Impact Objectives

- Explore symbolic cognitive modelling to describe the mechanisms of human cognition
- Quantify human behaviours using information technology and model human minds (cognition and emotion) on computational systems

Developing novel supports for mental health

Based on his knowledge of cognitive science, which combines artificial intelligence and psychology, ***Dr Junya Morita*** *is conducting important investigations that use computational models to improve our understanding of human minds*

Can you begin by talking a little about your research background?

When I was in my early teens, I noticed that human minds are mysterious, yet their inner workings and what they create appear to govern the world. I decided to spend my entire life developing technology that could objectively describe subjective internal states and processes. During my undergraduate degree, I spent time completing a course on sociology, which happened to involve reading materials relating to my original goal of using technology to describe the human mind. From there, I found the field of cognitive science, which combined artificial intelligence and psychology. I was excited to learn about this field and embarked on a postgraduate programme of cognitive science in Japan. This culminated in my founding the Department of Cognitive Informatics at Nagoya University.

In what ways have you been involved in this field more recently?

I worked under Professor Kazuhisa Miwa and enjoyed almost everything about it, especially the interdisciplinary aspects covering science and technology that targeted various computational and mental processes in individuals and across society. Of particular interest has been symbolic cognitive modelling, which clearly describes the mechanisms of human cognition. It took me a long time to learn this technology but I have since mastered the field. One of the most important experiences for me during this process was visiting the Applied Cognitive Science Laboratory at Pennsylvania State University led by Professor Frank E Ritter. I learned the philosophy of cognitive architecture and the application of cognitive modelling there.

What is the ultimate impact of your findings from your latest research quantifying human behaviours using information technology?

Every individual and society will benefit from the computational modelling of human minds and I believe it will drastically change our lives. Specifically, the modelling technology will boost our metacognitive functions and human rationality will exceed the boundaries innately set by nature. Humanity will have a perspective capable of looking long into the future and eventually obtain the freedom of thought described in Herbert Simon's *Sciences of the Artificial* and Daniel Dennet's *Freedom Evolves*.

What challenges have you faced in this research and how have you overcome these?

While examining the reaction for the interactive model-based reminiscence, we found huge individual differences. This is problematic when trying to write an academic paper in classic experimental scientific fields. To overcome this challenge, I changed my research strategy to focus on the patterns of interaction. In the future, I will conduct a large-sized crowdsourcing study for collecting individual traits and the reactions for the system of interactive model-based reminiscence.

Are there any future research themes you hope to be working on?

I hope to apply the interactive model-based reminiscence to various individuals, from typical adults to Alzheimer's patients, and those with depression and autism spectrum disorders. All of us have some problems with memory and mental health – I want to categorise these problems based on the reactions of model-based reminiscence and establish an interactive design that helps individuals.

How do you envisage your findings can be applied to a real-world setting?

The biggest barrier of applying the finding to the real-world is the cost (time and financial). To overcome this, we utilise recent innovations, including crowdsourcing, visualisation of the model codes and behaviours, and machine learning to reduce coding costs. I am always seeking new technologies that can be applied to the pursuit of our goals. ▶

Harnessing the effects of positive memories

*A team based in the **Applied Cognitive Modelling Laboratory** at **Shizuoka University** is using cognitive science and computational models to develop novel support mechanisms for mental health. The findings will have significant impacts on humanity's relationship with technology and could one day make it more symbiotic*

In more recent times, the exploration of the mind has led to the development of cognitive science, which seeks to understand the mind and its thought processes. It is hardly surprising then that with developments in technology happening at an ever-accelerating rate, researchers have turned to computers, Artificial Intelligence (AI) and computational models as a means of deciphering intelligence, behaviour and cognition.

Dr Junya Morita is based at the Applied Cognitive Modelling Laboratory (ACML) in the Department of Behavior Informatics at Shizuoka University, Japan. His team is conducting investigations that use computational models in an effort to improve our understanding of human minds and their inner workings.

THEORETIC COGNITIVE MODELLING AND ITS APPLICATIONS

There are currently two directions of study underway at ACML. The first is concerned with theoretical studies of cognitive modelling, where the team try to construct models that explain human minds as computational and algorithmic levels. 'We implement models of various mental functions as a computer program and run simulations,' outlines Morita. 'Current topics of modelling include emotion, intrinsic motivation, symbol emergence and communications. All of these are fundamental topics but are not yet fully answered in the field of cognitive science.'

The second direction of study is the application of computational cognitive models. Morita and his team believe that there are fundamental values within the basic endeavours of cognitive science and are working to prove these values exist and are valid. Current topics of application include education, driving, entertainment, graphic design, language development, web navigation and mental illness.

There are other topics of enquiry at ACML which have come from issues that have been personally experienced by Morita and his lab members. For example, studies which are related to autism spectrum disorder have come about from Morita's own experience, as he has a son that has been diagnosed with a moderate disorder with language impairments. 'We are all humans that experience mental activities,' says Morita. 'The personal experiences of our team are a strong motivation behind the research we are conducting.'

