Can Freight Train Cars Go Electric and Self-Driving

Chinmay Patil - T. Y. C. S. E.

Moving freight by rail hasn't changed a whole heck of a lot over the last several decades. And there are good reasons for this: Trains can move freight four times as efficiently as trucks can, and they can move a huge amount of it at once with minimal human supervision. The disadvantage of trains is that they're best at long-distance hub-to-hub freight transfers, and usually, you still need to put your cargo on a truck to get it to its final destination. Plus, if you just have a little bit of cargo, you may be at the mercy of a network that prioritizes large volume rather than small.

Parallel Systems, a startup founded by a trio of former SpaceX engineers that is coming out of stealth today, hopes to change this model substantially by introducing autonomous rail vehicles that can handle standard shipping containers—the same containers that currently move freely between cargo ships, traditional rail systems, and trucks. By moving containers one at a time, Parallel Systems believes that rail can be much more agile with no loss in efficiency, helping reduce the reliance on trucking. Can they do it? Maybe—but there are some challenges.

From a technical perspective, these autonomous electric-rail vehicles really seem like they're achievable. It's a substantial simplification of an autonomous-driving problem, in the sense that you only need to worry about control in one dimension, and (in particular) that most of the time you can be reasonably certain that you'll have right-of-way on the track. With some halfway decent sensors to detect obstacles on the track, reliable motors, and batteries that last long enough (current range is 800 kilometers with a subhour recharge time), and the software infrastructure required to sort it all out, I don't see any major obstacles to building these things and putting them on some tracks. Where things get more complicated is when you consider the long-term plan that Parallel Systems has for its technology:

The overall vision seems very compelling. Decentralizing freight transport and distribution can provide flexibility and increased efficiency, getting cargo closer to where it needs to go in a more timely manner while taking some stress off of overloaded ports. And with each individual container being effectively an independent autonomous vehicle, there are a bunch of clever things you can do, like platooning. In a traditional platoon, efficiency is unequal since the leader takes the brunt of the aerodynamic forces to make things easier on all of the following vehicles, and obviously rotating leaders won't work on rail. But Parallel Systems' vehicles can go bumper to bumper and push each other, meaning that overall energy use can be equalized. Neat!

The potential issue here, and it could be a significant one, is that Parallel Systems only builds and controls these little railcars. They don't build, own, or control the rail systems that their vehicles require. North America has rail all over the place already, but that rail is in the charge of other companies, who are using it to do their own thing.

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Dress Smart

Chinmay Patil - T. Y. C. S. E.

This article is part of our exclusive IEEE Journal Watch series in partnership with IEEE Xplore.

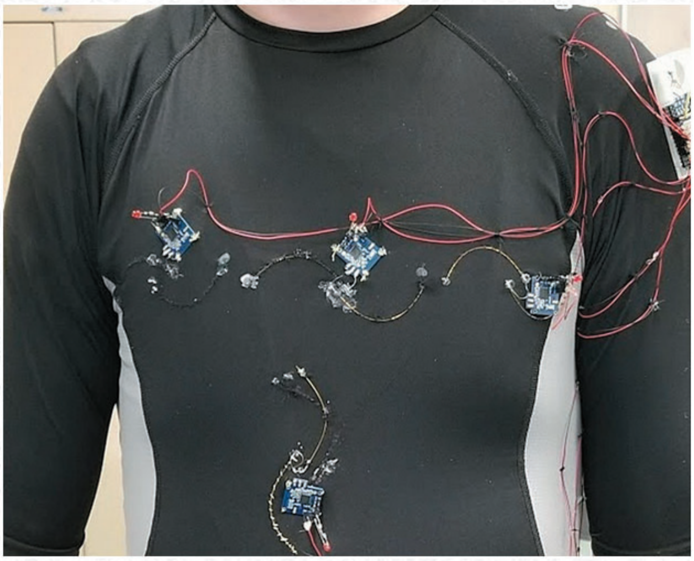
Clothes keep us warm, fashionable, and modest, but why stop there? A group of researchers in Canada has devised another use for clothing—they created a new smart T-shirt that can monitor the breathing of the person wearing it, which could be useful for a wide range of medical and athletic applications, among others.

Using the shirt to monitor a person's vital signs would be advantageous for a number of reasons, including its ability to conform to different body types without restricting mobility or sacrificing comfort.

"We believe that such technology will be very useful in hospitals, to reduce opioid overdose deaths, and prevent active people from [overexertion]," says Amine Miled, an associate professor at the department of electrical and computer engineering at Université Laval in Quebec City, Canada.

The smart shirt designed by his team, including colleagues Marc-André Dugas and YounèsMessaddeq, involves a network of thin, spiral antennas with Bluetooth capabilities embedded within the cloth. As the person wearing the shirt breathes in and out, the antennas deform slightly. A network of wireless sensors detect the deformations, and the data is transmitted wirelessly to a base station for analysis. In this way, a person's breathing pattern can be measured and monitored.

Through these experiments, it quickly became clear that people have vastly different breathing patterns, and especially among the sexes. For example, some people were more likely to breathe using their belly rather than their chest.



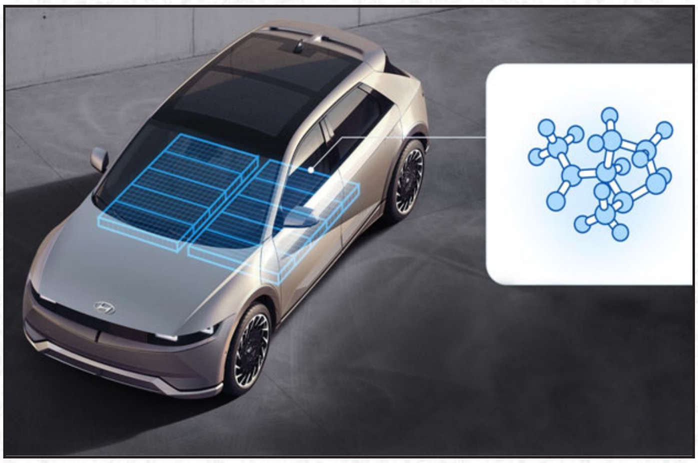
"We anticipated this challenge because the body of each person is unique," says Miled. To account for this, the smart shirt was designed so that it can "pick" which of its six sensors—distributed across the upper and lower torso, either to the right, left, or center—is most accurate for monitoring the breathing of the individual wearer. When first put on, the shirt completes a scan of its sensors to determine which one is best suited for the wearer given their unique breathing patterns.

Miled says several companies have expressed interest in this tech, but some additional steps are needed before commercialization.

"The next step that is ongoing now is to compare our results with other approaches...and with the help of doctors, try to extract some [breathing] profiles of some common disorders," says Miled, noting that the smart T-shirt is already able to detect sleep apnea. "We are also able to detect a significant change in breathing amplitude, [as well as] inspiration and expiration."

How Quantum Computers Can Make Batteries Better

Sanmesh Sunil Shinde - S.Y. Mech.



Hyundai is now partnering with startup IonQ to see how quantum computers can design advanced batteries for electric vehicles, with the aim of creating the largest battery-chemistry model yet to be run on a quantum computer, the companies announced yesterday.

A quantum computer with high enough complexity—for instance, enough components known as quantum bits or "qubits"—could theoretically achieve a quantum advantage where it can find the answers to problems no classical computer could ever solve. In theory, a quantum computer with 300 qubits fully devoted to computing could perform more calculations in an instant than there are atoms in the visible universe.

The nearest-term app for quantum computers may be chemistry—for instance, simulating molecules to see which ones might prove useful drugs. "Quantum computers are naturally suited for modeling molecular behavior because both are systems governed by quantum mechanics," says Peter Chapman, CEO and president of Maryland-based IonQ. Since quantum computers can model chemistry more accurately than classical computing, "it becomes possible to ensure that one is extracting maximum efficiency and eliminating sources of potential waste."

IonQ will join the classical and quantum computers in this work over the cloud. This includes IonQ's latest quantum computer, "which recently outperformed all other devices tested in a series of benchmarking tests run by industry consortium QED-C and which is currently in private beta," Chapman says.

Now IonQ aims to use quantum computing to analyze and simulate the structure and energy of lithium compounds for Hyundai's batteries, including lithium oxide in lithium-air batteries. "Lithium-air batteries have a higher energy density than lithium-sulfur batteries and thus have more potential power and capability," Chapman says.

In the new partnership, IonQ will develop new variational quantum eigensolver algorithms optimized for investigating lithium chemistry. These kinds of algorithms are often used in quantum chemistry to, for instance, model a molecule's ground state, the one in which it has the least amount of energy. Variational quantum eigensolvers are actually hybrid algorithms, where classical computers do much of the work while quantum processors solve the part of the problem that would prove difficult for conventional machines to handle.

Whereas Google, IBM, Amazon and others often use qubits based on superconducting loops, IonQ uses qubits based on electromagnetically trapped ions. Superconducting loops are compatible with conventional microchip technology, but trapped ions may offer advantages such as resistance to errors.

The partnership aims to create the most advanced battery chemistry model yet developed on quantum computers, measured by the number of qubits and quantum gates, the quantum computing version of the logic gates that conventional computers use to perform computations.

“The team plans to harness at least 12 qubits and over 100 gate operations for the project,” Chapman says. In comparison, a Daimler-IBM partnership using quantum computing to develop next-generation lithium-sulfur batteries used only four qubits, and no other commercial projects have published results yet, he notes.

Carmakers are increasingly looking into quantum computing “because it is naturally applied to a revolution taking place across the industry—the development of electric vehicles,” Chapman says. “There is enormous incentive to make a better, less expensive battery, and so it makes sense that forward-thinking companies like Hyundai are putting quantum in their tool kit.”

The companies noted this work aims to improve the cost, durability, capacity, safety, and charging behavior of lithium batteries, which are often the most expensive components of electric vehicles. “Electric vehicles are an important part of the global movement toward reducing our collective carbon footprint,” Chapman says. “It’s very meaningful to be partnering with Hyundai to advance science that will help make them more commonplace.”

Beyond chemical analysis for battery materials, quantum computing could also help explore fuel-cell technologies and material durability, Chapman notes. In addition, “quantum machine learning applications could be used to improve training time for autonomous vehicles and solve simple problems in predictive maintenance, warehousing, and more,” he says.

“Longer-term, more complex optimization problems such as multichannel logistics and routing are on automakers’ R&D slates,” Chapman adds. “For instance, Volkswagen has been exploring quantum computing in a variety of applications for several years, first looking at how best to optimize the routing of buses and vans in traffic using quantum hardware and quantum-inspired techniques. More recently, they’ve been looking at optimizing the distribution network of charging stations.”

