ASIA-PACIFIC

CHINA

AI weather model

The Shanghai Academy of Artificial Intelligence for Science and Fudan University unveiled Fuxi 2.0, an upgraded AI-powered large model for climate and weather forecasting. Fuxi 2.0 boasts higher prediction accuracy than previous models and is 1,000 times faster, while also being cheaper and able to generate longer-term forecasts. It is expected to enhance early warning, risk management, and disaster prevention capabilities across China.

"The rising frequency of extreme weather events due to climate change necessitates improved weather forecasts," said Qi Yuan, director of the academy. "Fuxi 2.0 aims to mitigate the damage caused by such events by providing more accurate and timely predictions."

Li Hao, who leads the academy's earth science research team, highlighted Fuxi 2.0's significant leaps in forecasting extreme weather phenomena, surpassing the accuracy of the European Centre for Medium-Range Weather Forecasts' short- and medium-term models.

The first version of Fuxi was launched at the United Nation's COP28 climate change summit in December, becoming the first Chinese sub-seasonal climate model capable of generating forecasts for the next 15 to 60 days. Li said Fuxi 2.0 can deliver nationwide high-resolution forecasts with ground meteorological elements, providing hourly updates accurate to within a kilometer — a vast improvement over existing models with resolutions of 10 to 25 km.

For the new energy sector, Fuxi 2.0 offers more accurate wind speed, irradiation, and power generation predictions, allowing for optimized wind and solar power generation, improved grid load balancing, and reduced curtailment. "It acts like an intelligent navigation system for wind farms and solar power plants," Li said.

The aviation industry can leverage Fuxi 2.0's ability to predict low cloud cover and total cloud cover, aiding in forecasting ice, turbulence, and uneven light conditions — factors impacting flight experiences and costs. The academy and 12 other institutions, including meteorological services, research bodies, and industry leaders, have announced the formation of an ecological alliance for intelligent meteorological innovation. It will leverage Fuxi 2.0 and foster collaboration between the research, education, and industrial sectors to drive further technological advances in intelligent weather forecasting.

https://www.chinadaily.com.cn

AI-based model to address streamflow, flood forecasting

Chinese scientists have recently proposed a novel artificial intelligence (AI)-based model to address streamflow and flood forecasting at a global scale for both gauged and ungauged catchments which remains one of the long-standing challenges in hydrology, given that more than 95 percent of small- and medium-sized watersheds worldwide do not have any monitoring data.

In light of global climate change, the frequency and intensity of extreme rainfall events significantly increased, leading to more frequent flooding disasters and more intensive flooding risks. Thus, the effective prediction of flood discharge serves as a crucial factor for reducing the risks of flood disasters. Despite the significant progress that has been made in physical process-based flood discharge prediction over the past few decades, forecasting results using current methods still heavily rely on monitoring data and parameter calibration. Recent progress and expansion in deep learning have made the AI technology-based data-driven models an alternatively novel solution for streamflow and flood forecasting in hydrological science.

A research team led by Ouyang Chaojun, a research fellow with the Institute of Mountain Hazards and Environment from the Chinese Academy of Sciences, proposed an AI-based novel streamflow and flood forecasting model to solve the streamflow and flood prediction problems at a global scale for both gauged and ungauged catchments.

Data-driven models are critically dependent on the quality of historical data. The research team is leveraging historical data sets across 2,089 catchments from the US, Canada, Central Europe, and the UK with a data collection frequency of 24 hours and the time span between January 1, 1981, and December 31, 2009, to train the model, while also using historical data sets between January 1, 2010, and January 1, 2012, to verify the accuracy of the model's forecasting capability, Ouyang told the Global Times. According to Ouyang, generally speaking, examining a longer time span results in richer data sets, despite having higher training costs. The significant diversity in the distribution of the data across these catchments ensures data variety and tests the accuracy and reliability of the model in the predictions for future time periods.

