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DEFTECH Update

Août 2018

Chers lecteurs,

J'ai le plaisir de vous présenter la quatrième édition 2018 du bulletin d'information technologique DEFTECH (Defence Future Technologies).

Vous avez désormais l'opportunité d'accéder l'intégralité des éditions précédentes à l'adresse suivante: https://deftech.ch/updates en utilisant les paramètres de connexion usuels.

Ce document propose une synthèse des technologies émergentes détectées par les services Scan et Explorer de Strategic Business Insights (SBI), auxquels est abonné le programme de recherche en veille technologique d'armasuisse Sciences et technologies.

Nous tentons d'anticiper les impacts potentiels de chaque nouvelle tendance sur le monde militaire. Chaque tendance est également liée au signal de changement initial émis par SBI, que les lecteurs intéressés pourront retrouver à la fin de ce document.

L'objectif est d'encourager une réflexion stratégique et prospective en matière de technologie, sous une forme concise et agréable.

Si vous souhaitez en savoir plus sur un thème précis ou si vous désirez accéder directement à la plate-forme SBI (lecteurs du gouvernement suisse uniquement), n'hésitez pas à me contacter.

Je vous souhaite une bonne lecture!

Meilleures salutations,

Dr. Quentin Ladetto
Directeur de recherche – Veille Technologique

P.S. Pour tout commentaire, suggestion ou discussion: quentin.ladetto@armasuisse.ch

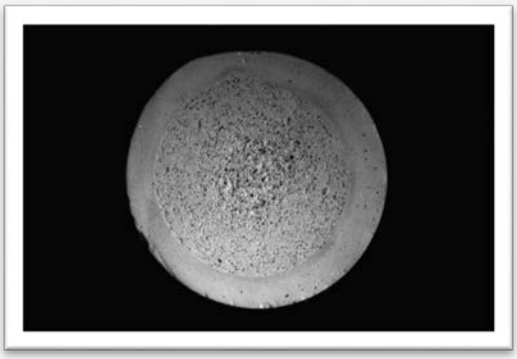

Illustration : MIT Media Lab

Matériaux à gradient de fonction : les matériaux à gradient de fonction (MGF) sont des matériaux dont la structure ou la composition varient graduellement au cours de la fabrication d'une pièce. De telles variations physiques permettent de modifier les propriétés des matériaux, notamment leur résistance, leur réactivité chimique, leur conductivité thermique ou encore leur densité. Grâce aux MGF, les ingénieurs peuvent créer des composants uniques affichant des caractéristiques matérielles non uniformes. Les chercheurs explorent actuellement de quelle manière le procédé de fabrication additive pourrait être la clé d'une utilisation commerciale de ces matériaux.

Quelles implications pour les domaines défense et sécurité ? *La possibilité de modifier considérablement la composition et la structure d'un matériau révolutionne la conception de pièces destinées à des applications militaires. Les MGF pourraient permettre aux ingénieurs de créer de nouveaux composants complexes et de remplacer une multitude de pièces par un seul et même composant. Dans le domaine de la défense, les composants pour l'aéronautique et les moteurs à réaction constitueront probablement les premières applications de cette technologie. Les composants pour véhicules terrestres et armes à feu comptent parmi les autres applications potentielles.*

Pertinence : *immédiate/à 5 ans/**à 10 ans**/à 15 ans*

Illustration : Roam Robotics

Combinaisons intelligentes : les fabricants continuent d'explorer de nouveaux concepts de textiles intelligents, combinaisons robotiques et autres exosquelettes. La start-up Xenoma développe actuellement un t-shirt intelligent robuste et lavable en machine qui surveille la température corporelle, la respiration et les mouvements du porteur. Roam Robotics développe quant à elle un exosquelette dont les muscles pneumatiques permettent de réduire la charge supportée par les genoux du porteur lorsqu'il skie. Des chercheurs de l'université de Harvard ont élaboré un algorithme d'apprentissage automatique (ou « machine learning ») qui optimise les paramètres exploités par les vêtements connectés en vue de s'adapter aux signaux physiologiques du porteur.

Quelles implications pour les domaines défense et sécurité ? *À terme, les progrès continus du domaine des textiles et des vêtements intelligents permettront d'élaborer des uniformes et vêtements intelligents à bas prix*

pour les forces armées (p. ex. pour surveiller les signes vitaux et l'effort physique du porteur). De plus, les exosquelettes « mous » représentent potentiellement une alternative intéressante aux exosquelettes « en dur » encombrants et gourmands en énergie. Les exosquelettes de demain pourraient faire appel à des vérins en tissu apportant une aide modérée sur une longue période pour réduire le niveau de fatigue des soldats.

Pertinence : *immédiate/**à 5 ans/à 10 ans**/à 15 ans*

Illustration : MIT

Des mousses qui emmagasinent de l'énergie : des progrès ont été réalisés en matière de développement de mousses céramiques et métalliques emmagasinant de l'énergie. Des chercheurs de l'université d'État de Pennsylvanie ont élaboré une mousse céramique piézoélectrique qui serait capable d'emmagasiner dix fois plus d'énergie que des composites piézoélectriques conventionnels. Des chercheurs du Massachusetts Institute of Technology ont quant à eux développé une mousse métallique thermoélectrique qui génère de l'électricité à partir des changements de température de l'air.

