UBC REPORTS

THE NEXT BIG THING IN 2009, AND BEYOND

The age of the cyborg

By GÖRAN FERNLUND and CHAD SINCLAIR, Associate Professors, Dept. of Materials Engineering

The melding of artificial materials within the body has long fascinated humans and been the basis for captivating science fiction. From the 1970's *Six Million Dollar Man*, to the 2008 movie *Ironman*, we have been enthralled by the idea of the half-human, half-machine with super-human abilities.

At UBC Materials Engineering, the combination of artificial systems within the human body has a target quite different from those devised in science fiction; it's the next big thing in the world of biomedical engineering and healthcare.

With age, the human body wears out. And engineered materials—metals, polymers and ceramics—increasingly help repair or replace injured or destroyed body parts. At UBC Materials Engineering, research focuses on improving the biological, mechanical and chemical properties of these materials, allowing us to better aid in tissue repair, make longer-lasting implants and enhance the quality of life.

Assoc. Prof. Rizhi Wang, Canada Research Chair in Biomaterials, and Assoc. Prof. Goran Fernlund collaborate with surgeons, cell biologists and pharmaceutical scientists to develop novel implantable biomaterials and have had great success in improving materials used for hip implants.

Building on the wealth of knowledge in traditional biomaterials for surgical implants, a new biomaterials frontier is being created at UBC in the area of functional nanofibre scaffolds for tissue regeneration and targeted drug delivery.

UBC's Professor Frank Ko, Canada Research Chair in Nanofibrous Materials, is spearheading efforts in nanomaterials—materials whose dimensions are nearly atomic in size. With these materials Ko is developing novel nano scaffolds for tissue regeneration.

Tissue scaffolds are the next big thing for implants of the future. Like the scaffolding we see on construction sites, the nano scaffolds are being created by Ko to reconstruct damaged tissue within the human body. Burn victims would benefit from scaffolds used to regenerate new skin. Those with failing heart valves or damaged nerves could count on scaffolds to regenerate these parts from within the patient's own body. As healing progresses, the scaffold, being constructed from a biodegradable material, is absorbed and metabolized by the body while slowly releasing drugs to aid in the healing process.

