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5G, connected vehicles and artificially intelligent virtual assistants among the tech on display at CES 2019
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COMMENT
There was a lot of talk on the benefits of 5G at CES, but do we need to ensure that we don’t get ahead of ourselves?

Researchers uncover eccentric physics that could transform lighting and photovoltaic technology

A technique that could double the efficiency of organic electronics has been developed by scientists

Aldec, a leader in automated and scalable verification for ASICs and SoCs, unveils latest HES-DVM release

A Fen Technology event looks to ‘help out’ a new generation of engineers working to exploit the IoT

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The future was on display at the Consumer Electronics Show in Las Vegas. Neil Tyler looks back at this year’s show

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Deep fools
Deep learning has come a long way in the past ten years, but neural networks can be easy to mislead. Can they be fixed? By Chris Edwards

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Here Art Schaldenbrand looks at the importance of being able to effectively simulate analogue production testing

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Rich Micron looks at how engineers can best control startup and shutdown power sequences in their designs

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Managing the hype around 5G

WITH MUCH TALK OF 5G AND ITS BENEFITS AT CES, DO WE NEED TO ENSURE WE DON’T GET AHEAD OF OURSELVES?

Speaking at CES in Las Vegas, Hans Vestberg, the CEO of Verizon, claimed that 5G would represent a ‘quantum’ leap over 4G.

The technology will have a much wider range of uses, according to Vestberg, as it’s being designed not only for consumers, but for industries and society at large.

“It’s so much more,” he said. “It’s going to result in cordless manufacturing, it could see retail stores able to capture real-time information giving you, as a customer, a much better experience when you’re in store.”

Verizon has deployed 5G Home on a limited scale in Sacramento, Los Angeles, Houston, and Indianapolis and is starting to market its first 5G smartphones - Motorola’s Moto Z3 and a Samsung phone – and Vestberg suggested that much of the new infrastructure needed to support 5G would be based on what was already there.

An upbeat assessment but are we seeing rather too much hype around 5G, especially as 5G proper is unlikely to appear until 2020-21?

The roll-out of services has been very limited to date, and it’s going to be a good 18-24 months before operators have network capabilities and handset manufacturers 5G enabled product in place.

We’re in a classic ‘hype phase’ when it comes to 5G. Operators, handset manufacturers and the media are all talking about it, but few can actually buy or use it.

Perhaps we need to hold off talking at length of the wonders of 5G and simply let the wireless operators and device manufacturers get on with working out the details, so that we can all realise the benefits of 5G wireless.

Neil Tyler, Editor (neil.tyler@markallengroup.com)
Paint-on semiconductor glows brighter

RESEARCHERS UNCOVER INTERESTING PHYSICS TO TRANSFORM LIGHTING TECHNOLOGY AND PHOTOVOLTAICS. BETHAN GRYLLS REPORTS

Researchers from Georgia Tech have discovered a way to create more desirable optoelectrical properties using a hybrid semiconductor material, halide organic-inorganic perovskite (HOIP). This comprises of two inorganic crystal lattice layers with an organic material between which acts like a sheet of rubber bands, making the crystal lattice into a wobbly, but stable surface.

According to the team, HOIPs could be painted on to make LEDs, lasers or even window glass that could glow in any colour. Lighting with HOIPs requires little energy, and solar panel makers could not only boost photovoltaics’ efficiency but slash production costs.

An electron has a negative charge, and an orbit it vacates after having been excited by energy is a positive charge called an electron hole. The electron and the hole can gyrate around each other forming a kind of imaginary particle, or quasiparticle, called an exciton.

“The positive-negative attraction in an exciton is called binding energy, and it’s a very high-energy phenomenon, which makes it great for light emitting,” Prof. Silva explained.

When the electron and the hole reunite it releases the binding energy to make light. But usually, excitons are very hard to maintain in a semiconductor.

“The excitonic properties in conventional semiconductors are only stable at extremely cold temperatures,” Prof. Silva continued, “but in HOIPs the excitonic properties are stable at room temperature.”

Excitons get freed up from their atoms and move around the material. In addition, excitons in an HOIP can whirl around other excitons, forming quasiparticles called bie excitons.

The uncommon participation of atoms of the material in these ‘dances’ with electrons, excitons, bie excitons and polarons creates repetitive nanoscale indentations in the material that are observable as wave patterns and that shift and flux with the amount of energy added to the material. The key observation in the study is that the wave pattern varies with different types of excitons. The indentations also grip the excitons, slowing their mobility through the material, and all these ornate dynamics may affect the quality of light emission, the team concludes.

Photonic-based medical device

Imec and Ghent University, together with Medtronic and other CARDIS project partners, have developed a prototype medical device based on silicon photonics.

The device is for screening of arterial stiffness and for the diagnosis of cardiovascular diseases.

The operating principle of the device is Laser Doppler Vibrometry (LDV), in which a very low-power laser is directed towards the skin overlaying an artery. The skin’s vibration amplitude and frequency, resulting from the heart beat, are extracted from the Doppler shift of the reflected beam. The device comprises of six beams, thereby scanning multiple points on the skin above the artery.

Avoiding Brexit disruption

Ahead of any potential Brexit disruption, Anglia is offering its 80/20 users the opportunity to hold increased levels of inventory at no cost.

The system offers customers an agreed level of inventory on their regularly used commodity components that are held on their site providing instant accessibility. The level of inventory is normally scaled according to the customer’s forecast demand – but customers can increase their inventory ahead of the March 29 deadline to insulate themselves against potential customs delays.

Steve Rawlins, CEO of Anglia, said, “We helped customers during component shortages, now we’re going to help in the event of Brexit disrupting the supply chain.”
Double the power

A BREAKTHROUGH IN ORGANIC ELECTRONICS COULD LEAD TO DOUBLY EFFICIENT POLYMER-BASED SEMICONDUCTORS. NEIL TYLER REPORTS.

A technique that could double the efficiency of organic electronics has been discovered by a team from Sweden’s Chalmers University of Technology. This could represent the tipping point needed to allow several emerging technologies to be commercialised.

Semiconductors require a process called doping, which involves weaving impurities into them to enhance their electrical conductivity, and for organic electronics this process is of extreme importance.

OLED-displays are an example of organic semiconductors which are already on the market. But other applications have not been fully realised, as polymers do not conduct current well.

Doping in organic semiconductors operates through what is known as a redox reaction. This means that a dopant molecule receives an electron from the semiconductor, which increases its electrical conductivity. The more dopant molecules that the semiconductor can react with, the higher the conductivity – at least up to a certain limit.

Currently, the efficiency limit of doped organic semiconductors has been determined by the fact that the dopant molecules have only been able to exchange one electron each.

The Chalmers team, together with colleagues from seven other universities, have now demonstrated that it’s possible to move two electrons to every dopant molecule.

“Through this ‘double doping’ process, the semiconductor can therefore become twice as effective,” said David Kiefer, a PhD student in the group.

“Research has been focused on studying materials, which only allow one redox reaction per molecule. We chose to look at a different type of polymer, with lower ionisation energy. We saw that this material allowed the transfer of two electrons to the dopant molecule,” explained Christian Müller, Professor of Polymer Science at Chalmers.

Wireless wonder

A cuttable, flexible power transfer sheet has been created by a team from the University of Tokyo, designed to charge devices wirelessly.

As well as being able to cut the charger, it is also thin and flexible enough for it to be moulded around curved surfaces such as bags and clothes.

Like a traditional charging system, conductive coils are used in the charger to induce a current in corresponding coils in the device, but in this new device, the useable charging area has been widened. These coils are also wired in such a way that, provided enough of them remain intact after the sheet is cut to shape, they can still charge a device.

According to the team, a 400mm square sheet currently provides about 2-5 Watts of power, enough for a smartphone. However, the belief is this could be increased enough to power a small computer.

Strata Developer Studio

ON Semiconductor has launched the Strata Developer Studio, a cloud-based development platform designed to offer a simpler, personalised and more secure environment for engineers to evaluate and design with its technologies.

“We’re adding more software to our hardware portfolio and that’s where Strata comes into play,” explained Edward Osburn, Strata Project General Manager at ON Semi. “We have more than 80,000 products – and counting – each of these have diverse and deep set information attached, from simple data sheets all the way application notes, software, source code and so on.”

According to On Semi, the platform will deliver the latest documentation, product information, design and application notes, and reference design files straight to the desktop.

