Title	Signal processing is being used everywhere in modern society : The future that analysis of ubiquitous Bio-Signals will open
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Author	田井中, 麻都佳(Tainaka, Madoka)
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Introducing Researchers

Featured in this issue is Associate Professor Yasue Mitsukura, who pursues the development of innovative systems by making the most of signal processing technology.

Signal processing is being used everywhere in modern society

The future that analysis of ubiquitous Bio-Signals will open

Brain-computer interfaces can measure our physical/mental states, such as pleasure/pain, stress and sleepiness by measuring and analyzing brain waves (electroencephalogram:EEG). Avatar systems can detect movements of our face and changes in facial expression using a compact web camera and project them instantaneously onto an avatar on the monitor screen . . . explained Associate Professor Mitsukura who focuses on the development of these innovative systems.

Measuring our physical/mental states in an instant from a combination of brain wave frequencies

"By simply wearing this device on your forehead, it is possible to measure your pleasure/pain, likes/dislikes, stress, sleepiness, or degree of your concentration or interest. It may be safe to say that this one is the most simplified and easiest-to-use device of its kind available today. Of course, its performance capability is never outdone by its category." Saying so, Dr. Mitsukura showed a headband-like electroencephalograph (EEG). The EEG is designed to send information from the headband-like sensor to a smart phone and instantaneously displays the measurement result on the smart phone screen.

If you are feeling stress, for example, the white face icon on the screen will turn blue and the degree of stress will be shown as a percentage. Likewise, if you start up an application for the state of concentration or sleepiness, as a test subject you will be able to clearly see your constantly changing state of concentration or sleepiness in real time.

Fig.1 Detection of sleepiness by means of brain wave analysis
Degree of sleepiness can be detected online by easily obtaining brain waves and analyzing them instantaneously.

Raw data obtained is also displayed on the screen simultaneously. The waveforms shown in line graphs represent frequency bands, such as α, β and θ waves, that are languages commonly used to indicate brain waves. According to Dr. Mitsukura, it is possible to measure a subject's state by analyzing a combination of his/her brain wave frequencies.

She continues, "You wear a sensor on your forehead to measure the state of what is called the FPI, the area of the brain in the left-side frontal lobe that governs emotions and sensitivity. At this time very small voltages in the microvolt order are measured. Types of brain waves can be known by converting these voltages into frequencies. Brain wave frequencies are limited to the 1~30Hz range. One's physical/mental states can be known from combinations of pieces of such slight pieces of information."

Take the sense of touch, for example. You can judge that you "like" an object if the value of a combination of ○Hz and ×Hz is large, while you "dislike" the object if the value of a combination of △Hz and ◇Hz is small. Finding out such rules and allowing the particular state to be identified instantaneously via the optimization method are the greatest features of this system.

In addition to the EEG (electroencephalograph), brain-measuring instruments available today include the f-MRI (functional magnetic resonance imaging) and NIRS (near-infrared spectroscopy). But each of these systems has its own measurement target. To examine the state of the brain, the f-MRI targets brain blood flow while the NIRS is dedicated to brain blood oxygen level. Here, we have to remember that brain waves quickly respond to any psychological change that occurs. As such, real-time measurement is fit for brain wave measurement.

Furthermore, it has been a major drawback with conventional brain wave measuring instruments that accurate measurement is not possible because the subject must have several electrodes adhered to his/her scalp, which is time-consuming while wearing the instrument itself is stressful. But Dr. Mitsukura's device is easy to wear and enables what a person is feeling to be measured accurately. In fact, the device already began to be used as a marketing research tool to determine the degree of interest in sound, taste, new products and so on.

Obtaining accurate measurement results by formulation of brain waveforms

However, is it really possible to obtain accurate measurement results using such a simple device? No problem. The signal processing technology, Associate Professor Mitsukura's field of expertise, enables measurement by the device well comparable in accuracy to other types of measuring instruments.

She says, "Most of simplified EEGs adopted in games operate by acquiring myoelectric signals that are generated, say, when you move your eyelids, and they do not deserve being called EEGs. A lot of noises are mixed into brain waves, most of which are myoelectric noises, making it very difficult to selectively pick out pure brain waves. In fact, myoelectric noises are not eliminated with most of the simplified instruments available on the market today. Our device, therefore, is designed to eliminate such noises