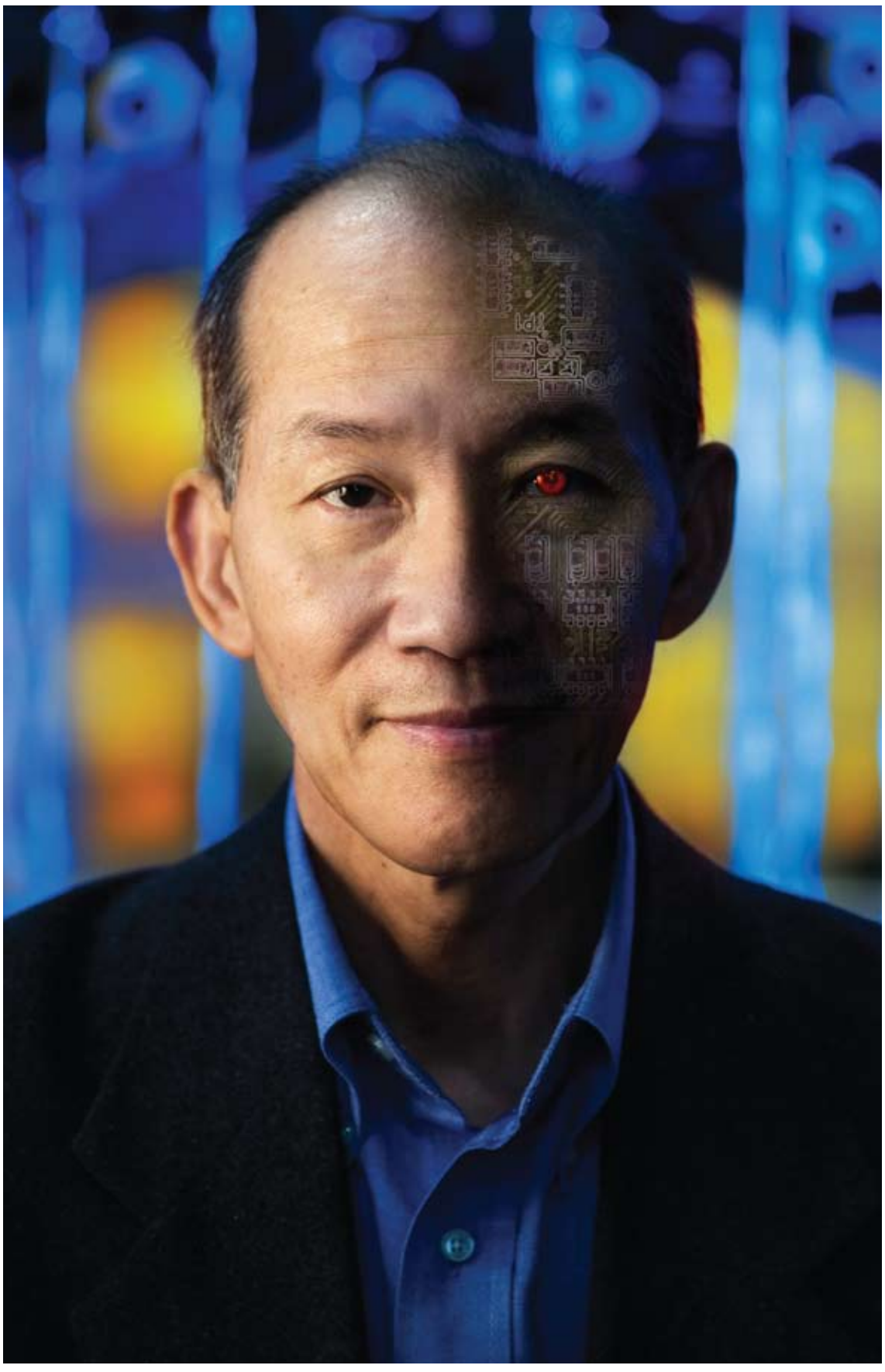

PHOTO ILLUSTRATION: MARTIN DEE

Like the scaffolding we see on construction sites, nano scaffolds are being created by Prof. Frank Ko to reconstruct damaged tissue within the human body.

The key to Ko's work is his unique technology for making scaffolds from millions of tiny fibres, each acting as a site for tissue growth. He accomplishes this using a novel technique known as "electrospinning" which can be used to fabricate fibres that are 10,000 times smaller than the thickness of a human hair. These nano-fibres, when piled on top of one another, provide a perfect scaffold for new tissue growth.

Victor Leung, a Materials Engineering undergraduate student who has been working with Ko on developing his electrospinning process for the next generation of scaffolding materials sees a day when biomaterials may be used to generate all kinds of new body parts.

"As we become more sophisticated in our ability to design materials, particularly at the nanoscale, we open all kinds of opportunities for repairing damaged body parts. The potential is really unlimited," says Leung.

Considering the great strides materials engineers are making in developing materials that are readily accepted by the body and that accelerate the process of recovery and healing, the age of the Cyborg seems not so much science fiction as it does science fact—a good thing given the increasing life expectancy and enduring desire to lead active lives. R

For the fourth year, UBC Reports has asked a handful of researchers to describe the next big thing that will change our world. Their predictions reveal that once-futuristic concepts may be closer than we think. They also reflect the delight of research: how outside-the-box thinking can feed discovery and human progress.

"If at first the idea is not absurd, then there is no hope for it." Albert Einstein

IN THE NEWS

Highlights of UBC media coverage in December 2008. COMPILED BY SEAN SULLIVAN

Parliament's Centre Block, Ottawa.

Prorogue, eh?

When Canada's opposition parties pledged to form a coalition and bring down the Conservative government, UBC political science professor **Allan Tupper** explained the political crisis to an international audience.

Reuters and ***Bloomberg*** joined the ***National Post, Globe and Mail, Financial Post***, and ***Vancouver Province*** in seeking Tupper's expert analysis on how a coalition would affect the provinces, and whether the government would have to play ball on its January budget.

"I think the circumstances are beyond the prime minister's control," Tupper told Bloomberg.

