Special Edition | 10.2016
WinWin

AUGMENTED INNOVATION

The mix of machine and human intelligence that will take us into a Better Connected World

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Augmented Innovation: A new dawn of creativity and productivity

A smart world is a connected world. And the time is fast approaching when ubiquitous connectivity will springboard the most advanced nations into the stage of Augmented Innovation – a time when the combined capabilities of machines and humans will create amazing gains in productivity that neither can achieve alone.

Complete data sets and the ability to action this data will have an unprecedented effect on life. As devices increasingly serve as gateways to massive cloud computing power, innovation will be within the reach of all.

No one will be excluded, because everyone will be connected.

Five technology enablers are the key to unlocking the door to this hyper-connected stage of Augmented Innovation: broadband, data centers, cloud services, big data analytics, and the Internet of Things (IoT).

These tech enablers will not only forge a better world in their own right, they will also work in concert to provide the bedrock for artificial intelligence (AI) to flourish and impact every aspect of life.

AI is already everywhere – in our hands as mobile assistants; before our eyes as machine-written news; in our cars as driver assistance functions; and in our banks, protecting our finances. The list goes on.

Advances in computer vision, natural language processing, machine learning, and robotics are as fascinating as they are far-reaching, each promising spectacular applications in real life, from advanced virtual assistants and driverless cars to mind-controlled prosthetic limbs and individualized, data-driven health and education programs.

However, to avoid another cycle of excitement and disappointment that has previously led us into two AI winters, we must approach AI with a clear and realistic mindset that recognizes how complex it actually is.

AI must be designed for practical application that's human-facing and makes life better. It must be developed in a collaborative and open environment where robustness is built in, not bolted on, and where forethought ensures responsible application with the betterment of humanity at the core.

The interplay of Augmented Innovation and AI will be seen in connected cities that are safe and smart, and it will equip every vertical with the tools to thrive in the digital age and deliver truly personal services for markets of one.

Connectivity is at the heart of Augmented Innovation. Augmented Innovation – the mix of data-driven machine intelligence and insight-driven human intelligence – will transport us into a Better Connected World.

Sally

Sally Gao, Editor-in-Chief

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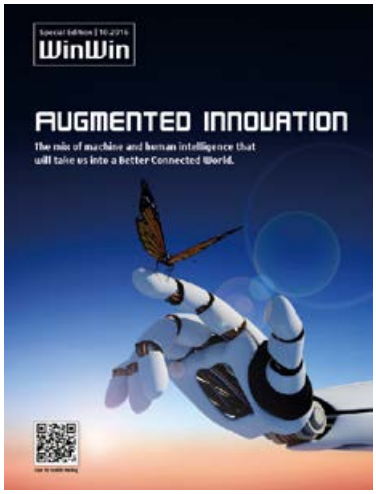

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GETTING AUGMENTED

KEY AI FIELDS

In the world of tomorrow, robots and artificial intelligence (AI) will play an increasingly important role. At this year's Global Mobile Internet Conference (GMIC), the movers and shakers of the industry took to the stage to set out their visions of the future of robotics and AI.

AN EYE ON AI

"It's likely to be either the best or worst thing ever to happen to humanity," warned physics legend Professor Stephen Hawking last year. AI will be an overwhelming force for good, but humanity must approach it responsibly.

A survey in 2013 by Vincent C. Müller and Nick Bostrom asked hundreds of scientists when they believe machines will achieve artificial general intelligence (AGI), meaning human-level intelligence. Although scientists' predictions vary, there are still many challenges to reaching human-level intelligence.

SMARTER & SAFER

The 21st century is the century of cities, with the urban population predicted to grow from 54 percent of the global population in 2014 to 66 percent in 2050. ICT enablers and AI will make cities safer and smarter than ever before. But, there are various steps that need to be taken to reach that stage.

GETTING AUGMENTED

The world's economies are turning digital and the age of Augmented Innovation is coming. We're not there yet, but ICT and AI are turning the key and the door is opening.

Connectivity

The heartbeat of a Better Connected World

By Cao Zhihui

IT has taken us from the industrial age to a digital age where networks and data are becoming a new factor of production alongside land, capital, and labor. In the fully connected age of Augmented Innovation, networks combine physical and virtual digital connections, ramping up the value both create.

The heartbeat of humanity will soon be as much digital as it is physical. Our cyber heartbeat – a unique multidimensional identifier of our online presence – will be with us for life, like its physical equivalent.

Mobile Internet is emerging as a game changer for billions of people, both at work and at home. People are flexing their personal financial muscles with e-commerce, while phone apps mean that things like clothing, food, accommodation, and transport are just a few taps away.

Connectivity has become a basic human right.

Better connected enterprises

In this connected world, enterprises will

By 2020, the world will have >>

100 million
gigabit broadband users

$236 billion
public cloud services market

$70 billion
AI industry value

focus on their strengths, which they'll deliver as services, and outsource their weaknesses.

Future enterprises will be borderless, digital, and global from the get-go. Cloud services under hybrid solutions designed for each vertical will boost innovation, collaboration, and efficiency.

Banking, the leading ICT adopter of all verticals, will evolve to Bank 3.0, where customers and not providers will decide what services are offered. ICT systems won't be just a support tool for bank operations, because they will take place in the cloud.

Telcos will establish digital ecosystems and develop new business models that support everything as a service (XaaS) on virtual infrastructure, platforms, and cloud data centers that enable E2E service and resource management.

Better connected nations

The world isn't lacking ICT strategies, with ITU reporting that 148 were in place around the world as of 2015. These include China's Internet+, Germany's Industry 4.0, Industrial Internet in the US, Digital Malaysia, Indonesia's broadband plan, Smart City in the Netherlands, and Smart Nation 2025 in Singapore.

Broadband standards are being redefined globally, and today more than 50 carriers across the globe offer gigabit broadband services. By 2020, all European families will have access to broadband at speeds of at least 50 Mbps.

Better connected economies

A better connected economy will have six key features:

- Real-time, precision matching of demand and supply
- Efficient resource utilization
- Real-time data collection and remote data processing
- Better quantification of data's value, which will end the dominance of money as the sole medium of exchange
- Old economic silos will break down as innovation crosses industry boundaries

- User needs will be defined at the individual level, making mass production obsolete

Better connected tech

The ICT industry will transform in five main ways:

Better devices that are personal and connected

Wearables that work seamlessly across platforms for things like health and fitness, micro-payments, and ambient awareness will cut the user-device distance to zero. Smart homes with open ecosystems will make isolated devices a thing of the past and create value like never before, especially with software development kits available to anyone with a creative brain. Digital natives, the middle-class, and women will be setting the bar high for vendors, and personalized demand will be the order of the day.

Better networks that are tailored to scenarios

Applications for different verticals will need different levels of network connectivity. Smart meters and smart buildings, for example, need power-lite, low-cost solutions for deep indoor coverage, while the Internet of Vehicles and smart transport will need wide coverage, low latency, and high mobility. Industrial control systems will demand super high-density connections with ultra-low latency.

5G will support 100 billion connections, 1-ms latency, and 10 Gbit/s speeds. SDN/NFV will help carriers establish agile, open, and flexible network architecture. Management systems will give a global view where resources can be deployed on demand

and consumers can purchase exactly the services they need.

The user experience will be ROADS: real-time, on-demand, all-online, DIY, and social.

Better platforms in elastic clouds

With extended functions that support entire business processes, from planning and design to development, cloud will drive ICT investment and underpin tech from driverless cars to AI. Enterprise investment in cloud will be the norm, because cloud can centrally provide services and share massive data, storage, and computing resources.

Telcos will provide enterprise customers with the hybrid cloud services they need to stay competitive over the long term. Demand for cloud data centers will grow fast with the widespread adoption of massive data storage, online analytics, and cloud services. By 2020, investment in cloud-based, IT infrastructure is expected to exceed non-cloud IT investment, meaning that cloud will soon be the primary facet of IT infrastructure.

Better ecosystems that are open and shared

Enterprises can no longer succeed alone. In the stage of Augmented Innovation, collaboration across an open ecosystem will create better products, and ecosystems will evolve from semi-open or alliance-based entities into fully open, fully shared platforms.

API platforms will allow ICT companies to share and monetize their capabilities and services with third parties and partners. Software vendors can offer software as a service (SaaS) to better serve individual users and SMEs. More telcos will build platform-based open ecosystems to become service enablers or service creators. Open-source hardware will open up hardware development platforms for vendors and tech enthusiasts fond of thinking up new things to innovate.

Better user experience that is scenario-driven

Synergy between clouds, networks, and devices coupled with big data and AI will identify user scenarios and provide them with the most desirable services from the entire ecosystem's resource pool.

Services include digital assistants that will coordinate life and work and free people up to spend their time more creatively. Video – 4K and 8K HD – will be massive at work and play. It will form a key part of telcos' revenues, the groundwork for which is being laid in current investment trends. Cloud computing will change how multimedia content is processed and transmitted, with video clouds sitting at the core of global video delivery networks.

We live in an information age, brimming with new ICT technologies: 5G, virtual reality, augmented reality, heterogeneous multi-core processors, non-volatile storage media, graphene, chip-level optical interconnections, and cloud-based security systems.

These are the engines for exponential growth in the number of connections. These are the engines of a better life for all and a Better Connected World.

We asked the experts >>

In a better connected world, what tech are you most excited about

Rob McHenry, VP of Public Sector Operations, PARC:

"For Augmented Innovation, I'm most excited by the potential for contextual deep learning and hybrid AI to revolutionize the way that we explore scientific literature ."

Glen Hiemstra, Founder & CEO, Futurist.com, Seattle, Washington USA:

"Three stand out – augmented reality, Internet of Things, and smarter AI... AI and technological enhancement continue to augment human capability."


Internet of things

Make your move into Augmented Innovation

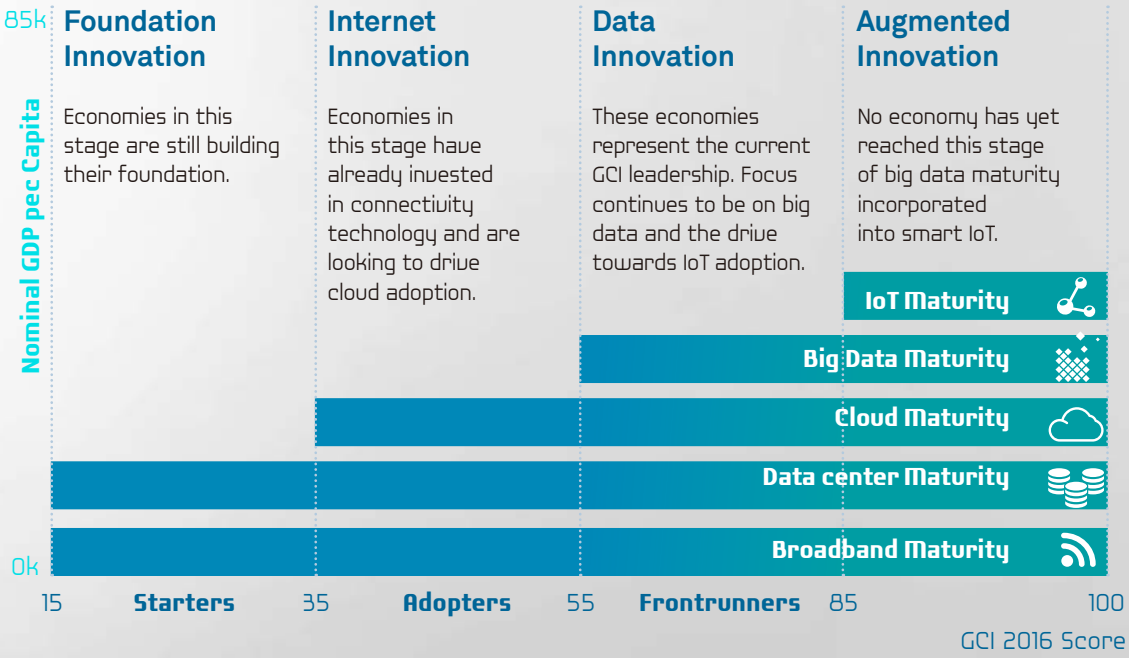
What's the remedy for slow economic growth? This year's G20 Summit believes it's innovation. ICT enablers are spreading innovation to all countries – and increasingly into the hands of individuals. Economies are turning digital, and the age of Augmented Innovation is coming. We're not there yet, but ICT and AI are turning the key and the door is opening.

By Julia Yao

Leveling up digital maturity

As countries reach full connectivity, the era of Augmented Innovation will arrive. Cloud, big data analytics, IoT, and AI will achieve a scale of innovation and economic digitalization never before possible – one that transcends physical barriers and the limits of the human mind, where humans and machines achieve more together than either can alone.