He continued: “If you think about all of these products having all of these different things available to it, the total amount of information for customers to look through is pretty daunting. We want to make sure our customers are up-to-date.”

The platform provides design teams with a user interface to the board, giving direct control of the configuration parameters and visual feedback of the board’s functionality. At the same time, Strata will download all the design information an engineer needs to start evaluation or design.

The Strata Developer Studio is provided as a Microsoft signed application connecting to the company’s software as a service (SaaS) platform. It features secure authentication, data transfers and full information containment using encrypted and EU General Data Protection Regulation (GDPR) compliant databases. All information and security also follows National Institute of Standards and Technology (NIST) Cybersecurity guidelines.

ON Semi intends to make all its new evaluation boards ‘Strata-Ready’, meaning they will automatically be recognised by the Strata Developer Studio when they are connected to the host computer.
Aldec unveils latest HES-DVM release

NEW RELEASE OF FULLY AUTOMATED AND SCALABLE VERIFICATION FOR SoCs AND ASIC DESIGNS. NEIL TYLER REPORTS

Aldec, a leader in mixed HDL language simulation and hardware-assisted verification for ASIC and FPGA designs, has unveiled the latest release of HES-DVM, the company’s fully automated and scalable hybrid verification environment for SoC and ASIC designs.

Release 2018.12 features enhancements to the level of automation in Prototyping mode, plus the faster compilation of HDL to FPGA.

The HES-DVM provides design partitioning and partition interconnection tools designed to meet the growing need for FPGA prototyping; i.e. FPGAs used as a pre-silicon SoC verification vehicle to assure ultimate speed or as a hardware software co-verification platform.

Thanks to the use of virtual partitions, HES-DVM can also be used in the process of designing new prototyping boards to establish the most efficient board architecture for the project or with third party and in-house developed FPGA boards.

The 2018.12 release means that users will now be able to quickly evaluate various partitioning scenarios and choose the one which provides the best performance on a given prototyping board.

With this release, the productivity of an FPGA prototyping team is greatly boosted, according to Aldec, thanks to the addition of two new automation enhancements.

The first of these is Automatic Routing, which automatically resolves feed-through connections if there are no appropriate chip-to-chip traces on a prototyping board. The second is Automatic Physical Connections for multi-FPGA prototyping boards, which routes all inter-partition connections using available chip-to-chip traces and it intelligently assigns various types of I/O - including integrated serialization (SERDES) and differential signalling (LVDS).

In addition, and to further reduce the design setup turnaround time in HES-DVM’s Emulation and Prototyping modes, Aldec has developed a proprietary HDL compiler, details of which will be announced later in the year.

“The latest release of HES-DVM boosts our FPGA Prototyping and Emulation solutions, through the addition of features that significantly shorten design setup time, enabling designers to evaluate more prototype scenarios than before in a given amount of time,” said Zibi Zalewski, General Manager of Hardware Division. “Users will also benefit from an ultra-fast turnaround time, from bug-fix to a revised prototype run, and potentially spare themselves from months of tedious work. Indeed, we are devoted to persistently raising the bar in FPGA-based emulation and prototyping technology.”

Small Robot Company raises £1.2 million

The Small Robot Company, a British agritech start-up for sustainable farming, has announced that it has raised £1.2 million on the Crowdcube equity crowdfunding platform.

According to the company it received support from the farming, technology and ‘eco’ communities.

Small Robot Company was set up to develop the precision of robots and Artificial Intelligence (AI) to improve the way that food is produced and minimise chemical usage.

Its farmbots Tom, Dick and Harry are able to plant, feed and weed arable crops autonomously, with minimal waste.

This new funding now takes the total raised by the Small Robot Company to £2.5 million in total. This includes two awards from Innovate UK, £300,000 seed funding from farmers (including £90,000 in presales), £50,000 raised from Indiegogo crowdfunding, and a £50,000 Horizontal Innovation Award from the Institute of Engineering and Technology.

CPI supporting LiNaMan project

The Centre for Process Innovation (CPI) has announced that it will be working alongside LiNa Energy and Lancaster University, in the development of a robust, low-cost and high performance energy storage battery that is intended to replace existing lithium-ion (Li-ion) batteries.

The project, known as LiNaMan, is looking to demonstrate the technical and commercial viability of sodium nickel chloride (Na-Ni-Cl) batteries as a new disruptive technology in the UK and European electric vehicle sector.

The collaboration is intended to highlight the benefits of Na-Ni-Cl batteries against Li-ion alternatives, in particular their highly recyclable and relatively cheap components of steel, nickel, iron, salt and ceramic, and display their capacity to operate across a much wider operating temperature range.

LiNa Energy is founded upon a patented novel sodium metal chloride planar cell, which unlocks the high power and energy density potential of established sodium battery chemistry while offering vastly improved safety and reduced product complexity.

The collaboration will take LiNa’s concept and apply the latest material engineering to design, develop, manufacture and test the first-ever LiNa cell.

Process development and process economics of LiNa’s single cell will take place at CPI’s state-of-the-art formulation facility, which is based in NETPark, Sedgefield, County Durham.

The project will complement existing Faraday Challenge projects by adding a strand currently missing from the portfolio and supporting the UK in a fresh sodium technology ideally suited to automotive applications.
With the opportunity the Internet of Things (IoT) offers, a new generation of engineers has emerged and, as a consequence, the role of the design consultancy has changed.

Noting the focus on IoT, Fen Technology, a design consultancy based in Cambridge, which was recently acquired by the Spanish development consultancy Inspiralia, held its first ever IoT focused product development surgery at the end of last year. According to Business Director, Ciaran McAleer, who devised the idea of a ‘surgery’, this was an event with a difference.

“We didn’t tell our engineers to follow up with anyone afterwards,” he said. “We just told them to help them. If the engineer is interested, they will get in touch with us. That’s how we run our business.

“We weren’t there to do a ‘hard sell’. The idea behind the event was to get some world-class engineers from Fen and our valued partner companies together in one building and offer advice and help.”

Despite its surgery’s IoT focus, McAleer also expressed the importance of the company’s “broad-based offering”, explaining that Fen Technology would – and always has – offered expertise within a number of vertical markets.

“There are a lot more design consultancies today than when we first started back in 2002,” admitted McAleer. “But customers have told me that it’s difficult to get a consultant that is as dynamic and flexible. There are a lot of great companies in Cambridge, but one thing we pride ourselves on is that we turn things around very quickly and work in a very agile way.”

So why is a design consultancy like Fen Technology so important? It’s impossible as an engineer to know everything, whereas a consultancy can provide a breadth of knowledge from its talent pool which it has developed and built up over the years.

“We used to receive specifications that were hundreds of pages long, now with the rise of ‘blue sky’ innovation, we’ll get five bullet points, but we’ve developed the skills and connections to accommodate for this new way of working,” explained McAleer.

When the company was first established, McAleer confessed that the founders – which included himself – discussed the possibility of having a more defined service rather than its broad-based offering. Born in the digital switchover era, he said they were tempted to specialise in the broadcast sector. “A lot of other companies setting up at the time actually did this. But, we recognised that all technology trends come and go – and I believe this decision is one of the main reasons why we still exist today.”

McAleer added that the same thinking goes for its surgery event. He explained the company is “dipping a toe in the water”, but there is potential to take this event on the road. He named places such as Oxford, London and Madrid as possibilities, but said that it remained to be seen whether the theme of IoT would remain a continued focus.

“We need to reflect and see what the market is demanding.”

As for the future, McAleer said the company is seeing other markets take to the fore including wearables, GPS and battery technology. He noted in particular a current client, who had an idea on microturbine systems and drones. “There is great potential there,” he said.

“From our modest beginnings – where we literally started from nothing, doing everything ourselves – and now with our new colleagues in Spain, Fen has grown exponentially,” continued McAleer. “We are currently in a period of review and analysis – trying to understand the business. Saying this, we have growth plans in place for 2019.”

But, he emphasised, even after the acquisition Fen Technology still holds true to its original ethos and offering – that is customer-focused, flexible services – and pointed to its IoT product surgery as evidence.
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Earlier this month the Consumer Electronics Show (CES) took place in Las Vegas, and with over 4,500 exhibitors and upwards of 180,000 visitors it remains the largest consumer electronics show in the US, with a global impact to match.

