University of Victoria

2006

FACULTY OF ENGINEERING RESEARCH

InGenium

Message from the Associate Dean Research

The Faculty of Engineering's research excellence is built upon strong basic Computer Science, Electrical and Computer Engineering, and Mechanical Engineering Departments, as well as on Research Institutes that bring together faculty and graduate students to pursue joint endeavours in research and development.

One of the frontiers in R&D in the foreseeable future is bridging engineering and computer science with life sciences and to understand the processes needed for the development of new tools and techniques for clinical applications, and to help define new paths to push the interdisciplinary frontier of bioengineering. In the current Ingenium issue, bioengineering research is spotlighted. Current bioengineering research includes cardiovascular fluid dynamics, microfluidic devices, microsensors for clinical and research applications, biological and biomedical imaging, robotic manipulation of molecules and particles, and biomimetics.

Our faculty excellence in research is demonstrated by the quality of their published articles and conference presentations and the education of highly qualified personnel. This naturally has lead to our inclusion in several provincial and federal Centres of Excellence as well as research partnerships with government laboratories, industry leaders and other universities worldwide. In 2006, the Engineering faculty was successful in obtaining over $8M in external grants and research contracts and fund research chairs. Additionally, graduate students are an essential part of our research program and it is noteworthy the annual Graduate Innovation Forum steered by students to showcase their graduate theses research.

The Office of Associate Dean Research supports the research efforts of all faculty and graduate students in Engineering, provides mentoring for research faculty, facilitates and fosters industrial collaboration, and identifies and disseminates research opportunities and collaborations.

"... bridging engineering and computer science with life sciences ...".

Afzal Suleman, PhD, PEng
Associate Dean Research

Computers & Music

Dr. Tzanetakis

"... in order for computers to achieve similar degrees of music understanding ..."

Dr. Tzanetakis's research group is designing techniques and building tools that facilitate the interaction between humans and computers in the context of music. The activities of the group revolve around the rapidly emerging area of Music Information Retrieval (MIR). The amount of music-related data available digitally is rapidly increasing. Portable music players can hold thousands of songs and online purchasing of music is a reality. MIR researchers are working on how computers can be used to efficiently, and effectively search, access and retrieve digital musical materials. Humans, even non-musically trained, regularly perform several music-related tasks such as recognizing the voice of a singer or identifying whether a piece heard on the radio is classical or reggae music. In order for computers to achieve similar degrees of music "understanding", state-of-the-art audio signal processing and machine learning methods are utilized.

The group's research is interdisciplinary and combines ideas from Computer Science, Electrical Engineering, and Music. Some representative current projects are: 1) Marsyas (http://marsyas.sourceforge.net), an open source audio processing framework, 2) Design and construction of sensor-enhanced musical instruments, 3) Visualization tools for music similarity based on self-organizing maps, 4) Automatic drum transcription for polyphonic music, 5) Emotion recognition based on motion-capture data, and 6) Singing Voice Identification. Most of the members of the group have interdisciplinary backgrounds and regularly compose and perform music.

For example, the use of several of the developed technologies and interfaces was demonstrated during a concert at the P.T. Young Recital Hall in November 2005. Through the activities of Dr. Tzanetakis's group, students in the new combined Computer Science/Music program and the Computer Music option in ECE have the opportunity to participate in state-of-the-art research in computers and music. An indication of the rising importance of the group in the field of computer music, is the hosting of the 7th International Conference in Music Information Retrieval. (http://ismir2006.ismir.net)

Digitizing North Indian Music: Preservation and Extension Using Multi-Modal Sensor Systems, Machine Learning & Robotics is the focus of Ajay Kapur's PhD research and falls under the supervision of Dr. Tzanetakis.

The goal of the research is to build custom technology to preserve and extend North Indian classical music. The technology that is produced from this work will serve as an infrastructure and set of tools for people to learn and teach Indian classical music. Besides preserving traditional techniques, this research will make progress towards a system for a musical robot to perform on stage, reacting, and improvising with a human musician in real-time.