This is a picture painted in Huawei's Global Connectivity Index (GCI) 2016 report, *Connect Where It Counts*. The study identifies four stages of digital maturity: Foundation,



It's estimated that the first augmented innovators will arrive around 2020. The top ranking GCI countries – the US, Singapore, and Sweden – are likely to be the first nations to arrive if they keep up their development momentum.

Internet, Data, and Augmented – the stage no country has reached yet. GCI 2016 estimates that the first augmented innovators will arrive around 2020.

The top ranking countries in GCI 2016 – the US, Singapore, and Sweden – are likely to be the first nations to arrive if they keep up their current development momentum. At that time, big data analytics will be ubiquitous and embedded into IoT systems, and used to empower machine-assisted innovation in the form of virtual assistants, advanced robotics, and probably other things we haven't yet thought of.

While many forms of innovation might already qualify as machine-assisted, the difference is that conventional forms of innovation will use machines and AI in the process. The scale of innovation will increase and barriers will be lowered. Features include:

- Processing information too complex for human attentions spans and distilling it into insights that humans can perceive and use.
- Tackling problems too tedious, repetitive, time-consuming, complicated or otherwise onerous for humans to solve.
- Providing accurate modeling, simulation, and predictions through the IoT-enabled consideration of all possible factors.
- Enabling more intuitive interaction so that innovation can be carried out by people with physical disabilities or people without specialized skills – innovation will no longer be for geeks and coders, it'll be for everyone.

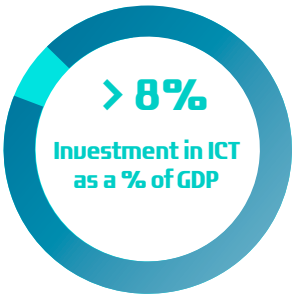
In the Augmented Innovation era, innovation will still be based on data analysis, but it will be accelerated by data sets complete enough for machines to start contributing insights, taking innovation to a whole new level.

Imagine the near future, when this level of machine-enhanced innovation is applied widely in manufacturing, finance, education, agriculture, and literally all walks of life, it will create a veritable big bang of growth in innovation and productivity.

This won't arrive automatically. Nations and enterprises need to invest in and promote five technology enablers: broadband, data centers, cloud, big data, and IoT. Combined, these form the digital infrastructure for competitiveness, innovation, and productivity.

With broadband and data centers in place, developed markets are shifting their focus to cloud, big data, and IoT, which is pushing them into the Augmented Innovation stage. Nations that are late to the party risk being left behind in the digital economic landscape.

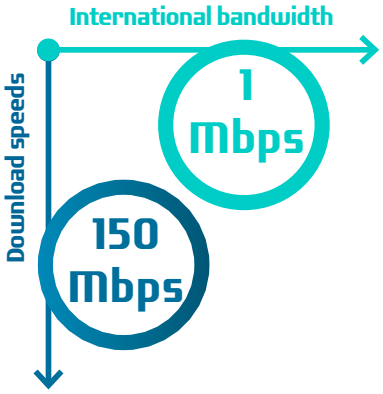
Augmented Innovation in stats >>



Investment in data centers as a % of GDP

Investment in cloud as a % of IT budget

Investment in big data tech as a % of IT



IoT will have made your nation smart:

Avg number of IoT devices per person: 12

Snapshot: GCI 2016 and the UK

Ranking fifth in the GCI 2016, the UK is a good model for other countries to follow. In 2014 the British Government invested £42 million in the Alan Turing Center for research into the collection, organization, and analysis of big data.

A further investment of £40 million was announced in September 2015 for the IoTUK program, with £10 million set aside for a single collaborative R&D project in a city region. These initiatives, among others, explain the UK's strong showing at fifth in the GCI league, up one place from last year. It's quite likely that the nation will become an early augmented innovator.

Snapshot: Augmented innovation in action – Quantum mechanics

Almost legendary for being confusing, designing experiments in quantum mechanics is as tough as it gets because the field tends to predict counterintuitive phenomena.

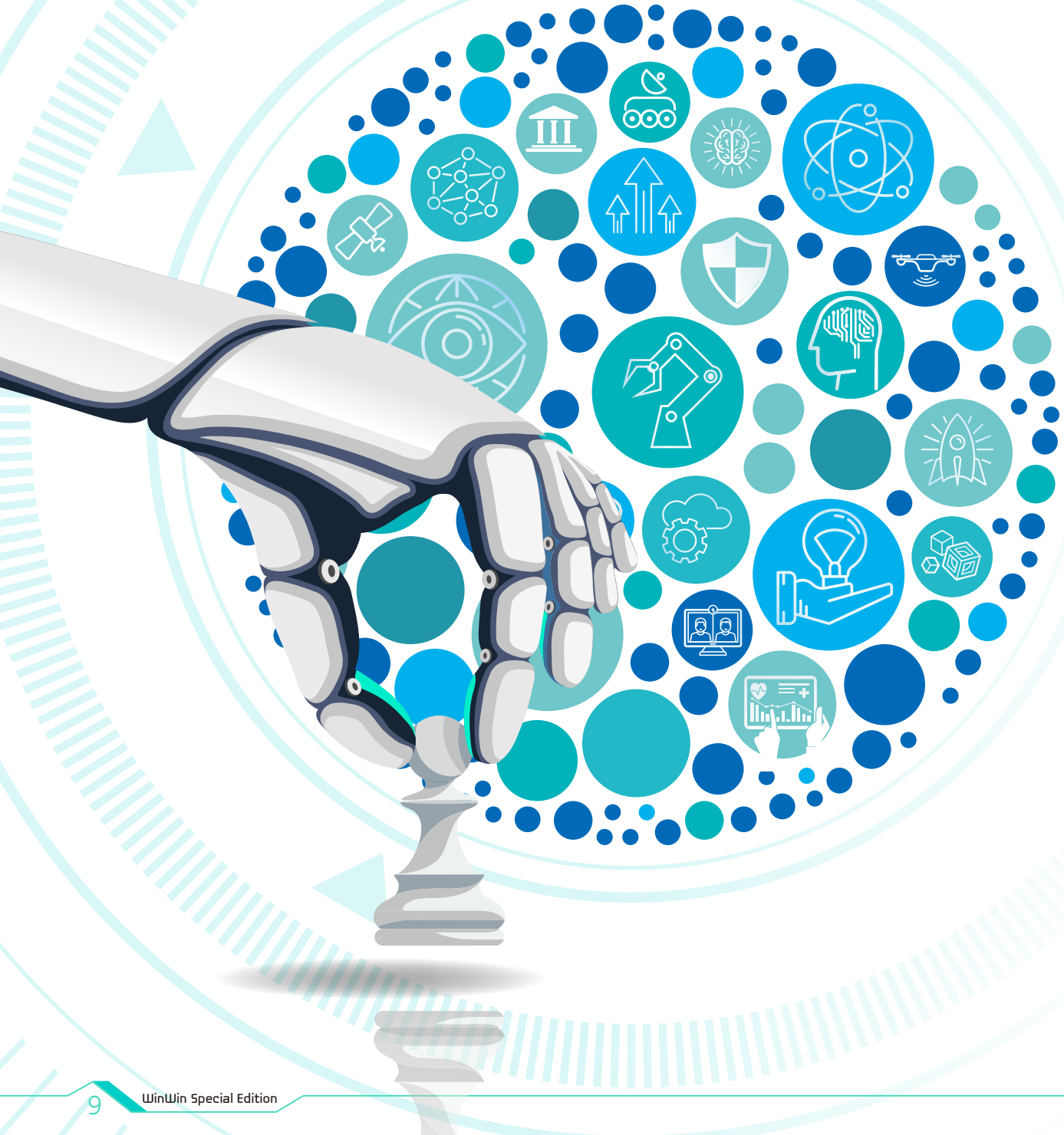
Enter AI. This year, a team at the University of Vienna developed the algorithm Melvin to design experiments with the aim of yielding a specific quantum state. The experiment designer, doctoral student Mario Krenn, knew he was guessing about how to configure these experiments, and realized that an algorithm could guess much faster.

Melvin ran the experiment's tools – lasers and mirrors – through random set ups to see if the desired quantum state had been achieved. It learned from its previous experience, often putting together set ups that humans would be unlikely to conceive. Of the 51 experiments Melvin ran, one achieved the quantum state the team was looking for.

Of course, Melvin still needs a human to interpret its experiments. But, the team's paper in *Physical Review Letters* concludes that: "Melvin autonomously learns from solutions for simpler systems, which significantly speeds up the discovery rate of more complex experiments. The ability to automate the design of a quantum experiment can be applied to many quantum systems and allows the physical realization of quantum states previously thought of only on paper." The use of Melvin in conjunction with human analysis is a great example of human-machine innovation.

KEY AI FIELDS

What's happening in the field of artificial intelligence right now? We take a look at approaches to developing AI and the key areas of machine intelligence, computer vision, and natural language processing.



Keeping it real with Educated AI

Using AI for the betterment of humanity

Intelligence has always been a marker that defines humanity. Now, it's also defining machines and how they interact with us and the world. They still can't do the things we can do with our adaptable intelligence, and for the time being artificial intelligence (AI) remains confined to fairly narrow and specific tasks. Educated AI is a field of AI that adopts a machine learning approach that's dynamic and responsive to the environment, but is tailored to specific applications and tasks. It's an intelligence that learns by trial and error to form a practical approach that solves real world problems to make life better and more efficient.

By An Wei & Zhang Baofeng, Huawei 2012 Labs

AI, specifically artificial narrow intelligence (ANI), where AI is really good at one task, has become an extension of human intelligence. Our smartphones are capable of routine tasks like backing up people's memories as stored photos, getting us places with maps and GPS, recommending books and music, and tracking our preferences. With network technologies and Internet prevalence cementing this trend, other ANI tech like driverless vehicles and domestic robots will see the worlds of human and machine intelligence further intertwine. When applied to practical problems, Educated AI is an enabler of ANI.

Educated AI doesn't seek to reproduce human intelligence, and instead is bound under five parameters:

Application-specific: It uses different intelligent systems with different applications to achieve different tasks where intelligence is only measured by the capability to complete these target tasks. For example, an AI home management system or AI tutor are only intelligent in their own fields; for example, a child asking the former for help doing his math homework might be met with a recommendation for an upgrade or different system. Application-specific AI greatly reduces the chance of mistakes.

Human centric: Usable intelligence needs to be understandable and predictable for a human. Equally, the AI has to share a person's value network; for instance, technology needs to comprehend how people will react to its actions.

User-educated: The system is relatively autonomous, but users can quickly teach it about new environments; for example, familiarizing a smart machine with your house can allow the AI brain to memorize the layout, but the system can decide what tasks it needs to do without further instruction.

In the Augmented Innovation stage, better results will be produced when the human brain works alongside an Educated AI system that can interact with its environment.

Self-learning: Educated by a user who's in the machine learning loop, the system learns both commands and patterns. It can correct errors, make judgments according to its environment, and provide the user with recommendations and reminders.

Personalized: Educated AI is designed to improve the user experience in specific applications. While not designed to reproduce human abilities, it can make decisions in a dynamic environment rather than just perform repetitive tasks; for example, an AI home manager can decide whether to adjust the temperature or close a window based on analyzing statistics from sensors and the user's habits.

In the Augmented Innovation stage, better results will be produced when the human brain works alongside an Educated AI system that can interact with its environment. Professor Pieter Abbeel from UC Berkeley provided an example when he trained the robot BRETT in a series of motor skills that could be applied to motor tasks like putting a clothes hanger on a rack, assembling a toy plane and Lego blocks, and screwing a cap on a water bottle. Previously Herculean tasks for a computer, the robot accomplished these without pre-programming, instead applying the human fail-safe approach: trial and error. Professor Abbeel told the *Berkeley News* that, "The key is that when a robot is faced with something new, we won't have to reprogram it. The exact same software, which encodes how the robot can learn, was used to allow the robot to

We asked the experts>>

What's the best way to approach AI research

Peter Z Yeh, PhD, Senior Manager, AI Technology and Senior Principal Scientist, Nuance Communications

"I want to emphasize that achieving artificial general intelligence [human-level intelligence in AI] should not be a prerequisite for advancement. Rather, we should continue to adopt an incremental approach where component technologies, both AI and others, will enable new applications and functionalities."

learn all the different tasks we gave it."

In some ways, this mirrors Professor Andy Clark's concept of *extended mind* for humans, where consciousness is embedded into interaction with what's around us. The Edinburgh University professor used the example of a child doing arithmetic with the help of its fingers, which is in effect part of the cognition process. Thus cognition is not bound by three pounds of brain tissue; rather it flows in the environment. In Professor Abbeel's project, BRETT also interacts with its environment to learn how to do a range of tasks by trial and error using a single artificial neural network.