Companies take the opportunity to unveil thousands of products and prototypes, and among the hottest technological trends were next generation wireless networks, connected vehicles and artificially intelligent virtual assistants.

On the first day Apple stole the show, despite not being in attendance, with the news that it was opening up AirPlay support for third party smart TVs. Once exclusive to Apple, AirPlay can now be accessed via TVs from Samsung, Vizio, LG and Sony suggesting that even the behemoths of technology can no longer operate in isolation.

Artificial assistants, both Amazon’s Alexa and Google’s Assistant, seemed to be everywhere. Both companies that were on display at CES have been designed to work with multiple virtual assistants.

As the CEO of Brilliant, Aaron Emigh, explained, “The more vendors that get put in the home, the more important it is that it all works together.” As a manufacturer of smart home products Emigh said that it was critical that virtual assistants were able to work alongside one another. Keep it simple for the consumer, seems to be the idea.

With artificially intelligent virtual assistants taking centre stage companies, large and small, unveiled a range of voice compatible devices from robot vacuum cleaners to refrigerators and car accessories.

Before the show started Gary Shapiro, the chief executive of the Consumer Technology Association, which owns CES, said that “AI would pervade the show,” and that proved to be an accurate assessment.

While virtual assistants remain in their infancy companies like Amazon, through its corporate vision – Alexa Everywhere – appear to be determined to expand their reach, so that voice is found in every part of a consumer’s experience.

Qualcomm showcased highly intuitive voice based technology using the natural language processing and speech recognition capabilities of Alexa to demonstrate an in-car virtual assistant that can provide natural interactions between the driver and the vehicle and offers in-vehicle navigation, points of interest and multimedia services.

“Leveraging Amazon’s natural language processing technology, allows us to offer an interactive in-car experience for both drivers and passengers,” said Nakul Duggal, senior vice president of product management.

South Korea’s LG had a stand on which it demonstrated a kitchen of the future, where the user was able to communicate with every appliance.

The company’s President/Chief Technology Officer, Dr I.P. Park said that for consumers to fully realise the
potential of AI it must be, “able to think and learn and not just generate data”.

He described an AI chip that has been developed for home appliances that combines voice recognition with visual recognition, Wi-Fi connectivity and sensor interfaces that will, “allow a whole range of devices to learn and evolve.”

Cambridge Consultants used CES to demonstrate Gerard, a contextually aware robotic assistant, that the company said showed what would be possible when a voice assistant was able to grasp more of the richness of human communication.

The robot is able to map and understand its environment as well as voice and physical gesture commands and, through autonomous exploration, can become more aware of its location and objects in its environment, essentially integrating voice, vision, gesture recognition and autonomous robotics.

Whether consumers want a digital assistant to be involved in everyday tasks, however, remains open to debate. The technology is still at an early stage, there are privacy concerns and consumers will need to feel comfortable using and talking to their devices.

With halls showing the latest augmented and virtual reality devices, robotics, vehicle technology, 5G and wearable technologies – the whole tech ecosystem was on display at this year’s show.

The next generation of mobility in the form of 5G took centre stage and both Verizon and AT&T, speaking at the conference that runs alongside the exhibition, talked about the impact it was likely to have.

While there’s a lot of marketing hype around 5G Verizon’s CEO, Hans Vestberg was unapologetic suggesting that it was “going to change everything,” and was going to be a, “quantum leap” over 4G.

To support this claim Skyward, a commercial drone company, was invited to show the conference session how using 5G a network of drones, using the instantaneous communications capabilities it provides, enables utilities, through the use of real time information, to monitor 27,000 miles of power lines.

**Automotive innovation**

While CES is dominated by consumer electronics and appliances it is fair to say that it is also a major car show.

**“Leveraging Amazon’s natural language processing technology, allows us to offer an interactive in-car experience for drivers and passengers.”**

Nakul Duggal

New vehicles debut and each year more technology finds its way into cars such as windscreen displays, gesture controls, face recognition, emotion detection and mood lighting.

CES saw the unveiling of the long-range version of Nissan’s Leaf EV, now with a larger battery pack and a range of over 226 miles, a significant boost over the current model, while Byton, an electric car start-up, unveiled a production version of its M-Byte SUV. This car came with a 48 inch screen and a touchscreen in the centre of the steering wheel.

Both Audi and Mercedes-Benz had new vehicles on display. Mercedes-Benz showed off its 2020 CLA-Class which was filled with technology including its MBUX connected infotainment system and driver assist technologies.

Augmented reality was also on show. Valeo’s XtraVue invisible towing system makes it possible for drivers to see what is happening on the road behind their trailer or caravan, making it much easier and safer to navigate.

The system uses cameras fitted at the rear of a vehicle and on the trailer, to feed into a single homogeneous image, allowing drivers to see what is going on behind them as if the trailer has disappeared.

Valeo also demonstrated the Augmented reality was also on show. Valeo’s XtraVue invisible towing system makes it possible for drivers to see what is happening on the road behind their trailer or caravan, making it much easier and safer to navigate.

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concept from Hyundai is an electric emergency response vehicle that has legs between its body and wheels and has a driving and walking mode, meaning that it could essentially ‘scramble’ over rough terrain.

Talking of infotainment Cypress Semiconductor used CES to announce the expansion of its wireless connectivity portfolio for automotive infotainment.

Its Wi-Fi and Bluetooth combo chipsets and supporting software have been designed to serve as application development platforms that will enable multiple users to connect and stream content to as many as 10 mobile devices simultaneously.

These new platforms include a Wi-Fi 6 (802.11ax) and Bluetooth combo solution that features Cypress’ Real Simultaneous Dual Band (RSDB) architecture. RSDB has become the de facto standard for high end connected infotainment experiences, enabling two unique data streams to run at full throughput simultaneously by integrating two complete Wi-Fi subsystems into a single chip.

“Car makers are looking to provide multi-user access and media streaming in their vehicles that is comparable to a premium personal media experience at home; Cypress offers a product line-up that’s been designed specifically for automotive infotainment with a platform approach for suppliers and OEMs,” said Brian Bedrosian, vice president of marketing for the IoT Compute and Wireless Business Unit at Cypress.

The lion’s share of CES car-related news, however, tends to be about autonomous and semi-autonomous technologies.

BMW demonstrated a self-riding motorbike, which was able to steer itself around the convention centre’s lot without falling over.

Trucking and logistics were also present and Udelv showed off a second-generation autonomous delivery truck, the Newton, which will be hitting the roads later this year as part of pilot delivery programme with Walmart.

On the John Deere stand visitors got to see connected, highly automated and artificially intelligent farming machines and at its booth it was possible to see a 20 ton combine harvester that uses artificial intelligence to make farming more efficient.

So what of the gadgets and tech that you’d expect to find at CES?

Much of what is shown at CES is conceptual and in many cases is never released commercially. However, among the technology on display were a range of 4K and 8K TVs.

Samsung’s Micro LED 4K TV was interesting, not so much because of its screen, but because of its modularity – panels could be added to make the screen larger.

LG’s Signature OLED TV R is a bendy TV. The 65 inch screen could be rolled up and stored in its aluminium base and with a display that was just 3mm thick, it was, for many, a standout product at this year’s show.

LG’s 88inch 8K Z9 OLED TVs were also impressive. The quality and clarity of the images were outstanding and they came with, you guessed it, Google Assistant and Alexa support built-in.

And speaking of impressive, on entering LG’s booth you were confronted by a truly spectacular installation – the ‘Massive Curve of Nature’ – which comprised of over 250 curved LG OLED TVs showing the night sky, running water and thousands of lanterns floating off into the sky.

As for wearables, a vast number of smart watches were on display this year but wearable technology is expanding into all sorts of areas.

For example, from Starkey Hearing Technologies, its Livio AI is said to be the world’s first hearing aid to come with AI. It is able to track brain and body health, monitor a person’s heart rate and even offer in-ear language translations.

Another interesting monitoring device came in the form of the Welt Smart Belt, which tracks waist size, activity and over eating and by doing so is able to provide comprehensive analysis of a person’s health.

Another device that caught NE’s attention was the Chronolife vest, which is able to predict heart attacks.

From a French start-up – the French tech industry had a big presence at CES this year – the vest has been designed with six sensors to anticipate medical emergencies before they happen.

And should you reach a ripe old age the Addison, the world’s first virtual caregiver, was on hand to turn the home into a fulltime health and wellness environment.

