



Technology & Innovation Lab
Korea Office

EMERGING TECHNOLOGIES CURATION SERIES

Issue #5:
Generative Artificial Intelligence



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Acronyms

AI	Artificial Intelligence
BERT	Bidirectional Encoder Representations from Transformers
RoBERTa	Robustly Optimized BERT
CLIP	Contrastive Language Image Pre-training
GAN	Generative Adversarial Network
GPT	Generative Pretrained Transformer
LLM	Large Language Model
MCST	Ministry of Culture, Sports, and Tourism
MSIT	Ministry of Science and ICT
MTIE	Ministry of Trade, Industry Energy
NLP	Natural Language Processing
SOC	Social Overhead Capital
GSN	Generative Stochastic Network
CNN	Convolutional Neural Network
RNN	Recurrent Neural Network
NADE	Neural Autoregressive Density Estimator
MADE	Masked Autoencoder for Distribution Estimation
VAE	Variational Autoencoders
RMF	Risk Management Framework
CVPR	Computer Vision and Pattern Recognition
ADA	Adaptive Discriminator Augmentation
DNA	Deoxyribonucleic Acid

INTRODUCTION

Generative artificial intelligence (AI) has been developing rapidly and has attracted significant attention in recent years, with numerous advances and breakthroughs. The generative AI market is expected to grow from \$1.5 billion in 2021 to \$6.5 billion by 2026—a compound annual growth rate of 34.9 percent.¹

Acknowledging the growing importance of generative AI in research and practical applications, including its use to solve international development challenges, this report provides a comprehensive overview of generative AI, introduces the basics, explains its development over time, and examines its types and applications. After highlighting the benefits and capabilities of generative AI, the report explores how it can be applied in various industries such as health care, manufacturing, media, and entertainment and then discusses potential opportunities and limitations users must consider. Finally, it describes initiatives and strategies that the Korean government and private sector players have implemented to adopt and advance generative AI in Korea and the global marketplace.

The fifth issue in the Emerging Technology series, “Generative AI” is the result of a collaboration effort of the World Bank Group Information Technology Solutions Technology and the World Bank Korea Country Office. The series captures new technology and trends and shares knowledge to help solve international development challenges.

¹ MarketsandMarkets. “Generative AI Market Size, Trends, Drivers, Opportunities & Global Forecast- 2030.” https://www.marketsandmarkets.com/Market-Reports/generative-ai-market-142870584.html?gclid=Cj0KCQjwu-KiBhCsARIS-APztUF0gXS7BeDcvYDNoFzfnFc2h8SwFE1eGogR5ZrF-YGrVmYpjmpuxEwcaAq10EALw_wcB.

I.

THE BASICS OF GENERATIVE ARTIFICIAL INTELLIGENCE

Gartner, Inc. announced the keyword “generative artificial intelligence (AI)” as a top strategic technology trend in strategic technology for 2022¹ and predicted that, by 2025, generative AI will generate 10 percent of all data, up from less than 1 percent currently. Generative AI is a disruptive machine-learning algorithm that learns about content from data and uses it to produce creative, realistic, completely new outputs. It is not a technology that works only in a world with a lot of data, which data-driven AI is good at; it can create new things from a small amount of information and can be used in various fields and for various applications.

- **Art and design:** Generative AI creates unique, diverse artwork such as digital paintings, three-dimensional designs, and animation. OpenAI’s DALL·E2 and Stability.AI’s Stable Diffusion are popular examples of such domains. Lexica.art is a web site that collects images created using generative AI by Stable Diffusion (Figure 1).²
- **Music:** AI algorithms can generate music tracks using input data and user preferences and can analyze existing music data, understand patterns and structure, and generate music that aligns with user preferences and specific criteria such as genre, style, or mood.
- **Text:** Generative AI can produce content, creating articles, stories, poetry, and programming code and can be used to generate automated responses to customer inquiries for customer service. ChatGPT (generative pretrained transformer) from OpenAI is a popular example of this application.³
- **Speech:** Generative AI can take content and create appropriate voice audio. The user inputs text, and AI converts it to voice in real time. The generated speech can be used for various purposes, including voice response systems and virtual assistants. Unlike traditional text-to-speech systems, it generates more-natural sounding, expressive speech.⁴

1 Gartner. 2021. “Gartner Identifies the Top Strategic Technology Trends for 2022.” <https://www.gartner.com/en/newsroom/press-releases/2021-10-18-gartner-identifies-the-top-strategic-technology-trends-for-2022>.

2 Lexica.art. <https://lexica.art/>.

3 OpenAI. “Introducing ChatGPT” <https://openai.com/blog/chatgpt/>

4 WellSaid Labs. <https://wellsaidlabs.com/>

FIGURE 1.
IMAGES CREATED USING GENERATIVE ARTIFICIAL INTELLIGENCE



Source: Lexica.ar.

II.

**BRIEF
HISTORY OF
GENERATIVE AI**

Generative AI was developed beginning in the 1950s and the 1960s, when computer graphics systems began to be developed using traditional statistical models, such as Markov models and Monte Carlo simulations. Ian Goodfellow and colleagues introduced the generative adversarial network (GAN) in 2014, which has become one of the most popular and successful generative models.⁵ After that, the public became aware of generative AI. Turing Award–winning computer scientist Yann LeCun described GAN models as “the most interesting idea in the last ten years in Machine Learning.”

Progress in generative AI has continued rapidly, fueled by the availability of more-extensive, more-diverse data sets, better algorithms, and more-powerful computer hardware. Generative AI is used for many applications, including image and video synthesis, speech synthesis, and language generation. It remains an active research area, with new models and applications being developed constantly.

In 2017, the transformer model,⁶—a groundbreaking method in the field of natural language processing—was proposed. Large language models (LLMs) such as GPT3, RoBERT, Gopher, and BERT started to gain widespread popularity and adoption.⁷ LLMs are a type of neural network model that are called LLMs because of their size. A language model usually consists of hundreds of billions of parameters. Because of the model’s size, it can learn about complex relationships between words and phrases in the input text. For example, BERT had about 340 million parameters. OpenAI’s GPT-2 (introduced in 2019) has 1.5 billion parameters, and GPT-3 (introduced in 2020) has 175 billion. The size of these models determines their quality. A model with many parameters allows things to be done that could not be done before.⁸ These large models have achieved state-of-the-art performance on a wide range of natural language processing tasks (Figure 2). The natural language processing tasks encompass sentiment analysis, question answering, text summarization, text classification, text generation, and more. Since the initial development of LLMs, technology companies have developed super-LLMs.

5 Ian Goodfellow, Jean Pouget-Abadie, Mehdi Mirza, Bing Xu, David Warde-Farley, Sherjil Ozair, Aaron Courville, and Yoshua Bengio. 2014. “Generative Adversarial Networks.” <https://arxiv.org/abs/1406.2661>.