The verification results show that the model yields a mean Nash-Sutcliffe efficiency coefficient (NSE) of 0.75 - a commonly used score to assess the predictive power of hydrological discharge models - across 2,089 catchments, highlighting improvements by the state-of-the-art machine learning over traditional hydrologic models. Based on the models pre-trained in the northern hemisphere, researchers conducted predictions on 160 entirely new river basins in Chile in the southern hemisphere without using any monitoring data, to test the model's prediction ability in ungauged catchments. The prediction results of different pre-trained models show strong spatial distribution consistency.

The model applied to 160 ungauged catchments in Chile shows that 76.9 percent of catchments obtain NSE higher than zero in the best situation, demonstrating the potential of deep learning methods to overcome the ubiquitous lack of hydrologic information and deficiencies in physical model structure and parameterization. The model was recently published online through the interdisciplinary journal *The Innovation*. This deep learning model can more effectively capture the spatial and physical attributes within the catchments.

Through this study, the model has demonstrated an enormous potential for streamflow and flood prediction across regions at a global scale. It is expected to enhance disaster prevention and mitigation efforts significantly if it is integrated with existing disaster forecasting systems to establish a real-time warning platform across various time scales, from days to hours to minutes.

https://www.globaltimes.cn

AI-enabled model to help mitigate ammonia emissions

An international research team led by the Hong Kong University of Science and Technology (HKUST) has achieved a significant breakthrough by developing an artificial intelligence (AI) model that can help mitigate global ammonia (NH_3) emissions from agriculture. The study, titled "Fertilizer management for global ammonia emission reduction", has been published in *Nature*.

A research team led by Prof. Jimmy Fung Chi-Hung, Chair Professor of HKUST's Division of Environment and Sustainability in the Academy of Interdisciplinary Studies and Department of Mathematics, and Prof. Zheng Yi from the School of Environmental Science and Engineering at the Southern University of Science and Technology (SUSTech), collected and compiled a dataset based on field observation data of NH_3 emission rates spanning between 1985 and 2022. They subsequently trained an AI-powered computer model to estimate global NH_3 emissions using the dataset while considering various geographical factors such as climate, soil characteristics, crop types, irrigation water, fertilizer, and tillage practices.

This model is capable of generating customized fertilizer management plans for different regions. For instance, in Asia, around 76% of wheat land is suitable for using enhanced-efficiency fertilizers (EEFs) to reduce NH_3 emissions due to the influence of global warming, as temperature plays a pivotal role in NH_3 emission from wheat land in Asia.

The AI model discovered that by optimizing fertilizer management, including adjusting the timing of fertilization, utilizing a specific blend of nutrients, and implementing suitable planting and tillage practices, it is possible to reduce global NH_3 emissions from the three crops by up to 38%, with Asia having the highest NH_3 reduction potential, followed by North America and Europe.

This finding holds particular significance as this work has projected a 4.0% to 5.5% increase in global NH_3 emissions from cropland over the 30-year period until 2060. Therefore, even achieving a fraction of this potential reduction would suffice to offset the projected increase.

https://phys.org

AI model for weather forecasting

A groundbreaking artificial intelligence (AI) weather forecaster has been released by the team behind China's Pangu-Weather prediction model, and it has a precision that has evolved from tens of kilometres to just a few kilometres. The newest iteration of the AI model, Zhiji, which focuses on regional weather, can give a five-day forecast with a precision that has been sharpened from 25km (15.5 miles) to 3km. Its launch came less than a month after Pangu-Weather, developed by Huawei Technologies, was named China's best scientific innovation of 2023. Since its release in August last year, Pangu has revolutionised weather forecasting, offering quicker and more accurate predictions than traditional meteorological methods.

Pangu-Weather first burst onto the scene in July 2023, when a paper detailing the AI model was published in the journal, Nature. A month later, it was launched on the European Centre for Medium-Range Weather Forecasts (ECMWF) website. The AI model hit a major milestone when it was able to complete a seven-day weather forecast in just 10 seconds – more than 10,000 times faster than traditional methods. Then on February 29, just months after its launch, Pangu-Weather was ranked first among China's top 10 scientific advances in 2023 by the National Natural Science Foundation of China (NSFC).