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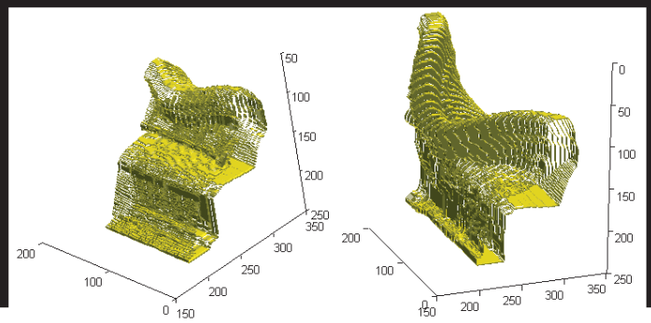
Video-Based Human Motion Analysis for Health Applications



Dr. Branzan Albu

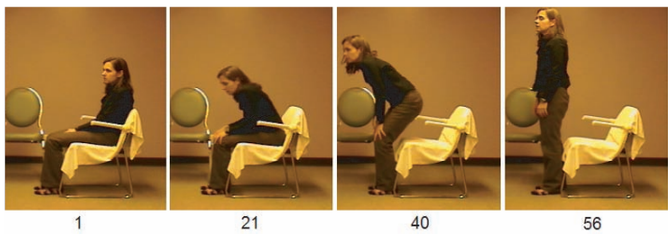
In 2005, Dr. Alexandra Branzan Albu started a fruitful collaboration with physiotherapists at Queen Alexandra in the field of video-based human motion analysis for rehabilitation purposes. Their work is directly related to rehabilitation in the context of elderly health care. They proposed a new tridimensional motion representation, namely the Volumetric Motion History Image, to be used for the analysis of irregularities in human motion. Such irregularities may occur either in speed or orientation and are strong indicators of the balance abilities and of the confidence level of the elderly subject performing the activity.

Dr. Branzan Albu's work focuses on the analysis of sway, which is the most common motion irregularity in elderly. Horizontal and vertical sways are visualized and quantified via an interactive user interface using a new measure of spatio-temporal surface smoothness, called the deviation vector.

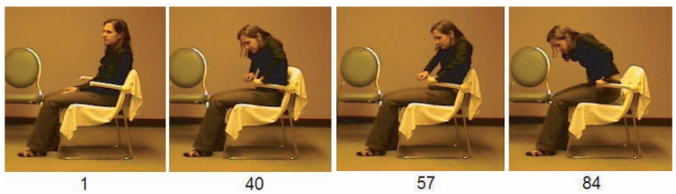
The experimental results show that this measure is reliable for quantifying the deviation of the abnormal motion from its corresponding normal motion. Ongoing work focuses on the development of methods for analysis and quantification of other types of motion irregularities.

The group addresses all aspects of markerless, video-based human motion analysis through the design, implementation, and validation of algorithms for background subtraction, motion tracking, motion representation, and quantitative analysis of motion irregularities. Their research is supported by NSERC. They also collaborate with the Center on Aging at UVic on several other projects using computer vision techniques for extracting relevant information about human motion.

For more information please contact:
Alexandra Branzan Albu - aalbu@ece.uvic.ca.



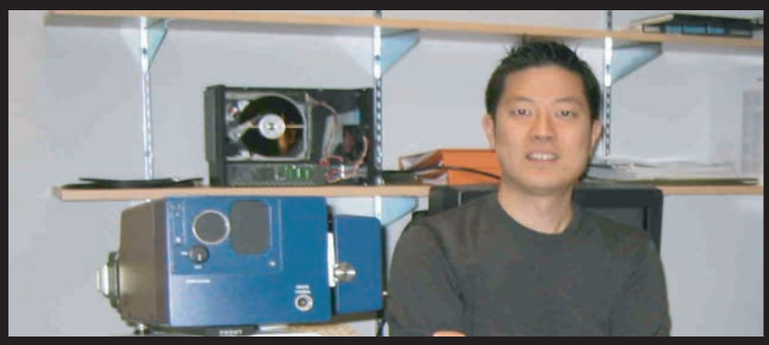
Key frames in abnormal sit-to-stand showing abnormal sway.



Key frames in normal sit-to-stand.

