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DEFTECH Update

August 2017

Dear Reader,

This document summarizes emerging technology signals related by Strategic Business Insights' (SBI) Scan and Explorer services that the Technology Foresight Research Program from armasuisse Science + Technology subscribes to.

For each trend, we try to anticipate what could be the implication for the armed forces. Each trend is also related to the original signal of change elaborated by SBI that the interested reader finds at the end of this document.

The intent is to stimulate strategic technology forward thinking in a form that is pleasant and quickly readable.

We hope you enjoy the journey!

Best regards,

Dr. Quentin Ladetto
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Image source: The Verge website

Establishing Wireless Connections: Novel approaches to creating wireless charging (including at room scale) or wireless communications could lower the cost of rolling out new wireless capabilities. Some companies including AT&T are developing systems that retrofit established infrastructures. Other companies, including mobile-telecommunications provider EE, plan to create temporary infrastructures using mobile blimps and drones to enable wireless connectivity.

Implications for Defense and Security*: Defense and security organizations could retrofit some military buildings with wireless charging technologies to ensure key military devices are always charged and available for use (for example, in a store of operational equipment). Also, opportunities exist to develop novel infrastructure such as mobile blimps and drones that can provide wireless connectivity to remote locations or to armies on the move.*

Timing of Implication: ***now/5 years****/10 years/15 years*

Image source: Road to VR website

Expanding the VR Ecosystem: New virtual reality (VR) headsets and applications are creating a competitive and accessible ecosystem of VR devices. Through hardware partnerships, Microsoft's VR and augmented reality (AR) software is yielding affordable and technologically competitive headset options (for example, from Dell and HP) some of which will ship with handheld motion controllers. Meanwhile, Oculus and HTC are working on stand-alone wireless VR headsets that do not require connectivity to personal computers.

Implications for Defense and Security*: New VR options offer opportunities for defense and security organizations to enhance immersive training environments, to aide rehabilitation of injured soldiers (for example, to treat post-traumatic stress disorders), and to build visual systems for remote piloting of drones, robots, and military vehicles. Windows-compatible VR headsets such as those from Dell and HP are low-cost and easy to customize.*

Timing of Implication: ***now/5 years****/10 years/15 years*

Image source: The New Economy website

Investment in Cybersecurity: The increasing volume, severity, and complexity of cyberattacks are leading to a record investment in cybersecurity start-ups that are capable of mitigating the threats.

Implications for Defense and Security*: Cyberattacks have the potential to cripple military capabilities and cause major service and network degradations. Although threats are increasing, record investment should yield new mitigation technologies and approaches—for example, artificial intelligence (AI)-based systems—that defense and security organizations can leverage.*

Timing of Implication: ***now/5 years****/10 years/15 years*

Image source: IBM website

Neuromorphic Chips: Large tech companies and start-ups are using neuroscience insights to develop neuromorphic chips with artificial neurons that are configured to mimic the human brain. Although neuromorphic chips are many years from reaching commercialization, the technology is progressing and opportunities exist for fast-processor chips that operate with brain-like speeds whilst having a low power draw.

Implications for Defense and Security*: Neuromorphic chips could find use in military devices that have power constraints and that need to perform complex tasks such as analysis of sensor data. Examples include battlefield sensors, autonomous vehicles, satellites, high-altitude aircraft, and drones. In the future, artificial brains that contain neuromorphic chips could find use in military field robots and in other autonomous equipment.*

Timing of Implication: *now/****5 years/10 years****/15 years*

Image source: ILIAS Solutions Infographic

Predictive Maintenance: Predictive-maintenance services use equipment data to optimize maintenance and predict failures. For example, software from Caterpillar's marine division analyzed shipboard-sensor data to deliver an optimized hull-cleaning schedule capable of saving $400,000 per ship in an eight-ship fleet. And General Electric operates a cloud platform to optimize the operation of its industrial machines.

Implications for Defense and Security*: As well as potentially reducing maintenance costs (by avoiding unnecessary repairs), predictive maintenance could increase the availability of military vehicles and equipment, and provide a method for monitoring for potential failure of equipment in the field. Defense manufacturers may provide predictive maintenance as an ongoing service.*

Timing of Implication: ***now/5 years****/10 years/15 years*

Image source: Geomarketing website

Voice-Assistant Devices: As the ecosystem of voice assistants grows, competition between manufacturers is increasing. As a result, venders are introducing new applications and upgrading the capabilities of voice-assistants to, for example, make calls, identify multiple users, and enable touch interfaces.

Implications for Defense and Security*: Defense and security organizations could plausibly repurpose consumer voice-assistant technology with customised hardware and software to develop voice interfaces for military personnel. For example, in-ear assistants could communicate with in-field personnel, providing real-time information such as enemy locations and battlefield terrain.*

Timing of Implication: ***now/5 years****/10 years/15 years*

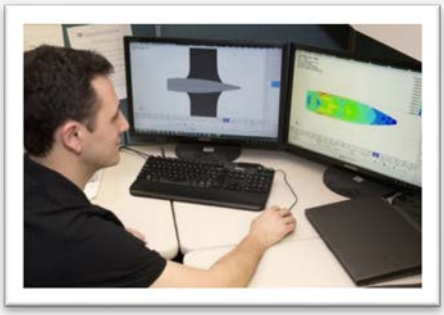

Image source: The U.S. Army website

Computer Modeling as an Enabler: Computer modeling applications are advancing. For example, start-up motorcycle company Vanguard Moto is using computer-modeling approaches to design vehicles and components and to simulate production methods. Also, research teams are developing computer-modeling approaches that can provide city planners with new software that can model entire urban environments and materials scientists with advanced simulation approaches that can aid in the design and testing of new materials.

Implications for Defense and Security*: Computer-modeling could help military personnel design battlefield environments for strategic mission planning and virtual training. Other model types could help engineers to design and test new military equipment and ammunition (for example, to optimize material performance).*

Timing of Implication: *now/**5 years/10 years**/15 years*

Image source: Defense Systems website

Drones' 1,001 Uses: Recently, the US Department of Defense tested a swarm of 104 electric microdrones, Perdix, and demonstrated their autonomous swarming capabilities that include self-healing communications, self-adapting formation flying, and collective decision-making. Also, H3 Dynamics unveiled a fuel-cell-powered lightweight drone that can fly for ten hours (flight distance of 500 kilometres) without refueling.