Another example is driverless cars – it might take several months to build a car that runs by itself, but it'll probably take years, if not decades, to perfect the autonomous tech, because it's impossible to exhaust all possible scenarios in traditional programming. A more efficient way is to teach driving by giving a huge number of examples, and let the machine generalize patterns rather than use an "if-then" model that fails in the face of infinite scenarios.

A third example is natural language processing (NLP) which enables computers to use language as well as humans. NLP is extremely difficult for two reasons: First, language comprehension theoretically requires reasoning ability and extensive knowledge. Second, everything a computer does must be depicted by a mathematical model. The key problem is how to represent all the knowledge of a language in a way that allows the program to reason and apply that knowledge in other areas.

In each case, the AI is designed to excel at a particular task by a process of deep learning and interacting with its environment to improve life.

Machine learning

in the age of Augmented Innovation

By Bo Begole, PhD, VP,
Global Head of Media Technologies Lab, Huawei

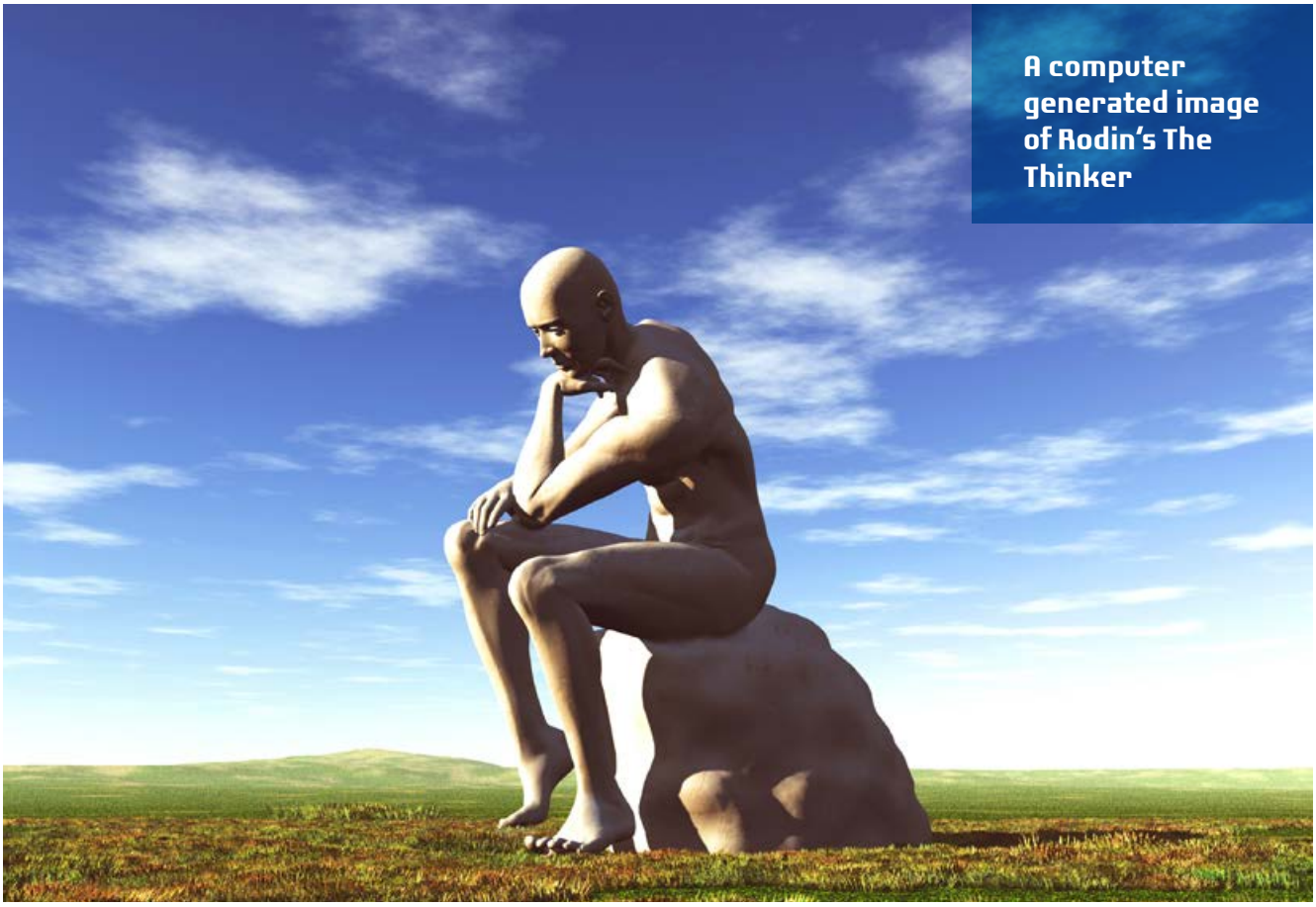
Information overload is a fact of modern life, creating a tyranny of choice often resulting in analysis paralysis. Too many options makes it difficult to understand any one option deeply enough to make an informed decision. That's a problem, because the whole point of Ubiquitous Computing – a term coined by Xerox PARC in the 80s to represent a dream of the time – was to make our lives and businesses better and more efficient.

Thankfully, amid the enormity of data lies the means to manage it. Our computing infrastructure has now reached a level of data and connectivity where it's possible for computers to recognize patterns and prioritize options, so it's easier for humans to make informed decisions.

A sensory life

One of the capabilities of human intelligence is recognizing patterns of varying complexity: from the primal shapes of edible plants, prey, and predators to the more abstract symbols used in mathematics, language, and philosophy. We're able to perceive these patterns through senses that detect light, sound, and other sensations. Our brains intuitively recognize recurring shapes, events, and the outcomes of our encounters – we give these things labels so we can communicate our accumulated knowledge to others.

Today, computer algorithms are emulating that capability in a set of technologies broadly called Machine Learning (ML). In ML, which is related to big data and data mining, large data sets are labeled by humans with the names of the objects within them: people, places, things, events, patterns, and the sequences of those objects. This labeled data set is called ground truth, which is then fed to set of algorithms that analyze the



A computer generated image of Rodin's The Thinker

data for statistical correlations, probabilities, patterns, and other features that detect the existence of the labeled objects. We call this the training phase, which isn't unlike the idea of parents and teachers interacting with children for thousands of hours, showing them examples and practising skills.

In fact, a currently popular form of ML uses a technique called a deep neural network that operates in a way analogous to how neurons in a human brain operate, firing pulses across a web of nodes such that recurring paths are reinforced. Like human brains, the DNN labels these reinforced paths with words or symbols and they represent knowledge that's triggered when the network encounters similar patterns in the future.

Learning the machine way

ML has created a breakthrough in artificial intelligence because it emulates the way humans learn and simplifies how we build an AI system. In traditional AI systems, knowledge had to be programmed into a logic framework that the computer could execute. Such knowledge would come from interviewing experts in a domain (for example, doctors, lawyers, and accountants), and then programming the knowledge into an expert system. Unfortunately, programming was labor intensive and never-ending. Sometimes experts cannot articulate what they know or even be aware of their own knowledge.

In the end, expert systems can be flat wrong at worst and incomplete at best. In ML systems, the statistical features of the data may be barely recognizable to humans, yet easily discernible to a computer. Now, attributes of knowledge that humans don't realize they know and that an expert system programmer would

have overlooked, are detected and incorporated into the machine's model of knowledge. Old-school AI hasn't gone away and the best AI systems today use a hybrid of programmed expert-system knowledge, machine learning, and searches.

Machines are also learning how to see and hear better than ever using ML techniques. In old-school AI, the input data had to be hand coded and entered by humans. The humans acted as sensors, encoding the state of the world and inputting that into the machine logic. Now, through computer vision and audio intelligence technologies, machines can see and hear nearly as well as, and sometimes better than, humans. Now, like humans, machines can make sense of their environment allowing them to improve and learn for themselves.

Enter the cloud

The secret to the success of ML is that the amount of labeled data has exploded. Online services offer many ways for people to upload their data, tagging a few items as they do so, and then the service can make sense of future data. As we increasingly make speech queries to search engines, tag photos of our family and friends on social networks, upload our finances to online accounting services, and conduct our lives online, the machines can see more of what's important to people. At the same time, networking and cloud-based data centers make it possible to create clusters of machines with enough power to churn through these enormous data sets.

Artificial intelligence has been coming for decades but there's a difference now. Until recently, the technology had to be contained into a single computer machine, but now the data and algorithms are distributed across the network. This provides richer knowledge bases and also puts the AI into more hands. As data, networking and cloud processing proliferate, the benefits of machine learning technologies will reach into more parts of our lives, propelling us into an age of Augmented Innovation.

At one time, we cursed our computers for being too dumb to detect the most obvious things in our lives but I hear the phrase "stupid computer" much less these days. Now, we're delighted by how clever they can be and are almost surprised when they fail to understand something about us.

These and other as-yet-unpredicted applications of machine intelligence will change how to live and work. The combination of machine and human intelligences will open up new categories of Augmented Innovation.

We asked the experts >>

How will AI improve efficiency

Rob McHenry, VP of Public Sector Operations, PARC

"AI will make us more efficient at operating in our increasingly complex and data rich world. This includes technological advancement itself, where AI plus Augmented Innovation builds on all relevant predecessors without unnecessary duplication."

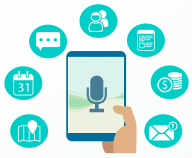
Where we can see AI in use now

Peter Z Yeh, PhD, Senior Manager, AI Technology and Senior Principal Scientist, Nuance Communications

"Many may not recognize or realize this, but AI is now an integral part of our day-to-day life. For example, we come into contact with AI technologies every time we interact with our devices, for example, smartphones, cars, through natural language conversation, receiving shopping or movie recommendations, reading automatically generated news articles, and so on."

Personal health

- ★ Securely share electronic medical records between institutions.
- ★ Track individual health trends and outcomes for tailored treatments.
- ★ Correlate health conditions with factors like pollution, O_2, temperature, lifestyle, diet, and sleep patterns via ubiquitous sensors.
- ★ Supplement human health providers with intelligent lifestyle coaches.



Intelligent assistants

- ★ Anticipate user needs like boredom, hunger, stress, and business goals.
- ★ Know etiquette; e.g., not interrupting conversations.
- ★ See what you see and hear through connected devices.
- ★ Give reminders, display maps, translate language on the fly, and infer what to do from the environment.

Public health and safety

- ★ Take on tasks where patience is a virtue; e.g., where constant observation is needed.
- ★ Enable machines to spot subtle trends through massive data sets segmented into sub-populations and sub-geographies too fine for humans to analyze. This will encourage research into diseases that were once considered too rare.

Business innovation

- ★ Boost profits through better back-office operations at lower costs.
- ★ Boost profits through creating new products and services by identifying trends that humans might miss.
- ★ Boost profits through enhancing strategic decision-making by accurately modeling, simulating, and predicting outcomes based on full data sets – like making the right chess move every time.

Disability support

- ★ Apply 3D manufacturing, robotics, and artificial biology to tech like exoskeletons.
- ★ Tailor information to help specific cognitive disabilities.
- ★ Use non-verbal communication and individualized speech recognition for those with speech difficulties.

Driverless cars

- ★ Drive more safely than humans can.
- ★ Receive more input from sensors than is possible from two eyes and two ears.

Education

- ★ Create personalized instruction that recognizes where an individual's strengths lie.
- ★ Recognize gaps in learning and rectify the misunderstandings that cause the gaps.

Computer vision and the AI boom

By Xu Chunjing, Huawei 2012 Labs

I see, therefore I am

A human's ability to conceptualize and think abstractly and logically about the world – what we consider intelligence – depends on the ability to receive external stimuli. Imagine a newborn that cannot use its sense of sight, hearing, smell, or touch. Even with a physiologically healthy brain, it's unlikely to develop any kind of intelligence if this state persists. Because what we see accounts for much of our stimulus, visual perception is an extremely important aspect of AI and intelligent systems.

Computer vision enables machines to understand the content of images, much like how image signals are formed by photoreceptors in our retinas. This includes objects in the image, the relationships between the objects, and the meaning of the image as a whole.

As recently as five years ago, most people – researchers included – believed that computer vision was a tangent, less complex precursor to AI rather being intrinsic to it, with AI being chiefly seen as a way to enable machines to master learning and reasoning.

However, research and recent progress in computer vision using deep learning doesn't just relate to visual perception, because many high-level semantic capabilities relating to intelligence are closely linked to vision. Solving the problem of scene recognition could therefore lead to great advances in AI in the relatively near future.

Challenges with computer vision

Typically, computers observe the world through cameras, but there's a huge gulf between seeing and perceiving. As shown in figure 1, the image of the letter "A" is read by a computer as a string of values, with each pixel represented as a value.

Computer vision recognizes that these strings of values represent the letter "A", which appears relatively simple until we look at Figure 2.