"In its recognition by the NSFC, Pangu had two major accomplishments: first, it improved the world's leading ECMWF weather forecasting system by about 0.6 days. This means it can predict extreme weather earlier and more accurately," Science and Technology Daily reported. "The second is 7-day predictions in 10 seconds, 10,000 times faster than numerical ones." According to a Huawei report in late February, Pangu delivered more accurate forecasts for crucial weather elements, such as temperature, pressure, humidity, and wind speed, than numerical simulations. Plus, its error margin for predicting the paths of tropical cyclones was 25 per cent lower than the ECMWF.

It is quite an achievement for the AI model, which has so quickly changed the face of global weather forecasting. By leveraging AI to predict weather patterns, scientists can bypass the complexities associated with traditional methods of forecasting. No mathematical physics knowledge or expert experience is needed for AI, something which has created a new avenue for weather prediction.

Now, researchers have used Pangu as a foundation to develop the new regional model, Zhiji. Created in collaboration with the Shenzhen Meteorological Bureau, Zhiji has been trained with high-resolution data from southern China.

According to the Huawei team, Zhiji can provide a five-day forecast with a precision of 3km for Shenzhen and its surrounding areas. While the Central

Meteorological Bureau already provides hourly forecasts with street-level precision, these are generally only available for the following 24 hours. "Zhiji is capable of forecasting core meteorological elements such as wind speed, temperature, humidity, and precipitation. Since its trial operation began in February, it has provided valuable insights to the Shenzhen Meteorological Bureau on multiple occasions," Huawei reported in late March.

https://www.scmp.com

INDIA

IoT and AI-powered automatic weather station

Forecastro, a pioneering climate tech startup based in Pune, proudly announces the launch of WeatherWise-an IoT/AI-boosted Automatic Weather Station (AWS). This patent-pending and exclusively Made in India product harnesses the power of IoT, Machine Learning (ML), and Artificial Intelligence (AI) to deliver precise weather data collection. WeatherWise offers an extensive suite of measurements, including UV radiation, humidity, and climate change predictions, to help the government and businesses monitor and mitigate the impacts of climate change. This innovative solution aims to fight the extreme climate crisis with advanced technology and early warning systems.

WeatherWise is the culmination of over a decade of dedicated research by Forecastro's founding team members, Somnath Varpe and Kiran Todekar. Varpe, with over six years of experience in embedded systems and microcontrollers, has previously worked on sophisticated systems such as telemetry and meteorological instruments for the DRDO Meteorology division of the Government of India. Todekar, a Data Scientist with a robust background in Machine Learning algorithms, Deep Learning, Computer Vision, and Image Processing, has served as a researcher at the Indian Institute of Tropical Meteorology.

https://www.business-standard.com

EUROPE

DENMARK

Using AI to develop early warning systems for flooding

Susanne Nielsen realizes that it is probably only a matter of time before her parents' summer house at Slettestrand in North Jutland is affected by flooding. Because under the house, which is just 400 meters from the bay of Jammerbugt in the municipality of the same name, the groundwater level is now often so high that there is a risk that large amounts of rain will not be able to seep away, but rather enter the house.

To give residents and decision-makers the best chance to protect themselves against flooding in the area, researchers from DTU have helped Jammerbugt Municipality develop an early warning tool. It can provide 48 hours' notice of local flooding along rivers, streams, and coastal areas in the municipality. It is the first of its kind to provide local flood warnings.

The tool—a so-called "wet index"—is based on artificial intelligence trained on freely available data on dynamics that influence the risk of flooding. Data comes from satellite imagery and weather forecasts, as well as information on ground and seawater levels and the topography of the landscape. However, the movement and accumulation of water in open landscapes are difficult to calculate because many parameters affect how water moves and accumulates. To handle this complexity, artificial intelligence was used in the development of the model behind the wet index.