Paradise Lost in prose

A new interpretation of Milton's Paradise Lost by UBC English professor, and distinguished Miltonist, **Dennis Danielson**, caused a stir in blogs for the ***New York Times*** and ***Washington Post***.

Danielson said his work frees the story from its "linguistic obscurity" in order to make the epic poem more accessible to modern readers. Paradise Lost: Parallel Prose presents Milton's original 17th-century text together with Danielson's modern prose rendition of the "story of all things" on facing pages.

"The value of his edition, he says, is that it 'invites more readers than ever before to enjoy the magnificent story – to experience the grandeur, heroism, pathos, beauty and grace of Milton's inimitable work,' " wrote the Times.

Danielson also spoke on CBC Radio.

Growing up in different worlds

Tom Boyce, B.C. Leadership Chair of Child Development at UBC, has co-authored a study that suggests the brains of children from low-income backgrounds function differently from the brains of kids from high-income environments.

The study, reported by The ***Canadian Press*** and ***Los Angeles Times***, found certain deficits in the functioning of the prefrontal cortex – the region of the brain that is critical for problem-solving and creativity – in kids from low-income environments.

"We believe that these are differences in the early experiences of kids growing up in low socioeconomic status families. It's not the fault of anybody. We're looking for things that can be done to make that better," Boyce said.

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PHOTO: MARTIN DEE

Expert Wade Huntley sees several possible steps toward disarmament in 2009.

Real nuclear disarmament

By WADE HUNTLEY, Simons Centre for Disarmament and Non-Proliferation Research, Liu Institute for Global Issues

Eliminating the threat of nuclear weapons: this ideal goal, as old as the nuclear age itself, has often seemed utopian. But history-making progress toward that goal may be the "next big thing" in global arms control and nonproliferation efforts.

The past decade has not been kind to this aspiration. North Korea tested a bomb, and Iran was exposed to be seemingly seeking one, too. The Bush administration sought to expand the variety and utility of the U.S. nuclear arsenal. Much of the world's nuclear materials remained poorly secured and, after September 11, the problem of preventing nuclear terrorism became a primary concern.

But behind the headlines, some key trends point to a reversal of fortune. Under the 2002 Moscow Treaty, U.S.- and Russian-deployed arsenals will soon number around 2,000 warheads each, less than 10 per cent of Cold War peaks. The Nuclear Non-proliferation Treaty (NPT) now includes all the world's non-nuclear states, and beyond North Korea and Iran concerns over new nuclear aspirants drop off quickly.

As important, there has been a discernable shift in thinking. In January 2007, a group of prominent U.S. ex-officials and experts, including previous Republican secretaries of state Henry Kissinger and George Shultz, called for "setting the goal of a world free of nuclear weapons" and mapping the first steps to achieving it. The overture revolutionized thinking in Washington and elsewhere in the world; President-elect Obama has stated his support for this goal unequivocally, and numerous other advocates will be staffing key positions in his government.

Several major steps are feasible in 2009. Concurrent with the nuclear posture review that the Obama administration will develop in its first year, immediate U.S. unilateral actions could include ending new warhead development (already resisted by Congress), adopting a policy of "no first use" of nuclear weapons, and seeking Senate ratification of the Comprehensive Nuclear Test Ban (CTBT) signed by President Clinton.

In the context of resuscitating U.S.-Russia relations, these two countries could quickly extend the verification provisions of their 1991 arms reduction treaty, agree to take nuclear missiles off their hair-trigger "alert" postures, plan further reduction of deployed warheads to 1,000 each, and examine seriously the idea of multilateral ballistic-missile defense systems proposed by Presidents Bush and Putin in 2002. These steps would help commence negotiations for a new treaty to end all states' production of nuclear explosive materials. This progress would presage negotiated, verifiable weapons reductions among all nuclear-armed states, including the three non-NPT states (India, Pakistan and Israel) – also helpful, in the case of Pakistan, to alleviating growing concerns over the security of its existing nuclear stocks.

