI-generated text for an immediate identifier.

In addition to running text through an online AI-content detector, there are a few other signs that content is AI-generated, such as the following:

- **Lack of typos.** Human writing often has typos and contains slang terms. AI-generated content rarely has typos such as grammar mistakes or misspellings.
- **Overuse of "the."** AI-generated content is based on predictive language by determining which word should be next, so it commonly uses words such as "the," "it" or "is" instead of more unusual terms.
- **No cited sources.** AI-generated text will often give facts and not cite the sources.
- **Shorter sentences.** AI content sentence length is typically shorter because it is trying to mimic human writing but often appears choppier.
- **Repetition of words or phrases.** If certain words or phrases are used abundantly, this could be a sign of AI-generated content because it is trying to fill space with relevant keywords.
- **Lack of analysis.** AI can collect data but cannot analyze the data. If an article feels full of facts without any insight, it might be AI-generated.

- Have you ever wondered how algorithms are capable of creating compelling stories, music, and even paintings? Well, get ready to be captivated by the enchanting world of

AI-generated content creation—a realm where machines channel their inner artists and bring imagination to life.

What is AI-generated content creation?

- AI-generated content creation refers to the process of utilizing artificial intelligence (AI) technologies to automatically generate or produce various forms of content. In fact, 85.1% of AI users use the technology for article writing and content creation.
- This includes text, images, videos, and even audio. Through the use of sophisticated algorithms, AI systems are able to analyze and interpret data, understand patterns, and generate content that closely resembles human-created content.
- This technology aids in streamlining the content creation process, by automating repetitive or time-consuming tasks. It has found applications in fields like marketing, journalism, advertising, and creative industries, enabling faster content creation, increased productivity, and cost-effectiveness.

Benefits of AI-generated content creation

- AI-generated content creation offers numerous benefits, making it increasingly popular. Firstly, it saves time and effort because AI algorithms can produce large volumes of content quickly and efficiently. This means that businesses can generate more content to meet their audience's demands without having to spend excessive time or resources.
- Moreover, AI-generated content is highly scalable. AI models can easily adapt to different content formats, enabling businesses to produce a variety of materials such as articles, social media posts, or even video scripts. This versatility ensures that the content can reach a wider audience across various platforms without compromising quality or consistency.
- Another advantage is the potential for enhanced personalization. AI algorithms can analyze user data and preferences to tailor content specifically to individual users. By delivering personalized content, businesses can create a more engaging and relevant experience for their audience, leading to increased customer satisfaction and loyalty. It has even been found, that 82% of content creators surveyed think AI-generated content is as good as human-generated content
- Additionally, AI-generated content is less prone to errors. Unlike humans, who might make occasional mistakes or overlook details, AI algorithms can meticulously proofread and edit content, ensuring accurate and error-free materials. This helps businesses maintain a professional image and build trust with their audience.
-

Furthermore, AI-driven content creation can offer valuable insights. By analyzing large amounts of data, AI algorithms can detect patterns, trends, and correlations that humans might overlook. This valuable information can be used to refine content strategies, improve decision-making processes, and better understand customer preferences.

Lastly, AI-generated content can contribute to cost savings. By automating content creation, businesses can reduce the need for human content creators, saving on labor costs. Additionally, AI algorithms can optimize content distribution and targeting, leading to better resource allocation and cost efficiency.

How AI-generated content creation works

Natural Language Processing (NLP)

Natural Language Processing (NLP) is a field of study that focuses on computer systems' ability to understand and interpret human language in a way that is similar to how we as humans do. It involves the use of algorithms and techniques to enable computers to process, analyze, and generate natural language text or speech.

Machine Learning algorithms

Machine Learning algorithms are computational tools designed to enable computers to learn and make predictions without being explicitly programmed. These algorithms use mathematical models and statistical techniques to analyze and identify patterns in large amounts of data, and then use these patterns to make accurate predictions or decisions. They are trained on historical data, learning from previous experiences to improve their performance over time.

Machine Learning algorithms can be used in various applications such as image recognition, speech recognition, natural language processing, recommendation systems, and autonomous vehicles.

Data sources and training

Data sources and training are crucial components in the field of machine learning. Here are the key points to understand:

1. Data sources: These are the origins of the data used for training a machine learning model. They can include various types of data, such as text, images, audio, or numerical values. Common data sources are:

- Databases: Structured collections of information stored in a systematic manner.
- APIs: Interfaces that allow systems to interact and exchange data with each other.
- Web scraping: Extracting relevant data from websites by parsing their HTML content.
- Sensors: Devices that capture real-time data like temperature, pressure, or motion.
- User-generated content: Data generated by users through actions like reviews, comments, or ratings.

1. Data labeling: Once the data is gathered, it often requires labeling. Labeling involves to annotate the data or to annotate texts in certain cases to provide meaningful information about its characteristics or relevant attributes. This labeled data serves as a reference for the model during training, enabling it to make accurate predictions.

2. Data preprocessing: Raw data is often messy and needs preprocessing to ensure its quality and compatibility for training. Preprocessing tasks may include:

- Cleaning: Removing irrelevant or redundant data points and handling missing values.
- Normalization: Adjusting data to a common scale to facilitate fair comparisons.
- Transformation: Modifying data to conform to specific requirements, such as log transformations or one-hot encoding.

4. Training process: After data preprocessing, the model can be trained using various machine learning algorithms and techniques. These include:

- Supervised learning: Training models with labeled data to enable them to learn patterns and relationships between input and output variables.
- Unsupervised learning: Training models on unlabeled data to discover inherent patterns, structures, or groupings.
- Reinforcement learning: Training models to interact with an environment and optimize their actions based on feedback.

5. Model evaluation: Once the training is complete, the model's performance is assessed to determine its accuracy and efficacy.

This evaluation is done using different metrics, such as accuracy, precision, recall, or F1 score. The model is refined and iteratively trained to achieve better performance.

AI Content Generation: Instant vs. Crafted

In the realm of AI-powered content creation, a pivotal choice arises between instant generation and crafted refinement. Two distinct methods, represented by 1-click AI generators and editable AI content creation tools, offer unique advantages tailored to your content needs.

1-Click AI Generators: Instant Results 1-click AI generators, such as ShortlyAI and Copy.ai, provide swift solutions by generating content snippets, headlines, and social media posts in a single click. These tools excel at quickly sparking ideas and generating content that often requires minimal post-generation adjustments.

Editable AI Content Creation Tools: Crafting and Tailoring Editable AI generators, like Writesonic and Conversion.ai, offer a different approach. They not only generate content but also provide the flexibility to refine and tailor it. Writesonic, for example, drafts comprehensive articles that you can then shape to match your audience and objectives. This approach empowers you to craft content that aligns perfectly with your vision.

Consider this analogy: 1-click AI generators are like instant sketches, while editable AI tools are your digital canvas, allowing you to create, modify, and perfect your work. Imagine using Conversion.ai to draft a product description and then seamlessly refining it to capture your brand's voice and messaging.

In the evolving landscape of AI-generated content, your choice of approach shapes your content's outcome. Whether you embrace the immediacy of 1-click AI or the hands-on refinement of editable tools, the blend of creativity and productivity in content creation is unprecedented. The future narrative unfolds through your decisions, each contributing to the tapestry of seamless efficiency and personalized craftsmanship.

Use cases of AI-generated content creation

Content generation for marketing campaigns

Content generation for marketing campaigns refers to the creation and development of various forms of content with the specific purpose of promoting a product, service, or brand. It involves creating engaging and compelling content, such as blog posts, social media updates, videos, and infographics, to capture the attention and interest of the target audience.

The main objective is to attract, engage, and ultimately convert potential customers into loyal buyers through strategic content creation.

Automated news and article writing

Automated news and article writing refers to the process of using artificial intelligence and algorithms to generate written content without human intervention. It involves the use of algorithms to gather and analyze data, creating coherent and engaging articles or news pieces automatically. This technology aims to streamline content creation and can be employed across various industries, including journalism, marketing, and e-commerce.

Social media post creation

Social media post creation refers to the process of composing and designing content to be shared on various social media platforms. It involves creating textual and visual elements that capture the attention of the target audience and effectively communicate the intended message. This task typically entails developing creative ideas, crafting compelling captions or text, selecting suitable images or videos, and incorporating relevant hashtags and links.

Social media post creation aims to engageusers, encourage interactions, promote brand awareness, and drive desired actions, such as website visits or product purchases.

Tips on writing with an AI content generator

Craft Clear and Specific Instructions

AI's magic lies in its understanding of your input. For desired output, provide clear instructions: topic, tone, style, key points. Specify the topic you want to explore, the tone you wish to convey (e.g., upbeat and informative), as well as the specific style that suits your content's purpose.

For example, swap "write about healthy eating" with "craft a 300-word piece on Mediterranean diet's heart health benefits, with a lively and informative tone." Outline key points, offer examples. AI's effectiveness depends on input clarity.

Collaborate with the AI

Think of AI as your writing partner. Start by writing a brief introduction or an outline to guide the AI's direction. This not only gives the AI context but also sets the tone for the content you're aiming to create.

Use AI for Efficiency, Not Replacement. AI content generators are tools designed to enhance your writing process, not replace your creativity. Use them to save time, generate ideas, or create drafts more efficiently.

