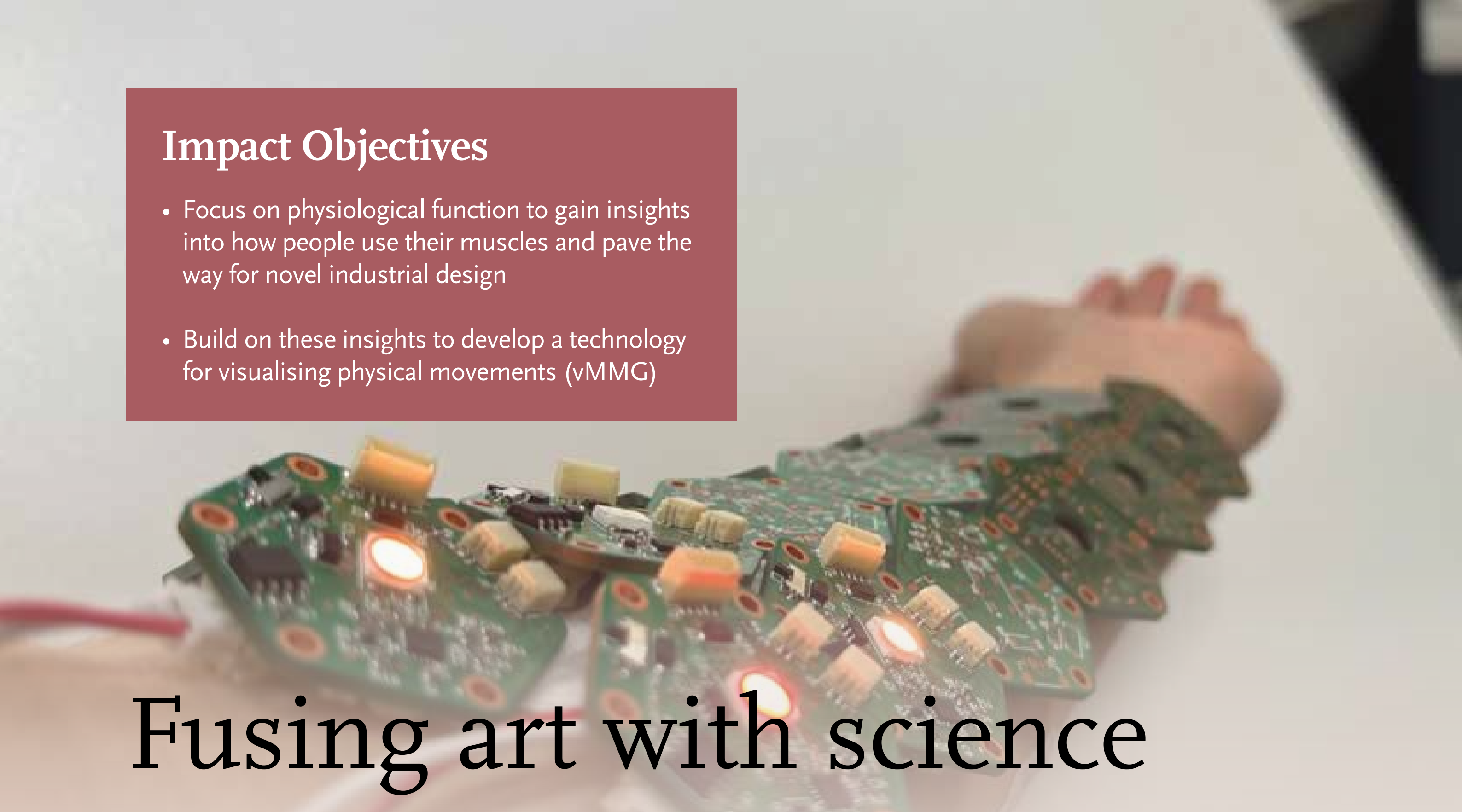


Impact Objectives

- Focus on physiological function to gain insights into how people use their muscles and pave the way for novel industrial design
- Build on these insights to develop a technology for visualising physical movements (vMMG)

Fusing art with science

***Professor Yoshihiro Shimomura** has built his career on blending painting, crafts, robot making and humans, he is now leading a project designing technology where users can observe muscle activity*

How has your background led you to merge engineering and design?

My earliest design and engineering memory is in kindergarten when I came up with a new way to fold paper aeroplanes and when we all flew them in class, mine flew the furthest. After that, I loved crafts and drawing. In elementary school, I won prizes in art exhibitions every year. Also, one of the characteristics in Japan is the so-called free research during summer vacation and I used to make small robots out of wood during these times. My hobby of creating robots continues until today. Basically, I often make robots that have arms on a trolley and reproduce human movements.