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These measures would reduce incentives to other countries to seek their own nuclear weapons and help mend the divisions with most non-nuclear states on dealing with key nuclear arms aspirants. The Bush administration has already gained North Korea's re-commitment to eliminating its nuclear capabilities. Iran is a tough challenge in the most volatile region of the world. But a renewed engagement of Iran, likely in some form next year, could produce a solution to the current conflict – perhaps linked to proposals to create an international system to manage the nuclear fuel cycle for nuclear energy facilities worldwide. Success in these two cases, combined with strengthening the global regime overall, could cap further proliferation indefinitely.

Progress toward disarmament requires a global commitment. But many countries have been awaiting only U.S. leadership, which is why many steps could transpire quickly. Other tasks will take longer: establishing systems for verification and compliance, weaning states of their reliance on nuclear deterrence, and securing materials and know-how against access by non-state actors are complex undertakings. It will take time to persuade a few states, thought not yet nuclear-armed, to forever forsake that option. But the preconditions for commitment to these tasks are already in place. With diplomacy equal to the opportunity, we could see, by the end of the next decade, a new nuclear weapons convention which, like the landmines ban, would set the goal of elimination and map the path to its realization.

Nuclear knowledge cannot be forgotten – we ate that apple. Perhaps that means we can never eliminate every last warhead. But we can readily envision a world free of the threat of nuclear weapons – a "virtual disarmament" in which whatever devices remain are few and restricted enough to serve only to prevent any new threat from arising. That world may now be closer than it seems. R

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The Autonomous Taxi: Safe, driverless cars and automated commuter systems are now within the realm of possibility

PHOTO: MARTIN DEE

Assoc. Prof. W.G. Dunford says automated cars are possible with advanced guidance technology.

By W.G. DUNFORD, Assoc. Prof., Dept. of Electrical and Computer Engineering

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A couple of generations ago it was common for communities to be tightly grouped around an employer, with most workers cycling or walking in. For various reasons, the modern worker typically lives far away from the work site and commutes.

Increased use of rapid transit is often suggested as the solution to commuting problems. This involves a large investment in a dedicated rail network, which usually results in the passenger being taken with some discomfort between points that may or may not be close to the final destinations. The trains and tracks will be empty for most of the day.

The main alternative is to travel by private car, which is typically not driven in an efficient way and then left unused for the rest of the day. The technology now exists for that journey to be controlled automatically, with the possibility of the vehicle then being used for other purposes. The autonomous taxi is at hand.

For many years research has been done on automatic control systems for cars. Some systems relied on following buried wires. Perfecting a system that would maintain a distance from another vehicle and not get confused by things like lampposts was particularly troublesome.

We have now reached a stage, thanks in part to work on guided missiles, where camera systems can do a better job than the human eye and brain. Couple this with communication of precise positions and headings of vehicles in the vicinity and you have the possibility of safe, driverless vehicles operating over existing roads. There would be no need for traffic lights or signs and vehicles would hardly ever need to stop. A central control would normally manage all vehicle movements.

At present some people can afford to summon a conventional taxi to do their bidding. In the future most people will use a handheld device to hail an automatic vehicle. The size of vehicle, limousine to multi-occupant van, could be specified and the power source would depend on the type of journey. Short trips would use all electric vehicles and longer trips might use diesel engines or involve some sort of transporter carrying several vehicles. After use, vehicles would be maintained, charged and stored.

The technology now exists for that journey to be controlled automatically, with the possibility of the vehicle then being used for other purposes. The autonomous taxi is at hand.

The user will normally not be able to do any more than specify where the vehicle should go or when a stop is desired, for example to pick up a friend. A limited amount of slow speed control will be allowed. You might want to go into the driveway to pick up a bag. However, it is unlikely that anything like a conventional steering wheel will be supplied. The user will probably point to an image on a screen and the manouevre will happen automatically.

Michael Robinson of Fiat has suggested that if warning labels are desirable on cigarettes it is even more necessary to advertise that driving can cause death. He speculates that in 50 years time driving will not even be allowed and the automatic car of the future will not need safety devices like airbags. Of course the autonomous taxi user will not need to worry about drinking or using the telephone while driving. R

A policy of happiness

By ELIZABETH W. DUNN, Assist. Prof., Dept. of Psychology

Should gay marriage be legal? Should paid parental leave time be increased? Should a former industrial space be converted into high-end condos, or community park space? Going beyond economic analyses, moral arguments, and opinion polls, new cross-disciplinary research on happiness is poised to shed light on important policy issues such as these.