By utilizing specific design principles in the construction of the model and feeding it with carefully selected data, the researchers have incorporated an understanding of water movement, distribution, and interaction with the surrounding environment, according to Roland Löwe. He is one of the developers of the wet index and an Associate Professor at DTU specializing in how water behaves.

Jammerbugt Municipality tested the tool in 2023. The results show better than expected predictions for the wet spring months. However, during the summer period, when Denmark was almost drought-stricken, the tool incorrectly predicted flooding in the same areas that had been flooded during the rainy spring.

https://smartwatermagazine.com

GERMANY

Highly resolved precipitation maps based on AI

Researchers of Karlsruhe Institute of Technology (KIT) have now developed a first method based on artificial intelligence (AI), by means of which the precision of coarse precipitation fields generated by global climate models can be increased. The researchers succeeded in improving the spatial resolution of precipitation fields from 32 to two kilometers and temporal resolution from one hour to ten minutes. This higher resolution is required to better forecast the more frequent occurrence of heavy local precipitation and the resulting natural disasters in the future.

Many natural disasters, such as floods or landslides, are directly caused by extreme precipitation. Researchers expect that increasing average temperatures will cause extreme precipitation events to further increase. To adapt to a changing climate and prepare for disasters at an early stage, precise local and global data on the current and future water cycle are indispensable. "Precipitation is highly variable in space and time and, hence, difficult to forecast, in particular on the local level," says Dr. Christian Chwala from the Atmospheric Environmental Research Division of KIT's Institute of Meteorology and Climate Research (IMK-IFU), KIT's Campus Alpine in Garmisch-Partenkirchen." For this reason, we want to enhance the resolution of precipitation fields generated e.g. by global climate models, and improve their classification as regards possible threats, such as floodings."

Currently used global climate models are based on a grid that is not

fine enough to precisely present the variability of precipitation. Highly resolved precipitation maps can only be produced with computationally expensive and, hence, spatially or temporally limited models. "For this reason, we have developed an AI-based generative neural network, called GAN, and trained it with high-resolution radar precipitation fields. In this way, the GAN learns how to generate realistic precipitation fields and derive their temporal sequence from coarsely resolved data," says Luca Glawion from IMK-IFU. "The network is able to generate highly resolved radar precipitation films from very coarsely resolved maps." These refined radar maps not only show how rain cells develop and move but precisely reconstruct local rain statistics and the corresponding extreme value distribution.

"Our method serves as a basis to increase the resolution of coarsely grained precipitation fields, such that the high spatial and temporal variability of precipitation can be reproduced adequately and local effects can be studied," says Julius Polz from IMK-IFU. "Our deep learning method is quicker by several orders of magnitude than the calculation of such highly resolved precipitation fields with numerical weather models usually applied to regionally refine data of global climate models." The researchers point out that their method also generates an ensemble of different potential precipitation fields. This is important, as a multitude of physically plausible highly resolved solutions exists for each coarsely resolved precipitation field. Similar to a weather forecast, an ensemble allows for a more precise determination of the associated uncertainty.

The results show that the AI model and methodology developed by the researchers will enable future use of neural networks to improve the spatial and temporal resolution of precipitation calculated by climate models. This will allow for a more precise analysis of the impacts and developments of precipitation in a changing climate.

"In the next step, we will apply the method to global climate simulations that transfer specific large-scale weather situations to a future world with a changed climate, e.g. to the year of 2100. The higher resolution of precipitation events simulated with our method will allow for a better estimation of the impacts the weather conditions that caused the flooding of the river Ahr in 2021 would have had in a world warmer by 2 degrees," Glawion explains. Such information is of decisive importance to develop climate adaptation methods.

https://www.preventionweb.net

UK

AI weather forecasts

Artificial intelligence (AI) can quickly and accurately predict the path and intensity of major storms, a new study demonstrates. The research, based on an analysis of November 2023's Storm Ciarán, suggests weather forecasts that use machine learning can produce predictions of similar accuracy to traditional forecasts faster, cheaper, and using less computational power. Published in *npj Climate and Atmospheric Science*, the University of Reading study highlights the rapid progress and transformative potential of AI in weather prediction.

