ASIA-PACIFIC

AUSTRALIA

Spatial digital twin

Five years since its launch, the NSW Spatial Digital Twin (SDT) continues to prove its worth as a transformative platform for government planning. The NSW Spatial Digital Twin has evolved into a robust ecosystem supporting a growing number of use cases across sectors, including education, infrastructure development, housing supply, emergency response and local government.

The value of the digital twin is not just about the technology itself but about unlocking the value of the State's data. An example of this is the release of the NSW Land Subdivision Pipeline into the Spatial Digital Twin, providing a forward view of new land development. This data empowers planners, developers and councils planning for communities and demand for infrastructure. It also informs the community of what neighbourhoods will look like in the future. It has been significant in supporting housing supply, unlocking new land, and finding efficiencies in the planning process.

One of the greatest benefits of the Spatial Digital Twin has been the ability to fully customise it to suit different needs across government. The NSW Department of Education leveraged a fully customised version of the Spatial Digital Twin to manage its school assets across the state. The tool allows them to manage their current assets and complete a rapid, early assessment of sites suitable for development, unlocking significant value.

Land information is not just about planning and development. During recent flooding events in NSW, the Spatial Digital Twin was used to identify land suitable for temporary housing and streamline the process for activating it. This provided much-needed relief for the impacted community.

https://www.spatialwa.wa.gov.au/

CHINA

Intelligent mining technology

The mining sector is currently witnessing a digital transformation as mine operators embrace autonomous vehicles, AI-driven monitoring systems, robotics and smart drill rigs, as well as more environmentally responsible practices, aimed at enhancing efficiency and safety. A major focus is on sustainable resource extraction and decarbonisation, with firms investing in technologies to lower emissions, manage water, and rehabilitate mined land, with several countries leading a global shift towards more intelligent and responsible mining.

As both the world's largest producer and consumer of coal, in recent years, China has made remarkable progress in upgrading its mining sector, with intelligent production capacity now representing more than 50% of total coal output. The number of mines adopting intelligent systems has increased significantly, and China now leads the world in the deployment of technologies, such as 5G-enabled industrial internet, autonomous vehicles and digital management platforms.

Underpinned by robust policy support from the Chinese authorities, this transformation promotes intelligent, safe, and sustainable mining. New regulations mandate the adoption of advanced technologies to protect workers and reduce risks, with environmental sustainability a key priority. For example, autonomous trucks and drills are enabling continuous, round-the-clock operations, reducing the need for personnel to work in hazardous conditions, while AI-powered predictive maintenance systems are helping to prevent equipment failures, minimising costly downtime and ensuring more reliable, efficient mining operations.

A pivotal player of this evolution is technology pioneer Huawei, whose innovative solutions are helping to address mining's most pressing challenges. Its 5G-Advanced (5G-A) networks deliver the high-speed, low-latency connectivity required for real-time data exchange between autonomous trucks, drills, and central control systems. This connectivity enables 24/7 operations, significantly boosting productivity while minimising human exposure to hazardous environments.

Huawei's AI-driven platforms are also transforming mine management, with predictive maintenance and cloud-based management systems enabling seamless coordination of complex mining processes. Huawei's autonomous vehicle solutions, such as those deployed at the Yimin open-pit mine, demonstrate the practical benefits of these technologies, with improved safety, greater operational efficiency, and reduced environmental impact.

In May 2025, the Yimin open-pit coal mine in Inner Mongolia became the world's first mine to deploy a fleet of 100 autonomous electric mining trucks, marking a significant milestone in the digital transformation of the mining sector. This achievement was the result of a joint innovation project between Huaneng Inner Mongolia Eastern Energy Co., Ltd., Huawei, and other partners, aimed at creating a zero-carbon, intelligent mine transportation system.

Huawei has been at the forefront of integrating AI and digital solutions into mining operations, and at the heart of the Yimin mine is the integration of a 5G-Advanced (5G-A) network, enabling seamless vehicle-cloud-network synergy. Huawei played a pivotal role by providing its Commercial Vehicle Autonomous Driving Cloud Service (CVADCS), which leverages crowdsourced mapping for real-time location updates and route optimisation.

This technology not only reduces waiting times and maximises fleet efficiency, but also supports the safe, continuous operation of trucks in harsh environmental conditions, including the extreme -40°C temperatures often found at the Yimin mine, frequent dust storms, and fog. The Yimin mine is also the first in China to operate autonomous mining trucks without

driver cabins, significantly improving personnel safety by removing workers from hazardous environments entirely.

