NEC's Vision for AI in Social Value Creation

For the past several years, the world has witnessed an explosion of activity in the domain of artificial intelligence that has been termed the 3rd AI boom. NEC has devoted over half of a century of research and development to the field of AI that has culminated in the development of NEC the WISE - an array of cutting technologies including machine recognition and natural language parsing. By examining the undercurrents that have driven our development of NEC the WISE including the concepts and directions for future AI research and development from the perspective of the three functions of AI: Recognition, Optimization and Reasoning, this article will introduce the reader to the expanded customer value and our approach to developing solutions to issues facing society that NEC aims to achieve through AI.

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1. Introduction

Beginning in the 1950s, AI research and development has aspired to creating "thinking machines" that can flexibly and rationally respond their environment like human beings. With the explosive increase in data that accompanied the arrival of the Information Revolution and the establishment of machine learning tools that enable efficient analysis of these data, the 3rd AI Boom has steadily gained momentum. From the enhancement of the efficiency of complex systems like autonomous driving systems and grasping even indistinct indications such as abnormal operation detection to even engaging people in a dialog, the application scope of AI is expanding to a degree unmatched by previous booms in development.

In response to the increasingly complex and highly sophisticated issues facing our society, NEC has developed NEC the WISE - a suite of state-of-the-art AI technologies founded on our strong belief in solutions that apply profound wisdom derived from the collaboration of human beings and AI. The inclusion of the phrase "the Wise" (people of wisdom) in the naming of our technology expresses NEC's aim of building a brighter world through the appropriate combination of diverse AI technologies to complement human capabilities and assist in the operation of various social systems. This special issue will introduce social innovation that we aim to achieve through NEC the Wise and the cutting-edge AI technologies that will support these changes.

2. Creation of Social Value through AI

In order to solve the complex social issues created by the six highly intricate and interlinked megatrends, NEC has set for itself the challenge of Seven Themes for Social Value Creation[1]. The factor shared in common by these seven value domains is how various social systems are making demands on their performance and efficiency far beyond the operation levels that have hitherto been provided by experienced workers with long years of experience. For this shortage of human resources with the needed advanced skills, the realization of a social system that offers safety, security, efficiency and equality far above current levels can only be achieved by the expansion of capabilities and productivity the individual. Here is where we see AI playing a key role.
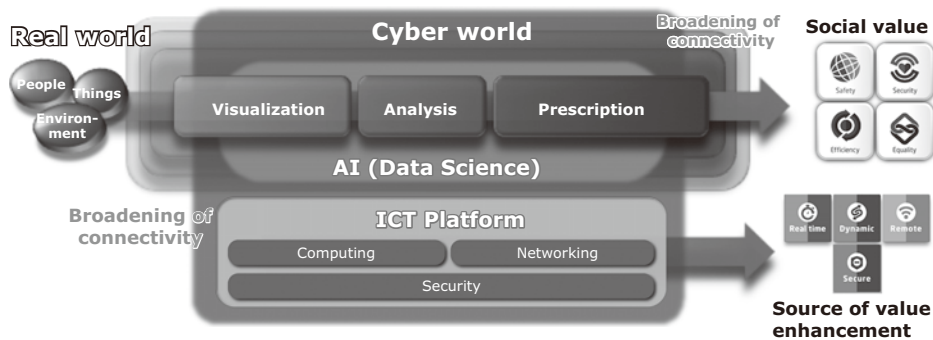
Fig. 1 Cyber Physical System (CPS) framework for social issue solutions.

In order to solve these social issues, we have established a concept for a working framework called the Cyber Physical System (CPS) (See **Fig. 1**).

In CPS, we will employ IoT technologies (various sensors) and convert "fresh" real world situations into digital data. These data will be recognized/understood and analysed by various AI technologies, and then action plans will be formulated to determine the best course of action in response to the real world circumstances. Finally IoT technologies (various types of actuators) are again used, and the results of the decision-making process are translated into real world execution.

Supporting this chain of steps will be 3 types of functions performed by AI: Visualization (Recognition/Understanding), Analysis (Forecasting/Deduction), and Prescription (Planning/Optimization). Through our application of statistical mathematical science and machine learning, we have created these functions from our exploration and exploitation of Big Data technologies. In order to provide these functions to the real world, technological innovation of the ICT platform supported by AI is also demanded; the computing technology that supports advanced processing, the network technology that links widely distributed data and processing modules, and the security technologies that protect data flowing through the system. NEC is also tackling the development of these advanced technologies in parallel with AI technologies.

During our over half-century of development of AI-related technologies, NEC has provided globally leading technologies in the fields of Visualization, Analysis and Prescription. **Fig. 2** shows some examples of our ground-breaking technology. The systematic combination of these technologies has led to business development in various fields including public safety, infrastructure/plant management (system operation), marketing, and operation innovation (manufacturing). Some typical solutions in each of those areas are shown in **Fig. 3**.