Implications for Defense and Security*: Military interest in drone technology is growing as the technology advances. Connected low-power drones can potentially play a variety of roles including low-cost surveillance (ground and airspace), supplementary air defense, and battlefield attack weapons.*

Timing of Implication: *now/**5 years/10 years**/15 years*

Image source: Digital Trends website

Eye-Tracking Interfaces Update: Efforts to develop eye-tracking software and hardware have increased with the growth of VR and AR technologies. Eye-tracking devices and sensors are likely to enable advanced navigation and control for devices and applications.

Implications for Defense and Security*: Eye-tracking technologies could help military personnel in navigation and in the control of devices—for example, to enable autonomous missile alignment and deployment. The technologies could also serve medical applications. For example, eye-tracking technologies can assist in rehabilitation, and potentially aid diagnostic testing.*

Timing of Implication: *now/**5 years**/10 years/15 years*

Image source: Scorchai website

Fast Inference Algorithms: Start-ups Aipoly, Scorchai, and Xnor.ai are developing software that accelerates execution of image-recognition applications on smartphones and other devices. Many applications would benefit from battery-operated systems that can interpret video scenes with no need for a network connection and no need for additional chips.

Implications for Defense and Security*: Advanced image recognition systems could find use in battery-powered military devices such as drones and in wearable cameras (for example, to help to identify multiple objects and people instantly) or in augmented reality headsets to quickly render object labels. Also, because these image recognition systems do not need network connections, they will help devices operate autonomously and in remote locations.*

Timing of Implication*:* ***now/5 years****/10 years/15 years*

Image source: Jen Underwood website

Update on Emotionally Intelligent Computing: Companies including Affectiva, nViso, Microsoft, and Eyeris are working toward the eventual development of emotionally intelligent AI by means of computer vision. Microsoft recently released the Emotion API (application programming interface) that analyses faces to detect emotions. Eyeris, with its EmoVu software, uses deep learning and convolutional neural networks to track faces and detect emotions in video.

Implications for Defense and Security*: Advances in computer-vision systems using emotion recognition could enable security camera systems and body cameras that can detect emotions in real time and perhaps predict ill intent or identify suspicious behavior. In addition, emotionally intelligent AI could be of benefit to security organizations for text, voice, and image analysis.*

Timing of Implication: *now/**5 years**/10 years/15 years*

STRATEGIC BUSINESS INSIGHTS

scan™

July 2017

P1090

Establishing Wireless Connections

By Lucy Young (Send us feedback.)

Novel approaches to creating wireless charging or communications could lower the costs of rolling out additional wireless capabilities.

Abstracts in this Pattern:

SC-2017-06-07-028 on AT&T
SC-2017-06-07-038 on Disney Research
SC-2017-06-07-067 on EE

Because of the spread of Wi-Fi and the introduction of induction charging, wireless connections are quickly becoming the norm for many devices. Some companies are developing systems that retrofit established infrastructures or create temporary infrastructures to enable wireless connectivity. In September 2016, telecommunications company AT&T (Dallas, Texas) revealed details about AirGig—a communications technology that uses existing aboveground power lines to enable a type of wireless connectivity. The wireless signal itself does not travel through the power lines; instead, the AirGig device uses the wires to act as a guide for the wireless signal. AT&T claims the technology could provide homes and mobile phones with multigigabit internet speeds and is currently in discussions with power companies to begin trials of the technology by the end of 2017.

Scientists from Disney Research Pittsburgh (The Walt Disney Company; Burbank, California) have been investigating room-scale wireless-charging systems. The scientists used quasistatic cavity resonance (QSCR) to turn a 16-by-16-by-7.5-foot room with aluminum walls, floor, and ceiling into a wireless-charging area. Currents flow up and down a copper pipe at the center of the room. Disney Research Pittsburgh associate research scientist Matt Chabalko explains, "Those currents travel through the ceiling, down through the walls, and back down to the floor, where they again flow up through the pole. It's those currents that generate magnetic fields that circulate around the pole." Special orthogonal receivers enable devices in the room to charge wirelessly at any orientation. Including windows and doors in the room's design will not significantly affect the system's efficacy. The scientists believe they could use modular metal panels or even conductive paint to achieve room-scale wireless charging, enabling them to retrofit buildings with QSCR.

Rather than retrofitting infrastructure, mobile-telecommunications provider EE (BT Group; London, England) plans to use mobile blimps and drones to provide emergency mobile-phone coverage. The company claims its technology could see use to help people and first responders stay connected during emergency situations and after floods and other natural disasters. The technology could also see use to improve mobile-phone reception in rural areas and at large events such as concerts.

Signals of Change related to the topic:

SoC929 — Rural Connectivity
SoC913 — …Urban Environments…
SoC630 — …Demand on Networks

Patterns related to the topic:

P0995 — Advances in Telecommunications
P0989 — Connected Objects
P0932 — Improve Thy Connectivity

STRATEGIC BUSINESS INSIGHTS

EXPLORER

Viewpoints

July 2017

User Interfaces

By Sean R. Barulich (sbarulich@sbi-i.com)

The Expanding VR Ecosystem

Why is this topic significant? New VR headsets and applications are creating a competitive and accessible ecosystem of VR devices.

Description

Although various virtual-reality (VR) headsets are already on the market (for example, HTC Vive, Oculus Rift, and PlayStation VR) new headsets and software continue to arrive, increasing competition. Microsoft recently revealed a long list of partners—including Acer, HP, Dell, and Lenovo—releasing mixed-reality (MR) headsets running on Windows 10. Some of the offerings improve on the technology of competitive devices—including Oculus Rift and HTC Vive—by providing better displays and software integration. Microsoft is also providing Windows Mixed Reality Controllers with the headsets. The Windows-based headsets provide an affordable VR entry point for consumers.