Indeed, at the end of a year when the words "hope" and "change" have resonated so deeply, I believe we are witnessing the beginning of a new era in policymaking. Traditionally, policymakers have relied heavily on economic indicators and other "objective" measures in formulating and evaluating new policies. But the time is now ripe for a "policy of happiness," in which happiness becomes the explicit goal—and carefully measured endpoint—of public policy.

Although happiness has been deeply valued since ancient times, it was once seen as too soft and ethereal to be measured. But careful, systematic research has convincingly demonstrated that happiness can be accurately measured using brief, validated self-report instruments. With these reliable measures in place, researchers have been able to examine the factors—from marriage and unemployment, to television viewing and exercise—that consistently influence happiness in the population.

Research in this area stands to shape policy in positive new ways. For example, my own recent field studies have demonstrated that spending money on others may represent a more effective route to happiness than spending money on oneself (Dunn, Aknin, & Norton, 2008, Science). This work provides support for policies designed to encourage people to use their money in generous ways.

Recent changes to Canadian tax law have introduced enhanced incentives for individuals to make charitable donations. These changes have been heralded for providing a financial boon to charities, but my research suggests that these changes may hold not only economic benefits for the recipients, but also emotional benefits for the individuals who have responded to these new laws by giving generously.

As such, a purely economic analysis would overlook the full range of benefits provided by these policies. Incorporating insights from research on happiness can expand policymakers' field of vision, potentially transforming hope into happiness. R

But the time is now ripe for a "policy of happiness," in which happiness becomes the explicit goal—and carefully measured endpoint—of public policy.

PHOTO: TODD DUNCAN

Happiness can now be accurately measured, says Assist. Prof. Elizabeth Dunn.

IMAGE COURTESY OF NRAO/AUI AND COMPUTER GRAPHICS BY ESO

ALMA's location in the Atacama Desert is one of the highest, driest places on Earth, making it ideal for astronomical research at millimeter wavelengths, which are absorbed by atmospheric moisture.

Observing the formation of new planets

Canadian astronomers will soon use an amazing new telescope to unravel the mysteries of our origins – from planets to the largest structures in the universe.

By ERIK ROSOLOWSKY, Prof. of Physics and Astronomy, UBC Okanagan

Astronomy has long grappled with telling the story of our origins and our relationship to the Universe as a whole. Over the past few decades, we developed the scientific narrative of our origins from the Big Bang up through the present day. However, many links in that story are inferences: they must have occurred since we are here, but we have been unable to actually observe the systems representing these connections – astronomy's own "missing link" problem, if you will.

In the Atacama desert of Chile, 5,000 metres above sea level, astronomers from across the world are now building a revolutionary new telescope that may help see that missing link. The desolate landscape, where annual rainfall is less than 100 millimetres, is precisely what attracts astronomers such as myself because the dry atmosphere is nearly devoid of water vapor.

At lower, wetter sites, the water vapor blocks the short-wavelength radio waves from the cosmos that the Atacama Large Millimetre/submillimetre Array (or the easier-to-swallow ALMA) will observe. When ALMA commences observations in 2011, it will enable astronomers unprecedented insight into our origins.

We cannot look back into our own history to see how our own solar system formed. However, a vast number of other solar systems are in the million-year-long process of formation right now. So, we will see the story of our solar system's birth playing out across the hundreds of systems in our galactic neighborhood.

Observations with current telescopes reveal some evidence for nascent planetary systems around these stars, but the new technologies and unparalleled location for ALMA will for the first time identify forming planets – known as proto-planets. Like putting on our glasses in the morning, we will have a new, crisp view of star and planet formation.

The secret to ALMA's much improved vision is that many of ALMA's 66 antennas, ranging in size from seven to 12 meters in diameter, can be moved around. Changing the relative positions of the antennas allows different modes of observing – a bit like using a zoom lens on a camera. ALMA will form images by continuously combining signals from each antenna with those from every other antenna. There are 1,225 such antenna pairs, with each antenna receiving radio signals from the astronomical object being observed.

