# NAVER-SAPI **AI REPORT**

 $\bigcirc$ 





The PDF file of this report is available for download at our website https://www.navercorp.com/en/value/research



For	eword by CEO of NAVER	04
For	eword by Director of SAPI	05
1.	Al for People	06
2.	<ul><li>Natural Language Communication</li><li>2.1 Chatbot</li><li>2.2 Machine Translation</li><li>2.3 Speech Recognition</li><li>2.4 Speech Synthesis</li></ul>	12 12 13 15 16
3.	<ul><li>Computer Vision</li><li>3.1 Object Tracking</li><li>3.2 Optical Character Recognition</li><li>3.3 Facial Recognition</li></ul>	17 17 19 20
4.	<ul><li>Recommendation</li><li>4.1 Item Recommendation</li><li>4.2 Place Recommendation</li><li>4.3 Content Recommendation</li><li>4.4 Music Recommendation</li></ul>	21 21 22 24 25
5.	Robotics5.1Robot Learning5.2Robot Vision5.3Cloud Robotics5.4Autonomous Driving	26 26 27 28 29
6. A	<ul> <li>Al Ethics at NAVER</li> <li>6.1 Impact of AI on Society</li> <li>6.2 NAVER AI Ethics Principles: Directions</li> <li>6.3 NAVER AI Ethics Principles: Development Process</li> <li>6.4 NAVER AI Ethics Principles: Details</li> <li>6.5 Next Steps</li> </ul>	31 31 32 33 33 36
7.	Beyond Connect	37
Ref	erences	38

# Foreword by CEO of NAVER

NAVER transforms cutting-edge technologies, including AI, into tools that anyone can easily use. In 2021, we introduced HyperCLOVA, Korea's very first hyperscale language model. It has since been applied to NAVER's various services including search and shopping, contributing to the company's development into a global leader in technology as an AI platform company.

Al is capable of efficiently addressing many issues we face in our daily lives. Applications of Al at NAVER are not restricted to CLOVA (NAVER's Al platform) or NAVER LABS' robotics. Al recommends personalized contents, products, and places to users, helps small business owners improve their business performance by giving them the means to effectively utilize their data, and assists artists and creators with various creative activities. For example, CLOVA AiCall, our customer service solution, helps small business owners handle inquiries and reservations made over the phone. Recently, it is also contributing to efforts combatting COVID-19 and to the safety of our society by making automated calls to those who have contracted COVID-19 and need periodic check-ins.

While many see AI as a helpful tool that can solve many issues we face in our daily lives, there are others who are more concerned about this cutting-edge technology. NAVER is making strenuous efforts both within and outside the company to meet social demands while remaining competitive in developing AI. NAVER has been working with Seoul National University Artificial Intelligence Policy Initiative (SAPI) since 2018 to consult external experts on a continuous basis. An outcome of this effort is the NAVER AI Ethics Principles, published in February 2021. NAVER believes our AI services are the outcome of not just NAVER's efforts in developing the services, but of various interactions between NAVER and users of our services.

This report provides a comprehensive overview of the AI technologies developed at NAVER -- natural language communication, computer vision, recommendation, and robotics. We also explain in detail the values we aim to provide to the users through these technologies. In addition, the report outlines how NAVER AI Ethics Principles were established to share our thoughts and experiences regarding AI and AI ethics with the larger AI community and society.

NAVER will continue to develop AI technologies and services with the aim of making people's lives more convenient and providing new values to our users, while striving to fulfill social responsibilities required of a global leader in AI. We would like to ask the users, members of NAVER community, scholars, external experts and stakeholders who make up NAVER's AI ecosystem for their support and advice along the journey.

Seong-sook Han Chief Executive Officer NAVER Corporation

# Foreword by Director of SAPI

As AI permeates more deeply into our daily lives and concerns related to the use of AI intensify, this report is a timely and meaningful joint effort by NAVER and Seoul National University Artificial Intelligence Policy Initiative (SAPI). NAVER has been working closely with SAPI to establish an implementable framework for AI ethics and governance, taking into consideration not only the potential AI holds, but also the varying impact it can have on different parts of society.

Building societal trust in AI is crucial especially as we enter an era driven by data and AI. Finding the 'right' answer from the start would be an impossible task. It should be noted that throughout history, when new groundbreaking technologies emerged, we have repeatedly tread a path of trial and error to find solutions that could ultimately be embraced by the wider society. We believe that it will be no different with AI.

This report is NAVER's first public communication since its announcement of NAVER AI Ethics Principles. One of the aims of this report is to provide insight into how AI is applied to NAVER's various services, and why NAVER utilizes AI. By doing so, NAVER hopes that the wider society can better understand what NAVER intends to incorporate into their AI technologies, and what knowledge and experiences it hopes to connect by applying AI technology. What is just as important will be the feedback from our society, including the readers of this report. It is through such communication that our society will be able to build a healthier digital ecosystem.

Towards the end of this report, we also provide details of NAVER AI Ethics Principles and how it came to fruition. The principles demonstrate NAVER's commitment to putting human-centered values at the core of AI development and to continuously reviewing the direction of related developments. We tried to be as detailed as possible in explaining the process by which the principles were established, perhaps even overdoing so, as we believe in the value of transparent communication.

Establishing a trustworthy AI governance framework is not just the responsibility of companies that utilize AI – it is a task that we should all take on as a society. We should facilitate in-depth discussions on what social and structural systems should be built, so that every member of society can enjoy the benefits of technological advancement in a sustainable way. Moving forward, we sincerely hope that active conversations will be held on how AI should be developed in a way that does not suppress creativity of companies and individuals in the digital age, and also does not harm the solidarity and connection among the members of society. We hope this report contributes to such conversations in the future.

# NAVER-SAPI AI Report

# 1. Al for People

Until only about a decade ago, Artificial Intelligence, or AI, was a term mostly used by scholars in the field of computer science. However, following the introduction of AlphaGo, and various other Alpowered services, the term is now widely used in many different contexts. Some use the term to refer to the training of machine learning or deep learning models, while others use it to refer to computers performing specific tasks such as playing a game of Go or driving an autonomous vehicle.

In general, the term AI is often used in areas where computers perform such intelligent tasks. However, there still doesn't exist a single clear definition of AI, as even among the experts no agreement has yet been reached. This is because while having a clear understanding of the concept of intelligence is a prerequisite for defining AI, human intelligence itself is a field that still needs further research. In one textbook on AI that is widely used at many universities across the world, the authors focus on explaining how an artifact like a computer becomes an agent capable of acting rationally in explaining the concept of AI (Russell & Norvig, 2016a). According to the authors, AI could be understood as a computer that acts as an intelligent agent that perceives the environment and takes appropriate actions.

NAVER offers a wide range of services enabled by AI. One example is CLOVA Lamp, a smart device released by NAVER in October 2020. CLOVA Lamp is a smart desk lamp embedded with AI, capable of not only providing light on books, but also reading them out loud. When a book written in Korean or English is placed open under a CLOVA Lamp, the lamp can read out the texts on the page. The lamp can also play music for some children's books (if applicable), and answer simple questions asked by a child such as "How old is the Earth?". CLOVA Lamp's ability to read books aloud is enabled by various AI technologies embedded in the device such as optical character recognition (OCR), speech synthesis which allows the device to fluently read the recognized texts, and image analysis that identifies whether the book is a pre-registered book from an affiliated publisher.

#### CLOVA Lamp by NAVER: a lighting device that can read books aloud



Various AI technologies have been incorporated into CLOVA Lamp, including OCR (for recognizing characters), speech synthesis (for fluent reading of texts), and image analysis (for recognizing books).

Source: NAVER CLOVA (https://clova.ai/ko/products/clova\_lamp.html)

CLOVA is an AI platform developed by NAVER. While the name CLOVA might sound like it was named after clover the plant, it is in fact an acronym of the CLOud-based Virtual Assistant that was jointly developed by NAVER and LINE. NAVER and LINE developed CLOVA to bring the AI technologies, contents, and services developed by each of the companies together onto one single platform. Nowadays, CLOVA is applied to a diverse line of products including CLOVA Lamp and in services for learning English, childcare, and online quizzes, contributing to making people's lives more convenient.



#### **CLOVA Platform Ecosystem**

The CLOVA platform consists of CLOVA Interface Connect that enables users who have applications and devices to use AI services, and CLOVA Skill Tools that helps them develop AI-enabled contents or services.