What inspired your current research path and interests?

When I was applying for university entrance exams, I could not decide whether to go for art or engineering. Consequently, I enrolled in Chiba University's Faculty of Engineering Design Course, where I could do both. During my time as a university graduate student and university assistant, I collaborated with the Japanese drum club at my alma mater's high school and was active in an amateur Japanese drum group. Incidentally, I played at my own wedding ceremony. Through this process, I realised once again that humans can create impressions that are not necessarily visible - this is a fundamental aspect of my current research. One year after entering the university, the late Professor Yasuyuki Kikuchi who is the founder of the Humanomics Lab and the first person in Japan to introduce ergonomics into the design field, asked me at the entrance of the Faculty of Engineering, "What do you want to do from now on?" I immediately answered, "I want to make a prosthetic arm". This summed up my interest in painting, crafts, robot making and humans. Professor Kikuchi immediately responded, "then come to my laboratory". This is where my research career began.

Can you talk about the approach to your work developing vMMG?

I was originally positioned as an electromyography (EMG) and biomechanics researcher, so I was not an mechanomyography (MMG) expert. When I first learned about MMG, my intuition was that this is an easy method for users. Consequently, I thought about what I could do to make it even easier. The conclusion was that instead of viewing digital waveforms on a monitor, we should be able to view them as analogue data on the spot. In the process of preparing teaching materials for classes, we were able to optimise the methods and components for detecting and processing biological vibrations while observing measurements taken by many students.

In general, what challenges have you faced in this research?

The biggest challenge was the need for time. Students initially have zero specialised knowledge and skills. Therefore, it took some time for the research to accelerate. I overcame this with the help of things other than the original vMMG development plan, such as science seminar classes, students' own aspirations and motivation from interviews like this. I believe that the bigger issue in the future will be materials and manufacturing methods for mass production. I am looking forward to overcoming this.

What type of learnings have you made through this work?

I was surprised and impressed that I was able to observe my own subcutaneous muscle activity as a colour. This joy has not diminished and I still feel excited when I introduce it in class. I was also happy when I discovered that the students were enjoying their own research. When I introduced it in class, I was also happy to receive comments from many students saying how interesting it was to see how the muscles were used differently depending on the design of the tool. ▶

Understanding muscle activity through visualisation

*With an aim to help patients rehabilitate from injury, a research team based within the **Design Research Institute** at **Chiba University** is working on the development of visualisation technology for physical exercise*

Art can be thought of as the systematisation of knowledge and skills within an individual, where the standard of value lies within each individual creator. In contrast to this, science and technology are systematised within a social group and the standard of value lies within society. If one field can be said to combine both artistic endeavours and those of scientists, perhaps design is it; it is often approached from both artistic and scientific methodologies.

However, no artist or designer can feel something unless the body's sense organs can detect it with the signal passing through the brain's sensory gate system and climbing into their consciousness. If we take the example of a chair, it is possible to be conscious of the sensation of the skin on the part of the chair that it is in contact with, but you cannot feel the blood vessels in your thigh being crushed, the compression of your lungs and abdominal cavity or that there is an uneven load on the intervertebral discs of your spinal column.

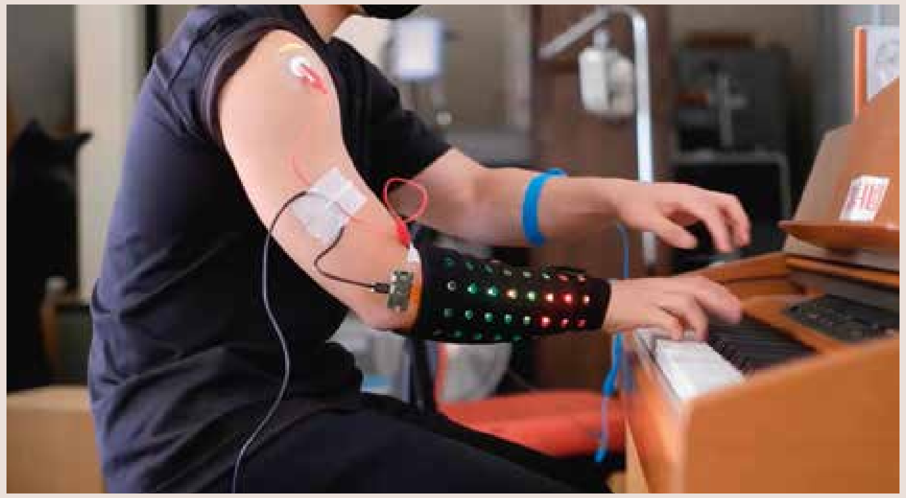
Thus, it is impossible to design a chair that is optimal for living organisms that relies on artistic methodology; it is necessary to use scientific methodology. It is this philosophy that defines the approach Professor Yoshihiro Shimomura adopts.