During Apple's WWDC (Worldwide Developers Conference) 2017, Apple did not present a headset-based mixed-reality system but did reveal two applications for VR: Metal 2 and ARKit. Metal 2 adds support for VR—including for games development—on macOS. ARKit is an iOS 11 application that provides mixed-reality capabilities to iPhone and iOS. Although Apple did not provide a headset, the company's interest in VR and mixed reality is clearly growing.

Sony—which produces PlayStation VR, one of the most affordable VR systems next to Acer's and HP's upcoming systems—is expanding its gaming library with a series of games and downloadable content from various publishers. PlayStation VR has performed fairly well, selling over a million units since launch in 2016.

Implications

Even though Oculus, HTC, and Sony are providing competent devices for VR, their products remain niche. Microsoft is looking to provide an affordable and technologically competitive VR option.

Microsoft is perhaps targeting enterprise customers with their partner-built headsets by placing emphasis on Windows 10 integration. The Windows OS integration provides users with a large software library for enterprise applications—though also for gaming. Apple seems to be exploring mixed-reality content for iOS by taking advantage

of its strong developer base as well as the large population of iOS users. Sony is continuing to improve PlayStation VR and still provides the most affordable entry to VR gaming for consumers who use the PlayStation 4 console.

Impacts/Disruptions

Although some new VR and MR offerings are promising, drawbacks exist in comparison with offerings from the current competition. Microsoft and its partners presented devices with better displays at a lower price point, but they lack VR game libraries such as the HTC Vive has with Steam, Valve's game-distribution platform. Another disadvantage of Microsoft's devices is that the controllers require that they remain in field of view to operate. If Microsoft can integrate Steam, its VR headsets will be able to compete directly with the HTC Vive.

Another challenge for Microsoft is to provide a wireless headset option. Oculus and HTC are currently working on providing stand-alone VR devices that do not require connectivity to a PC. Although new products will face challenging competition, opportunities exist for new, affordable, products that will appeal to consumers looking to experience VR.

Scale of Impact	Low	Medium	**High**	
Time of Impact	**Now**	**5 Years**	10 Years	15 Years

Opportunities in the following industry areas:
Consumer electronics, software development, enterprise, entertainment, gaming

Relevant to the following Explorer Technology Areas:
• User Interfaces • Collaboration Tools • Electronic Displays • Pervasive Computing

July 2017

P1081

Cyber(in)security

By Peter Batty (Send us feedback.)

As cyberattacks increase in frequency, new opportunities will emerge for players capable of mitigating threats.

Abstracts in this Pattern:

SC-2017-06-07-091 on start-ups

SC-2017-06-07-013 on Project Shield

SC-2017-06-07-040 on car apps

The increasing volume, severity, and complexity of cyberattacks is leading to record investment in cybersecurity start-ups. According to CB Insights (New York, New York), investors distributed $3.1 billion among 279 new cybersecurity firms in 2016.

Cybercrime journalist Brian Krebs works to uncover actors behind high-profile cyberattacks; in doing so, he faces retribution in the form of distributed-denial-of-service (DDoS) attacks on his website (https://krebsonsecurity.com). Jigsaw (Alphabet; Mountain View, California) recently added Krebs's website to its Project Shield (https://projectshield.withgoogle.com/public) program in an attempt to mitigate the DDoS attacks. DDoS attacks on Krebs's website had increased to such a large volume that the website's previous security provider had to stop supporting it. Ultimately, Alphabet's goal is to minimize downtime for its products and services. Proactively seeking out the largest and most powerful threats enables Alphabet's security engineers to find weaknesses in their own systems and develop new methods for mitigating attacks.

The quickest way for an attacker to gain control of a system is to take advantage of security vulnerabilities, and cars that have connectivity features are creating new opportunities for hackers. For example, Kaspersky Lab (Moscow, Russia) researchers Victor Chebyshev and Mikhail Kuzin found that seven Android smartphone apps for connected cars had vulnerabilities to malware and lacked security features such as data encryption (for example, some of the apps did not encrypt user credentials). In addition, none of the apps performed integrity checks or detected root permissions to app data and events, enabling hackers to create malware versions of the apps with relative ease. The researchers suggest that hackers could use a variety of methods to trick people into installing such malware versions of the apps on their smartphones. Because these Android apps enable users to unlock and sometimes even start their car, a malicious actor could take advantage of the apps' security vulnerabilities to steal cars. Such vulnerabilities will create opportunities not only for software designers and third-party security companies but also for insurance companies and liability mediators.

Signals of Change related to the topic:

SoC946 — Diffusion of Hacking…

SoC933 — Snooping Technologies

SoC930 — Trust(ed) Systems

Patterns related to the topic:

P1086 — Suspicion Plagues…Data

P1064 — Data and Privacy…

P1036 — Hacking's Reach Expands

STRATEGIC BUSINESS INSIGHTS

EXPLORER

Viewpoints

July 2017

Artificial Intelligence

By Sean R. Barulich and Michael Gold (mgold@sbi-i.com)
Barulich is a research analyst with Strategic Business Insights.

Neuromorphic Chips

Why is this topic significant? Suppliers that want to advance the status of AI might need to use neuroscience insights to help design chips.

Description

Neuroscience has inspired much artificial-intelligence (AI) software and some AI hardware. A few neuromorphic chips are available and are mostly for researchers and hobbyists. Adafruit sells mini circuit boards containing Intel's Curie chips. Each chip contains 128 interconnected artificial neurons, with each neuron containing tightly integrated processing and memory—attributes common to natural neurons. Intel licensed the design from start-up General Vision. Another start-up—Knowm—has reportedly delivered chips having arrays of neurons whose processors integrate with memristors. Such nonvolatile memory devices have programmable electrical resistance; brain cells have somewhat similar properties.

Perhaps the best-known neuromorphic chips are TrueNorth (developed by IBM with funding from the US Defense Advanced Research Projects Agency's SyNAPSE and Switzerland's Blue Brain projects) and SpiNNaker (developed by the University of Manchester with funding from Blue Brain and the European Union's Human Brain Project). In 2016, the Human Brain Project commissioned a six-rack SpiNNaker system containing 500,000 interconnected ARM cores. Natural neurons have similarly abundant interconnections. Recently, the Air Force Research Lab contracted IBM to build a unit that will contain 64 TrueNorth chips—reportedly, enough processing resources to simulate 64 million neurons while consuming only 10 watts. Power requirements are major obstacles to high-performance computing efforts; TrueNorth aims to make progress toward achieving brain-like energy efficiency by using voltage spikes for signaling (as natural neurons do) rather than steady-state ones and zeros (as most computers use).