Edit and Enhance

Though AI can create drafts, bear in mind it's an automated process. Treat the initial output as a canvas to paint your unique perspective. Dive into the content, tweak it to add your personal flair. Put your own voice front and center, shaping it into a story that feels genuine and relatable.

Think of yourself as the editor in charge. Refine sentences, amplify key points, and make sure everything flows together. This part, where you add your human touch, turns the AI's draft into a mix of tech efficiency and your creativity, resulting in a final product that captivates and resonates with your audience.

Fact-Check for Accuracy

AI can generate coherent text, but it might not always get facts, figures, or technical details accurate. Taking a moment to fact-check is a wise step to ensure your content maintains its credibility and reliability.

Maintain Consistency and Brand Voice

If you're using AI for business purposes, make sure the content aligns with your brand's voice, style, and guidelines. Consistency across all content is key to reinforcing your brand's identity.

This goes beyond the words conveyed; it's about how those words are conveyed. Every interaction contributes to the lasting perception your audience holds. By incorporating AI while staying true to your brand's authenticity, you reinforce its presence and elevate its impact in the market environment.

Challenges and considerations

Quality control and human input

Quality control is the process of ensuring that products or services meet certain predetermined standards. It involves various activities undertaken to detect and correct any faults or deficiencies that may compromise the quality of the end result. Human input plays a crucial role in quality control as it involves individuals using their knowledge, skills, and judgment to assess and improve the quality of the products or services being produced.

Through human input, potential issues can be identified, rectified, and prevented, ensuring that the final output meets the desired level of quality.

Ethical considerations and potential risks

Ethical considerations involve reflecting on the moral implications of our actions and decisions, considering how they may impact individuals, society, and the environment. These considerations ensure that our actions align with principles of fairness, honesty, respect, and responsibility.

Potential risks refer to the uncertainties and negative outcomes that may arise from a particular course of action. They involve analyzing the possible harm, adverse effects, and unintended consequences that could result from our decisions, and taking necessary measures to mitigate or minimize these risks.

Overcoming bias in AI-generated content

AI-generated content refers to content, such as articles or videos, that is created by artificial intelligence systems. However, these systems are not immune to bias, meaning they may produce content that is influenced by prejudiced perspectives or unfair judgments. Overcoming bias in AI-generated content involves taking steps to prevent or minimize the impact of bias, ensuring that the content generated is more accurate, fair, and inclusive.

This includes careful design and training of AI models, diversifying data sets, promoting transparency and accountability, and actively involving humans in the content creation process to ensure a more balanced and unbiased outcome. The goal is to create AI-generated content that better reflects the diverse perspectives and experiences of humanity, free from discriminatory biases.

The future of AI-generated content creation

Advancements in AI technology

Advancements in AI technology refer to the progress made in artificial intelligence systems and techniques. These breakthroughs involve improving the ability of machines to learn, reason, and perform tasks that typically require human intelligence. Through increased data processing

power and advanced algorithms, AI technology aims to enhance automation, decision-making, and problem-solving capabilities across various industries and applications.

The continual advancements in AI technology impact many aspects of our lives, paving the way for innovations and efficiencies in areas such as healthcare, transportation, finance, and entertainment.

Integration with other creative tools

Integration with other creative tools refers to the ability of a software or platform to seamlessly connect and work together with different tools and software that are used for creative purposes. This integration promotes collaboration and streamlines workflows by allowing users to easily transfer and share their creative work between various tools.

By integrating with other creative tools, users can combine the unique features and functionalities of different software, expanding their creative possibilities. This collaboration between tools enhances efficiency and productivity, as artists and designers can leverage the strengths of multiple tools without the need to switch between various applications constantly.

Whether it's integrating with graphic design software, video editing tools, or animation programs, seamless integration ensures a smooth and convenient workflow. It enables users to import and export files, assets, and project data across different applications without any loss of quality or compatibility issues.

Integration with other creative tools also fosters a sense of flexibility and adaptability. Artists and designers can choose the tools that suit their needs best and still maintain a cohesive workflow. It eliminates the need for manual file transfers or recreating work from scratch in different programs, saving time and effort.

Furthermore, integration enables real-time collaboration among team members, allowing them to work simultaneously on a project using their preferred tools. This encourages effective communication, boosts creativity, and ensures that everyone can contribute their expertise to achieve the desired outcome.

Impact on content creation industries

The impact on content creation industries refers to the influence and changes experienced by sectors involved in generating various forms of media, such as movies, music, literature, and art. It encompasses the effects of technological advancements, shifts in consumer behavior, and evolving market dynamics that affect how content is produced, distributed, and consumed. These industries must adapt and embrace new opportunities to thrive in this rapidly changing landscape.

Key takeaways

Artificial intelligence has revolutionized various industries, and content creation is no exception. AI-generated content is attracting attention for its ability to generate high-quality, creative, and engaging articles, stories, and other forms of content. With AI, businesses can streamline content production, saving time and resources. AI-powered tools can analyze data, identify trends, and generate personalized content for targeted audiences.

Moreover, AI-generated content can adapt to individual preferences, making it more appealing and tailored to specific users. Although there are concerns about the potential impact on human creativity and job security, AI-generated content creation opens new doors for efficiency and personalized communication.

1

AI-Generated Content (AIGC): A Survey

Jiayang Wu, Wensheng Gan*, Zefeng Chen, Shicheng Wan, and Hong Lin

Abstract—To address the challenges of digital intelligence in the digital economy, artificial intelligence-generated content (AIGC) has emerged. AIGC uses artificial intelligence to assist or replace manual content generation by generating content based on user-inputted keywords or requirements. The development of large model algorithms has significantly strengthened the capabilities of AIGC, which makes AIGC products a promising generative tool and adds convenience to our lives. As an upstream technology, AIGC has unlimited potential to support different downstream applications. It is important to analyze AIGC's current capabilities and shortcomings to understand how it can be best utilized in future applications. Therefore, this paper provides an extensive overview of AIGC, covering its definition, essential conditions, cutting-edge capabilities, and advanced features. Moreover, it discusses the benefits of large-scale pre-trained models and the industrial chain of AIGC. Furthermore,

the article explores the distinctions between auxiliary generation and automatic generation within AIGC, providing examples of text generation. The paper also examines the potential integration of AIGC with the Metaverse. Lastly, the article highlights existing issues and suggests some future directions for application.

Impact Statement– It is necessary for academia and industry to take an overview of what AIGC is, how AIGC works, how AIGC changes our lifestyles, and what AIGC will be in the future. This article proposes a survey of AIGC from its definition, pros, cons, applications, current challenges, and future directions to answer these urgent questions. We summarize the existing major literature, which helps relevant researchers become familiar with and understand the existing works and unsolved problems. Based on the review of literature and the commercialization of scientific and research findings, we conduct some cutting-edge AIGC research. In particular, the challenges and future directions of AIGC can be helpful for developing AI. Relevant technologies of AIGC will boost the development of artificial intelligence, better serve human society, and achieve sustainable development.

Index Terms—digital economy, artificial intelligence, AIGC, large model, applications.

I. INTRODUCTION

With Web 3.0 still in its blooming stage [1], Artificial Intelligence (AI)1 has proven to be an effective tool for many challenging tasks, such as generating content, classification

and understanding. In recent years, some advancements within AI have helped the technology complete more complex tasks

This research was supported in part by the National Natural Science Foundation of China (Nos. 62002136 and 62272196), Natural Science Foundation of Guangdong Province (No. 2022A1515011861), Fundamental Research Funds for the Central Universities of Jinan University (No. 21622416), the Young Scholar Program of Pazhou Lab (No. PZL2021KF0023), Engineering Research Center of Trustworthy AI, Ministry of Education (Jinan University), and Guangdong Key Laboratory for Data Security and Privacy Preserving.

Jiayang Wu, Wensheng Gan, Zefeng Chen, and Hong Lin are with the College of Cyber Security, Jinan University, Guangzhou 510632, China; and also with Pazhou Lab, Guangzhou 510330, China. (E-mail: wsgan001@gmail.com)

Shicheng Wan is with the School of Business Administration, South China University of Technology, Guangzhou 510641, China.

Corresponding author: Wensheng Gan

1https://en.wikipedia.org/wiki/Artificial intelligence

than before, such as understanding input data and then generating content. Artificial Intelligence Generated Content (AIGC) is a new content creation method that complements traditional content creation approaches like Professional Generated Content (PGC) and User Generated Content (UGC) [2], [3]. AIGC generates content according to AI technology to meet the requirements of users. It is supposed to be a promising technology with numerous applications. Understanding AIGC's

capabilities and limitations, therefore, is critical to exploring its full potential.The first stage

• The “1 The Road” is the the world's first novel completely created by artificial intelligence.

• Microsoft showcased a fully automatic simultaneous interpretation system.

• The world's first computer-completed music, “Iliac Suite”.

• The world's first human-computer interactive robot, “Eliza''.

The second stage

The third stage

• Goodfellow proposed GAN, which can use existing data to generate pictures.

• In this year, OpenAI released a new chat robot

model, called ChatGPT.

Fig. 1: Three stages of AIGC.