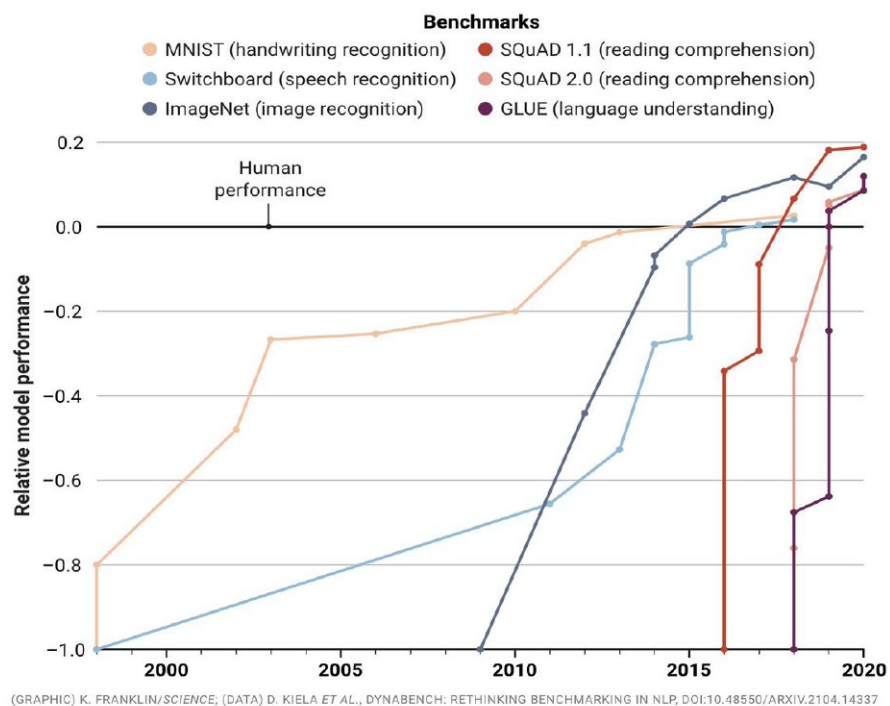
6 Ashish Vaswani, Noam Shazeer, Niki Parmar, Jakob Uszkoreit, Llion Jones, Aidan N. Gomez, Łukasz Kaiser, and Illia Polosukhin. 2017. “Attention Is All You Need.” *Advances in Neural Information Processing Systems* 30.

7 Jacob Devlin, Ming-Wei Chang, Kenton Lee, and Kristina Toutanova. 2018. “BERT: Pre-Training of Deep Bidirectional Transformers for Language Understanding.” arXiv:1810.04805.

8 Jordi TORRES.AI. 2022. “Transformers: The Bigger, the Better,” <https://towardsdatascience.com/transformers-the-bigger-the-better-19f39f222ee3>.

In 2021, OpenAI introduced DALL-E, a generative AI model that can create images from text. It is based on the transformer model, like other LLMs, and is trained on a massive dataset of images and textual descriptions so that it can learn to associate the two modalities in a way that is capable of generating highly detailed, imaginative images that do not exist in the real world. In 2022, Midjourney⁹ and Stable Diffusion,¹⁰ AI programs similar to DALL-E that generate images from textual descriptions, were introduced. Midjourney is an independent research lab whose service can be accessed using a Discord bot. It produces an image that resembles a piece of art rather than a photograph. It can be used for free up to 25 times.

FIGURE 2.
ARTIFICIAL INTELLIGENCE SYSTEM CAPABILITIES IN IMAGES
AND LANGUAGE

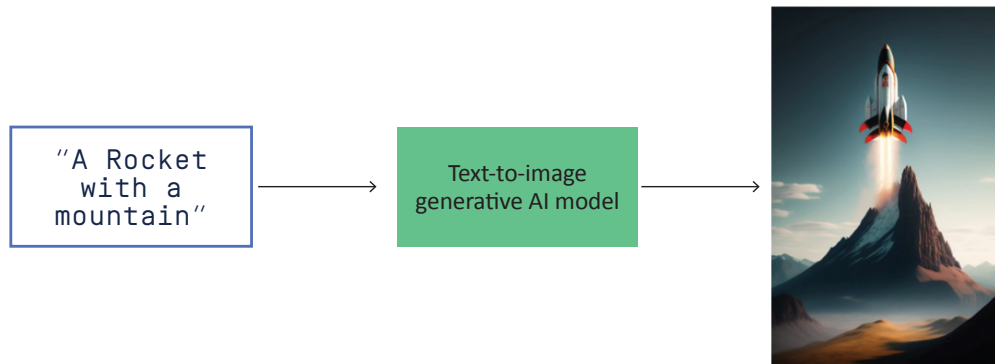


Source: Douwe Kiela, Max Bartolo, Yixin Nie, Divyansh Kaushik, Atticus Geiger, Zhengxuan Wu, Bertie Vidgen, Grusha Prasad, Amanpreet Singh, Pratik Ringshia, Zhiyi Ma, Tristan Thrush, Sebastian Riedel, Zeerak Waseem, Pontus Stenetorp, Robin Jia, Mohit Bansal, Christopher Potts, Adina Williams. 2021. "Dynabench: Rethinking Benchmarking in NLP" *Proceedings of the 2021 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies*, 4110–4124. <https://aclanthology.org/2021.naacl-main.324/>.

9 Midjourney. <https://midjourney.com/>

10 Stable Diffusion. <https://stablediffusionweb.com/>

FIGURE 3.
INPUT AND OUTPUT OF TEXT-TO-IMAGE GENERATIVE ARTIFICIAL INTELLIGENCE (AI) MODEL



In 2022, Stability AI created Stable Diffusion, an open-source model; all information is shared so that individuals freely access and utilize the model as all information is openly shared. Various models that researchers have tuned to suit their taste have also been published.¹¹ Because it is open source, anyone can download the trained dataset and build their own image-generation model. In this way, Stable Diffusion has created an environment in which developers and designers can easily apply image generative AI models, which has played a leading role in creating the current generative AI global trend.

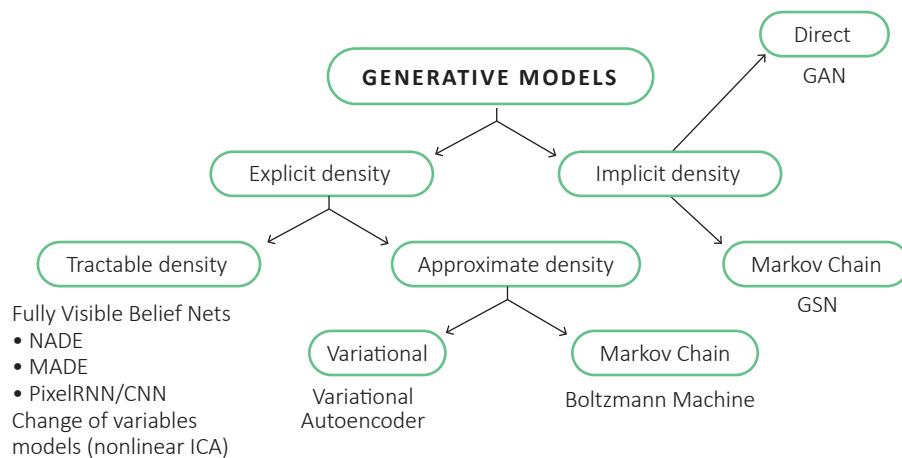
¹¹ Stable Diffusion Version2. <https://github.com/Stability-AI/stablediffusion>.

