



MEIJI INSTITUTE FOR ADVANCED STUDY OF MATHEMATICAL SCIENCES (MIMS)



Making an impact with mathematical sciences

Novel approaches to mathematical modelling and analysis are being developed at Meiji University to address new challenges in previously unexplored areas.

Founded in 1881, growth of Meiji University's is closely linked with the history of Japan's modernisation. At the leafy Ikuta Campus in Kawasaki, undergraduate- and graduate-level students and researchers are involved in diverse fields of science and engineering.

As an integral part of the Ikuta Campus, the Meiji Institute for Advanced Study of Mathematical Sciences (MIMS) has distinguished itself as a top-level international research centre pursuing mathematical analyses of various natural and social phenomena.

Masayasu Mimura, director of MIMS, comments: "Our goal is to develop mathematical sciences that contribute to society. Advances in experimental and observational techniques have enabled us to access a large body of data. We have also achieved a profound understanding of the individual components. However, it may be more important to analyse interactions rather than to track individual movements when probing the causes of a wide range of phenomena, such as disease epidemics, the instability of the financial sector, and traffic congestion. As an example, human genome sequencing alone will not yield the 'whole picture' of a system as complex as the human body. To move from studying the components that make up a system toward a deeper understanding of the bigger picture, mathematical sciences have a significant role to play in this transition."

Mimura also serves as project leader of the Global Center of Excellence (GCOE) Program titled 'Formation and Development of Mathematical Sciences Based on Modelling and Analysis', approved in 2008 by Japan's Ministry of Education, Culture, Sports, Science, and Technology (MEXT).

A specialist in mathematical modelling, Mimura himself coined the term 'mathematical modelling and analysis', which covers various aspects of modelling, mathematical analysis and simulation. Mimura's applied approach had at times been viewed as unconventional within the Japanese mathematical community, due to the importance it placed on the study of pure mathematics. The establishment of MIMS in 2007 marked a milestone in the development of a more diverse research environment.

Modelling visual illusions

Kokichi Sugihara, a deputy director of MIMS, is renowned for his work on illusory mechanisms involved in human perception and cognition, and has developed the field of 'computational illusion', whereby mathematical models can help to explain the basis of different perceptual processes.

"I brought mathematics into the field of perceptual illusion — an area that used to be the domain of psychologists and cognitive scientists," Sugihara explains. "We study the mechanism of perceptual illusion by developing mathematical models of the eye, which are thought to cause such illusions. In this way, we may be able to describe the parameters of illusion in numerical terms, and thus optimise and control these illusory perceptions." Accidents often arise as a result of perceptual illusions. By designing environments that are least likely to produce illusions, it may be possible to build a safer society. "And in contrast, we could also make road signs that are difficult to miss by 'strengthening' illusions," Sugihara adds. "We can contribute to society by applying computational illusion methods — by adjusting the strength and weakness of various illusions."

Origami engineering

Based on his background in mechanical engineering, Ichiro Hagiwara, another deputy director of MIMS, has collaborated with Taketoshi

Nojima of Kyoto University to establish a unique field of study called 'origami engineering'. Hagiwara says, "In Japan, there are many great origami artists, and their work is based on aesthetics — in other words, it is an artform. Recently, researchers outside Japan have popularised the geometry of origami and have even industrialised it. A British engineer developed a honeycomb structure based on decorations for the traditional Japanese 'Tanabata' festival, and it has grown to an industry worth tens of billions of dollars. We are working on new Japanese origami engineering to promote new industrial applications." Hagiwara's proposals include non-honeycomb structures based on metallic and other materials. He envisages applications in a wide variety of fields, including solar panels and the development of a new type of automobile bumper capable of absorbing energy on crash.

Education and collaboration at MIMS

Through its GCOE program, MIMS is setting up PhD scholarships, to attract high-calibre students from around the world. "Traditionally, we have a wealth of outstanding mathematicians in the country," says Mimura. "We aim for MIMS to be a melting pot of mathematical ideas. To this end, one of our top priorities is education."

MIMS is also engaged in research collaborations with institutions in Japan and abroad. "We are currently collaborating with the Centre for Mathematical Biology at the University of Oxford in the UK and the National Centre for Scientific Research in France," says Mimura. "We are planning to build on our global collaborations that leverage the strength of each partner."

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