Al can also be used to solve many of the challenges facing our society. In 2019, CLOVA hosted a campaign entitled "Together, we walk down the flower path", in collaboration with NAVER's philanthropic service Happybean, to use Al to create a font with handwritings of a patient suffering from cerebellar atrophy, a rare, incurable disease caused by issues with cerebellum that leads to symptoms such as gait disturbance, articulation disorder, and inaccurate movements. NAVER proposed the campaign after hearing about the patient's story when the patient's daughter submitted her mother's handwriting to a handwriting contest to celebrate the Hangul Day (Korean Alphabet Day) with the hope of increasing awareness of the disease. Using computer vision and image generation technologies, CLOVA analyzed the mother's handwriting and successfully created over 10,000 combinations of characters. Her handwriting was then turned into a font and named Let's Walk Together, to emphasize that those with rare, incurable diseases are not alone and that the society will walk the journey of life together with them. The Let's Walk Together font was distributed through Happybean free of charge, and over 6,000 people made donations to support patients of rare, incurable diseases.

네이버 한글날 손글씨 공모전에 제출하신 AI 기술로 어머님의 손글씨를 글꼴로 제작한 어머님의 손글씨 함께 걸어요 글꼴 가고州 2개 파고고 가고패고깨과꼬꼬 水山午上대副制气 냐뇌누느대뒤뒈드 平町田川計三三 또뛰뜨레라류르 티드비부 의으비뷔봬브 些水分午二 有户 巡巡外分子人 99 

Let's Walk Together: Font created from handwriting using AI

CLOVA's AI technologies such as computer vision were used to create a font (pictured right) using handwritten texts (pictured left), to share unique stories behind the handwriting.

Source: NAVER Happybean (https://happybean.naver.com/goodAction/1122)

In addition to language models, NAVER also conducts research on many other AI technologies, including chatbot, optical character recognition, speech synthesis, and item recommendation. NAVER's services such as Webtoon, Shopping, Papago and VIBE use AI to analyze languages, respond to users' questions, recognize texts, and recommend news articles or products to users. The AI technologies incorporated into NAVER's services can be sorted into four categories: natural language communication, computer vision, recommendation, and robotics (see the chart below).

#### AI Technologies in NAVER Services

Category	Sub-Category	Description
Natural Language	• Chatbot	Provides the optimal answer to users' inquiries
	Machine translation	Automatically translates texts from one language to another
	Speech recognition	Converts sound into text through signal analysis on human voice
	Speech synthesis	Synthesizes texts into natural-sounding voice
Computer Vision	<ul> <li>Object tracking</li> </ul>	Tracks changes in where a certain object is located in a video
	Optical character recognition	Finds text information from photos and distinguishes their meaning
	<ul> <li>Facial recognition</li> </ul>	Locates and analyzes faces in images and videos
Recommendation	Item recommendation	Recommends items based on customer's shopping behavior
	Place recommendation	Recommends places to visit based on the user's current location
	Content recommendation	Recommends content catered to the user's taste based on his/her content experience
	Music recommendation	Recommends music after learning the user's listening patterns
Robotics	Robot learning	Performs many complex tasks through reinforcement learning
	Robot vision	Identifies location by analyzing images collected through camera sensors
	Cloud robotics	Cloud-enabled multi-robot intelligence system
	Autonomous driving	Recognizes vehicles and pedestrians with precision and predicts their route

The fact that many services provided by NAVER incorporate AI technologies shows that there are many teams within NAVER that utilize AI. In fact, nearly every team at NAVER, including search, commerce, and content, are using AI. For example, AI Painter, a newly released service by NAVER WEBTOON, uses AI to automatically color characters or backgrounds in webtoons, helping creators to become more efficient in their work. Not only the teams planning and developing technologies, but also other teams including corporate support are showing a keen interest in using AI. This interest was witnessed during NAVER's internal meeting held early 2021 to discuss the NAVER AI Ethics Principles (which will be explained in detail in Section 6). The meeting was held for employees from many different teams in NAVER who either directly use AI in their work or are simply interested, to get together and exchange their thoughts on the Principles.

Now, AI technologies are developing faster than ever. In particular, there is a new trend in the field of AI research where the volume of training data and the scale of the AI model are increasing at an exponential rate. In AI, model size, or the number of parameters, has similar implications as the level of integration in semiconductors. Similar to how semiconductors with higher levels of integration show better performance, AI models with a larger number of parameters are capable of solving a greater number of issues. As such, global tech companies are heavily investing in the efforts to develop larger, more advanced AI models. In October 2020, NAVER became the first Korean company to set up a supercomputer with 700-PetaFlop (capable of processing 1,000 trillion calculations per second), to further strengthen the infrastructure for processing massive amounts of data.

In May 2021, NAVER announced HyperCLOVA, the company's own hyperscale AI. HyperCLOVA is a hyperscale language model optimized for Korean language trained on massive amounts of data, and as a single model can be applied to perform many different tasks. NAVER has since then applied HyperCLOVA to services including search engine and shopping. For example, Ai Review Summary is a feature introduced on Smart Store -NAVER's e-commerce platform- in July 2021 that uses HyperCLOVA. For each product, it first analyzes keywords in reviews, then clusters contents with similar meanings, and finally extracts a single sentence that best describes the product. With Ai Review Summary, users don't have to read all the reviews to make their purchase decisions, as HyperCLOVA summarizes them into a single sentence for users. HyperCLOVA is also embedded in the Shopping menu on NAVER's mobile app to automatically revise product names that are too complex, and in AiMD, a collection of items curated by AI.



Al Review Summary automatically generates one-sentence reviews that best describe products

Al Review Summary analyzes keywords in product reviews to group them by theme, and then clusters sentences that use similar expressions or have similar meanings. Among the clustered sentences, representative reviews are selected, which HyperCLOVA uses to generate a one-sentence summary of all the reviews.

Source: NAVER (https://blog.naver.com/naver\_search/222447193436)

NAVER views AI as a daily tool for humanity. In other words, NAVER believes that AI should be a tool that people can easily use, and that humanity must be the highest priority for developing and using AI. So far, NAVER has been developing technologies and services to make users' everyday lives more convenient, and the same applies to developing AI. For NAVER, users are at the center of the company's standards and principles. This was also highlighted in the keynote speech by NAVER CEO Seong-sook Han at the NAVER CONNECT 2020 event, where she emphasized that "the foundation of NAVER's business is to transform cutting-edge technologies such as AI and robotics into daily tools that users can quickly and easily get their hands on."

Using our expertise and experiences in AI, we hope to provide users with explanations about AI used around us at a level easy for them to understand. We believe that providing users with a clear picture of how AI is used around us can help prevent our society from being either overly optimistic or pessimistic about AI. We will also continue to work closely with external experts to address various ethical issues surrounding AI. NAVER has previously looked into the impact of AI on our society from engineering, legal, social, economic, and philosophical perspectives with external experts.

Publication of this NAVER-SAPI AI Report that shares our experiences with AI precisely captures our such aim and efforts. The report gives a detailed overview of the following four categories of AI: natural language communication, computer vision, recommendation, and robotics, and has a separate chapter on AI ethics at the end, to share what NAVER has been working on to tackle various issues around the topic. NAVER will continue to examine the AI technologies we use from various perspectives, and share the outcome with users and the wider society. NAVER hopes that sharing our experiences with society will contribute to boosting Korea's global competitiveness in AI.

## 2. Natural Language Communication

Natural language refers to the language people use in their daily lives to communicate with each other. It is the opposite of constructed language, which refers to the language created for a specific purpose. Languages such as Korean, English, Chinese, and Japanese that are naturally used and spoken in a country or region may be categorized as natural language. On the other hand, languages such as Esperanto, which was constructed with the intention to become an international second language, or Elvish language from *The Lord of the Rings* and alien languages from sci-fi films could be classified as constructed language.

Natural Language Processing (NLP) is a technology that uses computers to analyze and process human language (Jeong 2020). NLP mechanically analyzes natural language used by humans to transform it into a format that can be understood by computers. When a computer processes natural language, it means that the computer is capable of understanding at least some parts of the language used by humans to perform tasks such as text classification, information retrieval and extraction. One common NLP application is chatbot, which provides appropriate answers to questions asked by humans.

Communication refers to the act of transmitting and receiving signals to exchange information (Russell & Norvig, 2016b). Most animals use signals to transmit messages in many situations such as when they spot a prey, see a predator approaching, etc. Humans exchange far more diverse and complex signals than animals through language, and for computers to be able to communicate with humans, they must be able to process human language.

