National Institute of Information and Communications Technology (NICT)
Osaka University
Advanced Telecommunications Research Institute International (ATR)

http://cinet.jp

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ACCESS MAP

Monorail
Approximately 5 minutes on foot from “Handai Byoin-mae” station, Osaka Monorail Saito Line

Bus
Approximately 3 minute on foot from “Handai Koubunmei” stop
Hankyu Bus: From Semi-Chuo subway station for “Handai Homburnmei” or “Eki-Mihogaoka”
Kintetsu Bus: From Hankyu Kakenish station for “Handai Homburnmei” via JR Ikoma station

Train
Approximately 30 minutes on foot to the east of Kita Senri Station, Hankyu Senri Line
The development of ICT (information and communications technology) has led to fast and massive data communications networks, resulting in an unprecedented impact on our lives. However, each year the volume and speed in which data are processed increase by over 50%, which risks compromising information transmission due to network congestion, unstable connections, and excessive energy use. Furthermore, users can be overwhelmed by the abundant information. Therefore, constant research is needed to sustain these ever-growing demands.

One example of research focuses on organic information processing network systems like those inside the brain and biological cells. These networks function with an adaptability, autonomy, and low-energy consumption that is not seen in present ICT. As such, these systems may make a new paradigm for future ICT.

At CiNet, we are studying the information and neural network strategies used by living systems, including high-level brain function, and implementing these findings to artificial information and communications networks.

The “Working Group on Global Issues” panel for the “Task Force Concerning ICT Policies in the Global Age” conference hosted by the Ministry of Internal Affairs and Communications gave discussion on how to overcome the severe local and global concerns faced by various countries around the world, with special focus on environmental and medical issues. In particular, the council stated solutions require human- and earth-friendly technologies. The combination of brain research and ICT can be used for this purpose. In response, the ministry held the “Council Concerning Brain and ICT” conference, which identified priority issues. The list was long and wide, including technologies that aid the physically challenged and elderly, have low energy demands, and information and communications networks that are robust to breakdowns in a system. For these and other purposes, the Internal Affairs and Communications Minister, Vice Minister, and Parliamentary Secretary sat down with experts, listening on how to solve these and other problems by designing a research program that focused on brain research and ICT. In response to their conclusions, which can be seen at the link below, CiNet was inaugurated in the fiscal year of 2011.

To read the conclusions, please go to: Final Summary: Council Concerning Brain and ICT *http://www.soumu.go.jp/menu_news/s-news/01tsushin03/01000017.html*

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**Information and Neural Networks: A Council’s Report**

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Current times have seen an unprecedented growth in productivity and innovation, in large part due to ICT, which has been instrumental in our ability to work with large volumes of data at high speed. However, the volumes and speeds of data processing continue to increase, such that without innovations they will become unsustainably large and complex. Therefore, the networks responsible for these tasks need to be constantly upgraded. However, this comes at the cost of more energy.

To resolve this problem, we are considering alternative strategies. The brain, for example, is always transmitting and processing new and increasing levels of information without concurrent increases in its energy demands. Research in this area, then, may offer unique and profound solutions to the continuous problem of processing more information. Our vision is to bring ICT scientists together with people from the neurosciences, psychology, and the cognitive sciences to develop brain-based applications to ICT.

Such research is expected to realize more environmentally and user-friendly technologies. For example, new information processing and control technologies based on mechanisms used by the brain offer considerably lower energy demands than current models. They will also help us design user interfaces where one’s thoughts are directly transmitted to a machine or information terminal, which then carries out the corresponding action.

At CiNet, we have already made great gains on this by developing non-invasive techniques that allow us to measure brain activity with unprecedented accuracy in space and time. The results from these brain studies will then be turned back to make even better ICT, which will create a circle of discovery and innovation in both information and neural networks.
Understanding and applying how the brain identifies the “heart” of a message

The ultimate goal of communication is to convey an intended meaning that is correctly interpreted. Ironically, advances in communications technology like speed and capacity make this goal more and more of a challenge, because of the excessive amounts of data to be processed.

Normally, a person extracts subjective meaning from an excess or ambiguous amount of information. For example, consider a poem. Can the reader confidently interpret the author’s intended meaning? To varying degrees, this concern always arises whenever our senses receive information. In any form of communication, the individual receiving the data must process the information and extract the intended meaning, or what we refer to as the “heart” of the message. Combined with the act of transmitting this heart, we are aiming to optimize what we call “heart-to-heart communication”. However, the amount of data being processed by today’s networks often overwhelms an individual, making it increasingly difficult to recognize the heart. It is to conquer this challenge that HHS is conducting research and development to assist people in understanding the meaning of words and recognize the content of information by scientifically analyzing the higher brain functions that recognize, understand and react to a communication. In this way, HHS research seeks to improve BMI technologies by clarifying how higher brain functions arise and applying this knowledge to improving the quality of human communications. We envision heart-to-heart science leading to a better, more creative society.