Much additional early-stage research is under way. Belgium's IMEC research institute recently developed a prototype chip that uses oxide-based resistive memory; the chip can find patterns in audio and create music. The Massachusetts Institute of Technology recently reported on development of a chip that uses light and lenses rather than electricity and wires in an effort to build artificial neurons

having brain-like speeds. Other organizations that are developing chips having various neuromorphic attributes include Hangzhou Dianzi University; HRL Laboratories; Oak Ridge National Laboratories; Stanford University; the University of Heidelberg; the University of California, Santa Barbara; the University of Tennessee; and Zhejiang University.

Implications

Insights from neuroscience research inspired the invention of artificial-neural-network software, including deep-neural networks. Now, hopes are high for hardware that might make use of neuroscience insights to enable an AI breakthrough. Attempts to use such insights are what distinguish neuromorphic hardware from other AI chips, which typically serve to accelerate specific categories of artificial-neural-network software algorithms.

Neuromorphic chips are largely unproved for practical applications. They remain too immature for use in applications—such as web-services data centers, driverless cars, drones, and augmented-reality eyewear—that could benefit from accelerated AI operations. In order to commercialize neuromorphic chips, researchers will need to determine what aspects of the human brain are important and possible to model in hardware. When and if hardware appears having brain-like processing capability, developers will need further breakthroughs to produce software that can make effective use of such hardware.

Impacts/Disruptions

Use of spiking models promises rich possibilities for controlling how and when neurons fire, emulating how biological systems activate and inhibit neural activity. Spikes also help brains achieve superior energy efficiency; hardware that uses spikes instead of steps could therefore support greatly increased use of parallel processes. Implementation of spiking and other attributes of brains could become critical for realizing breakthroughs in image recognition, natural-language processing, and other AI goals.

Scale of Impact	Low	Medium	**High**	
Time of Impact	Now	**5 Years**	**10 Years**	15 Years

Opportunities in the following industry areas:
Artificial intelligence, machine learning, electronics manufacturing, software engineering

Relevant to the following Explorer Technology Areas:
• Artificial Intelligence • Mobile Communications • Nanoelectronics • Pervasive Computing • Portable Electronic Devices • User Interfaces

STRATEGIC BUSINESS INSIGHTS

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July 2017

P1085

Right to Repair

By Rob Edmonds (Send us feedback.)

Connected products are transforming maintenance and repair, but some product owners are rebelling.

Abstracts in this Pattern:

SC-2017-06-07-096 on predictive maintenance

SC-2017-06-07-101 on license agreements

SC-2017-06-07-035 on legislation

For years, smartphone manufacturers have tried to discourage consumers from repairing their own phones and using unauthorized repair shops. As the Internet of Things develops, more products than ever before include software, and the repair and maintenance markets are changing. Manufacturers are issuing product licenses that place restrictions on repairs, arguing that they need to protect their intellectual property and device security and safety. Manufacturers also believe that new data services could transform maintenance.

Predictive-maintenance services use equipment data to optimize maintenance and predict failures. For example, Caterpillar's (Peoria, Illinois) marine division offers predictive-maintenance and optimization services for the shipping industry. For one client, Caterpillar's software analyzed shipboard-sensor data to deliver an optimized hull-cleaning schedule capable of saving $400,000 per ship in an eight-ship fleet. And General Electric (Boston, Massachusetts) operates a cloud platform to optimize the operation of its industrial machines.

Some product owners are resistant to embedded and cloud software that ties product repair and maintenance to a particular manufacturer and its authorized partners. In October 2016, owners of John Deere (Deere & Company; Moline, Illinois) equipment had to sign a license agreement that forbids equipment repairs and modifications by entities other than John Deere dealerships and authorized repair centers. Some farmers are ignoring their license agreements with John Deere and using the black market to purchase modified firmware for use in repairing and modifying their farming equipment.

Some legislators are concerned that the repair market for electronic products is uncompetitive and have made efforts to enact so-called right-to-repair laws. Such laws would require companies to "make their service manuals, diagnostic tools, and parts available to consumers and repair shops—and not just select suppliers." In Nebraska, senators recently debated a bill that would establish the Fair Repair Act; however, lobbying from bill opponents such as Apple (Cupertino, California) and John Deere has been strong, and senators did not move the bill forward. In Minnesota, lobbying efforts contributed to a similar bill's failing to reach a hearing. Several other states are considering similar legislation, and some right-to-repair proponents expect to see the introduction of another version of the Nebraska bill in 2018.

Signals of Change related to the topic:

SoC935 — 5G and Connected Devices

SoC918 — The Road to Industry 4.0

SoC860 — 3D Technology and Tinkering

Patterns related to the topic:

P1041 — New Technologies and Liabilities

P0920 — Sustainable Thoughts

P0801 — Makers' Dream, SOHO's Promise

STRATEGIC BUSINESS INSIGHTS

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June 2017

P1074

Drones' 1,001 Uses

By Peter Batty (Send us feedback.)

The decreasing size and expanding capabilities of drones are enabling an increasingly wide range of applications.

Abstracts in this Pattern:

SC-2017-05-03-022 on conservation
SC-2017-05-03-086 on pollination
SC-2017-05-03-026 on military
SC-2017-05-03-083 on industrial use
SC-2017-05-03-075 on flight time

A project by Resolve's (Washington, DC) Biodiversity and Wildlife Solutions Program, the Tanzania Wildlife Research Institute (Arusha, Tanzania), and the Mara Elephant Project (Nairobi, Kenya) has had success in using drones to prevent conflicts between humans and elephants in communities close to the Tarangire and Serengeti National Parks in Tanzania. Data from 51 field trials show that drones can reliably drive wild elephants away from contested areas, thereby protecting them from humans. And in an effort to address concerns about dwindling bee populations, researchers at the National Institute of Advanced Industrial Science and Technology (Tokyo, Japan) have created a prototype insect-size drone capable of pollinating plants.