Quelles implications pour les domaines défense et sécurité ? *Les organisations de défense et de sécurité pourraient mettre en œuvre ces nouvelles mousses dans les domaines de la télédétection, des drones et de la robotique. Les dispositifs médicaux implantables pourraient également bénéficier de cette technologie. Les dernières mousses en date affichent un rapport solidité/poids remarquable ainsi qu'une efficacité énergétique accrue en comparaison des versions précédentes.*

Pertinence : *immédiate/**à 5 ans/à 10 ans**/à 15 ans*

Illustration : Forum économique mondial

Les interfaces neuronales se profilent à l'horizon : tandis que de nouveaux traitements basés sur les neurosciences font leur apparition, les chercheurs franchissent de nouvelles étapes vers la création d'interfaces cerveau-machine sophistiquées. Des chercheurs de l'université d'État de l'Ohio ont récemment mené des essais cliniques d'une forme de stimulation cérébrale profonde destinée aux patients atteints d'Alzheimer. BrainQ Technologies se sert d'un électroencéphalographe non implanté chirurgicalement pour récolter des données relatives aux patients victimes d'attaques cérébrales ou de lésions de la moelle épinière, tandis que Neurolutions utilise cette technologie pour restaurer la mobilité des patients paralysés.

Quelles implications pour les domaines défense et sécurité ? *Les premières applications des interfaces neuronales seront destinées aux personnes atteintes de pathologies et de blessures neurologiques, mais les soldats blessés pourraient également en bénéficier. De nombreuses études ont notamment mis en évidence une dégénération neurologique chez des soldats exposés à des explosions lors de combats. Après les implants neuronaux à des fins thérapeutiques, les chercheurs se focaliseront probablement sur les implants facilitant la communication et le contrôle d'équipements divers.*

Pertinence : *immédiate/à 5 ans/à 10 ans/****à 15 ans***

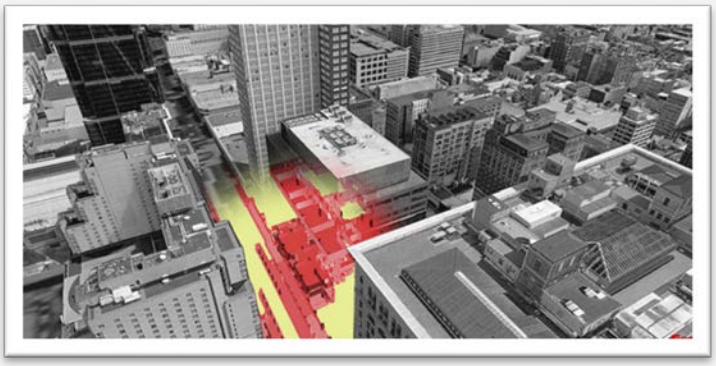

Illustration : GCN.com

La cartographie en milieu urbain : grâce aux nouvelles technologies, les cartes urbaines sont de plus en plus détaillées et offrent de multiples fonctions. De nouveaux types de cartes exploitent les données mobiles et énergétiques ainsi que de nouvelles technologies de capteurs et des projets novateurs (notamment en rapport avec les véhicules autonomes et leurs besoins en matière de cartographie). L'agence américaine pour les projets de recherche avancée de défense (DARPA) explore en outre les domaines de la modélisation et de la navigation sous-marine.

Quelles implications pour les domaines défense et sécurité ? *À terme, le développement de technologies de modélisation à bas prix, LIDAR à semi-conducteurs compris, permettra de modéliser champs de bataille et environnements urbains en 3D. Les armées pourraient créer des cartes 3D détaillées au moyen de capteurs à bas prix installés sur des véhicules, des soldats ou des drones. De plus, la disponibilité de cartes détaillées soutiendra les opérations urbaines et permettra aux véhicules et robots autonomes de mieux progresser dans ces environnements.*

Pertinence : *immédiate/****à 5 ans/à 10 ans****/à 15 ans*

Illustration : Festo

Cyberattaques contre des infrastructures : des groupes malveillants multiplient leurs attaques contre les systèmes cyber-physiques et les infrastructures critiques. Le Département de la Sécurité intérieure des États-Unis (DHS) et le FBI ont notamment publié une alerte décrivant des attaques étatiques visant des entités gouvernementales et des infrastructures énergétiques américaines.

Quelles implications pour les domaines défense et sécurité ? *Les organisations de défense et de sécurité doivent s'assurer que les infrastructures critiques sont protégées contre les groupes malveillants. Les systèmes nécessitent une surveillance constante, des mises à jour fréquentes et doivent éventuellement faire l'objet d'attaques tests par des groupes amis. En outre, les organisations de défense et de sécurité doivent collaborer avec les entreprises du secteur privé qui mettent en œuvre d'importants systèmes cyber-physiques.*

Pertinence : *immédiate/**à 5 ans**/à 10 ans/à 15 ans*

Illustration : Saildrone

L'océan connecté : des équipes de chercheurs développent actuellement des réseaux de capteurs destinés aux océans. L'agence américaine d'observation océanique et atmosphérique (NOAA) a déployé deux voiliers semi-autonomes équipés de capteurs qui ont récolté des données dans l'océan Pacifique pendant huit mois. L'agence américaine pour les projets de recherche avancée de défense (DARPA) œuvre sur le projet « Ocean of Things » ou « océan connecté » qui vise à disposer d'un réseau de surveillance maritime permanent sur une large surface océanique en déployant des milliers de petits flotteurs bon marché formant un vaste réseau de capteurs. Un autre projet DARPA étudie des approches spéculatives en matière d'analyse des données océaniques grâce à l'utilisation d'organismes vivants.