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THE PARTS OF SPEECH

Every name is called a noun
As field and fountain, street and town,
In place of noun the pronoun stands
As he and she can clap their hands
The adjective describes a thing
As magic wand or bridal ring
The verb means action, something done
To read and write, to jump and run
How things are done the adverbs tell,
As quickly, slowly, badly, well
The preposition shows relation
As in the street or at the station
Conjunctions join, in many ways,
sentences, words, or phrase and phrase
The interjuection cries out "Hark !
I need an exclamation Mark !
Through poetry, we learn how each
Of these make up The Parts of Speech.

- Collected

Making Driverless Cars More Expressive

Swapnil Subhash Nikam - F. Y. Electrical

Judging whether it's safe to cross the often road involves a complex exchange of social cues between pedestrian and driver. But what if there's no one behind the wheel? As self-driving cars become more common, helping them communicate with human road users is crucial. Autonomous vehicle company Motional thinks making the vehicles more expressive could be the key.

When he's waiting at a cross walk, Paul Schmitt, chief engineer at Motional, engages in what he calls the "glance dance"—a rapid and almost subconscious assessment of where an oncoming driver is looking and whether they're aware of him. "With automated vehicles, half of that interaction no longer exists," he says. "So what cues are then available for the pedestrian to understand the vehicles' intentions?"

To answer that question, his team hired animation studio CHRLX to create a highly realistic virtual reality (VR) experience designed to test pedestrian reactions to a variety of different signaling schemes. Reporting their results in IEEE Robotics and Automation Letters, they showed that exaggerating the car's motions—by braking earlier or stopping well short of the pedestrian—was the most effective way to communicate its intentions.

The company is now in the process of integrating the most promising expressive behaviors into their motion planning systems, and they've also open sourced the VR environment so other groups can experiment. Getting these kinds of interactions right will be essential for building trust in self-driving cars, says Schmitt, as this is likely to be most people's first encounter with the technology.

Self-driving car behaviors included having the car brake earlier and harder than the baseline, stopping the car a vehicle's length away, adding exaggerated braking and low-revving sounds, and finally combining these sounds with an exaggerated dipping of the nose of the car as if it was braking hard.

"That motivates a lot of the work that we're doing, to ensure that those first interactions go well," he says. "We want to make sure that people feel comfortable with this new technology."

The study carried out by Motional saw 53 participants don a VR headset that transported them to the corner of a four way intersection in an urban area. Each participant faced 33 trials of a car approaching the intersection as they try to cross, with the vehicle exhibiting a variety of different behaviors and appearances. While they were able to look around, they could not move and instead had to indicate when they felt it was safe to cross by pressing a button on a handheld controller.

Three baseline scenarios mimicked the way a human driver would come to a halt at a stop sign, but one featured a human driver behind the wheel, another had no driver and conspicuous sensors dotted around the car, and the third featured a large LED display that indicates when the vehicle is yielding—an approach popular among makers of driverless cars.

They then designed various expressive behaviors designed to implicitly signal to the pedestrian that the car is stopping for them. These included having the car braking earlier and harder than the baseline, stopping the car a vehicle's length away, adding exaggerated braking and low-revving sounds, and finally combining these sounds with an exaggerated dipping of the nose of the car as if it was braking hard.

To keep the participants honest, they also included a control scenario where the car didn't stop, and Schmitt says their reactions were testimony to the realism of the simulation. "I literally had people in our VR lab on the third floor of this office building raise the middle finger at a virtual car that just cut them off," he says.

The team then measured how quickly participants decided to cross and also gave them a quick survey after each trial to find out how safe they felt, how confident they were of their decision to cross, and how clearly they understood a car's intention. Both early, hard braking and stopping short led to a considerably higher proportion of participants crossing the street before the vehicle had come to a complete stop. But in the surveys, stopping short elicited the highest ratings for sense of safety, decision confidence, and intention understanding.

The fact that stopping short elicited the best response isn't surprising, says Schmitt, as this approach was inspired by the way human drivers behave when slowing down for pedestrians. What was more surprising was that there was little difference in reactions between the baseline scenarios with and without a driver, which suggests pedestrians are paying more attention to the movement of the vehicle than to the driver behind the wheel, he adds.

That's backed up by other research, says Wilbert Tabone, a doctoral student at Delft University of Technology in the Netherlands who works on robot-human interaction. While most attempts to solve this problem have focused on displays that stand in for explicit cues like eye contact or hand gestures, he says studies keep showing that the implicit behavior of the car is what most people are looking out for.

Nonetheless, he thinks a combination of explicit and implicit signaling will ultimately be the most effective. One promising avenue is augmented reality, and he has developed a system that would allow driverless vehicles to communicate their intention directly to a pedestrian's smart glasses, which would then indicate visually whether or not its safe to cross. The downside, he admits, is that it first requires widespread adoption of smart glasses, which is no sure thing.

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QUANTUM DOTS + OLED = YOUR NEXT TV

Sakshi Shambhushete - F. Y. Aids

FOR MORE THAN a decade now, OLED (organic light-emitting diode) displays have set the bar for screen quality, albeit at a price. That's because they produce deep blacks, offer wide viewing angles, and have a broad color range. Meanwhile, QD (quantum dot) technologies have done a lot to improve the color purity and brightness of the more wallet-friendly LCD TVs.

In 2022, these two rival technologies will merge. The name of the resulting hybrid is still evolving, but QD-OLED seems to make sense, so I'll use it here, although Samsung has begun to call its version of the technology QD Display.

To understand why this combination is so appealing, you have to know the basic principles behind each of these approaches to displaying a moving image.

In an LCD TV, the LED backlight, or at least a big section of it, is on all at once. The picture is created by filtering this light at the many individual pixels. Unfortunately, that filtering process isn't perfect, and in areas that should appear black some light gets through.

In OLED displays, the red, green, and blue diodes that comprise each pixel emit light and are turned on only when they are needed. So black pixels appear truly black, while bright pixels can be run at full power, allowing unsurpassed levels of contrast.

But there's a drawback. The colored diodes in an OLED TV degrade over time, causing what's called "burn-in." And with these changes happening at different rates for the red, green, and blue diodes, the degradation affects the overall ability of a display to reproduce colors accurately as it ages and also causes "ghost" images to appear where static content is frequently displayed.

Adding QDs into the mix shifts this equation. Quantum dots—nanoparticles of semiconductor material—absorb photons and then use that energy to emit light of a different wavelength. In a QD-OLED display, all the diodes emit blue light. To get red and green, the appropriate diodes are covered with red or green QDs. The result is a paper-thin display with a broad range of colors that remain accurate over time. These screens also have excellent black levels, wide viewing angles, and improved power efficiency over both OLED and LCD displays.

Samsung is the driving force behind the technology, having sunk billions into retrofitting an LCD fab in Tangjeong, South Korea, for making QD-OLED displays While other companies have published articles and demonstrated similar approaches, only

Samsung has committed to manufacturing these displays, which makes sense because it holds all of the required technology in house. Having both the OLED fab and QD expertise under one roof gives Samsung a big leg up on other QD-display manufacturers.,

Samsung first announced QD-OLED plans in 2019, then pushed out the release date a few times. It now seems likely that we will see public demos in early 2022 followed by commercial products later in the year, once the company has geared up for high-volume production. At this point, Samsung can produce a maximum of 30,000 QD-OLED panels a month; these will be used in its own products. In the grand scheme of things, that's not that much.

Unfortunately, as with any new display technology, there are challenges associated with development and commercialization.

For one, patterning the quantum-dot layers and protecting them is complicated. Unlike QD-enabled LCD displays (commonly referred to as QLED) where red and green QDs are dispersed uniformly in a polymer film, QD-OLED requires the QD layers to be patterned and aligned with the OLEDs behind them. And that's tricky to do. Samsung is expected to employ inkjet printing, an approach that reduces the waste of QD material.

Another issue is the leakage of blue light through the red and green QD layers. Leakage of only a few percent would have a significant effect on the viewing experience, resulting in washed-out colors. If the red and green QD layers don't do a good job absorbing all of the blue light impinging on them, an additional blue-blocking layer would be required on top, adding to the cost and complexity.

Another challenge is that blue OLEDs degrade faster than red or green ones do. With all three colors relying on blue OLEDs in a QD-OLED design, this degradation isn't expected to cause as severe color shifts as with traditional OLED displays, but it does decrease brightness over the life of the display.

Today, OLED TVs are typically the most expensive option on retail shelves. And while the process for making QD-OLED simplifies the OLED layer somewhat (because you need only blue diodes), it does not make the display any less expensive. In fact, due to the large number of quantum dots used, the patterning steps, and the special filtering required, QD-OLED displays are likely to be more expensive than traditional OLED ones—and way more expensive than LCD TVs with quantum-dot color purification. Early adopters may pay about US $5,000 for the first QD-OLED displays when they begin selling later this year. Those buyers will no doubt complain about the prices—while enjoying a viewing experience far better than anything they've had before.

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12 Indian-origin CEOs leading top companies across the world

Riddhi Patil - F. Y. C. S. E.

Time and again, India has proved itself to be the progenitor of some of the most brilliant minds across the globe. From tech geeks making their name heard across the silicon valley to tycoons who head some of the most successful conglomerates, India and Indian blood has gone on to lead some of the most successful businesses and companies across the world.

1. Sundar Pichai, Google

Sundar Pichai's name shines in a class of its own every time there is mention of Indian-origin CEOs leading global companies.

An IIT Kharagpur graduate, he rose to the position of the CEO of Google in 2015 and was eventually appointed the CEO of Alphabet Inc, the parent company of Google, in December 2019.

2. Satya Nadella, Microsoft

Another big name of the Silicon Valley, Satya Nadella, completed his undergraduation from Manipal University of Technology, and went on to study at University of Wisconsin-Milwaukee and University of Chicago.

Satya Nadella was added to the list of influential Indian-origin CEOs when he became the Executive Chairman and CEO of Microsoft in 2014.

3. Parag Agrawal, Twitter

One of the latest additions to the list, Parag Agrawal, is an IIT Bombay graduate and went to study at Stanford University.

Parag Agrawal was appointed as the Twitter CEO in November this year when its founder Jack Dorsey stepped down from the position.

4. **Leena Nair, Chanel**

· Leena Nair is another of the latest Indian-origin CEOs to have made her mark felt when she was appointed as the first woman and youngest CEO of Chanel this year in December.

