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Compiled by:-
Aditya Sharma,Manmeet Chauhan
Rahul Singh Negi (MCA 2nd sem)

Designed by:-
Sujeet Pratap Singh
(MCA Dept.)

Coordinated by:-
Ms. Shalika Arora
(Asst. Prof.,MCA)

Alumni Section

Aniket Bharti

System Engineer

TCS India

The Dynamic Duo: OpenCV and CNN Shaping the Future of Computer Vision

Introduction

In the fast-paced world of technology, where trends rise and fall, two stalwarts have emerged as the backbone of computer vision: OpenCV and Convolutional Neural Networks (CNNs). While new methods and algorithms continue to emerge, these two technologies have proven their lasting relevance by revolutionizing the field of computer vision. This article delves into the enduring impact of OpenCV and CNNs, highlighting their unique attributes and their contributions to shaping the future of visual data processing.

OpenCV: A Versatile Vision Toolbox

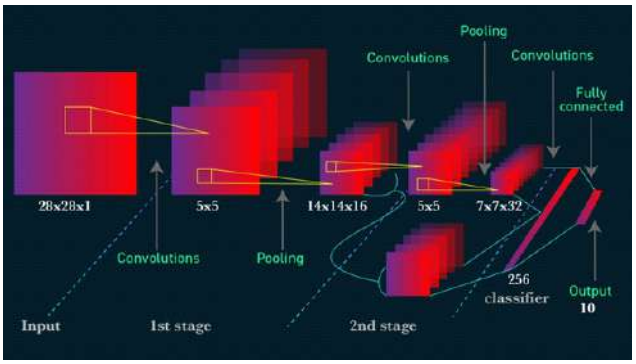
OpenCV, short for Open Source Computer Vision Library, has stood the test of time as a comprehensive and open-source toolbox for computer vision applications. Originally developed by Intel, OpenCV has evolved into a community-driven project with contributions from various developers around the world. Its adaptability and wide-ranging capabilities have established it as a go-to solution for various tasks in computer vision.

One of OpenCV's defining features is its extensive collection of pre-built functions and algorithms for image and video analysis. From basic tasks like image filtering and edge detection to more advanced tasks like object detection, facial recognition, and motion tracking, OpenCV offers a rich set of tools that simplify the development of computer vision applications. Its support for multiple programming languages, including Python, C++, and Java, further enhances its accessibility.

Convolutional Neural Networks (CNNs): Unleashing Visual Learning

Convolutional Neural Networks, or CNNs, have brought about a paradigm shift in the way computers interpret visual data. Inspired by the human visual system, CNNs have proven their efficacy in tasks like image classification, object detection, and image segmentation. Their ability to automatically learn relevant features from raw pixel data has propelled them to the forefront of modern computer vision.

CNNs excel at hierarchical feature extraction, allowing them to identify intricate patterns and structures within images. Through layers of convolutional and pooling operations, CNNs progressively extract increasingly abstract features from input images. This hierarchical representation enables CNNs to achieve remarkable accuracy in tasks that were previously challenging for traditional computer vision algorithms.



Synergy: OpenCV and CNNs in Harmony

The marriage of OpenCV and CNNs has created a powerful synergy that is transforming the field of computer vision. OpenCV provides the infrastructure and tools for data preprocessing, manipulation, and visualization, while CNNs bring the ability to automatically learn complex features for accurate analysis.

Modern computer vision pipelines often involve using OpenCV to prepare and preprocess data before feeding it into CNNs. OpenCV's functions for image augmentation, resizing, and normalization play a crucial role in enhancing the performance of CNN models. Once the data is ready, CNNs take over, leveraging their hierarchical feature extraction capabilities to make sense of visual information.

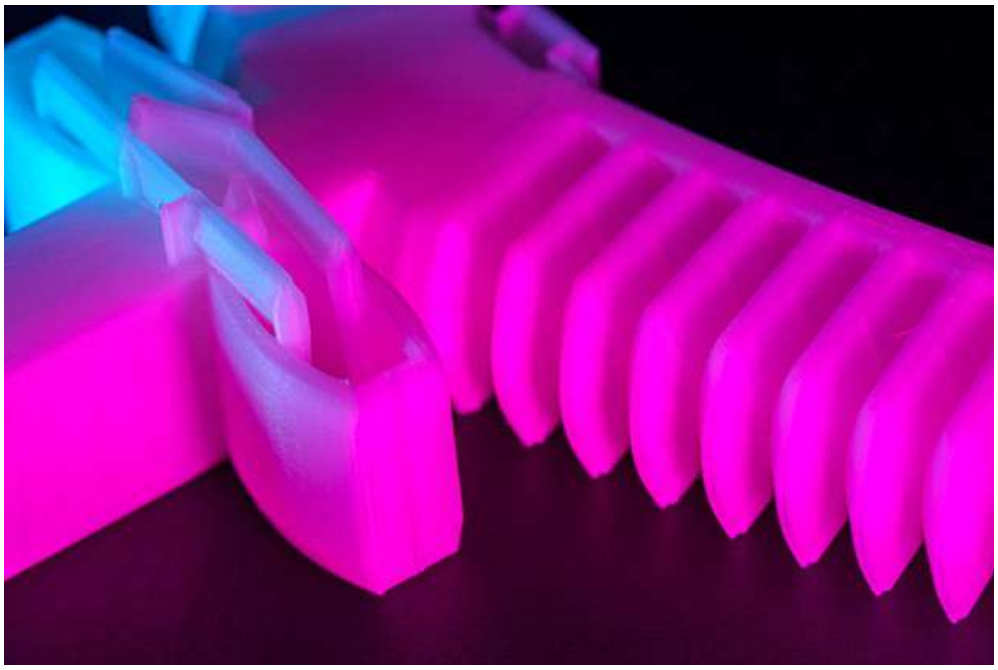
Applications in the Real World

The combined prowess of OpenCV and CNNs has led to groundbreaking applications across various industries. In healthcare, these technologies enable accurate medical image analysis, aiding in the diagnosis of diseases. In autonomous vehicles, they power object detection and lane tracking systems. Retail businesses use them for facial recognition and customer behavior analysis.

Conclusion

In the ever-evolving landscape of technology, where innovation is the norm, OpenCV and CNNs have established themselves as pillars of the computer vision domain. OpenCV's versatility and CNNs' ability to learn intricate patterns have transformed the way computers understand visual data. Together, they empower developers to create sophisticated computer vision applications that touch every aspect of our lives.

As we peer into the future, it's clear that OpenCV and CNNs will continue to shape the landscape of computer vision. Their collaborative potential will be harnessed to tackle new challenges, from augmented reality and virtual reality to advanced medical imaging and beyond. Just as mainframes continue to thrive alongside modern technologies, OpenCV and CNNs are set to remain cornerstones of visual data processing, paving the way for exciting advancements in the field.



3D printed robotic gripper doesn't need electronics to function

Highlights

- *A team from UC San Diego and BASF developed a 3D printed soft robotic gripper that lacks electronics and functions using fluidic logic.*
- *The gripper has gravity and touch sensors built-in, allowing it to grip, hold, and release objects by adjusting its orientation.*
- *The unique 3D printing method involves continuous nozzle tracing, reducing leaks and defects commonly associated with soft material printing*
- *The gripper's design and untethered operation hold potential for various applications including industrial manufacturing, delicate object handling, research, and exploration.*

A new soft robotic gripper is not only 3D printed in one print, it also doesn't need any electronics to work. The device was developed by a team of roboticists at the University of California San Diego, in collaboration with researchers at the BASF corporation, who detailed their work in *Science Robotics*.

The researchers wanted to design a soft gripper that would be ready to use right as it comes off the 3D printer, equipped with built in gravity and touch sensors. As a result, the gripper can pick up, hold, and release objects. No such gripper existed before this work.