Actually, the origins of AIGC can be traced back to an earlier time. The development history can be roughly divided into three stages (as shown in Fig. 1). In the first stage, researchers control the computer to realize the output of content through the most primitive programming technology. Hiller and Isaacson completed the world's first computer-completed music, Iliac Suite2, in 1957. Then, the world's first human-computer interactive robot, Eliza3, came out. Eliza shows the ability to search for appropriate answers through pattern matching and intelligent phrases but does not reflect a semantic understanding. However, most people still regard Eliza as the sources of inspiration for AI nowadays. During the next two decades, it was the stage of sedimentation accumulation. The second stage assumes AIGC progress as usability as a result of the increased availability of massive databases and advancements in computing equipment performance. The Road4 is the world's first novel completely created by AI. After that, Microsoft also demonstrated a fully automatic simultaneous interpretation system, which is capable of translating speech from English to Chinese in a short time with high accuracy [4]. However, the bottleneck of algorithms directly limits AIGC's ability to generate rich content. The third stage began in 2010 when AIGC entered a rapid development phase. Goodfellow

[5] proposed a Generic Adversarial Network (GAN), which uses existing data to generate pictures. In 2022, OpenAI

2https://en.wikipedia.org/wiki/Illiac Suite

3https://en.wikipedia.org/wiki/ELIZA

4https://en.wikipedia.org/wiki/1 the Road

released a new chat robot model, called ChatGPT. It is capable of understanding human language and generating text like humans do. Monthly active users exceeded 100 million within two months. There were about 13 million independent visitors using ChatGPT per day in January 20235. With the improvement of products (like ChatGPT), AIGC has shown great potential for applications and commercial value. It has attracted a lot of attention from various domains, including entrepreneurs, investors, scholars, and the public.

At present, the quality of AIGC content is significantly better than it was before. Furthermore, the types of AIGC content have been enriched, including text, images, video, code, etc. Table I lists some AIGC models or classic products developed by major technology companies, as well as their corresponding applications. ChatGPT6 is a machine learning system based on the Large Language Model (LLM)7. After being trained on humorous large text datasets, LLM not only excels at generating reasonable dialogue but also produces

compelling pieces (e.g., stories and articles). Thanks to its unique human feedback training process, ChatGPT is able to comprehend human thinking with greater precision. Google claims their upcoming product, Bard8 will have the same features but focus more on generating conversations. Compared to ChatGPT, Bard can make use of external knowledge sources, which can help users solve problems by providing answers to natural language questions instead of search results. In addition, Microsoft's Turning-NLG9 is an LLM with 17 billion parameters, and it is applied to summarization, translation, and question-answering.

The Diffusion model is a cutting-edge method in the field of image generation. Its simplicity of interaction and fast generation features significantly lower the barriers to entry. Several popular applications, such as Disco Diffusion10, Stable Diffusion11, and Midjourney12, have generated exponential social media discussions and showcases of work. NVIDIA is a pioneer in visual generation research. Their product (i.e., StyleGAN) is a state-of-the-art approach to high-resolution image synthesis, specializing in image generation, art, and design. In addition, because of the distinct requirements for generating pictures within different industries, StyleGAN provides opportunities for several startups. For example, Looka focuses on logo and website design, and Lensa focuses on avatar generation. GAN is already capable of generating extremely

realistic images. DeepMind is trying to apply it to the field of generating videos. Their proposed model, called Dual Video Discriminator GAN (DVD-GAN) [6], can generate longer and higher resolution videos using computationally efficient discriminator decomposition. DVD-GAN is an exploration of realistic video generation.

5https://www.theguardian.com/technology/2023/feb/02/chatgpt-100-million-users-open-ai-fastest-growing-app

6https://chat.openai.com/

7https://en.wikipedia.org/wiki/Large Language Mode

8https://blog.google/technology/ai/bard-google-ai-search-updates/

9https://turing.microsoft.com/

10http://discodiffusion.com/

11https://stablediffusionweb.com/

12https://www.midjourney.com/

TABLE I: The AIGC and major technology companies

Company	Product	Applications
OpenAI	ChatGPT	Text generation, chatbots, and text completion
Google	LaMDA	Question answering and chatbots
NVIDIA	StyleGAN	Image generation, art, and design
Microsoft	Turing-NLG	Summarization, translation, and question answering
DeepMind	DVD-GAN	Video generation
Stability.AI	Stable Diffusion	Text to images

EleutherAI GPT-Neo Text generation

Baidu ERNIE Question answering and chatbots

To provide more insights and ideas for related scholars and researchers, this survey focuses on the issues related to AIGC and summarizes the emerging concepts in this field. Furthermore, we discuss the potential challenges and problems that the future AIGC may meet, such as the lack of global consensus on ethical standards, and the potential risks of AI misuse and abuse. Finally, we propose promising directions for the development and deployment of AIGC. We suppose that AIGC will achieve more convenient services and a higher quality of life for humanity. The main contributions of this paper are as follows.

• We present the definition of the AIGC and discuss its key conditions. We then illustrate three cutting-edge capabilities and six advanced features to show the great effect AIGC brings.

• We further describe the industrial chain of AIGC in detail and list several advantages of the large pre-trained models adopted in AIGC.

• To reveal the differences between auxiliary generation and automatic generation within AIGC, we provide an in-depth discussion and analysis of text generation, AI-assisted writing, and AI-generated writing examples.

• From the perspective of practical applications, we sum-

marize the advantages and disadvantages of AIGC and then introduce the combination of AIGC and Metaverse.

• Finally, we highlight several problems that AIGC needs to solve at present and put forward some directions for future applications.

Organization: The rest of this article is organized as follows. In Section II, we discuss related concepts of the AIGC. We highlight the challenges in Section III and present several promising directions of the AIGC in Section IV. Finally, we conclude this paper in Section V. The organization of this article is shown in Fig. 2.

II. RELATED CONCEPTS

A. What is AI-generated content?

AI-generated content refers to writing pieces such as blogs, marketing materials, articles, and product descriptions that are created by machines. As shown in Fig. 3, AIGC has experienced three different modes of content generation. In the PGC mode, content is generated by professional teams [7], [8]. The advantage of PGC is that most of the generated content is high quality, but the production cycle is long and difficult to meet the quantity demand for output. In the UGC mode,

3Introduction (Section I)

Related Concepts (Section II)

What is AI-generated content?

Necessary conditions of AIGC

How can AI make the content better?

The industrial chain of AIGC

Advantages of Large-scale Pre-trained Models

Generation of smart text

Pros of AIGC

Cons of AIGC

AIGC and Metaverse

Challenges and Promising Directions (Section III) Challenges

Promising directions

Conclusion (Section IV)

Fig. 2: The outline of this survey.

users can select many authoring tools to complete content generation by themselves [9], [10]. The advantage of UGC is that using these creative tools can reduce the threshold and cost of creation and improve the enthusiasm of users to participate in the creation. The disadvantage of UGC is that the quality of output content is difficult to ensure because the level of creators is uneven. AIGC can overcome the shortcomings of PGC and UGC in terms of quantity and quality. It is expected to become the primary mode of content generation in the future. In the AIGC mode, AI technology uses professional knowledge to improve the quality of content generation, which also saves time.PGC

UGC

AIGC

Production

Efficiency

Content

production

mode

Professional teams

User

+

Creative platform

AI

+

User/Professional Teams

+

Creative platform

Fig. 3: Three different modes of content production.

Some entrepreneurs are planning to use AIGC products to automatically finish advertisement production tasks, which was costly and time-consuming before. In general, AIGC can be categorized into text, picture, and video generation.

Text generation. AIGC encompasses structured writing, creative writing, and dialogue writing as its main subfields [11], [12], [13]. Structured writing primarily generates text content based on structured data for specific scenarios, such as news. However, creative writing involves generating text with a higher degree of openness, which demands personalization

and creative capability. Creative writing is well-suited for marketing copy, social media, and blogs. Dialogue writing is mainly used for chatbots that interact with users through text. These bots are designed to answer questions, much like customer services.

Pictures generation. By leveraging AIGC, users can change and add new elements to their pictures based on the prompts given [14], [15], [16]. It makes it easier and more efficient to edit images without the need for advanced skills or knowledge. Additionally, AIGC can independently generate images to meet specific requirements. For example, if a user needs a poster or logo in a specific format, AIGC can generate it in a short time. Another exciting application of AIGC is the creation of 3D models from 2D images [17].

Audio generation. AIGC's audio generation technology can be divided into two categories. That is text-to-speech synthesis and voice cloning, respectively. Text-to-speech synthesis needs input text and outputs the speech of a specific speaker. It is mainly used for robots and voice broadcasting tasks. Until now, text-to-speech tasks have been relatively mature. The quality of speech has met the natural standard. In the future, it will develop toward more emotional speech synthesis and small-sample speech learning. Voice cloning takes a given target speech as input, and then converts the input speech or text into the target speaker's speech. This type of task is used

in intelligent dubbing and other similar scenarios to synthesize speech from a specific speaker.

Video generation. AIGC has been utilized in video clip processing to generate trailers and promotional videos [18], [19]. The workflow is similar to image generation, where each frame of the video is processed at the frame level, and then AI algorithms are utilized to detect video clips. AIGC's ability to generate engaging and highly effective promotional videos is enabled by the combination of different AI algorithms. With its advanced capabilities and growing popularity, AIGC is likely to continue to revolutionize the way video content is created and marketed.