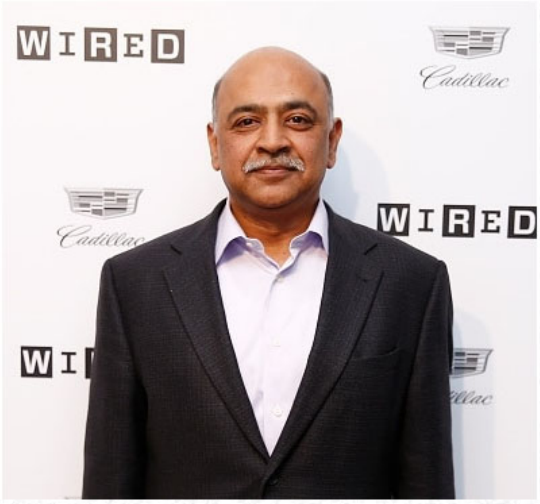
· An alumnus of the XLRI- Xavier School of Management and Walchand College of Engineering, Leena Nair was previously the Chief Human Resource Officer of Unilever.

5. **Shantanu Narayen, Adobe Inc**

· Born in Hyderabad, Shantanu Narayen studied at Osmania University, after which he went to Bowling Green State University and University of California.

· Shantanu Narayen served as Adobe Inc.'s President and Chief Operating Officer, after which he was appointed as the CEO in December 2007.

6. **Arvind Krishna, IBM**



· An alumnus of IIT Kanpur, Arvind Krishna studied further at University of Illinois Urbana-Champaign.

· He was appointed as the CEO of IBM in April 2020, while he was further appointed as the Chairman in January 2021.

7. **Sanjay Mehrotra, Micron Technology**

If you think your teacher is tough, wait till you get a boss.

· Born in Kanpur, Sanjay Mehrotra is a BITS Pilani alumnus and completed his higher education from UC Berkeley.

· Sanjay Mehrotra took over as the Micron Technologies CEO in 2017.

· He was also the co-founder of Sandisk and served as its CEO in 2016.

8. Nikesh Arora, Palo Alto Networks

- An alumnus of the Indian Institute of Technology, BHU, Nikesh Arora pursued further education from Boston College and Northeastern University.
- Nikesh Arora was appointed as the CEO and Chairman of Palo Alto Networks on June 2018.

9. Jayshree Ullal, Arista Networks

- London-born and India-raised JayshreeUllal shares her alma matter with Santa Clara University and San Francisco State University.
- She is the CEO & President of Arista Networks and has been serving in the position since October 2008.

10. AmrapaliGan, Only Fans

- Born in Mumbai, AmrapaliGan is an alumnus of California State University.
- She was appointed as the CEO of Only Fans in December 2021 and succeeded founder Tim Stokely to the position.

11. Ajaypal Singh Banga, Mastercard

- Ajaypal Singh Banga is a St. Stephen's College and Indian Institute of Management alumnus.
- He currently serves as the Executive Chairman of Mastercard and has served as the Chief Executive Officer (CEO) of the company from July 2010 until December 31, 2020.

12. IndraNooyi, Pepsico

- Born in Chennai, IndraNooyi is an alumnus of the University of Madras, the Indian Institute of Management, and Yale University.
- IndraNooyi became the fifth CEO of Pepsico in 2006 and continued to serve in the position till August 2018, when she stepped down as the CEO.

for a long period of time.

Scientists believe nuclear fusion could help humans maximise clean energy production. But the development of such tech is extremely difficult - even after decades of research, nuclear fusion reactors can only generate energy in lab settings.

By copying the physics of giant stars like our sun, nuclear fusion reactors merge atomic nuclei to create energy in massive amounts, which may then be turned into electricity. Essentially - the end to all our energy woes!

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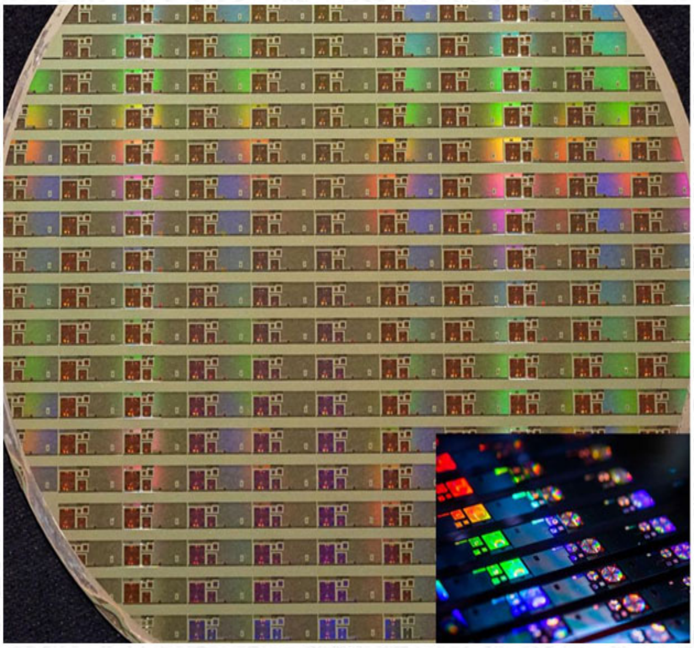
Life

Life, believe, is not a dream
So dark as sages say;
Oft a little morning rain
Foretells a pleasant day.
Sometimes there are clouds of gloom,
But these are transient all;
If the shower will make the roses bloom,
O why lament its fall?
Rapidly, merrily,
Life's sunny hours flit by,
Gratefully, cheerily
Enjoy them as they fly!
What though Death at times steps in,
And calls our Best away?
What though sorrow seems to win,
O'er hope, a heavy sway?
Yet Hope again elastic springs,
Unconquered, though she fell;
Still buoyant are her golden wings,
Still strong to bear us well.
Manfully, fearlessly,
The day of trial bear,
For gloriously, victoriously,
Can courage quell despair!

Sameena S. Makhmalla - S.Y. Electrical

For Better AR Cameras, Swap Plastic Lenses for Silicon Chips

Samir Nuramahmad Momin- S. Y. Mech.



Startup Metalenz announced that it has created a silicon chip that, paired with an image sensor, can distinguish objects by the way they polarize light. The company says its "PolarEyes" will be able to make facial authentication less vulnerable to spoofing, improve 3D imaging for augmented and virtual reality, aid in telehealth by distinguishing different types of skin cells, and enhance driving safety by spotting black ice and other hard-to-see road hazards.

The company, founded in 2017 and exiting stealth a year ago, previously announced that it was commercializing waveguides composed of silicon nanostructures as an alternative to traditional optics for use in mobile devices.

Metalenz recently began a partnership with ST Microelectronics to move its technology into mass production and expects to be shipping imaging packages sometime in the second quarter of this year, according to CEO Robert Devlin.

IEEE Spectrum spoke with Devlin last week to find more about the company's technology and what it will be able to do when it gets into consumer hands.

Before we talk about your new polarization optics, briefly help us understand how your basic technology works.

Robert Devlin: We use standard semiconductor lithography on 12-inch wafers to create nanostructures in the form of little pillars. These structures are smaller than the wavelength of light, so by changing the radius of the pillars, we can use them to control the length of the optical path of the light passing through. For the first generation of this technology, we are working with near-infrared wavelengths, which transmits through silicon, rather than reflecting as visible light would do.

What's the advantage of using nanostructures over traditional lenses?

Devlin: Our technology is flat, for one. When you are using a curved lens to put an image on a flat sensor, you have to make all sorts of corrections using multiple lenses and finely controlling the spacing between the lenses to make it work; we don't have to do that. We also can bring the functions of multiple traditional lenses onto one chip . And we can manufacture these lenses in the same semiconductor foundries as the image sensors and electronics used in camera modules.

The iPhone face ID system, for example, has three lenses: one diffractive lens, for splitting infrared light being projected onto your face into a grid of dots, and two refractive, for collimating the lasers to project onto the face. Some of these modules have an optical path that's folded by mirrors, because otherwise they would be too thick to fit into compact spaces required for consumer devices. With the single-chip flat optics, we can shrink the overall thickness, and don't need folded optical paths or mirrors in even the most space-constrained applications.

3D mapping is another infrared imaging application that uses multiple lenses today. Augmented reality systems need to create a 3D map of the world around them in real time, in order to know where to place the virtual objects. Today, these use a time-of-flight system—again, working in the infrared part of the spectrum—which sends out pulses of light and times how long they take to get back to the image sensor. This system requires several refractive lenses to focus the outgoing light and a diffractive lens to multiply the light to a grid of points. They also require multiple lenses on the imaging side to collect the light from the scene. Some of the lenses are needed to correct for the curvature of the lenses themselves, some are needed to make sure the image is crisp across the entire field of view. Using nanostructures, we can put all of these functions onto one chip.

So that's what the chips you announced do?

Devlin: Yes, and the first product to use our technology, shipping in the second quarter of this year, will be a module for use in 3D imaging.

Initially for mobile phones?

Devlin: For consumer devices generally but also for mobile phones.

What about AR?

Devlin: Of course, everyone is eagerly waiting for AR glasses, and the form factor remains a problem. I think what we are doing—simplifying the optics—will help solve the form-factor problem. People get suspicious if they see a big camera sitting on someone's face. Ours can be very small, and, for this application, infrared imaging is appropriate. It allows the system to understand the world around it in order to meld the virtual world with it. And it isn't affected by changes in lighting conditions.

Devlin: When we spoke a year ago, I talked about Metalenz wanting to not just simplify existing mobile-camera modules, but to take imaging systems that have been locked away in scientific laboratories because they are too expensive, complex, or big, and combine their optics into a single layer that would be small enough and cheap enough for consumer devices.

One of those imaging systems involves the polarization of light. Polarization is used in industrial and medical labs; it can be used to see where cancerous cells start and end, it can in many cases tell what material something is made of. In industry, it can be used to detect features of black objects, the shape of transparent objects, or even scratches on transparent objects. Today, complete polarization cameras measure around 100 by 80 by 80 millimeters, with optics that can cost hundreds of dollars.

Using metasurface technology, we can bring the size down to 3 by 6 by 10 mm and the price down to [US] $2 to $3. And unlike many typical systems today, which take multiple views at different polarizations sequentially and use them to build up an image, we can use one of our chips to take those multiple views simultaneously, in real time. We take four views—that turns out to be the number we need to combine into a normal image or to create a full map of the scene color-coded to indicate the complete polarization at each pixel.

Besides the medical and industrial uses you mentioned, why else are polarized images useful?