"We designed functions so that a series of valves would allow the gripper to both grip on contact and release at the right time," said Yichen Zhai, a postdoctoral researcher in the Bioinspired Robotics and Design Lab at the University of California San Diego and the leading author of the paper. "It's the first time such a gripper can both grip and release. All you have to do is turn the gripper horizontally. This triggers a change in the airflow in the valves, making the two fingers of the gripper release."

This fluidic logic allows the robot to remember when it has grasped an object and is holding on to it. When it detects the weight of the object pushing to the side, as it is rotating to the horizontal, it releases the object.

Soft robotics holds the promise of allowing robots to interact safely with humans and delicate objects. This gripper can be mounted on a robotic arm for industrial manufacturing applications, food production and the handling of fruits and vegetables. It can also be mounted onto a robot for research and exploration tasks. In addition, it can function untethered, with a bottle of high-pressure gas as its only power source.

https://youtu.be/A5mpy3X1dcc

Video of a soft robotic gripper is not only 3D printed in one print, it also doesn't need any electronics to work. The device was developed by a team of roboticists at the University of California San Diego, in collaboration with researchers at the BASF corporation, who detailed their work in a recent issue of Science Robotics. The researchers wanted to design a soft gripper that would be ready to use right as it comes off the 3D printer, equipped with built in gravity and touch sensors. As a result, the gripper can pick up, hold, and release objects. No such gripper existed before this work. "We designed functions so that a series of valves would allow the gripper to both grip on contact and release at the right time," said Yichen Zhai, a postdoctoral researcher in the Bioinspired Robotics and Design Lab at the University of California San Diego and the leading author of the paper, which was published in the June 21 issue of Science Robotics. "It's the first time such a gripper can both grip and release. All you have to do is turn the gripper horizontally. This triggers a change in the airflow in the valves, making the two fingers of the gripper release." Credit: University of California San Diego Jacobs School of Engineering

Most 3D-printed soft robots often have a certain degree of stiffness; contain a large number of leaks when they come off the printer; and need a fair amount of processing and assembly after printing in order to be usable.

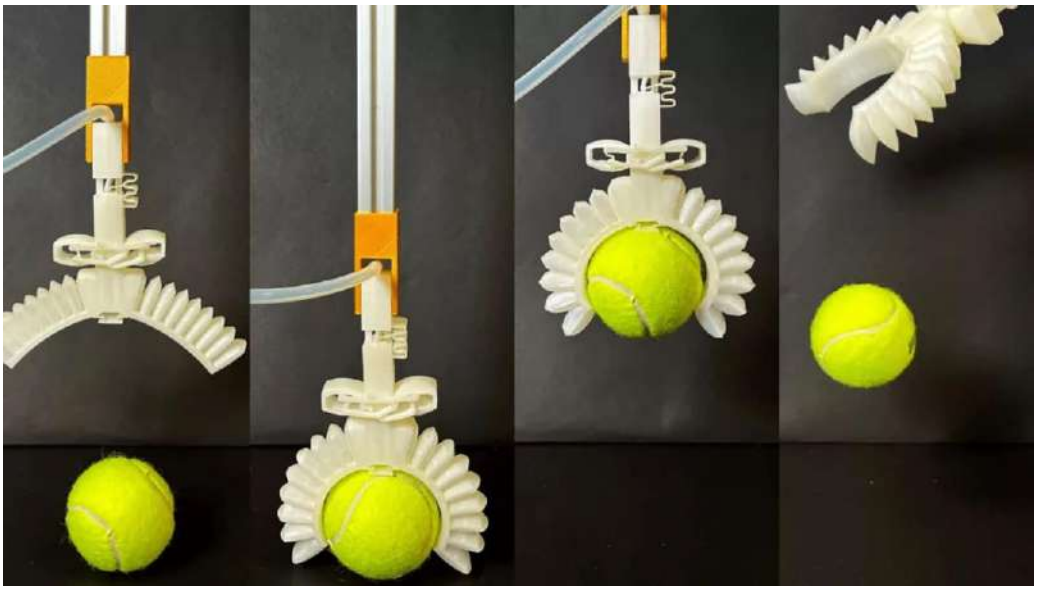
The team overcame these obstacles by developing a new 3D printing method, which involves the printer nozzle tracing a continuous path through the entire pattern of each layer printed.

"It's like drawing a picture without ever lifting the pencil off the page," said Michael T. Tolley, the senior author on the paper and an associate professor in the UC San Diego Jacobs School of Engineering.

This method reduces the likelihood of leaks and defects in the printed piece, which are very common when printing with soft materials.

The new method also allows for printing of thin walls, down to 0.5 millimeters in thickness. The thinner walls and complex, curved shapes allow for a higher range of deformation, resulting in a softer structure overall. Researchers based the method on the Eulerian path, which in graph theory is a trail in a graph that touches every edge of that graph once and once only.

"When we followed these rules, we were able to consistently print functional pneumatic soft robots with embedded control circuits," said Tolley.



India took a walk on the moon, says ISRO as rover rolls out of lander

Highlights

- *India's ISRO successfully executed a soft landing on the moon with Chandrayaan-3, making it the fourth country to achieve this feat & first in soft landing at south pole of moon.*
- *The mission included a lander and a rover, which autonomously guided themselves during a 17-minute descent phase to land near the lunar south pole.*
- *Chandrayaan-3's goals involve studying lunar quakes, mineral compositions, and particles near the moon's surface, with experiments operating for 14 days.*
- *The lander and rover run on solar power and are expected to cease functioning during the lunar night when temperatures drop drastically. Any revival attempts will be considered afterward.*
- *Prime Minister Narendra Modi congratulated the achievement, and Chandrayaan-3's scientific payloads focus on analyzing the lunar surface's chemical composition and elements through spectrometry.*

India took a walk on the moon! the Indian Space Research Organization (ISRO) said on Thursday morning after the rover rolled out of the lander late Wednesday night, hours after India made history with a soft landing of Chandrayaan-3 near the south pole of the moon at 6.04 pm.

Nearly four hours later, the foldable ramp on one side of the lander opened. And the six-wheeled, 26 kg lander with two science payloads came out of it. “Chandrayaan-3 rover: Made in India, Made for the MOON!” ISRO said.

The 17-minute descent phase went exactly as planned, with the lander autonomously guiding itself – slowing down from 1,680 meters per second to almost 0 meters per second, selecting the exact spot, and landing slowly and steadily as the country watched with bated breath.