B. Necessary conditions of AIGC

As illustrated in Fig. 4, AIGC consists of three critical components: data, hardware, and algorithms. High-quality data, such as audio, text, and images, serve as the fundamental building blocks for training algorithms. The data volume and data sources have a vital impact on the accuracy of predictions [20]. Hardware, particularly computing power, forms the infrastructure of AIGC. With the growing demand for computing power, faster and more powerful chips, as well as cloud computing solutions, have become essential. The hardware should be capable of processing terabytes of data and algorithms with millions of parameters. The combination of accelerating chips and cloud computing plays a vital role

in providing the computing power required to efficiently run large models [21]. Ultimately, the performance of algorithms determines the quality of content generation, and the support of data and hardware is crucial in achieving optimal results.

Data. The functionality of ChatGPT demonstrates that data is the foundation and basis for cloud computing and intelli-

Fig. 4: Relations between hardware, algorithms, and data.

gent AI business iterations. The accuracy of training models depends on the size of the training datasets. The larger sample datasets often result in more accurate models. Typically, training tasks require billions to hundreds of billions of files. Therefore, storing and managing these massive datasets is crucial. To solve these issues, many cloud computing and data storage services, such as Amazon S3, Microsoft Azure Blob storage, and Google Cloud Storage, have been booming. Cloud storage services strongly offer storage solutions that are scalable, fast, secure, easy to process, and acceptable for massive data. Additionally, organizing and managing humorous datasets puts forward higher-level special techniques, such as data cleaning, duplicate data elimination, labeling, and categorization. All the above demands aim to make data well-organized and easier to process, thereby better supporting large-scale training and intelligent AI business applications.

Hardware. While massive data provides vital support for big data and AI applications, new storage demands are also urgent. The implementation of large models is heavily reliant on large computing power. Companies must consider the challenges of computing cost and algorithms' efficiency [22]. Take ChatGPT as an example. ChatGPT can be divided into numerous AI models that require specific AI chips (e.g., GPU, FPGA, and ASIC) to handle complex computing tasks. According to OpenAI's report in 2020 [23], the total

computational power required to train the GPT-3 XL model with 1.3 billion parameters is approximately 27.5 PFlop/s-day. Since ChatGPT is based on the fine-tuning of the GPT-3.5 model, which has a parameter quantity similar to the GPT-3 XL model. In other words, ChatGPT will take 27.5 days to complete the training at a speed of 1 trillion times per second. ChatGPT runs more than 30,000 Nvidia A100 GPUs to meet 13 million independent visitors per day in January 2023. The initial investment cost for these chips was approximate $800 million, and the daily electricity charge is around $50,000.

Algorithm. With the help of current intelligent data mining algorithms (e.g., neural networks [24], [25] and deep learning [26], [27]), the potential rules inherent in data can be learned independently by iteratively optimizing parameters within the learning paradigm and network structure. Moreover, with the development of the large-scale pre-training model, AI can combine the information from data mining to generate high-quality content. Large pre-training models are artificial intelligence models that use a large amount of text data for pre-training, such as BERT, GPT, etc. Large pre-training models are an important part of AI-generated content, and their improvement and development help to continuously improve the quality and accuracy of generated content.

Actually, as shown in Fig. 5, the current high-performance AI algorithm has gone through a long way of exploration.

They gradually integrate the human thinking mode to improve the algorithm's efficiency. In traditional machine learning algorithms, data are classified by functions or parameters. The algorithms simulate the simple human brain, which improves the learning model through experience accumulation [28]. Neural network models further emulate the signal processing and thinking mechanisms of human brain nerves [29], [30]. Furthermore, generative algorithms, such as Google's Transformer architecture [31], draw on human attention mechanisms to enable the completion of multiple tasks by an algorithm.Meachine Learning Neural Network Model

Large-scale Pre-trained Model

They can accumulate experience through trial and error and reflection.

They can simulate the signal processing and thinking mechanisms of human brain nerves.

Language Model

Generative Algorithm

They can complete various natural language tasks and understand the complexity of human language.

They can model the

probability distribution
of the input data and
then generate new data.
They are trained by processing large amounts
of text data, then fine-tuned on specific tasks
with labeled data, enabling them to interact
according to contextual content and chat in a
manner similar to human beings.
Fig. 5: The evolution of AI models.
Goodfellow proposed the first generative model, Generative Adversarial Network (GAN), in 2014 [5]. Table II shows the evolution timeline of generative algorithms. In most cases, the significance of GAN is a source of inspiration for many popular variations and architectures. The transformer model has a wide range of applications in various domains (including NLP and CV). In addition, several pre-training models, such as BERT, GPT-3, and LaMDA, have been developed based on the Transformer model. The diffusion model is currently the most advanced image generation model because of its optimized performance.

With the development of generative models, language models have also made great progress. For example, Devlin et al. [32] proposed the BERT model to complete various natural language understanding tasks. BERT has revolutionary significance in understanding the complexity of human language.

Furthermore, in recent years, there has been a rise in the popularity of large-scale pre-training models, which boast impressive generalization performance. Large-scale pre-training models can effectively address the challenges of frequent parameter modification. These models interact in a contextually-relevant manner and exhibit behavior similar to that of human beings when chatting and communicating because they are trained by connecting large-scale real corpora.

C. How can AI make the content better?

AIGC owns three cutting-edge capabilities: digital twins, intelligent editing, and intelligent creation (Fig. 6). These

TABLE II: The evolution timeline of generative algorithms.

Algorithm	Year	Description
VAE [33]	2014	Encoder-Decoder models obtained based on variational lower bounds constraints.
GAN [5]	2014	Generator-Discriminator models based on adversarial learning.
Flow-based models [34]	2015	Learning a non-linear bijective transformation that maps training data to another space, where the distribution can be factorized. The entire model architecture relies on directly maximizing log likelihood to achieve this.
The diffusion model has two processes, namely the forward diffusion process and the reverse diffusion process. During the forward diffusion phase, noise is gradually added to the image until it is completely corrupted into		

Gaussian noise. Then, during the reverse phase, the model learns the process of restoring the original image

from Gaussian noise. After training, the model can use these denoising techniques to synthesize new “clean”

data from random inputs.

Diffusion [35] 2015

The diffusion model has two processes. In the forward diffusion stage, noise is gradually applied to the image

until the image is destroyed by complete Gaussian noise, and then in the reverse diffusion stage, the process of

restoring the original image from Gaussian noise is learned. Following training, the model can use these

denoising methods to generate new ”clean” data from random input.

Transformer [31] 2017

Originally used to complete text translation tasks between different languages, this neural network model is

based on the self-attention mechanism. The main body includes the Encoder and Decoder parts, which are

responsible for encoding the source language text and converting the encoding information into the target

language text, respectively.

Nerf [36] 2020

It proposes a method to optimize the representation of a continuous 5D neural radiance field (volume density

and view-dependent color at any continuous location) from a set of input images. The problem to be solved is

how to generate images from new viewpoints, given a set of captured images.

CLIP [37] 2021

Firstly, perform natural language understanding and computer vision analysis. Second, train the model with

pre-labeled ”text-image” training data. On the one hand, train the model on the text. From another aspect, train

another model and continuously adjust the internal parameters of the two models so that the text and image

feature values output by the models respectively match and confirm.

capabilities are nested and combined with each other to give

AIGC superior generation capability.

Digital twins. AIGC can be used to map real-world content

into the virtual world, such as intelligent translation and

enhancement [38], [39], [40]. Intelligent translation involves

transforming content across different modalities, e.g., lan-

guage, audio, and visual, based on an understanding of the

underlying meaning. This enables effective communication

between people who speak different languages. Intelligent

enhancement involves improving the quality and completeness

of digitized content by filling in missing information, enhanc-

ing the image and audio quality, and removing noise and

distortions. It is particularly effective when dealing with old

or damaged content that may be incomplete or poor quality.

Intelligent editing. AIGC enables interaction between vir-

tual and reality through intelligent semantic understanding

and attribute control [41], [42], [43]. Intelligent semantic

understanding enables the separation and decoupling of digital

content based on understanding. The attribute control enables

precise modification and attribute editing based on understand-

ing. The generated content can then be output into the real

world, resulting in a closed loop of twinning and feedback.

Intelligent creation. AIGC is a term used to describe the content generated by AI [44], [45], [46]. AIGC can be categorized into two types: imitation-based creation and conceptual creation. Imitation-based creation involves learning the patterns and data distribution features from existing examples. It creates new content based on previously learned patterns. Learning abstract concepts from massive data and applying studied knowledge to create new content that did not exist before is what conceptual creation entails.

AIGC technology has become an increasingly popular tool for generating content in various industries. ChatGPT is an appropriate illustration of AIGC. Advanced reinforcement learning techniques and expert human supervision enable ChatGPTDigital twins

Intelligent creation

Intelligent editing

Intelligent translation

Intelligent enhancement

Intelligent semantic

understanding

Attribute

control

Imitation-

based creation

Conceptual

creation

The generation

capability of AIGC

Fig. 6: Three cutting-edge capabilities of AIGC.

to acquire effective understanding and well-processed natural language. It was demonstrated to have a high degree of coherence in understanding the context. As shown in Fig. 7, ChatGPT has six key features that make it a powerful tool in natural language processing. In terms of making conversations, ChatGPT can actively recall prior conversations to aid in answering hypothetical questions. Moreover, ChatGPT filters out sensitive information and provides recommendations for unanswered queries, which improves its usage performance. ChatGPT is an ideal tool for customer service, language translation, content creation, and other applications due to its advanced features.

D. The industrial chain of AIGC

The AIGC industry chain is an interconnected ecosystem that spans from upstream to downstream. As shown in Fig.