III.

TYPES OF GENERATIVE AI AND HOW IT WORKS

an Goodfellow, who invented the GAN, has categorized generative AI models into two categories based on how they model the target data distribution. The criterion he used is how the model defines the probability density function for the target data distribution. According to the defined probability density function, one can generate new data by sampling from the data distribution. Explicit density models use the density function, and implicit density models do not. Implicit density models define a stochastic procedure that directly generates outputs.

FIGURE 4.
STRUCTURE OF GENERATIVE ARTIFICIAL INTELLIGENCE MODELS



Source: Ian Goodfellow, *Tutorial on Generative Adversarial Networks*

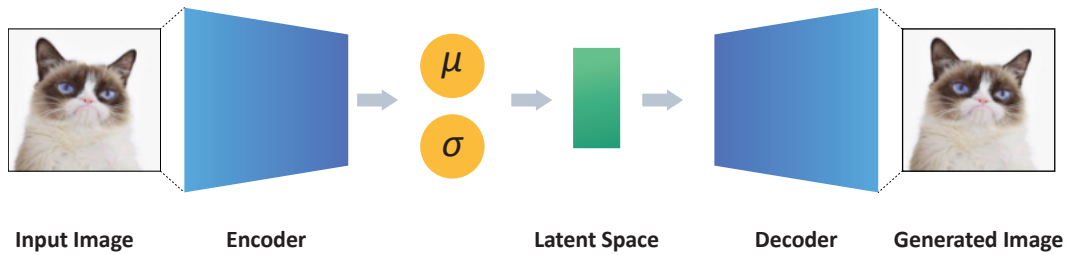
Explicit Density Models

Explicit density models define a density function for the data distribution, and then a sample is used from this density function to generate new outputs. Explicit density models can be divided into two sub-categories, depending on whether they are tractable density model or approximate density model.

A variational autoencoders (VAE)¹² is a popular example of this type of model. It consists of an encoder that maps input data to a reduced space (latent space) and a decoder that generates new data samples from data in a latent space. The latent space is typically chosen to be a lower-dimensional space than the input space and follows a multivariate gaussian distribution. During training, the encoder estimates the mean and the standard deviation of the latent space. After the training, the encoder is no longer used, and the estimated mean and standard deviation of the distribution are used to sample the latent variables, which are then passed through the decoder to generate a new output sample.

12 Diederik P. Kingma and Max Welling. 2013. "Auto-Encoding Variational Bayes." <https://arxiv.org/pdf/1312.6114.pdf>.

FIGURE 5.
ARCHITECTURE OF A VARIATIONAL AUTOENCODER (VAE)

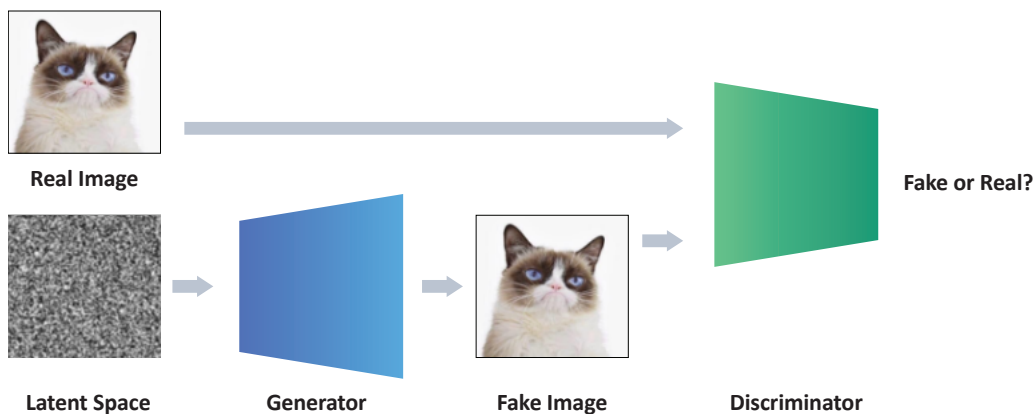


Implicit Density Models

In contrast to explicit density models, implicit density models define an implicit representation of the data distribution and generate new outputs by transforming random noise into samples that belong to the target distribution.

Examples of implicit density models include Generative Adversarial Networks (GANs), which consist of a generator that produces data and a discriminator that distinguishes data (Figure 6). The generator tries to fool the discriminator by generating data that look as much like real data as possible, and the discriminator tries to distinguish between real and fake data. The generator's objective is to create data that are indistinguishable from the real data, and the discriminator's objective is to identify which data are real and which are fake. The inventor of GAN, Ian Goodfellow, described this relationship as follows: "The generator is like counterfeiters who are trying to mint fake money, and the discriminator is like a police officer who distinguishes between fake and real money."

FIGURE 6.
ARCHITECTURE OF A GENERATIVE ADVERSARIAL NETWORK

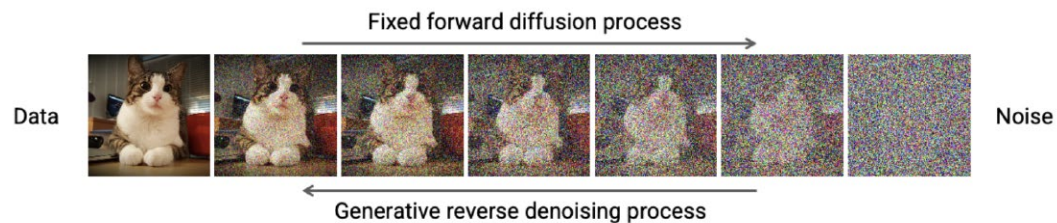


In the training phase, the discriminator is trained first, then the generator, and the process is repeated back and forth. The discriminator classifies real and fake data from the generator and is trained to be penalized for misclassifying real data as fake or fake data as real. This process allows the discriminator to classify real data as real and fake data as fake. Once a discriminator has been trained, the generator must be trained to fool the trained discriminator; fake data that the generator generates are fed into the discriminator, and the generator is trained to produce data that are similar enough to the real data to classify the fake data as real.

As the training process is repeated, the discriminator and the generator evolve to perceive each other as hostile competitors. As a result, the generator can create fake data that is the same as real data, and the discriminator cannot distinguish between real and fake data. In other words, GAN is designed to compete with each other, with the generation model trying to reduce the probability of successful classification and the classification model trying to increase the probability of successful classification. In the end, data can be generated that look like real data using only the trained generator.