Quelles implications pour les domaines défense et sécurité ? *Les océans sont des milieux particulièrement difficiles en ce qui concerne le suivi précis des sous-marins, navires et autres objets présentant un intérêt pour les organisations de défense et de sécurité. Le développement de dispositifs peu onéreux et d'embarcations autonomes pourrait permettre aux armées de mettre en place de solides réseaux de capteurs en vue d'améliorer le suivi des navires et autres menaces.*

Pertinence : *immédiate/à 5 ans/**à 10 ans**/à 15 ans*

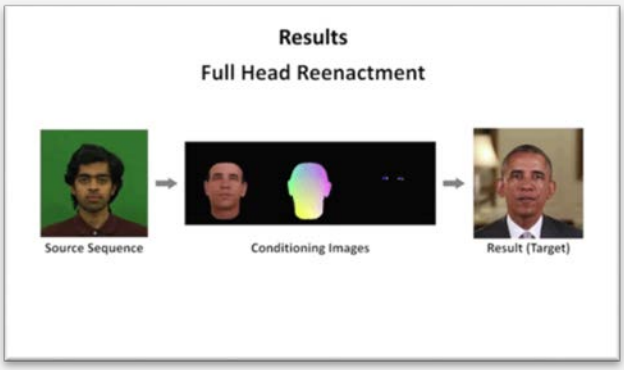

Illustration : TechCrunch

Les « deep fakes » : grâce à de nouveaux logiciels, les technologies d'intelligence artificielle de pointe sont accessibles au plus grand nombre. Les « deep fakes » sont des photos, vidéos ou fichiers audio manipulés par des moyens informatiques pour donner l'impression qu'une personne est en train de faire quelque chose qu'elle n'a pas fait, ou de dire quelque chose qu'elle n'a pas dit.

Quelles implications pour les domaines défense et sécurité ? *Le renseignement militaire est tributaire d'informations fiables et factuelles. Les logiciels d'édition vidéo étant toujours plus sophistiqués et simples d'utilisation, le renseignement militaire pourrait éprouver des difficultés à identifier les sources d'informations fiables. De plus, des insurgés sont susceptibles de falsifier des vidéos et fichiers audio pour servir leurs propres intérêts en influençant l'opinion publique d'une région. Les armées pourraient bénéficier de logiciels d'analyse spécialisés capables de détecter des signes de manipulation.*

Pertinence : *immédiate/**à 5 ans**/à 10 ans/à 15 ans*

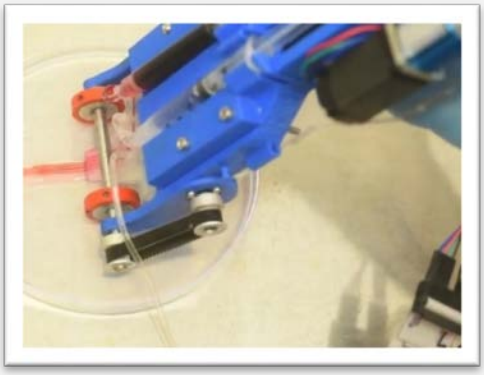
Illustration : université de Toronto

Impression avancée de tissus vivants : la technologie de bio-impression progresse à grands pas. Des systèmes d'impression de tissus biologiques avancée pourraient permettre de produire des tissus complexes, os et autres organes artificiels aptes à révolutionner le monde médical. Des chercheurs de l'université de Toronto ont notamment développé un nouveau système d'impression de peau capable de déposer des couches de tissu biologique à la surface de blessures cutanées profondes.

Quelles implications pour les domaines défense et sécurité ? *La production de tissus biologiques comme la peau, le cartilage et les os pourraient contribuer au rétablissement de soldats blessés. Le développement de dispositifs portatifs, rapides et simples à utiliser permettrait de refermer rapidement les blessures sur le terrain. Lorsqu'une greffe est nécessaire, les dispositifs avancés pourraient également créer de nouveaux organes fonctionnels, évitant ainsi de devoir trouver un donneur.*

Pertinence : *immédiate/à 5 ans/**à 10 ans**/à 15 ans*

Illustration : site web du MIT

Électronique embarquée avancée : les fonctionnalités et l'efficience des dispositifs électroniques portatifs progressent rapidement. Des chercheurs du MIT ont développé une nouvelle puce ainsi qu'un nouveau logiciel capable de chiffrer des données à l'aide de clés publiques plus rapidement et de manière plus efficiente qu'avec les techniques conventionnelles. La société Arm Holdings a récemment présenté deux nouvelles architectures de processeur optimisées pour les applications d'intelligence artificielle. Google a récemment présenté une architecture logicielle permettant de bénéficier de la réalité augmentée sur les dispositifs mobiles.

Quelles implications pour les domaines défense et sécurité ? *Grâce à des architectures matérielles et logicielles novatrices, soldats et équipements de base pourraient bientôt être dotés de systèmes électroniques avancés. L'informatique vestimentaire avancée pourrait disposer de nombreuses fonctions comprenant la reconnaissance faciale, la traduction en temps réelle, des communications sécurisées, la modélisation 3D ainsi que des calques de navigation se superposant à l'image affichée par des dispositifs de réalité augmentée. Un meilleur niveau de sécurité de l'appareil (qu'offre la puce du MIT par exemple) permettrait de bénéficier d'un environnement de l'Internet des objets sécurisé.*

Pertinence : *immédiate/**à 5 ans**/à 10 ans/à 15 ans*

Illustration : Butterfly Network

Santé à distance : grâce aux avancées technologiques, des équipements médicaux autrefois onéreux sont accessibles au grand public. Le Butterfly iQ du Butterfly Network est un scanner à ultrasons portatif qui fonctionne en conjonction avec un iPhone d'Apple. Des chercheurs de l'université de Washington ont développé une application pour smartphone capable de détecter les lésions cérébrales en analysant les réactions de la pupille à la lumière.

