# Creation of Artificial Intelligence Services through Open Innovation

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## Abstract

Amid growing expectations of service creation using artificial intelligence (AI), the NTT Group has announced the adoption of corevo® as a unified brand name encompassing the AI technologies born out of its research and development (R&D) efforts and the initiatives applying those technologies. The NTT Group aims to create new value using corevo in collaboration with a variety of partners. This article introduces the directions in R&D to drive the evolution of elemental AI technologies making up corevo and outlines NTT Group initiatives toward the creation of AI services through open innovation.

*Keywords: artificial intelligence, corevo, open innovation*

## 1. Introduction

With the aim of accelerating collaboration with a wide variety of partners in the field of artificial intelligence (AI), the NTT Group has unified its AI-related technologies and the initiatives using those technologies under a new brand name called corevo®. This word, meaning collaboration + revolution, evokes the idea of promoting innovation through a collaborative effort with a variety of players [1].

NTT classifies the AI technologies that make up corevo into four types: Agent-AI, Heart-Touching-AI, Ambient-AI, and Network-AI [2]. This classification reflects the type and meaning of the data handled by each AI and the functions and value provided. For example, Agent-AI deals mostly with media data including human speech, language, actions, and facial expressions, and features the ability to converse with humans. Ambient-AI, meanwhile, deals mostly with sensor data obtained from various types of equipment and environments such as automobiles and production facilities and aims to predict and control the near future.

Yet regardless of these four classifications, AI technology today is based for the most part on machine learning typified by *deep learning* and depends on data collection for achieving AI services. With this in mind, we have organized the elemental technologies needed for achieving AI services, that is, AI elemental technologies, data processing technologies, and data collection technologies, into the four layers shown in **Fig. 1** as an AI service architecture.

Here, the main role of data collection technologies making up the lowest layer is to gather data from the outside. This layer can also be treated as one made up of Internet of Things (IoT) technologies that are attracting attention today along with AI. The next higher layer consists of basic data processing technologies such as machine learning for processing the data collected in the lower layer. Continuing upward, the next layer consists of AI elemental technologies that apply those data processing technologies to perform tasks such as identification and inference as needed by services. Finally, the highest layer consists of AI services that are based on the processing results of the lower layers. Organizing the elemental technologies for AI services in this way makes it easy to understand that the four types of AI described above are not substantially different when it comes to configuring services.

In other words, Agent-AI, Heart-Touching-AI, Ambient-AI, and Network-AI are not necessarily independent when thinking about the final service configuration. For example, when conversing with a human by Agent-AI, it is sufficient to think of information obtained from peripheral equipment and the

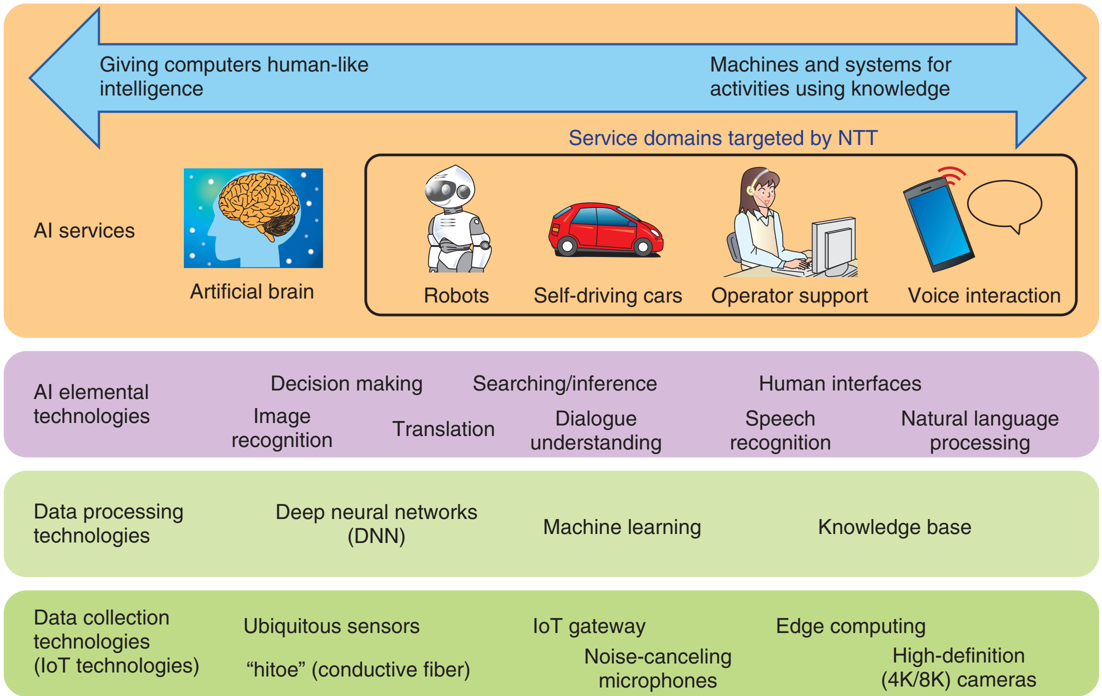


Fig. 1. AI service architecture.