Another example of an implicit density model is the diffusion model, which is the model behind stable diffusion that Stability AI introduced in 2022.¹³ The diffusion model is a deep generative model for generating data that uses a forward process (diffusion process) that adds noise to the data little by little to turn the data into complete noise and then uses a reverse process that gradually removes the noise to recover the original data (Figure 7). Stable Diffusion, the generation model of text to image using the diffusion model, has played an important role in the artistic and creative fields of AI.¹⁴

FIGURE 7.
DIFFUSION AND DENOISING PROCESS IN DIFFUSION MODEL



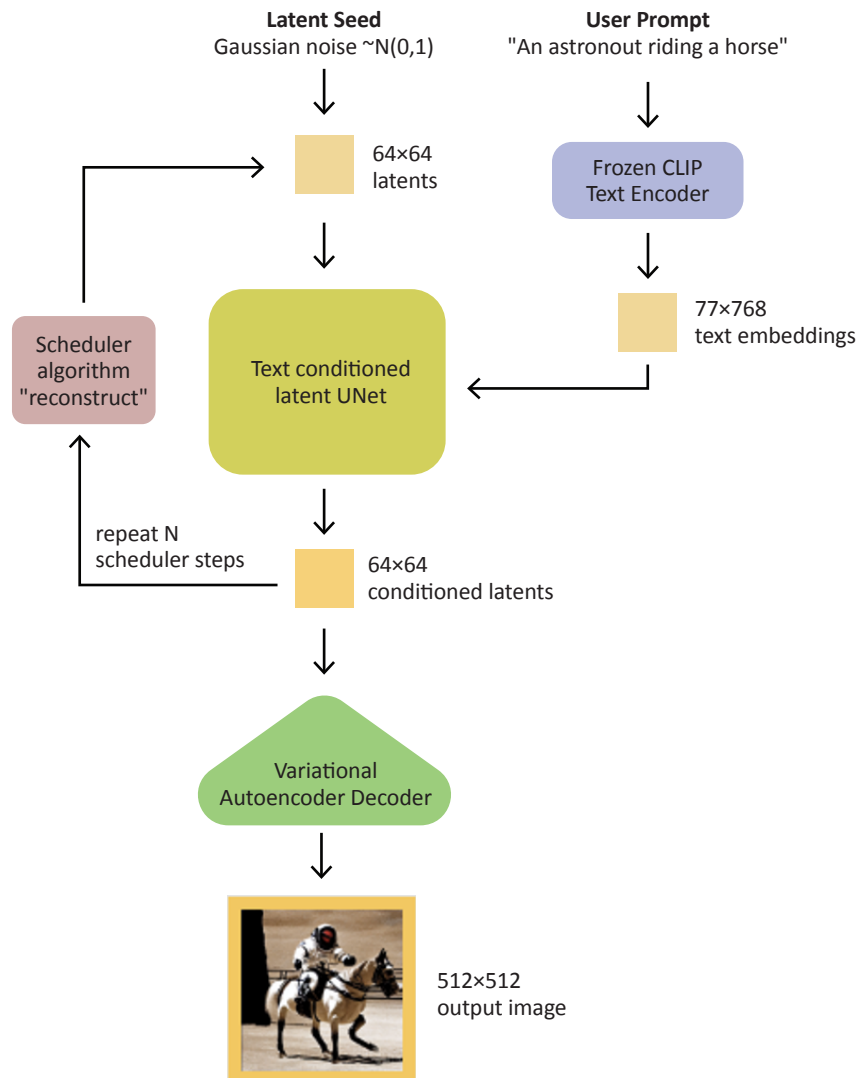
Source: “CVPR 2022 Tutorial: Denoising Diffusion-based Generative Modeling: Foundations and Applications.” <https://cvpr2022-tutorial-diffusion-models.github.io/>.

Stable Diffusion has three major components: contrastive language image pre-training, UNet, and variational autoencoders. When a user enters text, a text encoder (contrastive language image pre-training) converts the text into a language that UNet can understand, called a token, and UNet denoises randomly generated noise based on the token. Repeated denoising results in a proper image, and the variational autoencoder converts this image into pixels. The overall flow to generate an image is shown in Figure 8.

13 Robin Rombach, Andreas Blattmann, Dominik Lorenz, Patrick Esser, and Björn Ommer. 2022. “High-Resolution Image Synthesis with Latent Diffusion Models.” Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition. <https://arxiv.org/abs/2112.10752>.

14 Alberto Rometo. 2022. “Stable Diffusion Is the Most Important AI Art Model Ever.” <https://thealgorithmicbridge.substack.com/p/stable-diffusion-is-the-most-important>.

FIGURE 8.
ILLUSTRATED STABLE DIFFUSION



Source: Suraj Patil, Pedro Cuenca, Nathan Lambert, and Patrick von Platen. 2022. "Stable Diffusion with Diffusers." https://huggingface.co/blog/stable_diffusion.

Unlike conventional image-generation models, which use exponentially increasing resources as the resolution increases, this model introduces autoencoders at the front and back to remove noise in the latent space of much smaller dimensions instead of the entire image. This allows for a drastic reduction in resource use, even for high-resolution images, making it possible to use a general home graphics card. Before this development, text-to-image models such as DALL-E and Midjourney were available only through cloud services; this new approach is a departure from that proprietary model. As a result, individuals, rather than companies, are creating many modified models and sharing them via Hugging Face and others. They have also implemented and released a browser interface to make it easier for people to generate these images.¹⁵

15 "Stable Diffusion Web UI." <https://github.com/AUTOMATIC1111/stable-diffusion-webui>.

IV.

BENEFITS OF GENERATIVE AI

Creativity and Scalability

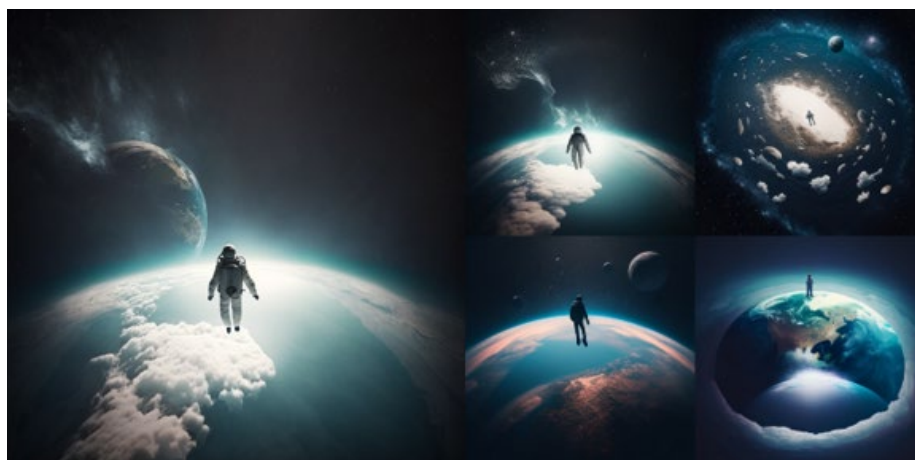
Although overreliance on generative AI can limit creative thinking,¹⁶ generative AI can benefit businesses and individuals in terms of creativity and scalability, enabling them to produce innovative, personalized content. Users and businesses can generate new ideas and concepts using generative AI, leading to new inventions and driving innovation. By providing suggestions and alternatives, generative AI models can augment human creativity and help users create text, images, and videos easily with their new ideas in a visually appealing way. Inventions can be made by leveraging generative AI in such areas as synthesizing chemicals and generating patterns.

Efficiency and Productivity

Generative AI can increase efficiency and automate time-consuming manual work. LLMs and image models can be used to automate and identify patterns and generate personalized content based on individual user preferences, allowing users and businesses to complete tasks and achieve results more quickly and efficiently.