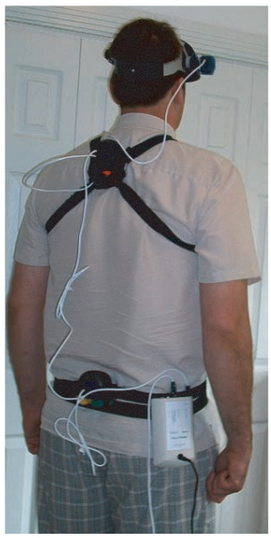
"... motion analysis for rehabilitation purposes".

Dynamic Body Testing



Dr. Park

Dr. Park's research group in the Laboratory for Applied Control and Bionic Systems (LACOBS) is currently developing a number of 'wearable technologies' for physical medicine and rehabilitation applications. The idea behind wearable technology is to attach miniature sensors to a patient's body or part of clothing, thus opening the possibility of continuously monitoring the body movements outside a specialized laboratory. It has the potential to redirect the clinical assessments from the confines of the clinical settings to the real-life settings, i.e. the home, where the patient's normal daily activities are actually carried out.



One such device that Dr. Park's group has recently developed is a novel inertial sensing-based motion tracking system for real-time, 3D measurement of the complex human spinal motion. Inertial sensors, such as accelerometers and rate gyros, are widely used in many applications in the aerospace, military, automotive and marine industries. With the availability of solid-state micro accelerometers and rate gyros, the miniature inertial sensors are ideal devices for wearable technology. Practical applications of Dr. Park's system include diagnosis of spine injury and ambulatory postural monitoring, in a portable and non-invasive manner. As a next step in the pre-competitive development of the spinal motion measurement system, Dr. Park's group is performing clinical trials on subjects with back problems, as they undergo standard clinical orthopedic tests. The system is being used to analyze the patient's spine before and after treatments at a clinic. While the use of 'static' techniques such as radiology and inclinometers or goniometers is the conventional method of diagnosing the spine, the proposed method will complement the assessment and diagnosis of the patient with 'dynamic' test data.

During the past decade, there have been profound changes in physical medicine and rehabilitation due to advances in engineering. In collaboration with researchers from UVATT (UVic Assistive Technology Team), ICORD (International Collaboration On Repair Discoveries) in Vancouver and DSRF (Down Syndrome Research Foundation) in Burnaby, Dr. Park's group is expanding the boundaries of wearable technology in physical medicine and rehabilitation applications, by integrating additional miniature physiological sensors such as: EMG (electromyography) sensor for monitoring muscle activity, ECG (electrocardiogram) sensor for monitoring heart activity, EEG (electroencephalography) sensor for monitoring brain electrical activity, blood pressure sensor, and/or breathing sensor for monitoring respiration, to name a few. The potential impact of wearable technology on patients with physical impairments is enormous.

"... potential to redirect the clinical assessments from the confines of the clinical settings to the real-life settings ...".

For further information please contact:
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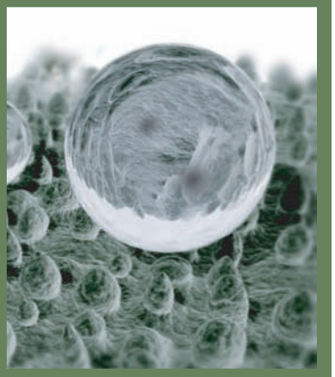


Design of visualization techniques based on human perceptual capabilities, as well as design for multiple co-located users (collaborative visualization) and **Display and Interaction Techniques for Medical Imaging** (e.g., MRI, CT, or SPECT data) in collaboration with SFU and Victoria General Hospital to design effective interfaces for physicians to study dynamic SPECT data.
Melanie Tory: http://www.cs.uvic.ca/~mtory/

The Pervasive Primary Care Informatics Laboratory research focuses on the intersection of software engineering and primary health care. Current research includes the **EGADSS (Evidence-Based Guideline and Decision Support)** project on the development of an open source tool designed to work in conjunction with primary care Electronic Medical Record (EMR) systems to provide patient specific point of care reminders in order to **aid physicians provide high quality care**.
Jens H. Weber-Jahnke: http://jens-weber.ca/