The 5G-A network deployed by Huawei ensures robust, low-latency connectivity, supporting high-definition video backhaul and real-time cloud dispatching. With 500 Mbps uplink and 20 ms latency, the network underpins the smooth operation of the autonomous fleet, setting a new benchmark for intelligent mining worldwide.

https://www.mining-technology.com/

Sea wind and wave detection satellite

China's first satellite designed to detect sea winds and waves has been officially named MAZU, officials announced Sunday at the 10th World Mazu Culture Forum in Fujian province. The satellite is scheduled for launch in 2027. The satellite will provide technical support for real-time monitoring of ocean wind and wave conditions, marine and weather forecasting, ocean resource development, and disaster prevention and mitigation at sea. It is part of China's national early warning initiative MAZU, unveiled in July.

Lin Mingsen, former director of the National Satellite Ocean Application Service under the Ministry of Natural Resources, said that "marine satellites, with their high resolution, speed, wide coverage, and comprehensive data advantages, can play a vital role in ocean disaster prevention and mitigation."

MAZU stands for "Multi-hazard", "Alert", "Zero-gap", and "Universal", coinciding with the name of an ancient Chinese sea goddess worshipped in south-eastern China's coastal areas for her death while rescuing people from a shipwreck in the 10th century. The core MAZU spirit lies in "virtue, kindness, and great love," which in the maritime context is expressed through "sea rescue".

https://www.ecns.cn/

INDIA

A novel spatially aware AI model

Now, researchers from the Indian Institute of Technology, Bombay, have developed a spatially aware domain adaptation network (SpADANet), which refers to an AI model designed to 'adapt' across different storms, even with a limited number of labelled samples from ground zero. The findings of the study, published recently in the IEEE Geoscience and Remote Sensing Letters, demonstrate that SpADANet achieves more than 5% improvement in damage classification accuracy compared to existing methods across different hurricanes.

"The existing models consider the problem of domain gap in a statistical sense, but often ignore the spatial context. Spatial context is basically the arrangement and relationship of any spatial object (like buildings) within an image, which is the heart of SpADANet," explains Pratyush Talreja, a PhD Candidate and Prime Minister's Research Fellow at IIT Bombay and also the first author of the study.

Further, the researchers have even optimised the model to run with limited computing power, and it can be used on tablets and phones as well. This feature makes it a handy tool in the field and addresses a genuine bottleneck in disaster response, particularly for regions with limited resources. While the researchers tested the model on hurricanes in the US, they are confident that the framework can be applied globally for damage assessments with appropriate local imagery. SpADANet can generalise effectively across varied environments, but modest amounts of locally labelled data enhance its adaptation performance and reliability, says Talreja.

"Agencies like NDMA (National Disaster Management Authority in India) face three main constraints: lack of labelled data, limited computing resources, and regional differences (domain gap) in the image characteristics. SpADANet can help overcome these barriers as it learns from fewer labels, adapts to new regions, and can run on modest hardware once trained. With continued collaboration between the researchers and the government agencies, such AI models can soon become part of near-real-time disaster response systems," highlights Talreja.

SpADANet is developed using ResNet as the background model, which is a type of deep neural network with proven superior image pattern recognition abilities.

Labelling satellite imagery is slow and expensive, as each image needs a human eye to mark whether a building is destroyed or lightly damaged. The findings, therefore, emphasise the effectiveness of domain-aware learning in real-world disaster response settings. While the results look encouraging, the ways that SpADANet employs to perform domain adaptation are also novel.

After introducing self-supervised learning, the researchers further enhanced the model using a new module called the Bilateral Local Moran's I (BLMI). Moran's I is a widely used statistical method to spot groups of similar patterns that appear close together in an image. BLMI builds on this idea to help the model understand how nearby pixels relate to each other. In other words, the model does not judge a patch solely by its colour or shape, but also by how neighbouring patches relate to one another, enabling SpADANet to recognise damage patterns based on location and context.

In essence, SpADANet makes sure each damage category, like 'no damage', 'minor damage', 'major damage', 'destroyed', matches properly across different hurricanes. It learns to recognise that a "destroyed" building in one storm should look like a "destroyed" building in another, even if the lighting, materials or layouts differ. This means a destroyed roof in one hurricane is treated the same way as a destroyed roof in another to avoid mix-ups across geographies. The BLMI module strengthens the model's ability to read spatial patterns, and the self-supervised learning step helps it adapt to a new hurricane smoothly, even when only a few labelled examples are available.