High-quality videos and images can be created with less effort than creating them manually. Especially for nonprofessionals who have little knowledge of content generation, generative AI can fill the gap and enable them to generate high-quality output without having to start from zero. It democratizes the user experience, with nonprofessionals, researchers, and developers engaging in user experience tasks without deep design training or education. It can be used to identify and reduce noise in images and videos, increasing the overall quality of the output of professional users as well. The images in Figure 9 were created in less than 1 minute using the Midjourney platform with the input text: “Person floating in space seeing the earth.”

FIGURE 9. IMAGE CREATED USING MIDJOURNEY



Source: Midjourney

16 Tyna Eloundou, Sam Manning, Pamela Mishkin, and Daniel Rock. “GPTs Are Gpts: An Early Look at the Labor Market Impact Potential of Large Language Models.” <https://arxiv.org/abs/2303.10130>.

V.

**GENERATIVE AI
APPLICATIONS IN
INDUSTRY**

There are various applications of generative AI, including image-to-image, text-to-image, and photo-to-emoji conversion; image processing; film restoration; and text and audio synthesis. These applications can then be tailored to and used in various industries and sectors. Venture capital firms have invested more than \$1.7 billion in generative AI technologies, with most investments focused on AI-powered drug discovery and AI-assisted software development.¹⁷

Table 1 shows some generative AI use cases according to industry. Although initial foundation models like ChatGPT concentrate on using generative AI to enhance creative tasks, the applications will be expanded to real industry situations.

TABLE 1.
GENERATIVE ARTIFICIAL INTELLIGENCE USE CASES ACCORDING TO INDUSTRY

	INDUSTRIES							
	AUTOMOTIVE AND VEHICLE MANUFACTURING	MEDIA	ARCHITECTURE AND ENGINEERING	ENERGY AND UTILITIES	HEALTHCARE PROVIDERS	ELECTRONIC PRODUCT MANUFACTURING	MANUFACTURING	PHARMACEUTICAL
Drug Design								●
Material Science	●			●		●		
Chip Design						●		
Synthetic Data	●		●	●	●	●	●	●
Generative Design (Parts)	●		●				●	

Source: Gartner

Health Care and Pharmaceuticals

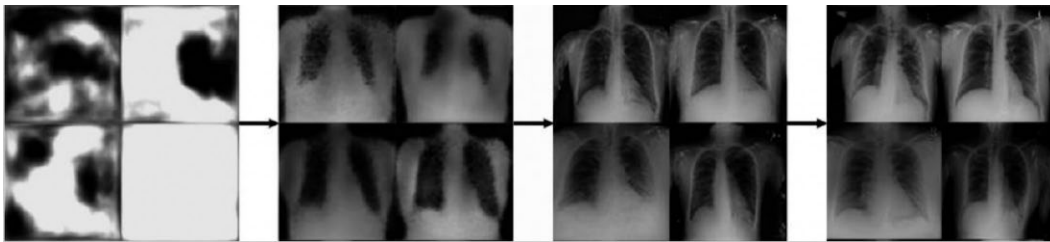
Generative AI can revolutionize how complex medical conditions are understood, diagnosed, and treated and could increase the accuracy, efficiency, and effectiveness of the health care system. The potential benefits of this technology include faster, more-effective treatment, smoother processes, and lower costs for health care providers and patients. Ultimately, generative AI has the potential to enhance patient outcomes and the overall quality of health care delivery.¹⁸ Generative AI can create medical images, such as X-rays and computed tomography and magnetic resonance imaging scans, increase accuracy and efficiency in

17 Gartner_Inc. 2023. "Beyond Chatgpt: The Future of Generative AI for Enterprises." <https://www.gartner.com/en/articles/beyond-chatgpt-the-future-of-generative-ai-for-enterprises>.

18 Charles Aunger. 2023. "Council Post: CHATGPT, Machine Learning and Generative AI in Healthcare." Forbes <https://www.forbes.com/sites/forbestechcouncil/2023/03/07/chatgpt-machine-learning-and-generative-ai-in-healthcare/>.

medical imaging techniques, and detect abnormalities. Generative AI, including GANs, can create fake data after learning the properties of real data and produce synthesized data. Synthetic data, for example in Figure 10, shows the generation of fake chest X-rays using NVIDIA's StyleGAN2-ADA model. Synthetic data have the potential to enlarge clinical research datasets and simultaneously protect patient privacy, enabling institutions to expand their data-sharing capabilities. Generative AI can accelerate creation of training materials and simulations for medical education, providing students with valuable learning resources.

FIGURE 10.
GENERATIVE ARTIFICIAL MODEL TO PRODUCE FAKE CHEST X-RAYS



Source: Anmol Arora and Ananya Arora. 2022. "Generative Adversarial Networks and Synthetic Patient Data: Current Challenges and Future Perspectives." *Future Healthcare Journal* 9 (2): 190–193. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9345230/>.

Generative AI can generate benefits for the pharmaceutical sector by streamlining drug discovery, helping develop pharmaceutical resources, and providing personalized medicine. For example, the variational autoencoder, a particular kind of generative model, is used to enable the new drug discovery process. Identifying potential drug candidates and conducting the testing based on AI simulations before moving to clinical, human, or animal trials can reduce the time and the cost of initial drug discovery and development of medicines.

Manufacturing

Generative AI can be used in manufacturing to develop components tailored to meet objectives and overcome limitations, used in improving performance, material selection, and production techniques. It has been beneficial in synthesizing new materials and chemicals similar to the original materials to produce the same level of perfection. AI has been gradually applied to manufacturing mainly in maintenance and quality control, although its use is expanding.

Generative AI helps analyze big data from factories to identify patterns, predict behaviors and future production, and spot anomalies, which reduces risks and costs associated with production and increases efficiency. In a practical application, the BMW Group used automated image recognition powered using generative AI for a range of quality assessments and inspections. This enabled identification of pseudo-defects, which are variations that deviate from the desired target without any faults being indicated. Generative AI helped achieve accurate, efficient detection, ensuring high quality standards in the manufacturing processes.

Media, Art, and Entertainment

Generative AI is also being used in the media and art. People can generate images using applications such as DALL·E 2 and Midjourney and create music with applications such as AIVA and SOUNDRAW. One can choose a genre and the length of the music or write a detailed prompt regarding what they want to draw. The French DJ David Guetta used generative AI to add deepfake vocals in the style of Eminem to a recent song and announced, “the future of music is in AI.”¹⁹ The music was not commercially released but indicated the impact that AI will have on the music industry. Generative AI has also been affecting the gaming industry, enabling the creation of personalized games and human-like characters. It is making gaming development more efficient in many ways and improving quality.