A conversational speech interface including visual, AI and augmented reality Addison appears on media screens throughout a home to provide users with support and is able to monitor vital signs, provide treatment support, medication management and memory stimulation.

Intended to fill gaps in care, primarily for the elderly, the device, from caregiver, was built using Amazon Sumerian that helped to create and run VR, AR and 3D applications.

After 4 days at CES I’d say that whatever the sector or industry every company now appears to be a technology company.
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Neural networks are easy to mislead. Can they be fixed? 

Chris Edwards investigates

In not much more than a decade, deep learning has moved from a research curiosity to a technology that could underpin a new generation of autonomous vehicles and robots: machines that can respond more intelligently to the world they perceive.

Among the examples of how deep learning can work in these systems was a 2011 project at the Swiss research institute IDSIA. The GPU-assisted deep neural network (DNN) could correctly read signs that, to the naked eye, looked completely bleached out. Six years later, University of Michigan PhD student Kevin Eykholt and colleagues put brightly coloured stickers on normal road signs and in doing so fooled a DNN into thinking a stop sign said “45mph speed limit”. A later experiment rendered the stop sign practically invisible to the computer.

The results might have surprised DNN researchers had they not followed a similar profile to those discovered by Christian Szegedy and colleagues at Google in 2013 when they discovered many tiny changes to an image would lead to bizarrely wrong misclassifications. Schools buses turned into birds – but to the naked eye there was no difference in correct and misclassified images.

In a keynote speech at the 2018 Deep Learning and Security workshop Google Brain research scientist Ian Goodfellow said of Szegedy, “He wasn’t trying to break the network, he was trying to analyse it. He thought if you tried to change a schoolbus into an ostrich you would make it grow feathers.”

Szegedy’s work uncovered a key aspect of the way in which DNNs analyse images. They often home in on tiny features that are imperceptible to the human eye. And, as later work by Anh Nguyen, assistant professor at Auburn University, has shown they do not readily separate objects within an image the same way biological brains do. Trained on images of weightlifters, the DNN will readily treat an arm and dumbell as one discrete object.

Although a lot of the demonstrations of the fallibility of deep learning have focused on image manipulation, a number of the researchers investigating how to make AI more robust started with an interest in security and malware detection. One of the earliest applications for AI-like software was in email spam filtering and a major thrust in development now is in intrusion detection that can move beyond simple rules.

Now working at Google, Nicholas Carlini worked on malware detection for his PhD dissertation at the University of California at Berkeley but while taking a break after writing up his research on AI security found a way to break the DeepSpeech voice recognition system published by Mozilla in a matter of hours. “The reason why it took less than two days was because I had been doing this work, looked at the system and thought ‘let’s put the two together’,” he says.

Though Carlini was not able to make the attack work with audio picked up a voice system’s microphone but only on digital files supplied to DeepSpeech directly, a series of tiny manipulations that would only be detected as noise by a human observer made it possible to turn a voice sample into any command Carlini wanted or even to convince the system it heard nothing.

Cat-and-mouse

The cat-and-mouse game discovering and fixing vulnerabilities among software that ranges from voice...
response to network intrusion detection illustrates a problem that many AI systems that take commands from a variety of sources tend to face. The potential targets range from factory-floor cobots to autonomous vehicles, which not only will take image inputs but will have to deal with a variety of sensor inputs while hackers attempt attacks over a network. Would confetti scattered in the path of oncoming cars make them unable to detect stop lights and pedestrians crossing a street? Are there attacks on other sensors that might prevent a robot from stopping before it injures someone or damages itself?

In their report ‘The Malicious Use of Artificial Intelligence’ published early last year, a group of authors from 14 institutions around the world concluded: “We should expect attacks that exploit the vulnerabilities of AI systems to become more typical. This prediction follows directly from the unresolved vulnerabilities of AI systems and the likelihood that AI systems will become increasingly pervasive.”

The problem that faces defenders against the dark arts of AI manipulation is why that work is not well understood. Numerous research teams, mostly working on images, have come up with proposals for dealing with the adversarial examples that upset DNNs. But, as Goodfellow points out: “Quite a lot of those papers get broken.”

A key problem for DNNs lies in their very depth. A typical network can contain millions of parameters. The huge number of dimensions in the model, tend to soften the distinctions between seemingly quite distant classifications. Mainuddin Jonas, a PhD student working in Professor David Evans’ group at the University of Virginia published work last year that shows how it is possible to guide a DNN away from the correct classification layer by layer through numerous small tweaks that push neuronal outputs away from the correct targets. Random noise does not have the same effect.

**Manipulation**

DNNs are not alone in being prone to this kind of manipulation. Even before Szegedy discovered the problems with DNNs, Battista Biggio at the University of Cagliari working with researchers from the University of Tubingen found support vector machines are vulnerable to adversarial examples. Spammers have also taken advantage of similar approaches to defeat filters that use Bayesian classification. Research at Google showed that humans can also be fooled in similar ways if they have only a fraction of a second to view an image.

For those designing robotic systems that use deep learning to provide better information for their control systems, another stumbling block besides high dimensionality is determining ground truth for inputs from the real world. Evans says: “Natural images and audio are inherently ambiguous. The question comes down to how a human will interpret something.”

In robotic control, ideally the system designers want something that outperforms humans: recognising signs of danger long before we would pick it up. Some comfort may come from research on malware detection. Carlini says in principle it is easier to determine ground truth for software behaviour. “I can list the things that I want the program to do. That can be checked. Did it create this file? Yes or no. There is no human perception there. Though it’s somewhat complicated to say what is and what’s not malware, we can always start by defining what is malicious behaviour. And we can find adversarial example that say ‘this is benign’ but is in fact malicious.”

As a result, malware classification provides an appealing domain for AI-security research. But will the experience in domains that offer solid ground truths cross over into areas such as image recognition? “What we’ve learned so far about adversarial malware tends to be specific to the type of malware,” Carlini says.

One way to reduce the ability of hackers to find adversarial examples is to constrain the inputs to the neurons, an approach Evans calls feature squeezing, and so reduce the hacker’s search space for successful adversarial examples. Reworking the input is an technique that Nguyen and colleagues have used. They converted pixel images of handwritten characters to vectorised forms that “purify” the image and remove much of the artificially induced noise.

Another option with images and sound is to enlist the help of a different kind of neural network: a deep generation network (DGN), a technology that became famous for synthesising believable faces and realistic landscapes from minimal information. As a sanity check, the DGN would reconstruct what the input is and what’s not malware, we can always start by defining what is and what’s not malware, we can always start by defining what is and what’s not malware. And we can find adversarial example that say ‘this is benign’ but is in fact malicious.”

In doing so, robots that attempt to process the world as it is may have to synthesise their own models of the world just to check they are not being fooled.
Art Schaldenbrand looks at the importance of being able to effectively simulate analogue production testing

Manufacturing test is an important part of product development and an incomplete test can result in defective parts being delivered to customers. These test escapes - the bad parts that escape test - result in parts being returned especially when target defect rates below one defective per part million (DPPM) are the goal of manufacturers.

There is always an issue to be found and it’s true to say that some applications are particularly sensitive to them.

In addition, test is a significant component of the recurring cost of a product and directly impacts on the profitability of a design. The expense of testers and the time spent testing each die will contribute significantly to the final cost of a product.

Finally, test is also a consideration in winning sockets. The better the quality of the samples delivered for prototype evaluation, the more likely the design of the product will be successful, with the caveat that test development time should not impact the delivery schedule.

Compared to digital design, one of the big differences in the design methodology is how test is addressed by analogue designers. Digital designers have tools to automatically include testability into their designs. This allows them to generate test patterns and assess the test coverage and implications on the additional area overhead. These tools are based on the concept of faults. By injecting faults, the ability of test to identify failures can be analysed and coverage reported. Coverage is the percentage of failures that the test can identify. For digital designers, the concept of faults - stuck-at-low, stuck-at-high, and traditional fault model - are sufficient to enable the automation of test.

**Analogue testing**

Traditionally, analogue testing has focused on the functionality and parametric performance of the die such that the circuit operates as it was designed. As a result, it has been a challenge for designers to apply the concept of faults to analogue design. Faults need to be defined for each macroscopic characteristic of the design - for example, the open loop gain fault, the offset voltage fault, and so forth.

Defining the faults and the failure modes for analogue circuits has proven challenging and difficult to correlate to DPPM. An alternative approach has been proposed, called defect-oriented test simulation. Instead of trying to define faults for every circuit characteristic, the approach focuses on defects.