*1 : Ranked 1st three consecutive times in task assessment sponsored by the U.S. National Institute of Standards and Technology (NIST)
*2 : Ranked 1st in task assessment sponsored by the U.S. National Institute of Standards and Technology (NIST) (2012)
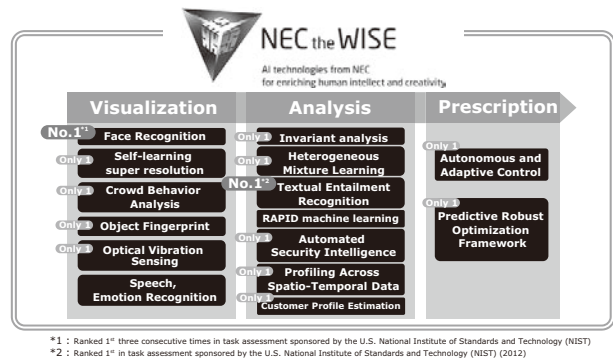
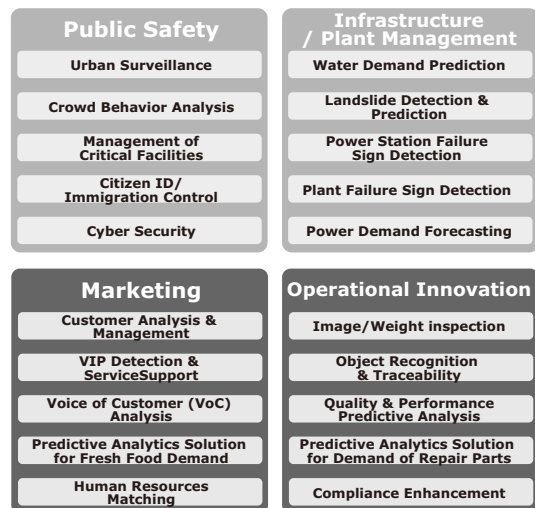Fig. 2 Cutting-edge technologies that comprise NEC the WISE.

Fig. 3 Business applications of NEC the WISE.

3. NEC's AI R&D Vision

As shown in Fig. 1, AI is comprised of three main function groups: Visualization, Analysis, and Prescription. In order to produce even more value in the future, we

should not approach the development of each of these function areas independently of each other. The key will be how to combine them systematically and synergistically as shown in **Fig. 4**. Also by understanding high-level semantics, we must realize a flexibility of response that is currently considered possible only by human beings (See **Fig. 5**.)

Based on these two approaches, NEC is advancing its AI research and development in the three directions shown in **Fig. 6**.

(1) Automatic Identification AI – Detection/Identification beyond human capabilities

AI is supporting the performance of tasks that require a high degree of accuracy by providing highly accurate status recognition with instantaneous, simultaneous and multiple evaluation.

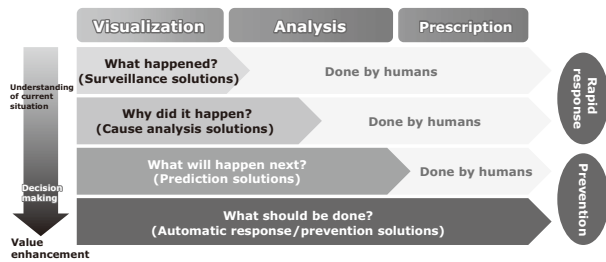Since the 1960s and our work on handwriting rec-

Fig. 4 Value enhancement through functional synergies.
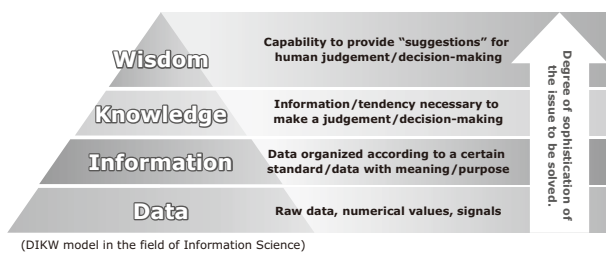
(DIKW model in the field of Information Science)

Fig. 5 Solving issues with "Wisdom".

ognition systems, NEC has pursued a variety of avenues in AI research and development. Recognition consists of translating information in the real world in all its myriad forms into data that can be analysed by machines. This domain of AI functionality is the heart of NEC's AI technology, and our advances in this field today provide personal authentication technology that can accurately detect and recognize face, fingerprints and veins; human behaviour recognition technology to support a safer and more secure society; and object recognition technology that enables the identification and management of individual items of every imaginable type – essentially using the "object fingerprint technology" to trace, authenticate and manage products and parts. Through these technologies, NEC is solving a human weakness in the value creation chain – human error, and realizing an order-of-magnitude improvement in safety compared with work undertaken only by human labour.

In recognition AI, although the degree of recognition accuracy is important, the ability to accurately distinguish details independent of sensing conditions is very important. NEC's face recognition technology is an example, which was ranked No. 1 in the world by the U.S. National Institute of Standards and Technology (NIST). Our solution's capability to persistently provide accurate identification using a 10-year-old photo as a reference regardless of ethnicity and age and despite purposeful attempts to disguise the identity with make-up and other contrivances is testament to the strength of our technology.