In addition to creating content, generative AI is helping increase the resolution of video and images. Legacy content that was recorded in low resolution can be remastered to high resolution through noise removal and made sharper using generative AI. Images and videos can be colorized to add realistic color to monochrome contents. Hollywood has adopted Cuebric, the first generative AI system to produce and edit images for film and television. Cuebric generates images from a stable diffusion model using the normal prompt interface and provides a real cinematic background so that actors do not have to be on location to film.²⁰

Fashion

Generative AI applications are being used to increase productivity, accelerate market entry, and improve customer service in the fashion industry. Generative AI could add \$150 billion to \$270 billion to the fashion industry, in particular by contributing to product innovation, marketing and sales, and customer experience.²¹

Generative AI has great potential in product development. It can provide information about fashion trends and individual preferences using multiple sources of consumer data, and designers and their teams can design and test new items using it. For example, at the Fashion X AI show in Hong Kong, the Laboratory for Artificial Intelligence in Design held a fashion show featuring generative AI–supported designs. More than 80 outfits from 14 designers were created with the help of an AI-based interactive design assistant.²² The consumer experience can be improved using generative AI. Stitch Fix, a retail fashion brand, used AI to recommend clothing to customers based on GPT-3 and Dall-E2 to boost sales and increase customer satisfaction. DALL-E program visualizes the clothing based on requested preferences such as color, fabric, and style.²³

19 British Broadcasting Company. “David Guetta Says the Future of Music Is in AI.” 2023. BBC News <https://www.bbc.com/news/entertainment-arts-64624525>.

20 Tom Davenport. “Cuebric: Generative AI Comes to Hollywood.” 2023. Forbes <https://www.forbes.com/sites/tomdavenport/2023/03/13/cuebric-generative-ai-comes-to-hollywood/?sh=3e9689db174b>.

21 Holger Harreis, Theodora Koullias, Roger Roberts, and Kimberly Te. 2023. “Generative AI: Unlocking the Future of Fashion.” McKinsey & Company. <https://www.mckinsey.com/industries/retail/our-insights/generative-ai-unlocking-the-future-of-fashion>.

22 “From Writing Articles to Helping Stroke Patients: Here Are 6 Updates from the World of AI This Month.” World Economic Forum. <https://www.weforum.org/agenda/2023/01/4-things-you-need-to-know-about-ai-january-2023/>.

23 Thomas H. Davenport and Nitin Mittal. 2022. “How Generative AI Is Changing Creative Work.” Harvard Business Review <https://hbr.org/2022/11/how-generative-ai-is-changing-creative-work>.

E-commerce and Marketing

Generative AI is affecting the e-commerce and marketing industry as well. It can help develop marketing strategy; produce marketing content and even virtual images or avatars for advertising; predict customer preferences by generating unseen but probable preference profiles; and identify patterns and trends in popular content, enabling it to generate new content that sticks to marketers' logic.

Generative AI can be used to create e-commerce materials such as flyers, advertising copy, and marketing materials. Although users must consider regulations and copyright when creating unique content, generative AI can be used to increase productivity and creativity. Companies providing generative AI text-generating services are growing. For example, the generative AI platform start-up Jasper helps users create copy and content tailored to their brand to improve the process and product,²⁴ and the generative AI-based content-generating startup Copy.AI²⁵ provides writing tools for blog content, digital advertising copy, e-commerce and sales copy, social media content, website copy, and more.

24 Jasper.AI. <https://www.jasper.ai/>.

25 Copy.AI. <https://www.copy.ai/>.

VI.

**OPPORTUNITIES FOR
INTERNATIONAL
DEVELOPMENT**

Generative AI holds great potential for addressing challenges in international development. It has potential to improve disaster relief and infrastructure development. Disaster relief involves a complex set of tools and processes that are used not only to reduce the number of lives lost during a disaster, but also to help communities become more resilient. Generative AI can be used to model the impact of natural disasters and help governments prepare for disasters by generating new patterns of disaster using generative AI. Text and voice generation can facilitate real-time updates and information dissemination during emergencies, ensuring efficient communication with affected populations.

AI applications are widely used in health care to address development problems. Healthcare and life science companies use the applications to diagnose diseases, make treatment recommendations, discover new medicine, and increase patient engagement and adherence. As discussed in the previous section, Generative AI Applications in Industry, generative AI can generate synthetic medical images, aiding in the training and augmentation of datasets for medical imaging. Generative models can also be employed in drug discovery and molecular design, enabling researchers to explore new possibilities and accelerate development of life-saving medications. Text-generation capabilities can be used to educate patients.

Generative AI can generate educational content such as quizzes, exercises, and interactive simulations, enhancing the learning experience for students; create personalized learning plans for any topic of interest; and recommend textbooks. Virtual tutors and language learning companions can be created using image- and voice-generation models, providing personalized, adaptive learning experiences.

Generative AI can conserve wildlife. An average reduction of 69 percent in species populations has been observed since 1970.²⁶ Generative AI can predict and model ecological changes and population dynamics in a region of interest, helping researchers create accurate, proactive strategies to protect endangered species.

Generative AI also has the potential to help solve development challenges in many areas, such as financial inclusion and human rights. It is rapidly evolving, and its capacity to contribute to global society is projected to grow considerably. The innovative use of generative AI to address the world's most complex challenges is expected to increase.

VII.

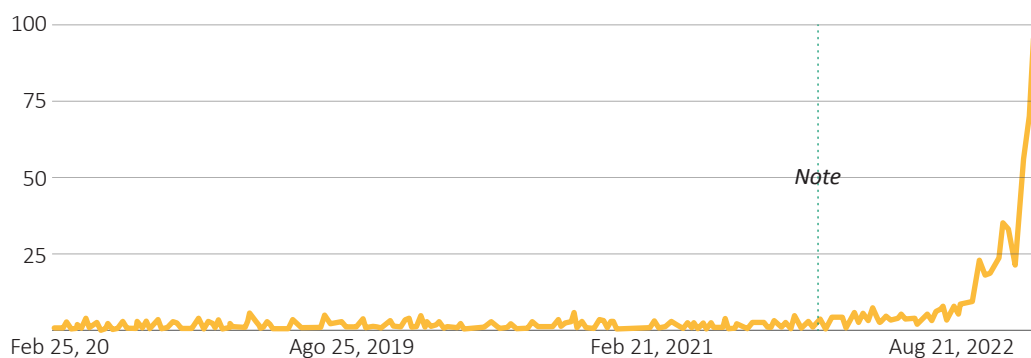
LIMITATIONS AND CONSIDERATIONS

One limitation of traditional machine learning is that the algorithm must be modified for the input data type, but since the 2000s, when deep learning started gaining attention, it has been recognized for its ability to highlight and address these limitations, offering solutions that alleviate the need for extensive algorithm modification based on input data types. Generative AI has gained interest in recent years because of potential applications in various fields and technological breakthroughs.

In April 2022, when DALL-E2 was released, it surprised people with dramatic quality improvements over DALL-E1. About four months later, Stability AI released Stable Diffusion, an all-open-source image-generation AI tool, and images generated using DALL-E2 began to spread on Twitter and other social media. The data used for training were also published as open source from the beginning, which spurred further development of generative AI technologies.

Within five days of its release at the end of 2022, ChatGPT, conversational AI based on large-scale language models, had more than 1 million users; by January 2023, it had 100 million users. ChatGPT is conversational AI that can answer questions and write poetry and even programming code in any language. There has been an overwhelming increase in the popularity of generative AI search keywords on Google since 2022, with two spikes in search volume in August and November of 2022, which is when Stable Diffusion and ChatGPT went public, respectively.

