

Canada Excellence Research Chair in Digital Media Research and Innovation

Digital media impact Canada and the world in profound ways, shaping how we work, learn, and play in an always-connected world. Canada has had a remarkable role in the development of the current generation of digital media, with notable industry leadership in video games, digital animation for film and visual effects, mobile devices and smart phones, digital network technology, and digital whiteboards for learning. Vancouver in particular over the last two decades has risen to prominence in animation, video games development, and film/TV post-production. In parallel, UBC has become a major research institution, marked by a strong spirit of interdisciplinarity and technology transfer in digital media.

The UBC CERC in Digital Media Research and Innovation will, in the context of the Digital Economy priority area, provide intellectual leadership in harnessing UBC strengths to envision opportunities and address critical problems in a fast-changing industry. Through an associated Centre, supported by four new dedicated faculty positions, the focus will incorporate additional areas of research strength, namely digital media economic and policy issues, and digital infrastructure. The Chair/Centre will focus initially on digital media content and user-interaction innovations, where UBC is particularly strong. Over time, the Chair/Centre will draw upon UBC expertise in social media, law (jurisdictional copyright/privacy issues), business (market viability), library and archival science (information storage, retrieval, distribution), electro-acoustic music, sociology (demographic issues), and other disciplines.

The trans-departmental reach of the Institute for Computing, Information, and Cognitive Systems (ICICS) at UBC will be an important mechanism in realizing these collaborations, in addition to strong continuing commitments from the departments of Computer Science and Electrical and Computer Engineering. ICICS has a mandate to promote multidisciplinary research in advanced technologies systems, and has been a major driver of innovation in its 27-year history. With 170 members from 18 different departments and strong connections to industry, ICICS has nurtured a unique culture of collaboration through its cross-disciplinary initiatives and provision of state-of-the-art infrastructure. In the digital media arena, ICICS is home to the Imager lab, one of the top five animations and computer graphics groups in North America. With support from Dolby, the ICICS Digital Multimedia Lab is conducting advanced research in 3D capture, compression, and display technologies, with international academic and industrial partners. Human-computer interaction and communications research groups have changed the way we communicate with technology and one another.

The Chair/Centre will enhance the bridge between UBC's world-class research expertise and industry innovation, propelling both to global leadership by driving change and providing an ongoing critical mass of highly trained personnel. This Centre will be structured around four digital media pillars that represent areas of significant strength at UBC, namely: Content Creation Tools, Interaction and Experience Design, Economic and Policy Issues, and Digital Infrastructure. UBC's internationally known researchers associated with these pillars are identified in the following section.

Criterion 1: Four Pillars of Existing Research Strength

Pillar A: Content Creation Tools

ICICS Director and Dolby Professor in Digital Multimedia **Panos Nasiopoulos (ECE)** is an internationally known innovator in digital multimedia. Prior to joining UBC, he was President and CEO of Daikin US, which developed the software components of the DVD. In his CFI-funded 3D Innovations Lab, he is revisiting the entire 3D technology pipeline, from capturing life-like high dynamic range (HDR) 3D video, to 2D-to-3D conversion, post-processing, display schemes, and interactive 3D content. Subjective and objective quality metrics being developed will affect future camera, transmission and display designs. His lab was the only academic facility in North America chosen by MPEG to participate in video compression standards testing (2011).

Computer graphics and animation specialist **Robert Bridson (CS)** is co-founder of Exotic Matter, a graphics company that creates physics-based smoke, liquid, and fabric simulation software. His software has been used in films such as *Avatar*, *Narnia: Voyage of the Dawntrader*, *X-Men First Class*, *Harry Potter and The Deathly Hallows Part 2*, *Pirates of the Caribbean 4*, *Rise of the Planet of the Apes*, and many others. Bridson's book, *Fluid Simulation for Computer Graphics*, is a key reference for work in the field.

Michiel van de Panne (CS) is known for his work on modeling skilled human and animal movement, with applications in computer animation and robotics. He is a cofounder of the ACM Symposium on Computer Animation and has twice co-chaired this leading forum for computer animation research. He recently completed the two terms of his CRC in computer graphics and animation. Van de Panne has developed hair-rendering techniques used in *The Chronicles of Narnia* and other films. He is the leader of the GRAND MOTION project.

Alla Sheffer (CS) focuses on digital geometry processing for reconstruction, mesh deformation, and cloth/garment modeling. Her parameterization algorithms are widely used by industry in applications such as Blender, the Maya plugin, and CATIA. She is a GRAND network investigator.