environment as a knowledge source. Information predicted by Ambient-AI, meanwhile, can be used not only to control equipment but also to provide beneficial outcomes by presenting it to humans. That is, when viewed from an Agent-AI perspective, Ambient-AI can be treated as a knowledge source, but when viewed from an Ambient-AI perspective, Agent-AI can be treated as an advanced user interface. In this way, the linking and merging of these four types of AI will become a necessity as the demand for more advanced services grows. NTT is committed to researching and developing ways of linking and merging these four types of AI.

## 2. Evolution of AI elemental technologies

Each of the layers in the AI service architecture described above is considered to be evolving toward more advanced AI services. For example, we can expect data collection technologies to become more ubiquitous as sensors become smaller and use less power, which should drive progress in data conversion techniques enabling the integrated use of diverse types of data. Similarly, we can expect progress in data processing technologies as in dedicated hardware and distributed processing to enable high-speed processing of even larger volumes of data.

In parallel with these technological advances, the NTT laboratories will promote research and development (R&D) toward the evolution of AI elemental technologies. Although there are many AI elemental technologies in corevo that are already being put to practical use, we do not consider them to be complete technologies. For example, speech recognition technology has already been introduced in voice mining systems for call centers, where it has been shown to be sufficiently accurate for analyzing the trend of a received call. Nevertheless, considering that a call center will automatically perform a knowledge search based on the content of a call, erroneous recognition would tend to lower search accuracy in subsequent steps, so improving recognition accuracy even further is desirable.

Expanding the scope of speech recognition technology as in multilingual support and handling of regional dialects is also desirable. Our aim is to improve the accuracy and utility of these AI elemental technologies by combining the collection of large volumes of data with a high-speed processing platform and promoting model construction and tuning.

The AI elemental technologies making up corevo are wide-ranging, but R&D toward the practical use

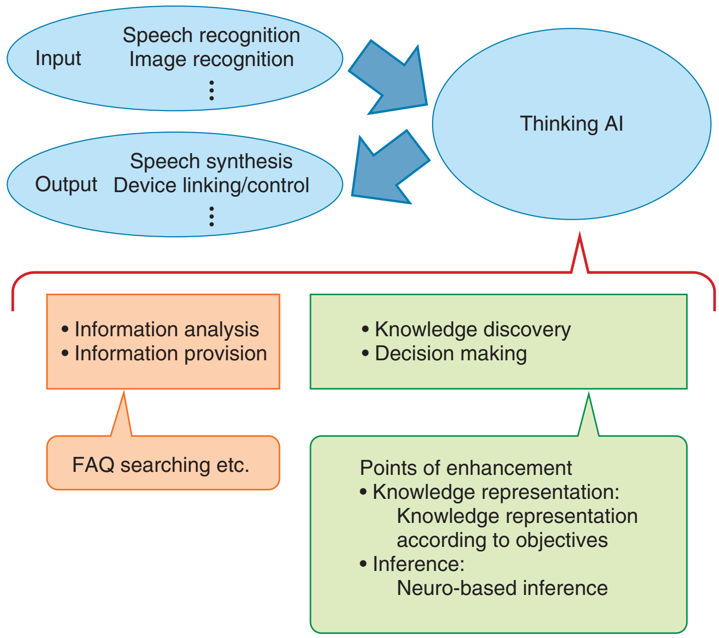


Fig. 2. Enhancement of Agent-AI elemental technologies.

of these technologies is moving ahead, particularly in the area of connecting people and computers. In terms of the four types of AI introduced above, this area would coincide most with Agent-AI. In addition, R&D within Agent-AI itself is focused on technologies such as speech recognition, image recognition, and device linking/control that involve input and output for interacting with the outside world. These are important elemental technologies for achieving AI services that *get close* to people (are considerate of human feelings), but achieving advanced AI services will require AI that understands input information and uses a variety of knowledge sources to derive output information.

We call this *thinking AI*, where *thinking* in this case refers to a processing mechanism achieved by a computer that corresponds to functions similar to those performed by humans. These would include basic processes such as comparing and analyzing the relationships among various items of data and then determining which are the same or different, judging which are good or bad, and classifying, associating, and surveying that data. We consider that thinking AI can be achieved by uncovering patterns of these functions through analytical analysis and machine learning such as deep neural networks for large volumes of data.

