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Adaptive optics maximizes the potential of the world's most powerful telescope

Photo: National Astronomical Observatory of Japan

An international team of engineers and scientists has been developing the technology for what will be the world's most powerful telescope, and University of Victoria researchers are playing a key role in its development. The Thirty Meter Telescope (TMT) project will break ground atop Mauna Kea, Hawaii in late 2013, and will be testing instruments that UVic engineers have been working on since 2005.

When it comes online in 2020, the TMT will be the largest and most advanced optical telescope in the world. With its 30-metre diameter mirror, the TMT will have nine times the light-gathering power of the largest telescopes in use today and more than 10 times the resolution of the Hubble Space Telescope. Astronomers will be able to detect and study light from the earliest stars and galaxies, analyze planets around nearby stars, and test many of the fundamental laws of physics.

Mechanical engineer **Dr. Colin Bradley** (PhD Mechanical Engineering 1992) and his adaptive optics team are developing test instruments to help solve one of the key challenges facing TMT observations—turbulence from the Earth's atmosphere. The TMT will have a set of deformable mirrors that Bradley says "will basically change shape in real time to compensate for image distortions caused by the Earth's atmosphere." This will provide a finer quality of detail, and allow for the correction of blurring caused by atmospheric distortion that limits terrestrial telescopic observations. "In terms of the engineering, this is an extremely complex optical system. Canada is a world leader in this kind of work."

Bradley's adaptive optics technology, called RAVEN, will be shipped to the Subaru telescope on Mauna Kea in December for a one-and-a-half-year testing period. Subaru is currently the world's 4th largest telescope.

What RAVEN will allow astronomers to see huge areas of space that were previously blurred by distortion, or washed out by light from stars. It will help answer questions about dark matter and dark energy, and the frequency and types of extra-solar planets—questions that can't be answered with today's telescopes.

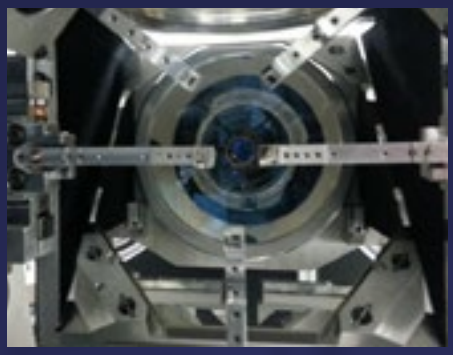
"What makes RAVEN special," says mechanical engineering graduate student, Reston Nash, "is that it has the ability to correct for multiple things at once. Imagine you had a circular dinner table, and all the plates were galaxies and stars. With old telescopes you could basically focus on one of the pieces of food. On the TMT you'll have a giant dining table, and with this style of instrument, you'd be able focus on every plate, and multiplex the information to get 25 times more data."

The TMT will be so powerful that astronomers will essentially be able to look back in time. "Since light travels at a finite speed, when we look into distant space, we are also looking back in time," says astronomer Dr. Kim Venn. "The TMT will make it possible to identify and study extremely faint sources in the very distant universe, when galaxies began to form."

Venn has been involved in writing science cases for testing the adaptive optics system. "I have a keen interest in adaptive optics, and the techniques for improving resolution on the sky because I am interested in very faint stars that are found in very crowded regions, like the Galactic Centre." The science case Venn wrote for RAVEN focused on the search for evidence of the First Stars that formed in our galaxy.

The TMT project is a partnership among the California Institute of Technology, the University of California, and the Association of Canadian Universities for Research in Astronomy (ACURA).

The summit of Mauna Kea in Hawaii is home to 13 telescopes, and is one of the world's most sought after locations for ground-based telescopic observations because of its altitude and isolation. Its height of 4,200 meters places the summit above the clouds, allowing for over 325 days a year of clear skies. Its isolation in the middle of the Pacific Ocean also cuts down light pollution, making it the best location on earth for submillimeter, infrared and optical observations.



RAVEN has moving arms to locate stars in the sky. It needs three stars to focus light and correct the atmospheric distortions. If there aren't enough natural stars in the field, then RAVEN can shoot a laser beam into the atmosphere to create an artificial star.

MESSAGE FROM THE DEAN

Welcome to the fall edition of *EngineeRing*. This September Dr. Jamie Cassels began his first term as UVic's seventh President, marking a significant changing of the guard. This marks a new era at UVic, having just passed its 50-year anniversary. The Faculty of Engineering hit a major milestone this year with its 30-year anniversary, and the 25th anniversary of our first graduating class (1988.) We're seeing unprecedented enrolment numbers this fall with 450 new undergraduate students, an increase of 35 per cent.