Quelles implications pour les domaines défense et sécurité ? *Les progrès de l'électronique grand public pourraient permettre aux armées de créer des dispositifs médicaux légers et à bas prix en vue d'évaluer et de traiter les blessures de guerre sur le terrain. De telles technologies pourraient bénéficier aux soldats engagés dans des régions isolées ainsi qu'aux troupes séparées de leur unité durant une opération.*

Pertinence : *immédiate/**à 5 ans**/à 10 ans/à 15 ans*

Illustration : Gilles Sabrie, New York Times

Initiatives technologiques de la Chine : un certain nombre d'initiatives technologiques lancées par le gouvernement chinois visent à assurer l'ordre public dans la société civile chinoise, dont des monnaies virtuelles, la généralisation de la reconnaissance faciale ainsi qu'un système de crédit social. L'influence globale de la Chine pourrait encourager d'autres gouvernements et multinationales à adopter des technologies similaires.

Quelles implications pour les domaines défense et sécurité ? *Si certaines de ces initiatives soulèvent des questions en matière de respect de la vie privée, elles font également progresser les capacités de surveillance du pays. Des technologies similaires à celles que la Chine est en train de développer pourraient contribuer à la surveillance de foules ainsi qu'à la détection de menaces potentielles.*

Pertinence : *immédiate/**à 5 ans**/à 10 ans/à 15 ans*

STRATEGIC BUSINESS INSIGHTS

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June 2018

P1214

AI Tools in Amateur Hands

By Guy Garrud (Send us feedback.)

Developers are creating software that puts high-end artificial-intelligence (AI) tools into the hands of relatively untrained users.

Abstracts in this Pattern:

SC-2018-05-02-066 on data analytics
SC-2018-05-02-093 on deep-fake technology
SC-2018-05-02-020 on deep-fake-porn creation
SC-2018-05-02-056 on deep-fake removal

Novel platforms offer relatively untrained individuals tools that enable them to use AI to extract useful insights from large data sets; however, these individuals can fail to understand the results of AI-based analyses or use such tools to manipulate content.

Self-service analytics platforms are one example of an expanding set of platforms that are placing high-end machine-learning tools into the hands of relatively unskilled individuals. Such platforms enable employees to make sense of data that businesses generate and store so they can extract knowledge without the aid of expert data scientists, who are in short supply; however, industry observers caution that nonexperts have a limited capability to understand AI-based analyses.

A more controversial type of software enables relatively unskilled users to create *deep fakes*—digital manipulations of images, audio, or video that give the appearance that someone is doing something that he or she did not do. The most recent versions of the software combine machine-learning technology with traditional sound and video editing and can see use to create very convincing images and video. For example, a user could generate video clips of politicians making statements that they did not make. Perhaps unsurprisingly, one of the early uses of deep-fake technology is to generate *deep-fake porn*—pornographic content in which the faces of public figures or celebrities replace the features of the original performers. Many social-media platforms and websites have banned deep-fake porn. Ironically, one such website is Reddit (Reddit; San Francisco, California), which had hosted online communities that focus on improving the quality and accessibility of deep-fake AI.

Policing malicious AI-generated content is nontrivial, because this fake content is of high quality. This matter has driven the creation of new tools that enable the identification and removal of such content. For example, Gfycat (Palo Alto, California), which hosts short user-generated video content, is using AI algorithms to detect and remove deep-fake content. The company's systems look for subtle imperfections that are indicative of a doctored image.

Signals of Change related to the topic:

SoC1002 — Recognizing and Analyzing Faces
SoC994 — Video Analytics…
SoC985 — …Alien Intelligence

Patterns related to the topic:

P1193 — Expanding Digitalization
P1187 — …Humans and AI
P1131 — Digital Transformation…

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June 2018

P1215

Advanced Onboard Computing

By Sean R. Barulich (Send us feedback.)

Dedicated hardware and software solutions are improving the functionality of consumer electronics.

Abstracts in this Pattern:

SC-2018-05-02-017 on MIT
SC-2018-05-02-034 on Arm
SC-2018-05-02-068 on Canon
SC-2018-05-02-045 on Google

Researchers are producing hardware that may improve the security of Internet of Things devices. For example, Massachusetts Institute of Technology (MIT; Cambridge, Massachusetts) researchers recently developed a new chip that can perform public-key encryption. The chip uses elliptic-curve protocols that enable the encryption process to work faster and use less energy than conventional encryption techniques do.

Companies are also designing hardware that brings artificial intelligence (AI) out of the cloud and directly into consumer electronics. For example, Arm Holdings (SoftBank Group Corp.; Tokyo, Japan) has introduced two new processor designs that it based on completely new architectures and optimized for AI applications. The design of the Arm Machine Learning Processor accelerates the execution of machine-learning models, which see use in AI applications such as machine translation and facial recognition. And the company optimized the design of the Arm Object Detection Processor for visual-data processing and object and people detection. Other companies are also integrating machine-learning features into devices. For example, Canon (Tokyo, Japan) recently introduced the Speedlite 470EX-AI—a camera flash module that can automatically change its orientation to optimize photograph quality. The module leverages AI to determine the distance from the camera to a subject and to the ceiling to determine the best flash angle for a photograph and uses built-in motors to move itself into the ideal orientation.