Devlin: When you get these into mobile devices, we will likely find all sorts of applications we haven't thought of yet, and that's really exciting. But we do have an initial application that we think will help get the technology adopted—that's in facial recognition. Today's facial recognition systems are foiled by masks. That's not because they couldn't get enough information from above the mask to recognize the user. They use a high-res 2D image that provides enough data to the algorithms to do that. But they also use a 3D imaging system that is very low resolution. It's meant to make sure that you're not trying to spoof the system with a mask or photograph, and that's what makes facial recognition fail when you are wearing a mask. A polarization imaging module could easily distinguish between skin and mask and solve that problem.

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Medal of Honor Goes to Microsensor and Systems Pioneer

Shoukat Mainuddin Shaikh - S.Y. Electrical

IEEE Life Fellow Asad M. Madni is the recipient of this year's IEEE Medal of Honor. He is being recognized "for pioneering contributions to the development and commercialization of innovative sensing and systems technologies, and for distinguished research leadership."

The IEEE Foundation sponsors the award.

Madni has been a distinguished adjunct professor of electrical and computer engineering and distinguished scientist since 2011 at the Samueli School of Engineering at the University of California, Los Angeles. He is also a faculty Fellow at the UCLA Institute of Transportation Studies and the university's Connected Autonomous Electric Vehicle consortium.

Before starting his career in academia, Madni served as chairman, president, and chief executive of Systron Donner and president, chief operating officer, and chief technology officer of BEI.

Madni led the development and commercialization of intelligent microsensors and systems for the aerospace, defense, industrial, and transportation industries. The GyroChip technology he helped develop at BEI revolutionized navigation and stability in aerospace and automotive systems, making them safer.

While at BEI, he also led the development of an extremely slow motion servo control system for NASA's Hubble Space Telescope's star selector. The system, which is still used today, provides the telescope with unprecedented pointing accuracy and stability, allowing astronomers to make new discoveries and learn more about the universe's history.

"Dr. Madni has outstanding accomplishments in both managing research and development, and in personally inventing and innovating technologies at the cutting edge of his field," says one engineer who endorsed Madni for the award. "I know of no one else more deserving of the IEEE Medal of Honor."

SMART SENSORS

Under Madni's leadership, BEI's quartz rate sensor technology, later known as the GyroChip, was developed in the early 1990s. The technology is the first microelectromechanical system (MEMS)-based gyroscope and inertial measurement unit for aerospace and automotive safety applications, according to an entry about Madni on the Engineering and Technology History Wiki. It is smaller and more cost-efficient and reliable than prior technologies.

The GyroChip is used worldwide in more than 90 types of aircraft, including the stability control systems of the Boeing 777; the yaw damper for the Boeing 737; and in most business jets as a sensing element in attitude control and reference programs. It also is used for guidance, navigation, and control in major U.S. missiles, underwater autonomous vehicles, and helicopters, as well as NASA's Mars rover Sojourner and AERCam Sprint autonomous robotic camera. The GyroChip is also employed in the U.S. Civil Air Patrol's

Airborne Real-time Cueing Hyperspectral Enhanced Reconnaissance system, which is deployed in search-and-rescue missions.

After the aerospace and defense markets began to decline following the end of the Cold War, Madni led the defense conversion of the GyroChip technology from the aerospace and defense sectors to the automotive and commercial aviation markets. The GyroChip became the foundation of vehicle dynamic control, which monitors a driver's actions including braking and steering to combat the loss of steering control that can occur in unsafe driving conditions. The GyroChip is used in more than 80 models of passenger cars worldwide for electronic stability control and rollover protection.

The GyroChip and numerous other sensing, actuation, and signal-processing techniques developed by Madni laid the foundation for autonomous vehicles. The technologies and techniques are used for features such as lane-change assist, autonomous cruise control, steering and wheel-speed detection, navigation, and drowsy- and drunken-driver detection.

While at Systron Donner, Madni led the development of RF and microwave systems and instrumentation—which significantly enhanced the combat readiness of the U.S. Navy and its allies. The technologies provided the U.S. Department of Defense with the ability to simulate more threats for warfare training that are representative of ECM environments.

His current research focuses on the development of wideband instruments with ultrahigh data throughput to detect one-time rare events and cancer cells in the bloodstream, as well as a single-shot network analyzer for fast characterization of electronic and optoelectronic devices.

Madni also is leading research in the areas of computational sensing; wearable sensors; artificial intelligence and machine learning; and demand-and-response techniques for the smart grid and electric vehicles.

He is a member of the U.S. National Academy of Engineering and a Fellow of the U.S. National Academy of Inventors, the Royal Academy of Engineering, and the Canadian Academy of Engineering.

Madni, an eminent member of the IEEE Eta Kappa Nu honor society, has received numerous other awards over the years. They include the 2020 American Society of Mechanical Engineers Soichiro Honda Medal; the 2019 IEEE Frederik Philips Award; a 2016 Ellis Island Medal of Honor; the 2012 IEEE Aerospace and Electronic Systems Society's Pioneer Award; the 2015 Institution of Engineering and Technology J.J. Thomson Medal; the 2010 IEEE Instrumentation and Measurement Society's Career Excellence Award; and an IEEE Millennium Medal.

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Dust

Someone spoke to me last night,
told me the truth. Just a few words,
but I recognized it.
I knew I should make myself get up,
write it down, but it was late,
and I was exhausted from working
all day in the garden, moving rocks.
Now, I remember only the flavor —
not like food, sweet or sharp.
More like a fine powder, like dust.
And I wasn'ÿþt elated or frightened,
but simply rapt, aware.
That'ÿþs how it is sometimes —
God comes to your window,
all bright light and black wings,
and you are just too tired to open it.

Kirankumar G. Chandanshive
F. Y. Elect.

Physicists Spin Up Quantum Tornadoes

Pankaj Dipak Arage - S. Y. Electrical

Shrink down to the level of atoms and you enter the quantum world, so supremely weird that even a physicist will sometimes gape. Hook that little world to our big, classical one, and a cat can be both alive and dead (sort of).

"If you think you understand quantum mechanics, you don't understand quantum mechanics," said the great Richard Feynman, four decades ago. And he knew what he was talking about (sort of).

Now comes a report on a quantum gas, called a Bose-Einstein condensate, which scientists at the Massachusetts Institute of Technology first stretched into a skinny rod, then rotated until it broke up. The result was a series of daughter vortices, each one a mini-me of the mother form.

The research, published in Nature, was conducted by a team of scientists affiliated with the MIT-Harvard Center for Ultracold Atoms and MIT's Research Laboratory of Electronics.

The rotating quantum clouds, effectively quantum tornadoes, recall phenomena seen in the large-scale, classical world that we are familiar with. One example would be so-called Kelvin-Helmholtz clouds, which look like periodically repeating, serrated cartoon images of waves on the ocean.

The way to make quantum cloud vortices, though, involves more lab equipment and less atmospheric wind shear. "We start with a Bose-Einstein condensate, 1 million sodium atoms that share one and the same quantum-mechanical wave function,"..., says Martin Zwierlein, a professor of physics at MIT.

The same mechanism that confines the gas—an atom trap, made up of laser beams—allows the researchers to squeeze it and then spin it like a propeller. "We know what direction we're pushing, and we see the gas getting longer," he says. "The same thing would happen to a drop of water if I were to spin it up in the same way—the drop would elongate while spinning."

What they actually see is effectively the shadow cast by the sodium atoms as they fluoresce when illuminated by laser light, a technique known as absorption imaging. Successive frames in a movie can be captured by a well-placed CCD camera.

At a particular rotation rate, the gas breaks up into little clouds. "It develops these funny undulations—we call it flaky, then becomes even more extreme. We see how this gas 'crystalizes' in a chain of droplets—in the last image there are eight droplets."

Why settle for a one-dimensional crystal when you can go for two? And in fact the researchers say they have done just that, in as yet unpublished research.

That a rotating quantum gas would break into blobs had been predicted by theory—that is, one could infer that this would happen from earlier theoretical work. "We in the lab didn't expect this—I was not aware of the paper; we just found it," Zwierlein says. "It took us a while to figure it out."

The crystalline form appears clearly in a magnified part of one of the images. Two connections, or bridges, can be seen in the quantum fluid, and instead of the single big hole you'd see in water, the quantum fluid has a whole train of quantized vortices. In a magnified part of the image, the MIT researchers found a number of these little holelike patterns, chained together in regularly repeating fashion.

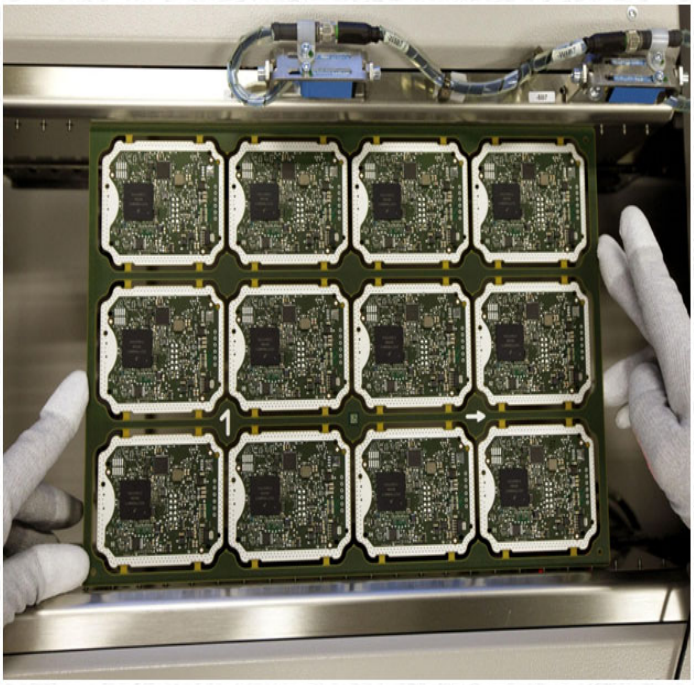
"It's similar in what happens when clouds pass each other in the sky," he says. "An originally homogeneous cloud starts forming successive fingers in the Kelvin-Helmholtz pattern."

Very pretty, you say, but surely there can be no practical application. Of course there can; the universe is quantum. The research at MIT is funded by DARPA—the Defense Research Advanced Project Agency—which hopes to use a ring of quantum tornadoes as fabulously sensitive rotation sensors.

Today if you're a submarine lying under the sea, incommunicado, you might want to use a fiber optic

Why IoT Sensors Need Standards

Prathmesh Uttam Jadhav - S.Y. Mech.