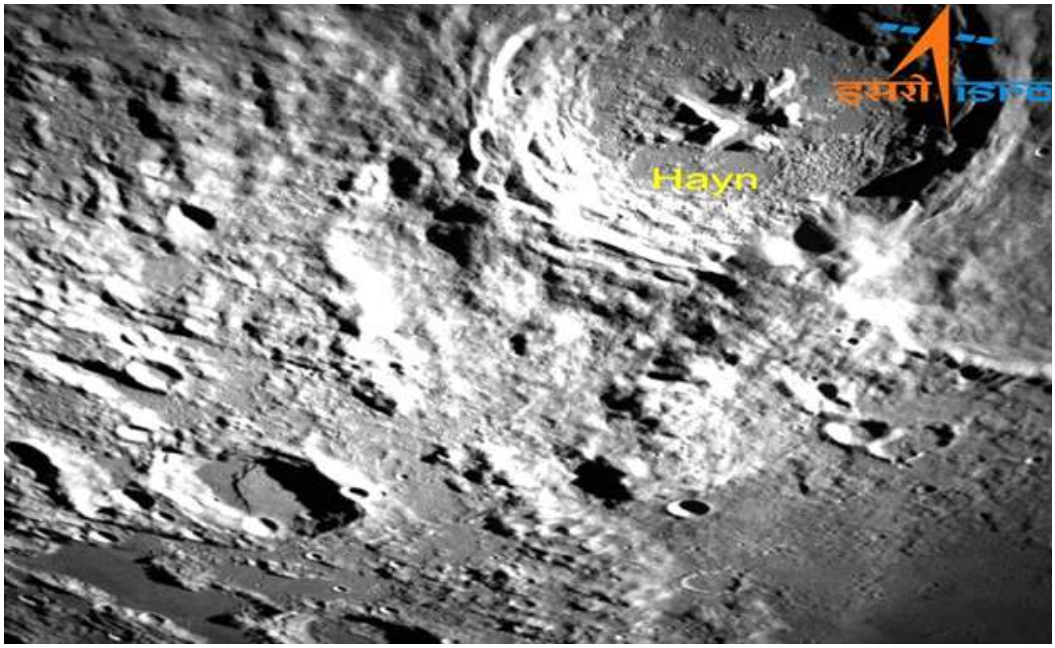
The mission has already achieved its goals of soft landing and roving, with the science experiments now getting 14 days to operate. With the lander and rover completely being operated on energy from solar cells, they will stop functioning when the landing spot goes into the lunar night. The electronics on board are unlikely to survive as temperatures plummet to -130 degrees Celsius on the lunar surface.

ISRO Chairman S Somanath has said previously that the space agency will check the viability of the lander-rover after the night and see whether it can be revived.

India became the fourth country to land on the moon after the United States, Russia, and China. It became the first country to do so near the lunar South Pole after the Russian mission that was to land a couple of days before it crashed. Prime Minister Narendra Modi congratulated the country from South Africa.

The Chandrayaan-3 payloads will further the science of the two predecessors by studying lunar quakes, mineral compositions, and the electrons and ions near the surface of the moon. The mission will attempt to study water ice, the presence of which was first confirmed by its predecessor.

There are two scientific experiments on the rover. The LASER Induced Breakdown Spectroscopy (LIBS) will determine the chemical and mineral composition of the lunar surface. The Alpha Particle X-ray Spectrometer (APXS) will determine the composition of elements such as magnesium, aluminum, silicon, potassium, calcium, titanium, and iron in the lunar soil and rocks.



Japanese scientists develop Novel, completely solid, rechargeable air battery

Highlights

- *Breaking the Mold: Japanese Researchers Unveil All-Solid-State Air Battery with Enhanced Organic Electrode*
- *Green Energy Advancement: Novel Solid-State Air Battery Shows Improved Performance and Endurance, Notes Japanese Study*
- *Organic Electrode Triumph: Japanese Scientists Develop High-Capacity Solid-State Air Battery for Sustainable Energy Storage*
- *Empowering Battery Tech: Japanese Study Introduces All-Solid-State Air Battery with Innovative Organic Electrode Design*

Metals traditionally serve as the active materials for the negative electrodes in batteries. However, there's been a shift towards using redox-active organic molecules like quinone and amine-based compounds as negative electrodes in rechargeable metal–air batteries, which feature oxygen-reducing positive electrodes.

Here, protons and hydroxide ions participate in the redox reactions. Such batteries exhibit high performance, close to the maximum capacity that is theoretically possible. Furthermore, using redox-active organic molecules in rechargeable air batteries overcomes problems associated with metals, including the formation of structures called 'dendrites,' which impact battery performance, and have negative environmental impact.

However, these batteries use liquid electrolytes, just like metal-based batteries—which pose major safety concerns like high electrical resistance, leaching effects, and flammability.

Now, in a new study recently published in *Angewandte Chemie International Edition*, a group of Japanese researchers have developed an all-solid-state rechargeable air battery (SSAB) and investigated its capacity and durability. The study was led by Professor Kenji Miyatake fromWaseda University and the University of Yamanashi, and co-authored by Professor Kenichi Oyaizu from Waseda University.

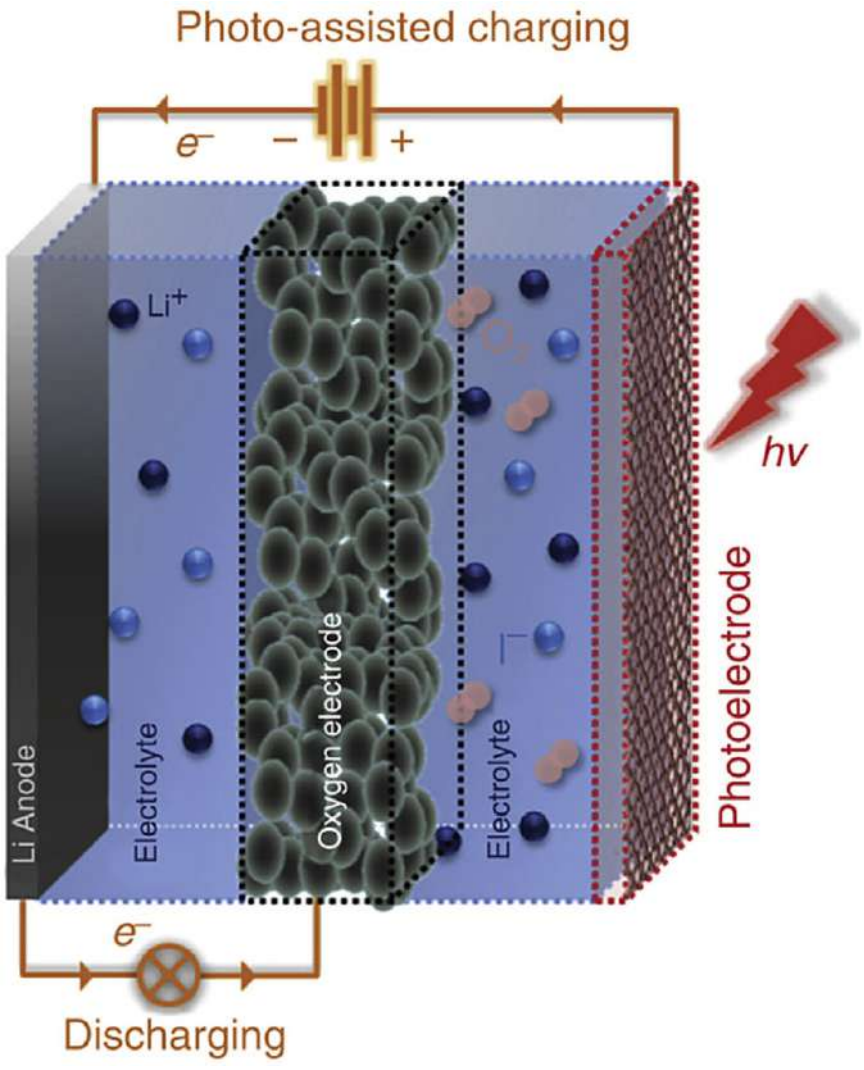
The researchers chose a chemical called 2,5-dihydroxy-1,4-benzoquinone (DHBQ) and its polymer poly(2,5-dihydroxy-1,4-benzoquinone-3,6-methylene) (PDBM) as active materials for the negative electrode due to their stable and reversible redox reactions in acidic conditions. In addition, they utilized a proton-conductive polymer called Nafion as the solid electrolyte, thereby replacing conventional liquid electrolytes. “To the best of my knowledge, no air batteries based on organic electrodes and solid polymer

electrolytes have been developed yet," says Miyatake.

After the SSAB was in place, the researchers experimentally assessed its charge–discharge performance, rate characteristics, and cyclability. They found that, unlike typical air batteries that use a metallic negative electrode and an organic liquid electrolyte, the SSAB did not deteriorate in the presence of water and oxygen. Furthermore, replacing the redox-active molecule DHBQ with its polymeric counterpart PDBM formed a better negative electrode. While the per gram-discharge capacity of the SSAB-DHBQ was 29.7 mAh, the corresponding value of the SSAB-PDBM was 176.1 mAh, at a constant current density of 1 mAcm-2.