FIGURE 11.
GOOGLE TREND FOR GENERATIVE ARTIFICIAL INTELLIGENCE KEYWORDS



Generative AI has several limitations that are being recognized. For example, questions about ethics in AI have emerged as a response to the personal and societal harm that can result from such things as the negative consequences of misuse or abuse of AI systems, poor design, and learning from biased data. In particular, with AI that generates text, it is challenging to identify hateful or violent language data in the total data used for training because it is very small in proportion to other data and is mixed with slang. It is even more challenging to determine because it has different meanings depending on cultural background. Efforts are

being made to address these concerns. Academia has also recognized these concerns, and the number of ethics papers is increasing. This applies not only to generative AI but also to AI in general, and AI can cause far-reaching damage, so it is necessary to seek appropriate measures and devise appropriate plans.

Responsible use of AI will be an increasing focus for ChatGPT, especially when it is being used in decision making and in products and services that affect people. Use of ChatGPT raises many specific risks.²⁷

Safe use means documenting risks and making sure that the organization using ChatGPT is using AI responsibly for those outputs. ChatGPT use may fall under the responsible AI paradigm and creating trustworthy AI. This includes involving human validation and maintaining human in the loop during the lifecycle use. Implementing human validation in the process is especially important with generative AI because ChatGPT may create untrue content, known as hallucination. In addition, governance structures and mitigation measures must be defined for proper, safe use to ensure transparency, accountability, and safety. Various AI trustworthy frameworks, such as the National Institute of Standards and Technology Risk Management Framework, may be used to mitigate risk.²⁸

27 "GPT4 System Card." 2023. https://cdn.openai.com/papers/gpt-4-system-card.pdf?mc_cid=47c1f3eb5f&mc_eid=51768751d5.

28 U.S. National Institute of Standards and Technology. 2023. "Artificial Intelligence Risk Management Framework (AI RMF 1.0)." <https://nvlpubs.nist.gov/nistpubs/ai/NIST.AI.100-1.pdf>.



VIII.

AI IN KOREA

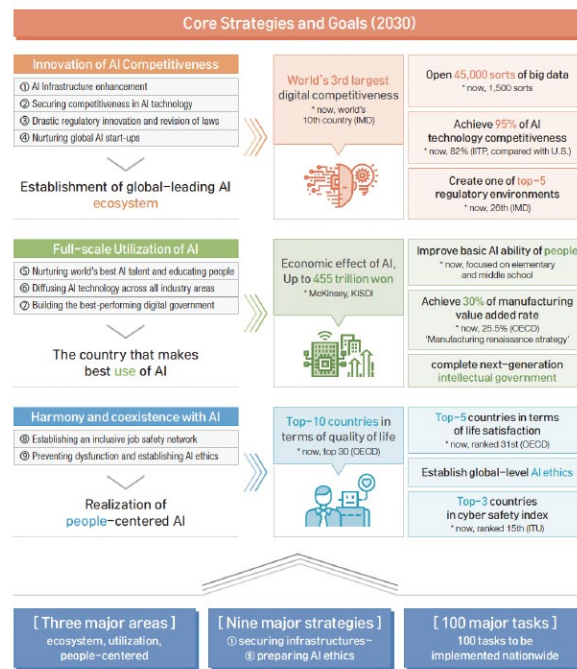
Public Sector Initiatives

Governments around the world have been adopting AI technology at an accelerating rate that skyrocketed with the COVID-19 pandemic. Although there is still some uncertainty because the technology is evolving, because of the advantages of the technology, governments are increasing their investments. McKinsey Global Institute modeling of trends in AI adoption revealed that AI has the potential to deliver additional global economic output of about \$13 trillion by 2030, which would increase global gross domestic product by approximately 1.2 percent per year.²⁹ There are many examples of global AI applications and use by governments to improve social welfare, national health care systems, domestic security and surveillance, and transportation. The Korean government has recognized the importance of adopting and using AI and its significance of scaling digital initiatives.

KOREAN APPROACH TO AI

The Korean government released its national strategy for AI on December 17, 2019, with the vision of Toward Global IT Leader, led by the Ministry of Science and Information and Communications Technology. The strategy was formed based on the AI ecosystem, AI use, and people-centered AI and consists of 100 government-wide action tasks under nine strategies (Figure 12). Korea has announced the national AI strategy and presented the of achieving digital competitiveness, creating positive economic effect and improving the quality of life of its people by 2030.

FIGURE 12. KOREAN NATIONAL ARTIFICIAL INTELLIGENCE (AI) STRATEGY

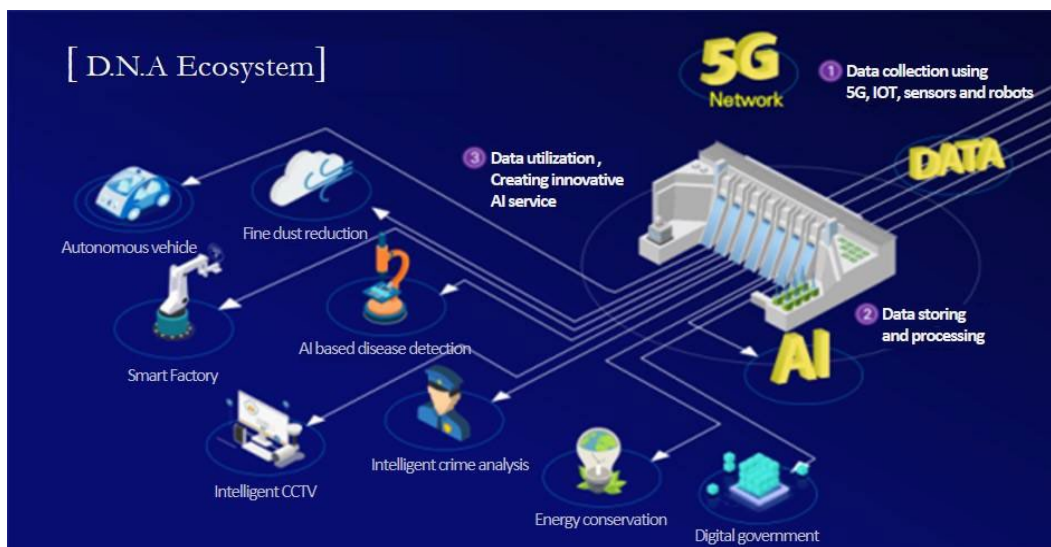


Source: Republic of Korea, Ministry of Science and ICT, National Strategy for Artificial Intelligence.

29 Jacques Bughin, Jeongmin Seong, James Manyika, Michael Chui, and Raoul Joshi. 2018. "Notes from the AI Frontier: Modeling the Impact of AI on the World Economy." McKinsey Global Institute. <https://www.mckinsey.com/featured-insights/artificial-intelligence/notes-from-the-ai-frontier-modeling-the-impact-of-ai-on-the-world-economy>.

The Ministry of Economy and Finance also announced National Strategy for Transformation called “the Korean New Deal Initiative” to share a national development strategy to support the country’s recovery from the pandemic. The plan is to invest 160 trillion won to create approximately 1.9 million jobs by 2025 based on the Digital New Deal and the Green New Deal, with the goal of building a digital economy and fostering innovation. Focus areas include integration of data, the 5G network, and AI (Figure 13) throughout the economy; digitalization of the education infrastructure; fostering and digitalization of social overhead capital (capital that the state owns that is used to produce goods and services that are not generally sold for money).