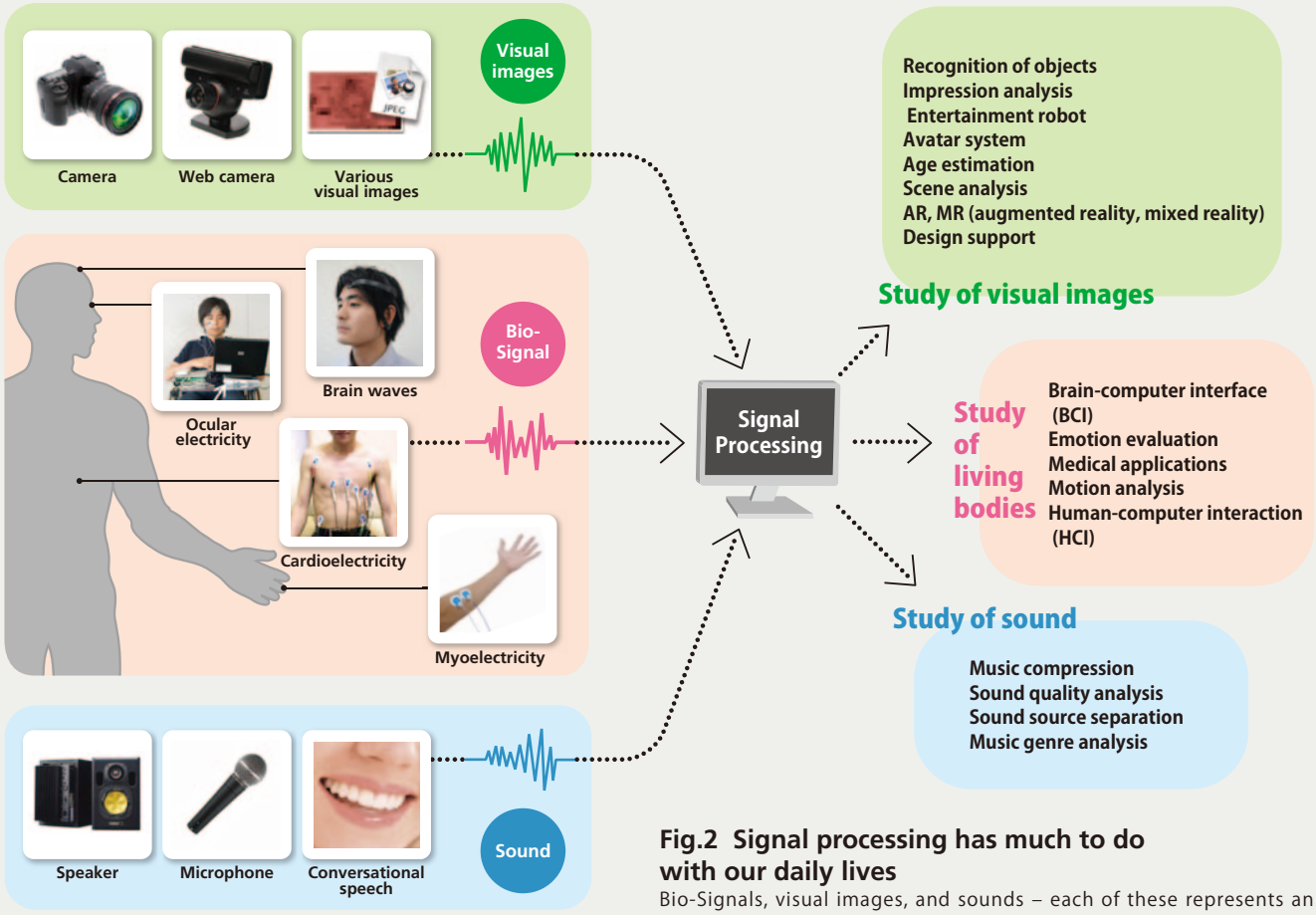

Fig.2 Signal processing has much to do with our daily lives

Bio-Signals, visual images, and sounds – each of these represents an aggregate of signals on a certain scale. Signal processing is a process of grasping the characteristics of these signals, classifying them into patterns, and imparting a meaning to each pattern. When it comes to living bodies, we generally deal with signals ranging in voltage from micro-volts to milli-volts; for visual images, signals ranging in RGB value from 0 to 255; and for sounds, signals ranging from 20Hz to 20kHz. Studies of analyzing these signals have much to do with a wide variety of products found in our daily lives.

instantaneously and enable accurate measurements."

In her early career, Dr. Mitsukura had long engaged in the study of formulating behavior of industrial plants and equipment for years. She says that the experiences she had nurtured through the work of formulating such behavior proved to be a great asset for the development of the current system.

"The impetus for my taking up the development of this system was an encounter with an ALS (amyotrophic lateral sclerosis) patient. As the disease progresses, ALS patients eventually become unable to communicate with the outside world except by the movement of their eyeballs. When the patient who used our EEG system became able to express his Yes/No, his family members were very pleased, which fueled my motivation. I was determined to accelerate this research project by all means. In the future, I aim to make this device an even more simplified and easy-to-use system – one that will allow users to express what they are thinking directly into letters," she remarks.

Fig.3 An online avatar system allows you to transform into a popular avatar in an instant

Only if you have a common inexpensive camera (shown in photo is a camera for Playstation) and a PC, you can analyze movements and expressions of your face in an instant and express them using an avatar.

An avatar system that can instantaneously follow the movement of one's face

The Mitsukura lab has also developed another signal processing-based system. It is an innovative avatar system. With this system, a web camera attached to a PC recognizes movements of a person's face, allowing an avatar on the PC screen to follow the movements in real time.

"We took up this research project with the aim of tracking facial movements and expressions within 0.1 second. The key behind the success of this system was that we enhanced computation speed by narrowing down tracking points – both ends of the eyes and both ends of the mouth – to facilitate instantaneous reactions," she explains.

As the avatar for this system, she used Hatsune Miku and uploaded it to the YouTube video-sharing website. This attempt was rewarded with over three million views. As a result, she is flooded with numerous inquiries from interested companies regarding its use for animations, promotional events and CMs, among others.

She adds "Also, we are handling the development of various other systems, such as a system for scrolling the PC screen with a whistle and a technology for moving a wheelchair using myoelectricity."

All of these innovative systems are based on signal processing technology. In conclusion, Ms. Mitsukura vigorously mentioned that she would like to continue to develop systems that could contribute to society by leveraging signal processing technology.

(Reporter & text writer: Madoka Tainaka)