For computers to understand human language, we need language models that can analyze and predict the statistical distribution of the language. Natural languages such as Korean or English can create an almost infinite number of sentences, and on top of that, there are many words and expressions with multiple meanings in natural language. For instance, the word 'cherry' in the sentence "...the cherry on top..." could either be referring to the fruit, or an expression that means the finishing touch. As such, a language model should be able to identify what meanings are possible for a given text and analyze each of their probabilities.

#### 2.1 Chatbot

NAVER conducts R&D on foundational NLP technologies including knowledge discovery, named entity tagging/linking, word sense disambiguation, and automatic text summarization. To further improve the performance of those technologies, we extract and establish natural language patterns from user logs and user text corpus and apply machine learning methods such as deep learning. NAVER's chatbot provides users with most suitable answers to their questions, by utilizing NLP-based cutting-edge machine learning technology that analyzes the named entity, morpheme, structure, and meaning of the input sentences. In addition to chatbots, NAVER offers various services through which computers can interact with humans such as machine translation, speech recognition, and speech synthesis.

NAVER Cloud's chatbot service is currently available on Samsung Card's mobile service for pet owners called Ajinyangi, which offers pet health and care information from veterinarians, online pet owner communities, etc. With NAVER Cloud's chatbot service incorporated into this service, users can more easily and quickly check information about their pet's health and care tips. Since simple questions can be easily answered by the chatbot, veterinarians are able to focus more on 1:1 sessions for cases that may need more of their attention. The chatbot incorporated in the Ajinyangi service also supports other languages including English, Chinese, and Japanese, so that people from countries outside Korea are also able to use the service.

NAVER's chatbot Dr. Aji & Dr. Nyangi applied to Samsung Card's Ajinyangi service



전문 수의상담 첫봇, 'Dr.아지 & Dr.냥이' 채팅창에서 궁금한 항목을 선택해보세요 전문 수의상담 챗봇 'Dr.아지'와 'Dr.냥이'가 모든 것을 친절하고 상세하게 알려 드립니다.

NAVER's chatbot offers answers to user inquiries by analyzing the meaning of the inquiries based on natural language processing (NLP) technologies. With the chatbot applied to Samsung Card's Ajinyangi service, users are able to quickly and easily check information about their pets' health and care tips, and veterinarians are able to focus more on 1:1 sessions for cases that may need more of their attention. Source: Samsung Card (https://www.samsungcard.com/personal/mobile/pet/UHPPM00114M0.jsp)

#### 2.2 Machine Translation

Machine translation refers to the process of automatically translating texts in one natural language (source) into another language (target) (Russell & Norvig, 2016b). It is an area that computers have been expected do well in since the early days of Al. However, it was only in the 21st century that machine translation started to become more widely used. This is because machine translation is in fact more complex than one would expect, as the computer must have a solid understanding of the input text in order to accurately translate the text into another language. Even simple words must be well understood to accurately translate them to another language, as they could have many different meanings depending on the context. For example, the word 'sigan(시간)' in Korean has two different meanings - 'time' or 'hour'. If the word was used to describe a 'time-consuming job(시간이 많이 걸리는 작업)', then in English it should be translated into the word 'time', not 'hour'. Likewise, if it was used to say 'I will be back in 3 hours (3시간 뒤에 돌아오겠습니다)', then the correct English translation would be 'hour', not 'time'.

The Korean language also has a system of honorifics which makes machine translation more complicated. For example, to translate the English word 'him' into Korean, the computer must not only determine who the person 'him' is referring to, but also the relationships between the people mentioned in the given text to decide whether it should be translated into an honorific term. Even a simple word like 'hi' should be translated differently depending on who says it to whom. In English-speaking countries like the United States, a child would say 'hi' to anyone regardless of their age or social status, but in Korea, different expressions are used to say 'hi' depending on the age or social status of the person being greeted. If the child is saying 'hi' to an elderly, for example, translating it to 'Annyeonghaseyo(안녕하세요)', the honorific expression for 'hi', would be more culturally appropriate than the non-honorific expression 'Annyeong(안녕)'.

NAVER's Papago team has been putting in tremendous efforts to translate the Korean language into other languages as naturally as possible. They were in fact the first in the world to add Korean honorifics mode to English-to-Korean machine translation. When 'honorific mode' is switched on, the English source text translates into Korean using honorifics. For example, the English word 'me' would be translated to 'jeo(저)' (honorific term for "me"), instead of 'na(나)' (non-honorific term for 'me'), and the English word 'you' to 'dangshin(당신)' (honorific term for 'you'), instead of 'neo(너)' (non-honorific term for 'you'), and the English word 'did' to 'haetseupnida(했습니다)' (honorific term for 'did'), instead of 'haetda(했다)' (non-honorific term for 'did'), and so on. Honorific mode was developed by training artificial neural networks on English and Korean honorific data pairs.

Papago's honorific mode gained much popularity among foreigners learning Korean. Mastering honorifics is important for gaining fluency in Korean but is in fact very difficult for foreigners when they first learn the language. Papago's honorific mode is widely acknowledged by Korean learners as a machine translator they can confidently rely on.

Papago can also translate texts in images. In October 2020, Papago introduced a feature that enables translation of texts in images, where the original texts would be overlaid with the translated texts. Before the introduction of the feature, to translate texts in an image, the texts had to be manually dragged and selected, which would then be extracted for translation and the translation would be provided in a separate area, instead of being overlaid on the image. This often resulted in inconsistent translation quality. However, with this feature, which is enabled by a deep learning based Hierarchical Text Structuring (HTS) model developed by NAVER's Papago team, Papago can directly analyze the design and sentence structure of the texts in the image, and overlay the texts with the translated texts. This image translation service can be easily used to translate road signs or restaurant menus in a foreign language, by simply taking a photo with the Papago app.



Papago Image Translation translates texts in images

Papago can translate text in image. When a user takes a photo of a sign with the Papago app (see image above), Papago Image Translation translates the texts in the image and overlays the translated texts onto the original texts, allowing the user to understand what the sign says directly by looking at the photo. NAVER's Papago team developed a deep learning based HTS (Hierarchical Text Structuring) model to enhance the translation quality by analyzing the design and sentence structure of the source text to provide the most optimal translation.

#### 2.3 Speech Recognition

Introduced in August 2019, CLOVA AiCall is NAVER's cloud-based AI customer service that combines AI technology with ARS (Automated Response System). It is a conversational AI service that uses NSpeech (CLOVA's speech recognition engine) and Neural End-to-end Speech Transcriber (NEST) to convert speech to text, and uses NLP technology to understand what the text means. It then processes what information to return, converts it into natural language in a sentence form, and delivers the sentence to the user in a realistic and natural voice using CLOVA's Speech Synthesis technology. The entire process is completed within just 0.2 second of the user finishing his/her inquiry. NAVER's Korean speech recognition and synthesis technologies have been widely recognized as top tier. Academic papers on these technologies were accepted by top-tier conferences on speech technology including INTERSPEECH 2020 and ICASSP 2020 (Ha et. al., 2020; Ryuichi et. al., 2020; Hwang et. al., 2020).

NAVER's AiCall also helped many people during the COVID-19 pandemic under the name Seongnam City CareCall Service. The service, introduced by Seongnam City Government in collaboration with NAVER, makes phone calls to people who contracted COVID-19 and are subject to periodic check-ins twice a day (at 9 am and 3 pm), to check if they are experiencing any severe symptoms. If the person does not pick up the call, two more calls are made automatically at a 10 minute interval. If all three calls are not picked up, the service sends an automatic email to a local public health center near the person. Before the introduction of the service, this used to be a job manually carried out by staff at public health centers, but they were becoming overwhelmed by the increasing number of cases. CareCall Service not only keeps a record of the conversations made in each call, but also analyzes and extracts keywords from the conversations so that if keywords indicating high risk are detected, it provides relevant advice accordingly. Government staff at Seongnam City Government said, "We expect that CareCall service will contribute to boosting the efficiency of public health centers and enable more prompt and timely response". As evidenced by this example, Al is effectively contributing to the pandemic response efforts and to the safety of people's lives.



Seongnam City CareCall Service: Al-enabled phone counseling service

AiCall, NAVER's conversational AI service, has been applied to the Seongnam City CareCall Service which makes phone calls to individuals who contracted COVID-19 and are subject to periodic check-ins twice a day, to check if they are experiencing any severe symptoms. AI extracts keywords from the conversations to evaluate if the person is at high-risk and offers real-time responses to help boost work efficiency at public health centers.