The array also relies on the world's most extensive superconducting receiving system, which gathers the astronomical signals, and extensive computing support. ALMA's processors will construct astronomical images by digitizing and processing receiver data at a rate of over 16,000 million-million operations per second.

Catching solar systems in the act of formation will represent a major discovery and resolve outstanding questions about how, exactly, planets form around stars. ALMA's vastly improved capability to peer into the dusty, cold clouds of molecular gas where stars form is central to this discovery.

Proto-planets are not the only missing link that ALMA will study. This new facility will unlock access to many other unseen processes in the Universe. With the telescope, I personally will be studying how the star-forming molecular clouds of gas themselves come to form within galaxies.

Using ALMA, we will be able to observe this process in other galaxies, which is crucial since our embedded perspective in our own galaxy prevents us from seeing this happening nearby. Other astronomers will turn their attention to the most distant observable galaxies in the Universe, seen in the infancy of the Universe thanks to the finite speed of light. Studying these proto-galaxies will answer abiding questions about the forces that shaped our own galaxy.

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ALMA is revolutionary in other ways. In addition to opening up new sections of the radio spectrum to deep observation, it will be more than 10 times larger and far more sensitive than any preceding radio telescope operating at these wavelengths. ALMA also represents the largest collaborative effort in ground-based astronomy to date.

Canada participates with the United States, European governments, and Japan in the construction of the array. Groundbreaking receiver technology has been developed at the Hertzberg Institute for Astrophysics in Victoria, B.C., and is incorporated in the array. In five years, the story of how we came to be will be illustrated with observations from ALMA and many lingering questions in this narration will be answered.And, as is the nature of science, many new questions will await us. R

PHOTO: COURTESY OF ICORD

Tetraplegic Don Danbrook demostrates a prototype BCI recording cap.

Directing objects with your mind

New brain-computer interface technology will revolutionize the lives of those with physical challenges

By DR. JOHN STEEVES, John & Penny Ryan BC Leadership Chair, Professor and Director, International Collaboration on Repair Discoveries (ICORD); DR. GARY BIRCH, Executive Director Neil Squire Society, Adjunct Professor, ICORD & Electrical and Computer Engineering (ECE); BORNA NOUREDDIN, PhD candidate, ECE.

Imagine being able to look at a light, think about turning it on, and it comes on without you moving. Or picture, with just a thoughtful wish, being able to control a computer or open a door. Now envision directing and controlling all manner of inanimate objects with your mind. It would be great fun and potentially very helpful in our multi-tasking world, but consider how it would transform the existence for a person who has lost all motor function due to spinal cord or brain damage. What if there were a technology that allowed people with severe disabilities to communicate, guide robotic limbs, and control the environment around them? This is not just science fiction, but the vision driving the development of brain-computer interfaces or BCI.

BCI is an emerging field of study that has attracted increasing media attention. Essentially, it is any technology that connects machines or computers to the thoughts emanating from your brain. Each and every one of your thoughts involves the activation of specific sets of neurons, which generate a minute amount of electrical activity that can be detected by a sensor array sitting on top of the scalp. Each distinctive pattern of impulses can be used to control a specific device to which it is linked via a wireless transmitter. And no, BCI is not designed to read people's thoughts. It is not possible to read someone's thoughts without their cooperation.

UBC and Neil Squire Society researchers of the Brain Computer Interface Lab at ICORD, an interdisciplinary research centre for the development of effective strategies to promote functional recovery and improved quality of life after spinal cord injury, have been collaborating to develop BCI technologies and applications. There have been some promising results, both here at UBC and abroad, where people have been trained to control lights and doors, move a computer mouse, type messages, and direct a wheelchair.

There are still many challenges to delivering a working prototype. Ideally a practical BCI must be easy to wear or implant, be unobtrusive, and not require a long training period. In the not too distant future, BCI will revolutionize the lives of people living with a physical challenge. The technology will profoundly change the lives of people with severe disabilities, and may also revolutionize how we interact with machines. R