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Department of Computer Applications

NEWSLETTER

TECHNICAL NEWS

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Mini cheetah is the first four-legged robot to do a backflip

MIT's new mini cheetah robot is springy and light on its feet, with a range of motion that rivals a champion gymnast. The four-legged powerpack can bend and swing its legs wide, enabling it to walk either right-side up or upside down. The robot can also trot over uneven terrain about twice as fast as an average person's walking speed.

Weighing in at just 20 pounds -- lighter than some Thanksgiving turkeys -- the limber quadruped is no pushover: When kicked to the ground, the robot can quickly right itself with a swift, kung-fu-like swing of its elbows.

Perhaps most impressive is its ability to perform a 360-degree backflip from a standing position. Researchers claim the mini cheetah is designed to be "virtually indestructible," recovering with little damage, even if a backflip ends in a spill.

In the event that a limb or motor does break, the mini cheetah is designed with modularity in mind: Each of the robot's legs is powered by three identical, low-cost electric motors that the researchers engineered using off-the-shelf parts. Each motor can easily be swapped out for a new one.

"You could put these parts together, almost like Legos," says lead developer Benjamin Katz, a technical associate in MIT's Department of Mechanical Engineering.

The researchers will present the mini cheetah's design at the International Conference on Robotics and Automation, in May. They are currently building more of the four-legged machines, aiming for a set of 10, each of which they hope to loan out to other labs.

"A big part of why we built this robot is that it makes it so easy to experiment and just try crazy things, because the robot is super robust and doesn't break easily, and if it does break, it's easy and not very expensive to fix," says Katz, who worked on the robot in the lab of Sangbae Kim, associate professor of mechanical engineering.

Kim says loaning mini cheetahs out to other research groups gives engineers an opportunity to test out novel algorithms and maneuvers on a highly dynamic robot, that they might not otherwise have access to.

"Eventually, I'm hoping we could have a robotic dog race through an obstacle course, where each team controls a mini cheetah with different algorithms, and we can see which strategy is more effective," Kim says. "That's how you accelerate research."

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Artificial intelligence to boost Earth system science

A study by German scientists from Jena and Hamburg, published today in the journal *Nature*, shows that artificial intelligence (AI) can substantially improve our understanding of the climate and the Earth system. Especially the potential of deep learning has only partially been exhausted so far. In particular, complex dynamic processes such as hurricanes, fire propagation, and vegetation dynamics can be better described with the help of AI. As a result, climate and Earth system models will be improved, with new models combining artificial intelligence and physical modeling.

In the past decades mainly static attributes have been investigated using machine learning approaches, such as the distribution of soil properties from the local to the global scale. For some time now, it has been possible to tackle more dynamic processes by using more sophisticated deep learning techniques. This allows for example to quantify the global photosynthesis on land with simultaneous consideration of seasonal and short term variations.

Deducing underlying laws from observation data

"From a plethora of sensors, a deluge of Earth system data has become available, but so far we've been lagging behind in analysis and interpretation," explains Markus Reichstein, managing director of the Max Planck Institute for Biogeochemistry in Jena, directory board member of the Michael-Stifel-Center Jena (MSCJ) and first author of the publication. "This is where deep learning techniques become a promising tool, beyond the classical machine learning applications such as image recognition, natural language processing or AlphaGo," adds co-author Joachim Denzler from the Computer Vision Group of the Friedrich Schiller University Jena (FSU) and member of MSCJ. Examples for application are extreme events such as fire spreads or hurricanes, which are very complex processes influenced by local conditions but also by their temporal and spatial context. This also applies to atmospheric and ocean transport, soil movement, and vegetation dynamics, some of the classic topics of Earth system science.

Artificial intelligence to improve climate and Earth system models

However, deep learning approaches are difficult. All data-driven and statistical approaches do not guarantee physical consistency per se, are highly dependent on data quality, and may experience difficulties with extrapolations. Besides, the requirement for data processing and storage capacity is very high. The publication discusses all these requirements and obstacles and develops a strategy to efficiently combine machine learning with physical modeling. If both techniques are brought together, so-called hybrid models are created. They can for example be used for modeling the motion of ocean water to predict sea surface temperature. While the temperatures are modelled physically, the ocean water movement is represented by a machine learning approach. "The idea is to combine the best of two worlds, the consistency of physical models with the versatility of machine learning, to obtain greatly improved models," Markus Reichstein further explains.

The scientists contend that detection and early warning of extreme events as well as seasonal and long-term prediction and projection of weather and climate will strongly benefit from the discussed deep-learning and hybrid modelling approaches.

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Hardware-software co-design approach could make neural networks less power hungry

Training neural networks to perform tasks like recognize objects, navigate self-driving cars or play games eats up a lot of computing power and time. Large computers with hundreds to thousands of processors are typically required to learn these tasks, and training times can take anywhere from weeks to months.