Defects may be due to issues in the manufacturing process - for example, incomplete etching of the metal that results in shorts between two adjacent metal interconnect lines going over a step.

Defect-oriented testing targets such anomalies in the circuit structure while applying the stimuli, observes their effects on circuit characteristics and assesses the number of defects in the structure that may become detected during production test.

As such, defect-oriented testing does not necessarily replace existing specification-based test. It is rather seen as a means to quantify the effectiveness of a certain test and provide information as to whether action needs to be taken to improve the test quality.

As this methodology has matured, an IEEE P2427 working group has been launched to define a standard for modelling manufacturing defects.
The device under test is a bandgap reference. The first point to keep in mind is that the production test is being simulated. The test bench is based on the load board used in the tester and the test stimulus.

The production test programme consists of five tests:
1. IDDQ, the quiescent power supply current
2. Vout, the bandgap reference output voltage
3. Rout, the output resistance of the bandgap reference
4. PSRR, the power supply rejection of the output voltage
5. Delta Isupply, the change of the power supply current with power supply voltageº

After creating the test bench, setting up the tests, and defining the measurements, the next step in the process is to use the Fault Assistant to define the rules for identifying the defects to be simulated.

For the device under test, we will look for the defects caused by device failures due to junction shorts.

Shown in Figure 2 are the simulation results for the device defects. The test coverage for the test program is high; however, the test misses one defect – namely fault “RB1_F11” in the picture above.

The reason that this defect is not found by the test is that the defect is in the start-up circuit and all the tests are performed on the circuit during normal operation, that is, after the start-up circuit has turned off.

Since the start-up circuit is not active when the tests are performed, it is not found. To achieve 100% test coverage, a new test would need to add a test that measures the circuit during start-up.

Here we have looked at the challenges to consider in the testability of analogue designs, and the significant progress that’s been made in the methodology for simulating analogue test.

Using a simple example of using defect-oriented test to simulate a production test, in order to calculate the test coverage, we’ve been able to demonstrate how a new flow allows analogue designers to evaluate the test program along with the testability of the design early in the design flow resulting in shortened test times – and thus translating into reduced production costs.

Figure 2: Defect simulation test results

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Figure 2: Defect simulation test results

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Many of the key technologies behind advancements in mobile devices, including smartphones, tablets and wearables, are based on the ubiquitous use of light. This does not only include visible light such as display lighting or flash applications.

Gesture recognition, iris scanning or facial recognition are just a few examples of how invisible infrared light can be used in mobile devices. What role can VCSEL technology (vertical-cavity surface-emitting laser) play in this space?

First, what is VCSEL? A VCSEL is a semiconductor-based laser diode which radiates the light vertically to the surface of the semiconductor chip, as opposed to edge-emitting laser diodes, where the light exits at the edge of the chip. As a surface mountable component, VCSEL combines the characteristics of a LED with those of a laser. VCSEL technology has been established and matured within the datacom industry, serving in data infrastructure links for more than 15 years.

The technology can also be used as an array – a composite of several hundred or even thousand VCSELs – for example a chip with 500 apertures of 1 mm x 1 mm, glued and bonded like a normal LED.

VCSEL use in biometrics
Biometrical user identification methods are the most reliable and secure access options that are currently available. They are an alternative to complex password management tools for mobile device security, access control, and increasingly authentication for mobile payments and other transactions. The need for these solutions is driven by users increasingly managing all aspects of their digital lives via their smartphone and other mobile devices which accelerates the development progress.

Biometrics make use of human characteristics, such as specific structures within the iris, facial features or fingerprints. Sensors identify these characteristics and compare them with previously stored biometrical data. In order to function reliably in mobile devices, infrared light is required to illuminate the target area. This technology was already being used in access control systems, with most countries using it for immigration purposes. But with a growing miniaturisation of infrared LED technology the adoption in mobile and consumer devices has been gaining speed. Now VCSEL technology is complementing infrared solutions enabling the utilisation of these applications in a wider market.

New application fields
VCSEL technology is not a new invention, but has been used previously for data communication. Recently, a multitude of application opportunities in different markets have been identified. The decisive features of the surface emitter are the lower production costs compared to edge emitters and the superior beam quality but lower output power.

VCSEL technology is primarily used for application fields like smartphones, drones and Augmented
and Virtual Reality (AR & VR) devices where high-speed modulation is an advantage. 3D sensing applications such as facial recognition, especially for consumer devices, are viewed as key market drivers.

LEDinside anticipates that the global infrared laser projector market for mobile 3D sensing is forecast to grow to around $1.9 billion by 2020.

**VCSEL operating principles**
The beam shape of a VCSEL is a circular spot, compared to the elliptical shape of FP-EEL (Fabry-Perot Edge Emitting Laser) and DFB (Distributed Feedback laser diodes). The optical resonator of a VCSEL array is only 4 µm, compared to approx. 600 – 1200 µm for FP-EEL (depending on the optical power) and 1000 – 2000 µm for a DFB (depending on the optical power).

Compared to the temperature sensitive wavelength of an FP-EEL, VCSELs suffer way less wavelength shift under the influence temperature changes.

VCSELs can be modulated with high frequencies, making them useful for optical fibre communications.

In addition to the high beam quality of low-power VCSELs, an important aspect is the low beam divergence, compared with those of edge-emitting laser diodes, and the symmetric beam profile. This makes it easy to collimate the output beam with a simple lens, which does not have to provide a very high numerical aperture.

Much higher powers can be generated with VCSEL arrays. A VCSEL array with many thousand emitters (with a spacing of some tens of microns) can emit several tens of watts continuous-wave.

The effective beam quality is, strongly reduced in this case, as the emission comes from a larger area while the beam divergence equals those of a single emitter (which is, although still substantial, smaller than for an edge-emitting laser).

Such devices can generate high output powers with a high wall-plug efficiency and thus compete with diode bars and (combining multiple arrays) even diode stacks based on edge-emitting semiconductor lasers. Their emission linewidth is very small, and the emission wavelength has a lower temperature dependence than those of a conventional laser diode. Quite high peak powers are possible in pulsed operations with nanosecond to microsecond pulse durations.

**Mobile 3D sensing**
Current solutions for mobile 3D sensing include structured light and time of flight (ToF). One of the most recent smartphone models uses structured light with its dot projector producing several thousand dots of infrared lights on the face. Then the infrared camera receives the light reflected back from the face to create a 3D facial landscape.

Additional application fields include autofocus and proximity functions in cameras, especially in smartphone cameras. 3D sensing is also being integrated with AR and VR – for smart glasses or future smartphones and other mobile devices, including drones.

Due to its broad range of advantages such as a very small footprint, relatively low costs, optical efficiency, low power consumption, wavelength stability and high modulating rates, VCSEL technology could be key for a wider adoption of applications such as 3D sensing in the mass market.

Although the technology offers many advantages compared to existing technologies, it is not the best solution for all segments. It should therefore be viewed as an expansion of infrared and other light-based technologies. In order to help customers and clients choose the best suited solution for each application field, leading providers of optoelectronics components are looking to complement their infrared technology portfolios with a growing number of VCSEL solutions.

VCSEL technology can be used in numerous applications including a wide range of markets for end customers. The technology is primarily deployed for application fields where high-speed modulation is an advantage – like cameras or biometrics.

There are already first application examples with VCSEL available in the consumer mobile device segment.
As more and more consumers look to film their experiences and share short-form videos through their mobiles, it’s fair to say that while camera technology has continued to advance, the audio quality of many videos has tended to remain poor.

“Audio technology on consumer devices just hasn’t kept pace with the innovation we’ve seen in video and image capture,” suggests Paul Melin, VP of Digital Media at Nokia, “and we think that it’s about time that changed.”

Melin believes that customers are keen to ‘elevate’ the quality of the audio experience and to that end Nokia has developed ‘intelligent audio’ that, “can dynamically target and track the desired source of sound. It provides a tremendous opportunity to enhance the user experience and to enable person in a scene where people are talking or playing an instrument.

“The technology is able to capture and deliver a natural sound experience within one degree of accuracy, similar to how the human ear works. It can reduce distracting background noise and captures sound, it can adjust the audio to a specific part of the screen and select what matters. OZO also allows users to maintain audio focus on moving people or objects and automatically follow a sound source with audio focus parameters controlled by object recognition.