In fact, in applications such as frequently asked questions (FAQ) searching based on natural language queries, progress has already been made in using large volumes of data to learn semantic closeness from a linguistic viewpoint so that an explicit question can be understood and an appropriate reply returned [3]. Our plan going forward is to enhance our R&D efforts toward AI that can achieve even higher levels of knowledge discovery and decision making (**Fig. 2**).

## 3. Service creation through open innovation

The application scope of AI technology is extensive. In the future, it is not inconceivable that AI will be applied to services in all kinds of fields. However, at the current level of technology, the scope of applicability is limited. It is therefore necessary to search for areas in which the use of AI technology is likely to produce a substantial effect while increasing the potential for application by improving the accuracy of the technology. The technologies needed to configure AI services are likewise many and varied, and it is unrealistic to expect the NTT Group to cover all of those technologies. Open innovation with partners that can complement the NTT Group in terms of service ideas, know-how, field (data), and technology is therefore essential for the creation of AI services.

At present, the NTT Group is promoting collaboration with many partners with the aim of creating services based on the B2B2X (business-to-business-to-X) business model. In the AI area, meanwhile, technology development and business creation are moving forward in the key areas of customer service, facilities maintenance support, healthcare and wellness, and hospitality services (navigation).

### 3.1 Customer service

The call center business is presently attracting attention as a very promising area for application of AI technology. For a business enterprise, a call center is an important point of contact with its customers, but the load on operators can increase as the quantity and complexity of products and services increase. As a result, operator turnover is high, while much time and effort is needed to train new people, and this presents major problems for call center businesses.

Efforts are underway to solve these problems at the NTT laboratories, and they have developed technologies such as voice mining and FAQ searching to support operators and supervisors. These technologies are already being put to use in actual services at many call centers [4]. Furthermore, as part of this trend, there are high expectations for automatic call reception by AI as a means of making call center operation even more efficient and for saving labor. The Feature Articles in this issue include an introduction to NTT's COTOHA$^{\mathrm{TM}}$ communication engine for achieving automatic responses by AI [5].

### 3.2 Facilities maintenance support

Maintenance and inspection of production facilities/equipment at plants and of infrastructure facilities/equipment have often been dependent on the intuition and experience of veteran technicians. However, the baby boomer generation reached 65 years of age in 2012, and the decrease in the number of veteran technicians is becoming a major issue. As a result, there are also expectations in the facilities maintenance field to use AI technology to make business more efficient and advanced. In response, the NTT laboratories are developing technology for inferring the degree of wear in manholes using image analysis and working on advanced facilities maintenance through the use of three-dimensional point cloud data [6]. These Feature Articles also introduce work on detecting equipment anomalies by expanding NTT-developed acoustic technology to analyze sounds emitted by equipment [7].

### 3.3 Healthcare and wellness

The population aging rate in Japan (the population ratio of people age 65 or older compared to the total population) exceeded 21% in 2010, marking the arrival of a super-aged society and making healthcare and wellness an important theme. The NTT laboratories are researching the prediction and prevention of lifestyle-related diseases, dementia, and other conditions by reading and interpreting a person's physical and mental state by linking and interacting with medical and healthcare equipment and providing effective feedback. Under the themes of health management support using communication robots and therapeutic-recreation support, we are conducting trials in collaboration with hospital-affiliated universities and nursing institutions to identify issues and test the utility of developed technologies and services [8, 9]. These Feature Articles introduce technology for predicting patient behavior through the use of medical data in collaboration with university hospitals [10].

### 3.4 Hospitality services (navigation)

Hospitality services, while covering a conceptually broad area, are aimed at guiding the user to the information or location desired in real or virtual space in a safe and comfortable manner. In Japan, it is a theme driven not only by the growing number of foreign visitors to Japan and the need for regional revitalization but also by expectations that hospitality services can help enrich our daily lives.

Against this background, the NTT Group has been conducting trials involving tourism, event guidance, and other scenarios using device integration services [11]. These Feature Articles introduce two key activities in this area. The first involves the provision of information based on an image taken by a smartphone [12]. This makes it easy for the user to access desired information simply by inputting an image in settings where text or speech input is difficult. The second activity involves the inference of a person's destination or potentially dangerous driving from that person's mobility history or automobile driving data [13]. The aim here is to support safe and comfortable mobility.

## 4. Future prospects

The NTT Group is promoting open innovation in a variety of fields toward the creation of AI services using AI technologies under its corevo brand name. Initiatives for applying these services to actual business efforts have been launched, but many are still in the trial stage. Looking to the future, we will continue to promote open innovation with a variety of players with the aim of developing AI technologies and creating services that can truly help to solve social problems and strengthen industrial competitiveness.

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