THE INTERDEPENDENCE OF HUMAN AND MACHINE

The idea of human versus machine has become a common one in literature, art and film (as well as other forms of expression). There is a sense that developments in information technology and AI will inevitably lead to the downfall of humankind, where we become subservient to machines. In sharp contrast to this, Morita and his team's focus is on adopting an attitude that recognises the interactive nature of the relationship between humanity and information technology. 'The two components are not independent but completely interdependent,' explains Morita. 'The human mind changes technology and the development of technology significantly changes the human mind.'

With this embracing of technology, Morita is working on developing an interactive model-based reminiscence using a cognitive model and physiological indices. The ultimate goal of the study is to develop novel support for mental health. 'Our study research assumes that the well-being of humans is heavily influenced by memory recall which is closely linked to emotion,' he confirms. 'From there, it is a short step to the idea that remembering positive memories can help sustain healthy minds in humans.'

The study involves the manipulation of an individual's memory recall. The team use a photo slideshow that utilises simulation technology of human memory. They use a cognitive architecture called adaptive control of thought–rational (ACT-R), which was first posited by the psychologist John Robert Anderson, as well as physiological sensing tools to construct a personalised memory model. 'Cognitive architecture is a platform of cognitive modelling that features a mechanism of simulating human memory traits for various situations and individuals,' clarifies Morita. 'By inputting individual lifelogs to cognitive architecture, we can create a personalised memory model for each individual and modulate parameters of memory from the result of physiological sensing, such as a heart rate monitor, which reflects the stress or pleasure of individuals.'

The system continuously presents personalised photos as memory contents of individuals, connecting each photo with several attributes, such as what the image contains, when and where the photo was taken, and who is on the photo.

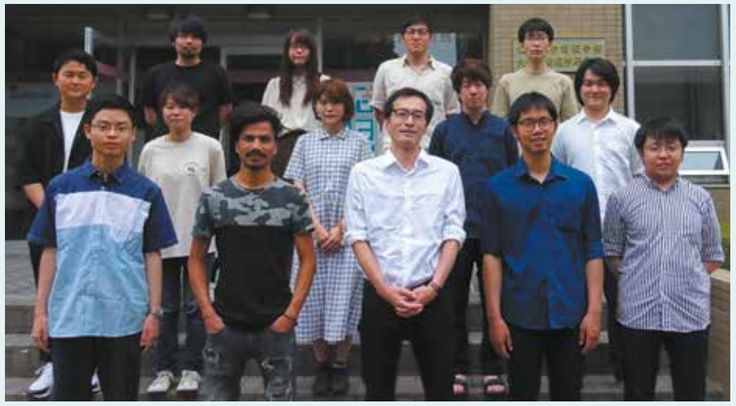
The retrieval of memory is also governed by several numerical parameters like activation and noise. These parameters reproduce several patterns of memory recall including convergent or divergent patterns. 'The model can also represent a ruminative pattern,' highlights Morita. 'This is frequently linked to depression and will help us identify whether our system is useful as a means of improving mental health.' Importantly, the model-based reminiscence tool can utilise these patterns to simulate the current state of the user and/or guide the user to their preferred mental state.

> *"Our study assumes that the well-being of humans is heavily influenced by memory recall which is closely linked to emotion. From there, it is a short step to the idea that remembering positive memories can help sustain healthy minds in humans"*

MODELLING INTRINSIC MOTIVATION

Although there is still some way to go in the team's investigations, they have already enjoyed some notable successes. They have developed a novel model that represents intrinsic motivation - an important emotional function of the human mind. While classical cognitive science has tended to focus on human intellectual functions, models of intrinsic motivation have become increasingly popular in the field. The work is ongoing, but the team received an Incentive Award from the Japanese Society for Artificial Intelligence in November 2019. 'I am pleased with this achievement, not just because of the result, but the work is the product of a collaboration with one of my students, Kazuma Nagashima,' enthuses Morita. 'Although the idea for the modelling was originally developed by me, the context was provided by him. He also collaborated by providing additional questions to address in the course of our research.'

Clearly, there is much to be positive about regarding Morita and his team's research, especially given the initial success and the fact that there is still more work to be done. Morita is embracing early career researchers, helping them improve their skills and encouraging their input, which is testament to the collaborative nature of his laboratory. Ultimately, we all have a mind and it is rare indeed for the brain to function properly 100 per cent of the time - in that regard, we may all ultimately benefit from Morita's research findings and attain positive mental health and well-being.



Members of ACML at the entrance of the laboratory

Project Insights

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- Kazunori Yamada, Panasonic Corporation
- Yugo Takecuchi and Yoshimasa Ohmoto, Shizuoka University
- Takashi Hashimoto, Japan Advanced Institute of Science and Technology
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TEAM MEMBERS

This research is the product of a team working alongside the lab members, including Kazuma Nagashima and Kazuki Itabashi

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BIO

Dr Junya Morita is a cognitive modeler aiming to extend the method to complex realistic human life. He received a PhD from Nagoya University, and worked as an Assistant Professor at the Japan Advanced Institute of Science and Technology. He is now leading the ACML in the Faculty of Informatics, Shizuoka University.