“AI has a big role to play in mobile audio and with OZO audio it is possible to teach the software to understand the scene being shot and make more intelligent decisions as to how to control and direct the audio.”

OZO audio is the company’s first licensed technology.

Nokia is bringing spatial audio to mobile phones without requiring hardware and design adjustments. By Neil Tyler

"Audio technology on consumer devices just hasn’t kept pace with the innovation we’ve seen in video and image capture.”
Paul Melin

"Spatial audio enables consumers to capture true to life sound that accurately reflects the original event by using multiple microphones to record the depth, direction and detail of sound,” Melin contends. “It is an industry-leading solution for capturing high quality audio on consumer devices and can work with as little as two microphones.”

Melin believes that the opportunity to bring spatial audio to a broad range of smart phones is a great opportunity and, crucially, the company’s intelligent audio does not require hardware or design adjustments.

“Because Ozo is a software-based technology and not reliant on specific microphone configurations or placements, there are very few limits when it comes to what cell phone or camera hardware can use it, which means that virtually any manufacturer can license the software from the company for improved audio,” he explains.

Melin believes that the use of intelligent audio, imaging and video technologies will completely transform the way in which people capture and share their experiences.

“This includes 360 video and other immersive formats. Using AI and machine learning to automatically create richer experiences in familiar formats will now be possible without having to put hours into editing images or videos,” he suggests.

“Consumers want the sound in their videos to be just right, and they want to be able to focus not only on the relevant audio sources but suppress unwanted noise.”

OZO audio recordings support the most common audio formats in use, like stereo AAC, so it will be possible for users to share content or post videos on social media and, crucially, no special playback equipment is required.

“OZO audio is a much more immersive and engaging experience and I believe it takes user generated content to a new level where the audio finally stands side-by-side with the pictures,” Melin concludes.
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Practical Security for the IoT

As more IoT systems are deployed so it becomes critical that TCP/IP communications are made secure, as Trevor Martin explains.

As an increasing number of IoT systems are being deployed one of the key enabling technologies has been the Message Queued Telemetry Transport (MQTT) protocol from IBM. MQTT is an easy to use publish and subscribe architecture with open source servers and client such as the Mosquito server and Paho embedded client.

However, many early systems have been designed without any form of communications security, sending unencrypted data packets which are easily intercepted and decoded.

An important design rule for modern cryptographic systems is called "Kerckhofs principle" this states that "the security of the system must depend on the secrecy of the key not the secrecy of the algorithm". This means that you should only use well researched and trusted algorithms rather than a secret proprietary system. As engineering professionals, we should resist any governmental attempts to restrict research or the weakening of algorithms under the auspices of law enforcement.

The strong advice is to use only well tried and trusted algorithms and a widely used source code library that is actively supported. This has generally meant using an open source library such as open-SSL. However such a library is not suitable for a small constrained device like a microcontroller. Here we have a much better option in the form of a cryptographic library called mbed-TLS. The mbed-TLS library has been specifically developed as a highly modular minimal footprint library for small embedded systems.

The mbed-TLS library was originally developed as a commercial library called Polar SSL. In 2015 Polar was acquired by ARM and the Polar SSL library was incorporated as the security component within ARM’s Mbed IoT platform. The Polar SSL library was then renamed as mbed-TLS and made free for commercial and non-commercial use available under either an Apache V2.0 license or GPL v2 license.

A cryptographic library needs to provide a range of security services to enable us to design a secure system. The most obvious of these services are ciphers to ensure confidentiality of user data. While a range of ciphers are supported the current best practice is to use the Advanced Encryption Standard (AES). We also need to ensure the integrity of the data and this is done with hashing algorithms and in particular the family of Secure Hashing Algorithms (SHA) published by the US National Institute of Science and Technology (NIST).

The original SHA-1 algorithm is no longer recommended for use and any new system should use SHA-2 as a minimum. We also need to provide non-repudiation, if a message is sent we need to be sure of who sent it. If two users can agree a password in advance, then we can use a Message Authentication Code (MAC) this will agree both the integrity and origin of the data. It is also possible to sign messages with public key cryptosystems. This is particularly elegant in the RSA system but there are also dedicated systems such as the Digital Signature Algorithm (DSA).

Random number generation

One of the corner stones of many security protocols is a cryptographically strong random number generator. A typical system will work by gathering true random data (entropy) into an entropy pool. This process is often too slow for real time communication so the random values in the entropy pool are then used as seed values for the pseudo random number generator.

While the mbed-TLS library provides a range of pseudo random number generators, support for gathering random values into an entropy pool is up to the designer.

So how do you know if you have a good enough random number generator? Fortunately, there is a Statistical test suite available from the US National Institute for Science and Technology which has fifteen...
tests which can be used to qualify your random number generator.

In addition to a wide range of cryptographic algorithms the mbed-TLS library includes a set of abstraction layers which provide a high-level API for each security service. This allows you to develop a system for example a range of ciphers are installed while a common API is used to select a cipher algorithm from the suite installed and then use the abstracted API to encrypt and decrypt data regardless of the underlying cipher algorithm.

Most of the major silicon vendors now provide Cortex-M based microcontrollers which include a cryptographic processor. Typically this cryptographic processor will provide a hardware implementation of symmetrical ciphers, Hash and MAC algorithms.

The mbedTLS library provides a series of software hooks which can be enabled to use a hardware cryptographic processor in place of the software algorithm.

As its name implies the mbed-TLS library is designed to support the Transport Layer Security protocol. A key part of the TLS protocol is negotiation of a session key using public key encryption. The most widely used public key cipher is the RSA asymmetrical cipher. While this is supported by mbed-TLS it is not the most suitable system for a small microcontroller because of very large key sizes and computational effort required. Fortunately, there are alternatives to RSA such as Diffie Hillman key agreement which can be realised using elliptic curve cryptography.

The use of an elliptic curve in place of a linear number line reduces the required key size and overall computational effort. To achieve the same level of security as the AES cipher with a 128 bit key requires the RSA system to have a key size of over 3000 bits while an elliptic curve implementation of the Diffe Hellman system requires a key size of just 256 bits. The simple take away here is to use elliptic curve cryptography where possible.

During the initial TLS handshake the public keys of the participants are exchanged in the form of X.509 certificates. A certificate consists of user data stored in a format called “Abstract Syntax Notation 1” (ASN.1) and uses a set of “Distinguished Encoding rules” (DER) which ensure that there is exactly one way to encode the certificate data. Once created the DER binary data is then converted to base 64 and stored as ASCII characters in a Privacy Enhanced Mail (.pem) file. If you are running your own website it is necessary to generate your own certificate and have it signed by a trusted certificate authority. However, if you are designing your own closed system it is possible to create and manage your own certificates. The mbed-TLS library contains both source code and command line tools to create and read X.509 certificates.

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Another useful tool is XCA. This is an easy to use windows or OS X application that allows you to create sign and manage your own X.509 certificates and is extremely useful during development or managing small scale systems.

All of the cryptographic algorithms used in the TLS protocol have been designed for general purpose computers such as PC’s and servers and as such they are not ideal for small microcontrollers. In 2013 the NSA release two new families of block ciphers called Simon and Speck.

These ciphers were specifically designed for very constrained devices which would typically be user as nodes in the internet of things.

The ‘Speck’ Cipher is designed to be a software implementation while the ‘Simon’ cipher has been optimised for hardware implementations. Currently there are reference implementations available and it is planned to add both ciphers to future releases of mbed-TLS.

The mbed-TLS library is primarily concerned with secure communications and is part of a wider security initiative from ARM. The ARM Platform Security Architecture is a framework designed to enable developers to analyse security threats then design and implement an appropriate architecture.

While this is fairly new it will be available to compliment the new generation of ARMv8-M (Cortex-M23 and Cortex-M33) microcontrollers featuring the Trust Zone security technology.
Scientists are trying new ways to push beyond the limits of electrical biosensing, as Chris Edwards explains

Since Galvani discovered the effect of electricity on frogs’ legs more than two centuries ago, scientists have gradually been able to tune into what the body’s nervous system is doing through charge transfers.

Wilder Penfield’s experiments in the early 1950s with electrical neural stimulation helped map areas of the brain for the first time. The homunculus who appears in biology textbooks, showing which parts of the brain are responsible for touch, smell, taste and movement, was the result of this work.