#### 2.4 Speech Synthesis

In the past, training AI to generate sounds as natural as a real human voice required 40 to 100 hours of human speech data. In November 2019, NAVER announced Natural End-to-end Speech Synthesis (NES) technology, which can generate high-quality synthesized sound with just 40-minute of speech data, allowing for quicker and easier development of voice services. Voices generated using the technology can also express emotions such as happiness or sadness. NAVER has been applying this speech synthesis technology to a wide range of services, such as Clova (smart speaker), NAVER News, NAVER Map, Papago and Audioclip. In May 2020, NAVER successfully synthesized the voice of former news presenter Oh Sang-jin to create an AI news presenter, to offer news reading service for articles published on NAVER News. As the AI news presenter was created specifically for the purpose of reading news, the exact tone and pitch patterns of the real news presenter Oh Sang-jin's voice were replicated. This was made possible with the newly developed High-quality DNN Text-to-Speech (HDTS) technology that is capable of higher quality speech synthesis technology at NAVER has now expanded from synthesizing basic emotional expressions to synthesizing a news presenter's respectable voice.



AI Voice technology applied to NAVER's news reading and chatbot services

NAVER CLOVA's AI Voice can synthesize high-quality sounds to naturally express humans' emotions and their ways of speaking. It has been applied to build services such as news reading and giving dating advice, using voices of well-known people such as former news presenter Sang-jin Oh and actress In-na Yoo.

Source: NAVER CLOVA (https://blog.naver.com/clova\_ai/221981676372)

# 3. Computer Vision

Computer vision is a technology that enables computers to see and understand the world via visual information (Kim, 2020). Humans process visual information through eyes, a sensory organ we are born with. However, computers need a visual system to 'see', as they do not have the same sensory organs as we do. When computers have vision, they can recognize letters on paper and identify faces and objects.

NAVER'S CLOVA Vision team develops algorithms that enable computers to understand and process visual information and provide new experiences to users. NAVER conducts research on various AI technologies in the field of computer vision, including image analysis, video analysis, optical character recognition, and facial recognition. The AI trained on NAVER's large database is able to extract useful information from images or search for specific images. When analyzing videos (streamed or saved), the AI automatically identifies, searches for, and edits various objects including humans, places, and scenes in the videos. When analyzing faces, the AI first identifies a face in an image or a video and analyzes various complex information such as gender, age, and facial expressions. Furthermore, using optical character recognition technology, the AI can detect and understand texts in images. NAVER CLOVA has its own text analysis technology that can identify various languages including Korean.

#### 3.1 Object Tracking

In fall 2018, NAVER Sports introduced a feature that allows users to replay home run scenes during KBO league games (the highest-level league of baseball in South Korea) on their devices, developed using CLOVA's AI technology. The feature makes use of the aforementioned computer vision technologies to enable real-time analysis of home runs during live broadcasts. This feature was developed using video and image analysis technologies that identify and analyze specific objects in each video frame.

Home Run Replay feature developed using NAVER's AI technology



Home Run Replay utilizes computer vision technologies and technologies that can read texts in videos to conduct real-time analysis of live broadcasts, automatically generating home run clips.

These AI technologies are now also applied to the pitcher's mound, batter's box, and the field. About a year later in August 2019, NAVER Sports introduced another feature called AI Score Highlight, which automatically produces clips of scoring scenes during baseball games. Unlike the previous video clips of the KBO League games that were manually edited, the AI Score Highlight feature automated the whole process of analyzing, extracting, editing, and uploading the finished clips. The feature is enabled by technologies including computer vision technology that analyzes the graphics of baseball broadcasts, and technology that identifies pitching scenes. Al is now capable of providing game highlights through real-time analysis of not only home runs, but also many other moments during baseball games including hits and base steals (*e.g.*: Kiwoom Heroes vs LG Twins AI Score Highlights [2020.11.02]).

NAVER's V LIVE is a live video platform that allows celebrities based in South Korea to broadcast live videos such as live chat sessions with fans, performances, etc. In 2018, NAVER introduced a feature called Auto Highlight into the platform, which automatically edits videos so that only scenes with a specific person are extracted and stitched together, allowing fans to watch only the scenes where a specific person (*e.g.*, from a K-pop group) that they like appears. The feature uses advanced face recognition and object tracking technologies.

The Auto Highlight feature has two subcomponents: Auto Cut and Auto Cam. Auto Cut selects only the scenes in a video where a specific individual appears and stitches them together into a new video clip. Auto Cam automatically crops a video to zoom in on a specific individual. Auto Cam tracks each member of a K-POP group in their stage performances and creates an individual fancam for each member. The technology boasts high accuracy in tracking a specific person in videos, offering fans a richer user experience. The Auto Cut and Auto Cam features have received positive feedback from fans after being applied to videos of K-POP groups such as BTS, Wanna One, TWICE, BLACKPINK, and VERIVERY.



Auto Highlight: technology which uses AI to automatically edit videos

Al-powered facial recognition technologies and object tracking technology have been implemented in V LIVE. Auto Cut only selects scenes in a video where a specific person appears, and creates a new video with only those scenes stitched together (left). Auto Cam automatically edits stage performances of K-POP groups to emulate solo fancams (right).

Source: NAVER V LIVE (https://m.vlive.tv/search?query=autocut & https://m.vlive.tv/video/185637)

#### 3.2 Optical Character Recognition

Optical character recognition (OCR) is a technology that scans hand-written or printed texts as an image file and identifies the texts in the image. This technology is often used to recognize documents and accurately extract texts from an area in the document specified by the user. For instance, verifying a business license in the past took a long time as it had to be scanned and sent in, and humans had to manually check the information in the document. With OCR technology, computers can automatically recognize and verify the texts. OCR technology is also used in many other applications, including automatic identification of license plates in self-parking lots and for scanning payment bills.

NAVER used CLOVA's AI technology to develop a high-performance OCR model, optimized for various key business activities. CLOVA OCR supports Korean, English and Japanese. For Korean and Japanese, it recognizes not only printed texts, but also handwritten texts. To recognize characters in many different forms, the CLOVA team developed its own text area extraction and recognition technologies. These technologies won first place in four different categories at ICDAR (International Conference on Document Analysis and Recognition) in 2019, the most prestigious competition in the field of OCR.

In 2021, NAVER Cloud launched CLOVA Document OCR service that is optimized for extracting desired information from business documents. The CLOVA Document OCR model utilizes natural language processing technology to learn from unstructured data (various forms of business documents), and can automatically extract key information from documents such as business name, branch name, and corporate registration number, as well as automatically classify them by category. Receipts and business licenses come in various forms depending on the issuer, which means that automatically extracting the information the user wants is often a challenging process. Using the Document OCR service, it is possible to accurately extract key information from receipts including branch information, transaction details, and payment method, by automatically analyzing the types and pattern of receipts. The OCR technology, capable of readily recognizing documents like name cards and credit cards that come in many shapes and designs, will become a core technology for businesses in the near future.



CLOVA Document OCR accurately extracts key information from documents

CLOVA OCR uses world-class AI technology to extract key information from documents with high accuracy, which can recognize nonlinear texts, italics, and cursives. OCR automatically extracts information from receipts, business licenses, credit cards and name cards, reducing the amount of time humans spend on repetitive tasks.

#### 3.3 Facial Recognition

NAVER'S AI-powered facial recognition system is contributing to improving test taking experiences. In June 2020, NAVER collaborated with Korea TOEIC (Test of English for International Communication) Committee to implement NAVER's facial recognition system in TOEIC speaking test, to prevent impersonations and to streamline the identification process. TOEIC speaking test is a test designed to evaluate English speaking ability, and is widely used by over 1,700 companies and institutes in their recruitment decisions.

NAVER's facial recognition system determines whether the test taker is the same person as the one who applied to take the test, using AI to calculate and compare the facial features of the test taker and the photo submitted in the application. The entire process only takes 0.1 second and boasts an accuracy rate of over 99%. It was also designed to improve the test taking experience, as test takers can now check in without having to enter additional information for identification such as their date of birth and examination number. NAVER plans to implement facial recognition technology with caution, focusing on areas where user demand for the technology is highest.



Facial recognition technology implemented in TOEIC Speaking

NAVER and Korea TOEIC Committee collaborated to apply NAVER's facial recognition system to TOEIC speaking test to streamline the test taker identification process and prevent stand-ins.

Source: Korea TOEIC Committee (https://www.toeicstory.co.kr/1483)

### 4. Recommendation

To recommend means to suggest that something or someone would be suitable for a particular purpose. For example, if a customer at a bookstore asks AI for book recommendations, it will select and suggest a few books that match the customer's taste. AI-powered recommendation engines are now being used in various domains including online shopping, video streaming, and social media. If a customer searches a specific book online (*e.g.*, 'Reasons for Travel' by Kim Young-ha), the AI will suggest other books written by the same author. If a customer purchases a product online, the AI will display products that are often purchased together with the product by other customers.