8, downstream applications are heavily reliant on the basic support of upstream productions. Data suppliers, algorithmic institutions, and hardware development institutions are major parts of upstream AIGC. Data suppliers utilize web crawling technology to collect vast amounts of text from news websites, blogs, and social media [47]. Then, these wild data have to be automatically labeled or processed by NLP technologies

6Understand
context
Improve accuracyCapture user intention
Generate continuous
dialogue
Dare to question
Admit not knowing

Fig. 7: The six features of AIGC.

[48]. Algorithmic institutions typically consist of a group of experienced computer scientists and mathematicians with deep theoretical backgrounds and practical experience. They can develop efficient and accurate algorithms to solve various complex problems. Hardware development institutions focus on developing dedicated chips, processors, accelerator cards, and other hardware devices to accelerate the computing speed and response capabilities of AI algorithms.

The midstream sector includes big technology companies that integrate upstream data, hardware, and algorithms. These

companies leverage these resources to deploy algorithms that set up computing resources and configure corresponding parameters in cloud computing, such as virtual machines, containers, databases, and storage. According to the specific properties and requirements of the algorithm, they ensure the optimal performance and efficiency of the algorithm through reasonable configuration. Then, the performance-optimized algorithm is encapsulated to generate a tool with an external interface. They are the bridge between upstream and downstream, connecting data suppliers and algorithmic institutions with content creation platforms and end-users. These companies earn revenue through personalized marketing, such as advertising placement and virtual brand building. In addition, midstream companies also play a critical role in advancing AI technologies. They invest in most research and development, which continuously enhances the performance and efficiency of AI systems. They also provide training data and feedback to upstream data suppliers and algorithmic institutions. The midstream companies contribute to the continuous improvement of the entire AIGC industry chain.

The downstream segment mainly consists of various content creation platforms. It lowers users' learning costs for creating content. Users can efficiently complete tasks with the help of midstream tools. For example, news media and financial institutions can quickly generate reports using text-generation

tools. Since they are the primary recipients of the value that these technologies generate, downstream users are crucial in promoting the adoption and commercialization of AI technologies. By utilizing AI-powered tools and their services, downstream users can improve their productivity, enhance their decision-making, and create new opportunities for growth and innovation in their respective industries.Data supplier

Research organization of algorithm

Open source algorithm

Computer hardware

Cloud computing

Automatic real-time interaction

Upstream

Midstream

Downstream

Many large technology companies

Content design

Operational efficiency improvement

Personalized marketing

Build tool

Content creation platform

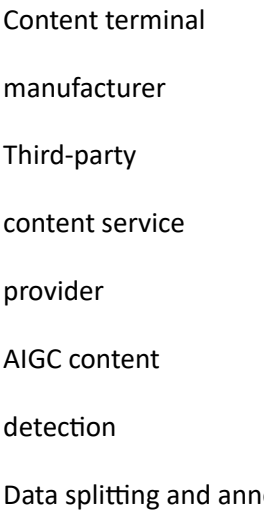

Fig. 8: The industrial chain of AIGC.

E. Advantages of large-scale pre-trained models

The large-scale AI model is a significant milestone in the development of AI towards general intelligence [49]. The use of large-scale models is a clear indication of greater generalization for AIGC. Despite the challenges posed by the proliferation of general-purpose data and the lack of reliable data, deep learning entirely depends on models to automatically learn from data, and thus significantly improves performance [50], [51]. Large-scale models possess both large-scale and pre-training characteristics and require pre-training on massive generalized data before modeling for practical tasks [52]. These models are known as large-scale pre-trained models [53]. In fact, AI's large-scale models can be seen as an emulation of the human brain, which is the source of AI's inspiration [54]. In fact, the human brain is a large-scale model with basic cognitive abilities [55]. The human

brain can efficiently process information from different senses and perform different cognitive tasks simultaneously. Thus, the AI large-scale model is not only expected to have numerous participants but also be able to effectively understand multi-modal information, perceive across modalities, and migrate or execute between different tasks simultaneously. The improved accuracy of AI large-scale models in understanding human thinking is attributed to systems based on human feedback data for model training [56].

As illustrated in Fig. 9, the process of developing large-scale pre-trained models can be divided into three main steps. The first step is gathering explanatory data to train a supervised learning strategy. The second step involves collecting comparative data to train a reward model, which allows the model to make more accurate predictions. The final step is to collect explanatory data to optimize the model using augmented learning techniques. This will enhance the performance and efficiency of the model.

Hence, the use of large-scale pre-training models can improve the performance and generalization of AI. Specifically, large-scale pre-trained models have the following advantages for AI as well as AIGC:

• Better generalization ability. By pre-training on large-scale data, the model can learn more features and patterns, improving its generalization ability and allowing it to

adapt to different tasks and scenarios.

• Save training cost. The training cost of pre-trained

7Collecting illustrative

data and training

supervised strategies

Collecting explanatory

data to train a supervised

strategy

Revealing the desired

output behaviors

Data for supervised

learning and fine-

tuning

Collecting comparative

data to train a reward

model

Sampling of the

training dataset and

the results of several

models

Sorting the results

from best to worst

Data for feedback

models

Collecting explanatory

data to optimize the model

using augmented learning

Resampling from the

dataset and generating

output with the help

of the model

Feedback model

calculates a feedback

result for the output

Feedback results are

used to optimize the

strategy

Fig. 9: The specific steps of large-scale pre-trained models.

models is relatively low because the data collection and labeling work only need to be performed once. The pre-trained models can be used for multiple tasks.

• Improve training efficiency. Pre-trained models are fine-tuned in a fine-tuned way. Therefore, training can be done faster, and the results obtained can be better on smaller datasets.

• Support multiple tasks. The pre-trained model can be used for multiple tasks, such as natural language processing, computer vision, and speech recognition. Due to fine-tuning training, these tasks greatly improve the applicability of the model.

• Continuous optimization. The pre-trained model can be continuously optimized to expand the model's capability and make it more intelligent and adaptable by continuously adding new data and tasks.

F. Generation of smart text

As previously mentioned, AIGC technology is unable to produce original content if you request specific needs and interests. Nevertheless, they can still play a useful role in the content creation process as writing assistants. We believe that there is a significant distinction between AI-assisted writing and AI-generated writing.

AI-assisted writing (AIAW). The goal of AIAW is to provide assistance for human writing, which improves the coherence of the user's writing experience. This kind of writing tool can significantly improve the efficiency of writing in specific fields, such as legal documents. In fact, assisted writing can offer help in different stages of writing, like confirming the theme, writing content, and publishing the article. Before writing, the topic should be established first. The algorithm can recommend suitable text materials by analyzing current topics [57]. This saves searching and sorting time. During the writing process, the algorithm can provide writing inspiration assistance [58]. Through learning numerous similar articles, the AI model infers the subsequent parts of unfinished sentences from the perspective of statistical

probability. AIGC can provide real-time error detection and correction suggestions for writing articles [59] by collecting misspellings and incorrect word combinations from the corpus. Then, the algorithm provides comments on modifications to help authors improve their writing results. Before publishing, AIGC will add appropriate titles and labels about writing content.

AI-generated writing (AIGW). AIGW technology enables machines to write articles independently. Currently, computers are capable of automatically generating news alerts, hot press releases, and poetry articles. Intelligent writing algorithms can describe the main information contained in structured data. Due to the speed of machine processing, which is far faster than that of humans, AIGC works better in terms of generating time-sensitive news. For hot-draft writing, AIGC is useful in mining associated and related information [60]. AIGC can select appropriate content based on massive materials and extract relevant information through content analysis, ultimately organizing the results based on the writing logic [60]. Moreover, AIGC produces creative results that meet specific format requirements, including intelligent poetry writing and intelligent couplets [61]. Because the model's output cannot be predicted in advance, AIGC has similar creativity to human writing. For example, if we want to use AIGC to write ancient poetry, we should input sufficient training data of poetry to

train the model.

AIAW vs. AIGW. The major differences between AIAW and AIGW are listed in Fig. 10. Human beings have irreplaceable advantages in the field of writing. Deep learning models can easily create high-quality texts, but they cannot replace the subjective role of humans in writing practice. AI is superior to a human in data collection, but it cannot really create innovative, compassionate, and humorous texts. In addition, human writers have profound analytical abilities. Good writers not only have literary talent but also know how to effectively use words to express their thoughts. Human writers can purposefully decompose complex topics into easy-to-understand languages and provide valuable information for readers. Therefore, since AI tools are a valuable resource in content creation, it is important to balance usage, human creativity, and expression in writing. A reasonable division of labor between humans and machines is essential for achieving optimal results. In the future, AI should focus on data col-

TABLE III: Several main pros of AIGC

Pros	Description
Efficiency and scalability	AIGC can provide many benefits over traditional human writing, including speed and language localization. Another benefit of AIGC is its ability to create personalized social media posts for various sites.
Help scientific research	AI can assist in analyzing large datasets through machine learning algorithms to identify patterns and correlations

that might not be easily visible to humans.

For search engine optimization AI can analyze the content on a website and suggest changes to make it more SEO-friendly.

Overcome writer’s block AI tools can create detailed outlines and key points to help the writer determine what should be included in the

article.

lection, while humans should be responsible for the creative

process of writing.Provide help in different

stages

Advantage Write independently

Can't create innovative

texts

AIAW AIGW

Waste of time on data

collection

Disdvantage

VS.