However, researchers highlight that factors such as the availability of standardised datasets and data-sharing limitations from the agencies may pose a short-term barrier to immediate large-scale implementation. Their next step in this research is integrating multimodal data, such as combining images with LiDAR data. In a warming world, where both frequency and intensity of hurricanes continue to increase, a faster, cheaper damage assessment tool like

SpADANet can prove critical for a timely and reliable damage assessment.

The Indian model is developed independently for hurricane damage assessment using ResNet as the background, adding spatial awareness and self-supervised learning to achieve domain adaptation.

https://researchmatters.in/

JAPAN

Sulfated yeast rises to the challenge

A research group led by Professor Masayuki Azuma and Associate Professor Yoshihiro Ojima at Osaka Metropolitan University's Graduate School of Engineering successfully achieved selective recovery of metals with S-yeast, a sulfated yeast. The study was published in *Environmental Research*.

When testing the removal of copper (Cu) from a solution, S-yeast's metal adsorption capacity was found to absorb approximately 2.3 times more than the phosphate-modified baker's yeast (P-yeast) previously created in their past studies. Furthermore, S-yeast can desorb Cu using hydrochloric acid, then adsorb it again, effectively providing a possible sustainable and cost-effective solution to metal recovery. Additionally, it was found that S-yeast adsorbs more zinc, cadmium, lead, and rare earth elements than P-yeast.

"We hope these research findings lead to applications in efficient and environmentally-friendly rare earth recovery technology. Moving forward, we plan to advance toward practical implementation by scaling up material production and conducting evaluations using actual waste liquids," stated Professor Azuma.

https://phys.org/

REPUBLIC OF KOREA

Smart measurement to enhance flood forecasting accuracy

A research team from the Republic of Korea has developed an artificial intelligence (AI)-based automatic water level measurement system to improve the accuracy of flood forecasting and the reliability of hydrological data in Southeast Asian countries. The Korea Institute of Civil Engineering and Building Technology (KICT) announced on the 29th that a team from its Water Resources and River Research Division has developed an AI-based automatic water level measurement system called the 'Smart Staff Gauge'. A staff gauge is a measuring instrument installed in rivers and streams with a graduated scale to allow for direct observation of the water level.

The research team developed the Smart Staff Gauge, a low-cost, highly field-applicable, contact-type automatic water level measurement system that applies AI technology and can precisely measure both river water levels and inland inundation levels simultaneously. The newly developed Smart Staff Gauge overcomes the limitations of conventional manual staff gauges. It performs an integrated process of automatic water level measurement, data transmission, anomaly analysis, and flood prediction. A key feature is its integration of AI technology, which manages the quality of water level data in real-time and can predict future water level changes and the possibility of flooding.

The Smart Staff Gauge's measurement device uses both resistance-type sensors, which measure changes in electrical resistance between sensors, and laser-type sensors, which detect the position of a float to measure the water level. The newly developed device is capable of precise water level measurement within an error range of ±2mm. It operates on solar power, eliminating the need for an external power source. Installed on the main stream of the Mekong River in Laos during the flood seasons from 2023 to 2024, the Smart Staff Gauge measured water levels with an accuracy of within ±2mm. It recorded an accuracy level equivalent to manual observation, successfully demonstrating the effectiveness of its AI-based hydrological data quality control and prediction capabilities.

Furthermore, the Smart Staff Gauge can be installed at less than half the cost of existing foreign-made equipment and is easy to maintain. As the collected data is transmitted automatically, it is highly useful for developing countries with limited personnel and budgets. It can be installed not only in rivers but also in flood-prone areas such as roads and underpasses, and it is highly scalable, allowing for integration with disaster response systems that include LED warning signs, sirens, and CCTVs.

The research team plans to further advance the Smart Staff Gauge technology to suit various field conditions and expand its development into a modular product suitable for urban areas, including underground spaces. They also intend to seriously pursue global market entry through cooperation with domestic local governments, as well as international organisations, and foreign cities.

https://www.dongascience.com/

THAILAND

Smart aquaculture IoT solution

HydroNeo is a Thailand-based aquaculture technology company. Since 2020, it has grown into a leading provider of smart water monitoring and farm management systems, and is nowadays trusted by farmers in six countries across Asia. HydroNeo's IoT-based system enables shrimp and fish farmers to monitor key parameters such as dissolved oxygen, pH, and temperature in real time, while automating operations to improve energy efficiency, reduce costs, and support more sustainable farming through digitalisation.