Although these early experiments helped elucidate much about the way in which the brain works, the methods for interfacing electronics to biology have not advanced quickly. A major problem is that electrical stimulation and recording from outside the cells is a blunt instrument for picking up what is happening at a cellular level. In the watery environment of the body, electrical stimulus can easily interfere with multiple cells at a time and sensors get an extremely blurred picture of what is happening to the cells around them.

Focused or laser light can provide a more precise way to stimulate cells and also to read data from them. Potentially light can also show changes in activity not just per cell but as signals move through the cell and onto neighbouring synapses. But it has a major drawback: it only works on cells that have been genetically modified to produce and react to light. Used on cells in culture and modified test animals, optogenetics proved invaluable for scientists who want to see how neurons in culture communicate with each other. Recent advances in identifying light-emitting proteins, such as a project at MIT led by associate professor Edward Boyden that analysed 1.5 million variants of one promising proteins, is helping to increase the resolution of the photon signalling to track changes within neurons and synapses.

When it comes to dealing with live patients, electrical stimulation and measurement remains the primary mechanism and, despite the low resolution, has led to the point where brain-computer interfaces let people with severe spinal injuries gain control of artificial limbs. They may, in time, provide a way to bridge severed connections and reconnect organic limbs to the brain’s signals. One of the reasons why brain-computer interfaces work is that the brain itself adapts to their presence. Through lengthy training, patients can direct activity to the array of neurons closest to the probes that result in useful movement. But the technology remains some way from being able to decode brain activity directly without relying on the ability to train the user.

Integrated silicon sensors

In terms of probe resolution, highly integrated silicon sensors with multiple electrodes across their surface is increasing precision.

Research institute Imec made its Neuropixels probe available to neuroscientists late last year. The probe has 384 dual-band recording channels that can be picked from almost a thousand conductive electrodes tiled across the 10mm-long flat, square tip. In principle, the probe will make it possible to record signals from hundreds of neurons that touch its surface and is light enough to support experiments with freely moving animals.

For the kind of resolution needed to detect neuronal activity in humans, light may still provide an answer. One method is to employ gene therapy on the recipient, though this comes with serious ethical challenges. Neurons in the vicinity of an injection can be infected using a carrier virus that inserts the genes used to create light-emitting proteins. An alternative is to employ infrared light to stimulate neurons, a technique…
discovered by scientists at Vanderbilt University at around the same time that optogenetics became a practical tool for research.

As well as helping to improve on the resolution of electrical measurement, the technique offers enough accuracy to map nerve impulses with applications in neurosurgery to help guide incisions when removing tumours as well as connecting prostheses to nerve endings. The main challenge is to find a way to miniaturise laser arrays to the point where they can interact with groups of neurons in a living brain.

In the past few years, sound has emerged as another potential way to stimulate and suppress neuron activity. Experiments showed it was possible decades ago, but they used damagingly high levels of ultrasound. William Tyler of Arizona State University working with colleagues at Johns Hopkins found low-intensity ultrasound can control neurons and map their activity to reasonably high precision with less risk of damage, mainly through self-heating, although the scientists caution more work is needed to test the systems. A key potential advantage of the technique is that the probes need not penetrate the skull; they can lie on the surface of the skull. But there are a number of obstacles to overcome to get the required level of focusing from speaker arrays and to work out whether the technique is, indeed, safe.

**Working like cells**

Ken Shepard’s group at Columbia University is taking a different approach to bio-interfacing by extending the usable signals beyond light or electrical impulse. It is one that could be used with the wide variety of cells that grow in the body. Rather than focus on instrumenting biological cells using electrical signals, this work makes electronic devices work more like the cells themselves. It is an approach that recognises the way in which most pharmaceutical drugs work. They interact with the proteins that are embedded in the soapy “lipid” membrane that coats each cell.

Lipid membranes are incredibly flexible although if stretched too far they will burst. But that flexibility provides the ability to have a wide variety of proteins form pores over the surface of the cell. Many of them are ion channels: specialised pincer-like proteins that open and close to drag in or expel specific ions, such as sodium or potassium. It is these ion channels that are mechanically controlled in recent experiments with ultrasound. As the particles that pass through the channels are charged, their flux can be converted to electrical signals that solid-state sensors are able to use.

From a modelling standpoint, the ion channels behave in a similar way to transistors. Some biological systems have molecular amplifiers that can apply gain: one protein signals to others in the membrane to convey much larger quantities of ions than the first protein would be able to do on its own. Artificial membranes with embedded ion channels can deal with biological signals directly rather than trying to sense electrical currents crossing biofilms.

Construction is difficult as the interface between the biological membrane and the electronic systems needs to offer extremely high impedance to limit leakage as well as very low capacitance to support realistic signal bandwidths. Currents are so low that leakage is a major obstacle. However, such an interface can even be used to supply energy to an electronic system.

In a 2015 experiment, Shepard’s group used the technique to harness the cell’s own energy source, the molecule adenosine triphosphate (ATP). Proteins liberate energy stored in the bonds of this molecule by lopping off phosphate groups. Ion channels in the experimental membrane provided low levels of current to a charge pump and a group of ring oscillators.

Although biopowered sensors are attractive for smart drugs and sensor implants, applications for the membranes seem more likely to turn up in electronic systems that exploit biological proteins to increase the accuracy of sensors. For example, by embedding a variety of different ion-channel proteins in the surface, it should be possible to build taste and smell sensors that react in a similar way to those found in mammals.

In principle, it would be possible to construct electronic noses that have the sensitivity of those found in dogs. However, such a device would involve finding a way to recruit the much more complex groups of ion channels found in mammals.

In the short term it will be easier to target channels that identify specific molecules.

Although it has taken decades to reach this point, the recent discovery of multiple techniques for accessing the information processed by biological cells promises to speed up the process.
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Managing power sequencing

Rich Micron explains how engineers can best control startup and shutdown power sequences in their designs

Microprocessors, FPGAs, DSPs, analogue-to-digital converters (ADCs), and system-on-chip (SoC) devices typically run from multiple voltage rails. To prevent lock-ups, bus contention issues, and high inrush current, designers need these power rails to be started and shutdown in a specific order in a process known as power sequence control or power sequencing.

Some designs may necessitate different sequences, but in any case, proper power-up and power-down sequencing is necessary.

The various power sequencers, monitors and supervisors that have emerged to provide effective ramp up and shutdown have also adopted techniques to monitor voltage and current levels to calculate power levels in protect complex integrated circuits and sub-assemblies.

FPGAs and similar complex ICs are broken down internally into many power domains which require a specific order when starting up or shutting down the device.

The core typically comprises the processor and logic foundation of the FPGA. This domain is characterized by a low voltage and high current power profile. Due to the extremely low voltage, there are very high accuracy requirements, and due to the dynamic nature of the digital load, transient performance must be excellent.

Auxiliary circuitry comprises the noise-sensitive analogue circuits in an FPGA, such as phase-locked loops (PLLs) and other analogue circuit elements. Current requirements are reasonably low, but ripple voltage is a major concern and must be minimised to avoid excessive jitter and phase noise in PLLs.

Starting up the power supplies for each domain in the incorrect order can cause problems and can result in damage to the FPGA. Consider that the I/O section is based on transmitting and receiving data on a tristate bus. The I/O control is handled by the core. If the I/O domain is powered on before the core, the I/O pins end in indeterminate states. If the external bus components are powered up, there may be bus contention resulting in high currents in the I/O drivers. As such, the core should be brought up before the I/O domain.

Similarly, devices like power operational amplifiers have two power domains: the analogue and the digital. The digital supplies power to the amplifiers’ diagnostic status flags for over-temperature and overcurrent states and supports the amplifier enable/shutdown functionality. The device specification requires that the digital domain be powered up prior to the analogue supply so that these status flags are functional before the analogue domain is powered on. This is to prevent possible damage to the device.

Power sequence methodology

There are three common types of multi-rail sequencing (Figure 1). The most common is sequential where one supply rail is turned on first, followed by a delay before the next rail is turned on. The delay is set so that the first rail reaches regulation before the second rail is started.

The second is ratiometric. Here, the rails start up at the same time and reach their rated voltages at the same time. This requires that the rise time of the rails be proportional to the rail voltage in order to achieve regulation at the same time.

Some devices may not tolerate the instantaneous voltage differences occurring before regulation is reached and can lead to the device drawing higher current from one supply during this period.