Sensors traditionally have been used for camera imaging, as well as communicating information about humidity, temperature, motion, speed, proximity, and other aspects of the environment. The devices have become key enablers for a host of new technologies essential to business and to everyday life, from turning on a light switch to managing one's health.

Several factors are fueling sensors' growth, including miniaturization, increased functionality, and higher levels of integration into electronic circuitry. There are also greater levels of automation being incorporated into products and systems, such as with Internet of Things and Industrial Internet of Things applications.

Prominent users of sensors include the defense, energy, health care, and transportation industries. The global sensor market is large and growing fast. By one estimate, it is projected to reach US $346 billion in sales by 2028, up from $167 billion in 2019.

SAFE AND RELIABLE APPLICATIONS

As the sensor industry races to take advantage of market opportunities, the need to ensure the devices will operate safely and reliably is a growing concern.

In the energy industry, for example, drill rigs for oil and gas exploration are now equipped with sensors to achieve optimal, safe performance at the lowest cost possible. The sensors must operate under harsh environmental conditions. Their failure could result in a rig being taken out of service, leading to significant, costly downtime.

In industrial applications, worker safety would be compromised if gas sensors fail to detect the presence of toxic fumes. If the light detection and ranging remote-sensing system lidar fails in semiautonomous vehicles, they will be unable to function properly. Lidar is fundamental to advanced driver-assistance systems (ADAS).

Because there are now thousands of sensor products on the market, adherence to standards that could improve their performance or accelerate development of new applications has grown in importance, as has the need for independent conformity and certification protocols.

It has become challenging to effectively deploy sensors in complex IoT and IIoT applications given the interoperability issues that can arise when attempting to integrate systems from multiple vendors. Hardware compatibility, wired and wireless connectivity, security, software development, and cloud computing are key interoperability considerations as well as major issues in their own right.

STANDARDS FOR IOT SENSORS

For many years, the IEEE Standards Association (IEEE SA) has provided an open platform for users, those in academia, and technical experts from sensor manufacturers to come together to develop standards. Here are a few examples of IEEE standards and projects that have come from the collaboration.

IEEE 2700-2017: IEEE Standard for Sensor Performance Parameter Definitions. A common framework for performance specification terminology, units, conditions, and limits for eight common sensor types.

IEEE P1451.99: IEEE Standard for Harmonization of Internet of Things Devices and Systems. Current implementations of IoT devices and systems do not provide a way to share data or for an owner of such devices to authorize who has the right to control them or access the devices' data. This standard will define a metadata bridge to facilitate IoT protocol transport for sensors, actuators, and other devices. It will address issues of security, scalability, and interoperability for cost savings and reduced complexity. The standard will offer a data-sharing approach that leverages current instrumentation and devices used in industry.

IEEE P2020: Standard for Automotive System Image Quality. Most automotive camera systems have been developed independently, with no standardized reference point for calibration or measurement of image quality. This standard will address the fundamental attributes that contribute to image quality for ADAS applications; identify existing metrics and other useful information relating to the attributes; define a standardized suite of objective and subjective test methods; and specify tools and test methods to facilitate standards-based communication and comparison among system integrators and component vendors.

IEEE P2520: Standard for Testing Machine Olfaction Devices and Systems. This standard aims to establish a collection of performance measurement methods and conformity assessment processes for e-nose devices that simulate human chemosensory responses with greater accuracy and precision.

IEEE P2846: Assumptions for Models in Safety-Related Automated Vehicle Behavior. This standard will describe the minimum set of reasonable assumptions used in the development of safety-related models that are part of automotive ADAS. P2846 will consider rules of the road and their regional and temporal dependencies, which involve the impact of previous behavior.

A Dream Within a Dream

Take this kiss upon the brow!
And, in parting from you now,
Thus much let me avow —
You are not wrong, who deem
That my days have been a dream;
Yet if hope has flown away
In a night, or in a day,
In a vision, or in none,
Is it therefore the less gone?
All that we see or seem
Is but a dream within a dream.

I stand amid the roar
Of a surf-tormented shore,
And I hold within my hand
Grains of the golden sand —
How few! yet how they creep
Through my fingers to the deep,
While I weep — while I weep!
O God! Can I not grasp
Them with a tighter clasp?
O God! can I not save
One from the pitiless wave?
Is all that we see or seem
But a dream within a dream?

Namrata Patil - S. Y. Mechtronics

THE ROLE OF EDUCATED WOMAN IN INDIAN SOCIETY

- Collected

Man and Woman are integral parts of human civilization. In fact, their lives are inseparatble from each other. However, since ages women have been looked upon as the inferior of the races. This has resulted in the restriction of the women only to certain fields of life. Male chauvinism made the woman restrict herself give birth and home for a long time. Exploitation of women became a common tradition in the society, whereby customs like child marriage and sati came into existence. This made the women race more vulnerable and helpless as most of the lat was uneducated and bent down by ignorance, economic dependence and lack of courage to fight with the society for their rights.

However, if we peep into the glorious history of India, we will realise that this was not the condition of the women int he ancient times. During the earlier history and even earlier in the vedic period women enjoyed respectful status in the society. They were not only educated but they were also considered as equals and without whom mankind would be incomplete. So, we can understand that the above picture was only the later state of the society, whereby women became weaker of the races. In fact, this inequality of races is only of very recent origin in the country.

This kept the woman away from the developmental process for sometime, as also she lost her zeal todo anything other than homely tasks for her own empowerment. However, we have again seen a drustic change in the status of the woman. She has become aware about her status as also her right to an independent existence. She now knows that she is no more a man's slave or merely a thing of entertainment for him. With the efforts of many social reformers like Raja Rammohan Roy, Mahatma Jyotiba Phule, Savitribai Phule and the participation of the women force in the reofrms activity, lot of improvements were brought about inthe deteriorated position of the women.

As a result of the feminist movement, women began to get education, evil systems, against their independence existence got abolished and they acquired the right to expand their field of work beyond the hearth and home. Today, women are considered to be capable of all sorts of odd jobs that were for many years. Considered ony to be men's area of working. In India, too, women are playing their part to improve their positions. We have shining examples of women like Lata Mangeshkar, Sunita Williams, Sania Mirza, Bedi and many more such women who have carved a niche for themselves in their area of work.

In the Indian villages still there are many such practices are observed that suppress the women's right of equality. It is said that if a 'man is educated ony one person is educated, but if a woman is educated an entire family is educated'. It is important that this awareness is spread among the people of the entire country, so that the ignorance towards women's education reduces to a great extent.

The feminist movement has gained a good momentum and it won't be long when both the sexes will enjoy equal rights very soon. Dominating the otehr sex does not imply equality of rights or liberation. It implies that both the sexes work in tundem with each other and lead the human race onthe path of progress. With new realization and awareness spreading rapidly among the Indian society, very soon the country will see the dawn that will have men and women walking together on the path of success.

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The Graduate Leaving College

What summons do I hear?
The morning peal, departure's knell;
My eyes let fall a friendly tear,
And bid this place farewell.
Attending servants come,
The carriage wheels like thunders roar,
To bear the pensive seniors home,
Here to be seen no more.
Pass one more transient night,
The morning sweeps the college clean;
The graduate takes his last long flight,
No more in college seen.
The bee, which courts the flower,
Must with some pain itself employ,
And then fly, at the day's last hour,
Home to its hive with joy.
To Those of You Alive in the Future
who somehow have found a sip of water,
on this day in the past four syndicated
series involving communication with the dead
were televised and in this way we resembled
our own ghosts in a world made brief with flowers.
To you, our agonies and tizzies
must appear quaint as the stiff shoulders
of someone carrying buckets from a well
or the stung beekeeper gathering honey.
Why did we bother hurrying from A to B
when we'd get no further than D, if that?
On Monday, it sleeted in Pennsylvania
while someone's mother was scoured further
from her own mind. A son-in-law smoked
in the parking lot, exhaling white curses
torn apart by the large invisible indifference.
The general anesthetic wore off
and someone else opened her eyes to the results.
In this way our world was broken and glued.
But why did we bother shooing away the flies?
Did we think we could work our way
inside a diamond if we ground more pigment
into the paper's tooth, tried to hold fire
on our tongues, sucked at the
sugars of each other?
Many the engagement rings in the pawnshop.
Many the empties piled at the curbs.
A couple paused on a bridge to watch
chunks of ice tugged by bickering currents.
One who slept late reached out
for one who wasn't there. Breads, heavy
and sweet, were pulled from wide infernos
of stone ovens. My name was Dean Young,
I wrote it on a leaf. Sometimes
I could still manage to get lost,
there was no guidance system wired inside me yet.
Laughter might have come from a window
lit far into the night,
others were dark and always silent.

Prajkta P. Ghorpade - S. Y. Electrical

BOOKS AND MAN

- Collected

Happy is the man who acquires the habit of reading while young. He secures for himself a life long source of pleasure instruction and inspiration. He has understood that books are best friends of man and that they will never let you feel lonely. He has a pleasant occupation for himself in the leisure hours. He is possession of wealth more precious than gold. Ruskin called books,"Kings Treasures" - treasures filled not with gold and silver and precious stones, but with riches much more valuable than these knowledge, noble thoughts and high ideals. Poor is the man indeed who refrains himself from reading and keeps his life empty.

The blessings which the reading habit confers upon its possessor are many provided the reader chooses the right kind of books for his reading. Reading should give a very high kind of pleasure what so ever. Some books are read in order to derive simple pleasure and amusement out of them. Novels are the best examples of such type of reading. Such novels and fiction works have a special place in everyone's life at a specific point of time. When one is exhausted and the brain becomes weary with a log of work, it is a good healthy recreation to engross ourselves insome nicely plotted story written by a master storeteller.

But reading of fiction alone seems like eating only sweets and pastries or watching brainless serials on the T.V. Just as our body needs a wholesome and nutritious diet, our mind also requires some serious and healthy reading. This reading can vary according to each person's taste and interest. We can choose from an entire gamut of topics to select a book of our liking. History, geography, science, philosophy, religion, travel biography etc. All have a noble choice of boks for a varacious reader. These books should give us not only the required pleasure but also the knowledge that we are looking forward to acquire. These books should give us something for more than the works of fiction. Due importance should be given to the other part of literature which is the poetry. Poetry gives us noble thoughts beautiful imaginations elothed in lovely musical language.

Books are the most beautiful friends of man. Our friends may change, some may leave us and some may pass, but books are ones who will patiently wait toalk to us, to interact with us. They are never angry with us, never peevisb or unwilling to talk to us liek some of our friends. No wonder a good reader becomes a 'Book-lover".