The SIFT object-recognition algorithm developed by **David Lowe (CS)** is used around the world. The original and follow-up papers have received over 17,000 citations, one of the highest in Science. SIFT has been licensed to numerous companies, e.g., Sony for their robotic dog, AIBO. Lowe's company Cloudburst Research, Inc. has developed one of the top-selling panorama stitching apps for the iPhone and iPad.

Dolby Research Chair **Wolfgang Heidrich (CS)** works at the intersection of computer graphics, machine vision, optics, imaging, and perception. He is co-developer of the world's first HDR display (which led to a startup acquired by Dolby) and developer of a markerless facial capture system. Heidrich collaborates with Nasiopoulos on 3D HDR video innovations, is a member of the GRAND NCE, and recently won the 2011 Charles McDowell Award for Excellence in Research.

CRC **Dinesh Pai (CS)** is an expert in modeling sensorimotor human and animal motor control and the creation of highly realistic anatomically correct model for computer animation. These models have applications in rehabilitation medicine, robotics, film, and games. A former student's start-up developed the Osmos game, which was selected by Apple as the 2010 iPad game of the year.

Pillar B: Interaction and Experience Design

Kellogg Booth (CS) is a senior HCI researcher who has made advances in large-screen collaboration technology, educational technology, computer graphics, and virtual/augmented reality. He is Scientific Director of the \$23.25M GRAND NCE, with 56 investigators across Canada (9 from ICICS), and was Associate Director of the 6-university Network for Effective Collaboration Technologies (NECTAR, 2004-09). Booth is also co-founder of the Imager lab in the ICICS/CS building, where many of the researchers named in this proposal collaborate to advance the science of computer graphics, computer animation, visualization, haptics, and HCI.

Joanna McGrenere (CS) designs adaptive and adaptable interfaces that support people with cognitive disabilities and the elderly, computer-based collaboration, and mobile phone applications (sponsored by Google). Her work on interaction for older users will address the needs of the Zoomer generation. She is a member of the GRAND NCE, and was recently awarded the 2011 CACS/AIC Outstanding Young Computer Researcher Prize.

Haptics researcher **Karon MacLean (CS)** focuses on affective design, low-attention interfaces, mobile interaction techniques, and embedded haptics interfaces. Her work is sponsored by Nokia, SAP, and other companies. She was Chair of the IEEE Haptics Symposium (2010/12), is a cofounder and associate editor of the IEEE Transactions on Haptics, is a member of the GRAND NCE, and winner of the 2008 Charles McDowell Award. She has received best-paper awards at CHI, the Haptics Symposium, and Human Robot Interaction.

Ron Rensink (CS/Psychology) applies his understanding of visual attention to design displays that are effective and transparent to the user. He is also a leading visual analytics researcher, developing systems that enable the user to visually analyze immense amounts of data.

Alan Kingstone (Psychology) is a behavioural psychologist with expertise in visual attention and social cognition. His work has direct commercial application, e.g., assessment of a new type of light to determine the effect of different luminance levels on perception, cognition, attention and affect. Kingstone conducts quality of experience assessments for Nasiopoulos' 3D Innovations Lab.

Sid Fels (ECE) is Director of the Media and Graphics Interdisciplinary Centre (MAGIC) and a member of the GRAND NCE. He develops interaction technologies that integrate HCI and AI, as well as virtual/augmented reality technologies. His work is supported by Autodesk Research Inc., Microsoft-FAPESP (Brazil), Nokia, and many others.

Pillar C: Digital Media Economic and Policy Issues

Kevin Leyton-Brown (CS) investigates and applies game-theory to highly complex economic interactions, such as auctions with separate, overlapping bids. Leyton-Brown has studied the sale of bandwidth spectrum for mobile devices for the US FCC. His expertise is important for developing novel means of content delivery, and in the broader economic context of incentives modeling. Leyton-Brown's book *Essentials of Game Theory* is a primary text in the field. He co-chair of the 2012 ACM Conference on Electronic Commerce.

The ease of distributing copies of digital content facilitates piracy, a significant challenge for the movie and audio industry. Watermarking can be used to either identify the recording device or enable access control. **Nasiopoulos (ECE)** is developing watermarking methods that allow tracking the theatre projection device, identifying where the copy was made or providing authorization information on video playback devices.

Statistical signal processing researcher **Jane Wang (ECE)** will contribute her expertise on information management and security in media-sharing networks, as well as collusion-resistant

multimedia fingerprinting, to content protection applications. Wang is co-author of the book, *Multimedia Fingerprinting Forensics for Traitor Tracing*.