Companies are also developing software that improves the accessibility of augmented-reality (AR) and computer-vision features on devices. For example, Google (Alphabet; Mountain View, California) recently rolled out its ARCore AR software framework into wide release. ARCore enables more than 100 million Android smartphones to run AR applications. Additional research, development, and investment in the field of computing will enable the advance of consumer devices and the introduction of new computing functionality.

Signals of Change related to the topic:

SoC926 — Quantum Computing's Security…
SoC857 — Guesswork Computing
SoC022 — Cognitive Computing

Patterns related to the topic:

P1206 — Investing in Novel Computing
P1128 — Moore's Law Extends
P1126 — Hot Computing

STRATEGIC BUSINESS INSIGHTS

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June 2018

P1216

China's Technology Initiatives

By David Strachan-Olson (Send us feedback.)

A number of technology initiatives from the government of China aim to improve the orderliness of Chinese society, but technologies from these initiatives could find adoption outside China.

Abstracts in this Pattern:

SC-2018-05-02-044 on digital currency
SC-2018-05-02-013 on facial recognition
SC-2018-05-02-052 on social credit
SC-2018-05-02-087 on software platform

China's government is spurring a number of technological innovations to improve the orderliness of Chinese society, thereby providing stability and maintaining economic growth. The People's Bank of China (Beijing, China) has been working on a cashless monetary system since 2016. The bank intends to create a digital currency that integrates seamlessly with existing services and financial-management systems. Unlike transactions with decentralized cryptocurrencies, transactions with this digital currency will see processing through centralized clearinghouses. China's government is also testing the use of facial-recognition technology to help police identify criminals. Officers wear smart glasses developed by LLVision Technology Co. (Beijing, China) and scan crowds. The glasses feature a camera and facial-recognition technology that can, according to the company, identify people from a database of 10,000 criminal suspects in as little as 100 milliseconds. China's government is also developing a social-credit system that uses machine learning, online databases, municipal records, and smartphone data to generate a social-trustworthiness score for individuals. The government believes that the system will help bring order to the complex social interactions in urban areas by guiding people's behavior. People with a high score will receive benefits such as discounts on products and services, and people with low scores could face restrictions on the products and services they can purchase.

Although individuals may label some of China's ambitions as dystopian, China clearly believes that technology can help bring order to the complexities of society. Because China's government is backing the above technologies, they will see very rapid development. In addition, China's global influence could encourage the governments of and companies from other countries to adopt the same or similar technologies. Such an outcome is already occurring with autonomous-vehicle technology. China's government recently designated Baidu's (Beijing, China) Apollo—an integrated software platform for guiding self-driving road vehicles—as the "national autonomous driving platform" of China. This action creates a significant market for hardware and software that function with Apollo and encourages adoption of the Apollo platform outside China.

Signals of Change related to the topic:

SoC1000 — Losing the Fight for…Privacy
SoC933 — Snooping Technologies
SoC930 — Trust(ed) Systems

Patterns related to the topic:

P1213 — China's Automotive Adventures
P1107 — …Pervasive Surveillance
P1064 — Data and…Safety, and Security

STRATEGIC BUSINESS INSIGHTS

scan™

July 2018

P1226

Evolving Cybersecurity Threats

By Sean R. Barulich (Send us feedback.)

Cybersecurity vulnerabilities continue to increase in number as more systems gain connectivity and researchers discover flaws in legacy software.

Abstracts in this Pattern:

SC-2018-06-06-060 on CPUs
SC-2018-06-06-100 on Russia
SC-2018-06-06-073 on China
SC-2018-06-06-078 on Saudi Arabia

New vulnerabilities in computing hardware are enabling more powerful exploits for hackers. For example, cybersecurity firm CTS-Labs (Tel Aviv, Israel) recently published a report about flaws in central processing units (CPUs) from Advanced Micro Devices (AMD; Santa Clara, California). The report describes 13 vulnerabilities that affect multiple lines of AMD processors and enable hackers to infect systems at the secure-boot level—albeit only if attackers have administrator access. The flaws could allow hackers to install persistent malware that would be undetectable by security software on infected systems.

Flaws in hardware often introduce serious threats to cybersecurity, but governments and hackers also threaten cybersecurity. For example, the US Department of Homeland Security (DHS; Washington, DC) and the Federal Bureau of Investigation (FBI; Washington, DC) recently published an alert that describes state-led attacks against US government entities and energy infrastructure. The DHS and FBI claim that Russian-state-led actors used tactics such as spear phishing and malware staging to target multiple commercial facilities. Ultimately, the attackers gained access to systems and extracted data about industrial control systems—data that could see use in future attacks. Countries other than Russia have made efforts to advance their abilities in the cybersecurity space. For example, the government of China is reportedly preventing groups of Chinese *white-hat hackers*—ethically motivated hackers and computer-security experts who identify and safely disclose the security vulnerabilities of systems to improve the systems' security—from joining international competitions to discover and publicize flaws in operating systems and popular software. Although cybersecurity professionals typically compete to improve the security of systems, China appears intent on using its cybersecurity experts to stockpile rather than share vulnerabilities.

Cyberattacks by hacking groups continue to advance and become increasingly dangerous. In August 2017, an advanced cyberattack targeted a petrochemical plant in Saudi Arabia and would have caused an explosion if not for an error in the hackers' computer code. Investigators believe that hackers designed the attack primarily to sabotage the plant's operations. This attack is similar to recent state-led attacks that often target critical infrastructure.