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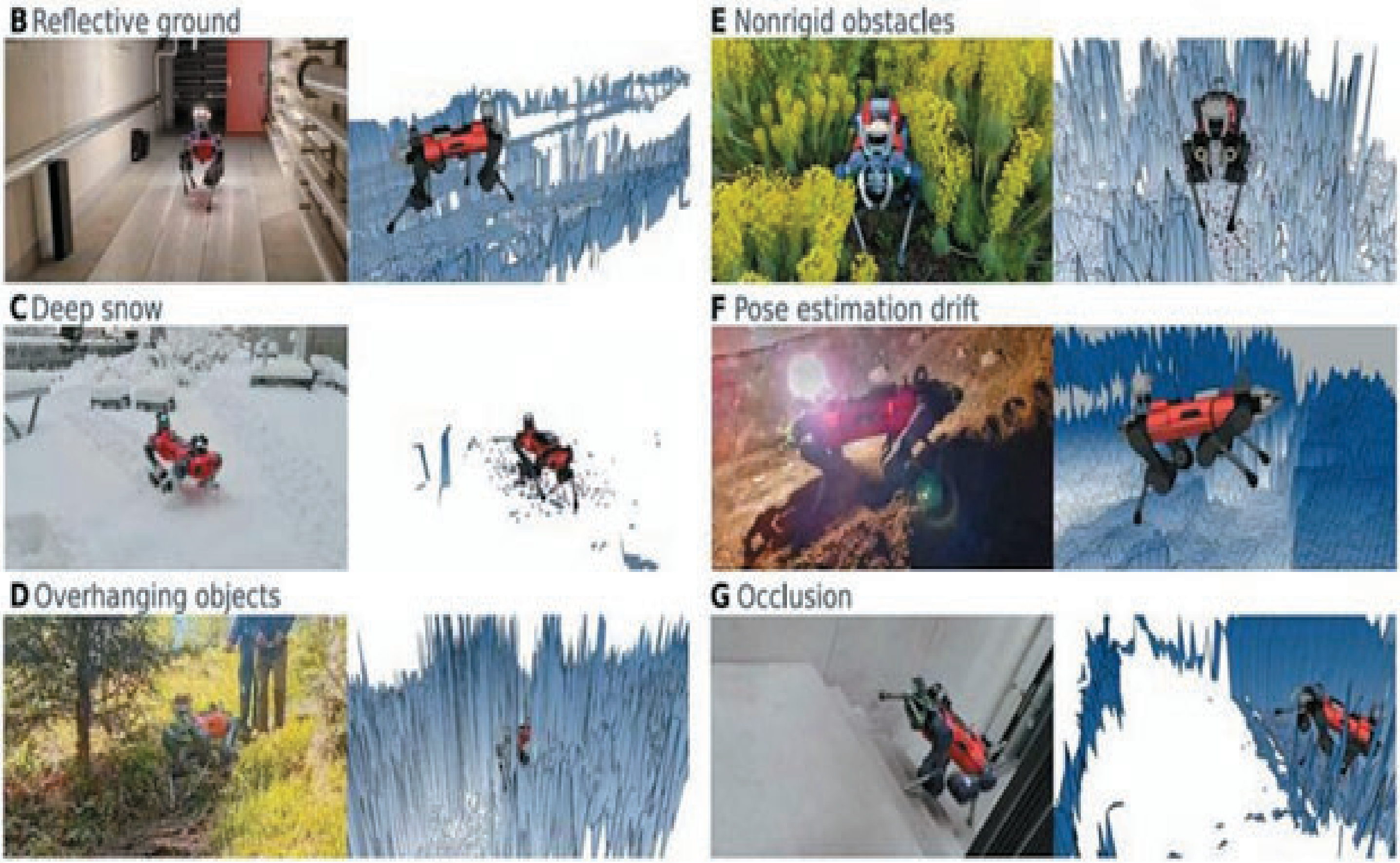
IMPORTANT PROVERBS

1) *Well begun is half done.*
2) *Walls have ears.*
3) *United we stand, divided we fall.*
4) *To err is human.*
5) *Lost time is never found.*
6) *Live not to eat, but eat to live.*
7) *A little learning is dangerous thing.*
8) *Time and tide wait for no man.*
9) *The pen is mightier than the*

- Collected

Legged Robots

Samiulla Patel - F. Y. Automation & Robotics



Robots, like humans, generally use two different sensory modalities when interacting with the world. There's exteroceptive perception (or exteroception), which comes from external sensing systems like lidar, cameras, and eyeballs. And then there's proprioceptive perception (or proprioception), which is internal sensing, involving things like touch, and force sensing. Generally, we humans use both of these sensing modalities at once to move around, with exteroception helping us plan ahead and proprioception kicking in when things get tricky. You use proprioception in the dark, for example, where movement is still totally possible—you just do it slowly and carefully, relying on balance and feeling your way around.

For legged robots, exteroception is what enables them to do all the cool stuff—with really good external sensing and the time (and compute) to do some awesome motion planning, robots can move dynamically and fast. Legged robots are much less comfortable in the dark, however, or really under any circumstances where the exteroception they need either doesn't come through (because a sensor is not functional for whatever reason) or just totally sucks because of robot-unfriendly things like reflective surfaces or thick undergrowth or whatever. This is a problem because the real world is frustratingly full of robot-unfriendly things.

The research that the Robotic Systems Lab at ETH Zürich has published in Science Robotics showcases a control system that allows a legged robot to evaluate how reliable the exteroceptive information that it's getting is. When the data are good, the robot plans ahead and moves quickly. But when the data set seems to be incomplete, noisy, or misleading, the controller gracefully degrades to proprioceptive locomotion instead. This means that the robot keeps moving—may be more slowly and carefully, but it keeps moving—and eventually, it'll get to the point where it can rely on exteroceptive sensing again. It's a technique that humans and animals use, and now robots can use it too, combining speed and efficiency with safety and reliability to handle almost any kind of challenging terrain.

We got a compelling preview of this technique during the DARPA SubT Final Event last fall, when it was being used by Team CERBERUS's ANYmal legged robots to help them achieve victory. I'm honestly not sure whether the SubT final course was more or less challenging than some mountain climbing in Switzerland, but the performance in the video below is quite impressive, especially since ANYmal managed to complete the uphill portion of the hike 4 minutes faster than the suggested time for an average human.

Those clips of ANYmal walking through dense vegetation and deep snow do a great job of illustrating how well the system functions. While the exteroceptive data is showing obstacles all over the place and wildly inaccurate ground height, the robot knows where its feet are, and relies on that proprioceptive data to keep walking forward safely and without falling. Here are some other examples showing common problems with sensor data that ANYmal is able to power through:

Other legged robots do use proprioception for reliable locomotion, but what's unique here is this seamless combination of speed and robustness, with the controller moving between exteroception and proprioception based on how confident it is about what it's seeing. And ANYmal's performance on this hike, as well as during the SubT Final, is ample evidence of how well this approach works.

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LIFE

Life is dream
Search of the destination
Full of bright prospect
with hard labour and sea\
Life is sea
Of made waves,
difficult to pass
but struggle lot
To see the coast
Life is a flower
smiling today
But dying tomorrow
Perfume left to smell
Life is golden gift
Given by the God
Worship the work
to shine like star.

- Collected

NASA'S NEW SHORTCUT TO FUSION POWER

Virendra Band - S. Y. Mechatronics

PHYSICISTS FIRST SUSPECTED more than a century ago that the fusing of hydrogen into helium powers the sun. It took researchers many years to unravel the secrets by which lighter elements are smashed together into heavier ones inside stars, releasing energy in the process. And scientists and engineers have continued to study the sun's fusion process in hopes of one day using nuclear fusion to generate heat or electricity. But the prospect of meeting our energy needs this way remains elusive.

The extraction of energy from nuclear fission, by contrast, happened relatively quickly. Fission in uranium was discovered in 1938, in Germany, and it was only four years until the first nuclear "pile" was constructed in Chicago, in 1942.

There are currently about 440 fission reactors operating worldwide, which together can generate about 400 gigawatts of power with zero carbon emissions. Yet these fission plants, for all their value, have considerable downsides. The enriched uranium fuel they use must be kept secure. Devastating accidents, like the one at Fukushima in Japan, can leave areas uninhabitable. Fission waste by-products need to be disposed of safely, and they remain radioactive for thousands of years. Consequently, governments, universities, and companies have long looked to fusion to remedy these ills.

Among those interested parties is NASA. The space agency has significant energy needs for deep-space travel, including probes and crewed missions to the moon and Mars. For more than 60 years, photovoltaic cells, fuel cells, or radioisotope thermoelectric generators (RTGs) have provided power to spacecraft. RTGs, which rely on the heat produced when nonfissile plutonium-238 decays, have demonstrated excellent longevity—both Voyager probes use such generators and remain operational nearly 45 years after their launch, for example. But these generators convert heat to electricity at roughly 7.5 percent efficiency. And modern spacecraft need more power than an RTG of reasonable size can provide.

One promising alternative is lattice confinement fusion (LCF), a type of fusion in which the nuclear fuel is bound in a metal lattice. The confinement encourages positively charged nuclei to fuse because the high electron density of the conductive metal reduces the likelihood that two nuclei will repel each other as they get closer together.

The deuterated erbium (chemical symbol ErD3) is placed into thumb-size vials, as shown in this set of samples from a 20 June 2018 experiment. Here, the vials are arrayed pre-experiment, with wipes on top of the metal to keep the metal in position during the experiment. The metal has begun to crack and break apart, indicating it is fully saturated. Source: NASA

The vials are placed upside down to align the metal with the gamma ray beam. Gamma rays have turned the clear glass amber. Source: NASA

We and other scientists and engineers at NASA Glenn Research Center, in Cleveland, are investigating whether this approach could one day provide enough power to operate small robotic probes on the surface of Mars, for example. LCF would eliminate the need for fissile materials such as enriched uranium, which can be costly to obtain and difficult to handle safely. LCF promises to be less expensive, smaller, and safer than other strategies for harnessing nuclear fusion. And as the technology matures, it could also find uses here on Earth, such as for small power plants for individual buildings, which would reduce fossil-fuel dependency and increase grid resiliency.

Physicists have long thought that fusion should be able to provide clean nuclear power. After all, the sun generates power this way. But the sun has a tremendous size advantage. At nearly 1.4 million kilometers in diameter, with a plasma core 150 times as dense as liquid water and heated to 15 million °C, the sun uses heat and gravity to force particles together and keep its fusion furnace stoked.