Decreases in the cost and size of drones have increased military interest in drone technology. The US Department of Defense (Arlington County, Virginia) recently tested a swarm of 104 electric microdrones, dispersing the drones from three jets above the Naval Air Weapons Station China Lake in California. The Perdix drones—originally developed during a student project at the Massachusetts Institute of Technology (MIT; Cambridge, Massachusetts)—have been modified for military use by researchers at the MIT Lincoln Laboratory. During the test, the Perdix drones demonstrated autonomous swarming capabilities such as "self-healing communications, self-adapting formation flying, and collective decision-making." And industrial use of drones can prevent human workers from experiencing deadly accidents such as falls from power lines and electrocutions. Power utility AES Corporation (Arlington, Virginia) is working with Measure (Washington, DC), which develops software that turns drones into service machines, to create fleets of inspection drones that can perform hazardous inspections and maintenance work. AES is making increasing use of drones that take close-up video of power lines and electrical equipment that human inspectors can view on a computer monitor.

Most small electric rotor-driven drones suffer from short flight times because of the shortcomings of the batteries they use. H3 Dynamics (Singapore, Singapore) recently unveiled a fuel-cell-powered multirotor drone that weighs only 7 kilograms and can fly for ten hours without refueling, which gives it a flight distance of 500 kilometers. Such capabilities could one day enable a broad array of new drone applications.

Signals of Change related to the topic:

SoC866 — A Flock…of Drones
SoC796 — Drone Update
SoC677 — The Sky's the Limit for UAVs

Patterns related to the topic:

P0998 — Drones on Top of the Hype Cycle
P0942 — Drones: Ability to Save…
P0911 — Drones' Capabilities Expand

June 2017

P1079

Computer Modeling as an Enabler

By Guy Garrud (Send us feedback.)

Advanced computer modeling can benefit an increasingly wide range of applications.

Abstracts in this Pattern:

SC-2017-05-03-014 on Vanguard Moto
SC-2017-05-03-012 on Fraunhofer
SC-2017-05-03-049 on MIT
SC-2017-05-03-061 on Harvard

Start-up motorcycle company Vanguard Moto (New York, New York) is using computer modeling as an integral part of its design process. Computers enable engineers not only to iterate a design rapidly but also to use computer-aided engineering and simulation systems to test components and vehicle designs without making a physical product. Vanguard is also taking advantage of advances in computer design to simulate production methods, enabling it to enter a usually capital-intensive industry.

New computer-modeling approaches can even provide detailed analyses of entire urban environments. Researchers at the Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut (Fraunhofer Society for the Advancement of Applied Research; Munich, Germany) have developed VITRUV—software that drastically simplifies the structural-risk-analysis process by supporting city planners during all phases of their work: "In the concept phase, a rapid assessment of the safety-related topics is performed. In the planning phase, the tool provides insights into vulnerability, weaknesses and specific areas of risk. Finally, in the detail planning, it develops concrete solutions to minimize risks."

Computer modeling is playing a significant role in cutting-edge research. For example, researchers from the Massachusetts Institute of Technology (MIT; Cambridge, Massachusetts) used atomistic computer modeling in their efforts to fuse and compress two-dimensional graphene flakes into strong, lightweight three-dimensional structures. The researchers discovered that the geometric arrangement of the flakes following a treatment of heat and pressure forms a very strong structure. Using a 3D printer, the researchers printed large versions of these microscopic structures for mechanical testing. "Their mechanical response under loading was simulated using the team's theoretical models. The results from the experiments and simulations matched accurately." And researchers from Harvard University (Cambridge Massachusetts) used computer modeling to devise a general framework for the design of *metamaterials*—materials with functions determined by the materials' structure rather than by their bulk properties—that are reconfigurable. The researchers discovered that "assemblies of polyhedra can be used as a template to design extruded reconfigurable thin-walled structures." In principle, the Harvard researchers' design method is scale independent, which means it can see use in small applications such as nanoscale systems and large applications such as architectural structures.

Signals of Change related to the topic:

SoC910 — Origami-Inspired Design…
SoC905 — …Future Urban Environments
SoC870 — …Nanoscale Manufacturing's Science

Patterns related to the topic:

P0990 — Medical Origami
P0955 — Algorithmic Guidance
P0835 — Visualization for…Engineering

STRATEGIC BUSINESS INSIGHTS

EXPLORER

Viewpoints

June 2017

User Interfaces

By Sean R. Barulich (sbarulich@sbi-i.com)

Eye-Tracking Interfaces Update

Why is this topic significant? Eye-tracking technology may create effective controls for VR gaming and entertainment and enable hyperaccurate marketing that tracks users' attention.

Description

Efforts to develop eye-tracking software and hardware have increased with the growth of virtual-reality (VR) and augmented-reality technologies. Developers are working on eye-tracking technologies to create hands-free controllers and attention trackers.

Tobii, one of the leaders in eye-tracking technology, offers multiple stand-alone eye-tracking devices and supplies product makers with eye-tracking modules and components (for example, for some current VR devices, laptops, and PC monitors with built-in eye tracking).

Google and Oculus VR are interested in improving the capabilities of their VR devices and have, respectively, acquired eye-tracking start-ups Eyefluence and The Eye Tribe. Eyefluence's technology primarily used distinct eye gestures as a method of navigating menus and making selections. Before acquisition, The Eye Tribe was also advancing user interfaces by implementing eye-controlled navigation for software.

Other vendors also see benefit in eye tracking for VR. For example, HTC recently revealed an eye-tracking upgrade—aGlass—for the Vive VR headset. Chinese start-up 7invensun supplied the eye-tracking module. Other companies developing eye-tracking technology include SMI, iMotions, EyeLink, and Fove.

Implications

Eye-tracking devices and sensors may enable advanced navigation and control for devices and applications. In addition, the technology could provide marketers and advertisers with useful feedback about consumer responses.