FIGURE 13.
KOREAN NEW DEAL DATA, 5G NETWORK, ARTIFICIAL INTELLIGENCE (AI)
(DNA) ECOSYSTEM



Source: Republic of Korea, Ministry of Economy and Finance, Korean New Deal

AI takes up a big part throughout the Digital New Deal. The government plans to build a data ecosystem and establish a data control tower for integrated management of public and private data. The goal is to disclose 142,0000 public data and collect 1,300 types of additional data for AI training. The plan is also designed to expand integration of AI into industries and make a smart government that uses AI. The Korean government created the Smart Korea Fund with 6 trillion won and provides vouchers for AI solutions to 3,400 small and medium-sized enterprises.

With its New Deal strategy, Korea is expected to transform into the smarter country to use data and digital technologies, including AI, and leads the innovative public services.

STRATEGIES FOR AND APPROACHES TO GENERATIVE AI

Use of generative AI is still in early stages, and its impact on society and the global market will continue to grow. Governments are cognizant of the emergence of this technology and have been working to understand the technology and devise strategies to adopt it.

Considering the risks and unknown potential of the technology, it is critical for policy makers and public and private sector entities to consider the importance of establishing a solid governance framework and ethics so that positive expansion of generative AI and goods and services derived from the new technologies can be supported.³⁰

The Korean government has been actively pursuing development and adoption of generative AI technologies. According to the 2023 Master Plan for Research and Development Projects in the Ministry of Science and ICT (MSIT) of the Republic of Korea, the government plans to invest 6.41 trillion won in 2023 to support development of innovative digital technologies.

In February 2023, Minister Lee Jong-ho of the Ministry of Science and ICT Technology discussed the trend and policy direction of ChatGPT with Korean AI companies and academic experts. The AI-data subcommittee discussed the potential of ChatGPT programs that can be used in government work, such as for writing emails, press releases, and social network service publicity texts targeted to government employees.³¹ The ministry reported that “the AI policies that the Korean government established so far, such as data platform, computing resources, and AI R&D support, will serve as a foundation for the growth of the giant AI industry.”³²

The Ministry of Culture, Sports, and Tourism (MCST) announced the official launch of three working groups to prepare the cultural, institutional, and industrial foundation that generative AI and ChatGPT will bring. In particular, the focus will be on improving the copyright system, learning the Korean text corpus for Korean proficiency of AI, and using AI in content creation and industry applications.

Because there is a no existing governance system or regulations regarding generative AI, especially for content that ChatGPT has created, the copyright system improvement working group is working to look into the copyrighted works for AI learning data, identify legal status of AI outputs and recognition in the copyright system, and examine copyright infringement and regulations.

30 Benjamin Larsen and Jayant Narayan. 2023. “Generative AI: A Game-Changer Society Needs to Be Ready For.” <https://www.weforum.org/agenda/2023/01/davos23-generative-ai-a-game-changer-industries-and-society-code-developers/>.

31 “과거정통부, LG·SK·네이버와 초거대ai 경쟁력 제고방안 논의, 코리아타임스.” 2023. <https://www.koreaittimes.com/news/articleView.html?idxno=119700>.

32 “AI 무한 경쟁시대...한국은?” 데일리굿뉴스, 데일리굿뉴스.” 2023, <https://www.goodnews1.com/news/articleView.html?idxno=416252>.

In 2023, the Ministry of Culture, Sports, and Tourism formed the AI Taskforce for Digital Contents Sector, consisting of nine experts from the public and private sectors to respond to use of generative AI in the digital contents industry. The task force plans to build and distribute 25 types of high-quality Korean text corpus, comprising about 120 million words, to develop the Korean version of ChatGPT. The plan includes development of a pilot program to evaluate the system to verify whether the generative AI model understands Korean and has knowledge of Korean society and culture.³³

The Korean government announced that it plans to increase the number of companies using AI from 1 percent as of January 2023 to 30 percent by 2030 and foster more than 100 globally competitive AI companies. The Ministry of Trade, Industry, and Energy (MTIE) held the Industrial Digital Transition Committee and established an industrial AI internalization strategy focused on internalizing AI technology and expanding industry applications, which have mostly been limited to finance and administrations.³⁴

Private Sector Initiatives

kakao

KAKAO

Kakao is a Korean Internet company that provides a diverse set of services, including entertainment, fashion, finance, investment, transportation, and others. The company is known for Kakao Talk, a free mobile instant messaging application for smartphones that offers text and call features similar to WhatsApp. Kakao is set to create a 10 billion won fund by June 2023 to establish an ecosystem for AI startups. Kakao launched Karlo, a generative AI technology that it developed based on image-generation AI models developed by Kakao Brain, Kakao's research subsidiary.³⁵

Kakao Brain released KoGPT, a generative AI service, in 2021 based on OpenAI's GPT-3 model; an advanced version will be released based on GPT 3.5.³⁶ Kakao Brain has also released minDall-E, a large-scale AI system.³⁷

33 “한국어 잘하는’ K-챗GPT 만든다...올해 고품질 말뭉치 1억2000만 어절 공급.” 서울경제. 2023. <https://www.sedaily.com/NewsView/29LUMGTUJ1>.

34 “2030년까지 AI 활용기업 30%로 늘린다... 공급기업 100개 이상 육성.” 세계일보. 세계일보. 2023. <https://www.segye.com/newsView/20230113507585>.

35 Ko Min-suh and Han Yubin. 2023. “Kakao to Create \$7.6mn Fund to Support AI Startups—Pulse by Maeil Business News Korea.” <https://m.pulsenews.co.kr/view.php?year=2023&no=160078>.

36 Baek Byung-yeul. 2023. “Kakao to Release Generative AI Models.” Korea Times https://www.koreatimes.co.kr/www/tech/2023/03/133_346465.html.

37 “minDALLE-E on Conceptual Captions.” 2021. <https://github.com/kakaobrain/minDALL-E>.



NAVER

Naver is a Korean online platform that the Naver Corporation launched in 1999 that was introduced as the first web portal in South Korea to develop and use its own search engine.³⁸ Naver became the third company to introduce its own large-scale language model with HyperCLOVA, after OpenAI's GPT-3 and Huawei's PanGu- α . According to Naver, HyperCLOVA was processed with 50 years of Naver articles; the amount of Korean language-based dataset that HyperCLOVA learned is 6,500 times as large as that of GPT-3.³⁹ By advancing from the existing development method that relied on developer expertise, CLOVA provides a service that allows anyone to develop and tune AI through HyperCLOVA, which has already learned a considerable amount of data.

³⁸ NAVER Company. <https://www.navercorp.com/en/naver/company>.

³⁹ "As AI War Rages, Korea Seeks a Place among Giants." 2023. *Korea JoongAng Daily* <https://koreajoongangdaily.joins.com/2023/02/08/business/tech/Korea-ChatGPT-AI/20230208191532013.html>.



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