Signals of Change related to the topic:

SoC1000 — Losing…Privacy
SoC963 — Hacking: Now…Pervasive
SoC946 — Diffusion of Hacking…

Patterns related to the topic:

P1214 — AI Tools in Amateur Hands
P1202 — Smartphone-Data Surprises
P1190 — Cryptocurrency Issues

July 2018

P1230

Smart Suits

By David Strachan-Olson (Send us feedback.)

Companies continue to explore new concepts for smart clothing, exosuits, and exoskeletons that wrap individuals in sensors and actuators.

Abstracts in this Pattern:

SC-2018-06-06-034 on Xenoma
SC-2018-06-06-097 on Roam Robotics
SC-2018-06-06-058 on Harvard University
SC-2018-06-06-053 on L. L. Bean

Electronics components have become cheaper and more capable, and companies are showing an increasing interest in creating wearable electronics. Most companies are focusing on smartwatches and fitness trackers, but some are developing smart clothing and smart suits. For example, start-up Xenoma (Tokyo, Japan) is developing a durable, machine-washable smart shirt that monitors the wearer's body temperature, breathing, and movements. The shirt includes sensors that cover more than a dozen sections of the upper body, and "as the shirt expands and contracts, the sensors transmit signals to a nearby smartphone or PC via a small Bluetooth device on the chest." Xenoma believes its smart shirt could find use in areas such as athletics and fitness, preventative health care, and video games.

Companies are also developing exosuits and exoskeletons that use motors and actuators to provide wearers with active assistance. Roam Robotics (San Francisco, California) is developing an exoskeleton that uses pneumatic muscles to reduce the loads on wearers' knees while they are skiing or snowboarding. The company claims that the system will enable users to ski or snowboard better and for longer periods with less fatigue. Adapting to a wearer's capabilities and body mechanics is a key requirement for exosuits and exoskeletons. Researchers from Harvard University (Cambridge, Massachusetts) recently developed a machine-learning algorithm that optimizes the control parameters for assistive wearable devices on the basis of real-time measurements of the wearer's physiological signals. The researchers' algorithm-based optimization method was able to reduce the metabolic expenditure of people using an exosuit that provides walking assistance.

Traditional-clothing manufacturers may face difficulties in developing smart clothing and smart suits because they often lack an understanding of the technology and of consumer attitudes toward technology. For example, L. L. Bean (Freeport, Maine) recently called off a "data collection and analytics project that would have tested the use of a blockchain ledger and sensors attached to coats and boots" after a misunderstanding about the type of data the clothing would collect led to a public backlash. The project aimed to collect data about how consumers use the clothing and how the clothing performs, but the media incorrectly reported that the company aimed to track customers' locations, creating privacy concerns.

Signals of Change related to the topic:

SoC938 — …Human Augmentation
SoC928 — Wearables…
SoC865 — Wearable Robotics

Patterns related to the topic:

P0968 — Fashionable High Tech
P0923 — Sensing Skin
P0515 — Robots for Help…

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July 2018

P1234

Steps toward Neural Interfaces

By Guy Garrud (Send us feedback.)

As new neuroscience-based treatments emerge, researchers will take small steps toward developing sophisticated brain–machine interfaces.

Abstracts in this Pattern:

SC-2018-06-06-072 on implanted electrodes
SC-2018-06-06-076 on EEG
SC-2018-06-06-103 on prostheses

Researchers at the Ohio State University (Columbus, Ohio) recently conducted trials of a form of deep-brain stimulation for Alzheimer's patients. The researchers implanted into patients' frontal lobes electrodes that act as a form of pacemaker for the brain to help reduce cognitive decline in Alzheimer's sufferers. As researchers gain a better understanding of neurostimulation, implants capable of affecting brain activity could find use in interface technologies.

Other research groups are exploring noninvasive forms of neurological health care. Several companies are looking at non–surgically embedded electroencephalography (EEG) for use in a range of applications. For example, BrainQ Technologies (Jerusalem, Israel) is using a non–surgically embedded EEG machine to collect data for use in improving treatments for patients who have suffered strokes or spinal injuries, Neurolutions (Saint Louis, Missouri) is using EEG technology to restore movement to paralytic patients, and NeuroPace (Mountain View, California) is using EEG technology to treat patients suffering from seizures. In addition to providing treatment options, EEG technology may eventually provide a way for users to interact with computer systems—in fact, some video games already use an EEG headset as a control device.

Meanwhile, systems that enable interactions between the brain and a device are under development and seeing progress. For example, researchers at the Cleveland Clinic (Cleveland Clinic Foundation; Cleveland, Ohio) Lerner Research Institute have developed a system that provides wearers of advanced prostheses with a sense of how their prostheses are moving through space. Although advanced prostheses can move in response to electrical signals from the body that occur when users think about moving their missing limbs, they do not provide users with feedback about their movement, so users must watch their prostheses to move them properly. The system uses a device to vibrate muscles that contain rerouted nerves from amputees' missing limbs, replicating the sensation of joint movement and enabling the patients to sense the movement of their prostheses without having to monitor the movements visually. Such systems may play a role in the development of sophisticated brain–machine interfaces.

Signals of Change related to the topic:

SoC1009 — Implantables: Progress and Concerns
SoC872 — Brain Implants
SoC827 — Human Resources and Neuroscience

Patterns related to the topic:

P1210 — Reading Minds
P1111 — Tackling Dementia…
P1056 — Implants Overcome Paralysis

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June 2018

SoC1019

Enabling Remote Health Care

By Lucy Young (Send us feedback.)