While a person can recognize each letter without difficulty, a computer sees a sequence of completely different values for each image, meaning it's much harder for it to see the letter "A". This is even more complex in photographs of natural settings where letters may appear in road signs or adverts, and where many factors like light or unrelated background objects come into play. These increase the difficulty for a computer to recognize them.

When light reflects off objects in the real world and is captured by a camera's image sensors, responses are produced as strings of values. While objects are defined by fixed concepts, the responses produced by them vary constantly. The main task of computer vision is to summarize and represent the fixed elements – a number of unchanging semantic concepts – that are contained in complex and variable pixel-formed images.

Substantial progress has been made in inferring semantic concepts from variable pixels using feature representation and supervised learning. Current intelligent systems can locate and recognize text in photographs captured by digital cameras and mobile phones, such as house numbers, restaurant names, and signs, even when the font, angle, or lighting varies.

Deep learning and semantics

Feature representation of images by inputting a series of values at the pixel level is the most important aspect of computer vision. However, image representation by pixel is the lowest level of feature representation. Slight variations in the image result in huge changes to the corresponding value strings, even though the concepts (objects) remain

Figure 1

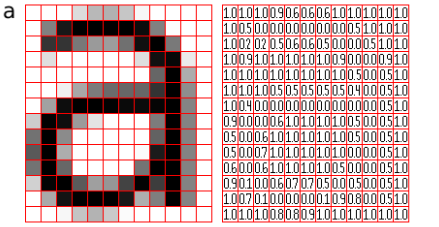


Figure 2

unchanged. At higher levels of representation, variations in images when the concepts are also unaltered don't significantly change the value strings. The highest level of representation is the semantic concept.

Before deep learning became popular, research on computer vision focused on how to artificially design a form of representation by combining experience and mathematics. For instance, pixel color does not strongly correlate to the concept of the letter "A", but pixel-formed borders and the particular shape they create are. Therefore, a type of value representation designed to describe pixel-formed borders and shapes overcomes the problem computer vision has in dealing with image variations such as changes in background color or light and – to a certain extent – changes in viewing angle.

I can't see what you see

This type of feature representation design works on a case by case basis, so a system designed for character recognition couldn't be applied to animal recognition. In object recognition in humans, light signals captured by the retina are processed hierarchically by different parts of the brain before high-level concepts are formed. The processing channels in the human neural network are constant. We don't need many different mechanisms to recognize different concepts. Computer vision's ultimate goal is to devise a single feature representation method that can be applied to a wide range of situations, akin to the way feature representation works in the human neural network.

Scientists began to use mathematics to describe the way neurons work in the 1940s, giving rise to the field of artificial neural networks. The 1960s and '70s saw much development in this field, but it quickly stagnated. The neural networks designed at the time were too shallow, with only two or three layers, and their ability to represent features was limited; however, when deeper networks with more layers were designed, training these networks became extremely difficult.

Researchers designing neural networks later focused on neural networks formed by many small convolution filters. In the 1980s, LeCunn and others designed a series of deeper neural networks with seven to eight layers that could be trained under the conditions of the time, and convolution neural networks were particularly adept at recognizing ZIP codes.

When convoluted is best

Convolution neural networks have been in low-level use for many years. Following a series of improvements, the technique is now used in large-scale natural image classification as part of ImageNet (image-net.org), a large public image database that outperforms almost all traditional methods of image recognition and testing. Deep learning is now an integral method of mainstream computer vision research.

Driven by companies such as Google, Microsoft, Facebook, and Baidu, deep learning's role in problem solving is increasing. It's now a standard tool in, for example, image retrieval, video surveillance, and autopilot visual perception.

An important aspect of training large-scale neural networks is data. Because large companies can collect and use large amounts of data, when directed this data can be used to improve the performance of

neural networks. In terms of the amount of data, training artificially designed feature representation requires data containing many thousands of samples, while large-scale neural networks require millions. In autopilot applications, for instance, millions of hours of video samples are needed to train neural networks.

This presents a new challenge – sourcing data for such applications. In visual perception for autopilot functionality, vehicles, people, and other targets must be accurately detected with cameras, requiring many images of different scenarios. In the currently popular technique of supervised learning, labelled images are used to train neural networks with given structures, which require manually labeling cars and other targets in images. Mainstream neural networks can contain hundreds of millions of parameters, and it costs an enormous amount in labor and time to label the massive amounts of data.

But, the success of applications often depends on obtaining effective samples. There are currently two ways to source data. The first is straightforward but investment-heavy: build large image databases to train basic data representation. For new applications, training feature representation using these databases can be used as a foundation application in other areas because feature representation in deep learning neural networks is versatile.

ImageNet uses this method, which is used in many academic fields to enable research that couldn't otherwise take place and create deep network structures and new training methods.

Downsizing samples

Unlike human perception and image recognition that can form abstract concepts from a very small number of samples, deep learning methods are vastly different. This has led scientists to explore a second method: small sample size learning. This method explores enabling neural networks to learn concepts in a compositional way by teaching machines basic modular concepts like "wheel" and "frame", which can then be combined into higher concepts such as "bicycle".

It also includes causality where compositional concepts maintain a logical cause and effect structure (for example, wheels cannot be placed above frames) and a self-learning capability. This method is still at a nascent stage but meaningful progress will advance visual intelligence as we know it.

While it's important not to overhype AI – something that's arguably happening now – computer vision will slowly impact every aspect of our lives.

Some future applications of computer vision >>

ADAS: Advanced Driver Assistance System

Will work with LiDAR, image processing, and in-car networking for safer and better driving

Detecting events

Recognition events; e.g., for security

People counting

Surveillance

Human-AI interaction

Input method for interacting with AI

Enable mobile robots to navigate

Manufacturing

Controlling processes in industry

Automated inspections

Modeling objects and environments

Topographical modeling

Medical image analysis

Natural language processing in action

Intelligent agents
Tomorrow's digital valets

By Bo Begole, PhD, VP,
Global Head of Media Technologies Lab, Huawei

What is natural language processing (NLP)?

With origins dating back to the 1950s, NLP combines AI, computer science, and computational linguistics in a way that aims to let humans and computers communicate seamlessly through language. Although conversational agents (think HAL 9000, C3PO et al) are what most people associate with the NLP lexicon, NLP does in fact cover a diverse range of applications. A few examples include machine translation, automatic summarization (for example, news articles), sentiment analysis (includes detecting judgments, opinions, and emotions), information extraction (such as detecting events in an email and placing it on your calendar), and parsing (understanding syntax).

Where are we now with NLP? Simple speech-based systems that understand natural language are already widely in use. AI can answer questions about things like flight times, give directions, tell you where restaurants are, and perform simple financial transactions. Such systems don't need to understand a sentence but they do need to recognize keywords that indicate the user's intention (for example, "Make a reservation ...") and parameters of the task ("... for 6pm at the French bistro.").

More advanced systems can summarize news articles and recognize complex language structures. Such systems must have a coarse understanding to compress the articles without losing the key meaning.

How does NLP work? NLP employs two main techniques: symbolic and statistical. Symbolic relies on a series of pre-programmed rules that cover grammar, syntax, and so on. Statistical uses machine learning algorithms.

Main challenges: context and ambiguity

Context

Example: "clear" can be a verb or an adjective. In this case, a machine can understand the form a word takes in a sentence through Part-of-Speech (PoS) tagging.

Sentence: *James cleared the path*
Rule: A noun is a verb if the previous tag is a pronoun (in this case "James")

Therefore, the machine knows

"clear" is a verb in the example sentence, and can work out that "path" is a noun.

Ambiguity

Word Sense Disambiguation (WSD) is used in cases of polysemy (one word has multiple meanings) and synonemy (different words have similar meanings).

Example of a polyseme: "Fix"
He fixed dinner yesterday (made)
He fixed the car yesterday (repair)

In this case, PoS tagging and syntax will yield the same result. So, a deeper approach is required that can pinpoint exact meaning based on real-world understanding. In the previous example, it's understanding that you can't "repair" dinner. For WSD, WordNet is the go-to resource as the most comprehensive lexical database for the English language.

Listening is not the same as hearing

Speech interaction will be increasingly necessary as we create more devices without keyboards such as wearables, robots, AR/VR displays, autonomous cars, and Internet of Things (IoT) devices. This will require something more robust than the scripted pseudo-intelligence that digital assistants offer today. We'll need digital attendants that speak, listen, explain, adapt, and understand context – ***intelligent agents***.
Not long ago speech recognition was so bad that we were surprised when it worked at all, but now it's so good that we're surprised when it doesn't work. Over the last five years, speech recognition has improved at an annual rate of 15 to 20 percent, and is approaching the accuracy at which humans recognize speech. There are three primary drivers at work here.

First, teaching a computer to understand speech requires sample data and the amount of sample data has increased 100-fold as mined search engine data is increasingly the source.

Second, new algorithms have been developed called deep neural networks that are particularly well-suited for recognizing patterns in ways that emulate the human brain.

Finally, recognition technologies have moved off of a single device to the cloud, where large data sets can be maintained, and computing cores and memory are near infinite. And though sending speech over a network

Among enthusiasts, an intelligent agent is an artificial intelligence (AI) capable of making decisions based on prior experiences. Among consumers, an intelligent agent would need a few more qualities.

may delay response, latencies in mobile networks are decreasing.

The results? My kids are increasingly talking to their smartphones, using digital assistants to request directions, ask for information, find a TV show to watch, and send messages to friends.

Speaking does not make you intelligent

But to make interaction truly natural, machines must make sense of speech as well. Today's digital assistants seem amazingly intelligent, but they actually use a superficial form of understanding called intents and mentions, which detects what task the user is trying to accomplish (intent) and the properties of the task (mentions).

Basically, the system recognizes a command phrase (usually a verb) that identifies a task domain like "call", "set an alarm for", or "find". If it doesn't find all the necessary information in the user's statement, it can ask for more details in a kind of scripted dialog.

Such assistants take commands well, but they're a far cry from a personal concierge who intuitively understands your desires and can even suggest things you wouldn't think to ask for. Today's assistants can't go off-script when recognition fails. They often can't explain their own suggestions. They can't anticipate problems and suggest alternatives. They rarely take the initiative.

You have to spell everything out to a digital assistant, and even then you may not get what you want. Soon, we'll stop being amazed by their mimicry of intelligence and start demanding actual intelligence.

What would this look like? What would a truly intelligent agent be, that can actually converse and function as the primary interface in the coming IoT revolution as we head into the stage of Augmented Innovation, where wearables, autonomous vehicles, robots, and embedded appliances will abound?

Intelligent agents can speak, listen, and hear

Among enthusiasts, an intelligent agent is an artificial intelligence (AI) capable of making decisions based on prior experiences. Among consumers, an intelligent agent would need a few more qualities.

Conversational: Language understanding needs to be less superficial than what we have today. Computers can easily miss intent or become confused and fall

back to simple web searches. That's because the system doesn't really understand what you're saying. If it doesn't recognize the type of task it's being asked to do, it doesn't have a predefined script with which to ask for more details. A human would be able to remedy the specific misunderstanding by saying, "I'm sorry. What kind of restaurant were you looking for?"

Explanatory: With a deeper language model, a conversational system can explain why it recommends a particular action or why it thinks something is true, just as a human can, unlike the "black box" recommendation systems today. For example, if I ask my TV for a legal drama and the system recommends the Marvel show *Daredevil*, I might need an explanation at first because I might not know that the title character is a lawyer by day when he isn't cleaning up the streets with his fists at night.

Resourceful: Human assistants are resourceful. When we detect a problem, we can plan around it and suggest alternatives. A deeply intelligent agent must proactively notice, for example, that the restaurant I scheduled for lunch with a colleague is closed that day for a religious holiday (this just happened to me).

Attentive: Intelligent agents should be constantly attentive. If one of my kids tells me he just used up the milk, the agent should notice and add it to my online shopping cart without me having to tell it to.

Sociable: Intelligent agents should be aware of my engagement with other people in my environment and know when and where not to interrupt.

Context-aware: Social intelligence is actually a subset (but important enough to call out separately) of the broader category of contextual intelligence, which requires understanding the situation a person is in and proactively selecting services that he or she has used in similar situations. Near the end of dinner at a restaurant, the intelligent agent should offer to call a taxi.

Engaging: Perhaps most importantly, I want my intelligent agent to engage me and express understanding of the importance of my requests. In human conversation, a tone of urgency is met with responsiveness. Humor is met with amusement. Concern is met with suggestions. I'm not looking for a mechanical personality to replace human companionship, just a genuine conversationalist that offers a level of engagement that indicates it understands and will act on my desire for urgency, mirth, or resolution.