Professor Andrew Charlton-Perez, who led the study, said, "AI is transforming weather forecasting before our eyes. Two years ago, modern machine learning techniques were rarely being applied to make weather forecasts. Now we have multiple models that can produce 10-day global forecasts in minutes.

To understand the effectiveness of AI-based weather models, scientists from the University of Reading compared AI and physics-based forecasts of Storm Ciarán—a deadly windstorm that hit northern and central Europe in November 2023 which claimed 16 lives in northern Europe and left more than a million homes without power in France.

The researchers used four AI models and compared their results with traditional physics-based models. The AI models, developed by tech giants like Google, Nvidia, and Huawei, were able to predict the storm's rapid intensification and track 48 hours in advance. To a large extent, the forecasts were 'indistinguishable' from the performance of conventional forecasting models, the researchers said. The AI models also accurately captured the large-scale atmospheric conditions that fueled Ciarán's explosive development, such as its position relative to the jet stream—a narrow corridor of strong high-level winds.

The machine learning technology underestimated the storm's damaging winds, however. All four AI systems underestimated Ciarán's maximum wind speeds, which in reality gusted at speeds of up to 111 knots at Pointe du Raz, Brittany. The authors were able to show that this underestimation was linked to some of the features of the storm, including the temperature contrasts near its center, that were not well predicted by the AI systems.

To better protect people from extreme weather like Storm Ciarán, the researchers say further investigation of the use of AI in weather prediction is urgently needed. The development of machine learning models could mean artificial intelligence is routinely used in weather prediction in the near future, saving forecasters time and money.

https://phys.org

AI-led innovation protects communities hit by climate change

The United Nations World Food Programme (WFP), Oxford University Physics Department, IGAD Climate Prediction and Applications Centre (ICPAC), and various national forecasting and meteorology agencies across East Africa are joining forces to pioneer a transformative initiative that is revolutionising extreme weather forecasting and early warning systems in the region.

In East Africa, where deadly floods have succeeded the worst drought in decades, climate change is accelerating the frequency and severity of extreme weather events, and the need for precise and timely forecasts has never been more critical. In an era marked by escalating weather variability, accurate weather predictions are essential to safeguard lives and livelihoods.

Climate scientists at Oxford University Physics have developed a ground-breaking AI-based weather model that enhances the accuracy of rainfall forecasts, offering high-resolution predictions without the need for additional costly supercomputers. "We believe the approach we have pioneered and are using here is a game-changer for parts of the world which have previously suffered from a lack of resource and infrastructure but nonetheless find themselves bearing the brunt of climate change," said Dr. Shruti Nath, a climate scientist at Oxford University Physics.

This initiative was made possible with the support of Google.org to World Food Program USA, in support of WFP's efforts to mitigate the impacts of climate change. The funding and in-kind contribution of computational resources from Google Cloud are crucial in overcoming the resource constraints faced by many forecasting organisations in Eastern Africa.

The success of this initiative in East Africa sets a precedent for broader application. The vision extends beyond this region, aiming to replicate this model in other parts of the world facing similar challenges. By continuing to refine AI-based models and expanding our partnerships, the goal is to build a more resilient global community capable of withstanding the worsening impacts of climate change.

https://www.ox.ac.uk

NORTH AMERICA

CANADA

Predictive AI models to protect cities from climate damage

Canadian cities can use artificial intelligence to save millions while predicting and protecting themselves against climate change, say two McMaster engineering researchers behind a new virtual modelling system. "We're already seeing the impact of climate change and extreme weather on our municipal infrastructure," explains Moustafa Naiem Abdel-Mooty, a researcher and instructor in the Department of Civil Engineering.