Changes are occurring in how, where, and from whom people receive health care. Developments in technology are bringing once-expensive equipment to schools, workplaces, and homes. Similarly, novel innovations in medical technology are creating smart tools that can find use outside hospital environments. In combination, these factors are enabling remote health care.

Redesigning existing medical technology is helping to reduce the cost of some types of equipment. On the basis of research by a professor from Stanford University (Stanford, California), Butterfly Network (Guilford, Connecticut) developed the Butterfly iQ—a handheld ultrasound scanner that works with an Apple (Cupertino, California) iPhone and is much cheaper and more versatile than are existing ultrasound systems. The scanner uses techniques from the semiconductor industry: Instead of using piezoelectric crystals that vibrate in response to a changing electric field as existing ultrasound systems do, the iQ uses a micromachine in which an applied voltage causes a membrane to move and generate the ultrasound. Because production of the iQ largely uses silicon as the core material and relies on the photolithographic techniques in use in microprocessor manufacturing, the production costs of the iQ are lower than are the production costs of existing piezoelectric ultrasound scanners. Butterfly Network envisions a future in which every household has access to one of its scanners. Although the company hopes to continue lowering the price of the iQ, it is currently marketing the device at about $2,000—a price likely out of reach of most households. However, schools and offices may find the scanner a worthwhile investment. For example, a school staff member could use the device to check a child's injured arm. Schools—and other organizations such as sports clubs—may find the PupilScreen smartphone app very useful as well. Developed by researchers from the University of Washington (Seattle, Washington), the app leverages the technology present in smartphones to assess whether someone is concussed or suffering from another traumatic brain injury. The app uses artificial intelligence and the smartphone's camera to look for changes in a person's pupil response to light. Assessing the pupillary light reflex is a standard method of determining whether a person has a serious brain injury, but recent research has revealed that it is also helpful in diagnosing concussions. The app not only makes the detection of brain injuries simpler but also enables people without medical training—for example, coaches and parents—to perform assessments.

Medical organizations and regulators will need to make efforts to ensure that the quality of care does not suffer as health care and support spreads to homes, schools, workplaces, and other locations away from medical facilities.

Making medical apparatuses more patient friendly can also benefit health care. Design Academy Eindhoven (Eindhoven, Netherlands) graduate Alissa Rees redesigned the intravenous (IV) system, which typically consists of a bag of fluid that hangs from a pole and connects to a patient's veins. Rees's system comprises a soft-fabric container that a patient wears over his or her shoulders and chest. Pouches in the fabric container hold fluids that pump into a vein in the patient's arm. The wearable system allows greater patient mobility than does the existing IV system, and it includes a connected system

that sends an alert if a problem with the pump occurs. Such a portable IV system could find home use to enable patients to convalesce in their own environments, which would also free up hospital facilities for patients who require hospitalization. The redesign of existing medical devices is not the only factor that is contributing to health care's becoming more portable; new technological innovations are also making health care away from hospitals feasible. Scientists from the Massachusetts Institute of Technology (Cambridge, Massachusetts) and Brigham and Women's Hospital (Boston, Massachusetts) used piezoelectric materials to create an ingestible flexible sensor. When a patient swallows the sensor, it sticks to either the wall of the stomach or the intestinal lining and measures the rhythmic contractions of the digestive tract. The sensor, which remains active for as long as two days, could find use in diagnosing gastrointestinal disorders and in monitoring a patient's intake of food and liquid. The scientists plan to continue developing the sensor, and future versions may include wireless transmitters. Wireless connectivity could enable patients to use the sensor at home while medics remotely gather data that are representative of the patient's normal day-to-day life.

The ability to monitor patients for a long period can enable more rapid diagnosis and treatment—both within and away from hospitals. PMD Solutions (Cork, Ireland) has created a wearable sensor that monitors breathing and can help detect blood poisoning, of which rapid respiratory rate is a significant indicator. The device uses piezoelectric material to measure a patient's breathing rate and algorithms to account for signal noise that activities such as walking can cause. The sensor also alerts medical staff if a patient's breathing rate goes above or below certain thresholds, which could indicate a medical problem. The device interfaces with smartphones and tablets, which means that it could find use in all clinical settings and in patients' homes.

The redesign of existing medical equipment and the creation of novel technologies are enabling remote health care. As the examples above demonstrate, remote health care can enable patients to receive diverse types of medical care at almost any location. Significantly, nonexperts are able to administer some of this medical care. Remote health care could alleviate pressure on centralized medical facilities—particularly in countries with aging populations. However, the emergence of remote health care could present challenges and require careful management. For example, medical infrastructure will likely need to adapt to support remote health care, and medical organizations and regulators will need to make efforts to ensure that the quality of care does not suffer as health care and support spread to homes, schools, workplaces, and other locations away from medical facilities.

SoC1019

Signals of Change related to the topic:
SoC767 — Ubiquitous…Health-Care Tools
SoC762 — Health-Care Devices…
SoC760 — Diagnosed Self

Patterns related to the topic:
P1198 — …Detection of Health Issues
P1197 — Distributed Monitoring
P1173 — Patching Patients

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June 2018

SoC1022

Layers of Sensor Infrastructures

By Martin Schwirn (Send us feedback.)

Sensors are application enablers—a fact to which every smartphone user can attest. Often entire networks of sensors develop organically as more and more sensor-containing devices see deployment. But new research efforts aim at establishing expansive sensor infrastructures and implementing them to achieve multiple goals—each of which is worth pursuing in its own right. As advanced sensor infrastructures emerge, each infrastructure will form a layer of a comprehensive sensor-infrastructure network that will enable the placing of various types of data in context. Although each of these layers initially saw implementation to achieve a specific goal, the totality of such sensor-infrastructure networks will enable a wide range of applications that researchers and developers will discover as they imagine new uses and fortuitously notice relationships among phenomena.