We'll need intelligent agents soon

Deep intelligence will be more important for tomorrow's environments than today's smartphones, because robots, autonomous cars, and smart homes will need to converse, explain, re-plan, and engage in ways appropriate to the user and situation. The same deep learning technologies that have made speech recognition surprisingly accurate can achieve this.

With so much potential at our fingertips, what else would you want to see from intelligent agents?

A robotic vision of the future

In the world of tomorrow, robots and artificial intelligence (AI) will play an increasingly important role. At this year's Global Mobile Internet Conference (GMIC), the movers and shakers of the industry took to the stage to set out their visions of the future of robotics and AI.

By Xue Hua

Industry players' predictions on AI were particularly interesting. Microsoft outlined five AI concepts: artificial intelligence, collective intelligence, adaptive intelligence, invisible intelligence, and human-machine interfaces. The software giant sees a future where we will be able to leverage AI to mine, systematize, and adapt big data on human behavior to create cognitive capabilities, and strengthen our own cognitive abilities and empower humanity through deep learning. Microsoft touted the example of using AI to help a visually challenged engineer "hear" the world around him through a pair of special glasses. The device combines computer vision and natural language processing to "see" the outside world and describe it to the user through natural language.

The audience at GMIC saw demonstrations of a number of similarly revolutionary robotics and drone applications. SuitX, an affordable and accessible exoskeleton, was one such application. SuitX CEO Homayoon Kazerooni spoke of how their product design was inspired by a desire to design a tool that can help personnel like paramedics, nurses, and high-risk assembly line workers that's affordable, uses as little hardware as possible, and is consumer friendly.

SuitX exoskeleton

More lifelike robots suit scenarios where they directly interact with humans. As technology develops, AI will become more capable and intelligent, and will be able to learn how to live among us more naturally, which is one of the goals of the AI-robotics mix.

David Hanson, CEO and founder of Hanson Robotics, gave a live demonstration of the humanoid Sophia, who told the audience in Mandarin: "I hope everyone has a nice day. I'm a robot but I look like a real person. I've just come to say hello. Goodbye." Sophia incorporates a range of technologies that enable it to express human facial emotions, including flexible facial skin, components that allow it to mimic facial movements, voice recognition, and cameras that can track people's movements.

Han and Sophia
from Hanson Robotics

Qualcomm also showed off a three-wheel robot that can navigate obstacles and return to its starting point, and is working on using smartphone technology in robots.

Another major theme at GMIC was commercial drones. 3D Robotics CEO Chris Anderson predicts that the commercial drone market will exceed US$20 billion within five years, overtaking the consumer market. Commercial drones will be used in agriculture, construction, insurance, and the energy sector to carry out tasks such as surveying equipment. "This year the United States will approve the commercial

Robot Facts

01

The word "robot" is from the Czech word "robota", which means servitude. It was first used to describe humanoid robots in the play R.U.R (Rossum's Universal Robots) by Czech writer Karel Capek in 1920.

02

Approved for use by the FDA in 2000, the Da Vinci surgical system has been used in procedures for 3 million patients. Before that, the first-ever robot-assisted surgery was performed in 1985 by the PUMA 560 robotic surgical arm.

03

The earliest robot can be traced back to 350-400 BC – a steam-powered pigeon conceived by the Greek mathematician Archytas and apparently built using wood.

04

Robots are made up of the controller (the brain), mechanical parts (for example, pistons and mechanical parts), and sensors (to inform it about its environment).

05

Leonardo Da Vinci built a robot knight over 500 years ago that could stand, sit, raise its visor, and independently work its arms. It also had an anatomically correct jaw. Modern replications testify that Da Vinci's design is fully functional.

06

Five countries buy 70% of all robots: China, Japan, the United States, Korea, and Germany.

use of drones without the need for a pilot's license. This is good news. It shows that we have already entered the era of the commercial drone," said Anderson.

Exciting innovations to come

Another hot topic at GMIC was visual recognition. Intelligent recognition, such as visual recognition, plays a crucial role in technology and platform support. Professor Tang Xiaoou from the Chinese University of Hong Kong and SenseTime CEO Xu Li both spoke at length about their predictions for computer vision.

From the perspective of the whole vision chain, they believe computer vision can be divided into three steps: imaging, perception, and understanding. Imaging is taking photographs. Technology can be used to better represent the content of images by suppressing noise. Perception involves acquiring content in images via sensors and acquiring perceptual input via algorithms that we compute. Understanding is actually based on what we call visual recognition, and includes facial detection, facial recognition, and the analysis of facial attributes to determine things like age and gender.

Research on vision goes back many decades. Today, trends have moved on from specialized systems to being purely data driven. Once the whole vision chain has been completely opened up, it will be possible in the future to produce more powerful visual services and products that will quietly and steadily change our lives.

What this makes clear is that we're currently experiencing a stage of huge innovation, which will gather momentum as nations enter the Augmented Innovation stage, enabled by broadband, data centers, cloud computing, big data, and Internet of Things. This enablement through the maturity of digital infrastructure is crucial because normal tasks for conventional robots are in fact extremely hard; for example, it took Pieter Abdeel's team at Berkeley University years to teach the robot BRETT to fold a pile of laundry, largely because each pile is different and there's so much going on that can confuse a robot, like a crumpled sock. Even grasping an object requires a huge amount of processing and preprogrammed information, meaning that sophisticated systems like humanoid robots need very powerful computing capabilities.

But, cloud robotics has the potential to make massive gains, with research in this area happening across the globe. Access to a cloud computing infrastructure would give robots access to the massive processing power and data they need to perform complex, compute-intensive tasks, and let them offload things like image processing and voice recognition. More excitingly, it would make the possibility of downloading new skills feasible, much like sci-fi fans witnessed in the *Matrix* when the ability to do Kung Fu and fly a helicopter are downloadable. As nations move into the stage of Augmented Innovation through greater ICT maturity, such capabilities will no longer only exist in the realms of cool sci-fi movies – robots will really start making life better on the individual level, and live up to what the name of Berkeley's task-learning robot BRETT stands for: the Berkeley Robot for the Elimination of Tedious Tasks.

The world of tomorrow is poised to be an exciting time, augmented by robot bodies and AI brains that will make life better in a hyper connected world.

AN EYE ON AI

A closer look at some of the bigger questions surrounding artificial intelligence.

Artificial Intelligence: Friend or frenemy?

"It's likely to be either the best or worst thing ever to happen to humanity," warned physics legend Professor Stephen Hawking in 2015, neatly summing up the dichotomy that artificial intelligence (AI) inspires in even the planet's greatest minds. AI is poised to be an overwhelming force for good, but we're still dipping our collective big toe in its relatively uncharted waters. Major public concerns include safety and security, the possibility of clever machines liberating people's jobs, and AI deployed in warfare.

By Gary Maidment

In safe hands?

While a Hollywood-style robot rebellion may be the stuff of CGI pixels, safety fears are tempering the excitement and interest surrounding AI with a large dose of skepticism.

Driverless cars, for example, are literally just around the corner, with 10 million such vehicles expected to be on the roads by 2020. But, a 2016 survey by insurance provider AAA revealed that 75 percent of Americans are afraid to ride in one. Equally telling, a survey by the British Science Association in March of this year revealed that 53 percent of Brits wouldn't fancy going under the knife of a robot surgeon. Notably though, the public doesn't seem to have the same reservations about unmanned flight, domestic robot helpers, and things that are ostensibly less likely to hurt or kill them.

Much like the initial fear of using credit cards online, society remains a little wary of transferring the burden of personal safety to the virtual or robotic hands of AI. But as history shows, the tipping point of acceptance is likely to pass without much fanfare, not least because today's open-minded generations are growing up with Siri, Alexa, Cortana, and the like.

Get ready to be a backseat driver

Another compelling reason for the widespread acceptance of AI will be the mounting evidence that it's safer than humans. In the case of getting from A to B, AI doesn't get tired, drunk, or distracted. Each year, 1.3 million people are killed on the world's roads, with more than 90 percent of all crashes attributed to human error.

Audi, Mercedes-Benz, and Google are all testing out tech like LIDAR, with Google having already clocked up 1.5 million miles on the road to commercializing its driverless vehicles by 2020. Although AI has some ground to cover before it can read road signs and hand signals, negotiate snow, and fully act without human intervention, the gradual inception of driverless vehicles is a case of when, not if.

There are several measures essential to fostering peace of mind in Joe Public, many of which apply to AI in general. Coherent regulations and policies are needed to safely introduce driverless vehicles alongside human drivers, while strong cyber security measures must be developed to minimize hacking risks and

> While the employment landscape may be vastly different 30 years from now, technology will increasingly democratize innovation, and a clear gain in economic value is likely to occur. when the time freed from doing repetitive tasks is used for creative thought.

future threats like ransomware. Interactive interfaces are required to engender trust between human and machine, and robustness in AI must be designed into technology. Equally important, technology must be rolled out when it's ready and not before, with clear liability policies in place if something goes wrong.

A better bedside manner

Despite the reticence of the British public for robot surgery, AI will inevitably add more brains to the brawn of surgical technologies like the da Vinci System, which broke new ground in 2000 as the world's first FDA-approved, all-inclusive teleoperated surgical robot. It has since been used to perform procedures on more than 3 million patients.

Fast-forward to 2016, and STAR (Smart Tissue Autonomous Robot) stitched up a pig's small intestines early in the year using its own vision, tools, and intelligence. Crucially, the surgical bot performed better than human surgeons tasked with the same procedure.

Although STAR doesn't herald the arrival of fully autonomous surgery, it represents a huge breakthrough in supervised autonomy on soft tissue procedures, an area that's far harder to automate than things like knee surgery because tissue is messy and slips about.

In 2015, Google and Johnson & Johnson started working on applying machine vision, image analysis, augmented reality, and analytics to assist surgeons. AI in these contexts isn't necessarily designed to fully replace humans; it's more about working alongside people to improve diagnostics, predictions, and precision. Bots like STAR will provide an opportunity for surgeons to concentrate on higher-value tasks and offload repetitive and precision tasks to the tech.

Employment blues

When the autonomous tech in cars and robot surgeons proves its safety credentials, doing so will fall in the same ballpark as showing that AI can perform better than people – a trend that doesn't bode well for taxi and truck drivers or specialist surgeons.

The AI revolution has indeed put a new spin on technological unemployment in that it's starting to affect white collar workers, and highly skilled ones at that. Architects, pharmacists, financial advisers, translators, lawyers, and judges are all on a long list of skilled jobs stamped "at risk", not to mention the new wave of manual jobs that are being automated now – Foxconn and Samsung have replaced 60,000 workers in China

with precision robots capable of completing phone assembly tasks previously only possible with a human's nimble fingers.

This year, leading computer scientist Moshe Vardi warned the American Association for the Advancement of Science that half of all jobs could be at risk in 30 years – around the same time many scientists believe AI will achieve human-level intelligence. Tom Goodwin, Senior VP for Havas Media US, told us in a recent interview that the employment issue could also pose something of an existential conundrum, despite AI's huge potential for productivity, health, and happiness gains: "If we're outsourcing productivity to machines, then ethics and the very role of humanity come into question."

When it comes to unemployment, there's no real way around the fact that transitioning into an increasingly automated world will require a long-term approach to changing the global economic paradigm. Avenues being considered include maximizing the consumer pool; revamping education programs to support life-long learning; creating an unconditional basic income to stimulate economic activity; ensuring that people have the freedom to innovate in all areas of life, including ideas, business, products, services, and the arts; and encouraging investment to capitalize on this new wave of innovation.

While the employment landscape may be vastly different 30 years from now, technology will increasingly democratize innovation, and a clear gain in economic value is likely to occur when the time freed from doing repetitive tasks is used for creative thought. Autodesk VP Pete Baxter told *The Guardian's* Tom Meltzer earlier this year that the kind of software his company works on will put architecture in the hands of the little guy: "A one-man designer, a graduate designer, can get access to the same amount of computing power [on the cloud] as these big multinational companies. So suddenly there's a different competitive landscape."

The same article holds that the legal profession will see a slew of new jobs that read like an IT roll call: legal knowledge engineer, legal technologist, project manager, risk manager, and process analyst. This will be part of a trend that sees traditional professions split into different specialist areas, some of which don't exist now. Because the prices of services from architects, doctors, lawyers, and other specialist fields will probably drop thanks to technology, many more people will start using these services, which will in turn stimulate the supply of jobs.

Sorry to keep droning on

The issues of safety, security, and employment are just the tip of the algorithmic iceberg that's floating in the public consciousness. Heavy hitters like Hawking, Elon Musk, and Bill Gates joined more than 1,000 AI researchers in signing the now famous open letter released last year, which pointed out the risks of autonomous weaponry and the potential disaster of a global AI arms race.