In entertainment and VR gaming, eye tracking can increase the immersive experience for users by using foveated rendering—a technique that prioritizes graphics performance on areas where users are looking and can add depth-of-field effects to simulate human vision better. This efficient method of rendering can provide 4K graphics while maintaining a high and smooth frame rate for viewers.

In marketing and advertising analytics, software can use data from eye-tracking monitors or headsets to gain a detailed understanding of advertising effectiveness. By tracking users' attention and focus, advertisers can tailor and improve their messages based on the likely interest and attention of viewers.

Eye-tracking devices also serve medical applications. For example, the devices can provide communication interfaces, assist in rehabilitation, and potentially aid diagnostic testing.

Impacts/Disruptions

Although eye-tracking technology is developing rapidly, it is unlikely to play a significant role as a primary interface anytime soon. Touch and gesture controls may remain more effective than eye-tracking technology until manufacturers can integrate the latter into mobile displays.

Another concern for eye-tracking technology is data privacy—especially for marketing and analytics applications. Users may be unwilling to share eye-tracking data without some sort of compensation. In addition, integration of eye tracking into TV displays, although ideal for cable companies and advertisers, would at this time seem to provide minimal if any benefit to viewers.

Scale of Impact	Low	**Medium**	High

Time of Impact	Now	**5 Years**	10 Years	15 Years

Opportunities in the following industry areas:
Electronics manufacturing, sensors, software development, augmented reality, virtual reality

Relevant to the following Explorer Technology Areas:
• User Interfaces • Collaboration Tools • Connected Cars • Mobile Communications • Pervasive Computing • Portable Electronic Devices

STRATEGIC BUSINESS INSIGHTS

EXPLORER

Viewpoints

June 2017

User Interfaces

By Sean R. Barulich (sbarulich@sbi-i.com)

Ultrasound Touchless Interfaces

Why is this topic significant? Ultrasound touchless interfaces may provide advanced gesture control for various virtual- and augmented-reality devices and for software applications.

Description

Some touchless interfaces use ultrasound to receive inputs and, in some cases, provide feedback to users. Most current touchless interfaces, including Microsoft's Kinect, use depth cameras. Cameras are challenged by bright light and transparent objects and cannot provide feedback to the user. Although ultrasound interfaces are still in development, promising examples of the technology exist.

- Google's Soli interaction sensor chip uses the reflection of electromagnetic waves off objects to determine the characteristics of the object by analyzing the varying properties of the reflected waves. The sensor and associated software are effective enough to detect subtle gestures that can simulate physical tools for specific interactions such as turning a key or pushing a button.

- Ultrahaptics is developing a touchless interface device that integrates a gesture-tracking sensor coupled with a microprocessor and field-programmable gate array. By using ultrasound waves, the device may provide haptic feedback for users as well as accurate gesture detection, simulating in air the actual feeling of switches and buttons.

- Chirp Microsystems' low-power ultrasonic sensor uses transducers and reflects sound waves off objects to measure depth and motion.

- Elliptic Labs' ultrasound technology uses the existing audio hardware in phones to emit ultrasound waves and record reflection via microphone to recognize gestures.

Implications

Touchless interfaces provide potentially intuitive and simple controls for devices and applications. If they integrate with PCs or virtual- and augmented-reality devices, touchless gesture interfaces may replace some peripheral devices and controllers. For example, virtual keyboards coupled with haptic feedback could enable navigation through software applications and the web with augmented-reality headsets.

Because of the small form factor of some touchless sensor systems, integration into mobile devices may be possible, adding advanced gestures to touch-screen interfaces. Elliptic Labs' technology even requires no new hardware.

Impacts/Disruptions

Although ultrasound interfaces have some advantages over camera-based approaches, the outcome for ultrasound interfaces is uncertain.

As manufacturers of touchless gesture systems search for applications, computer vision and cameras may end up providing advanced gesture recognition to consumers more easily than ultrasound approaches can. This possibility becomes more plausible because cameras already integrate into many devices and are constantly improving along with computer-vision software. For example, some computer manufacturers already integrate depth cameras—including Intel RealSense—into their devices. Facial recognition is another benefit to using cameras as a touchless interface. Touchless gesture interfaces using ultrasound will need applications—such as haptic feedback or robust outdoor operation—that computer vision cannot effectively compete against. If both interfaces continue development, a chance exists of a symbiotic relationship between the technologies that ultimately provide a combined interface.

Scale of Impact	Low	**Medium**	High

Time of Impact	Now	**5 Years**	10 Years	15 Years

Opportunities in the following industry areas:
Sensors, electronics manufacturing, computer vision, wearables

Relevant to the following Explorer Technology Areas:
• User Interfaces • Connected Cars • MEMS/Micromachining • Mobile Communications • Pervasive Computing • Portable Electronic Devices

STRATEGIC BUSINESS INSIGHTS

EXPLORER

Viewpoints

July 2017

User Interfaces

By Sean R. Barulich (sbarulich@sbi-i.com)

Voice-Assistant Devices: Update

Why is this topic significant? New voice-assistant devices are introducing new applications and capabilities and increasing competition among manufacturers.

Description

As Amazon.com and Google race to add third-party integrations and new capabilities to their voice-assistant devices, other new devices are arriving that provide new uses to consumers.

Microsoft and Apple recently introduced their voice-assistant speaker devices. Microsoft and Harmon Kardon have presented the Invoke speaker that integrates with the Cortana artificial intelligence (AI). The Invoke speaker has base functions including music streaming and query response, and the device can make and receive Skype voice calls. Apple revealed the HomePod at its WWDC (Worldwide Developers Conference) 2017 and placed emphasis on the high-fidelity audio capabilities of the device. Although Apple's speaker integrates with Siri and can interact with some mobile apps on iOS, it lacks the capability of assistants in established devices including Amazon Echo models and Google Home.

Although Google has not responded with any new voice-assistant devices, Amazon has introduced two new products. First, Amazon's Echo Look is an Alexa-enabled camera that can provide fashion advice and catalog outfits in the Echo Look mobile app. Second, the Echo Show is another smart speaker like the Echo but with a touch-screen display. The display provides visual answers to queries and can also play videos and enable voice and video calls in combination with the Amazon Alexa app.

