OPENING NEW HORIZONS FOR HUMANITY

A hub for innovative and ground-breaking research, KAIST is using science, engineering, and good governance, to make a significant difference.

Established in 1971 by the South Korean government, KAIST was given a mission to make innovations that would drive the nation's economic growth. KAIST has achieved its goal by creating a successful educational model that is now used as a benchmark by many other countries.

Celebrating 50 years in 2021, KAIST's R&D strategy has shifted to focus on creating global value. "We aim to make breakthroughs that will make a huge difference to the people all over the world," says its president, Sung-Chul Shin.

Under its Global Singularity Research Projects initiative, researchers are collaborating with the private and public sectors to help solve some of the most challenging global problems. Projects selected under this initiative will be funded for up to 10 years, with no strings attached.

"We now want to be a 'first mover' who can present an innovative global model before others. For that, we need to identify what will be needed for the future more precisely, and make a longer-term commitment so that researchers are more likely to achieve tangible results," he adds.

The first two projects selected for the initiative focus on neuro-rehabilitation and new materials.

"WE NOW WANT TO BE A FIRST MOVER WHO CAN PRESENT AN INNOVATIVE GLOBAL MODEL."

Precise neuro-rehabilitation engineering for the future

People with physical disabilities, caused by injuries or illnesses, face barriers to a healthy, active, and productive life. By developing treatments tailored to specific needs and conditions, researchers at KAIST are working to improve rehabilitation programs, helping patients reach their full potential, despite their physical limitations.

"Current rehabilitation procedures use similar methods for patients with the same diseases or injuries, but because people vary in the severity of their condition and their individual circumstances, their needs are different," says Hyung-Soon Park, Professor in the M&M (Mechanical and Medical) group at the Department of Mechanical Engineering.

Park is spearheading KAIST's RENEW (Rehabilitation Engineering for Neurological Disorders Worldwide) initiative, where he specializes in rehabilitation robotics, neuro-rehabilitation engineering, and biomechanics.

By using engineering principles to model how the brain reacts and adjusts to physical impairment, his work is helping to improve the accuracy of clinical assessments and the development of more effective rehabilitation programmes.

"In 1998, I was involved in the development of South Korea's first wheelchair mounted robotic system for helping disabled people," explains Park. "However, I later realized that I had spent five years making a high-end robotic system that most users couldn't afford. Since then, I have been focusing on novel but practical and effective rehabilitation devices that are affordable to those who need them."

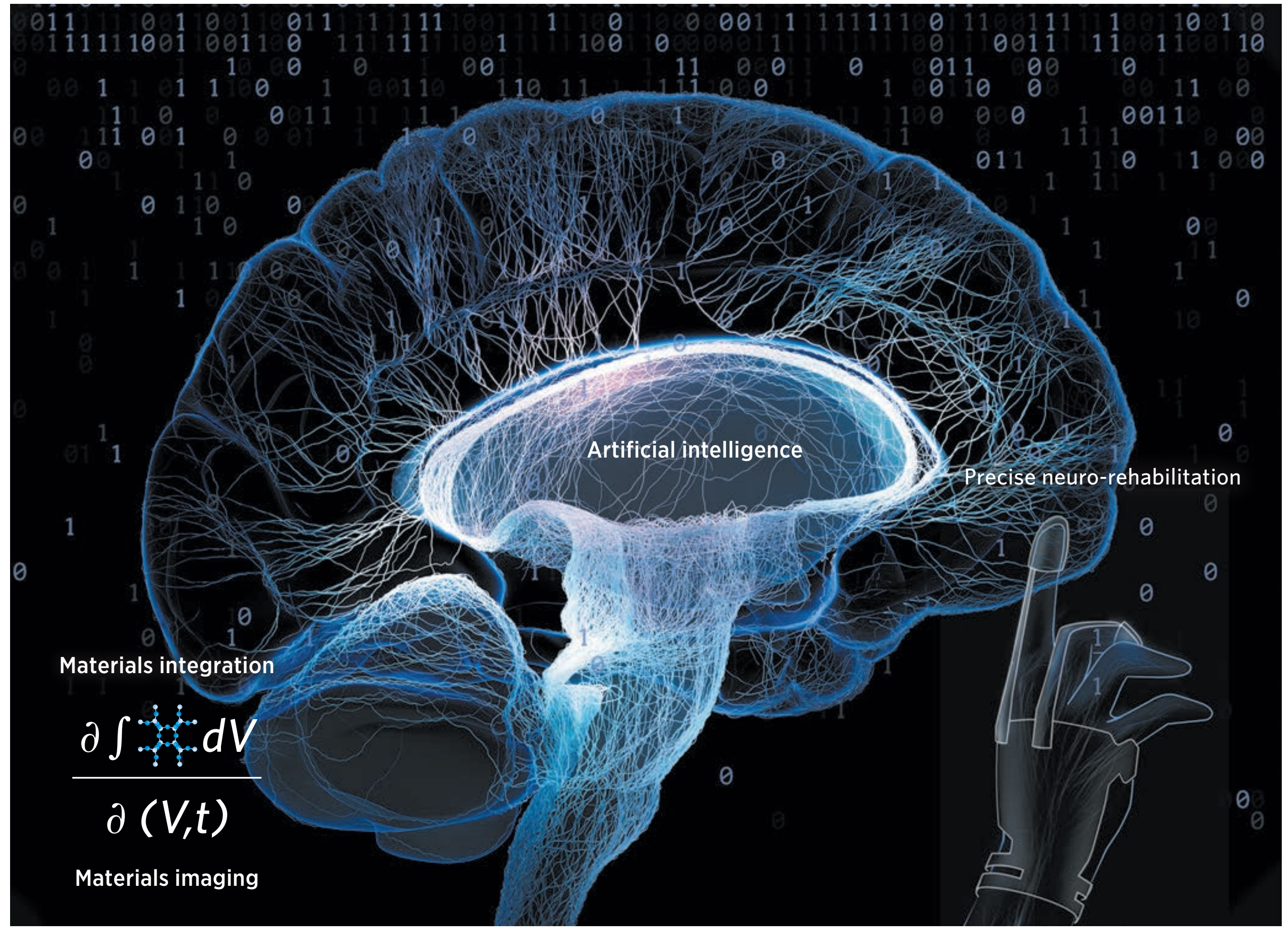
One of the biggest challenges in rehabilitation medicine is how to accurately measure the effectiveness of a rehabilitation programme. For example, stroke patients who experience the same level of impairment will often receive the same rehabilitation programme but may have very different responses.