With 40 countries researching weapons deployed with AI, Hawking and Musk offered respective warnings that AI could "spell the end of the human race" and pose "our biggest existential threat". It's also a sentiment echoed by more than a third of Britons, albeit in less specific form – in

We asked the experts >>

What positive impacts will AI have

Peter Z Yeh, PhD, Senior Manager, AI Technology and Senior Principal Scientist at Nuance Communications

"Advances in AI will have major positive impact on society as a whole....and [bring] numerous benefits such as improved quality of life, increased standard of living, and greater workforce productivity and efficiency."

Bo Begole, PhD, Head of Media Technologies Lab, Huawei

"AI will elevate our lives and business practices to new heights of happiness and achievement."

What are the potential pitfalls

Glen Hiemstra, Founder & CEO, Futurist.com, Seattle, Washington USA

"AI and a more mature ICT will gradually change employment, reducing jobs for drivers or for factory assembly workers, for example. So policy makers must emphasize education, and encourage economic growth so that new kinds of jobs are created, even invented."

this year's survey by the British Science Association, 36 percent believe that AI could threaten the long-term survival of humanity.

Taranis

Britain is also the home of Taranis, the most advanced aircraft on the planet. Though controlled by a human operator on the ground, Taranis has the technical capability to operate autonomously at 700 mph and apply super stealth for things like marking targets, gathering intelligence, and carrying out ground strikes.

In a similar vein, AI showed off some serious skills in aerial combat across the Atlantic in June 2016. The pilot AI ALPHA consistently bested veteran US Air Force Colonel Gene "Geno" Lee, evading him and shooting him down in every simulation: "I was surprised at how aware and reactive it was.....reacting instantly to my changes in flight and my missile deployment," said Lee in an interview about the simulation with *Popular Science*. Based on fuzzy logic, ALPHA's genetic fuzzy tree system approaches complex problems like a human, but reacts 250 times faster than a human can blink.

What does this mean for war? The UN hasn't yet defined where the boundaries lie with autonomy. So, it's unclear where humans fit in on the decision-making chain for weapons that will evolve from demo tech like Taranis. The new breed of weaponry will have the ability to select and engage targets based on pre-defined criteria without human intervention, or take the form of defensive systems that are better off without us because they need to react faster than we can.

Hawking, Musk et al want to keep a human finger on the trigger if there is war, because full autonomy could spell disaster. With autonomous weaponry as its central theme, the UN met in Geneva on April 15, 2016, where it scheduled six weeks over 2017 and 2018 for a group of UN-appointed government experts to consider the implications of AI deployed in weapons.

Connecting the AI dots

A Better Connected World isn't just about nations coming together through technology – it also means scientists, private enterprises, governments, and the public working towards a common vision of how we enter the Augmented Innovation era and where we go from there. It means creating AI systems that work with people, for people, rather than replacing us or being used against us. And it means a holistic approach that's smarter than either people or machines alone, where robust AI serves humanity as a trusted partner that makes innovation easier and life better for all.

How intelligent will machines get?

A survey in 2013 by Vincent C. Müller and Nick Bostrom asked hundreds of scientists when they believe machines will achieve artificial general intelligence (AGI), meaning human-level intelligence. The median years for 10, 50, and 90 percent probability of reaching AGI were 2022, 2040, and 2075, respectively. But, there are still many challenges to reaching human-level intelligence.

By An Wei & Zhang Baofeng, Huawei 2012 Labs

Current limits to achieving AGI

The first is domain limitation. Today's artificial intelligence primarily applies a mathematical approach that can solve a finite set of statements for a finite set of terms described under a finite set of rules. Marvin Minsky, widely regarded as the father of AI, dismissed deep learning as a fad that wasn't a good model of intelligence because it mostly models bottom-up perception. Quite often, the potential scenarios and number of parameters are infinite, and the only way to get around this are to limit how the AI can be applied.

The second is causality. Current state-of-the-art technology is built upon a complex model that requires massive compute power and huge volumes of data to simulate relatively weak patterns and correlations. However, it cannot

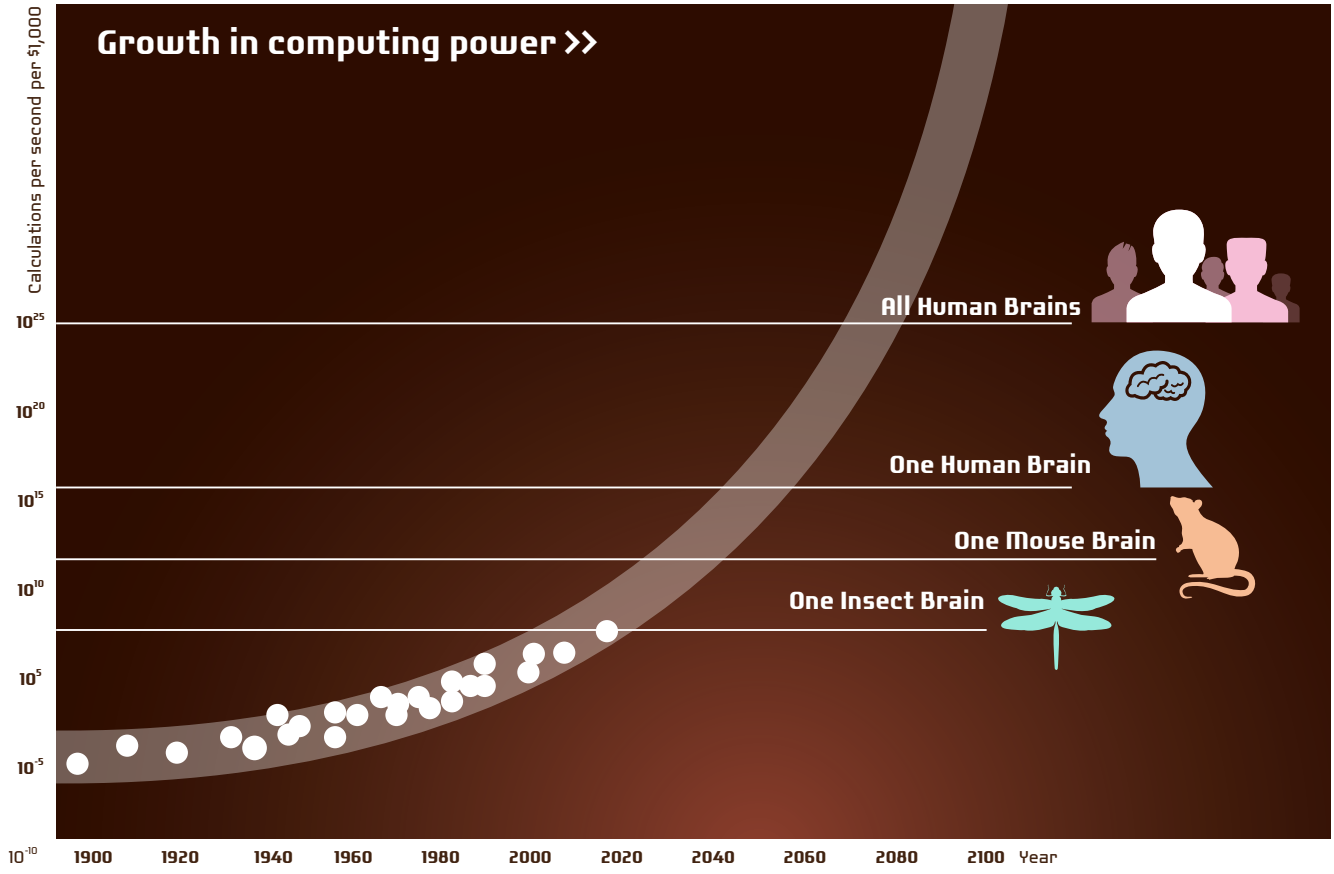
easily solve causality. An analogy is WWII bombers, which were great for the war effort but easy targets. On returned bombers the wings were the most popular destination for bullets, and so the knee-jerk response was to fit them with armor. But the Jewish mathematician Abraham Wald saw things differently, believing it wasn't the most bullet-riddled places that needed armor; it was the place with the least – the engine. Why? Planes that were hit in the engine never returned. However, data analysis without human abstraction doesn't reveal this causality.

The brain: A force to be reckoned with

The third reason complicating AGI is that transistors and neurons are not born equal. Equating intelligence to computing power is likely to be a misguided over-simplification. For one thing, transistors have already far surpassed the speed of neurons, which can process a single lexical decision task at no faster than 60 bps; however, transistors are far less efficient at extracting information.

Computers also lack the punching power of the brain, which can perform 20 petaflops of computations per second compared with the 91 gigaflops of a high-end desktop PC. Parity won't be reached for some years yet – not until around 2041 according to cognitive neuropsychologist Chris Westbury, which ties in with the predicted arrival of AGI.

An Elon Musk-funded AI project headed by two PhD students compares the human



brain and computers based on a measurement they specifically developed: Traversed Edges Per Second (TEPS). Their work suggests that our gray matter is 30 times more powerful than IBM's number cruncher, Watson. Current TEPS prices means that an hour of computing time at the brain level would cost up to US$170,000, a dollar value that's expected to drop to US$100 in the next 7 to 14 years.

Marshalling the same level of computing power isn't impossible now, but it's clearly expensive and we still can't get computers to do the same things our brains can so effortlessly. It's still worth noting that the efficiency of AGI design may be such that it could surpass human-level performance using much less computing power than the human brain does. One thing is seems to be inevitable: the rate of growth in computing power will be exponential.

Two sides of the same coin

Our brains may be superior at the moment, but machines and humans still work in different ways to solve different sides of the same problem, with machines adept and at rapid calculations and correlations, and the human brain more skilled at finding causality, abstracting, and applying common sense.

Many people underestimate how difficult AI is, which doesn't help the industry. Most optimists base estimates on a linear path towards AGI and non-linear progress in IT. The logic here is flawed, and in fact is the kind of thinking that led us into two AI winters in the past where interest in AI and funding by governments and venture capitalists evaporated. The fact is we're not even close to understanding human intelligence in all its multi-faceted glory: reasoning, abstraction, generalization, consciousness, dreams, memory, imagination, quantum waves in our brains – there are so many questions that we've yet to answer. Replicating something we don't really understand is far from easy, and is perhaps not the best avenue to explore when it comes to AI.

Popular areas in the field, such as machine self-awareness and passing the Turing test aren't necessarily practical and don't help solve real world problems. Educated AI, however, puts more emphasis on applied intelligence, with the goal of allowing intelligent technologies to serve society - the purpose of all tech. The principles of Educated AI in a world of Augmented Innovation can result in a positive symbiosis of collaboration between man and machine where the whole is greater than the sum of the parts.

We asked the experts >>

Will we achieve AGI (AI with human-level intelligence)

Glen Hiemstra, Founder & CEO, Futurist.com

"In truth we may never create an AI as flexible and intuitive as the human brain, but more generalized AI capable of functioning in multiple fields should be arriving by 2025 or 2030."

Rob McHenry, VP of Public Sector Operations, PARC

"I'm pretty pessimistic that I'll see artificial general intelligence in my lifetime. There's a critical element of self-motivation at the core of human intelligence that I think isn't even mimicked, much less replicated by even the boldest claims of the AI systems on the horizon."

Peter Z Yeh, PhD, Senior Manager, AI Technology and Senior Principal Scientist at Nuance Communications

"The outlook of achieving artificial general intelligence is definitely more promising today than twenty years ago. Recent technology advances and breakthroughs have put us on a good trajectory. Hence, achieving artificial general intelligence is something to be optimistic about, and possible within our lifetime."

SMARTER & SAFER

A look at how technology enablers and AI will benefit how we live, including smart cities, tailored markets for one, industry, and cyber security.

Drivers of smart city initiatives >>

- Citizen transformation
- The digital universe will hit **40,000 EB**
- Staff shortages
- Govts will use the most **big data**
- **1 billion** vehicles worldwide by 2020
- Cost pressures
- Urban population up by **72%** by 2050
- Economic uncertainty
- Aging population
- In 2015, mobile Internet access surpassed PC access in the US
- Internet of Things
- In 2013, **45%** of local govt apps were mobile

Smart cities
in the city century

Urbanization is on the rise

The 21st century is the century of cities, with the urban population predicted to grow from 54 percent of the global population in 2014 to 66 percent in 2050. Cities already generate over 70 percent of an average country's GDP, more than 70 percent of energy consumption, and over 50 percent of global greenhouse gas emissions.

Worldwide demographic and technological trends are driving the need for cities to rethink how they use ICT, existing infrastructure, and core resources like government workers, citizens, and community and business groups.

A question of money

Many cities in both developed and developing countries face financial challenges that are exacerbated by current financial uncertainty and global austerity. In many countries, the aging workforce is felt more heavily in government, where a higher percentage of workers are nearing retirement age.

City leaders must do more with less and look at problems in new and innovative ways to achieve change and digital transformation, both of which are necessary. They can then move seamlessly into the stage Augmented Innovation and the era of smart cities and digital economies can truly begin.