Implications

A growing voice-assistant ecosystem will probably be good for consumers as manufacturers and third parties improve quality and add functionality to voice-assistant devices in their bid to compete for consumers.

Apple's HomePod could end up a popular product even if creating an intelligent hi-fi speaker with an audio focus has implied the immaturity of Siri as a voice assistant. Keen Apple customers may want to maintain their Apple-device ecosystem and place their bets on Apple's Siri's growing into a more competent AI than it is today.

Other consumers may opt for Echo devices. Amazon is looking to grow its foothold with Alexa not only by adding functions but by introducing a new interface (via touch display) that still keeps the device hands free but provides more informative feedback to users than voice alone provides.

Impacts/Disruptions

Although new products have expanded the voice-assistant ecosystem, many of the new devices do not provide significant or unique capabilities.

The HomePod's cost is Apple's primary obstacle, because the device is the most expensive smart speaker available, costing $349. Without a competitive amount of Siri functions and app integrations, consumers may not find the high cost justifiable for a hi-fi audio smart speaker. With other devices upgrading capabilities to make calls and identify multiple users, Apple will most likely need to do more to distinguish the HomePod.

Amazon's Echo Show offers unique benefits to users by providing a touch interface, but—for now—the Echo Look appears to offer consumers little beyond niche use cases in fashion recommendations and outfit logging.

With a more populated ecosystem of voice assistants, manufacturers will need to distinguish their devices and ultimately offer better AIs to encourage sales.

Scale of Impact	Low	**Medium**	High

Time of Impact	**Now**	5 Years	10 Years	15 Years

Opportunities in the following industry areas:
Artificial intelligence, cloud computing, natural-language processing, software services

Relevant to the following Explorer Technology Areas:
• User Interfaces • Artificial Intelligence • Big Data • Connected Cars • Connected Homes
• Pervasive Computing

STRATEGIC BUSINESS INSIGHTS

EXPLORER

Viewpoints

June 2017

Artificial Intelligence

By Michael Gold (mgold@sbi-i.com)

Fast Inference Algorithms

Why is this topic significant? As some developers focus on improved chips for AI, others focus on achieving similar benefits by developing improved algorithms.

Description

Start-ups Aipoly, Scorchai, and Xnor.ai are developing software that accelerates execution of image-recognition applications on smartphones and other devices. Developers use deep-learning methods to pretrain the software, for example by using cloud resources or multiple graphics processor units in rack-mounted computers. Afterwards, battery-powered devices can efficiently recognize objects in video images. Ordinary general-purpose microprocessors—not graphics-processing chips or other special-purpose hardware—execute the software. The inference software runs on the device, not in the cloud.

Similar software could accelerate many kinds of applications that exploit deep learning, but developers of fast inference algorithms have focused on image recognition. Aipoly and Xnor.ai have published video demonstrations of smartphones that seem to identify multiple objects, people, and animals instantly. Xnor.ai has also implemented its software on a Raspberry Pi platform (which can be smaller than a phone). Scorchai has expressed intention to support smartphones, wearable cameras, augmented-reality headsets, and drones.

Instead of expressing inference procedures in conventional computer languages, Xnor.ai developers reduce algorithms to microprocessor-friendly binary operations. Further gains arise from extensive use of reduced-precision calculations. The developers are not simply being sloppy; they monitor the effects of reduced precision to understand when such mathematical shortcuts are harmless and do not degrade performance. Aipoly indicates that it uses a related approach; Scorchai has disclosed little about its methods.

Implications

Experts lack consensus about the merits of recent developments toward fast inference algorithms. And Android smartphones have performed non-cloud-based speech recognition for some years. So what is new? Increased efficiency promises to reduce battery drain during continuous operations. And

systematic work flows promise to reduce the effort needed to produce a broad range of deep-learning applications for embedded devices.

Many applications would benefit from battery-operated systems that can interpret video scenes with no need for a network connection and no need for additional chips. A basic smartphone app that identifies flowers, plants, and trees might inspire initial interest from nature lovers and gardeners. Aipoly demonstrated food recognition, which might eventually prove useful for apps that estimate how many calories a person on a diet is consuming.

Other battery-powered platforms including drones, robots, and augmented-reality headsets also face design constraints and could benefit from image recognition technologies that add little to no weight, size, or hardware costs to designs. With or without image recognition, general-purpose microprocessors and video cameras are required for many such products; fast inference algorithms might run with minimal revisions to hardware. Drones and robots might benefit from fast image recognition to aid maneuvers and avoid collisions. AR headsets will need fast image recognition to help render video labels for real-world objects and correct perspectives of superimposed virtual objects.

Impacts/Disruptions

Makers of automotive systems could see disruptions. Ambarella, MediaTek, Mobileye, Nvidia Corporation, and Renesas Electronics Corporation are among the companies wagering on needs for special hardware in autonomous and semiautonomous vehicles. In an ideal case, cars will not need special chips for AI. Alternatively, developers of driverless vehicles might need to use every trick in the book to achieve safety and affordability goals, combining special hardware and accelerated inference algorithms—possibly, algorithms and chips that are different from those currently under development.

Scale of Impact	Low	Medium	**High**	
Time of Impact	Now	**5 Years**	**10 Years**	15 Years

Opportunities in the following industry areas:
Smartphone application development, augmented reality, drones, robots, vehicle manufacturing

Relevant to the following Explorer Technology Areas:
• Artificial Intelligence • Big Data • Connected Cars • Portable Electronic Devices • Robotics • User Interfaces

STRATEGIC BUSINESS INSIGHTS

EXPLORER

Viewpoints

June 2017

Artificial Intelligence

By Sean R. Barulich and Michael Gold (mgold@sbi-i.com)
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Update on Emotionally Intelligent Computing

Why is this topic significant? Emotional recognition can advance the contextual understanding of AI and expand the capabilities of computer-vision systems.

Description

"Emotion Recognition via Machine Vision" in the October 2013 Viewpoints describes progress made in commercializing "affective computing" to evaluate human responses visually. Some of the companies mentioned, including Affectiva and nViso, as well as others, are providing new products toward eventual development of emotionally intelligent AI by means of computer vision.