HydroNeo's vision is simple: to empower farmers to make decisions with confidence, no more guessing. Farming becomes more efficient, predictable, profitable, and better for everyone: the animals, the farmers, and the environment. What makes HydroNeo's journey unique is that they are farmer themselves. They understand farmers' daily struggles and test their solutions directly in real ponds. From there, they built technology step by step, ensuring it truly serves the needs of farmers upgrading their operations rather than forcing them to adapt to technology on a green-field.

It also highlights why aquaculture farms today must modernise with technology, not as a luxury, but as a smart investment to strengthen financial performance, improve sustainability, and secure the future of farming.

https://enaca.org/

Smart water management

In a quiet district along the Thai-Lao border, a new kind of digital transformation is taking shape – one powered by solar panels, smart sensors, digital tools, and most importantly, by the people who use them. Bung Khla Sub-district, home to *Moo* 1, 2, and 3 *(Moo means villages in Thai)* in Bueng Kan Province, has recently emerged as a pioneering innovation site for a smart, community-led water management solution under the P-LINK Project – *People's Livelihoods Initiative through water-energy-food Nexus in the Mekong Region*. Rooted in South-South and triangular cooperation, the community is stepping into the future with smart water technology, designed not just to function, but to last.

Also known as the ROK-UNOSSC Facility (Phase 3), this initiative brings together the United Nations Office for South-South Cooperation (UNOSSC), the Republic of Korea's Ministry of Science and ICT (MSIT), the Mekong River Commission, Thailand's Office of the National Water Resources (ONWR)/Thailand National Mekong Committee Secretariat (TNMCS), the Mekong Institute (MI), ROK Science and Technology Policy Institute (STEPI) and Korean start-up WI.Plat, all working closely with local government and communities to deliver results. At the core of the project is a smart water system—a major upgrade to the community's existing infrastructure. Installed across three villages, the system includes:

- AI-powered leak detection and water pressure sensors
- Automated chemical dosing systems to improve treatment consistency
- Solar-powered energy units for sustainability

A centralised real-time monitoring room outfitted with digital dashboards. These tools allow local operators to monitor water quality, track system performance, and detect problems quickly – something that was not possible before.

"Before this project, we relied mostly on manual checks and didn't have tools to detect leaks or monitor water quality in real time," said Mr Piya Panumas, Director of Public Works at Bung Khla SAO. "Now, we can see what's happening in the system right away and respond faster. Since installation, the water looks clearer and more consistent. I really hope everyone in the village will take care of it together."

They have installed a digital water metre and a mobile app for real-time leak detection via IoT. Smart systems only reach their full potential when people are equipped to use them. This is why the project placed strong emphasis on training, local capacity, and ownership.

While full automation remains limited by cost and uneven internet access, this semi-digital approach already marks a significant step forward in efficiency and service delivery. The smart water system has already begun to reduce water loss, improve supply quality, and support clean energy use. As ONWR/TNMCS's Director of Foreign Affairs Division, Dr Winai Wangpimool noted, "There are real production costs to ensure water is clean and safe. It is crucial that water reaches households as efficiently as possible." As results are tracked over the coming months, stakeholders are already looking at scaling the model across Thailand and the wider Mekong region.

The Bung Khla pilot is more than a technical upgrade – it is a human story about what happens when innovation is grounded in cooperation and driven by community. For Moo 1, 2, and 3, it is not just about water flowing downstream. It is about progress flowing forward.

https://unsouthsouth.org/

EUROPE

GERMANY

Diving robot collects underwater trash

German researchers have developed a groundbreaking AI-powered underwater robot that could transform how we tackle marine pollution by collecting ocean debris with its giant four-fingered robotic hand. To address one of the world's greatest environmental problems, marine litter, the engineering team at the Technical University of Munich (TUM) built the robot as part of the EU project SEACLEAR.

The autonomous diving robot uses an integrated AI system with ultrasound and cameras to detect underwater litter. Once identified, it then picks up the waste and brings it to the surface. Demonstrating its capabilities for the first time in the port of Marseille in France, the diving robot collected various debris from the seabed, including objects as heavy as 551 lbs (250 kilograms). With ocean litter ranging from e-scooters and lost fishing nets to old tyres from the harbour basins and broken glass, the system is engineered to handle both heavy-duty lifting and delicate precision.