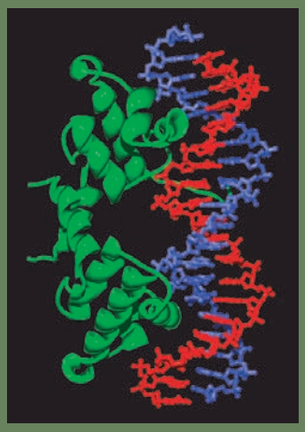
The **Sonic Palpometer** (also known as dolorimeter) developed at UVic is a device for monitoring the pressure exercised during manual palpation of arthritic joints that allows for objective **assessment of threshold of pain**. The palpometer is being used and tested at leading clinics in the US and Canada including Harvard Medical School, UCLA, University of Washington, and others. Worldwide patents have been applied for by University of Victoria's IDC.
Adam Zielinski: http://www.ece.uvic.ca/~adam/

Three-dimensional reconstruction of the human shoulder from MR images for visual assessment of shoulder pathologies and therapy planning. Other projects include **automatic segmentation of prostate markers for radiation therapy** and assessment of the quality of motion in frail elderly adults using computer vision techniques in collaboration with the BC Cancer Agency and DRDC Valcartier, Quebec and Queen Alexandra Hospital for Children.
Alexandra Branzan Albu: http://www.ece.uvic.ca/~aalbu/

Development of a mouse click detection system based on the **wavelet denoising of EMG detected signals obtained from a head band worn by severely disabled patients** in order to communicated on-demand through the generation of mouse clicks events triggered by intensional activation of their forehead muscles. Through denoising the signals false triggers due to eye blink events can be significantly reduced as well as user fatigue; also development of an adaptive assistive leg brace system to enable a person with degenerating leg muscles to regain basic locomotion.
Stephen W. Neville: http://www.ece.uvic.ca/~sneville/

Research on experimental fluid dynamics and design aspects of **replacement heart valves** includes development of a realistic simulator of a human heart capable of reproducing the hydrodynamic characteristics of the blood flow through diseased ventricles and valves using accurate **quantitative visualization techniques**, will provide clinicians with a tool for quantitative estimation of the benefits of valve replacement operation for a particular patient.
Peter Oshkai, http://www.me.uvic.ca/Faculty/POres.html

Development of **fluid-structure interaction dynamics tools and algorithms** to model heart muscle disorders such as **cardiomyopathy**. The development of computational models of a human heart capable of reproducing the hemodynamic characteristics of the blood flow through diseased ventricle and valve will allow significant progress to be made towards an optimum design of surgical plan and will provide clinicians with a tool for quantitative estimation of the benefits of valve replacement operation.
Afzal Suleman: http://avt.uvic.ca



Optical Imaging and Digital Microscopy lies in the application of novel spatial-light-modulator technology and signal processing techniques to improve contrast, dynamic range, and resolution in optical microscopes. The new DOM techniques can have direct impact on public well-being, through **improved medical imaging capabilities** by combining: array-processing optical integrated circuits, high-speed charge-coupled device cameras, and optical signal processing techniques derived from optical communications.
Ted Darcie: http://www.ece.uvic.ca/~tdarcie/

Transparent haptic rendering of bone surgery based on volumetric object models proposes to develop a haptic simulator that provides surgeons with realistic force feedback while they drill through bone of varying quality. Other related projects include the development of local models for realistic haptic rendering of heterogeneous tool-tissue interaction and cooperative **haptic manipulation of virtual organs** for providing several, possibly remote, surgeons with physically accurate force sensations in both hands while interacting within a virtual environment.
Daniela Constatinescu: http://www.me.uvic.ca/Faculty/DPres.html

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Robotic Manipulation of Biological Cells using visual servoing includes the development of a system to automatically manipulate biological cells, and to individually inject them with exogenous molecules such as DNA, RNA or proteins. Other bioenginerring related projects include (i) vestibular motion, a distributed inertial sensing based postural biofeedback/control device for balance disorder patients, and hand in motion, a rehabilitation device for **hand movement injuries and disorders** using artificial sensors and muscle actuators.
Ed Park: http://www.me.uvic.ca/Faculty/EPres.html