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Communicating only the true message: sending what we need to send and receiving only what we need to receive

The brain extracts meaning even if the sensory information obtained is incomplete. We study the brain mechanism that processes incomplete information by focusing on how it produces information coding and voluntary action, and use this mechanism to design an intelligent information system model that can autonomously solve problems when given ambiguous inputs.

The theory of brain temperature

\[ T = \frac{V}{1 + C \exp(-M/S)} \]

When a human being communicates with others, the manner of communication varies between individuals. Our group researches brain mechanisms related to interactions during social activities. We are using this information to identify how to create environments that optimize communication for a given individual.

Understanding social action in terms of brain information science

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Understanding the brain’s communication network

Interpersonal communication is supported by information and communication between various areas in the brain. We are studying the mechanism used by the brain to process and communicate this information by applying a wide range of methods like psychophysics, brain activity measurement tools and clinical studies.

I got it

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Building a Low Energy Information and Communications Network Based on Human Brain Function

By understanding and applying the mechanisms used for brain function, we aim to develop computer networks and information and communications networks that mimic the flexible, robust and autonomous properties of the brain.

What is the difference between the human brain and a CPU? The former consists of approximately 14 billion brain cells, while the latter is composed of approximately a billion transistors. While the clock speed—a measurement of the speed of a computer—of a human brain is approximately 100 Hz, that of a CPU is overwhelmingly faster at several GHz, more than 10 million times that of the brain. Furthermore, computers can be connected together to increase their processing power by even greater magnitudes. Consider the more than 700 million computers now online and how much more powerful they are than when working as isolated units. Yet at the same time computer networks are inferior to the human brain in many ways. For example, the brain is much more flexible than a computer, can solve problems innovatively, and can adapt to its ever-changing environment. Preliminary work has indicated that incorporating such fluctuations into a computer network has similar benefits. In the BFI (Brain-Function Installed Information Network) component of CiNet, we strive to push this fluctuation research and its application to computer networks by expanding into other unique information processing systems seen in the brain to develop robust ICT. We believe this can be realized at CiNet by “networking” the information sciences with brain science, biology and sociology.

Energy-efficient and robust information network control based on neural and biological functions

We are researching the topology and self-organization of robust information networks along with developing energy-saving information network techniques by analyzing the topological and hierarchical structures of the networks seen in neural and biological functions and applying these properties into information networks.

Modern ICT system design based on the brain

Power consumption has become a serious constraint in systems, both at the device and circuit level as well as in communications networks. The brain deals with such problems innovatively, by proactively utilizing noise and fluctuations rather than suppressing them. Investigating and applying these mechanisms is expected to lead to more flexible and robust ICT systems.

Robot control based on biological fluctuations

We are conducting research and development on how biological fluctuations can be used in robot control, with the greater goal of designing robots that can do complex tasks while remaining robust to an ever-changing environment. Applying such theories, we aim to design robots that resemble human beings and behave like living organisms when exposed to dynamic and different environments.

Simple, energy-efficient network control using fluctuations

It has been found that in living organisms the response to an external force corresponds to the scale of the fluctuation in the system. This behavior can be described as a fluctuating complex system by using an attractor perturbation model. We are applying this model in the research and development of simple and energy-efficient methods for effective network control.

Introduction of research

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Developing Brain-Machine Interfaces for Human Care and Advanced Communications

Applying how the brain processes information for better human care devices and technologies and advanced communication networks.

With its low birthrate and greying population, Japan is a nation aging faster than most. This will lead to a large expansion in health care, as it has been estimated that by 2025, Japan will have 3 million stroke patients to care for, with at least one million having chronic mobility and communication problems. Additionally, Japan has an alarming number of suicides, having reached 30,000 annually mostly due to mental disorders and stress. This group too will require a great deal of personal attention to prevent such tragic acts. Because of factors like these, a third of Japan’s workforce is estimated to become caregivers for the disabled and the elderly by 2030. This is far too high a proportion for any country, therefore requiring alternative care-giving options including technologies and services that can replace the human component.

As such, we are focusing on brain-machine interface (BMI) that can achieve sophisticated human care by studying and applying the neurosciences. For example, we are designing robots that can be controlled by the brain signals of a user to aid in simple tasks during nursing care. In addition, we are investigating ways to use BMI with robotic technology in information and communication technologies. The purpose here is to develop science fiction like communications technology where a machine can intuit a user’s feelings and thoughts in way people do when interacting with one another. Current noninvasive BMI technologies in Japan are the most advanced in the world, and are already being applied. Furthermore, BMI technology has the potential to significantly alter our way of viewing communications systems. One ambitious goal is to use BMI technology in inter-personal communications by decoding information from one brain (decoder and extract) and encoding it to another (code and approach).