Fig. 10: The differences between AIAW and AIGW.

G. Pros of AIGC

There are some pros to AIGC as shown in Table III. AI-

generated content is becoming increasingly popular due to

its strong abilities. AIGC is efficient, cost-effective, and even

frees up human resources for other tasks. In this section, we

will discuss some major benefits of AIGC.

Efficiency and scalability. AIGC can provide many ben-

efits over traditional human writing, including speed and

language localization [62]. An AIGC production can produce an article in minutes, whereas a human writer will take a much longer time to finish it. This advantage allows AI tools to produce massive content in a short time. Additionally, AIGC can function in language localization according to translate content into a common language, which will be tailored to certain geographic areas. Another benefit of AIGC is its personalized social media creation ability. It is very useful for various websites. By analyzing users' online data, AI can create individual content for different users.

Help scientific research. AIGC can have a significant impact on scientific research in multiple ways [63]. Firstly, AI can assist in analyzing large datasets through machine learning algorithms to identify patterns and correlations that might not be easily visible to human researchers. Secondly, AI can analyze existing scientific literature and generate hypotheses that can be tested in further research, which can help identify new avenues for research. Additionally, scientists can use AI's learning ability in specific fields to get some research that benefits mankind. For example, AI can help in the development of new drugs and treatments by predicting the interactions between molecules and proteins. Overall, the use of AI-generated content can lead to more accurate and efficient research outcomes, saving time and resources in the process.

For search engine optimization. AI improves search engine optimization (SEO) in several ways [64]. Due to the ability to provide data-driven insights and automate the workflow of AI, website owners are able to focus on creating high-quality content and providing better services. For example, AI-powered tools can analyze search queries and suggest relevant keywords to users. These tools make identifying patterns and trends easier by identifying keywords. AI tools optimize the length, structure, and readability of content, as well as suggest relevant keywords, to make websites more SEO-friendly.

Overcome writer's block. AI may be a helpful tool for writers solving writer's block according to inspiration, assistance, and polishing [65]. For instance, AI tools generate suggestions based on inputting keywords or topics. The tools analyze search data, trending topics, and popular queries to create fresh content. What's more, AIGC assists in writing articles and posting blogs on specific topics. While these tools may not be able to produce high-quality content by themselves, they can provide a starting point for a writer struggling with writer's block.

H. Cons of AIGC

One of the main concerns among the public is the potential lack of creativity and human touch in AIGC. In addition, AIGC sometimes lacks a nuanced understanding of language and context, which may lead to inaccuracies and misinterpre-

tations. There are also concerns about the ethics and legality of using AIGC, particularly when it results in issues such as copyright infringement and data privacy. In this section, we will discuss some of the disadvantages of AIGC (Table IV).

Ethics and trust. AI relies on data and algorithms to generate content, which may result in a lack of intended tone and personality [66]. While AI tools can effectively cover the black-and-white areas of a topic, they may struggle with the more subjective gray areas. Additionally, plagiarized events will occur frequently, since AI tools often pull information from the same sources and reword it. To ensure authoritative and informative content, proper human review and curation are needed, especially if the information is pulled from various sources. The content can be crafted to maintain the intended tone, flow, and context by adding a human touch, thus improving the user experience.

Exacerbate social imbalances. AIGC has the potential to exacerbate social imbalances. As a result, those who have access to and can afford advanced AI tools and technologies may have an unfair advantage over those who do not or cannot afford them. Some people can use AI tools to complete the original tasks at multiple speeds, while those who do not

TABLE IV: Some major cons of AIGC

Cons Description

Ethics and trust Due to the lack of intended tone and personality, the generated answers may be filtered out.

Exacerbate social imbalances Some people can use AI tools to complete the original tasks at various speeds, whereas others may need to spend a

significant amount of time thinking and creating content.

Negative effects on education AIGC may lack the human touch and personalization that are necessary for effective learning.

Inadequate empathy For instance, AI-generated music might not have the same emotional depth and authenticity as music performed and

composed by humans.

Human involved People still need to be involved and articles quality-checked.

Missing creativeness It is hard for AIGC to come up with new content with the latest, trending ideas and topics.

use AI tools may need to spend a lot of time thinking and

creating content. This could lead to a situation where a small

group of people dominates the production of content, creating

a concentration of power and influence that can exacerbate

existing inequalities.

Negative effects on education. There are some potential

negative effects of relying solely on AI-generated content for

education [67]. AIGC, for example, may lack the human touch

and personalization required for effective learning. The use

of AIGC can create a dependency on technology and dis-

courage critical thinking and problem-solving skills. Students

may become too reliant on the information provided by AI-

generated content and fail to develop their own analytical

skills. Additionally, AIGC may transfer the basic knowledge to

users if the underlying data used to train the AI algorithms is biased or flawed. It may cause students to form a permanently wrong knowledge system.

Inadequate empathy. While AI-generated content can be efficient and cost-effective, it may lack the creativity, emotion, and nuance that humans can bring to their creations. In the AI tool's work, it just generates content based on the parameters and objectives by analyzing large amounts of data and patterns, but it cannot truly comprehend the underlying meaning or context of the content. For example, compared to the music generated by composers and performers, AI-generated music may lack emotional depth and authenticity.

Human involved. While AIGC can certainly save time and effort in most cases, it is important to note that human involvement is still crucial in ensuring the quality and accuracy of the content [68]. AI tools have the ability to aggregate information from multiple sources, but they may lack the nuanced understanding of language that humans possess. Because of this, the output can have mistakes and inconsistencies that need to be fixed by a person. For example, AIGC product descriptions may mix up textures and colors because of the tool's limited understanding of adjective meanings.

Missing creativity. AI tools rely heavily on existing data to generate content, which can limit their ability to create fresh and original ideas [69]. While they assist in streamlining

content creation and generating ideas, they do not have the ability to generate completely new concepts on their own. This means that AIGC may not always be innovative or up-to-date with the latest trends. In other words, it may cause missing creativity. They may be able to analyze rich data to understand what types of content are popular or engaging, but they may not fully understand the nuances of a particular audience or be able to create content that truly resonates with them.

I. AIGC and Metaverse

The Metaverse [70], [71] builds a persistent multi-user environment that combines physical reality with digital virtuality. It is a multi-user virtual space that allows multiple users to express their individual creativity. People communicate and interact with others through digital objects in a virtual environment [70]. AIGC, in our opinion, can round out the Metaverse's personalized services and make it more vivid and vital.

AIGC enables efficient content creation, meets increasing demands for interaction, and improves personalized experiences [72]. It can simulate the virtual human brain to generate content for the Metaverse, including intelligent NPCs, automated QA, dialogue systems, and digital humans [73]. The Metaverse's concentration on cutting-edge technologies and users' interaction data accumulation can further enhance AIGC's intelligence and content creation abilities. By launch-

ing standardized and low-code development tools, AIGC enables small and medium-sized studios and individual developers to produce richer interactive content in the Metaverse.

In the Metaverse, the immense amount of data is the basis of maintaining smooth execution. With the help of AIGC technology, AI replaces humans to solve the Metaverse's needs in terms of massive data. Synthetic data based on AIGC technology has seen significant development in the Internet domain [74]. AIGC data can be particularly useful in creating various scenarios within the Metaverse. For instance, considering an example of constructing a school online, a vast amount of environmental data is required to ensure a highly simulated scenario. Such work volume is a tedious and expensive process, which involves significant labor costs and resource utilization. However, AIGC can assist in generating the required environmental data, thereby saving a lot of time and money. By leveraging this process, AIGC contributes to the Metaverse data generation, which promotes the development of related technology in turn.

III. CHALLENGES

A. Data

Data is one of the keys to ensuring the accuracy of training algorithms. In order to make output results more effective, the training datasets should ensure data quality and fairness [75]. If the data contains deviations and inaccuracies in information,

it may lead to biased and inaccurate responses, especially in terms of sensitive topics such as race, gender, and politics. To address this issue, synthetic data can be used in training. In the past, using real-world data to train AI models posed various

problems, such as high costs for data collection and labeling, difficulty in ensuring data quality and diversity, and challenges in protecting privacy. Synthetic data can effectively solve these issues by serving as a cost-effective substitute for real-world data in training, testing, and validating AI models [76], [77]. Using synthetic data not only makes training AI models more efficient but also enables AI models to self-learn and evolve in a virtual simulation world constructed from synthetic data. When training with data, it is important to adhere to legal and ethical standards. If data collected through web scraping is used in large-scale model training, it is important to ensure that the data does not violate copyright or other legal regulations. If it only uses the public dataset, it is usually not necessary to obtain the consent of the copyright owner, as these data are already considered part of the public domain. However, if copyrighted data is used, it is necessary to obtain the permission of the copyright owner or provide appropriate compensation according to local legal regulations.

B. Hardware

The large-scale pre-training model's hardware problems are

mainly troubling in two aspects: insufficient computing power and high energy consumption. The insufficient computing power problem is due to the models becoming increasingly complex. The number of parameters and calculation complexity are increasing exponentially, but hardware performance is not keeping up. In practice, high-performance computing devices such as GPUs and TPUs are required for the training and inference of large-scale pre-training models. However, even with these dedicated chips, it is difficult to meet the training and inference needs of super-large-scale models. In the paper published in 2020 [23], researchers from OpenAI reported that the pre-training of their language model GPT-3, which has 175 billion parameters, required 3.2 million core hours on a supercomputer with 2,048 CPUs and 2,048 GPUs. The inference of GPT-3 required a cluster of 2,048 CPUs and 2,048 GPUs, and the cost of running the model for a day was estimated to be around $4,000.