Al uses collaborative filtering and content-based filtering algorithms to recommend suitable items to users (Droesser, 2018). Collaborative filtering algorithm analyzes how people rated items, in order to recommend items that are highly rated by people similar to the user. For example, if user A and B liked the same video, Collaborative filtering algorithm predicts that the two users have similar tastes, and recommends videos that user A watched to user B, and vice versa. Content-based filtering algorithm, on the other hand, analyzes information about the items. To take movie recommendation as an example, content-based Filtering algorithm first analyzes features of different movies such as their director, genre and cast and categorizes them into different groups, then evaluates user's preferences to recommend movies that closely match the preferences. (Jeong, 2020).

#### 4.1 Item Recommendation

One of the domains where Al-based recommendation systems are most widely used is online shopping. Many local and international e-commerce websites have collaborative filtering algorithm embedded in their platforms to recommend suitable products to users. This algorithm creates a matrix from customer ratings of products and analyzes buying patterns of the customer to recommend items that were highly rated by customers with similar buying patterns. However, this approach is not applicable to users with little or no purchase history. To address this problem, in August 2017, NAVER launched AITEMS, a deep learning-based personalized recommendations are made with Al. AITEMS is capable of recommending products even to users who rarely shop online, as the recommendation is based on the user's behavioral data related to shopping.



#### AiTEMS recommends items by evaluating user preferences

AiTEMS filters out a set of products that match the preferences of a set of users, then analyzes each user's purchase history and profile as well as product metadata to make personalized recommendations. Users can access a more diverse range of products as AiTEMS recommends new products listed on less known websites as much as best selling items, if the products match the user's preferences. Source: NAVER (https://www.navercorp.com/promotion/pressReleasesView/24101)

#### 4.2 Place Recommendation

NAVER's Al-powered recommender system also assists users in their offline activities. If a user is looking for a place to eat in an unfamiliar neighborhood, NAVER's SmartAround service recommends places based on various information about the user and nearby businesses, such as age, gender, type of business, as well as current time and location. The service relies on an Al-based location recommendation engine named AirSPACE (Al Recommender System + Place and Context Embedded).

AirSPACE deploys AI to utilize contextual information about users, such as age, gender, and current time and location, to recommend places most suitable for them. When a user logs in to SmartAround, it first determines the most optimal radius around the user's current location, then finds places within the radius, analyzing customer ratings by time slot, age and gender, to suggest restaurants and other places of interest that best fit the user's preferences. SmartAround can also recommend various activities (e.g. performances, exhibitions, movies, one-day classes and workshops) and provide location based services such as delivery and booking on a single platform.

Since its launch in 2018, SmartAround has on average 2.5 million monthly users. According to D-Commerce Report 2020, NAVER's annual report on digital businesses operating on NAVER platform, users are more likely to visit local stores and restaurants using SmartAround than through keyword search. In addition, the conversion rate (ending in phone calls, using NAVER Map for directions, and saving the location to the user's personal favorite list) was 23.2 times higher for SmartAround than that of keyword searches. The AI technology embedded in NAVER's SmartAround is creating new growth opportunities for stores and restaurants that were previously less known or relatively less accessible to the public.

ForYou, NAVER's search service that is tailored to each user, also runs on AirSPACE. When a user searches, "famous restaurants in the Gangnam district", a list of ForYou restaurants is recommended by considering the user's preferences and top-ranking restaurants. ForYou uses matrix factorization to provide customized recommendations from user preferences. When the user clicks on one of the recommended restaurants, a responsive recommendation model based on long short-term memory(LSTM) makes recommendations for other places near the clicked restaurant.

AirSPACE is also applied to NAVER Booking, NAVER's reservation service. When a user makes a reservation for an accommodation through NAVER Booking, they will see a list of recommendations that include nearby restaurants or places to visit. For example, NAVER will recommend family-friendly restaurants or amusement parks for users who booked a kid-friendly hotel, and for users who have booked a guesthouse, NAVER will recommend places that are good to visit alone.

Every day, AirSPACE makes place recommendations to 2.2 million users and helps 45,000 SMEs (Small and Medium Enterprises) receive new clicks. Going forward, AirSPACE will be implemented in more services, to help connect more users and SMEs.

SmartAround: a location-based recommendation system that suggests places to visit based on user preferences and interests

SmartAround uses AI to recommend places for users based on information including the user's age, gender, current time and location. By suggesting places most suitable for each user instead of simply recommending most popular places, it has also created new growth opportunities for stores and restaurants that used to be less known or were relatively less accessible to the public.

Source: NAVER (https://www.navercorp.com/promotion/pressReleasesView/30274)

AirSPACE incorporated in MY Bookings

AirSPACE embedded in NAVER Booking makes recommendations based on the attributes of the accommodation booked by the user. For example, NAVER will recommend pet-friendly restaurants and cafes to users who have booked a pet-friendly accommodations.

Source: NAVER (https://www.navercorp.com/promotion/pressReleasesView/30466)





#### 4.3 Content Recommendation

In February 2017, NAVER introduced AiRS (AI Recommender System), an in-house AI-based recommendation system. As the word 'air' in the name AiRS suggests, AiRS was built with the objective of being around the users all the time to recommend useful contents. The core technology of AiRS is a quality model that uses collaborative filtering algorithm (explained in 4.1 Item Recommendation) and neural networks, to provide users with informative contents with higher user satisfaction rate. Quality model recommends content to users based on the analysis and rating of title, body, image(s), and time taken to create the content. AiRS uses collaborative filtering algorithm and quality model to recommend contents a user might like best among contents consumed by users with similar tastes and interests.

In 2019, NAVER incorporated AiRS to WEBTOON, one of NAVER's global businesses. AiRS applied to WEBTOON analyzes various user attributes including recently read webtoons, hours spent reading those webtoons, genres consumed, etc. For first-time users, an onboarding feature is activated that asks them to select preferred genres and drawing styles. Once first-time users start reading webtoons on the platform and enough data is collected about the webtoons and the users' behavior reading those webtoons, a recommendation service called 'Recommendations for You' is activated to recommend webtoons they might like based on those data. This recommender system increased user satisfaction and returning user rate to a great extent, and contributed to the success of WEBTOON in the U.S. market.



WEBTOON embedded with AiRS

AiRS (Al-based recommender system) is embedded in WEBTOON. First-time users are asked to select their preferred genres and drawing styles, based on which WEBTOON recommends stories that the user might like to read (left). Once more data is collected about the user, such as recently read webtoons, hours spent reading those webtoons, genres consumed, etc., AiRS will offer recommendations (right).

Source: NAVER (https://m.blog.naver.com/naver\_diary/222046293232)

#### 4.4 Music Recommendation

Al-powered recommendation services are also available in various entertainment services. NAVER's VIBE uses deep learning to recommend music to users, largely through two different systems. One is an item-based system, which recommends artists or songs similar to what users listen to. Recurrent neural networks and collaborative filtering are used to learn metadata of the items (songs and artists) and properties of the songs in consideration of the listening context.

The other is a personalized recommender system, which provides unique recommendations to users based on their preferences. Al creates music taste profiles for each user from their mid to long term listening patterns, and recommends music users might like by utilizing the results of learning the metadata of the user profile and the properties of songs through matrix factorization. This personalized recommender system is currently applied to features such as Mixtape, DJ Station, and New Songs You Might Like. The quality of VIBE's recommender system tends to increase with the number of users. VIBE used to recommend music based on popular songs and similar music, but now it is capable of recommending better content to users by considering the user's mood, listening context and situations.

Mixtape: VIBE's AI-powered feature that automatically recommends what songs to listen next



Using AI, VIBE recommends users songs that match their tastes or songs that are similar to the one they are currently listening to. Mixtape recommends the songs users might like or be in the mood for by learning their preferences and their mid to long term listening patterns.

Source: NAVER VIBE (https://vibe.naver.com/about)

### 5. Robotics

Robots are physical agents that perform various tasks using effectors such as arms, legs, and wheels that can apply forces to the surrounding environment (Russell & Norvig, 2016b). It is this physical property that distinguishes robots from NAVER's various online services – robots can provide useful services directly to humans in the real world. However, even to this day, robots have mostly been used only in factories. Bringing robots into our daily lives to provide services safely and efficiently is not as easy as it may sound, since our daily lives take place in a much more complex environment than in factories. To tackle this challenge, integrating AI with robotics is necessary. To this end, at NAVER LABS—NAVER's affiliate that specializes in R&D— robotics engineers and AI researchers are working closely together to develop new methods and technologies.