He used machine learning to predict the impact of climate change on infrastructure systems but soon realized he could do more using what's called "digital twins" technology — creating an evolving virtual model of something based on real data and subjecting it to projected influences to predict how its physical version will be affected. Naiem created a virtual, self-updating replica of a city that continuously exchanged data with what was happening in real life.

With his former PhD advisor Wael El-Dakhakhni, a professor in the Department of Civil Engineering, and postdoctoral fellows Maysara Ghaith and Ahmed Yosri, Naiem founded a business called Resilio Climate Solutions, to help bring Canada up to date. Using a digital twin, they can now play out "what-if" scenarios and employ different measures to predict the best ways to reduce the impact of extreme weather events. That includes protective actions such as building levees beside rivers or improving other flood-proofing measures to protect critical infrastructure.

The Resilio team virtually went back in time to before the flood to create a case study to test their model. They were able to predict the flood with 85 per cent accuracy and to suggest ways in which Calgary could have mitigated its physical and financial impact.

"Our digital twin tool is a game changer in climate adaptation and resilience building. It is designed to empower government and business leaders to optimize their adaptation budget spending while also educating community stakeholders on possible impacts of future climate extremes," says El-Dakhakhni.

https://brighterworld.mcmaster.ca

AI to improve building energy use and comfort

A new study from Waterloo researchers creating climate change-proof buildings with deep learning-powered inspections. University of Waterloo researchers have developed a new method that can lead to significant energy savings in buildings. The team identified 28 major heat loss regions in a multi-unit residential building with the most severe ones being at wall intersections and around windows. A potential energy savings of 25 per cent is expected if 70 per cent of the discovered regions are fixed.

Building enclosures rely on heat and moisture control to avoid significant energy loss due to airflow leakage, which makes buildings less comfortable and more costly to maintain. This problem will likely be compounded by climate change due to volatile temperature fluctuations. Since manual inspection is time-consuming and infrequently done due to a lack of trained personnel, energy inefficiency becomes a widespread problem for buildings.

Researchers at Waterloo, which is a leader in sustainability research and education and a catalyst for environmental innovation, solutions, and talent, created an autonomous, real-time platform to make buildings more energy efficient. The platform combines artificial intelligence, infrared technology, and a mathematical model that quantifies heat flow to better identify areas of heat loss in buildings.

Using the new method, the researchers conducted an advanced study on a multi-unit residential building in the extreme climate of Canadian prairies, where elderly residents reported discomfort and higher electricity bills due to increased demand for heating in their units. Using AI tools, the team trained the program to examine thermal images in real-time, achieving 81 percent accuracy in detecting regions of heat loss in the building envelope.

"The almost 10 per cent increase in accuracy with this AI-based model is impactful, as it enhances occupants' comfort as well as reduces energy bills," said Dr. Mohamad Araji, director of Waterloo's Architectural Engineering Program and head of the Symbiosis Lab, an interdisciplinary group at the university that specializes in developing innovative building systems and building more environmentally friendly buildings.

The new AI tools helped to remove the element of human error in examining

the results and increased the speed of getting the data analyzed by a factor of 12 compared to traditional building inspection methods. Future expansions to this work will include utilizing drones equipped with cameras to inspect high-rise buildings.

https://uwaterloo.ca

USA

New AI model for weather, climate

Working together, NASA and IBM Research have developed a new artificial intelligence model to support a variety of weather and climate applications. The new model – known as the Prithvi-weather-climate foundational model – uses artificial intelligence (AI) in ways that could vastly improve the resolution we'll be able to get, opening the door to better regional and local weather and climate models.

Foundational models are large-scale, base models that are trained on large, unlabeled datasets and can be fine-tuned for a variety of applications. The Prithvi-weather-climate model is trained on a broad set of data – in this case NASA data from NASA's Modern-Era Retrospective Analysis for Research and Applications (MERRA-2)– and then makes use of AI learning abilities to apply patterns gleaned from the initial data across a broad range of additional scenarios.