The high energy consumption issue mainly stems from training and inference. Firstly, for the training phase, a large amount of computing resources are required to complete the model's training. This involves numerous matrix operations and neural network backpropagation. Secondly, for inference phase, due to the large number of parameters and complex calculation processes in large-scale pre-training models, the energy consumption of the inference phase is also high.

Optimizing the calculation process and algorithm is a feasible approach to solving the above problems [78]. Utilizing efficient computing devices and technologies (e.g., mixed-precision computing and distributed training) also is another practical way [79].

C. Algorithm

One of the most significant advantages of large pre-trained language models is their ability to perform information retrieval tasks. In the past, information retrieval tasks were completed using a search-first-then-read approach. Reviewing several relevant contextual documents from external corpora is the first step. Then, answers were predicted from these documents. Due to powerful memory and reasoning skills, large language models significantly improve traditional steps [80]. Despite the significant progress made by large language models in information retrieval tasks, there are still some limitations that need to be addressed. For starters, a lack of vocabulary has an impact on retrieval accuracy and completeness. Since these models may only understand the vocabulary in the training data, specialized terms or new vocabulary may not be accurately comprehended. Second, contextual limitations cause the model to miss some implicit meanings and even cause some logical relationships to fail. To enhance the information retrieval capabilities of large language models, it is necessary to explore better language representation methods

[81], [82].

To better meet user needs and handle complex tasks, the models should continuously improve and optimize themselves. The use of user feedback is an important part of the optimization algorithm [83], [84]. Large pre-trained models can collect user responses by engaging them in feedback loops and using this feedback to optimize the model. This process typically involves presenting the model's prediction results to the user and requesting feedback. Feedback can be direct. For example, users can choose an option to indicate whether the prediction result is correct. Feedback can also be free-form. For instance, users can write a text to describe their views on the prediction result. Once enough feedback data is collected, the model can analyze this feedback to determine how to adjust the model. This process typically uses natural language processing techniques and machine learning algorithms to automatically analyze and summarize user feedback and transform it into data that can be used to optimize the model.

When it comes to algorithms that generate content using AI, they are likely to be vulnerable to malicious attacks [85]. These attacks can take many forms, such as generating fake data or tampering with the generated content. Attackers can manipulate the model's input and output to deceive it and generate misleading content, which can affect the model's results and performance. This can lead to serious consequences such

as the spread of misleading information, social engineering attacks, and forgery of evidence, among others. To address these attacks, it must improve the model's robustness and security, employ adversarial training techniques and encryption technologies, and increase user security awareness and vigilance [86].

D. Privacy protection issues

While training large pre-trained models, an unavoidable issue is how to rightly use sensitive personally identifiable information such as names, phone numbers, and addresses. During pre-training, this sensitive information may reflect the model's weights and parameters, which could be leaked to attackers or unauthorized third parties. Additionally, these large pre-trained models may also be used as the base models for text classification, sentiment analysis, and image recognition tasks, which further increases the risk of privacy breaches.

Moreover, distributed computing techniques are typically used to distribute the data across multiple computing nodes to relieve operation pressure. During this process, if appropriate security measures such as data encryption, access control, and data de-identification are not taken, attackers may obtain data by monitoring network traffic and attacking computing nodes [87]. Therefore, a series of privacy protection measures need to be taken to protect the sensitive data contained in

large pre-trained models, including but not limited to data de-identification, model security, restricting data access, and accountability. At the same time, corresponding security measures such as data encryption, access control, and data de-identification should be taken to maximize privacy protection when using these models [88].

E. NLP for General AIGC

With the continuous improvement of the capabilities of large language models [89], natural language processing (NLP) faces many challenges (Figure 11). In this era, we need a new generation of language models to further enhance the model's generation capabilities and then improve its descriptive ability and computability. Besides, carrying out a deep understanding of natural language (NLU) also needs the adoption of connectionist and symbolic approaches to solve various natural language processing tasks [90]. On this basis, we need to ensure the credibility of the output results of NLP models, while also considering issues such as security, values, ethics, politics, privacy, and ethics.with the physical,

human systems, and

information intelligent society

Adoption of

connectionist and

symbolic approaches

Incremental Learning, continuous

learning, and human-in-the-loop

capabilities

Complex reasoning abilities

and interpretability

Considering issues

such as security, values,

ethics, politics, privacy, and ethics

ensure the credibility

and verifiability of the output

NLP for

General AIGC

Fig. 11: NLP for general AIGC.

To achieve these goals, it is essential to develop NLP models with complex reasoning abilities and interpretability. Addressing issues related to knowledge modeling, acquisition, and utilization can enhance the expressiveness and efficiency of these models. NLP models with incremental learning, continuous learning, and human-in-the-loop capabilities are also should be considered, as well as the creation of smaller models, model editing, domain adaptation, domain-specific models, and models tailored to particular applications and tasks. Furthermore, it is crucial to prioritize human-well learning and alignment to ensure the alignment of NLP technology with physical, human systems, and the intelligent society of information. By focusing on these aspects, we can

make significant progress in advancing the field of NLP and ensuring it benefits society as a whole. In the era of large language models, the application of in-contextual learning (ICL) [91], [92] has emerged as a new paradigm in natural language processing. By incorporating ICL into large language models, these models show a better understanding of context and produce more accurate and relevant results. Therefore, it is crucial to consider the use of ICL in improving the performance of NLP models.

F. Human attitudes towards AIGC

There is a distinction to be made between AIGC and human-generated content, as illustrated in Fig. 12. Human-generated content is the product of human intelligence, experience, creativity, and intuitive thinking. From another aspect, AIGC utilizes AI technology to train models to learn and simulate humorous data, analyze problems, and behave like humans.AIGC

Human

Creatation

Fig. 12: Human creation vs. AIGC.

What aspects of AIGC need to be regulated by legislation? The first one is the ownership of creating content. At present, AIGC has taken the lead in media, e-commerce, film and television, entertainment, and other industries with high digitalization degrees and rich content demand to achieve significant development, and its market potential is gradu-

ally emerging. Using AIGC to automatically generate videos, music, and even computer games to make profits. Who does the income belong to? Is it the users or AI? Governments need to clarify protection rules about the intellectual property and data rights of AIGC which are based on the development and applications of AIGC technology. Since the commercial application of AIGC will mature quickly and the market scale will grow rapidly, the second aspect is that pursuing profit will cause people to spread rumors and make forgery easier than before. This urges governments to formulate appropriate policies (including positive and negative requirements). The policies should supervise programmers to take control and safety measures to ensure safe and controllable AIGC applications. More importantly, adopting content identification, content traceability, and other technologies to ensure a reliable source of AIGC is needed.

What is the scope of AIGC's activities? The key advantage of AI systems over other software systems is their superior efficiency. AI products have demonstrated the ability to perform tasks that are beyond the capacity of humans, such as creating hundreds of unique images within an hour or

producing billions of words in a single morning. However, these capabilities have also raised concerns among many people. As we are all aware, technology is a double-edged

sword that can either enhance human life or have detrimental consequences. Therefore, it is imperative to not only establish laws but also consider the morality of users when designing AI products. Several unethical incidents have occurred due to the use of AIGC products, including cheating, plagiarism, and discrimination. As a result, it is necessary to promote the ethical development of AI. Industry organizations can aid this effort by creating ethical guidelines for trustworthy AIGC. Additionally, programmers developing AIGC applications should follow the “ethics by design” paradigm. Finally, the ethics committee must establish a comprehensive and universal ethical review system.

What is the relationship between humans and AI? We are very much in the habit of seeing ourselves in the world around us. And while we are busy seeing ourselves by assigning human traits to things that are not, we risk being blindsided. As the saying goes, “a coin has two sides”. The ChatGPT has jolted some people out of secure jobs and made them fearful of losing their jobs. At the same time, it makes AI employees see the dawn of AI. Since an AI-generated picture surprisingly beat other contestants [93], some critics suppose AIGC will lower the creativity of humans. Until now, there has been a trade-off: you accept the disadvantages of AI products in order to get the benefits they bring. The powerful function of AIGC may make workers lazy and rest on their laurels.

Furthermore, it will discourage enthusiasm among new blood in industries. However, we tend to regard different AIGC applications as strong assistants. The growth of AI-powered data-driven technologies will bring more opportunities for most people. The bloom of the car industry causes thousands of new jobs to be created, which is far more than that of raising horses. AI will be a powerful ally for humans if we establish a comprehensive AIGC governance system.

G. Trusted AIGC

Large language models can provide detailed and informative responses to various complex questions. However, surveys indicate that these models may generate inaccurate and biased answers due to some reasons [94], [95]. For example, poor-quality data may be collected, and thus the model may not be able to differentiate the credibility of information sources or even assign a higher weight to unreliable information sources. Moreover, errors may also occur because of training. The model cannot determine whether the generated answer complies with ethical standards. Unfortunately, current algorithms cannot effectively solve the above issues. Humans checking the final answers are still indispensable.

