Natural Sciences and Engineering Research Council of Canada | Conseil de recherches en sciences naturelles et en génie du Canada

1507

Institutional Identifier

System-ID (for NSERC use only): 125527857

# FORM 101
## Application for a Grant
## PART I

Date: 2009/10/25

| Family name of applicant | Given name | Initial(s) of all given names | Personal identification no. (PIN) |
|---|---|---|---|
| Booth | Kellogg | KS | **Valid** 10455 |

Institution that will administer the grant: British Columbia

Language of application: [X] English [ ] French

Time (in hours per month) to be devoted to the proposed research / activity: 80

Type of grant applied for: Discovery Grants - Individual

For Strategic Projects, indicate the Target Area and the Research Topic; for Strategic Networks and Strategic Workshops indicate the Target Area.

Title of proposal: Collaboration technology and multi-user interfaces

Provide a maximum of 10 key words that describe this proposal. Use commas to separate them.

augmented reality, collocated teamwork, computer-supported cooperative work, document authoring, instructional technology, interaction design, multi-touch, participatory design, shared display, usable security

| Research subject code(s) | | Area of application code(s) | |
|---|---|---|---|
| Primary | Secondary | Primary | Secondary |
| 2700 | 1605 | 1207 | 802 |

**CERTIFICATION/REQUIREMENTS**

If this proposal involves any of the following, check the box(es) and submit the protocol to the university or college's certification committee.

Research involving : Humans [X] Human pluripotent stem cells [ ] Animals [ ] Biohazards [ ]

Does any phase of the research described in this proposal a) take place outside an office or laboratory, or b) involve an undertaking as described in Part 1 of Appendix B?

[ ] NO [X] If YES to either question a) or b) – Appendices A and B must be completed

**TOTAL AMOUNT REQUESTED FROM NSERC**

| Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
|---|---|---|---|---|
| 74,100 | 74,100 | 74,100 | 74,100 | 74,100 |

**SIGNATURES (Refer to instructions "What do signatures mean?")**

It is agreed that the general conditions governing grants as outlined in the NSERC *Program Guide for Professors* apply to any grant made pursuant to this application and are hereby accepted by the applicant and the applicant's employing institution.

Applicant

Applicant's department, institution, tel. and fax nos., and e-mail

Computer Science
British Columbia
Tel.: (604) 822-8193
FAX: (604) 822-5485
ksbooth@cs.ubc.ca

Head of department

Dean of faculty

President of institution (or representative)



The information collected on this form and appendices will be stored in the Personal Information Bank for the appropriate program.

**PROTECTED WHEN COMPLETED**

Version française disponible

Canada

| Personal identification no. (PIN) | Family name of applicant |
|---|---|
| **Valid** 10455 | Booth |

**SUMMARY OF PROPOSAL FOR PUBLIC RELEASE (Use plain language.)**

**This plain language summary will be available to the public if your proposal is funded. Although it is not mandatory, you may choose to include your business telephone number and/or your e-mail address to facilitate contact with the public and the media about your research.**

Business telephone no. (optional): 1 (604) 822-8193

E-mail address (optional): ksbooth@cs.ubc.ca

Interaction techniques for shared displays in collocated and distributed environments present a number of challenges. The proposed research will examine the affordances of tabletop, large wall-mounted, and hand-held displays to determine how each best fits with specific tasks during face-to-face collaboration, and how each can support the other. Included in this will be development of novel interaction techniques for use at a distance from the display, especially when used in collaborative environments where mutual awareness must be traded off against interference and distraction by one user's interaction with another's workflow. One component will look at the special case of collaborative authoring, which is often performed asynchronously.

Classroom and meeting room presentation support using shared displays is a special case of the more general work that is of particular interest. As with the more general topic, this continues recent work. In this case, studies in actual classrooms using special-purpose software designed to support multiple projectors to extend standard PowerPoint presentations to a much larger screen area more like traditional multi-blackboard "chalk talk" lectures is the topic of a just-finishing doctoral disseratation. Further work will assess specific pedagogical hypotheses and ways to engage students as active participants, rather than simply passive receptors.

Augmented, mixed, and hybrid reality offer another avenue for extending the research on shared displays. In this case the displays will be super-imposed or embedded in physical objects, and interaction techniques that flow seamlessly back and forth between the real and virtual representations of the objects or the information underlying them will be studied. Current work has looked at a variety of multi-projector augmented reality techniques for architectural plans.

**Other Language Version of Summary (optional).**

| Personal identification no. (PIN) | Family name of applicant |
|---|---|
| **Valid** 10455 | Booth |

Before completing this section, **read the instructions** and consult the *Use of Grant Funds* section of the NSERC Program Guide for Professors concerning the eligibility of expenditures for the direct costs of research and the regulations governing the use of grant funds.