Rabab Ward (ECE) is a world-renowned researcher in signal, image, and video processing, whose innovations have been applied to cable TV, HDTV, medical imaging, infant cry signals and brain-computer interfaces. Her collaboration with Vancouver multimedia company BBTV resulted in algorithms that protect audio, songs, images, and video from piracy.

Andrew Warfield (CS) is a CRC in Computer Systems and Security and is well known for his work on virtualization, cloud-based storage, improving the security and stability of complex software, and other systems issues. He received the prestigious 2012 Sloan Research Fellowship, recognizing that his work will strongly benefit society.

Bill Aiello (CS) brings a wealth of industry experience from his time at AT&T Bell Labs, where he managed research into network security, cryptography and data privacy. He now focuses on network and systems security, routing, cryptography, structures of the Web and other massive graphs. Along with Beznosov, Aiello is part of the NSERC Internetworked Systems Security Network, which is addressing the vulnerability of government and industrial information networks to attacks.

Kosta Beznosov (ECE) works in the areas of usable security, distributed systems security, secure software engineering, and access control. His investigation of new vulnerabilities introduced by social networks will be relevant to the Chair/Centre. He is co-leader of the GRAND NCE project on Privacy of New Media.

Pillar D: Digital Infrastructure

Matei Ripeanu (ECE) characterizes large-scale distributed systems, peer-to-peer systems, and high-performance computing, to design new systems optimized for common usage patterns. His group developed MosaStore, a versatile storage system that aggregates contributed storage space from network-connected nodes into a high-performance, low-cost store. The CERC Chair/Centre will leverage Ripeanu's innovations to develop novel cloud-based and other large-scale content delivery solutions.

Victor Leung (ECE) is the TELUS Mobility Industrial Research Chair in Advanced Telecommunications Engineering. His research focuses on architectural and protocol design and performance analysis for digital networks, with an emphasis on wireless networks and mobile systems. He will address multiplatform access and content delivery.

The concept of universal media access--everywhere and by everyone--is reinforced by recent advances in digital video coding that are pushing the bounds of video delivery to more versatile applications for a wider range of playback devices. **Nasiopoulos (ECE)** is working on scalable video technology, which is a key factor in achieving universal access and allowing users to receive the best possible quality of service in relation to their resources. Research challenges involve quality of service, efficiency, bandwidth, power and protection necessary to overcome losses, as well as the limited capacity of wireless channels and limited battery life of mobile devices.

Software engineer **Ali Mesbah (ECE)** focuses on software testing and dynamic analysis of modern web-based systems, and will contribute to Web-based content delivery. He is the primary author of Crawljax, an open source framework for crawling and testing Web 2.0 applications that is widely used in industry (e.g., by Google, Fujitsu, eBay).

Karthik Pattabiraman (ECE) is an expert in fault-tolerant and secure computer systems. He will ensure the developed delivery infrastructure is robust and secure.

Criterion 2: Promise of the CERC

Digital media are undergoing a continual and rapid transformation in a multiplicity of new directions. Computer animation and digital cinematography are moving to 3D displays of various form factors. New generation of tools are allowing artists to express their intent in increasingly powerful and abstract ways during the creation of geometric shapes, animated motion, and visual appearances. Mobile devices and game consoles are becoming increasingly aware of their context and user preferences. The power of crowds is being readily exploited through gamification and crowd-sourcing of content. Visual effects of ever-increasing sophistication are rapidly becoming ubiquitous and draw on the latest advances in computer vision, fluid and cloth simulation, and digital human models. An array of new devices and technologies are providing ever-expanding possibilities for merging our digital worlds with the real world, including the Kinect, embedded pico-projectors, programmable friction screens, “empty hand” body-based interfaces, displays and touchscreens that can take arbitrary organic forms, embedded cameras capable of object and person recognition, vibrotactile devices, and more. New monetization strategies are overturning traditional business models and leading to privacy and security concerns. Changes in the compute power of mobile devices and cloud-based infrastructure allow for many new choices for content transcoding and delivery.

The opportunities (and challenges) for the digital media industry in Canada and elsewhere lie in understanding and exploiting these disruptive ideas and technologies while avoiding their pitfalls. The UBC Chair/Centre for Digital Media Research and Innovation will play a number of key roles: providing sound intellectual leadership that is looking 5-10 years ahead; being a world-class research centre for ideas and technologies in digital media; and training the highly qualified personnel required to build an ecosystem of Canadian companies capable of capitalizing on next generation ideas in digital media. The Chair/Centre will initially focus on digital media content and user-interaction innovations, where UBC is particularly strong. As the Centre coalesces, supported by four new dedicated faculty positions, the focus will incorporate additional areas of research strength, namely Economic and Policy Issues, and Digital Infrastructure. In this, the Centre will be a fully interdisciplinary endeavor.