"Advancing NASA's Earth science for the benefit of humanity means delivering actionable science in ways that are useful to people, organizations, and communities. The rapid changes we're witnessing on our home planet demand this strategy to meet the urgency of the moment," said Karen St. Germain, director of the Earth Science Division of NASA's Science Mission Directorate. "The NASA foundation model will help us produce a tool that people can use: weather, seasonal, and climate projections to help inform decisions on how to prepare, respond, and mitigate."

With the Prithvi-weather-climate model, researchers will be able to support many different climate applications that can be used throughout the science community. These applications include detecting and predicting severe weather patterns or natural disasters, creating targeted forecasts based on localized observations, improving spatial resolution on global climate simulations down to regional levels, and improving the representation of how physical processes are included in weather and climate models.

"These transformative AI models are reshaping data accessibility by significantly lowering the barrier of entry to using NASA's scientific data," said Kevin Murphy, NASA's chief science data officer, Science Mission Directorate at NASA Headquarters. "Our open approach to sharing these models invites the global community to explore and harness the capabilities we've cultivated, ensuring that NASA's investment enriches and benefits all."

Prithvi-weather-climate was developed through an open collaboration with IBM Research, Oak Ridge National Laboratory, and NASA, including the agency's Interagency Implementation and Advanced Concepts Team (IMPACT) at Marshall Space Flight Center in Huntsville, Alabama.

Prithvi-weather-climate can capture the complex dynamics of atmospheric physics even when there is missing information thanks to the flexibility of the model's architecture. This foundational model for weather and climate can scale to both global and regional areas without compromising resolution.

"This model is part of our overall strategy to develop a family of AI foundation models to support NASA's science mission goals," said Rahul Ramachandran, who leads IMPACT at Marshall. "These models will augment our capabilities to draw insights from our vast archives of Earth observations."

Prithvi-weather-climate is part of a larger model family– the Prithvi family– which includes models trained on NASA's Harmonized LandSat and Sentinel-2 data. The latest model serves as an open collaboration in line with NASA's open science principles to make all data accessible and usable by communities everywhere. It will be released later this year on Hugging Face, a machine learning and data science platform that helps users build, deploy, and train machine learning models.

https://science.nasa.gov

AI to create carbon-capturing plants

A unique partnership at Salk leverages the deep learning software known as SLEAP to study plant characteristics, speeding up the development of plants that can combat climate change. Scientists in Salk's Harnessing Plants Initiative are using a sophisticated new research tool called SLEAP—an easy-to-use artificial intelligence (AI) software that tracks multiple features of root growth. Created by Salk Fellow Talmo Pereira, SLEAP was initially designed to track animal movement in the lab. Now, Pereira has teamed up with plant scientist and Salk colleague Professor Wolfgang Busch to apply SLEAP to plants.

In a study published in *Plant Phenomics*, Busch and Pereira debut a new protocol for using SLEAP to analyze plant root phenotypes—how deep and wide they grow, how massive their root systems become, and other physical qualities that, prior to SLEAP, were tedious to measure. The application of SLEAP to plants has already enabled researchers to establish the most extensive catalog of plant root system phenotypes to date.

What's more, tracking these physical root system characteristics helps scientists find genes affiliated with those characteristics, as well as whether multiple root characteristics are determined by the same genes or independently. This allows the Salk team to determine what genes are most beneficial to their plant designs.

"This collaboration is truly a testament to what makes Salk science so special and impactful," says Pereira. "We're not just 'borrowing' from different disciplines—we're really putting them on equal footing in order to create something greater than the sum of its parts."

Prior to using SLEAP, tracking the physical characteristics of both plants and animals required a lot of labor that slowed the scientific process. If researchers wanted to analyze an

image of a plant, they would need to manually flag the parts of the image that were and weren't plant—frame-by-frame, part-by-part, pixel-by-pixel. Only then could older AI models be applied to process the image and gather data about the plant's structure.

What sets SLEAP apart is its unique use of both computer vision (the ability for computers to understand images) and deep learning (an AI approach for training a computer to learn and work like the human brain). This combination allows researchers to process images without moving pixel-by-pixel, instead skipping this intermediate labor-intensive step to jump straight from image input to defined plant features.