On Earth, we lack the ability to produce energy this way. A fusion reactor needs to reach a critical level of fuel-particle density, confinement time, and plasma temperature (called the Lawson Criteria after creator John Lawson) to achieve a net-positive energy output.

Fusion reactors commonly utilize two different hydrogen isotopes: deuterium (one proton and one neutron) and tritium (one proton and two neutrons). These are fused into helium nuclei (two protons and two neutrons)—also called alpha particles—with an unbound neutron left over.

Existing fusion reactors rely on the resulting alpha particles—and the energy released in the process of their creation—to further heat the plasma. The plasma will then drive more nuclear reactions with the end goal of providing a net power gain. But there are limits. Even in the hottest plasmas that reactors can create, alpha particles will mostly skip past additional deuterium nuclei without transferring much energy. For a fusion reactor to be successful, it needs to create as many direct hits between alpha particles and deuterium nuclei as possible.

In the 1950s, scientists created various magnetic-confinement fusion devices, the most well known of which were Andrei Sakharov's tokamak and Lyman Spitzer's stellarator. Setting aside differences in design particulars, each attempts the near-impossible: Heat a gas enough for it to become a plasma and magnetically squeeze it enough to ignite fusion—all without letting the plasma escape.

Inertial-confinement fusion devices followed in the 1970s. They used lasers and ion beams either to compress the surface of a target in a direct-drive implosion or to energize an interior target container in an indirect-drive implosion. Unlike magnetically confined reactions, which can last for seconds or even minutes (and perhaps one day, indefinitely), inertial-confinement fusion reactions last less than a microsecond before the target disassembles, thus ending the reaction.

Both types of devices can create fusion, but so far they are incapable of generating enough energy to offset what's needed to initiate and maintain the nuclear reactions. In other words, more energy goes in than comes out. Hybrid approaches, collectively called magneto-inertial fusion, face the same issues.

Current fusion reactors also require copious amounts of tritium as one part of their fuel mixture. The most reliable source of tritium is a fission reactor, which somewhat defeats the purpose of using fusion.

The fundamental problem of these techniques is that the atomic nuclei in the reactor need to be energetic enough—meaning hot enough—to overcome the Coulomb barrier, the natural tendency for the positively charged nuclei to repel one another. Because of the Coulomb barrier, fusing atomic nuclei have a very small fusion cross section, meaning the probability that two particles will fuse is low. You can increase the cross section by raising the plasma temperature to 100 million °C, but that requires increasingly heroic efforts to confine the plasma. As it stands, after billions of dollars of investment and decades of research, these approaches, which we'll call "hot fusion," still have a long way to go.

The barriers to hot fusion here on Earth are indeed tremendous. As you can imagine, they'd be even more overwhelming on a spacecraft, which can't carry a tokamak or stellarator onboard. Fission reactors are being considered as an alternative—NASA successfully tested the Kilopower fission reactor at the Nevada National Security Site in 2018 using a uranium-235 core about the size of a paper towel roll. The Kilopower reactor could produce up to 10 kilowatts of electric power. The downside is that it required highly enriched uranium, which would have brought additional launch safety and security concerns. This fuel also costs a lot.

But fusion could still work, even if the conventional hot-fusion approaches are nonstarters. LCF technology could be compact enough, light enough, and simple enough to serve for spacecraft.

How does LCF work? Remember that we earlier mentioned deuterium, the isotope of hydrogen with one proton and one neutron in its nucleus. Deuterided metals—erbium and titanium, in our experiments—have been "saturated" with either deuterium or deuterium atoms stripped of their electrons (deuterons). This is possible because the metal naturally exists in a regularly spaced lattice structure, which creates equally regular slots in between the metal atoms for deuterons to nest.

In a tokamak or a stellarator, the hot plasma is limited to a density of 10 14 deuterons per cubic centimeter. Inertial-confinement fusion devices can momentarily reach densities of 1026 deuterons per cubic centimeter. It turns out that metals like erbium can indefinitely hold deuterons at a density of nearly 1023 per cubic centimeter—far higher than the density that can be attained in a magnetic-confinement device, and only three orders of magnitude below that attained in an inertial-confinement device. Crucially, these metals can hold that many ions at room temperature.

The deuteron-saturated metal forms a plasma with neutral charge. The metal lattice confines and electron-screens the deuterons, keeping each of them from "seeing" adjacent deuterons (which are all positively charged). This screening increases the chances of more direct hits, which further promotes the fusion reaction. Without the electron screening, two deuterons would be much more likely to repel each other.

Using a metal lattice that has screened a dense, cold plasma of deuterons, we can jump-start the fusion process using what is called a Dynamitron electron-beam accelerator. The electron beam hits a tantalum target and produces gamma rays, which then irradiate thumb-size vials containing titanium deuteride or erbium deuteride.

When a gamma ray of sufficient energy—about 2.2 megaelectron volts (MeV)—strikes one of the deuterons in the metal lattice, the deuteron breaks apart into its constituent proton and neutron. The released neutron may collide with another deuteron, accelerating it much as a pool cue accelerates a ball when striking it. This second, energetic deuteron then goes through one of two processes: screened fusion or a stripping reaction.

In screened fusion, which we have observed in our experiments, the energetic deuteron fuses with another deuteron in the lattice. The fusion reaction will result in either a helium-3 nucleus and a leftover neutron or a hydrogen-3 nucleus and a leftover proton. These fusion products may fuse with other deuterons, creating an alpha particle, or with another helium-3 or hydrogen-3 nucleus. Each of these nuclear reactions releases energy, helping to drive more instances of fusion.

In a stripping reaction, an atom like the titanium or erbium in our experiments strips the proton or neutron from the deuteron and captures that proton or neutron. Erbium, titanium, and other heavier atoms preferentially absorb the neutron because the proton is repulsed by the positively charged nucleus (called an Oppenheimer-Phillips reaction). It is theoretically possible, although we haven't observed it, that the electron screening might allow the proton to be captured, transforming erbium into thulium or titanium into vanadium. Both kinds of stripping reactions would produce useful energy.

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One day

One day you finally knew
what you had to do, and began,
though the voices around you
kept shouting their bad advice --
though the whole house
began to tremble
and you felt the old tug
at your ankles.
"Mend my life!"
each voice cried.
But you didn't stop.
You knew what you had to do,
though the wind pried
with its stiff fingers
at the very foundations,
though their melancholy was terrible.
It was already late
enough, and a wild night,
and the road full of fallen
branches and stones.
But little by little,
as you left their voice behind,
the stars began to burn
through the sheets of clouds,
and there was a new voice
which you slowly
recognized as your own,
that kept you company
as you strode deeper and deeper
into the world, determined to do
the only thing you could do --
determined to save
the only life that you could save.

Vinod Pandurang Patil - S. Y. Electrical

New Filter Doubles Nuclear Fuel Extractable from Seawater

Maithili Kumbhar- F. Y. C. S. E.

The International Atomic Energy Agency expects nuclear power to grow significantly in the coming decades, by up to 82 percent by the year 2050. That would create an increase in demand for uranium that reserves on land may not be able to meet.

But the world's oceans, according to the U.S. Department of Energy, contain at least 500 times more uranium than in all known terrestrial reserves. That equates to more than 4.5 billion metric tons of the element in seawater, albeit present at an extremely dilute concentration of 3.3 parts per billion, and scientists have been trying to find efficient ways to extract it.

Researchers recently reported one of the best-performing materials to do this. The porous membrane soaks up 20 times more uranium from seawater than membranes made so far. When the researchers pumped natural seawater across it, the membrane captured over 9 milligrams of uranium per gram of the material in four weeks, more than other uranium-extracting materials reported previously have been able to collect in double that time period.

The membrane's high uranium-capturing capacity is appealing and indeed surpasses its predecessors, says Costas Tsouris, a chemical engineer at Oak Ridge National Laboratory. What's also really important, especially for the marine setting, is the membrane's kinetics. The high speed with which it captures uranium would require a shorter immersion time in seawater, avoiding the growth of microbial films that foul the material, he says. That should make it easier to separate the extracted uranium from the membrane and to reuse the membrane.

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The researchers drew inspiration from the porous structure of blood vessels—leading them toward a hierarchical membrane with pores of multiple sizes.

Tsouris and his colleagues worked on seawater uranium extraction for six years starting in 2011. They used an adsorbent—a material that, unlike an absorbent with a ‘b,’ only uses its surface to attract substances—based on a chemical group called amidoxime that Japanese researchers pioneered in the 1980s. Amidoxime shows a preference for binding chemically with uranium ions that occur naturally in seawater over other competing ions that are also present such as iron, copper, and calcium.

The ORNL scientists coated the adsorbent on plastic fibers, braided those fibers, and placed the braids in seawater. Eight weeks later, the fibers had picked up nearly 8 mg/g of uranium.

In 2018, researchers from Pacific Northwest National Laboratory and LCW Supercritical Technologies reported a similar amidoxime-coated fiber that extracted about 5 mg/g of uranium when seawater was pumped through it in the lab.

Some teams have recently put amidoxime on host materials with high surface areas, such as nanostructured materials or porous membrane, which makes more sites available for adsorption and increases uranium uptake. This is the approach that Liping Wen and colleagues from the Chinese Academy of Sciences took. Their research was recently published in the journal Nature Sustainability.

Inspired by the hierarchical porous structure found in blood vessels and other organs, the researchers made a membrane with pores of multiple sizes. The pores are coated with amidoxime. When seawater flows across the membrane, uranium and other molecules first quickly pass through the larger 20 micrometer-wide pores from where they go into narrower channels and into tinier 300–500 nm pores where the slower speed lets uranium bind with amidoxime. This multi-scale design lets water flow through quickly and maximizes surface area for adsorption.

In the laboratory, the researchers pumped a solution with a uranium concentration of 32 ppm across their new membrane and others with uniform pores. The new membrane extracted 20 times more uranium.

Next, they placed a 10-mg membrane between two pieces of sponge in a tube, and continuously pumped natural seawater through the tube. In one week, the membrane accumulated 6.63 mg/g or uranium, reaching 9.03 mg/g after four weeks. The researchers were able to recover the uranium and reuse the membrane five times without any loss in its extraction capacity.

The membrane’s test will of course be in a real-world marine setting, Tsouris says. That will show how stable the membrane is and how much it resists microbial fouling. Plus, it would have to be simply suspended. Pumping seawater across membranes does not make practical sense. “To recover relevant amounts of uranium from seawater we need to process a lot of water,” he says. “If we start pumping that amount, the energy we spend on the process would be more than the energy we get from uranium.”