A question of technology

As the next cycle of e-government innovation, the key objectives of smart cities are to improve economic development, sustainability, innovation, and citizen engagement. Progress requires building an ecosystem of partners to improve the quality of life for residents.

Smart city projects, including citizen engagement, depend on the major technology enablers of Augmented Innovation: broadband, data centers, big data analytics, cloud, and the Internet of Things (IoT). Other crucial technologies in the smart city mix are AI and cognitive systems, robotics, 3D printing, next-gen security, augmented and virtual reality, and social networks.

AI, in particular, will form the cornerstone of smart cities, a fact that telcos are

By Gerald Wang
Head of Government & Education, IDC Government Insights

Gerald heads up research in the government and education sector of IDC Asia Pacific.

He's been an IT research specialist in the areas of public sector and smart cities for over 15 years. He also provides consultancy services in various domains, including strategic planning, optimizing operations, innovation-based policies, and digital transformation.

Snapshot: Tech enablers in Asia Pacific

20% of Asia Pacific governments are looking at innovation accelerators:

- **IoT.** Singapore's government agencies deployed 1,000 sensors in 2015 to boost the government's approach to environmental management, for example, monitoring air and water quality; transportation management and traffic monitoring; and public safety initiatives like citizen policing.
- **Pervasive robotics.** Under a science park initiative, Hong Kong government is working with local SME start-ups to use its intellectual and design infrastructure to establish a social robotics hub. This hub will improve nursing and pharmaceutical services in hospitals; enhance education tools, which will benefit children with disabilities; and boost public safety in the shape of disaster response.
- **3D printing.** The South Korean government will promote 3D printing as a future economic driver of technology exports.
- **Natural interfaces.** The state government of Victoria in Australia and the University of Melbourne will jointly invest US$7 million with Microsoft in new social interactive technologies to be created in a research center for natural user interfaces.
- **Cognitive systems.** Singapore's government will use Watson cognitive technology to provide personalized and cross-agency e-government services like income tax, employment and work passes, and workplace health and safety initiatives.

waking up to. Currently, smart city data collected from sensors is done so vertically and, according to Deutsche Telekom board member Claudia Nemat, is confined to a "landlocked lake." She believes that, "The content of such data 'oceans' will be so massive, and the relevant analysis so complex, that only artificial intelligence will be able to carry out the relevant data processing and forwarding with the necessary accuracy and speed."

Technological progress will underpin the shift from *second platform technologies* to *third platform technologies*. Second platform tech focuses on cost cutting, sustainability, outsourcing, citizen engagement, and performance and risk management. Third platform tech centers on economic development; sustainability, resilience, and climate preparedness; partnerships and ecosystems; civic tech; open data, transparency, and accountability; and innovation management.

Roadblocks to smart cities

All cities focus on driving economic development, foreign investment, and job creation. But, challenges exist in various areas:

Technology infrastructure: includes fragmented, aging, outdated, or undeveloped infrastructures; information and process siloes; and bureaucratic and cultural issues.

Data use: involves a lack of data interoperability standards within and across domains and a lack of policies or guidelines defining how to securely exploit the value of data in a multi-stakeholder environment.

City infrastructure: includes traffic, crime, and poor waste and energy resource management.

Development path: refers to the complex goal of achieving growth in a way that keeps pace with technology and the changing expectations of citizens and businesses.

Threats: includes factors like financial, organizational, civil unrest, cyber security, and public safety.

Most cities don't look for a single silver bullet, and instead aim for shared goals and close partnerships between stakeholders, which tend to include government organizations, tech and domain suppliers, manufacturers, planners and developers, academia, NGOs, energy providers, users, and community groups.

Citizen engagement

Large-scale transformation requires experimentation, collaboration, and new ideas that iteratively build upon successes and failures over time. One way is to engage citizen groups, business leaders, and IT vendors in IT organizations, city administration, and innovation.

People have high expectations. They want 24/7 access to services through any channel — in person, by mobile device, or computer. They want these services with some level of personalization, or at least preference recognition, and consistent interaction.

This influences mobile strategies in how cities interact with citizens, how services can be delivered, and how ICT works to support government departments and citizens. A strong digital infrastructure must exist alongside ways to engage citizens and business communities in designing the services they want to use. A key feature of the Augmented Innovation stage is that people will have the ICT tools to do this.

Cities can use open data and transparency initiatives to drive more private, citizen, or crowdsourced mobile apps for government services than cities, and this is a trend we expect to see.

By making high-value data and content openly available through web application programming interfaces (APIs) and websites, cities make it easier for departments to share key data internally and with other agencies. Additionally, developers can build applications around city data, which the public can find, use, and visualize on user-friendly charts, graphs, and maps.

The key steps for using open data strategically are choosing data sets to open up based on their impact and usability; providing a platform on which developers can build; balancing improved access to local government information against security and privacy issues based on the types of APIs used; and promoting the use of data via hackathons, ideas, challenges, and other means.

Innovation, experimentation, and knowledge creation are no longer primarily in the hands of universities and research organizations. As people are enabled by more complete data sets alongside the technology and computing power to use them, innovators will emerge from business and community groups, individuals, and so on.

Looking ahead to Augmented Innovation

Innovation, experimentation, and knowledge creation are no longer primarily in the hands of universities and research organizations. As people are enabled by more complete data sets alongside the technology and computing power to use them, innovators will emerge from business and community groups, individuals, government agencies, philanthropic organizations, and other nonprofits and private companies that serve government clients. The challenge is how to promote and harness the ideas from those inside and outside of government.

Innovating to improve services for citizens and operate more efficiently is invariably the foundation of smart city projects and is often accompanied by an expectation of lower costs.

However, there are other benefits that innovation inspires: one, harnessing the collective wisdom of citizens and, two, attracting and retaining younger government workers.

Innovation requires the ability to experiment and collaborate, which means policy makers must be willing to try new things and take risks, potentially expose themselves to failure, and use an iterative process built upon successes and failures over time.

Notably, more mayors and CIOs with vision are getting the attention of constituents, other cities, and the media via high-profile projects with vendors, heavy involvement in the smart cities movement, and personal interaction with citizens via social media. As other key players watch their success, more are becoming open to using emerging technologies and fostering new relationships with citizens and stakeholders.

The big six

We've identified six key ways for how cities can promote innovation, increase citizen sourcing and digital participation, and improve service delivery through IT:

Defining new leadership roles where the CIO serves as chief innovation officer (CIO).

Formalizing innovation as a citywide function using civic innovation organizations.

Developing an innovation ecosystem to involve the larger urban community.

Using open data and transparency as a citizen engagement and sourcing strategy.

Using next-gen, cross-functional, cross-agency systems as platforms for transforming operations and performance.

Developing new contract and vendor relationship models that allow everyone to benefit.

When enabled by a strong technological and digital infrastructure alongside open data and citizen engagement channels, anyone can become an innovator in nations that enter the Augmented Innovation stage. Then, we can realize smart cities, smart states, and smart nations in a truly connected world.

We asked the experts >>

How can we maximize the benefits of technological advancement and AI?

John Suffolk,
Global President of Privacy and Security, Huawei

"Start the open debate now. Don't rush to conclusions or policies, but rush to be inclusive of different thoughts, values, cultures, and beliefs. Move towards making decisions based on today's knowledge step-by-step. As knowledge improves, adapt policies. Recognize what we don't know what we don't know."

Smart cities become smart nations >>

Smart Cities

- Single city with an urban sphere of influence
- Water and waste management
- Connected street lighting
- Smart parking
- Public transportation
- Particulate monitoring
- Connected police and ambulances
- City hall services
- Connected museums
- Smart buildings

Smart States

- Multiple cities and towns with an urban, suburban, and rural influence
- Smart grid
- Smart lotteries
- Infrastructure maintenance
- Justice: offender transport and rehabilitation visits
- Smart tollbooths, highways, and inter-urban transport
- Smart public health, healthcare, and welfare programs
- Emergency and disaster response
- Smart buildings

Smart Nations

- Country level, covering multiple states
- Policies and regulations
- Imports and exports
- Exporting brands
- Climate change and alternative energies
- Funding for innovation
- Education and healthcare policies
- Border protection
- Emergency and disaster response
- The military and defense

Why you should be excited about smart cities >>

Citizen engagement

- Crowdsourced community planning as a web-based service for citizens to turn ideas into projects

Sustainability

- Energy-efficient and sustainable buildings
- Solar panels on roofs and bike paths
- A sharing economy, with more companies like Netflix and Airbnb reducing consumption and waste
- Water recycling systems
- Ride-pooling programs
- Smart climate control in homes and businesses

Traffic

- Rapid public transport system
- Parking payment systems on apps
- Kiosks that display information in real-time; e.g., traffic and weather and traffic rerouting apps
- Street lamps that count foot traffic to help businesses

Connectivity

- Ubiquitous broadband, with every property covered
- Wi-Fi on trains and subways, including stations

Convenience

- City guide apps
- Bacteria-resistant, city-wide touchscreens and kiosks to access services
- Mobile payments everywhere

Public Safety

- An emergency response system as an app or on social media
- Policing, including OLED and surveillance in crime spots
- Gunshot detection technology like ShotSpotter

Markets of one

After years of hyperbole, mass customization is finally within our grasp

We are, all of us, sitting on a gold mine. For the last three decades or so, we've been collecting a treasure trove of digital information on everything from changing weather patterns to the spread of infectious diseases. We've digitized the history of the world's literature. We track and store the movements of automobiles, trains, planes and mobile phones. And we're privy to the raw, real-time sentiments of billions of people through social media.

By Jason Jercinovic
Global Head of Marketing Innovation, Havas

Jason is a veteran digital marketer with over twenty diverse years of experience in technology, advertising, and marketing. Most recently he's been focusing on successfully applying digital innovation to enterprises and leading Havas' Global Innovation Practice.

It's not unreasonable to expect that within this untamed corpus of digital data lay the secrets to defeating cancer, reversing climate change, or managing the complexity of the global economy. But until recently, we haven't had the means to mine this resource properly. It was too big, too messy, and too disparate.

Today, all of that is changing. For the first time since the digital revolution began in earnest, the tools we use to process and analyze data are catching up with the tools we use to produce it. Artificial intelligence, made accessible by a powerful network of broadband connectivity and cloud computing, is able to quickly and purposefully analyze the world's information and put it to use. Using machines that learn, reason, and understand, we can transform vast amounts of complex, ambiguous information into insight, including things that don't fit neatly into databases or spreadsheets: images, video, text, and sound.

This capability holds profound implications for nearly every company in every industry. But for those of us in the marketing profession, it brings us ever closer to reaching a long-sought-after goal: markets of one.

It's easy to misunderstand or underestimate the implications of this concept. In part that's because we've been promised this capability for years, but all we've gotten is incrementally smaller market segments.

Now we're finally in a position to literally tailor millions of customer relationships to each individual, from the way their products and services are designed and delivered to the way their customer service requests are addressed.

I believe the impact of this capability will go far beyond improvements in marketing efficiency and

customer satisfaction. While those are worthy pursuits, they're just the beginning. In our lifetimes, we could be seeing the disintegration of mass markets, the death of one-size-fits-all, and a redefining of economies of scale. It's actually already happening.

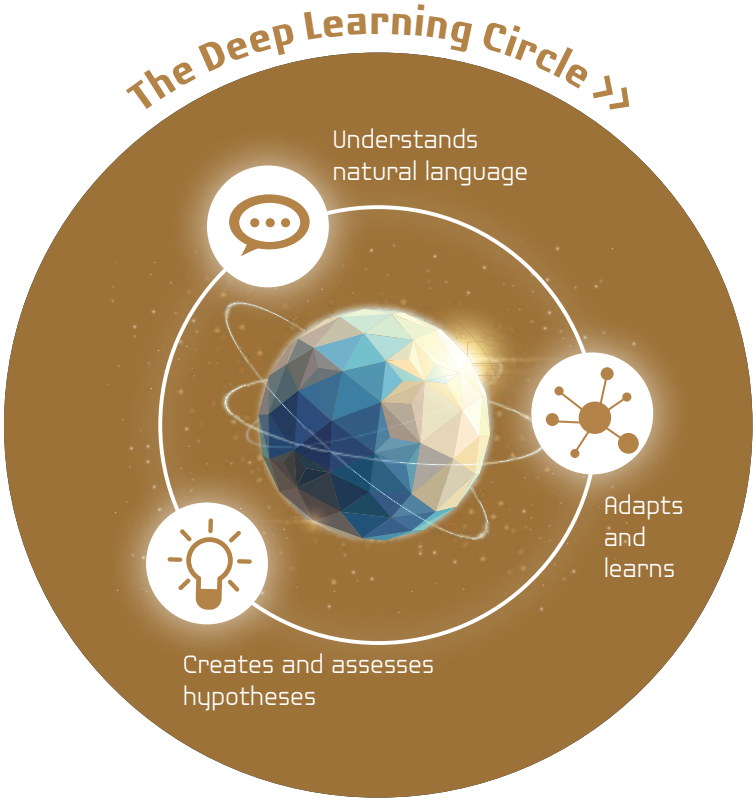
Hi, I'm Watson

In February 2011, the world was introduced to Watson, IBM's cognitive computing system that defeated Ken Jennings and Brad Rutter at *Jeopardy!* It was the first widely seen demonstration of cognitive computing, and it marked the end of the so-called AI winter. The pace at which this technology has progressed since then is breathtaking.