The researchers also found that the coulombic efficiency of SSAB-PDBM was 84% at a 4C rate, which gradually decreased to 66% at a 101 C rate. While the discharge capacity of SSAB-PDBM was reduced to 44% after 30 cycles, by increasing the proton-conductive polymer content of the negative electrode, the researchers could significantly improve it to 78%. Electron microscopic images confirmed that the addition of Nafion improved the performance and durability of the PDBM-based electrode.

This study demonstrates the successful operation of an SSAB comprising redox-active organic molecules as the negative electrode, a proton-conductive polymer as the solid electrolyte, and an oxygen-reducing, diffusion-type positive electrode. The researchers hope that it will pave the way for further advancements. "This technology can extend the battery life of small electronic gadgets such as smartphones and eventually contribute to realizing a carbon-free society," concludes Miyatake.



WhatsApp enables screen sharing option on video calls

Highlights

- *WhatsApp Unveils Screen Sharing: Mark Zuckerberg Introduces Dynamic Video Call Feature*
- *Immersive Collaboration: WhatsApp Adds Landscape Mode and Live Screen Sharing*
- *WhatsApp Enters the Arena: New Screen Sharing Puts It in Competition with Video Conferencing Giants*
- *Enhanced Communication: WhatsApp's Latest Screen Sharing Feature Challenges Established Video Call Platforms*

Mark Zuckerberg announced the latest feature on WhatsApp, enabling Screen Share during a video call.

Whether sharing documents for work, browsing photos with family, planning a vacation or shopping online with friends, or just helping grandparents with tech support screen sharing lets you share a live view of your screen during the call. You can initiate screen sharing by clicking on the 'Share' Icon and choosing between sharing a specific application or sharing the entire screen.

You can now also enjoy video calls in Landscape mode for a wider and more immersive viewing and sharing experience on your phone.

With this new feature WhatsApp will now be directly competing with established video conferencing giants like Microsoft Meet, Google Meet, Zoom and Apple's FaceTime.

Meta has stated that it will be rolled out in phases across Android, iOS, and Windows Desktop platforms. The feature was initially tested among beta users of WhatsApp.

How To Share Screen on WhatsApp

- Start a video call with the person or group you want to share your screen with.
- Once connected, simply tap or click the 'Share' icon.
- The app will ask to grant screen share access.
- Users can then opt to share a specific app or their entire screen.

WhatsApp's screen-sharing feature has been gradually releasing in beta for a couple of months.

WABetaInfo, a publication that often spots WhatsApp features ahead of their official announcement, has previously reported on the feature's rollout in beta versions of WhatsApp's app on Android, iOS and Windows.

Meanwhile to complement screen sharing, WhatsApp is also allowing landscape mode video calls now, reported The Verge.

This mode enhances the viewing experience, particularly complementing the screen-sharing feature and providing a broader perspective during collaborative video calls.

WhatsApp's journey in video communication spans over six years. With recent additions like picture-in-picture support for iOS and the ability to share short video messages within chats, WhatsApp has been consistently expanding its capabilities.

A single drop changes everything: new technique to revolutionize nanosensor manufacturing

Highlights

- *Macquarie University Engineers Redefine Nano Sensor Production, Cutting Costs and Carbon Emissions*
- *Revolutionizing Nano Sensors: Macquarie University Introduces Efficient Ethanol-Based Method*
- *Efficiency Boost: Macquarie Engineers Develop Ethanol Technique for Superior Nano Sensors*
- *Sustainable Breakthrough: Macquarie's Nano Sensor Innovation Enhances Efficiency with Ethanol Integration*

Engineers at Macquarie University have pioneered a new method for producing nano sensors that is significantly less carbon-intensive, cuts costs, and enhances efficiency and versatility, substantially improving a key process in this multi-trillion-dollar global sector.

The team has found a way to treat each sensor using a single drop of ethanol instead of the conventional process that involves heating materials to high temperatures.

Their research was recently published in the journal *Advanced Functional Materials*.

“Nano-sensors are usually made up of billions of nano particles deposited onto a small sensor surface but most of these sensors don't work when first fabricated,” says corresponding author Associate Professor Noushin Nasiri, head of the Nanotech Laboratory at Macquarie University's School of Engineering.

The nano particles assemble themselves into a network held together by weak natural bonds which can leave so many gaps between nano particles that they fail to transmit electrical signals, so the sensor won't function.

Associate Professor Nasiri's team uncovered the finding while working to improve ultraviolet light sensors, the key technology behind Sun watch, which saw Nasiri become a 2023 Eureka Prize finalist.

Nano sensors have huge surface-to-volume ratio made up of layers of nano particles, making them highly sensitive to the substance they are designed to detect. But most nano sensors don't work effectively until heated in a time-consuming and energy-intensive 12-hour process using high temperatures to fuse layers of nano particles, creating channels that allow electrons to pass through layers so the sensor will function.

“The furnace destroys most polymer-based sensors, and nano sensors containing tiny electrodes, like those in a nano electronics device, can melt. Many materials can't currently be used to make sensors because they

can't withstand heat," Associate Professor Nasiri says.

However, the new technique discovered by the Macquarie team bypasses this heat-intensive process, allowing nano sensors to be made from a much broader range of materials.

"Adding one droplet of ethanol onto the sensing layer, without putting it into the oven, will help the atoms on the surface of the nanoparticles move around, and the gaps between nanoparticles disappear as the particles to join to each other," Associate Professor Nasiri says.

"We showed that ethanol greatly improved the efficiency and responsiveness of our sensors, beyond what you would get after heating them for 12 hours."

The new method was discovered after the study's lead author, postgraduate student Jayden (Xiaohu) Chen, accidentally splashed some ethanol onto a sensor while washing a crucible, in an incident that would usually destroy these sensitive devices.

"I thought the sensor was destroyed, but later realized that the sample was outperforming every other sample we've ever made," Chen says.

Associate Professor Nasiri says that the accident might have given them the idea, but the method's effectiveness depended on painstaking work to identify the exact volume of ethanol used.

"When Jayden found this result, we went back very carefully trying different quantities of ethanol. He was testing over and over again to find what worked," she says.

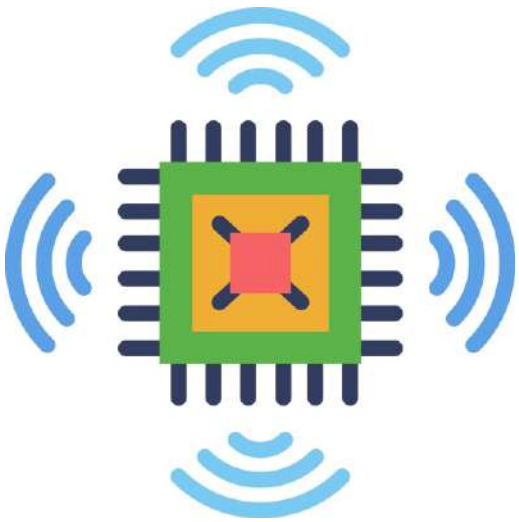
"It was like Goldilocks – three microlitres was too little and did nothing effective, 10 microlitres was too much and wiped the sensing layer out, five microlitres was just right!"