Research on “**Content Creation Tools**” will be a high priority for the Chair. In relation to the film, TV, and advertising industries, this will span research into capture (including high dynamic range 3D video), post-processing, display schemes, and interactive content. Conversion of legacy 2D content to 3D will also be an important research strand. Subjective and objective quality metrics that put the user’s quality of experience first will be important tools in realizing these innovations. For animation, this pillar will encompass research into authoring, capture, and editing of multiple forms of content, including 3D shape, 3D animated motion, and 3D depth from 2D images for stereoscopic display. A common attribute of future tools will be their ability to allow for increasingly abstract manipulations. Another important direction is the development of tools to interpret new types of sensory data, such as the Kinect, accelerometers, cameras, touch screens, and the increasing number of other types of devices.

“**Interaction and Experience Design**” defines the second pillar, and will also be a research priority for the Chair. Central to the success of digital media giants like Apple, Facebook, and Google has been an unwavering attention to the user’s experience and a compelling vision for what this could be. This has been key to their ability to succeed in the battle for hearts, minds and

market share. Canadian high-tech companies have not always recognized the crucial role of this focus and vision, sometimes with severe consequences. Technology alone does not win. Examples of this abound: touch-screens, videophones and indeed the Internet itself existed dormant for years, yet became game-changing only when rendered relevant to human needs and imagination through creative interaction design. Technology that outstrips its capacity to work for people, through unusable complexity or a focus on the wrong utility, dies out in a selection process driven increasingly by end-users. This CERC pillar will provide the next generation of Canadian companies with “user experience” insights and innovations that are necessary to thrive in the digital economy, through closely coupled creation of interaction techniques, technologies and algorithms that solve actual human problems and inspire human delight. Specific topics that build on the group's internationally renowned track record in multidisciplinary and commercially relevant design include user experiences that are mobile, implicit, touch-based, context-aware, accessible to the elderly and disabled, collaborative, and ever-more intelligent.

The third pillar investigates “**Digital Media Economic and Policy Issues**”. Increasingly, our communications, social interactions and commercial exchanges are moving online. We have a vague notion that there is a quid pro quo in using these services, but do not know specifically what is being exchanged. Because economic innovation in the digital media space invariably goes hand-in-hand with changes in the social impact of technology, a thorough and well-communicated analysis of privacy, security, and user rights is critical to the success of Canada's digital media industry in the decade to come. Also, new business models are underpinned by a complex web of digital technologies, including collaborative filtering, auction theory, preference elicitation, market design, and social network analysis. This pillar will help Canadian digital media companies leverage these new technologies in their own businesses, and help them innovate for the future.

The fourth pillar tackles issues of “**Digital Infrastructure**” related to digital media and user experiences. The need for digital media to be universally accessible and scalable to millions of users means that issues specific to network infrastructure become part of understanding and improving the user experience. Issues related to this pillar include multi-platform access, transcoding, and flexible migration of computation, among others.

Designing compelling digital media experiences depends heavily on innovations that bridge all four of these pillars. For example, the success of products such as iPhone stems from developing designs based on an unwavering attention to the user's experience. This philosophy also drives ongoing innovations in the development of 3D video where design decisions are impacted by user quality of experience considerations drawn from all of these pillars.

Development within and across these four pillars will help generate wealth and employment in currently well-established industries in visual effects, streamed video content, advertising, and games. More importantly, the digital media advances realized by the Chair/Centre have the potential to impact every commercial and industrial sector of the modern economy.

Criteria 4 & 5: University and Other Resources Devoted to the CERC

Infrastructure and Other Support

It is expected that UBC's ongoing budgets will accommodate salary support and benefits for the Chair, as well as associated new research, technical, and administrative staff positions. Four new faculty positions (two each from CS and ECE), will be supported by the associated departments/faculties, along with start-up funds. Office space for these faculty members will be provided by ICICS.

Lab and office space for the Chair and associated centre will be provided by ICICS in its 5,600m² building. Existing state-of-art infrastructure, including the Imager Lab, ICICS Multimedia Lab, Media and Graphics Interdisciplinary Centre (MAGIC), and others, will be drawn upon to support the initiatives of the Chair.