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World's Fastest AI Supercomputer

Sanket Balkrishna Kinekar - S. Y. Mech.

Meta, parent company of Facebook, says it has built a research supercomputer that is among the fastest on the planet. By the middle of this year, when an expansion of the system is complete, it will be the fastest, Meta researchers Kevin Lee and ShubhoSengupta write in a blog post today. The AI Research SuperCluster (RSC) will one day work with neural networks with trillions of parameters, they write. The number of parameters in neural network models have been rapidly growing. The natural language processor GPT-3, for example, has 175 billion parameters, and such sophisticated AIs are only expected to grow.

RSC is meant to address a critical limit to this growth, the time it takes to train a neural network. Generally, training involves testing a neural network against a large data set, measuring how far it is from doing its job accurately, using that error signal to tweak the network's parameters, and repeating the cycle until the neural network reaches the needed level of accuracy. It can take weeks of computing for large networks, limiting how many new networks can be trialed in a given year. Several well-funded startups, such as Cerebras and SambaNova, were launched in part to address training times.

Among other things, Meta hopes RSC will help it build new neural networks that can do real-time voice translations to large groups of people, each speaking a different language, the researchers write. "Ultimately, the work done with RSC will pave the way toward building technologies for the next major computing platform—the metaverse, where AI-driven applications and products will play an important role," they write.

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"The experiences we're building for the metaverse require enormous compute power (quintillions of operations / second!) and RSC will enable new AI models that can learn from trillions of examples, understand hundreds of languages, and more," Meta CEO and cofounder Mark Zuckerberg said in a statement.

Compared to the AI research cluster Meta uses today, which was designed in 2017, RSC is a change in the number of GPUs involved, how they communicate, and the storage attached to them.

In early 2020, we decided the best way to accelerate progress was to design a new computing infrastructure from a clean slate to take advantage of new GPU and network fabric technology. We wanted this infrastructure to be able to train models with more than a trillion parameters on data sets as large as an exabyte—which, to provide a sense of scale, is the equivalent of 36,000 years of high-quality video.

The old system connected 22,000 Nvidia V100 Tensor Core GPUs. The new one switches over to Nvidia's latest core, the A100, which has dominated in recent benchmark tests of AI systems. At present the new system is a cluster of 760 Nvidia DGX A100 computers, with a total of 6,080 GPUs. The computer cluster is bound together using an Nvidia 200-gigabit-per-second Infiniband network. The storage includes 46 petabytes (46 million billion bytes) of cache storage and 175 petabytes of bulk flash storage.

Speedups:

Computer vision: 20x

Large-scale natural-language processing: 3x

Compared to the old V100-based system, RSC marked a 20-fold speedup in computer vision tasks and a 3-fold boost in handling large natural-language processing.

When the system is complete in the middle of this year, it will connect 16,000 GPUs, which, Lee and Sengupta write, making it one of the largest of its kind. At that point, its cache and storage will have a capacity of 1 exabyte (1 billion billion bytes) and be able to serve 16 terabytes per second of data to the system. The new system will also focus on reliability. That's important because very large networks might take weeks of training time, and you don't want a failure partway through the task that means having to start over.

For reference, the largest production-ready systems tested in the latest round of the MLPerf neural network training benchmarks was a 4,320-GPU system fielded by Nvidia. That system could train the natural language processor BERT in less than a minute. However BERT has only 110 million parameters compared to the trillions Meta wants to work with.

The launch of RSC also comes with a change in the way Meta uses data for research:

Unlike with our previous AI research infrastructure, which leveraged only open source and other publicly available data sets, RSC also helps us ensure that our research translates effectively into practice by allowing us to include real-world examples from Meta's production systems in model training.

The researchers write that RSC will be taking extra precautions to encrypt and anonymize this data to prevent and chance of leakage. Those steps include that RSC is isolated from the larger internet—having neither inbound nor outbound connections. Traffic to RSC can flow in only from Meta's production data centers. In addition, the data path between storage and the GPUs is end-to-end encrypted, and data is anonymized and subject to a review process to confirm the anonymization.

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Artificial sun and Moon

Chinmay Patil - T. Y. C. S. E.

China's "artificial sun" set a new record after it ran at 120 million degrees Celsius for 101 seconds, according to the state media. The Experimental Advanced Superconducting Tokamak (EAST) device designed by China replicates the nuclear fusion process carried out by the sun.

For 20 seconds, EAST also achieved a peak temperature of 160 million degrees Celsius, which is over ten times hotter than the sun. The experiment was conducted at the Institute of Plasma Physics of the Chinese Academy of Sciences (ASIPP), in Hefei.

The ultimate goal of EAST is to create nuclear fusion like the Sun, using deuterium abound in the sea. Deuterium from one-litre of seawater can produce energy equivalent to 300 litres of gasoline through a nuclear fusion reaction.

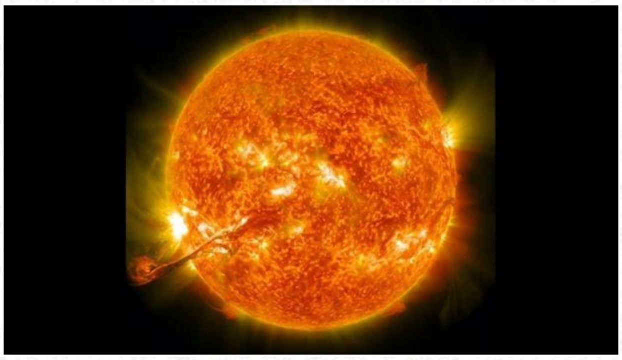
Revolutionising clean energy

If the claim holds weight, it could revolutionise the way China creates and absorbs clean energy. For starters, the goal is to deliver endless supply of clean energy by imitating similar reactions that take place in stars like our sun.

The project has cost China a whopping $943 billion and the experiment is expected to run until June, 2022.

For nuclear fusion to occur, tremendous heat and pressure are applied to hydrogen atoms so that they fuse together. Unlike fission, nuclear fusion is considered a safer process with no nuclear waste. Nuclear fusion could potentially provide unlimited clean energy at very low costs.

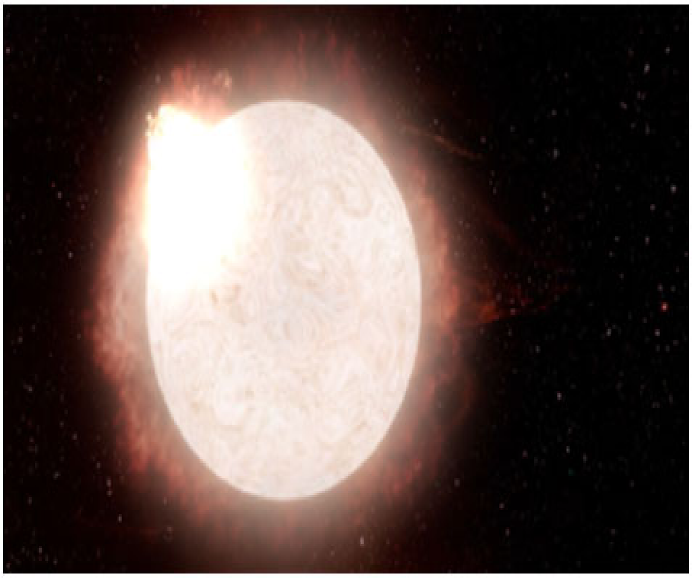
China's EAST project is part of the International Thermonuclear Experimental Reactor (ITER) facility that will become the world's largest nuclear fusion reactor after it becomes operational in 2035. Several countries are a part of this project, including South Korea, Japan, Russia, India, and the United States. The next goal for the EAST project is to maintain the high temperature



In the absence of fossil fuels and toxic waste, nuclear fusion is cleaner and more environmentally friendly than our current methods.

According to the Independent, China's nuclear fusion team is also slated to offer technical support to the team building a similar project in France - The International Thermonuclear Experimental Reactor (ITER). The ITER would become the world's largest reactor once completed.

Artificial moon



Chinese scientists have built an “artificial moon” research facility that will enable them to simulate low-gravity environments using magnetism.

Chinese scientists have built an "artificial moon" research facility that will enable them to simulate low-gravity environments using magnetism.

The facility, slated for official launch this year, will use powerful magnetic fields inside a 2-foot-diameter (60 centimeters) vacuum chamber to make gravity "disappear." The scientists were inspired by an earlier experiment that used magnets to levitate a frog.

Li Ruilin, a geotechnical engineer at the China University of Mining and Technology, told the South China Morning Post that the chamber, which will be filled with rocks and dust to imitate the lunar surface, is the "first of its kind in the world" and that it could maintain such low-gravity conditions for "as long as you want."

Scientists plan to use the facility to test technology in prolonged low-gravity environments before it is sent to the moon, where gravity is just one-sixth of its strength on Earth. This will allow them to iron out any costly technical kinks, as well as test whether certain structures will survive on the moon's surface and assess the viability of a human settlement there.

"Some experiments, such as an impact test, need just a few seconds [in the simulator]," Li said. "But others, such as creep testing, can take several days." A creep test measures how much a material will deform under a constant temperature and stress.

According to the researchers, the inspiration for the chamber came from Andre Geim, a physicist at the University of Manchester in the U.K. who won the satirical Ig Nobel Prize in 2000 for devising an experiment that made a frog float with a magnet.

The levitation trick used by Geim and now in the artificial-moon chamber comes from an effect called diamagnetic levitation. Atoms are made up of atomic nuclei and tiny electrons that orbit them in little loops of current; these moving currents, in turn, induce tiny magnetic fields. Usually, the randomly oriented magnetic fields of all the atoms in an object, whether they belong to a drop of water or a frog, cancel out, and no material-wide magnetism manifests.

Apply an external magnetic field to those atoms, however, and everything changes: The electrons will modify their motion, producing their own magnetic field to oppose the applied field. If the external magnet is strong enough, the magnetic force of repulsion between it and the field of the atoms will grow powerful enough to overcome gravity and levitate the object — whether it's an advanced piece of lunar tech or a confused amphibian — into the air.

The tests completed in the chamber will be used to inform China's lunar exploration program Chang'e, which takes its name from the Chinese goddess of the moon. This initiative includes Chang'e 4, which landed a rover on the far side of the moon in 2019, and Chang'e 5, which retrieved rock samples from the moon's surface in 2020. China has also declared that it will establish a lunar research station on the moon's south pole by 2029.

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