According to Stefan Sosnowski, PhD, Chair of Information Technology Control at TUM, waste disposal using autonomous underwater waste collection becomes profitable at depths of 52 feet (16 metres) or more. That's why the entire system consists of an unmanned service boat with a dinghy, a drone, a small underwater search robot and the TUM diving robot. The service boat supplies the robots with power and data connections through cable. At the same time, it also sends ultrasonic waves into the depths to generate a rough map of the seabed. The small 20-inch (50-centimetre) search robot then quickly and efficiently scans the seabed.

Powered by eight mini turbines, the submarine then dives to the locations where the litter is detected and collects the objects. It uses a which to load them onto an additional autonomous dinghy that serves as a floating waste container. "Since we first have to identify the rubbish and grasping objects requires a high degree of precision, we have a camera and sonar on board that enable orientation even in murky water," Sosnowski stated. Identifying underwater rubbish is no easy task, as there's little image data available to train neural networks. Nevertheless, the team have managed to label more than 7,000

images as potential objects which don't belong on the seabed. Once the waste is detected, the AI transforms the images into 3D models. "This is important for deciding where the object can be gripped securely," Sosnowski elaborated. He stated that the autonomous gripper's four-fingered hand can exert a force of 4,000 Newtons (N) and lift objects weighing up to 551 lbs (250 kilograms). Its grip is, however, regulated by special sensors that measure how much force can be applied without causing damage. This, for instance, prevents plastic buckets from breaking or glass bottles from shattering.

Although the boat operates autonomously, researchers kept it tethered during the experiment. The onboard battery lasts only two hours, and the cable boosts AI performance while also helping pull heavy objects to the surface. Meanwhile, the 264-lb (120-kilogram) submarine is encased in buoyancy foam, keeping it suspended in water when the mini turbines are off. This lets the robot move freely and stay on course. "This is important for approaching objects precisely," Sosnowski concluded.

https://interestingengineering.com/

UK

AI supercharges science on the Antarctic seafloor

Using the latest AI technology, scientists from the British Antarctic Survey have dramatically sped up the process of detecting animals found in photographs and videos taken of the seafloor—from taking several hours to a few seconds per image. The use of this tool, in combination with expert scientists, is fast enough that it could even be used on research vessels in Antarctica to label photographs in real time as they are taken. This major increase in speed and efficiency enables researchers to cover a much larger area of the seafloor when trying to decide which parts of Antarctica need special protection.

The Antarctic seafloor is home to more than 94% of all the species known from the Southern Ocean, most of which live nowhere else on Earth and are adapted to sub-zero temperatures. As climate change and human activities threaten these specially evolved animals, it is important to gather information to help us understand where these animals live and which species are at greatest risk.

"This new AI technology will massively speed up how marine biologists analyse the data they collect. Before we developed this tool, image analysis was performed by hand, taking up to eight hours per photo. By having the AI work alongside the human experts, we can cut this down to a few seconds per photo," said Dr Cameron Trotter, machine learning research scientist at the British Antarctic Survey and lead author of the study, which is posted to the *arXiv* preprint server. "This allows us to analyse far more data than ever before, speeding up our understanding of these unique and globally important ecosystems."

Training AI tools to understand the Antarctic seafloor, along with the creatures that call it home, is extremely challenging. The model was trained on images taken on board Germany's polar research ship, the RV *Polarstern,* of the Alfred Wegener Institute, in the Weddell Sea. Dr Trotter added, "The images we used to train the AI are extremely high-resolution and packed full of weird and unusually shaped animals, often living on top of each other, some of which have never been seen before."

Scientists labelled each animal in 100 images, which captured a range of seafloor species, representing a range of conditions. Learning from these labelled images, the AI can now find and label the same types of animals in photographs taken in regions across the Southern Ocean. It can identify many of the most commonly seen seafloor creatures, including starfish, corals, sponges and fish.

"This is a game-changer for the way in which we analyse the seafloor, unlocking vast quantities of data crucial for the conservation of Antarctic ecosystems," said co-author Dr Rowan Whittle, a paleobiologist at the British Antarctic Survey. "Traditionally, scientists have relied on destructive dredging and fishing methods to collect biodiversity data, but the use of photography and AI allows rapid data collection, while not causing any disturbance to this vulnerable environment."

Researchers are already using this technology in their research, with a backlog of more than 30,000 images from the Antarctic Peninsula and Weddell Sea currently being analysed. The findings have strong potential for discovering species, as well as providing policymakers with crucial information that will help protect the creatures found in this vulnerable ecosystem.

https://phys.org/

NORTH AMERICA

USA

AI-powered geothermal discovery

Zanskar Geothermal and Minerals has announced a major breakthrough in geothermal energy with the discovery of the first commercially viable geothermal system in over 30 years. This achievement was made possible by leveraging artificial intelligence (AI), signalling a new era in renewable energy exploration and development. The new geothermal system, "Big Blind", is located in a remote part of western Nevada.