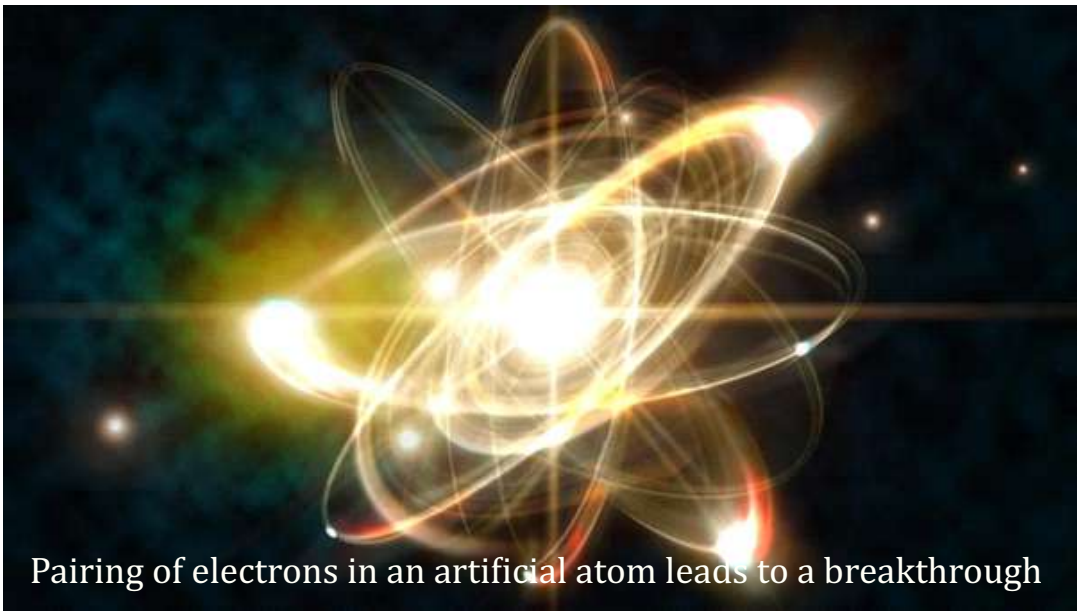
The team has patents pending for the discovery, which has the potential to make a very big splash in the nano sensor world.

"We have developed a recipe for making nano sensors work and we have tested it with UV light sensors, and also with nano sensors that detect carbon dioxide, methane, hydrogen and more – the effect is the same," says Associate Professor Nasiri.

"After one correctly measured droplet of ethanol, the sensor is activated in around a minute. This turns a slow, highly energy-intensive process into something far more efficient."

Associate Professor Nasiri has already been approached by companies in Australia and internationally who are keen to work with her to put the technique into practice.





Pairing of electrons in an artificial atom leads to a breakthrough

Highlights

- *Breakthrough Discovery: Physicists at Hamburg University observe the Machida-Shibata state, where paired electrons within an artificial atom on a superconductor's surface unlock a rare quantum state predicted over 50 years ago.*
- *Quantum Dot Superconductivity: By inducing superconductivity in quantum dots, researchers validate theoretical predictions from the 1970s, holding potential for nanostructured electronics and quantum computing advancement.*
- *Quantum Tech Implications: The newfound Machida-Shibata state's potential to reduce noise in quantum computers and its relevance for transmon qubit devices could revolutionize quantum technology development*

A team of physicists from Hamburg University has made a breakthrough in the field of quantum physics by observing a rare state of matter that was predicted by Japanese theorists more than half a century ago.

Machida-Shibata state

The state, known as the Machida-Shibata state, involves the pairing of electrons in an artificial atom on the surface of a superconductor. The discovery, published in the journal Nature, could have implications for the development of nanostructured electronic devices and quantum computers.

Electrons are negatively charged particles that usually repel each other. This affects the properties of many materials, such as their electrical resistance. However, under certain conditions, electrons can form pairs and behave like bosons, which are particles that can occupy the same space or have the same motion.

When this happens, the material can exhibit superconductivity, which means that it can conduct electricity without any resistance. Superconductivity has many important applications in technology, such as magnetic resonance imaging or highly sensitive detectors for magnetic fields.

Superconductivity in the smallest possible unit

The researchers from Hamburg University managed to induce superconductivity in the smallest possible unit: a quantum dot, which is an artificial atom that can trap electrons in a tiny space. They did this by creating quantum dots from silver atoms and coupling them to a superconductor made of lead. By tuning the number of electrons in the quantum dots, they were able to observe the formation of electron pairs and

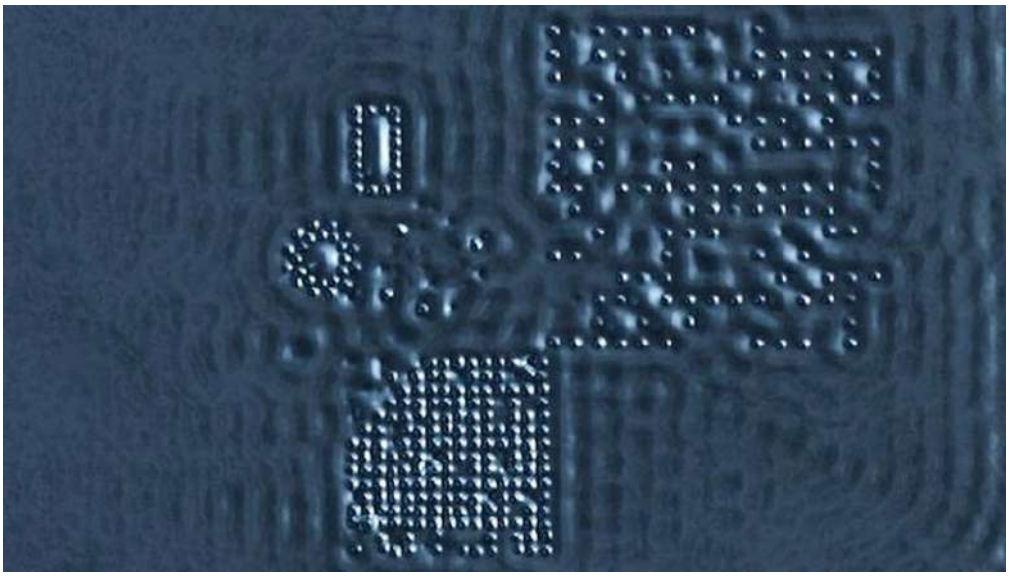
measure their energy spectrum.

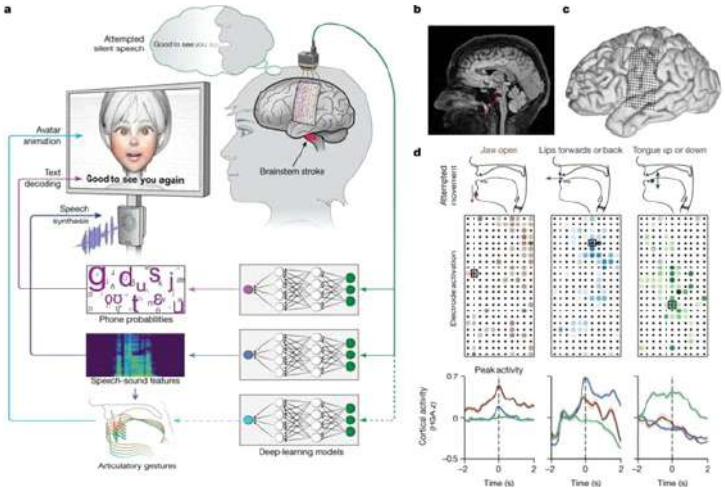
The experimental results matched the theoretical predictions made by Kazushige Machida and Fumiaki Shibata in the early 1970s. They proposed that electron pairs in quantum dots coupled to superconductors would have a special state with a very low energy peak. This state had never been directly detected before, despite its relevance for understanding quantum phenomena at the nanoscale.

The researchers also found out that the Machida-Shibata state could be useful for reducing noise in transmon qubits, which are essential components of modern quantum computers. This was confirmed by recent work from researchers from the Netherlands and Denmark.