Minimally invasive **Fibre Bragg Grating (FBG) sensor for in vivo pressure measurements in intervertebral discs** for research related to the mechanics of degenerated discs and as **diagnostic tool in clinical applications**. The sensor will be used to identify pathologicaly degenerated discs in a painful region for planning surgical treatment. In another application, pressure measurements will be taken in patients with spinal instability to characterize disc degeneration as a guide for clinical treatment.
Peter Wild: http://me.uvic.ca/Faculty/PWRes.html

Acoustic Confocal Interferometry Medical Diagnostics (ACIM) allows non-intrusive observation of the three dimensional internal states inside the human body. The ACIM is aimed to provide first-time information that allows an observer to differentiate organs, a foreign object inside the body, or a fetus within the body. Applications include **differentiating cancerous from non-cancerous tissue, diagnosing retinal disease and breast and prostate gland cancer non-intrusively**, and is capable of being integrated into fetal ultrasound devices
Rodney Herring: http://www.me.uvic.ca/Faculty/RHres.html

Microfluidics for biomedical lab-on-chip technologies are geared toward increasing the quality and quantity of analytical tests performed, while decreasing the time and cost required per analysis. Also through the BC Research in Nano Optics (BC-RiNO) initiative, several collaborative projects underway include on-chip synthesis of quantum dot nanoparticle assemblies having unique optical/physical properties targeted towards biomedical imaging, and the microfluidic integration of nanohole array based sensors for protein detection."
David Sinton: http://www.me.uvic.ca/Faculty/DSIres.html

Quantitative Structure Activity Relationship is a novel way to train neural networks that will generalize based on a limited set of exemplars and it has been applied successfully to model the Aldose Reductase enzyme inhibitory activity of several chemical compounds. The inhibition of the enzyme is considered to be **an approach to control diabetic complications, ischemia, abnormal vascular smooth cell proliferation, cancers, and mood disorders**.
Nikiltas Dimopoulos: http://www.ece.uvic.ca/~nikitas/

The Graduate Engineering Forum

Bringing Research to Reality

On May 15, 2006 the 1st Graduate Engineering Forum: UVic Engineering Research (GIF) was held in the MacLaurin Building at the University of Victoria. This event was organized by graduate students in the Faculty of Engineering, which included students from Computer Science, Electrical and Computer Engineering, and Mechanical Engineering. This was a great opportunity for graduate students from the faculty to present their research to fellow students, faculty, staff and industry guests. A mini-exhibition of industry guests provided an excellent platform for networking. Guests included Shell Canada, Enigma Interconnect Inc., Acrohelipro Global Services Inc., MITACS, IDC, and UVic Engineering Co-op.

Dr. Ged McLean, former UVic Mechanical Engineering Professor, President and CTO of Angstrom Power Inc., delivered a thought provoking talk on bringing research to reality.

All of the student talks and poster presentations were excellent, and in particular, awards for Outstanding Oral Presentations were awarded to: Robert Prinz (ECE), Ahmad Kermani (MECH), Jennifer Murdoch (CSC), and Adam Schuetze (MECH). The Outstanding Poster Presentation went to Kerem Gurses (MECH). Congratulations to these award recipients and to all the students who participated! Please join us at the next GIF!

For further information please contact:
Aimy Bazylak – abazylak@uvic.ca

The Faculty of Engineering is proud to welcome it newest faculty

Computer Science

Dr. Amy Gooch

Assistant Professor
Image-Based Rendering, Human Perception, Animation, Virtual and Immersive Environments

Dr. Bruce Gooch

Assistant Professor
Computer Graphics and Scientific Visualization

Electrical and Computer Engineering

Dr. Ahmed Hassan

Assistant Professor
Software Architecture Recovery, Software Evolution, Mining Software Repositories, Performance Engineering, Distributed Fault Tolerant Systems

Mechanical Engineering

Dr. Majid Bahrami

Assistant Professor
Microelectronics Cooling, Heat Transfer, Fluid Flow, Material Science, Contact Mechanics.

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