The third approach, simultaneous startup, minimises instantaneous differences in voltages. A common way of implementing this method is

Figure 1: Diagram of three techniques for sequencing power supplies

Figure 2: Simultaneous startup of 5 volt and 3.3 volt supplies is accomplished by daisy chaining the regulators

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Simultaneous power up, in which the voltage rails rise together and at the same rate, with the higher rail, usually the I/O voltage rail, continuing after the lower or core voltage rail has reached its final value.

Regardless of the technique, the voltages must rise monotonically. Failing this, the device may not initialise correctly due to an unexpected drop in the voltage.

A soft start may be applied to limit inrush currents during startup. This practice limits the current during startup, permitting gradual charging of the capacitance of the power rail on startup.

Power supply shutdowns are generally specified to occur in the reverse order from the startup.

**Power supply sequencing examples**

Simultaneous startup is relatively easy to setup. The highest voltage output is connected to the input(s) of the lower voltage regulator(s) (Figure 2).

In this example the higher voltage is the 5 volt supply. This is fed into the 3.3 volt regulator as well. The 5 volt and 3.3 volt outputs are shown as they rise simultaneously with a minimum voltage difference up to the regulation point of the 3.3 volt supply.

The sequential technique is best implemented using a sequencer integrated circuit e.g. the LM3880 from Texas Instruments. The LM3880 can control multiple independent regulators or power supplies using their enable inputs.

The LM3880, when enabled, will sequentially release its three output flags with individual time delays between the flag. This will permit the connected power supplies to start up. During shutdown the output flags will follow a reverse sequence.

A design example using the LM3880 is shown using TI’s WEBENCH Power Designer software (Figure 3). This free software tool helps the engineer design power related circuits providing schematics, bills of materials, and simulated results. The figure shows the schematic and charts, the enable, and the three flag outputs.

The delay times and sequence order in the LM3880 are fixed, but are factory customisable using the built-in EPROM.

A slightly more sophisticated power control device is the LTC2937 from Analog Devices. Like the LM3880, it can control the order and time delay of up to six power supplies or regulators (Figure 4).

In addition to sequencing up to six power rails, it also monitors the voltages on those rails to detect over voltage, under voltage, drop outs and stalled power startups. In the event of a fault, the device can be programmed to shut down or restart the supplies. Error conditions are logged to internal EEPROM.

The LTC2937 can be programmed and controlled via I2C or SMBus. Programming is supported by Analog’s LTpowerPlay GUI software. The EEPROM allows autonomous operation without software. When a system requires more than six power rails, multiple LTC2937’s can be chained together to control as many as 300 supplies.

For complex multicore processors, FPGA’s, and other SOC devices, Texas Instruments provides the TPS650860, a configurable multi-rail power management unit.

This single IC, with an input voltage range from 5.6 to 21 volts, contains three step-down controllers, three step-down converters, a sink or source low dropout (LDO) linear regulator, three low voltage input LDOs, regulators, and three load switches.

This device has 13 regulated outputs to supply the needs of the FPGA or other load device.

The buck converters include a built-in power stage, while the buck controllers require an external power stage. Both converters and controllers have integrated voltage sensing inputs to monitor the supply outputs, which can be controlled for sequencing.

The load switches include slew rate control, permitting programming of the rails associated with these switches for any of the three sequence types, sequential, ratiometric, or simultaneous.

The TPS650860 is controlled via an I2C interface allowing simple control either by an embedded controller or by an associated SoC manager. This power management IC offers leading-edge control flexibility.

There are multiple methods to control the order of power startup or shutdown varying from very simple to very intricate. These differ in the number of rails controlled, precision, and range of control functions, as well as the cost.

![Six Power Supply Sequencer and Controller](image)
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**Eaton's XLR-48 supercapacitor module**

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**Lattice Expands Ultra-Low Power sensAI Stack**

Lattice Expands Ultra-Low Power sensAI Stack with Optimized Solutions for Always-On, On-Device AI  
CNN accuracy with flexible milliwatt FPGA solutions; New reference designs for human presence and hand gesture recognition with scalable performance/power  
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- Enhancement to CNN Accelerator IP for ECEP® FPGAs with up to 2x increase in DRAM memory bandwidth, for improved performance in smaller devices  
- New hardware platforms, reference designs, and demos showcase scalable performance and power optimized for always-on, on-device AI applications  
Lattice Semiconductor Corporation (NASDAQ: LSCC) today unveiled expanded features of the company’s popular Lattice sensAI™ stack designed to speed-to-market for developers of flexible machine learning on consumer and industrial IoT applications. Building on the ultra-low power [1 mW/W] focus of the sensAI stack, Lattice is releasing new IP cores, reference designs, demos and hardware development kits that provide scalable performance and power for always-on, on-device artificial intelligence (AI) applications.

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**Nexperia and Avnet Celebrate 50 Years of Success**

Nexperia and Avnet Celebrate 50 Years of Success  
Two industry leaders deliver performance and quality  
Nexperia, the global leader in discrete, logic and MOSFET devices, and global technology solutions provider Avnet, which supports customers from idea to design and from prototype to production, today announce celebrating a half century of successfully working together with strong results.  
The initial engagement started in 1968 when Avnet added Signetics as one of its first franchises. Signetics was subsequently bought by Philips and became NXP in 2006. More recently, the same products division of NXP has emerged as a separate company, Nexperia, becoming a dynamic force in discrete, logic and MOSFET devices. Nexperia is serving global markets, delivering components at high volume to automotive, mobile and other markets that demand the highest efficiency, quality and performance.

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**OMC introduces new FDH36 rugged bulkhead housing**

OMC introduces new FDH36 rugged bulkhead housing for fibre optic transmitters and receivers with ST connector  
Suits industrial, automotive and mass-transit applications  
OMC, the pioneer in optoelectronics design & manufacture, has announced its new FDH36 rugged bulkhead-mount housing for fibre optic receivers and transmitters. The new device incorporates an ST connector and has been developed as the ST version of OMC’s popular FDH16 transmitter and receiver housing. The robust design of the FDH36 helps it withstand the harsh operating environments often found in industrial, automotive, mass transit and similar applications, including off-road vehicles.  
The new FDH36 consists of an all-metal, rugged turret design with a square base flange. The flange features mounting holes in each corner and is designed to bolt down firmly to the bulkhead, helping to ensure a robust and secure fix. As well as offering greater physical resilience than plastic housings, the FDH36’s metal construction also helps with screening against radio frequency interference.

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**Sloping Front Instrument Enclosures**

METCASE Launches Sloping Front Instrument Enclosures  
METCASE has added new sloping front versions of its advanced TECHNOMET aluminium table-top enclosures. TECHNOMET SL is designed for applications including medical and laboratory instruments, test and measurement, industrial control and communications.  
These smart and modern cases are supplied fully assembled and feature an 18 degree inclined front bezel which provides a perfect viewing angle of the controls and displays.  
The cases also feature snap-on trims which hide all the fixing screws, internal PCB mounting pillars, ventilation slots in the base and rear panel, and four moulded non-slip feet. Recessed side handles allow easy portability.  
TECHNOMET SL can be supplied fully customised on request.

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**PXI RTD simulator modules from Pickering Interfaces**

PXI RTD simulator modules from Pickering Interfaces  
Cost-effective, high-accuracy PXI RTD simulator modules from Pickering Interfaces features simple programming control  
Flexible, scalable units are easy to use  
Pickering Interfaces, a leading provider of modular signal switching and simulation products for electronic test and verification, today launched a model 40-263 PXI RTD simulator module range that provides a cost-effective method of simulating PT100, PT500 or PT1000 RTDs (resistance temperature detectors) with high accuracy. The range supports 4, 12, 16, 20 or 44 channels in one or two PXI slots with channels able to be set as short or open circuit to simulate faulty wiring to a sensor.  
The modules are available with resistance ranges of 4Ω to 900Ω for PT100 simulation, 20Ω to 450Ω for PT500 simulation and 400Ω to 900Ω for PT1000 simulation. All versions are suitable for simulating a temperature range of approximately -50°C to +85°C for their given sensor type. The use of resistance value calls makes programming simple.

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Mouser Electronics, Inc., the industry’s leading New Product Introduction (NPI) distributor with the widest selection of semiconductors and electronic components, stocks the full line of gallium arsenide (GaN) modules from Texas Instruments (TI).  
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