In an email to the first author of the paper, Dr. Lucas Schneider, Kazushige Machida expressed his gratitude for "discovering" his old paper and verifying it experimentally after 50 years. He wrote: "I thought for a long time that transition metal non-magnetic impurities produce the in-gap state, but the location of it is so near the superconducting gap edge, thus it is impossible to prove its existence. But by your ingenious method, you have finally checked it to be true experimentally".

Gapless materials in electronic contact with superconductors acquire proximity-induced superconductivity in a region near the interface. Numerous proposals build on this addition of electron pairing to originally non-superconducting systems and predict intriguing phases of matter, including topological, odd-frequency, nodal-point, or Fulde–Ferrell–Larkin–Ovchinnikov superconductivity. Here we investigate the most miniature example of the proximity effect on only a single spin-degenerate quantum level of a surface state confined in a quantum corral11 on a superconducting substrate, built atom by atom by a scanning tunneling microscope. Whenever an eigenmode of the corral is pitched close to the Fermi energy by adjusting the size of the corral, a pair of particle–hole symmetric states enter the gap of the superconductor. We identify these as spin-degenerate Andreev bound states theoretically predicted 50 years ago by Machida and Shibata, which had so far eluded detection by tunnel spectroscopy but were recently shown to be relevant for transmon qubit devices. We further find that the observed anticrossings of the in-gap states are a measure of proximity-induced pairing in the eigenmodes of the quantum corral. Our results have direct consequences on the interpretation of impurity-induced in-gap states in superconductors, corroborate concepts to induce superconductivity into surface states, and further pave the way towards superconducting artificial lattices.





Brain-computer interface enables woman with severe paralysis to speak through digital avatar

Highlights

- *Revolutionary Brain-Computer Interface (BCI) Enables Speech and Facial Expressions: Researchers at UC San Francisco and UC Berkeley have developed a groundbreaking brain-computer interface that allows a woman with severe paralysis to communicate through a digital avatar. This marks the first time that brain signals have been transformed into both speech and facial expressions, enhancing communication possibilities for people with disabilities*
- *Impressive Speed and Accuracy: The BCI system can decode brain signals into text at a remarkable speed of nearly 80 words per minute, a significant advancement compared to existing technologies. By translating phonemes – the building blocks of speech the system achieved improved accuracy and efficiency, potentially enabling users to have more natural and fluid conversations.*

Researchers at UC San Francisco and UC Berkeley have developed a brain-computer interface (BCI) that has enabled a woman with severe paralysis from a brainstem stroke to speak through a digital avatar.

It is the first time that either speech or facial expression have been synthesized from brain signals. The system can also decode these signals into text at nearly 80 words per minute, a vast improvement over commercially available technology.

Edward Chang, MD, chair of neurological surgery at UCSF, who has worked on the technology, known as abrain computer interface, or BCI, for more than a decade, hopes this latest research breakthrough, appearing Aug. 23, 2023, in *Nature*, will lead to an FDA-approved system that enables speech from brain signals in the near future.

"Our goal is to restore a full, embodied way of communicating, which is really the most natural way for us to talk with others," said Chang, who is a member of the UCSF Weill Institute for Neuroscience and the Jeanne Robertson Distinguished Professor in Psychiatry. "These advancements bring us much closer to making this a real solution for patients."

Chang's team previously demonstrated it was possible to decode brain signals into text in a man who had also experienced a brainstem stroke many years earlier. The current study demonstrates something more ambitious: decoding brain signals into the richness of speech, along with the movements that animate a person's face during conversation.

Chang implanted a paper thin rectangle of 253 electrodes onto the surface of the woman's brain over areas his team has discovered are Critical for speech. The electrodes intercepted the brain signals that, if not for

the stroke, would have gone to muscles in her, tongue, jaw and larynx, as well as her face. A cable, plugged into a port fixed to her head, connected the electrodes to a bank of computers.

For weeks, the participant worked with the team to train the system's artificial intelligence algorithms to recognize her unique brain signals for speech. This involved repeating different phrases from a 1,024-word conversational vocabulary over and over again, until the computer recognized the brain activity patterns associated with the sounds.

Rather than train the AI to recognize whole words, the researchers created a system that decodes words from phonemes. These are the sub-units of speech that form spoken words in the same way that letters form written words. "Hello," for example, contains four phonemes: "HH," "AH," "L" and "OW."

Using this approach, the computer only needed to learn 39 phonemes to decipher any word in English. This both enhanced the system's accuracy and made it three times faster.

"The accuracy, speed and vocabulary are crucial," said Sean Metzger, who developed the text decoder with Alex Silva, both graduate students in the joint Bioengineering Program at UC Berkeley and UCSF. "It's what gives a user the potential, in time, to communicate almost as fast as we do, and to have much more naturalistic and normal conversations."

research participant in the Dr. Edward Chang's study of speech neuroprostheses, is connected to computers that translate her brain signals as she attempts to speak into the speech and facial movements of an avatar on Monday, May 22, 2023, in El Cerrito, Calif. At left is UCSF clinical research coordinator Max Dougherty. Credit: Noah Berger

To create the voice, the team devised an algorithm for synthesizing speech, which they personalized to sound like her voice before the injury, using a recording of her speaking at her wedding.

The team animated the avatar with the help of software that simulates and animates muscle movements of the face, developed by Speech Graphics, a company that makes AI-driven facial animation. The researchers created customized machine-learning processes that allowed the company's software to mesh with signals being sent from the woman's brain as she was trying to speak and convert them into the movements on the avatar's face, making the jaw open and close, the lips protrude and purse and the tongue go up and down, as well as the facial movements for happiness, sadness and surprise.

"We're making up for the connections between the brain and vocal tract that have been severed by the stroke," said Kaylo Littlejohn, a graduate student working with Chang and Gopala Anumanchipalli, Ph.D., a professor of electrical engineering and computer sciences at UC Berkeley. "When the subject first used this system to speak and move the avatar's face in tandem, I knew that this was going to be something that would have a real impact."

An important next step for the team is to create a wireless version that would not require the user to be physically connected to the BCI.

"Giving people the ability to freely control their own computers and phones with this technology would have profound effects on their independence and social interactions," said co-first author David Moses, Ph.D., an adjunct professor in neurological surgery.

World-first software predicts geo-disasters to save lives

Highlights

- *GeoXPM Software Innovation: Civil engineers at Monash University develop GeoXPM software, a groundbreaking tool capable of predicting and assessing the impact of geo-disasters caused by climate-related events, aiding in mitigating loss of life and property damage.*
- *World's First Continuum Particle-Based Model: GeoXPM is the world's first fully functional continuum particle-based software that can predict onset and aftermath responses of geomaterials and geo-structures, offering countermeasures to minimize damage and save live*
- *Climate Change Mitigation: As global warming triggers more natural disasters, GeoXPM's capabilities to forecast complex environmental events, suggest safety measures, and aid insurance firms and authorities hold potential to reduce casualties and habitat destruction caused by extreme weather related events.*

Global warming is causing more and more natural disasters which often lead to devastating consequences including loss of life. These take the shape of extreme weather events such as heavy rainfall, droughts, tsunamis, cyclones, landslides, avalanches, earthquakes and forest fires.

Now, civil engineers at Monash University have conceived of a first-of-its kind software called GeoXPM that can not only predict where a geo-disaster might occur but also assess the event's impact on its surrounding environment in order to mitigate its consequences. This is because the model can make suggestions of next steps to take to avoid dire loss of life and save as much property as possible.

World's first fully functional software model of its kind

“This is the world's first, fully functional continuum particle-based software to model and predict both the onset and post-failure responses of geomaterials and geo-structures across several scales - including rock, soil, water and complex mixtures of these should natural features such as slopes and hillsides destabilize or artificial structures fail,” said the statement.

