

# Basic Research in the Era of Artificial Intelligence, Internet of Things, and Big Data—New Research Design through the Convergence of Science and Engineering

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## Abstract

To build a productive relationship between humans and artificial intelligence (AI), we must grasp the current situation as accurately as possible and make investments in the future toward developing such a relationship. This article introduces how we see and interpret the AI, Internet of Things, and big data era from the standpoint of promoting research and development of basic technologies.

*Keywords: artificial intelligence, Internet of Things, big data*

## 1. Artificial intelligence that approaches and gets closer to people

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In the Future of Go Summit held in May 2017, the artificial intelligence (AI) program AlphaGo competed against and defeated China's 18-year old Ke Jie, the world's number one ranked *go* player. AlphaGo produced three solid, consecutive wins against Ke to win the best-of-three match. Computer AI programs had already defeated humans in chess and *shogi* (Japanese chess); however, because *go* is more complex than chess or *shogi*, it was said that it would take more than 10 years to develop an AI program that could defeat *go* professionals. However, the calculation abilities of AlphaGo quickly exceeded human capabilities.

This event in the world of games provides a suitable lesson for us to think about for the future. A new partner has come into our lives, and from now on we will have to share our lives with such partners. This may seem bothersome at first, but, whether we like it or not, we now have to put our heads together and find ways of building appropriate relationships with these

new AI devices.

## 2. A new future emerging from convergence of AI, Internet of Things, and big data

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The convergence of three fundamental elements—new data technology known collectively as AI, new data infrastructure called the Internet of Things (IoT), and vast collections of data of unprecedented size and quality known as big data—is now having a major transformative impact on the world [1]. Yet today we can only foresee a tiny fraction of the services and technologies that might arise in the years ahead, so we must rack our collective brains to come up with possible applications and to consider the potential impacts on society. Convergence of AI × IoT × big data will open the way to global-scale technological infrastructure in two basic ways: digitization of information permitting precise replication of data, and global networking that enables simple accumulation and dissemination of data (**Fig. 1**). As we build on this infrastructure, we are poised to create a new future with machine learning and algorithms for processing

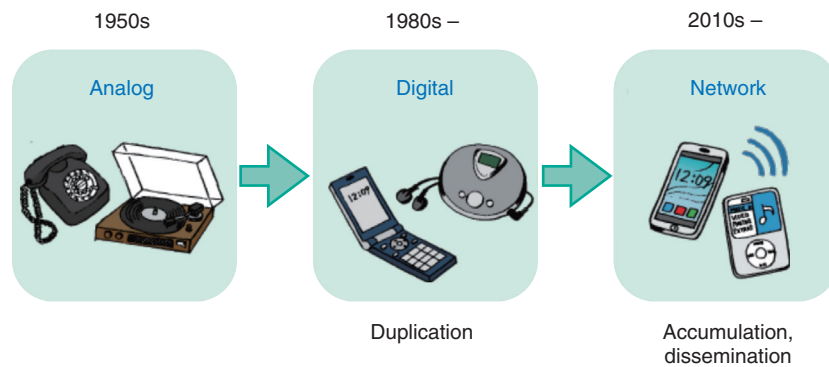


Fig. 1. Evolution of technology.

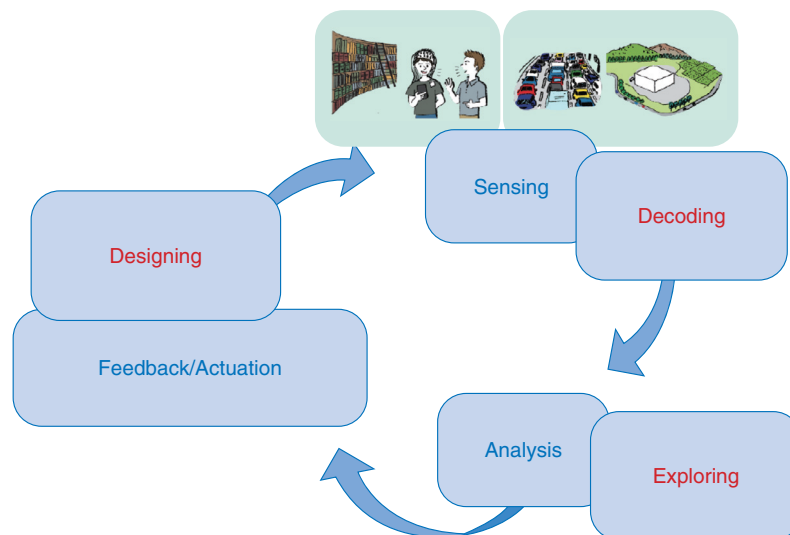


Fig. 2. Decode, explore, and design.

information.

### 3. Cycle of decoding, exploring, and designing

Data encompassing everything under the sun—people, things, environments—are acquired, decoded, explored, then designed and fed back to society (Fig. 2) [2]. Intelligence is modeled from every conceivable type of data related to real people, for example, writings, actions, speech, images, sounds, biological reactions, muscle activity, and brain activity. As this process unfolds, the day is fast approaching when intelligence will be able to be broken up and reassembled as components that can be treated as products on the open market.

Pure science and engineering have always been pursued as independent disciplines, but this is now undergoing a major change caused largely by the developments outlined above. With the availability of low-cost sensing and intelligence, we are now able to amass vast amounts of basic scientific data across a wide range of fields within a remarkably short period of time, which can readily be applied to engineering tasks thanks to more reliable processing and analysis.

At the same time, however, this is creating a need for people who are skilled in reading raw data, designing experimental plans, and performing tasks in other empirical sciences in engineering fields such as signal processing and data analysis. The former might be called *engineering of science*, while the



Fig. 3. Navigating real-world data.

latter is the *science of engineering*. Feedback loops from science to engineering to implementation and back to science repeat to become ever thicker, and the sequence revolves at an ever faster rate. Thus, even areas of scientific research that up to now have been conducted in idyllic independence must be strategically reexamined in terms of overall economic efficiency.

#### 4. Who steers the real world

The AI boom will eventually lose momentum, but even at a slower pace, it will continue to make steady progress [3, 4]. What ultimate vision can we anticipate in the future? Just as Marvin Minsky, the father of AI, sought to peer inside the brain to unravel the secret of intelligence, it should soon be possible for ordinary non-specialists to easily access and view the world's data. People will be able to view and manipulate and control a full range of decoded data going well beyond mere sounds and photographic images. Even today we see young children, only two and three years old, who are surprisingly adept at playing with tablet computers and watching YouTube videos and other content. In much the same way, we can fairly assume that you and I—ordinary people—will be able to navigate real-world data with nothing more than a tablet computer in the not-too-distant future (**Fig. 3**). Whether this is good or bad, it certainly suggests that we are moving toward a more open democratization of information.

#### 5. Communication science that enables corevo®

The NTT Group recently rolled out a new AI brand

called corevo®. We are proud to see corevo on the market, for this new technology is largely based on basic research from our labs, NTT Communication Science Laboratories. The Feature Articles in this issue introduce some of our latest findings and research results [5–9].

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