#### 5.1 Robot Learning

NAVER LABS capitalizes on AI to achieve natural human-robot interaction (HRI) and to make service robots readily available to the public. For example, NAVER LAB'S AROUND, a platform for service robots, utilizes reinforcement learning for robots to be able to quickly adapt to a complex environment that keeps changing. This is because crowded places like restaurants and supermarkets are full of obstacles and unexpected surprises to robots. It is also important that humans do not feel intimidated or frustrated by robots. Reinforcement learning enables robots to achieve high performance autonomous driving under various conditions and circumstances. NAVER LABS is concentrating its research efforts on practical reinforcement learning techniques to achieve both efficiency and stability.



AROUND C: an autonomous driving robot trained with reinforcement learning

AROUND C was developed to verify natural human-robot interaction by delivering coffees at cafes. The autonomous driving method that utilizes reinforcement learning reflects human preferences, enabling robots to choose the most efficient walking route and move at a speed similar to that of humans, and to smoothly avoid obstacles and reduce its speed to keep a safe psychological distance when it detects humans ahead.

Source: NAVER LABS (www.naverlabs.com/storyDetail/151)

NAVER LABS also conducts research on methods to teach human physical intelligence directly to robots. Physical intelligence is a concept proposed by Kim Sang-bae, a professor at MIT and advisor at NAVER LABS. It refers to the physical ability to perform trivial tasks unique to humans, such as the ability to perform tasks such as spreading jam on bread or taking a coin out of the pocket. While performing those tasks is rather trivial to humans, it is difficult to explain or quantify the process and principles, which makes it challenging for engineers to teach such tasks to robots. To tackle this challenge, NAVER LABS devised a creative method which enables humans to control robots through a haptic device to have them perform tasks. The data collected through this process is then used as training data for robots, thereby teaching robots the physical intelligence of humans. The process is similar to how athletes learn new skills or moves by first observing demonstrations by their coaches, then trying those out themselves. Through this training method, engineers can teach robots to perform various complex tasks.

Task Learning process that utilizes haptic devices



Through the haptic device developed by NAVER LABS, humans can demonstrate and teach movements to robots. The data collected from the demonstrations is then used as training data for robots. Using this method, robots can successfully perform tasks with high accuracy even with a single demonstration.

Source: NAVER LABS (www.naverlabs.com/storyDetail/184)

#### 5.2 Robot Vision

For robots to be able to move around by themselves and provide services, they must know where to go and which route to take. However, that is often not possible in places where GPS does not work. To tackle this challenge, NAVER LABS utilizes an AI technology called Visual Localization, which performs a real-time analysis of images through the robot's camera sensor to determine the robot's current location. It is similar to how humans often figure out their current location by observing sign boards or streets around them. NAVER LAB's Visual Localization technology is capable of determining locations with high accuracy even when there are changes in the environment, including the weather, season, lighting, space design, etc.



Visual Localization technology can determine the robot's current location even with a single photo

NAVER LAB's Visual Localization (VL) technology can identify the robot's location with high accuracy under various conditions such as the time of day, season, and shooting angle from a single photo. It works in buildings where GPS lacks precision or fails entirely. The acquisition of Xerox Research Center Europe (XRCE) in 2017 allowed NAVER to expand their technological capabilities and presence in the global market. This pictured building is NAVER LABS Europe (NLE) located in Grenoble, France, that developed the VL technology. NLE won first place in Autonomous Vehicle Challenge, second place in Local Feature Challenge, and fourth place in Handheld Devices Challenge at CVPR 2020, a premier annual computer vision event.

Source: NAVER LABS (www.naverlabs.com/storyDetail/166)

#### 5.3 Cloud Robotics

NAVER LABS believes that cloud technologies, together with 5G communication network, is key to the commercialization of service robots. NAVER LABS predicted that cloud technology would be able to control the movement of robots by utilizing the ultra-low latency communication performance of 5G communication network, which was verified by successfully demonstrating the world's first 5G robot control at CES 2019, one of the world's most influential tech events. Furthermore, in November 2020 at DEVIEW (Korea's largest developer conference), NAVER LABS unveiled ARC (AI, Robot, Cloud), NAVER's cloud-based system that connects to robots through 5G communication networks.

ARC consists of the latest algorithms and high-precision data necessary for robots to coexist with humans. Multiple robots can become more intelligent at the same time by simply being connected to the ARC via ultra-low latency communication. NAVER's cloud platform can identify the exact location and route of robots even in places where GPS completely fails, and plan and process tasks on their behalf so that it can understand and manage both online and offline environment surrounding robots and humans.

#### ARC: a multi-robot intelligence system



Multiple robots can become more intelligent at the same time by simply being connected to the ARC via ultra-low latency communication. ARC acts as the eyes of robots to identify the exact location and route even in places where GPS completely fails to work. In addition, ARC acts as the brain of the robots to efficiently plan and execute tasks on their behalf. ARC will be commercialized for the first time in NAVER's second office building.

Source: NAVER LABS (www.naverlabs.com/storyDetail/185)

Interesting things can happen when tasks originally performed by robots are transferred to the ARC system. Since the functions necessary for robots to offer services can be changed or updated directly on NAVER's Cloud platform, robots that deliver parcels in the morning can be automatically switched to do another task in the afternoon such as delivering coffee at cafes. It is also possible to simultaneously update the algorithms of all robots with new data collected by a single robot. ARC will be commercialized for the first time in NAVER's second office building, which is the world's first robot-friendly building. It is expected to serve as a global reference for how our future workspace should look like as the presence of robots become more prominent.

#### 5.4 Autonomous Driving

In 2017, NAVER LABS became the first Korean IT company to obtain a license for autonomous vehicles from the Korean Ministry of Land, Infrastructure and Transport. Since then, NAVER LABS internalized all fields of autonomous driving technology, ranging from mapping, positioning, and recognition to planning and control. NAVER LABS was able to develop the technologies at a fast rate by utilizing AI technologies including computer vision and deep learning from the start. Accurately identifying the vehicle's location, distinguishing nearby objects such as vehicles and pedestrians, and predicting routes are all examples of those AI technologies. It is also important that all these technologies work together in harmony instead of operating separately on their own. NAVER LABS is currently working on ALT Project, which utilizes advanced autonomous driving technologies to connect hubs in different cities to provide various unmanned services including delivery.

NAVER LABS has also been conducting research on High-Definition Map (HD Map), an essential element for autonomous driving. While many mapping companies usually create HD maps using mobile mapping system vehicles, NAVER LABS devised a unique method named Hybrid HD Mapping that extracts road layouts by scanning an entire city using an aircraft. Various technologies are applied to this method, including a computer vision technology that recreates a 3D space using aerial photos and a deep learning-based computer vision technology that automatically extracts vehicle lanes and road signs. These all contribute to reducing the production time and increasing the accuracy of the maps. Deep learning is also being used in technologies to detect changes to keep the HD map up to date, and in technologies that enable precise positioning even with low-cost sensors like cameras as opposed to high-end sensors like LiDAR. These technologies will play a key role in the next-generation autonomous driving ecosystem. NAVER LABS is currently providing the latest HD map data of major areas to startups, universities, and R&D labs in Korea for free, to contribute to the improvement of Korea's autonomous driving technology.

Map of Seoul with a complete road layout constructed by NAVER LABS using aerial photos



NAVER LABS created a 3D model of the entire city of Seoul based on 2D aerial images (photo above) and extracted the road layout of the entire city from the 3D model (photo below). This layout shows vehicle lanes and road signs in detail, which makes it possible to provide directions and road information based on lanes as well as roads.

Source: NAVER LABS (https://www.naverlabs.com/storyDetail/165 & www.naverlabs.com/storyDetail/175)

## 6. AI Ethics at NAVER

NAVER views AI as an everyday tool for people. This is because we believe that humanity should be the utmost priority for the development and use of AI, and that AI should be easy to use. NAVER has so far developed technologies and services with the aim of making users' everyday lives more convenient, and will continue to do so. NAVER AI Ethics Principles is a natural extension of this belief.

#### 6.1 Impact of AI on Society

While interests in what AI can achieve and expectations that it will create a significant ripple effect across the economy continue to grow, there is also an increasing interest in the social and ethical impact of AI. In this context, NAVER decided that, instead of only focusing on how to best utilize AI, it is necessary to look into how our society views AI and what they expect from AI companies like NAVER. However, as the public perception of AI is often influenced by science fiction, NAVER decided it was important to approach the issue from a practical perspective, focusing on the practical issues faced while developing AI rather than relatively abstract topics.