The work saw a collaboration of national and international teams of experts to engineer this unique computing solution capable of foreseeing climate-related events and their after-effects long before they even occur.

“Modelling worst-case scenarios and understanding them in detail allows us to design counter-measures that can minimize loss of life and damage,” explained associate professor Ha Bui from the Department of Civil Engineering and an ARC Future Fellow and founder of the Monash Computational Geomechanics (MCG) laboratory.

The tool can suggest countermeasures to avoid the worst impacts of geo-disasters and save lives. An

example of this would be in the case of a dam overflow. The software would indicate buffers that could divert the water away from populated areas and vital infrastructure, leading it to a safe location where no harm to human life can take place while also saving human habitats.

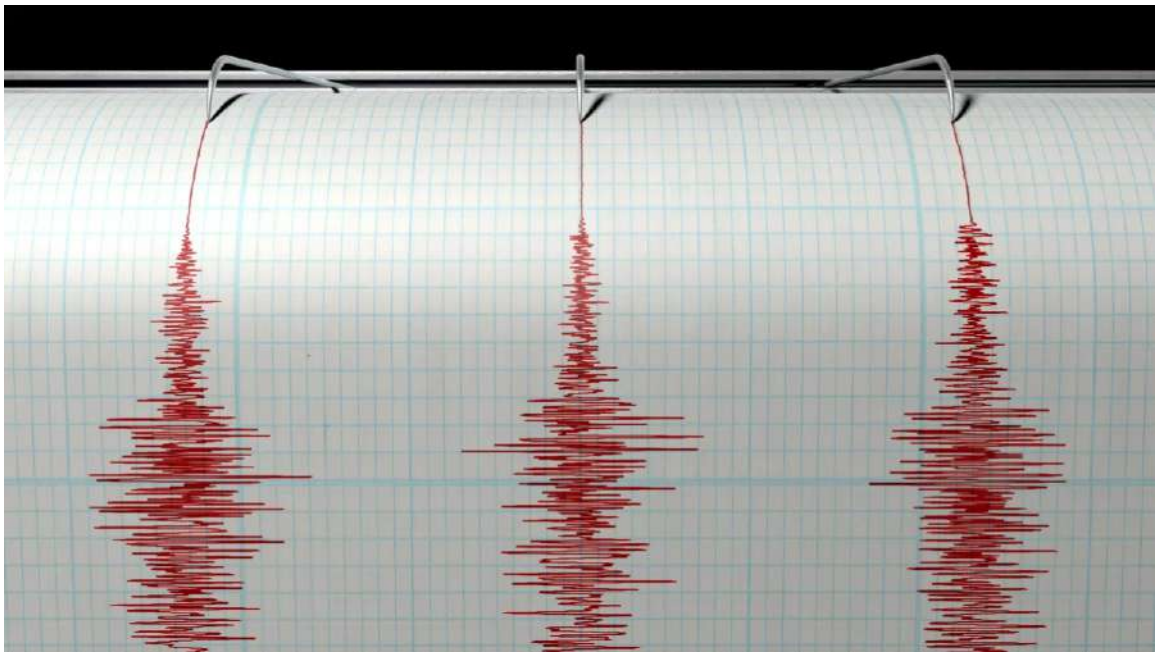
Complex geo-environmental conditions

"GeoXPM can predict behavior and failure under complex geo-environmental conditions, including the flow of granular materials with complex behavior of soil-fluid mixtures, soil-structure interactions and even fracture and fragmentations of rock and concrete." added Bui.

The researchers provide a visual example of the tool that recreates the path of debris following the Bingham copper mine collapse, an important natural disaster.

The tool comes at a crucial time as global warming has been responsible for mudslides, landslides and other debris flows that cause hundreds of deaths each year. The planet has also witnessed an increase in storms, floods, drought and wildfires that can disturb human habitats and cause untold damage, leaving resources companies liable for billions of dollars in compensation.

The software model can thus be used by insurance firms as well as local authorities to avoid the worst kind of damages and to save human lives. As climate change seems to increasingly take its toll despite best attempts to thwart it, these types of tools may mean the difference between life or death. It's innovations such as these that may allow humanity to face the worst of global warming without increasing death tolls and habitat annihilation.



Driverless cars can now operate 24/7 in San Francisco

Highlights

- *California Grants Cruise and Waymo Full-Fledged Driverless Service: California's Public Utilities Commission has approved Cruise and Waymo to offer commercial passenger services using driverless vehicles in San Francisco, a significant milestone for autonomous cars.*
- *Expanded Services and Speeds: The permit allows Cruise and Waymo to charge passengers at any time of day and expands their operational areas. Waymo can now operate at speeds of up to 65 mph in severe weather, while Cruise is limited to 35 mph and weather-dependent operations*
- *Safety Concerns and Technological Improvement: Despite safety concerns, both companies have been granted permission to operate without safety drivers. Reports of incidents such as abrupt stops and traffic disruptions have raised questions, but Waymo emphasizes ongoing technological advancements to improve its driverless technology and performance.*

In a massive win for driverless cars in the United States, California has permitted Cruise and Waymo to conduct full-fledged commercial passenger service using driverless vehicles in San Francisco.

The permission granted by the California Public Utilities Commission (CPUC) allows both firms to charge fees for journeys at any time of day. The approval comes after a disputed six-hour hearing on the matter that included residents voicing their concerns about autonomous vehicles (AVs) roaming their roads. Hearing all the arguments, the commission voted 3-to-1 to allow the two businesses to run their cars across San Francisco at any time of the day.

“While we do not yet have the data to judge AVs against the standard human drivers are setting, I do believe in the potential of this technology to increase safety on the roadway. Collaboration between key stakeholders in the industry and the first responder community will be vital in resolving issues as they arise in this innovative, emerging technology space," said John Reynolds, CPUC Commissioner, in a statement released by the agency.

Permit to expand services

Previously, both firms were only allowed to offer their services under certain conditions. Cruise was authorized to provide fared passenger service in limited areas of San Francisco from 10 pm to 6 am without the presence of a safety driver and non-fared passenger service throughout San Francisco at any time without the presence of a safety driver.

In the case of Waymo, they could provide fared passenger service throughout San Francisco at any time while a safety driver is present, as well as non-fared passenger service throughout San Francisco at any time without a safety driver. Waymo was also permitted to provide non-fared passenger transportation in sections of Los Angeles and in and around Mountain View, with or without the presence of a safety driver.

In contrast, the approval now allows the firms to expand their services and offer a genuine alternative to other taxi players on the market. "Cruise in a position to compete with traditional ride-hail, and challenge an unsafe, inaccessible transportation status quo," said Prashanthi Raman, Cruise vice president of global government affairs, in a statement.

Waymo will now be able to travel at speeds of up to 65 miles per hour in severe weather, whereas Cruise will be limited to 35 miles per hour and will not be authorized to operate when the weather does not permit, according to the commission on Thursday. Both services currently have more than 500 autonomous vehicles already in operation in the San Francisco area.

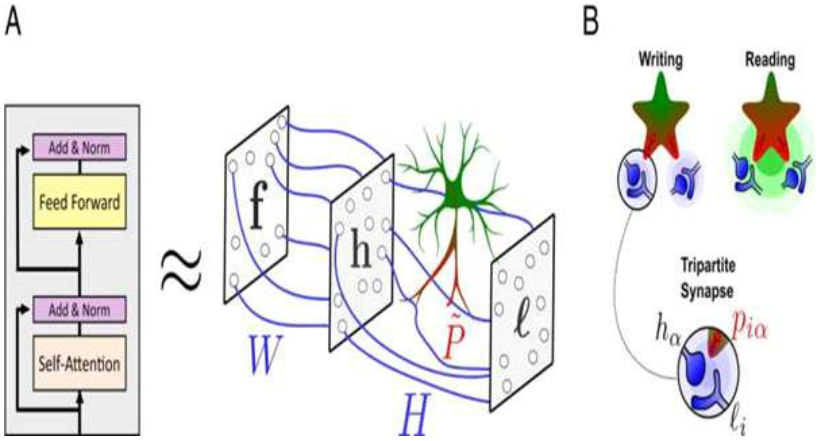
Safety concerns

There have been reports of issues with the technology during the time such services were operational, with even certain limitations in place. It is claimed that such cars have been abruptly stopping, blocking traffic, flashing wrong turn signals, and impeding emergency responders from doing their jobs.