Park and his team are developing models that simulate how neurons in the brain adjust their response to compensate for physical impairment from injury or disease — an ability often referred to as brain or neural plasticity.

By attaching electrodes to the scalps of people who had suffered from strokes that led to damaged or dysfunctional nerves that control motor functions, they were able to develop brain connectivity models for motor function deficiencies in each patient. They then used the model to identify the specific changes to the neural circuits associated with the deficient motor skills, which allowed them to develop treatment programmes that maximize the therapeutic outcome.

"At the neuron level, we are developing cell-based disease models to test what kinds of physical therapies would have a positive effect on the enhancement of neural plasticity.

"We are also developing brain network models that help us to understand how the brain learns specific motor skills so that repetitive tasks carried out in physical therapy transfer to the daily activities of life," says Park.



By developing individualized models for predicting a particular patient's response to different treatment, the work could significantly improve the effectiveness of rehabilitation programmes.

Building the materials of the future

"The importance of materials to the advancement of human society is reflected by the many eras of human history named after them — the stone age, bronze age, and iron age," says Daniel Seungbum Hong, an Associate Professor in Materials Imaging and Integration Laboratory at KAIST's Department of Materials Science.

Hong and his team are using materials imaging and machine learning techniques to investigate the structure-property relationship of new materials that are more reliable, easier and cheaper to make, and less damaging to the environment.

The team is part of KAIST's M3I3 Initiative: Materials and Molecular Modeling, Imaging, Informatics, and Integration. The initiative aims to streamline the three core components of materials science engineering: processing, structure, and property.

"We are now in the era of the 4th industrial revolution. By utilizing the enormous amounts of data available on materials and the tools to observe and manipulate them at the atomic and molecular level, materials science will soon make a quantum leap forward in the development of advanced materials for a wide range of new applications," says Hong.

By mapping the connections between a material's structure and properties, Hong is developing a method that will lead to advanced materials that can be manufactured with bespoke properties by creating molecular blueprints for candidate materials with those properties.

The work has already led to a breakthrough with the development of cathodes made from lithium-rich materials that significantly enhance the discharge capacity of lithium-ion batteries.

"By using a design algorithm developed here, we were able to extract useful structural and processing data from researcher papers and patents. We then used a machine learning technique called transfer learning to identify a material that could improve the performance of lithium-ion batteries," says Hong.

The work could lead to next-generation lithium-ion batteries for use in a range of applications, including electric vehicles, drones, ships, aeroplanes, and many more.■

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