Accordingly, NAVER has been working with Seoul National University AI Policy Initiative (SAPI) since 2018 to consult external experts in examining the impact of AI on our society. NAVER also participated in SAPI's annual Seoul AI Policy Conference and seminars to learn about global trends in the development of AI technologies and policies, as well as discussions on the effects AI could have on the wider society including economic growth and labor, and on AI ethics. Observing these discussions happening outside NAVER served as a great opportunity to not only understand our society's awareness and requirements of AI, but also to realize the need for NAVER to actively communicate with the public about how NAVER views AI.

So NAVER came to develop its own set of principles for AI ethics. During the process of developing the principles, we tried to find the right balance between allowing for sustainable application of the principles, avoiding interruption of AI innovations, and satisfying our society's expectations for AI. Since taking into account a diverse range of perspectives is essential to finding that balance, NAVER has worked closely with external AI policy experts in the process.

In early February 2020, SAPI provided NAVER with reference material to help NAVER proceed with internal discussions on establishing NAVER AI Ethics Principles. SAPI advised NAVER to first think about the values most important to NAVER and design the principles based on those values, and at the same time collect opinions from various stakeholders from both inside and outside the company in order to establish principles that can gain the trust of our society.

Agenda Research, NAVER's industry and policy research department, collaborated with SAPI to discuss and produce a report on NAVER's AI technologies, services, and corporate philosophy. The report, which included details about the characteristics of NAVER's industry surroundings, NAVER's goals, and NAVER's vision of providing users with new experiences of connectivity through incorporating cutting-edge technologies in everyday services, ultimately served as the foundation for NAVER AI Ethics Principles.

#### 6.2 NAVER AI Ethics Principles: Directions

NAVER focused on three aspects in developing NAVER AI Ethics Principles: content, method, and practice. As much as thinking about what to include in the Principles, NAVER believed it was important to deliberate on how to construct the Principles, and how to build a sustainable implementation system.

Based on these aspects, NAVER decided on three directions for developing the Principles. Firstly, in considering what to include in the Principles, NAVER deemed it necessary to first understand what society demands from an AI company like NAVER, and explain how NAVER views AI. Also, NAVER's business philosophy and values had to be embedded in the Principles so that they can be incorporated into NAVER's company culture, instead of becoming platitudes.

Secondly, NAVER adopted a method of external collaboration in developing and implementing NAVER AI Ethics Principles. This meant collaborating with external experts, and continuing the collaboration even after implementation, to continue to address ethical issues in AI development through industry and academia cooperation. This method was a natural choice that considered both the societal demands and NAVER's industrial perspectives comprehensively.

Thirdly, NAVER believed it was important to closely examine how NAVER AI Ethics Principles are being practiced. If there are no such examples, it might be an indication that the Principles are too abstract to be used in the field. In order to prevent NAVER AI Ethics Principles from becoming estranged from the development and use of AI, it was necessary to continuously improve the Principles through real cases.

Based on these directions, NAVER collaborated with SAPI to create a set of principles that embodies NAVER's perspective on AI and could be practiced in the field. We plan to continue to work closely with external experts in implementing and improving the Principles. We believe this presents a new cooperation model for practicing AI ethics principles both within and outside Korea. NAVER will continue to develop and utilize models like this to sufficiently reflect what our society demands from AI in developing our AI technologies and services.

#### 6.3 NAVER AI Ethics Principles: Development Process

In November 2020, a draft of NAVER AI Ethics Principles was reviewed by NAVER's tech leaders, and multiple discussions were held. Some parts of the Principles were revised during this process, an example of which was a clause that stated, 'Designing a reliable and safe service'. While the word 'reliable' was initially chosen to highlight the word that comes next, 'safe', concerns were raised that the word 'reliable' in Korean could be interpreted to instead mean 'trustworthy,' which is a larger concept that is often regarded as one of the final objectives of AI Ethics. As we did not want to cause confusion in interpretation, NAVER revised the clause to 'Accounting for safety in service design' after extensive discussions with SAPI.

NAVER and SAPI then made final revisions in late 2020 and planned to announce the Principles internally and externally. We decided to first host a company-wide meeting to collect feedback about the Principles especially from employees who develop or use AI in their work, then announce the NAVER AI Ethics Principles to the public through a webinar.

On February 3rd, 2021, NAVER and SAPI hosted the company-wide meeting online. One month prior to the meeting, Executive Leaders at NAVER recommended members from their respective teams to participate and provide expert opinions on the Principles. The meeting also served as a valuable opportunity to realize once again that all teams in NAVER view AI technology central to their work to the extent that it is impossible to separate AI from their work.

#### 6.4 NAVER AI Ethics Principles: Details

On February 17th, 2021, NAVER announced the NAVER AI Ethics Principles to the public in a joint webinar with SAPI. Since the values and philosophy of the NAVER AI Ethics Principles reflect that of NAVER, the same values and philosophy can be found in NAVER's other external presentations and company introduction materials. For example, NAVER's CEO Seong-sook Han stated during the NAVER CONNECT 2020 event, "The essence of NAVER's business is enabling anyone to quickly and easily use cutting-edge technologies such as AI and robotics by transforming them into tangible daily tools." Also, description of Project Flower, NAVER's project to support SMEs and creators, on the company website states, "NAVER Project Flower is about promoting the value of niche content, diamonds in the rough, and more. It's about the collective fountain effect of such individual successes", pointing out that diversity is a core value that should be recognized in our society.

#### NAVER Artificial Intelligence Ethics Principles

NAVER will create cutting edge artificial intelligence ("AI") technology that can be easily and conveniently used as a daily tool by everyone. We wish to open new possibilities and opportunities by continuously striving to provide users with new experiences of connectivity. To this end, every one of us at NAVER will respect the following ethics principles in developing and using AI.

1. Developing	NAVER develops and uses AI as a daily tool for humanity. NAVER will prioritize human- centered values in developing and using AI.		
Human-centered Al	We have developed technology with the purpose of improving the daily lives of our users. We are also advancing AI so it can be used as a daily tool by people. We recognize that while AI can make our lives convenient, it is also not infallible like all other technologies used today. We will continuously follow and improve our AI so that it can be used as a daily tool by humanity.		
2. Respecting	In consideration of the value of diversity, NAVER will endeavor to develop and use AI that does not unjustly discriminate against anyone, including our users.		
Diversity	We have created technology and services that enable connections to carry greater meaning through diversity. Throughout this process, we have provided various new possibilities and opportunities for users and endeavored to prevent undue discrimination that cannot be reasonably justified. We will continue this commitment as it relates to our AI services by striving to prevent unjust discrimination and providing experience and opportunities in which diverse values coexist.		
3. Balancing Reasonable Explainability with Convenience	NAVER will assist the convenient use of AI, while also fulfilling our responsibility to provide reasonable explanation to users when they interact with AI in their daily lives. NAVER acknowledges that the method and level of reasonable explainability for AI can vary, depending on the context in which the AI is used, and will take this into consideration as we endeavor to achieve this objective.		
	We do not view the AI we develop as a technology for technology's sake, but a tool that anyone should be capable of using with ease regardless of whether they have technical knowledge. While pursuing convenience in the service we provide, NAVER will also endeavor to explain our AI service in a manner that users can easily understand upon their request or when necessary.		
4. Accounting for	With safety in mind, NAVER will design AI services that do not cause harm to people at any stage of the service.		
Safety in Service Design	We will pay attention to safety during all stages of designing and testing our services, including after the service is deployed, to prevent a situation where AI as a daily tool threatens life or causes physical harm to people.		
5. Protecting Privacy and Data Security	In the process of developing and using AI, NAVER will endeavor to protect the privacy of users beyond the responsibility and obligation proscribed under law that protects personal information. In addition, NAVER will apply designs in consideration of data security during all stages of our AI service, including its development.		
	NAVER actively promotes the protection of users' privacy beyond what is required and obliged under the law protecting personal information. We also apply designs in consideration of data security during all stages of our services so that users do not have to be concerned about data breaches while using the services. NAVER will endeavor to allow users to freely utilize our AI services to make their lives more convenient without having to be concerned about their privacy and data security.		

NAVER AI Ethics Principles, developed jointly with SAPI, reflect NAVER's views on AI and its business philosophy, and consist of a preamble and five principles. The five principles are as follows: ① Developing Human-centered AI, ② Respecting Diversity, ③ Balancing Reasonable Explainability with Convenience, ④ Accounting for Safety in Service Design, and ⑤ Protecting Privacy and Data Security.