UVic has again been ranked as one of the world's top universities for engineering and science, according to the prestigious Leiden rankings. UVic's engineering program was ranked 68th worldwide, and third in Canada, with Computer Science placing 128th worldwide and sixth nationally.

I would also like to welcome Dr. Rishi Gupta to the faculty. Dr. Gupta comes to UVic from BCIT, and is a valuable addition to our new Civil Engineering program.

Our students and faculty are grateful for your continued and sustained support. Your role in the life of the Faculty is critical to our success. I encourage you to keep in touch, and to be involved with the Faculty of Engineering and the university. We welcome your feedback, and hope to see you on campus throughout the year.

Tom Tiedje *Ph.D., FRSC, P.Eng.*

Harnessing the power of the world's most powerful microscope

On a quiet afternoon this past March, mechanical engineer Rodney Herring took an image of a cluster of gold atoms using UVic's new STEHM microscope, and produced the world's most highly magnified image. The image he took proved what he had hoped—the scanning transmission electron holography microscope (STEHM), the microscope he conceptualized 11 years before, was indeed exceeding all expectations, opening the door for scientific research that was never possible before.

The microscope's impact on the scientific community will be enormous. It will allow scientists to see images in the picometer range, which is four times better than a standard electron microscope, and two million times larger than what the human eye can see. This increased magnification will make it possible to investigate electron bonds—the electrons bonding atoms together. Researchers in physics, chemistry, biology, medicine, materials science and electronics may all see unprecedented and transformative advances in their fields because of the STEHM.

Dr. Elaine Humphrey is the manager of the Advanced Microscope Facility, housed in the Bob Wright Centre for Ocean, Earth and Atmospheric Sciences on campus. "The STEHM has all kinds of new technologies in it," says Humphrey. " For example, the STEHM's vacuum is similar to that of the moon or space, and when examining electrons, the better the vacuum, the better the resolution. A typical transmission electron microscope has 20 electromagnetic lenses to make the beam round. This one has 65."When the shape of the electron beam is made more round, the spatial resolution of the image becomes sharper.

Dr. Humphrey and Adam Schuetze, a mechanical engineering graduate student, are in the process of creating training programs for users of the microscope, and UVic graduate students are some of the first able to get their hands on it. Nima Moghimian, a master's student working in Dr. Rustom

Photo: Nik West

Dr. Rodney Herring works on UVic's scanning transmission electron holography microscope (STEHM), which is opening the door to transformative scientific research.

Bhiladvala's mechanical engineering lab, is going to use the microscope to look at gold and rhodium nanoparticles. Zeinab Mohammidi, also a master's student, working in Dr. Reuven Gordon's electrical and computer engineering lab, will be looking at electron vortex beams, harnessing the full pico power of the microscope.

Academics, national and international scientists and engineers are all lining up to use the microscope with businesses and governments joining the queue. Fuel cell research will see huge benefits from the STEHM, with companies such as Ballard Power Systems, as well as government organizations such as the National Research Council of Canada all collaborating with UVic scientists.

Mechanical engineering student finds seaweed a viable biofuel

Aaron Philippsen's master's thesis examined the viability of seaweed as a sustainable biofuel and he found that there is significant capacity and economic promise for such an industry in BC.

The study is the first to look at the logistics and engineering required, assessing whether it makes sense to further examine brown seaweed *(Saccharina latissima)*, which can be readily farmed and is already popular for use in food and cosmetic products, as an alternative fuel source. He looked specifically at whether the potential ethanol output outweighs the greenhouse gas emissions and energy required for the system to be profitable and sustainable.

Philippsen estimates the BC coastline could produce 1.3 billion liters of ethanol, significantly more than the 240 million liters currently consumed annually in BC.

Philippsen adds that as research progresses, consultation will be needed with various stakeholders, including First Nations, environmental groups, and the general public. "Seaweed is a foundational part of our coastal cultures and the ocean ecosystem, and that will play a critical role in determining the feasibility of seaweed-based fuel in BC."

Aaron Philippsen

Engineering 110 lab instructor Iman Moazzen prepares to launch a bottle rocket made by first-year students during a one-day design challenge in September.

Photo: Armando Tura

FIRST YEAR, HANDS-ON

First-year engineering students don't have to complete years of coursework before they start building and designing—they do it in the first few weeks.

The mandatory Design and Communication course brings in industry instructors and has students working in project teams right away to develop solutions for real industry-based problems.