"The city of San Francisco said there have been over 240 such reported incidents since the beginning of the year. But you wouldn't know it if you asked regulators or the robotaxi companies themselves. They don't have to report such incidents," said Justin Kloczko, tech and privacy advocate for Consumer Watchdog, in a press statement.

The group also claimed that according to the city departments' estimates, Waymo vehicles were involved in collisions, with injuries reported at a rate 1.3 times higher than the national average of human-driven cars.

Waymo says that the technology behind its driverless cars is constantly improving, learning from every mile it drives. "From handling heavier levels of rain and fog to smoothly navigating construction zones and improved rerouting around emergency scenes. We're seeing strong performance and rapid ongoing advancements across the board," said the firm.



AI models are powerful, but are they biologically possible

Artificial neural networks, ubiquitous machine-learning models that can be trained to complete many tasks, are so called because their architecture is inspired by the way biological neurons process information in the human brain.

About six years ago, scientists discovered a new type of more powerful neural network model known as a transformer. These models can achieve unprecedented performance, such as by generating text from prompts with near-human-like accuracy. A transformer underlies AI systems such as ChatGPT and Bard, for example. While incredibly effective, transformers are also mysterious: Unlike with other brain-inspired neural network models, it hasn't been clear how to build them using biological components.

Now, researchers from MIT, the MIT-IBM Watson AI Lab, and Harvard Medical School have produced a hypothesis that may explain how a transformer could be built using biological elements in the brain. They suggest that a biological network composed of neurons and other brain cells called astrocytes could perform the same core computation as a transformer.

Recent research has shown that astrocytes, non-neuronal cells that are abundant in the brain, communicate with neurons and play a role in some physiological processes, like regulating blood flow. But scientists still lack a clear understanding of what these cells do computationally.

Highlights

- *Bio-Inspired Transformers: Researchers from MIT, MIT-IBM Watson AI Lab, and Harvard Medical School have proposed a hypothesis that explains how a biological network involving neurons and astrocytes in the brain could perform the core computation of transformers, which are powerful neural network models used in AI applications like ChatGPT. This groundbreaking insight bridges the gap between AI technology and brain functions, potentially advancing both fields.*
- *Astrocytes' Computational Role: Astrocytes, non-neuronal brain cells, have long been enigmatic in terms of their computational functions. The researchers suggest that astrocytes, which form unique tripartite synapses with neurons, might act as a memory buffer, allowing them to participate in complex computations such as those found in transformer models, specifically the self-attention mechanism.*
- *Implications for Future Research: This study paves the way for further exploration of astrocyte involvement in brain computation and memory processes. By mathematically modeling neuron-astrocyte networks to replicate transformer-like behavior, the researchers have sparked interest in the relationship between AI architecture and biological brain components, potentially revolutionizing our understanding of both realms.*

With the new study, published this week(15 August) in *Proceedings of the National Academy of Sciences*, the researchers explored the role astrocytes play in the brain from a computational perspective, and crafted a mathematical model that shows how they could be used, along with neurons, to build a biologically plausible transformer.

Their hypothesis provides insights that could spark future neuroscience research into how the human brain works. At the same time, it could help machine-learning researchers explain why transformers are so successful across a diverse set of complex tasks.

"The brain is far superior to even the best artificial neural networks that we have developed, but we don't really know exactly how the brain works. There is scientific value in thinking about connections between biological hardware and large-scale artificial intelligence networks. This is neuroscience for AI and AI for neuroscience," says Dmitry Krotov, a research staff member at the MIT-IBM Watson AI Lab and senior author of the research paper.

Joining Krotov on the paper are lead author Leo Kozachkov, a postdoc in the MIT Department of Brain and Cognitive Sciences; and Ksenia V. Kastanenka, an assistant professor of neurobiology at Harvard Medical School and an assistant investigator at the Massachusetts General Research Institute.

A biological impossibility becomes plausible Transformers operate differently than other neural network models. For instance, a recurrent neural network trained for natural language processing would compare each word in a sentence to an internal state determined by the previous words. A transformer, on the other hand, compares all the words in the sentence at once to generate a prediction, a process called self-attention.

For self-attention to work, the transformer must keep all the words ready in some form of memory, Krotov explains, but this didn't seem biologically possible due to the way neurons communicate.

However, a few years ago scientists studying a slightly different type of machine-learning model (known as a Dense Associated Memory) realized that this self-attention mechanism could occur in the brain, but only if there were communication among at least three neurons.

"The number three really popped out to me because it is known in neuroscience that these cells called astrocytes, which are not neurons, form three-way connections with neurons, what are called tripartite synapses," Kozachkov says.

When two neurons communicate, a presynaptic neuron sends chemicals called neurotransmitters across the synapse that connects it to a postsynaptic neuron. Sometimes, an astrocyte is also connected, it wraps a long, thin tentacle around the synapse, creating a tripartite (three-part) synapse. One astrocyte may form millions of tripartite synapses.

The astrocyte collects some neurotransmitters that flow through the synaptic junction. At some point, the astrocyte can signal back to the neurons. Because astrocytes operate on a much longer time scale than neurons. They create signals by slowly elevating their calcium response and then decreasing it. These cells can hold and integrate information communicated to them from neurons. In this way, astrocytes can form a type of memory buffer, Krotov says.

"If you think about it from that perspective, then astrocytes are extremely natural for precisely the computation we need to perform the attention operation inside transformers," he adds.

Building a neuron-astrocyte network With this insight, the researchers formed their hypothesis that astrocytes could play a role in how transformers compute. Then they set out to build a mathematical model of a neuron-astrocyte network that would operate like a transformer.

They took the core mathematics that comprise a transformer and developed simple biophysical models of what astrocytes and neurons do when they communicate in the brain, based on a deep dive into the literature and guidance from neuroscientist collaborators.

Then they combined the models in certain ways until they arrived at an equation of a neuron-astrocyte network that describes a transformer's self-attention.

"Sometimes, we found that certain things we wanted to be true couldn't be plausibly implemented. So, we had to think of workarounds. There are some things in the paper that are very careful approximations of the transformer architecture to be able to match it in a biologically plausible way," Kozachkov says.

Through their analysis, the researchers showed that their biophysical neuron-astrocyte network theoretically matches a transformer. In addition, they conducted numerical simulations by feeding images and paragraphs of text to transformer models and comparing the responses to those of their simulated neuron-astrocyte network. Both responded to the prompts in similar ways, confirming their theoretical model.

The next step for the researchers is to make the leap from theory to practice. They hope to compare the model's predictions to those that have been observed in biological experiments, and use this knowledge to refine—or possibly disprove—their hypothesis.

In addition, one implication of their study is that astrocytes may be involved in long-term memory, since the network needs to store information to be able act on it in the future. Additional research could investigate this idea further, Krotov says.

"For a lot of reasons, astrocytes are extremely important for cognition and behavior, and they operate in fundamentally different ways from neurons. My biggest hope for this paper is that it catalyzes a bunch of research in computational neuroscience toward glial cells, and in particular, astrocytes," adds Kozachkov.