At its Build 2017 conference, Microsoft revealed a new portfolio of Microsoft Cognitive Services. One service, Emotion API, first detects a face in a photo or video by invoking Microsoft's Face API. Emotion API then estimates and establishes confidence levels in the face's resemblances to faces in many training images that people previously labeled with particular emotions. Computer vision systems can call the API for use in various applications.

Eyeris, with its EmoVu software, uses deep learning and convolutional neural networks to track faces and detect emotions in video. The company claims it has implemented "continuous learning" and that accuracy improves as EmoVu analyzes features and aggregates data.

The annual Emotion Recognition in the Wild challenge that concluded in November 2016 demonstrated efforts from seven winning research teams in both video and group-based emotion recognition using computer vision.

Implications

Emotion recognition may endow computer-vision, voice-assistant, and other AI-based systems with some important capabilities through the large number of APIs provided to developers. For example, ultra-high-definition security camera systems and body cameras may be able to supply

systems with information needed to detect signs of ill intent and to prioritize people of interest for effective and efficient surveillance.

Emotion analytics also has potential roles in cars, determining when drivers are not at full attention or are inebriated. But much of the commercial utility would likely be in marketing analytics applications for infotainment purposes, especially as autonomous driving progresses.

Generally, computer-vision systems using emotion recognition also have promising applications in advertising and marketing, tracking consumers' emotional responses to ads, products, and brands, and designing more effective campaigns. In psychological research and therapy applications, emotion recognition can also potentially help in diagnosis of mental illness, assist therapists in addressing patients' issues, or log dialogue and emotion for deeper analysis.

Impacts/Disruptions

Although there has been some progress in visual, audio, and text-based emotion recognition, AI still struggles with the recognition and interpretation of irony, sarcasm, slang, and references to popular culture. Companies such as Lexalytics, Aylien, and Clarabridge are attempting to address the challenges of sentiment analysis. Until better understanding of context is integrated into audio and text-based emotion recognition, AI systems may continue to struggle with reliable interpretation.

Beyond the challenges of accurately interpreting data, there also may be obstacles regarding data privacy and trust in emotion-recognition systems. Many commercial applications require divulgence of personal user data, which presents ethical concerns in implementation. The commercial value of emotion-recognition systems depends strongly on people's willingness to cooperate with and contribute data to the systems.

Scale of Impact	Low	**Medium**	High	
Time of Impact	Now	5 Years	**10 Years**	15 Years

Opportunities in the following industry areas:
Computer vision, high definition cameras, advertising analytics, software development

Relevant to the following Explorer Technology Areas:
• Artificial Intelligence • Big Data • Connected Cars • Connected Homes • Mobile Communications
• Portable Electronic Devices • User Interfaces

STRATEGIC BUSINESS INSIGHTS

EXPLORER

Viewpoints

July 2017

Artificial Intelligence

By Michael Gold (mgold@sbi-i.com)

Neuromorphic Software

Why is this topic significant? In ideal cases, software that simulates how a brain works would mimic the brain's behaviors. With or without special chips, software will be key to using neuroscience to advance artificial intelligence.

Description

Some software makes use of insights from neuroscience and operates on commercially available processor hardware. Like neuromorphic chips, such software is inspired by biology; it does not simulate brains in detail. Brain Corporation is a key player in commercialization of neuromorphic software. In a 2016 report, the company describes how it applied insights from neuroscience in the design of its computer-vision software, "without implying a physiological correspondence" to real brains.

Software exhibits various degrees of fidelity to nature. Artificial neural networks (ANNs) use thoroughly artificial learning methods, but they were first inspired by neuroscience during the 1940s and saw robust software implementations by the 1970s. During recent years, findings about layers of neurons in brains helped to inspire development of deep-learning systems. One class of deep-learning ANN, a long short-term memory (LSTM) network, shares attributes of brains that many other ANNs lack—namely, feedback loops and rewriteable memory. Google uses LSTM networks for speech recognition and language-translation services; Amazon.com uses them to synthesize Alexa's voice. Many software-development tools are available for developing LSTM networks, including tools for the popular Python programming language.

Some neuromorphic software is exclusively for research and experimentation. Numenta's software tools reportedly support "rewiring" of ANNs—analogous to the natural process of neuroplasticity. Canada's University of Waterloo publishes Nengo, a tool that implements models of neural signals in the form of voltage spikes instead of direct-current analogues. For software developers, spiking models promise rich possibilities for controlling how and when artificial neurons fire, based on insights about how natural neurons behave.

Implications

Neuro-inspired software has a long road map toward improvements and innovations. Many established findings about brains have seen limited

use in research and no commercial applications. For example, future software tools might model two-way communications—as occurs across gap junctions in real brains. New research findings are likely to emerge to inspire software that emulates the structure, function, and roles of various kinds of neurons; how they connect; and ways that synapses modulate neuron behaviors.

Impacts/Disruptions

Monitoring of large natural neural nets will not be feasible for years. Meanwhile, software simulations might yield insights about how brains work. According to *Wired*, a team led by the controversial brain scientist Henry Markram is now conducting a yearlong simulation on a supercomputer at Argonne National Laboratory as part of a quest to see if the exotic field of algebraic topology can explain odd behaviors that large collections of simulated neurons exhibit. Whether the team is investigating natural or invented phenomena will remain a mystery for some time—but unusual projects have inspired previous ANNs that saw success. Markram's research implies that enterprises that want to exploit the latest findings in neuroscience to "build a brain" may need to learn higher math, not just hire engineers and scientists.

DeepMind cofounder Demis Hassabis has several independent careers—as a deep-learning software developer, as a game developer, and as a contributor to several peer-reviewed reports in neuroscience and cognitive-science journals. Apparently, his neuroscience research remains quite distinct from his software developments. His unique skill set might sooner or later have the effect of disrupting road maps for neuromorphic software.

Scale of Impact	Low	Medium	**High**	
Time of Impact	Now	5 Years	**10 Years**	**15 Years**

Opportunities in the following industry areas:
Neuroscience, mathematics, software development, advanced research, independent research

Relevant to the following Explorer Technology Areas:
• Artificial Intelligence • Connected Cars • Robotics • User Interfaces