That's because doing these computations involves transferring data back and forth between two separate units -- the memory and the processor -- and this consumes most of the energy and time during neural network training, said senior author Duygu Kuzum, a professor of electrical and computer engineering at the Jacobs School of Engineering at UC San Diego.

To address this problem, Kuzum and her lab teamed up with Adesto Technologies to develop hardware and algorithms that allow these computations to be performed directly in the memory unit, eliminating the need to repeatedly shuffle data.

"We are tackling this problem from two ends -- the device and the algorithms -- to maximize energy efficiency during neural network training," said first author Yuhan Shi, an electrical engineering Ph.D. student in Kuzum's research group at UC San Diego.

The hardware component is a super energy-efficient type of non-volatile memory technology -- a 512 kilobit subquantum Conductive Bridging RAM (CBRAM) array. It consumes 10 to 100 times less energy than today's leading memory technologies. The device is based on Adesto's CBRAM memory technology -- it has primarily been used as a digital storage device that only has '0' and '1' states, but Kuzum and her lab demonstrated that it can be programmed to have multiple analog states to emulate biological synapses in the human brain. This so-called synaptic device can be used to do in-memory computing for neural network training.

"On-chip memory in conventional processors is very limited, so they don't have enough capacity to perform both computing and storage on the same chip. But in this approach, we have a high capacity memory array that can do computation related to neural network training in the memory without data transfer to an external processor. This will enable a lot of performance gains and reduce energy consumption during training," said Kuzum.

Kuzum, who is affiliated with the Center for Machine-Integrated Computing and Security at UC San Diego, led efforts to develop algorithms that could be easily mapped onto this synaptic device array. The algorithms provided even more energy and time savings during neural network training.

The approach uses a type of energy-efficient neural network, called a spiking neural network, for implementing unsupervised learning in the hardware. On top of that, Kuzum's team applies another energy-saving algorithm they developed called "soft-pruning," which makes neural network training much more energy efficient without sacrificing much in terms of accuracy.

Energy-saving algorithms

Neural networks are a series of connected layers of artificial neurons, where the output of one layer provides the input to the next. The strength of the connections between these layers is represented by what are called "weights." Training a neural network deals with updating these weights.

Conventional neural networks spend a lot of energy to continuously update every single one of these weights. But in spiking neural networks, only weights that are tied to spiking neurons get updated. This means fewer updates, which means less computation power and time.

The network also does what's called unsupervised learning, which means it can essentially train itself. For example, if the network is shown a series of handwritten numerical digits, it will figure out how to distinguish between zeros, ones, twos, etc. A benefit is that the network does not need to be trained on labeled examples -- meaning it does not need to be told that it's seeing a zero, one or two -- which is useful for autonomous applications like navigation.

To make training even faster and more energy-efficient, Kuzum's lab developed a new algorithm that they dubbed "soft-pruning" to implement with the unsupervised spiking neural network.

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New technique improves accuracy of computer vision technologies

Researchers from North Carolina State University have developed a new technique that improves the ability of computer vision technologies to better identify and separate objects in an image, a process called segmentation.

Image processing and computer vision are important for multiple applications, from autonomous vehicles to detecting anomalies in medical imaging.

Computer vision technologies use algorithms to segment, or outline the objects, in an image. For instance, separating the outline of a pedestrian against the backdrop of a busy street.

These algorithms rely on defined parameters -- programmed values -- to segment images. For example, if there is a shift in color that crosses a specific threshold, a computer vision program will interpret it as a dividing line between two objects. And that specific threshold is one of the algorithm's parameters.

But there's a challenge here. Even small changes in a parameter can lead to very different computer vision results. For example, if a person crossing the street walks in and out of shady areas, that would affect the color a computer sees -- and the computer may then "see" the person disappearing and reappearing, or interpret the person and the shadow as a single, large object such as a car.

"Some algorithm parameters may work better than others in any given set of circumstances, and we wanted to know how to combine multiple parameters and algorithms to create better image segmentation by computer vision programs," says Edgar Lobaton, an assistant professor of electrical and computer engineering at NC State and senior author of a paper on the work.

Lobaton and Ph.D. student Qian Ge developed a technique that compiles segmentation data from multiple algorithms and aggregates them, creating a new version of the image. This new image is then segmented again, based on how persistent any given segment is across all of the original input algorithms.

"Visually, the results of this technique look better than any given algorithm on its own," Lobaton says. "However, the nature of this work doesn't line up with the existing metrics for measuring computer vision accuracy. So we need to develop a new means of assessing computer vision accuracy -- that's a future project for us."

Lobaton notes that the new image segmenting technique can be used in real time, processing 30 frames per second. This is due, in part, to the fact that most of the computational steps can be run in parallel, rather than sequentially.

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Wi-Fi not required: Google's new AI-based dictation feature for Gboard works without Internet too

SAN FRANCISCO: Google is adding an Artificially Intelligent (AI) offline dictation feature on its Gboard keyboard for Pixel phones that would allow users to speak out emails and texts even without an Internet connection.