The phrase in the preamble, 'technology that can be easily and conveniently used as a daily tool by everyone', not only reflects NAVER's perspective on AI, but also embraces NAVER's business philosophy on connection, challenge, and diversity. The last sentence of the preamble emphasizes that all employees at NAVER shall observe the Principles.

The first principle declares that the development and use of AI should be human-centered, meaning that AI should be developed and used to benefit people. It states that NAVER will make human-centeredness its top priority in the development and use of AI, and that while technology can make our lives convenient, it is also not infallible. Additionally, it underscores NAVER's direction towards continuously overseeing and improving AI so that it can be used as a daily tool for people.

The second principle highlights the value of respecting diversity. Diversity is a value that amplifies the importance of connection and is important to NAVER as a technology platform. NAVER's search service is fundamentally based on diversity. If there were no diversity and only one type of information or product existed, there would be no need for search to begin with. NAVER included diversity in its AI Ethics Principles because it believes in the importance of diverse and unique creators and entrepreneurs, thereby connecting more diversities.

The third principle stipulates the duty to explain AI services as a way to realize transparency, which is a principle put forth in many AI principles both within and outside Korea. However, we were concerned that the convenience of service could be reduced if the explanation about how the AI behind the service works is too excessive or difficult to understand. Therefore, while pursuing convenience in developing AI services, we will provide explanations about the services in a way that users can easily understand upon request or when necessary.

The fourth principle specifies that protecting people's life and physical safety will be the safety standard based on human-centered values. Specifically, it states to make people's safety the priority in designing AI services, and to continuously pay attention to safety during all stages of designing, testing, deploying of the services, as well as post-deployment.

The fifth principle, in line with the NAVER Privacy Center's Principles for Protecting Personal Data, states NAVER will endeavor to protect privacy beyond the responsibility and obligation proscribed in privacy laws. It emphasizes that the rule of Privacy by Design will be applied from the very early stage of designing AI services, just as it is being applied in developing other (non-AI) NAVER services. Here, Privacy by Design refers to the designing of services with built-in privacy protection measures.

#### 6.5 Next Steps

NAVER has considered several ways to implement NAVER AI Ethics Principles in practice. In the end, we decided to conduct several phased experiments, which is in line with NAVER's culture.

Firstly, NAVER plans to create a convenient internal communication channel to facilitate discussion on issues related to NAVER AI Ethics Principles when developing AI services. It will be a space to freely ask questions and exchange ideas, and also receive help from outside experts like SAPI if necessary. Once the operation of the communication channel becomes more structured, we hope and expect to have a wider range of employees participating in the discussions.

Secondly, NAVER plans to publish two joint reports with SAPI — one containing case studies of where and how the AI Ethics Principles were applied, and a more general progress report on our implementation of the AI Ethics Principles including forementioned case studies and also future directions for the Principles, etc. Through this effort, we hope to be able to both affirm the value of the AI Ethics Principles and continuously improve them by adding clauses where necessary.

Thirdly, NAVER plans to create a program to share our experiences in designing and implementing NAVER AI Ethics Principles with startups. While NAVER can afford to work with external experts to establish the Principles, it is realistically difficult for startups to make such efforts. Since AI is not an area where social responsibility can be avoided based on company size, we hope to create an opportunity where our reflections and know-hows on AI ethics and our external network can be shared with startups. Through this, we hope that startups will be able to establish their own AI ethics principles that fit their company philosophy, and also consider ethical issues about AI from various perspectives.

NAVER believes the NAVER AI Ethics Principles is only the first step. We will ensure that the Principles do not end up being platitudes, and will be embodied in our corporate culture so that our employees can observe them with ease in their daily work. NAVER will also continue to cooperate with external experts on AI ethics, to be able to lead in this area as well as in AI technology. NAVER will explain and present AI in a way that can be easily understood by users and the wider society, while also cooperating with external experts to consider and find suitable solutions for ethical issues surrounding AI technology and services we develop. We plan to closely track such processes to turn them into a resource that anyone can access such as this NAVER-SAPI AI Report, as we believe NAVER's views and experiences on AI should also be the asset of the wider society. We hope our efforts can contribute to boosting Korea's competitiveness in AI.

# 7. Beyond Connect

In this report, we have described the AI technologies incorporated in NAVER's various services in four categories: natural language communication, computer vision, recommendation, and robotics. We have also explained what NAVER has been working on regarding AI ethics.

Natural language communication between humans and computers is enabled by language models, through which computers understand human language, answer users' inquiries, translate texts from one language to another, and synthesize voices. NAVER's services powered by natural language communication include chatbot, machine translation, speech recognition, and speech synthesis. Chatbot is a technology that provides optimal answers to users' questions, and machine translation automatically translates texts from one language to another. Speech recognition converts a person's voice signal into text, and speech synthesis synthesizes input text into human speech.

Computer vision enables computers to see and understand the world through visual information. Object detection and tracking technology tracks changes in the location of a specific object in an image. Optical character recognition technology automatically recognizes typed, handwritten or printed text from scanned documents and images. Facial recognition technology maps, analyzes, and confirms the identity of a human's face in an image or video.

Al can recommend items to users through Collaborative Filtering and Content-based Filtering algorithms. NAVER offers various recommendation services including AiTEMS, AirSPACE, AiRS, and VIBE. AiTEMS recommends products to consumers by analyzing user preferences based on consumers' shopping behavior. AirSPACE recommends places to visit based on the user's current location. AiRS recommends suitable content to users by analyzing their preferences. VIBE recommends songs based on the user's mood, the listening context and situation.

NAVER conducts R&D on robotics to offer useful services through both online and offline channels. NAVER LABS capitalizes on AI technology with the goal of achieving natural human-robot interaction (HRI), and to make robots more readily available to the public. This report covered reinforcement learning, Visual Localization, ARC system, and Hybrid HD Mapping, which are some of the major AI technologies used in today's robotics.

Finally, this report gives an account of how NAVER thinks about AI Ethics and examines NAVER AI Ethics Principles in detail. Going forward, NAVER will continue to strive to provide our expertise and experiences in AI as an asset to everyone in our society.

#### References

- 1. Kim, Jin-hyeong (2020), <sup>®</sup>The Best Lesson on Al<sub>J</sub>, Maeil Business Newspaper.
- 2. Jeong, Yong-chan (2020), <sup>r</sup>Understanding Al Algorithm<sub>J</sub>, CommunicationBooks.
- 3. Droesser, Christoph, <sup>r</sup>Total berechenbar? Wenn Algorithmen fuer uns entscheiden<sub>J</sub>, translated by Jeon, Dae-ho (2018), Henamu.
- 4. Russell, Stuart, and Norvig, Peter, <sup>®</sup>Artificial Intelligence. 1: A Modern Approach<sub>J</sub>, translated by Ryu, Gwang (2016a), Jpub.
- \_\_\_\_\_, <sup>r</sup>Artificial Intelligence. 2: A Modern Approach<sub>J</sub>, translated by Ryu Gwang (2016b), Jpub.
- Ha Jung-woo, Nam Kihyun, Kang Jingu, Lee Sang-Woo, Yang Sohee, Jung Hyunhoon, Kim Eunmi, Kim Hyeji, Kim Soojin, Kim Hyun Ah, Doh Kyoungtae, Lee Chan Kyu, Sung Nako, Kim Sunghun (2020), ClovaCall: Korean Goal-Oriented Dialog Speech Corpus for Automatic Speech Recognition of Contact Centers, INTERSPEECH 2020.
- Ryuichi Yamamoto, Song Eunwoo, Kim Jae-Min (2020), Parallel WaveGAN: A Fast waveform generation model based on generative adversarial networks with multi-resolution spectrogram, ICASSP 2020.
- Hwang Min-Jae, Song Eunwoo, Ryuichi Yamamoto, Frank Soong, Kang Hong-Goo (2020), Improving LPCNet-based Text-to-Speech with Linear Prediction-structured Mixture Density Network, ICASSP 2020.
- NAVER (2019), <sup>r</sup>D-Commerce Report 2019, https://www.navercorp.com/value/research/ view/7
- 10. SAPI (2021), <sup>r</sup>Seoul National University AI Policy Initiative Report 2017-2020」, http://sapi.co.kr/blog/2021/04/21/sapi-활동보고서2017-2020/

#### **NAVER-SAPI AI REPORT**

**Date of Publication** Nov. 28, 2022 Original Korean material published Nov. 29, 2021

Authors NAVER Agenda Research Seoul National University Al Policy Initiative

This report is not available for sale. Unauthorized disclosure, distribution, copying, or use of any or all material may infringe copyright.