Sensors' need for energy is a limiting factor for many proposed applications.

Many urban environments around the world already make use of a broad range of sensor networks; however, the oceans—expansive bodies of water that cover a large percentage of Earth's surface—so far have remained out of reach of comprehensive sensor solutions. The US National Oceanic and Atmospheric Administration (NOAA; Silver Spring, Maryland) recently concluded an experiment during which two semiautonomous sensor-equipped sailboat drones spent eight months collecting data in the Pacific Ocean. Saildrone (Alameda, California) collaborated with NOAA to develop the drones, which carry 15 scientific instruments capable of collecting ocean, weather, and climate data. The purpose of the experiment was to determine whether a fleet of such drones could replace the aging network of research buoys that scientists have used to gather data about specific climate and weather patterns in the Pacific Ocean since the 1980s. In a separate effort, the US Department of Defense's (Arlington County, Virginia) Defense Advanced Research Projects Agency (DARPA; Arlington, Virginia) is working on the Oceans of Things program. The program employs smart floats to collect a wide range of environmental and activity data, including information about ocean temperature and the movement of commercial boats. The program aims at creating "persistent maritime situational awareness over large ocean areas by deploying thousands of small, low-cost floats that could form a distributed sensor network" ("Ocean of Things Aims to Expand Maritime Awareness across Open Seas," DARPA, 6 December 2017; online). DARPA is also looking at speculative approaches to gain a better understanding of ocean areas that are of strategic interest. The Persistent Aquatic Living Sensors (PALS) program will identify organisms that could find use in sensor systems to detect the movements of underwater vehicles. The program will research "marine organisms' responses to the presence of such vehicles, and characterize the resulting signals or behaviors so they can be captured, interpreted, and relayed by a network of hardware devices" ("PALS Turns to Marine Organisms to Help Monitor Strategic Waters," DARPA, 2 February 2018; online). Employing organisms as sensors has several practical advantages: Organisms do not require a power source, they are highly attuned to their natural environment, they are cheap, and they can cover a large area. The methods and technology under development in the PALS program are speculative; however, if they see success in military applications, they could find use in commercial applications.

Another effort focuses on using river and lake systems as sensors to gather useful data.

Researchers at Michigan State University (East Lansing, Michigan) are looking at monitoring waterways to gain a better understanding of a region's ecosystem. Through the use of streams as sensors, farmers, land-use managers, and scientists can identify watersheds ideal for sustainable development to enable their use in food production. According to researcher Jay Zarnetske, "Our methods show that we can learn much from a relatively small number of samples if they are collected more strategically than current watershed management practices dictate" ("Streams Can Be Sensors," *MSUToday*, 29 December 2017; online). A better understanding of waterways will aid in the development of better farming methods.

Sensor solutions for use on land are also under development. For example, the Fraunhofer Society for the Advancement of Applied Research (Munich, Germany) and the government of Portugal hope to advance digital tools to support agriculture and forestry. Their plans include not only using drones and satellites to gather data that can see use in increasing crop yields, decreasing the use of pesticides, and monitoring the growth of produce but also deploying sensor-equipped "small electrically driven vehicles that work cultivation areas autonomously and in swarms" ("Fraunhofer drives intelligent agriculture forward," Fraunhofer, 8 December 2017; online). DARPA is also working on a land-based monitoring approach that, similar to the approach in its PALS program, relies on organisms. The Advanced Plant Technologies (APT) program "envisions plants as discreet, self-sustaining sensors capable of reporting via remotely monitored, programmed responses to environmental stimuli" ("Nature's Silent Sentinels Could Help Detect Security Threats," DARPA, 17 November 2017; online). The plants' intrinsic sensing mechanisms will find use to detect chemicals, electromagnetic signals, pathogens, and radiation, and the plants' biological systems eliminate the need for an energy source to power the sensing mechanism.

Such sensor infrastructures will enable a plethora of applications, but many of the sensors that researchers envision require enabling technologies. In particular, sensors' need for energy is a limiting factor for many proposed applications. Some of the applications that this Signal of Change has already mentioned are experimenting with conceivable solutions to the energy problem. One very straightforward approach is to put such sensor arrays on platforms that provide the necessary energy. A second approach is to use organisms that provide the energy necessary for their sensing capabilities. A third approach is to develop sensors that can use ambient sources of energy. Researchers at Northeastern University (Boston, Massachusetts) developed an infrared (IR) sensor that, unlike other IR sensors, consumes no standby power until the wavelengths it detects are present. In the presence of IR light, the energy from the light itself heats sensing elements, resulting in the movement of crucial components of the sensor. The sensor's ability to operate without a dedicated power supply or even a battery dramatically increases the number of potential applications for the sensor. And US research consortium Bridging the Innovation Development Gap (Kissimmee, Florida) is partnering with Face International Corporation (Face Companies; Norfolk, Virginia) to commercialize an energy-harvesting power-cell device for wireless Internet of Things sensors and transmitters. The device uses a thermoelectric material to harvest thermal energy from the environment and convert it into electricity.

SoC1022

Signals of Change related to the topic:
SoC1013 — Quantifying…Urban Environments
SoC997 — Sensors…in Health Care
SoC983 — Smart Infrastructures…

Patterns related to the topic:
P1197 — Distributed Monitoring
P1168 — …Constant Monitoring
P1138 — Energy from Everywhere