"We're happy to announce the rollout of an end-to-end, all-neural, on-device speech recognizer to power speech input in Gboard which is always available, even when you are offline," Johan Schalkwyk, Speech Team, Google wrote in a blog post on Tuesday.

Google has designed the feature to work at the character level.

"As you speak, it outputs words character-by-character, just as if someone was typing out what you say in real-time. It is exactly as you'd expect from a keyboard dictation system," Schalkwyk said.

To increase use-parameters of the speech recognition feature, Google said it has hosted the new model on device in order to avoid the latency and inherent unreliability of communication networks.

For now, the on-device Gboard speech recognizer has been made available in American English language on all Pixel devices.

"We are hopeful that the techniques presented here can soon be adopted in more languages and across broader domains of application," Schalkwyk added.

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Wipro launches third industrial internet of things centre of excellence in Kochi

Kochi: WiproNSE -0.60 % Limited has launched its industrial internet of things (IIoT) centre of excellence (CoE) in Kochi. This is the third such centre of the company after California and Bengaluru.

The CoE will develop innovative IIoT solutions that span across the technology stack for its customers in the industrial manufacturing, automotive, healthcare and pharmaceutical, consumer products and goods, and utilities space. Leveraging artificial intelligence, blockchain and robotics, t he lab will develop proofs of concept (POCs) and market-ready IoT solutions.

Inaugurating the centre Kerala IT secretary M. Sivasankar said with the rollout of the Kerala fibre optic network (KFON), the fibre2home/enterprise/institution network in the next 18 months, local economy stakeholders will increasingly benefit from IoT deployments. So, Wipro's decision to set up its third global IIoT lab in Kerala is a timely one. Jayraj Nair, Vice President & Global Head - IoT, Wipro Limited said, " Kerala has grown into a technology hub that offers access to a dynamic talent pool with an aptitude for new-age technologies. IoT presents a huge opportunity for industries in a hyper-connected world and we are confident that our end-to-end services and offerings will help our clients leverage IoT as part of their digital transformation goals."

By combining its services and offerings across engineering, analytics, consulting and applications with domain expertise in specific industry verticals, Wipro offers comprehensive engineering solutions for IoT adoption. These range from sensors, connectivity, edge computing, storage, artificial intelligence, machine learning and analytics.

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New 3-D printing approach makes cell-scale lattice structures

A new way of making scaffolding for biological cultures could make it possible to grow cells that are highly uniform in shape and size, and potentially with certain functions. The new approach uses an extremely fine-scale form of 3-D printing, using an electric field to draw fibers one-tenth the width of a human hair.

The system was developed by Filippos Tourlomousis, a postdoc at MIT's Center for Bits and Atoms, and six others at MIT and the Stevens Institute of Technology in New Jersey. The work is being reported today in the journal *Microsystems and Nanoengineering*.

Many functions of a cell can be influenced by its microenvironment, so a scaffold that allows precise control over that environment may open new possibilities for culturing cells with particular characteristics, for research or eventually even medical use.

While ordinary 3-D printing produces filaments as fine as 150 microns (millionths of a meter), Tourlomousis says, it's possible to get fibers down to widths of 10 microns by adding a strong electric field between the nozzle extruding the fiber and the stage on which the structure is being printed. The technique is called melt electrowriting.

"If you take cells and put them on a conventional 3-D-printed surface, it's like a 2-D surface to them," he explains, because the cells themselves are so much smaller. But in a mesh-like structure printed using the electrowriting method, the structure is at the same size scale as the cells themselves, and so their sizes and shapes and the way they form adhesions to the material can be controlled by adjusting the porous microarchitecture of the printed lattice structure.

"By being able to print down to that scale, you produce a real 3-D environment for the cells," Tourlomousis says.

He and the team then used confocal microscopy to observe the cells grown in various configurations of fine fibers, some random, some precisely arranged in meshes of different dimensions. The large number of resulting images were then analyzed and classified using artificial intelligence methods, to correlate the cell types and their variability with the kinds of microenvironment, with different spacings and arrangements of fibers, in which they were grown.

Cells form proteins known as focal adhesions at the places where they attach themselves to the structure. "Focal adhesions are the way the cell communicates with the external environment," Tourlomousis says. "These proteins have measurable features across the cell body allowing us to do metrology. We quantify these features and use them to model and classify quite precisely individual cell shapes."

For a given mesh-like structure, he says, "we show that cells acquire shapes that are directly coupled with the substrate's architecture and with the melt electrowritten substrates," promoting a high degree of uniformity compared to nonwoven, randomly structured substrates. Such uniform cell populations could potentially be useful in biomedical research, he says: "It is widely known that cell shape governs cell function and this work suggests a shape-driven pathway for engineering and quantifying cell responses with great precision," and with great reproducibility.

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