Remarkably, there were no prior surface or geological signs indicating geothermal activity there, highlighting how AI has revolutionised exploration. Traditionally, geothermal exploration involved extensive drilling and many non-productive wells, leading to high costs and environmental disruption. By incorporating AI, Zanskar analysed large datasets to more accurately predict promising geothermal sites, significantly reducing unproductive drilling, cutting exploration expenses, and minimising environmental impact. This success builds on Zanskar's previous projects at Pumpernickel in northern Nevada and Lightning Dock in New Mexico, which utilised technology-driven approaches to geothermal development. However, Big Blind stands out due to its location in an area previously considered unlikely for geothermal activity.

This discovery underscores the vast untapped potential of geothermal resources in overlooked regions. Zanskar now plans to obtain permits to move Big Blind from discovery to development,

aiming to create a power-generating geothermal facility within this decade. This is part of a broader strategy to harness advanced technologies to unlock new geothermal sources and expand the U.S. renewable energy portfolio. Such projects are expected to promote cleaner energy, decrease greenhouse gas emissions, and strengthen energy security. The implications extend beyond Zanskar and Nevada.

Amid rising energy demands, fossil fuel price volatility, and environmental challenges, Zanskar's discovery represents a promising step toward diversifying and strengthening energy systems. Big Blind not only demonstrates technological ingenuity but also provides a practical pathway to commercially viable geothermal power. This landmark find suggests that ongoing integration of AI and technology could reveal many hidden geothermal resources globally, opening new opportunities for sustainable energy production. It also signals hope for a future in which clean, renewable geothermal energy can notably reduce reliance on carbon-intensive sources, advancing the global fight against climate change and fostering a sustainable energy system for future generations.

https://neuron.expert/

Efficient ways to extract rare earth elements

A team of scientists at The University of Texas at Austin has created a cleaner and more efficient way to extract rare earth elements, which are vital for technologies such as electric vehicle batteries and smartphones. The technique could strengthen domestic production and lessen dependence on expensive imports. The new process makes it possible to separate and collect rare earth elements from sources that were previously too difficult or inefficient to use, offering a potential solution to supply challenges heightened by global trade tensions.

"Rare earth elements are the backbone of advanced technologies, but their extraction and purification are energy-intensive and extremely difficult to implement at the scales required," said Manish Kumar, professor in the Cockrell School of Engineering's Fariborz Maseeh Department of Civil, Architectural and Environmental Engineering and the McKetta Department of Chemical Engineering. "Our work aims to change that, inspired by the natural world."

The study, recently published in *ACS Nano*, describes how the team engineered artificial membrane channels, tiny pores within membranes, that imitate the highly selective transport systems of natural proteins in living organisms. In biology, such channels guide ions as they move between cells. Each channel has unique properties that allow only ions with specific traits to pass through while blocking others. This fine-tuned selectivity is essential for many biological functions, including the way the human brain processes information.

The researchers' artificial channels use a modified version of a structure called pillararene to enhance their ability to bind and block specific common ions while transporting specific rare earth ions. The result is a system that can selectively transport middle rare earth elements, such as europium (Eu^{3+}) and terbium (Tb^{3+}), while excluding other ions like potassium, sodium, and calcium.

Rare earth elements are split into several classes (light, middle and heavy), each with different properties that make them ideal for specific applications. Middle elements are used in lighting and displays, including TVs, and as magnets in green energy technologies, such as wind turbines and electric vehicle batteries.

Using advanced computer simulations, they discovered that the channels' selectivity is driven by unique water-mediated interactions between the rare earth ions and the channel. These interactions allow the channels to differentiate between ions based on their hydration dynamics—how water molecules surround and interact with ions.

Kumar and his team have been working on this research for more than five years. He is an expert in membrane-based separations, applying that knowledge to clean water generation as well. The researchers envision their technology being integrated into scalable membrane systems for industrial use. The goal is to make it easier to conduct ion separations in the U.S., using clean energy. They're working on a platform for these channels that allows users to select a variety of ions to gather. This could include other critical minerals like lithium, cobalt, gallium, and nickel.

This is a first step towards translating nature's sophisticated molecular recognition and transport strategies into robust industrial processes, thus bringing high selectivity to settings where current methods fall short.

https://scitechdaily.com/