Recently, ChatGPT was used to summarize a systematic review of the effectiveness of cognitive-behavioral therapy (CBT)13 on anxiety-related diseases published in JAMA Psychiatry. However, ChatGPT provided some responses that

contained factual errors, false statements, and false data. For instance, ChatGPT erroneously stated that the review was 13https://en.wikipedia.org/wiki/Cognitive behavioral therapy based on 46 studies, where it was based on 69. In addition, it overstated the effectiveness of CBT, which could have serious consequences, such as misleading academic research and affecting medical diagnosis and treatment. Moreover, if ChatGPT generates unethical responses, it could affect people's values and have a significant negative impact on society, such as endangering social security when lawbreakers ask ChatGPT questions about retaliation and terrorist attacks. Therefore, filtering out harmful responses is essential in improving the algorithms/models.

In the future, it is important to improve the transparency of large language models [96], [97]. Currently, the training sets and large language models used by these algorithms are not publicly available. Technology companies may conceal the internal operations of their dialogic AI and generate answers that contradict reality. These practices run counter to the trend of transparency in open science. To address these issues, we propose that scientific research institutions, including scientific funding organizations, universities, non-governmental organizations, government research institutions, the United Nations, and technology companies should collaborate to develop advanced, open-source, transparent, and

democratically controlled algorithm models. By doing so, we can ensure that these models are trustworthy, reliable, and accountable to the public, while also promoting openness and transparency in the AI domain.

The source code of open-source large models can be used for free by anyone, which means that the organizations need to be responsible for the code, as the users of these models may use them for various purposes, including commercial or malicious purposes. As contributors or maintainers, they should ensure that the code is stable, reliable, and secure to prevent any negative impact from improper use. To ensure responsibility for the code, the organizations should add an appropriate license that explicitly allows or prohibits certain use cases. They should also stay closely connected with the community to understand the usage of the code and promptly address any potential issues. Finally, they should always be vigilant against potential abuse and malicious behavior and take measures to prevent them.

IV. PROMISING DIRECTIONS

With the rapid development of hardware and algorithms, the future of AIGC is expected to see even more substantive applications. We believe that the most promising directions for AIGC include cross-modal generation, search engine optimization, media production, e-commerce, film production, and other fields, as illustrated in Fig. 13.

A. Cross-modal generation technology

The information present in the real world is a complex system comprising text, audio, vision, sensors, and human tactile senses. To accurately simulate the real world, it is necessary to utilize cross-modal generation capabilities. The development of large-scale pre-training models has enabled the maturation of cross-modal generation. Text-to-images and text-to-video are classic examples of cross-modal generation,

13AIGC and

various

fields

Media Film

Education

Industry

Medical

treatment

Financial

E-commerce

Fig. 13: The combinations of AIGC and other fields.

which involve generating visual content based on language. Text to images [98], [99], like DALL-E from OpenAI, can create creative images based on textual descriptions, and significantly improves the efficiency of generating complex paintings. Previously, professional painters had to accumulate materials for years to build complex paintings, but now AI

paintings can generate numerous complex paintings in a short period of time. Text-to-video has also yielded satisfactory experimental results [100], [101]. Existing products for text-to-video, such as Lumen5 and CogView2, allow users to input image and text information, such as articles, search queries, or PPTs, to generate videos. However, there is still room for improvement in terms of video duration, clarity, and logic.

In future applications of cross-modal generation, there are several problems that need to be addressed. Firstly, there is a usability issue, where users need to input long text descriptions to obtain high-quality content. This is time-consuming. Secondly, there is a controllability issue. Although text-to-images can generate delicate images quickly, it may not generate images that match specific user requirements. When the model overfits, the image results may not meet expectations. For example, after entering the style description, the model may produce images that do not correspond to the expectations because the style model is overfitting to a specific scene.

B. Search engine

Search engines are very suitable for finding websites, but they are often not enough to solve more complex problems or tasks. Every day, there are about 10 billion search queries in the world, but perhaps half of them do not get accurate answers [102]. Now, combined with AIGC technology, it seems that this problem can be changed. With the support

of OpenAI technology, Microsoft has updated the Bing search engine and Edge browser. The new version of Bing and Edge integrates search, browsing, and chat into a unified experience. The search engine could provide better search service, more complete answers, a chat experience, and the ability to generate content. Through cooperation with OpenAI, Microsoft has added an advanced AI dialogue model to its search engine. Users can directly communicate with AI chat robots and ask questions in chat interfaces such as ChatGPT. The ChatGPT model could provide fast, accurate, and powerful search capabilities so that it can get the most accurate and relevant answers for basic search queries. In addition, Microsoft has also cooperated with OpenAI to implement special protection measures against harmful content. The Microsoft team is working hard to prevent the propagation of harmful or discriminatory content according to its own principles.

C. Media

AIGC is a game-changer in the media industry. It revolutionizes all aspects of news production, from news collection to manuscript writing, video editing, and news broadcast [103], [104]. Fig. 14 illustrates the impact of AIGC on the media industry. By leveraging AIGC, media organizations can improve the efficiency and quality of their content generation and expand their influence after publishing. In news collection, for instance, AIGC can automatically sort and record voice data,

which ensures timely news releases. In manuscript writing, the AIGC algorithms combined with structured text writing and press releases can expedite the process of content generation while enabling real-time error correction to enhance accuracy. In video editing, AIGC can perform automatic editing, letter configuration, and video attribute repair. Automatic editing, for example, can significantly reduce manual labor by rapidly generating videos from materials. By leveraging cross-modal generation technology, AIGC can also produce subtitles in sync with the video. Additionally, AIGC's video enhancement tools can improve video clarity. Furthermore, AIGC can synthesize broadcast videos using news text during a news broadcast, which delivers more efficient and accurate results than manual generation.

D. E-commerce

E-commerce is another mature application field for intelligent text generation. At present, most product titles and descriptions on e-commerce websites, such as JD.com and Taobao [105], [106], are generated automatically by algorithms. In addition, e-commerce websites commonly implement intelligent customer service systems to address users' inquiries pertaining to shopping, post-sale assistance, and other communication necessities [107], [108]. The intelligent customer service system must have the ability to accurately comprehend the user's intention and utilize text-generation

techniques to generate an appropriate response. Moreover, certain e-commerce websites utilize dialogue summary technology to condense the exchanges between customer service and users into a concise summary [109], [110]. Finally, in order to promote their goods and services, many companies use intelligent text generation technology to generate advertising and marketing copy for their products, which they then disseminate across a variety of multimedia platforms in order to attract users' attention and boost sales [111]. It can be seen that intelligent text generation technology has been applied to all aspects of e-commerce, and the use of this technology can reduce the cost of labor.

14News gathering and editing

News manuscript writing

News video clipping

News broadcast

◆Speech to text:

Automatic recording arrangement, ensure the timeliness of news, reduce mechanical duplication of

labor.

◆Structured text

writing:

Algorithm-based

press releases

that speed up

content

production and

improve content

accuracy.

◆Automatic video editing:

Quickly generate videos from

materials, reduce manual editing

labor, and speed up frequency

release.

◆Cross-modal video generation

text:

Automatically generates subtitles

synchronized with the video.

◆Video attribute editing:

Video enhancement tools to

improve video clarity and bring

viewers better experience.

◆Cross-modal video

synthesis:

Synthesizing anchorman
videos from press
releases improves
broadcasting efficiency
and accuracy and brings
audiences different
broadcasting experience.

Fig. 14: AIGC's empowerment in the field of media.

E. Film

The combination of AIGC and film has enormous potential to inspire directors with fresh creative ideas [112]. By assisting with scriptwriting, replacing original roles and settings, and simplifying post-production editing, AIGC can help overcome physical limitations and improve the quality of films. For example, AI technology can analyze vast amounts of script data and generate scripts that fit predetermined styles, which can stimulate directors' creativity. After reviewing and refining the AI-generated script, the director can significantly reduce the time needed for script creation and increase overall productivity. During video capture, AI technology allows for flexible replacement of characters and backgrounds, and can even create digital avatars capable of complex actions. AI can also create virtual scenes and depict scenarios that cannot be captured in real-time. It provides a more immersive viewing experience for audiences. In post-production editing, AI can be

used to repair film images and enhance picture quality, as well as quickly generate promotional movie trailers for publicity.

F. Application in other fields

With big data still in its blooming stage, the growth of AI-powered data-driven technologies will bring more opportunities in the future. In our opinion, AIGC has a wide range of applications beyond the fields mentioned above. For example, in education, AI technology can convert abstract textbooks into concrete visualizations, making it easier for students to learn [113]. In finance, AI can automatically produce financial information videos and create virtual digital customer service to improve operational efficiency [114]. In healthcare, AI can assist patients in rehabilitation and enhance medical imaging to aid doctors in diagnosing conditions [115]. Additionally, speech synthesis technology can generate speech audio for individuals with aphasia, enabling them to communicate effectively. In industry, AIGC can rapidly transform digital geometry into real-time 3D models based on physical environments, and digital factories can analyze process flow to reduce design time [116]. All in all, there are still too many applications that cannot be listed one-by-one, and need to be further explored.

V. CONCLUSION

With the support of massive amounts of high-quality data and high-performance hardware, a number of algorithms for large models have rapidly developed in recent years. These

algorithms possess the ability not only to comprehend text but also to assist in, or automatically generate rich content. Application examples such as ChatGPT have demonstrated the business value and application performance of AIGC technology, leading to widespread attention and investment from numerous front-line companies in a short period of time.