He is based within the Humanomics Lab at the Design Research Institute, Chiba University in Japan, where joint research is being conducted with more than 130 institutions in the fields of medical devices, automobiles, home appliances and environment design and lifestyle related to energy, including those projects that have been completed. Drawing on the expertise within the Humanomics Lab, Shimomura is now working on several projects that seek to develop visualisation technology for physical exercise, which enables users to observe the spatial distribution between muscles and provide many benefits.

> *"Using this technology, patients can monitor their own muscle activity and work on their rehabilitation"*

PHYSIOLOGICAL FUNCTIONS

For Shimomura, there are benefits to placing an emphasis on physiological functions in his design work. 'Humans are almost never conscious of what is happening in our own bodies. How is your morning meal digested? How are you able to breathe while talking? How do you use your body while stabilising yourself in a gravitational environment? How does the heartbeat rate change depending on whether you are lying down or standing up? How do the eyes and head work together to see various things? You hardly notice these things,' he highlights. He explains that when a person works outside, their attention is directed outward, so they may be even less aware of fatigue. However, they may feel tired as soon as they get home. This is because attention has turned inward and sensory signals from the body have risen to consciousness. 'Physiological anthropology emphasises systemic physiological reactions, whether we are conscious of it or not,' he observes. By focusing on physiological function, Shimomura and his team can examine the nature of health, fatigue and comfort, and come up with designs that have real meaning, going beyond just the appearance and aesthetic appeal.



Mapping of muscle activity during piano playing where the activity of skeletal muscles that are the basis of finger and hand movements can be seen unaided

EMG VS. MMG

One of the team's main research projects at present sees them working on an alternative method to surface EMG to measure muscle vibrations called MMG. MMG is seen to offer more benefits than EMG because the modality is more concise. 'EMG is obtained by inducing the electric potential that runs through the muscle fibres from two electrodes placed at a certain distance in the same direction of the fibres and differentially amplifying the electric potential that runs through the muscle fibres,' explains Shimomura. He says it is necessary to carefully prepare the path for electrical signals. 'Specifically, the distance and orientation of the two electrodes must be made appropriate to reduce anatomical inaccuracies and the signal can be increased up to 1000 times using an amplifier with two input pins and one output pin.' He points out that on the other hand, with MMG, if only the sensor is attached to the skin, the vibrations are directly inputted to the sensor, so no knowledge or skill is required for attaching electrodes.

Mapping of muscle activity during Japanese drum playing allows observation of the unconscious momentary muscle relaxation by the expert upon impact with the drum

This latter point is extremely important to this research. When we think of a stethoscope, we realise that anybody can use them to hear someone's heartbeat - no specialist knowledge is required. In the same way, while EMG requires electrodes and a specialist to understand, MMG is more intuitive and can be measured easily. There is also the fact that microphone technology is abundant and the amplification degree can be less than 100 times, which essentially means miniaturisation is possible at low cost. In these ways, the team can focus on the benefits for users in the application of the technology they develop.

MANY BENEFITS AND APPLICATIONS

The technology being developed by the team allows users to observe the spatial distribution between muscles and can be applied in an impressive array of ways. 'Using this technology, patients can monitor their own muscle activity and work on their rehabilitation, see how Olympic athletes use their muscles, visualise the muscle activity of physical labourers and the elderly to reveal which movements cause shoulder and lower back pain and, when observing facial muscles, study nonverbal and emotional communication,' highlights Shimomura. 'Motion capture is used in biomechanics, film production, etc. If you shoot vMMG or vEMG at the same time with existing motion capture, it is possible to simultaneously quantify skeletal movement and the underlying muscle activity, so we expect that it will become a next-generation movement analysis technology.'

The team believes that a venture business is necessary to realise these applications and they have begun the necessary preparations. They are looking to secure intellectual property rights, such as patents, in various areas and are keen to find a partner to procure the materials and start manufacturing.

THE IMPORTANCE OF INTUITION

Ultimately, for Shimomura, research is a 'play throughout life, and that play is just as essential to the quality of human life as longevity'. He considers it is no good living until you are 100 years old if you cannot enjoy life and move freely without pain or physical burden. It is this belief that lies at the core of the Humanomics Lab and informs the team's research endeavours. He believes that by enabling anyone to intuitively understand muscle activity by displaying it as a colour on the skin, the team is aiding rehabilitation, as well as encouraging correct posture and physical activity to improve standards of movement and the enjoyment of life in people around the world. ●

Project Insights

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CHIBA UNIVERSITY

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