"We created a robust protocol validated in multiple plant types that cuts down on analysis time and human error while emphasizing accessibility and ease-of-use—*and* it required no changes to the actual SLEAP software," says first author Elizabeth Berrigan, a bioinformatics analyst in Busch's lab.

Without modifying the baseline technology of SLEAP, the researchers developed a downloadable toolkit for SLEAP called *sleap-roots* (available as open-source software here). With *sleap-roots*, SLEAP can process biological traits of root systems like depth, mass, and angle of growth.

The Salk team tested the *sleap-roots* package in a variety of plants, including crop plants like soybeans, rice, and canola, as well as the model plant species *Arabidopsis thaliana*—a flowering weed in the mustard family. Across the variety of plants trialed, they found the novel SLEAP-based method outperformed existing practices by annotating 1.5 times faster, training the AI model 10 times faster, and predicting plant structure on new data 10 times faster, all with the same or better accuracy than before.

Together with massive genome sequencing efforts for elucidating the genotype data in large numbers of crop varieties, these phenotypic data, such as a plant's root system growing especially deep in the soil, can be extrapolated to understand the genes responsible for creating that especially deep root system.

This step—connecting phenotype and genotype—is crucial in Salk's mission to create plants that hold on to more carbon and for longer, as those plants will need root systems designed to be deeper and more robust. Implementing this accurate and efficient software will allow the Harnessing Plants Initiative to connect desirable phenotypes to targetable genes with groundbreaking ease and speed.

https://scitechdaily.com

AI model for weather prediction

Researchers from private sector companies like Nvidia and Google have started developing large artificial intelligence (AI) models, known as foundation models, for weather forecasting. Recently, scientists at the U.S. Department of Energy's (DOE) Argonne National Laboratory, in close collaboration with researchers Aditya Grover and Tung Nguyen at the University of California, Los Angeles, have begun to investigate this alternative type of model. This model could produce in some cases even more accurate forecasts than the existing numerical weather prediction models at a fraction of the computational cost. Some of these models outperform current models' prediction capability beyond seven days, giving scientists an additional window into the weather.

Foundation models are built on the use of "tokens," which are small bits of information that an AI algorithm uses to learn the physics that drives the weather. Many foundation models are used for natural language processing, which means handling words and phrases. For these large language models, these tokens are words or bits of language that the model predicts in sequence. For this new weather prediction model, the tokens are instead pictures — patches of charts depicting things like humidity, temperature, and wind speed at various levels of the atmosphere.

"Instead of being interested in a text sequence, you're looking at spatial-temporal data, which is represented in images," said Argonne computer scientist Sandeep Madireddy. "When using these patches of images in the model, you have some notion of their relative positions and how they interact because of how they're tokenized."

The scientific team can use quite low-resolution data and still come up with accurate predictions, said Argonne atmospheric scientist Rao Kotamarthi. "The philosophy of weather forecasting has for years been to get to higher resolutions for better forecasts. This is because you are able to resolve the physics more precisely, but of course, this comes at great computational cost," he said. "But we're finding now that we're actually able to get comparable results to existing high-resolution models even at coarse resolution with the method we are using."

While reliable near-term weather forecasting seems to be a near-term achievable goal with AI, trying to use the same approach for climate modeling, which involves analyzing weather over time, presents an additional challenge. "In theory, foundation models could also be used for climate modeling. However, there are more incentives for the private sector to pursue new approaches for weather forecasting than there are for climate modeling," Kotamarthi said. "Work on foundation models for climate modeling will likely continue to be the purview of the national labs and universities dedicated to pursuing solutions in the general public interest."

The introduction of Argonne's new exascale supercomputer, Aurora, will help researchers train a very large AI-based model that will work at very high resolutions. "We need an exascale machine to really be able to capture a fine-grained model with AI," Kotamarthi said.

https://www.newswise.com