Examples of Externally Sponsored Research Funding

The stature of the digital media researchers identified in this proposal is underscored by their ability to secure external support for their research. To cite just a few examples, Booth as Scientific Director of the GRAND NCE, with 30 non-university partners, was awarded \$23.25M in 2010 to support the games, animation, and new media work of 56 investigators across Canada, 9 of them named in this proposal. Nasiopoulos is Dolby Professor in Digital Multimedia, supported by a \$1M endowment. The 3-year Dolby Computer Science Research Chair held by his colleague Heidrich is funded by a \$750,000 investment from Dolby Canada. Victor Leung is the inaugural holder of the TELUS Mobility Industrial Research Chair in Advanced Telecommunications Engineering, established by a \$500,000 pledge from TELUS.

CFI External Funding

In 2009 ICICS was awarded a \$14.1 million dollar CFI Leading Edge Fund grant. This success built upon a \$22.1M CFI grant awarded ICICS in 2001, which allowed ICICS to build an addition to its existing building, adding approximately 35 labs of collaborative research space and a wide range of state-of-the-art equipment.

The 2009 CFI grant enabled ICICS to expand research and innovation in five key areas involving roughly 30 researchers from a wide variety of disciplines, many of them named in this proposal. Among other relevant labs, the grant allowed **Nasiopoulos** to establish the 3D Innovations Lab, where many of the content creation, protection, and delivery innovations to be realized through the Chair will occur. ICICS leveraged over \$2.8 M in external partner funding in securing this grant. A significant portion of this funding supports researchers involved in this proposal.

Criteria 3 and 6: Fit with Priority/Sub-priority Areas, Benefit to Canada

The CERC Chair is aligned with the "Digital Economy" priority area and more specifically the "digital media: creating Canada's digital content advantage" subpriority area. The Chair is also strongly aligned with provincial strengths and priorities. British Columbia has more than 600 digital media companies, which employ about 16,000 people and generate \$2.3 billion in annual sales. Greater Vancouver accounts for more than 60 per cent of the digital media companies in the province. The Government of British Columbia strongly promotes digital media through multiple channels, including New Media Tax Credit, the government's \$90 million B.C. Renaissance Capital Fund, and the B.C. Innovation Council.

Other Canadian organizations active in the area: Numerous institutes in Canada do work related to Digital Media. In comparing the proposed Centre to existing institutes, we shall restrict ourselves to those that are in close geographic proximity to Vancouver's digital media industry and those that have a significant international reputation for research in at least two of the four pillars that lie at the core of this proposal. The Centre for Digital Media at the Great Northern Way (CDMGNW) in Vancouver is jointly founded by UBC, SFU, Emily Carr University, and BCIT. It is well known for its Masters of Digital Media program, which engages students in real world projects and coursework. The Chair/Centre will do forward-looking research that is highly complementary to the project-based training provided by CDMGNW. Within UBC, the ICICS Media and Graphics Interdisciplinary Centre (MAGIC) has a 20-year multi-disciplinary track record of fostering collaborative research in new media at UBC. The Chair/Centre will be significantly larger in terms of scale and ambition, and will come with a critical mass of funded faculty positions. The University of Toronto has research expertise that spans various aspects of digital media, including computer graphics and human computer interaction. The Chair/Centre will build on the strong ecosystem of digital media companies in the greater Vancouver area, build on unique research strengths of UBC, and continue collaborations with other Canadian researchers through networks such as the GRAND NCE, hosted at UBC.

Commercialization and Benefits to Canada The University of British Columbia has excellent technology transfer services through the University Industry Liaison Office (UILO). This office is the leader among Canadian universities in securing patents and ranks in the top tier in North America. The office has an extensive network of high-tech companies interested in licensing UBC patents and works closely with UBC researchers to take promising inventions to market. As documented earlier, current UBC faculty working in the area of digital media bring with them an impressive record of technology transfer through founding spinoff companies or working with existing companies, both large and small. The GRAND NCE led by Booth is an important facilitator of collaborations and technology transfer with industry. MITACS, also hosted out of the same UBC department, plays a key role in developing industry connections through the facilitation of graduate student internships.

The greater Vancouver area is advantageously situated close to a large number of potential industry receptors. Nokia's Burnaby office focuses on the development of the next generation of wireless devices and services. Vancouver is a significant centre for film and visual effects production. Companies in this space include Pixar Canada, Digital Domain, Moving Picture Company, The Embassy, Image Engine, Rhythm & Hues, to list but a few. It further has one of the top video game clusters in the world, with presence from major publishers including EA (Electronic Arts), Nintendo, THQ, Vivendi/Activision, and Microsoft. Vancouver is also close to the entertainment industry in Los Angeles, software centres in Seattle and Redmond, Washington, and rapidly growing markets in Asia.