(2) Optimization AI – Optimization beyond human calculation

Systems with a scale and complexity beyond a human's ability to process are generally performed by experienced personnel under certain rules. The improved efficiency of such system operations is
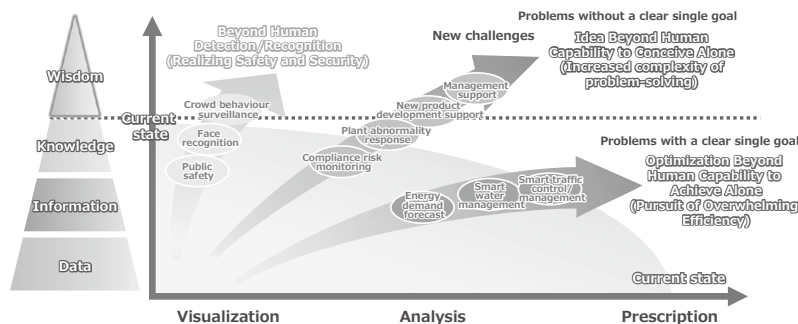
Fig. 6 Directions of NEC AI research and development.

achieved by AI supporting real-time decisions from a global viewpoint.

In the field of numerical value data analysis – a typical function demanded for business intelligence, AI has driven advances for decades.

NEC's technology development has begun with factor analysis related to various phenomena such as detection of abnormalities and has progressed into the field of highly accurate and reliable forecasts for complex systems. It is now evolving into a predictive robust optimization framework technology that produces highly efficient and low-risk plans based on predictions. For example in the case of urban-scale water systems, our AI technology can thoroughly optimize system operations and achieve a 20% reduction in power consumption while maintaining current service levels.

In recent years, the "white box" as it applies to optimization is garnering increasing attention. In the case of critical systems that perform a vital role in maintaining society, it is not sufficient to simply perform forecasting and suggest a response to conditions. These systems demand elucidation of the basis to the conclusions. NEC has realized the world's first "white box" approach (a model that provide the processes or basis of the conclusions reached by the optimization) with a level of accuracy on a par with "black box" approaches (conclusions for which the basis is unknown) such as deep learning.

(3) Reasoning AI – Ideas beyond human conception

As a measure to respond to the scarcity of human resources capable of meeting the challenge of the gravity and complexity of social problems, AI that supports consideration and decision-making by humans enables the efficient solution of these issues.

Knowledge work support systems such as search systems have been the engine driving the third industrial revolution ("Information Revolution") and have dramatically improved the productivity of human intellectual activities. In addition, rapid advances have been made in the area of interactive agents. It understands the context of human intellectual activities in the human-generated queries, and then searches a huge knowledge database to propose appropriate answers. These agents are unravelling the problem of an appropriate query creation.

Free from simple research activities, human intellectual activities now can be shifted to new creative pursuits; however, such reasoning-type AI that is mounted in an interactive system can only abstract various inferences (inductions/deductions) from past instances. By realizing agents that can transcend a framework based on historical cases and create new knowledge, NEC is aiming at both a qualitative and efficiency leap in activities such as brainstorming.

4. Challenges for the Future

AI technology at the cutting edge is outperforming humans from the perspectives of the speed, accuracy and quantity. On the other hand, the human brain possesses a clear advantage in the quality of flexibility, and there are many AI technological issues that need to be met in the mid- to long-term. Among them, NEC is putting a strategic priority on the following two areas and meeting the challenge.

(1) Small data AI

Analytical and inference technologies that support current AI are realized using big data. However, human beings are able to flexibly and appropriately generate knowledge by applying general common sense or exploiting even extremely limited data (experience). In order to realize stable social system operations and eliminate the unexpected, NEC aims to establish mechanisms that can generate knowledge and wisdom from a limited quantity of data.

(2) "Energy Friendly" AI

In data analysis and logical analysis, AI commands a bird's eye view of the entire issue and solves it. This process necessitates accessing vast volumes of data and performing repeated evaluation of the data selection, requiring a huge amount of energy. Consuming only a little energy, the human brain is able to perform similar tasks with clearly higher efficiency. In order to realize the wide-ranging application of AI real-time inference, the embedding of AI in edge devices that are subject to severe power consumption and computing performance restrictions will be indispensable. NEC is meeting this challenge and setting its sights on the development of innovative ICT systems modeled on the human brain.

5. Conclusion

NEC is moving forward with the establishment of technology systems that use globally leading technology in the areas of recognition AI, optimization AI and reasoning AI to understand and analyse the "now" of the real world as compiled by IoT and then suggest an appropriate prescription (action) for issues in various fields. Through these development activities, NEC aims at advancing the management of social systems that have

hitherto been reliant on human resources and accomplishing this at a higher level with fewer personnel, and at solving the increasing strain on urban resources and other social issues.

Reference

1) NEC Vision for Social Value Creation,
   http://www.nec.com/en/global/about/vision/index.html

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