"ENGR 110 presents a glimpse of some of the important elements of engineering practice that will not be apparent from other more technically focused courses," says course instructor Dr. Peter Wild.

One of these elements is working in project teams. Jordan Dagg, IT Director at Schneider Electric, has been involved with the program for years and is a "very credible spokesman for the importance of teamwork in engineering practice," says Wild. Dagg will be giving two lectures and leading 14, two-hour lab sessions this academic year.

Lab supervisor **Dr. Iman Moazzen** (PhD Electrical 2013) says, "The design-based teaching approach is really fun for students because they can see the application of theories in reality and accordingly improve their understanding of the engineering profession."

With this kind of fun, experiential learning, the hope is to sustain student interest in engineering through a busy and academically challenging first-year program. Students hear lectures from a handful of local industry partners, such as Schneider Electric, Viking Air, Starfish Medical, and Bic Canada—all speaking on design practice in industry.

Dr. Ulrike Stege

Bridge-builder, incoming computer science chair

Dr. Ulrike Stege

Dr. Ulrike Stege believes in building bridges—interdisciplinary bridges. She believes that an important strength in a computer science degree lies in the ability to apply that knowledge to other disciplines. Many of her graduate students are co-supervised because of their interdisciplinary work; currently, one of her PhD students is co-supervised with biology and another is co-supervised in cognitive psychology.

Stege is also committed to building interest in computer science for young students. In 2007, Stege and her colleague, Dr. Yvonne Cody, began SPARCS, (Solving Problems with Algorithms, Robots and CompterS), a program for kids in grades 3-8 to learn about computer science in fun after-school clubs. SPARCS has grown so much that it's now run by UVic's Science Venture program.

The SPARCS program underscores Stege's focus on getting more students interested in computer science. At a time when job vacancies were everywhere, interest in computer science programs across the country remained low. That has started to change, and enrolment in the program is at an all-time high, with a 37 per cent increase in first-year students this semester. Stege sees this as an opportunity to change perceptions about computer science.

Stege will assume the position of chair of the Department of Computer Science this January and plans to focus on curriculum, among other things, and make sure it reflects the ongoing and rapid pace of change in the industry. "Things change so quickly and we have to keep the curriculum current," she says

Stege's teaching is focused on algorithms and data structures, and she believes in taking a hands-on approach in class, giving students a chance to reflect on whether they are understanding the material. She joined the Faculty of Computer Science in 2001.

CanDo: A smart app for cognition wins National Cognition Challenge

Celina Berg (left) and Yvonne Coady (right) pose with Sabine Mai from the University of Manitoba.

Funding of $50,000, lab space at the Canadian Technology Accelerator in San Francisco, and a chance to bring international attention to a homegrown innovation —these are just a few of the perks of being one of two winners of the grand prize for Johnson & Johnson's Innovation Cognition Challenge. Computer science post-doc fellow Celina Berg has been working on software applications that help improve the quality of life for people living with Alzheimer's disease and cognitive disorders.

Her winning proposal, *CanDo: A Smart App for Cognition*, describes a series of software applications, including one that helps its users break down daily tasks using photos along with text or audio cues. With the ability to set reminders and send notifications to caregivers, the app effectively increases independence for people living with cognitive disabilities. Not just a high-tech post-it-note, this innovation capitalizes on built-in sensor technologies in smart phones such as GPS, time stamps, and accelerometers, which can provide valuable data to caregivers but also to researchers who now have accurate data to evaluate different theories and track the progress of users.

Berg's expertise lies in the principles of software engineering for complex software systems, with a recent focus of parallel software. Throughout her university education she has received three NSERC grants and has contributed to numerous journal articles working under her former PhD supervisor Dr. Yvonne Coady, an associate professor in the Department of Computer Science. Berg has participated as chair and committee member of local and international symposiums and conferences dealing with outreach, learning and software systems.

With six months to work in the Canadian Technology Accelerator lab, Berg and her team will have access to experts from Johnson & Johnson Innovation to help prepare CanDo for commercialization.

Johnson & Johnson Innovation created the Cognition Challenge, with support from the Consulate General of Canada. Its goal is to help Canadian researchers and entrepreneurs bring their scientific innovations for cognitive disorders to the next level.

Entrepreneurial alumni uniting people through play

Launched in 2008 by **Tim Teh** (BSc Computer Science 2003), **Eric Alpini** (BEng Computer Engineering 2003) and **Eric Haight** (BEng Electrical 2002) without external investments or loans, social gaming developer KANO/APPS has not only beaten the daunting start-up odds in a highly competitive industry, it's thriving.