Currently, our best understanding of how the brain processes information is by looking at temporal correlations between the brain activity recorded and the information manipulated in the experiment ranging from sensory stimuli, motor acts and cognitive states. By developing entirely innovative method to directly induce spatio-temporal patterns of brain activity, we could directly examine the cause and effect relationships between brain activity and mind. This requires a very organic approach that combines the neurosciences, biophysics, and information technology along with new measuring devices enabling BMI technology to revolutionize healthcare and welfare, while at the same time advancing our understanding of the neurosciences and information and communication sciences. CiNet provides the best environment for such a project.

Investigating the mechanisms for cognition and motor control and applying them to BMI

Technology that can extract information from the brain and then be applied to computer process is fundamental for brain-machine interfaces. We are investigating where, how and when information for cognition and motor control exists in the brain, and developing technologies that can extract this information in an efficient manner. The ultimate goal is to apply these technologies to the real-time operation of a computer robot and to improving the cognitive abilities of human beings themselves.

Using BMI to enhance brain function and environmental adaptability

The wish for a healthy and active life is common to all humankind, and is expected to be even more so as societies become older. Recent progress in brain science is making it possible to develop new technologies that support this by facilitating a number of human activities that become more difficult with age. In this project, we are developing new technologies for understanding the basis of neural activity by researching techniques that can exploit the brain’s plasticity to enhance brain function, use BMI to expand human capabilities, and produce robots that can respond to their environments in anthropomorphic ways. As these methods develop, we will then apply these techniques to understanding how changes in neural behaviour coordinate with changes in thoughts.

Supporting handicapped people with advanced ICT – Motor BMI

In our project, advanced ICT is applied to infer a person’s intent by decoding his or her brain signals and using this information to drive various external devices that are used to support the person with a given task. For example, we anticipate being able to help even the most severely disabled people who have lost most of their motor and speech function by implementing robotic arms or electrical equipment that can be activated by the user’s thoughts. Therapeutic devices will be invaluable in giving a disabled person more independence, with the greater aim of applying them to a clinical setting.

Developing next-generation artificial retina – Sensory BMI

We are developing original artificial retina based on BMI technology, which would be safer and more sophisticated than current artificial retinas (Fig. 1). Already, we found a totally blind patient was able to identify the position of a chopstick when using our prototypes (Fig. 2). By increasing the number of stimulating electrodes that can be used on a patient, our current goal is to restore reading and walking vision in blind patients. Furthermore, we are investigating the central mechanism the brain uses to recognize an object and developing an efficient electrode stimulation system for visual rehabilitation.
Our understanding of the life sciences has dramatically improved thanks to breakthroughs in measuring and imaging techniques. In recent years noninvasive methods, especially for measuring human brain activity, have become significantly more sophisticated and effective due to their size-reduction, higher performance and operational speed. As a result, it has become possible to measure and analyze fine brain activity that was once not conventionally measurable in real-time without placing a great burden on the subject. The result has been gradual clarification of the mechanisms and functions that drive brain activity.

Much of this has come from improvements in both hardware and software, helping us realize unprecedented spatial-temporal resolution to detect more details about the brain in less time. This will only continue, as new non-invasive methods with even better spatial-temporal capabilities are constantly being made. The result will be our ability to observe brain properties that are currently impossible to extract. At the same time, the development of small and highly plastic brain function-measuring devices in conjunction with large and low-plasticity ones have the potential to create new interfaces that connect brain activity and information terminals. The development of such measuring devices and systems is fundamental for the development of brain-imaging techniques and an important part of combining information and neural network technologies. For this reason, we aim to establish next-generation imaging techniques including fMRI (functional magnetic resonance imaging), phase-contrast cerebral blood flow imaging, temperature function imaging, nerve fiber function imaging, brainstem nucleus function imaging, and magnetic resonance spectroscopy imaging (MRSI) to acquire information about brain function that can then be used in ICT. In particular, by using a state-of-the-art super-high magnetic field 7-tesla MRI device, we will combine various kinds of imaging at the molecular, cellular and tissue levels to acquire high-definition information on biological function. This will require a highly interdisciplinary and comprehensive approach that investigates from the level of neural metabolism to high-level brain function.

By developing and integrating a number of non-invasive techniques to measure brain function, we seek to design new techniques that can help us apply brain processing strategies to information and communications systems.
CiNet: a new scientific partnership between government, industry and academia

On January 7, 2009, the National Institute of Information and Communications Technology (NICT) and Osaka University came to an agreement on a large-scale collaboration for the study of brain function and applying these results to new ICT and networks. Since then, the Advanced Telecommunications Research Institute International (ATR), a leading institute in BMI technology, has joined to make this an even more potent partnership, with the future being expected to reign in even more institutes and companies that will expand CiNet’s impact in biology and medicine.

On March 10, 2007, CiNet held its kickoff symposium on information and neural networks to showcase its success and vision. The minister of Internal Affairs and Communications was one of many to show support. With its laboratories based at the Suita Campus of Osaka University, where advanced research for non-invasive techniques on human brain function is well on its way, and by bringing together the learning and research environments at universities and industries, CiNet aims to take neuro-based ICT from science fiction to science.