My agency works closely with IBM's Watson team. And I have been in a constant state of awe for the last 18 months as I've watched the technology develop and its capabilities unfold. But the future of my profession started to come into clearer focus recently when IBM announced a new partnership with Sesame Street, in which Watson will be crafting individualized curricula for early childhood learning.

This is the customizing of educational programs to fit a child's skill level and learning style. Those of us who have fretted over the class sizes at our children's schools understand what this means: classes of one. More than that, Watson is not limited to what has been tried before. It has no preconceived notions about the best way to teach. It has no biases. It can try out entirely new combinations, and adapt its content to each person that's using it.

What happens when that same capability is applied to investing? We're currently working with a financial services client that is using artificial intelligence to gauge



each investor's risk tolerance, financial sophistication, and the clarity of their goals. It doesn't do this by asking them to fill out surveys (which we know are inaccurate and rife with bias) or have a conversation with an investment advisor (which doesn't scale). It assesses the investor by having a natural language conversation, chatting about sports, food, and money. And it then offers unique investment advice based on the results.

Similar technology can be applied to improve the customer call center experience of major online service providers. Using a combination of self-service solutions, in which customers use natural language to query the system and find fast answers, and agent-assist solutions, in which call center agents use artificial intelligence to resolve complex customer issues, we can finally scale competency in the call center; a problem that has plagued thousands of companies for decades.

Mine's a brandy

And on a more whimsical note, we know that even within a market of one, preferences can change, from year to year, season to season, or even day to day. Until now, this impermanence of desire has been impossible for marketers to address. Too much change in too short of a time span. But we're working with a cognac maker to concoct cognitive cocktails; specific drink mixes to suit your mood, however fleeting it may be. The system analyzes your social media feeds to assess your state of mind, and finds a mix to match it.

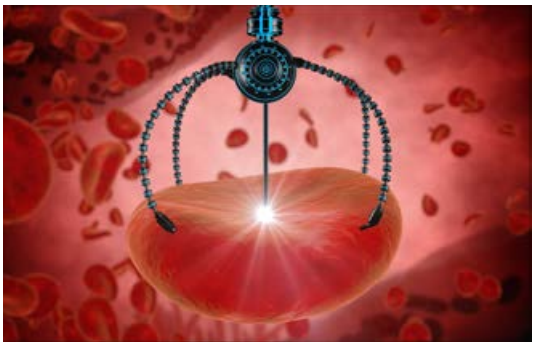
Going forward, it's not hard to imagine physical goods that are custom made to an individual's specifications. Artificial intelligence, robotic manufacturing, and 3D printing make customization possible for everything from clothing to cars. And the fundamental building blocks for this future of Augmented Innovation are in place: broadband, data centers, cloud, analytics, and IoT. They are the drivers of modern day insight. And together they will yield a new understanding of the complex systems that facilitate life on this planet and drive the majority of economic development.

As a marketer, I'm excited about the prospects of mass customization. But as a global citizen, I'm even more excited about the potential to mine the world's greatest natural resource – its data – for centuries to come.

Industry snapshots: Tech enablers and innovation in different verticals

By Gary Maidment

Healthcare



Cloud tech: A survey by HIMMS Analytics in 2014 showed that 83 percent of healthcare providers were using cloud, mainly for SaaS. Future areas of expansion include hosting archived data, backup disaster recovery, and hosting operational apps and data. Expect a cloudy future in healthcare.

Big data and IoT: Huge datasets will be used for great things, for example, fully understanding patients to predict illnesses, predicting epidemics, finding cures, and establishing links. IoT is especially useful for constant monitoring. Current examples include fetal, ECG, and blood-glucose monitors, and smart beds that can detect if they're occupied, when a patient gets up, and adjust pressure and support. IoT is also likely to be applied to inventory management and workflows.

Be excited about: smart drug dispensers in the home, remote robot surgery, nanobots in the blood that act like white-blood cells, mind-controlled prosthetic limbs, big data and AI-enabled research into rare diseases, sensor-enabled preventive medicine, increased collaboration breaking down silos.

Agriculture

Cloud tech: Cloud computing will centralize operations and use virtual desktops to share information across the supply chain. Farmers will be able to track orders, manage inventory, and track crop cycles remotely and on mobile devices. Drones used to collect data will need the support of a smart cloud system.

Big data and IoT: A keen IoT adopter, this vertical is heading towards precision agriculture. GPS and sensors deployed in fields and equipment can provide a steady stream of big data for analytics to unscramble. Farms can use less water, optimize feed mix for cattle, and maximize yield. For example, a cloud-connected mobile device can tell a tractor's planting machine how to vary seed density in real time. Farmers can know when to plant and harvest, and predict expected yield.

Be excited about: indoor vertical farms that use 95 percent less water, genome editing that can change a crop or animal's genetic code down to the letter, lab grown meat that's healthier and tastier than animal meat.

We asked the experts >>

How will AI impact industry?

John Suffolk
Global President of Privacy and Security, Huawei

"I think in finance we will see a shift from robot trading to more "pure" AI, but I have a sneaking feeling regulators might want a say especially in the areas of computerized trading."

Rob McHenry, VP of Public Sector Operations, PARC:

"First and foremost I expect AI to drive the next wave of significant productivity gains across every sector of the global economy. There are an ever growing number of examples where AI systems are producing intelligent results and serving as effective tools... Look at high-speed stock trading for example, where even after early forays into AI systems crashed the markets, the industry doubled down with even more deeply embedded AI – not because they necessarily wanted to, but because it became fundamentally necessary to operate at the speed of the market and succeed."

Education

Cloud tech: Cloud can and will benefit education in many ways: replacing costly and outdated textbooks with digital books that can be updated in real time; slashing costs by replacing traditional management systems with SaaS; and increasing options for learners to study remotely.

Big data and IoT: The increasing use of sensors and data collection through channels like mobile devices, learning software, and digital games will provide actionable insights for students in real time. An example of a correlation that could be tracked is: Do students perform better at math after exercising? Teaching will become personalized, and teachers will be able to collaborate and share to improve teaching outcomes.

Be excited about: students interacting remotely, a shift towards competency-based programs based on skills rather than years of study, eLearning tailored to individuals' preferred pace and style of learning.

Banking

Cloud tech: Overheads will drop as banks don't have to invest in pricey hardware. Expect quicker responses as banks can scale up or down, faster service rollout, closer interaction on the cloud between buyers and sellers, and fully mobile banking.

Big data and IoT: Unlimited computing power and massive data sets will forge closer relationships between banks and consumers, making services more individualized and seamless. Banks will evolve to become a platform run on data, IoT, analytics, and algorithms, positioning them as ideal information brokers for other services like credit and insurance.

Be excited about: banks predicting the type of financial packages you need based on your purchases; building your own suite of products from multiple vendors; robot advisors to stop you making unsound decisions in real-time; more open APIs; proximity beacons pushing offers to you in real-time from banks partners, for example, restaurants and shops.

Cyber security
in the augmented age

By Gary Maidment

Connectivity is increasing and will continue to do so as the first nations stride into the hyper-connected stage of Augmented Innovation. Huawei estimates that there will be 100 billion connected devices by 2025, which in turn will create a considerably larger playing field for digital crime. John Suffolk, Huawei's President of Cyber Security and Privacy, shares his thoughts on this vitally important facet of today and tomorrow's world.

Telling it like it is

In July 2015, Symantec CTO Amit Mital declared that, "Cyber security is basically broken," a sentiment with which Suffolk agrees, in part because technology has a history of outpacing our ability to secure it: "PCs were invented 35 years ago, and we still haven't got the ability to fully secure them," he points out. Given that security and privacy issues don't discriminate when it comes to tech, the fact that it's extremely tough to make any system 100 percent secure is likely to hold true in the future.

Not quite enterprising enough

Hacked enterprises regularly make the news, and will continue to do so if vulnerable or outdated IT equipment remains prevalent. High-profile attacks last year included the toymaker VTech, where hackers compromised the data of 6.8 million children and 4.9 million adults – the largest cyber attack involving children ever. A significant data breach last October saw the entire data cache from the crowdfunding service provider Patreon published online, affecting millions of accounts and involving gigabytes of data and code. And last year, attacks on multiple financial institutions were found to be connected, allegedly laying the groundwork for stock scams before the perpetrator was caught. Affected firms included JP Morgan Chase, which had 83 million customer details stolen, and Scottrade, which saw the data of 4.6 million customers compromised.

Stuck in a timewarp

Alongside vulnerable equipment, enterprises are also at risk because today's tech environments are increasingly complex, and the boundaries of where your tech starts and ends are indistinct, "Many security experts talk of an attack surface," says Suffolk. "In this new world you can't see the edge of the technology your company might be using, so how do you defend what you cannot see? The current and future world is much more complex – it's all about sub- and cross-border systems and ecosystems."

While the environments in which technology exists are moving forward, approaches to cyber security are lagging behind. "By focusing on protecting single products, the ICT industry and policy makers are stuck in the 1980s," says Suffolk. "Standards like PCI, FIPS, TL9000, Common Criteria, and ISO management systems are useful, but they focus on a single product or system and that simply isn't enough."

The Internet of Hackable Things?

And it's not just enterprises. The nascent world of IoT is seeing more products connected than ever before,

and greater device visibility ramps up security risks. Low-cost devices may not see as much investment in security measures, and the design efficiency of smaller-capacity, low-power devices restricts some of the options for security countermeasures. This creates the risk of so-called zombie IoT botnets that could potentially affect networked systems like CCTV surveillance cameras and medical devices. Last year, two hackers demo-hacked a Jeep Cherokee for Wired magazine, causing Chrysler to recall 1.4 million units after the hackers remotely took over dashboard functions, steering, transmission, and brakes.

When discussing Mital's comment about the state of play in the cyber security world, Suffolk is quick to point out the root cause: "It's not just that cyber security is broken; our approach to risk management at a government and corporate level is broken. This, he feels, is due to the interplay of multiple factors: "The complexity of technology products and systems, business commercial pressures, cloud computing, and international laws, and not having a model for assessing a complex risk position that can quickly shift."

Look to the layers for answers

But, it's not all doom and gloom. Suffolk advocates a risk-based, layered approach which recognizes that some data must be 100 percent secure, or at least as secure as we can make it. "The issue is how secure do I need to be for the service I'm providing or receiving?" he says. "Not all systems, or data, are born equal; for example, health data is more important than your shopping list, air traffic control is more important than your games console."

Suffolk is clear that we can't treat everyone the same in a world of 5G, cloud, and IoT. Because of the blurry nature of current and future attack surfaces, he asserts that security must be layered, zoned, or segmented because you can't pick a single best approach when one size definitely doesn't fit all. While verticals are good at managing their own technology, the challenge, Suffolk believes, comes when you connect to different clouds from multiple service providers using a range of BYOD and work devices, because you don't always know what cloud or infrastructure you're connecting to.

Another must is ensuring that security measures are built-in and not bolted-on. According to Suffolk, this is starting to happen, "Vendors are working hard to improve product security, and standards bodies are building better security designs, such as north bound interfaces for IoT, which builds in protection when technology components start talking to each other."

Equally important for enterprises, this built-in security approach needs to exist in a seamless and complete context. "We're focusing on an end-to-end approach to security and privacy across our complete product portfolio," states Suffolk, "from design and build to deploy and maintain."

Prevention is better than cure

In the current state of play, experts like Suffolk are pushing cyber security in the right direction, layering new technologies as the armor in the augmented age and using agility as the spear. Advancements have been made in cloud, big data, analytics, and high-performance computing, which can cover much more ground when acting in concert to protect systems and networks. "Computers are much better than humans at looking at vast amounts of data and working out anomalies in patterns," explains Suffolk. "We're doing that with our next-generation security products, such as firewall and anti-DDoS, connecting through cloud and using big data to be more insightful."

The reality of cyber threats that span boundary-less attack surfaces requires that security measures are agile, risk-based, and layered. In Suffolk's words, "You need to understand what the key assets are you want to protect and how to protect them – all of that is a journey, and in a time of dramatic technological change, a journey with no end."

Wagenia man fishing in the Congo River

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