Four of its five social-media titles are top-rated strategy games on Facebook and have millions of players worldwide. Its first games—*Pirate Clan* and *Viking Clan*—rocketed to hundreds of thousands of users within its first year.

This success earned the company's founders the Greater Victoria Chamber of Commerce's *2013 Young Entrepreneur of the Year Award*. At just five-years old, still self-supported and with a 20-person team, the firm is on solid ground with a culture of valuing the input of the newest hire as seriously as that of the CEO.

"Victoria has an awesome technology culture and a talent pool that rivals bigger centres like San Francisco, thanks to respected schools like UVic," says Teh. "We're focused on cementing our reputation as a west-coast developer of immersive, innovative and compelling social games that unite people through play."

www.kanoapps.com

Eric Haight, Tim Teh and Eric Alpini (l-r)

ALUMNI GOING PLACES

Sky-High Ambitions

By Nicole Rutherford

Ever since Damineh Akhavan (BEng Mechanical 2005, BSc Physics 2006) was a little girl, she's had sky-high ambitions. "I was three when I watched the Challenger Space Shuttle take off. I wanted to be an astronomer to discover a planet on which human beings could exist. I wanted to be an engineer to build a spaceship, and I wanted to be an astronaut to take all the poor people on Earth with that spaceship to the planet I'd discovered."

As an adult her aspirations haven't diminished. She did her double degree in seven years, and through an onslaught of job and graduate school offerings, she chose to join Viking Air Limited in Victoria where she has been working for the past eight years. As a structures engineer, she's in charge of engineering support for the more than 1300 de Havilland legacy aircraft that remain flying in the world, and is a Transport Canada delegate.

Simultaneous to maintaining this career, Akhavan completed an MBA at UVic in 2010. "My education and experience in engineering and science have given me strong analytical capabilities. However, it's important to understand qualitative skills, something that we engineers typically lack. Doing an MBA broadened my perspectives by introducing me to non-technical concepts, such as organizational behavior, and has given me the confidence to tackle projects that I otherwise wouldn't get involved in—as well as extra credibility in my career."

Women in engineering are still a relative rarity, so much so that Akhavan is the only female engineer in her workplace and has even met animosity throughout her career travels. But recently Akhavan was recognized at the 60th annual Canadian Aeronautics and Space Institute by *Women in Aerospace* as one of the leading woman in her field. "It was perhaps one of the proudest moments of my journey so far."

Damineh Akhavan

Akhavan has since been working with *Women in Aerospace* to promote engineering and technology in aerospace amongst women in Western Canada. "The hardest thing [for women in this field] is a lack of mentorship," she says, noting that she was inspired by Sally Ride, the female astronaut on the 1983 launch of the Challenger.

She continues to pursue her dreams. Her next step is to gain a doctorate in aerospace engineering while applying for any upcoming astronaut positions.

Student teams prepare for competition

The Association for Computing Machinery (ACM) is the world's largest educational and scientific computing society. This fall, student teams from around the world will compete in the ACM International Collegiate Programming Contest (ICPC). Led by computer science grad student Sahand Sabah, and undergrads Leon Senft and Corey Binnersley, the teams solve as many computer-programming problems as possible in under five hours.

Leon Senft and Corey Binnersley have ACM-ICPC competition experience, and they've recruited five teams to join them in Vancouver for the Pacific Northwest Regional Contest this November. The top two teams from each regional contest will qualify to advance to the ACM-ICPC World Finals, which will be held in Russia in June 2014. UVic's top teams placed ninth in 2012 and third in the 2013 world finals—an incredible achievement as UVic competes against teams from much larger schools, such as Stanford, U.C. Berkeley, UBC, SFU and the University of Washington.

To support the ACM team and our other student teams visit give.uvic.ca

Giving Back

Our alumni make a difference by volunteering at events, speaking to classes, hiring co-op studentsor supporting scholarships. To explore how you can help change the lives of our current students, contact Jody Kitts, Development Manager, at 250-853-3245 or kittsj@uvic.ca.

Planning a reunion?

The UVic Alumni Association can help by promoting your event to classmates, arranging speakers or providing door prizes. Network and keep involved by exploring the list of groups and upcoming events to find something that's right for you. http://alumni.uvic.ca/events/reunions.php

Alumni Newsletter

EngineeRing is published twice yearly by the Faculty of Engineering to communicate the faculty's goals, strategic direction and activities in order to connect alumni with each other and the university.

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