**TOTAL PROPOSED EXPENDITURES (Include cash expenditures only)**

| | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
|---|---|---|---|---|---|
| 1) Salaries and benefits | | | | | |
| a) Students | 42,500 | 42,500 | 42,500 | 42,500 | 42,500 |
| b) Postdoctoral fellows | 12,000 | 12,000 | 12,000 | 12,000 | 12,000 |
| c) Technical/professional assistants | 7,500 | 7,500 | 7,500 | 7,500 | 7,500 |
| d) | 0 | 0 | 0 | 0 | 0 |
| 2) Equipment or facility | | | | | |
| a) Purchase or rental | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 |
| b) Operation and maintenance costs | 500 | 500 | 500 | 500 | 500 |
| c) User fees | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 |
| 3) Materials and supplies | 1,200 | 1,200 | 1,200 | 1,200 | 1,200 |
| 4) Travel | | | | | |
| a) Conferences | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 |
| b) Field work | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 |
| c) Collaboration/consultation | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 |
| 5) Dissemination costs | | | | | |
| a) Publication costs | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 |
| b) | 0 | 0 | 0 | 0 | 0 |
| 6) Other (specify) | | | | | |
| a) | 0 | 0 | 0 | 0 | 0 |
| b) | 0 | 0 | 0 | 0 | 0 |
| **TOTAL PROPOSED EXPENDITURES** | 74,100 | 74,100 | 74,100 | 74,100 | 74,100 |
| **Total cash contribution from industry (if applicable)** | | | | | |
| **Total cash contribution from university (if applicable)** | | | | | |
| **Total cash contribution from other sources (if applicable)** | 0 | 0 | 0 | 0 | 0 |
| **TOTAL AMOUNT REQUESTED FROM NSERC (transfer to page 1)** | 74,100 | 74,100 | 74,100 | 74,100 | 74,100 |

**Budget Justification**

The budget on the previous page has the following components.

**Salaries**

The bulk of the funds requested in this application are for personnel. Funding requested for student stipends is the full-time equivalent of NSERC support for two master's and one doctoral student per year. Usually students are supported from more than one source, depending on their research. This represents about 40% of the total annual costs for 5-6 graduate students and 1-2 undergraduate students per year, which is the average I expect to have over the five years.

A Discovery grant is rarely substantial enough to fully fund a postdoctoral fellow. The requested funds will provide partial support for a shared postdoctoral fellow, with additional support coming from other grants that I hold, grants held by a co-supervisor, or funding obtained by the postdoctoral fellow (NSERC PDF or other sources). I hope to have one postdoctoral fellow working with me at all times, typically co-supervised by one or two other faculty working on collaborative projects.

A similar situation exists for research technicians. They are essential for large research projects, but cannot be supported solely by a Discovery grant. Again, I expect to pay part of the salary for a shared technician who supports a larger set of researchers and their students.

**Equipment**

Most equipment used in my research is either commodity computing (laptops or off-the-shelf input devices) or is specialized equipment obtained through NSERC RTI grants, CFI, or similar sources.

Purchase of the equivalent of one laptop computer or a small number of input devices is anticipated each year, mostly for use by students.

Operation and maintenance costs cover repairs and servicing of existing and future equipment.

User fees pay for centralized printing, file storage, and other direct costs of research provided through the departmental infrastructure.

**Materials and Supplies**

Cables, adapters, connectors, and other small components are often required, and from time to time physical support structures (made of wood or shelving components) are necessary to conduct experiments mimicking workplace settings, or to provide experimental control of stimuli. One example is a set of wooden supports suspended from the Unistrut grid in the ceilings of our lab. The supports were used to mount Polhemus Latus sensors for a VR experiment – wood was required because the Polhemus senses a magnetic field, so the metal Unistrut could not be used directly, hence the need for a custom solution built by one of my graduate students.

**Travel**

Conferences where my students and I present papers include the annual ACM CHI, UIST, and CSCW conferences, and the Canadian Graphics Interface conference. UIST (User Interface Software & Technology) is a primary venue for research on new interaction techniques and devices; CSCW (Computer-Supported Cooperative Work) focuses on various aspects of collaboration; and CHI (Computer-Human Interaction) is the premiere international HCI conference. Graphics Interface, sponsored by the Canadian Human-Computer Communications Society, is the longest running conference in the area of computer graphics and interaction. It provides excellent opportunities for students to present their work and meet with their peers from other Canadian research labs as well as other international attendees.

I endeavor to provide at least partial support for each supervised graduate student to attend one conference each year, and additional

conferences if they are presenting a paper or attending a workshop or doctoral symposium.

The cost of conference travel for students is reduced when students are student volunteers (most of my students apply for this and many are selected), or when university travel grants are available if students present their own work. This still totals about $1000 per student per year. The funds requested in this application will only pay a portion of the total travel costs. I expect other grants to cover the costs for conference travel related to research funded under those grants.

Postdoctoral fellows also require travel funds for conferences, and to enable them to serve on program committees (postdoctoral fellows supervised by me have served multiple times as poster or demo chairs for various conferences, and in some case have been on paper selection committees). Again, the funds requested in this application pay only a portion of these travel costs.

**Dissemination costs**

Dissemination of results is largely in digital formats, with most conference and journal papers submitted electronically as PDF files. These have little or no incremental cost. Printing and laminating for posters, and occasional shipping costs for equipment used in demos at conferences, are the only significant dissemination expenses. To illustrate new interaction techniques, videos are often produced. Students usually shoot and edit these using in-house facilities, sometimes incurring modest user fees. Distribution is often via YouTube, which is free. The funds requested in this category are therefore modest.

**Research Support**

As I approach my final five years as a full-time research faculty member (I plan to start phased retirement in 2015), I have one continuing funded project and three grant applications that are under review (this Discovery grant application being one of them). The other three grants have the following relationships to the research proposed in this application.

**NSERC Strategic Project grant: ARTIFACT**

A four-year strategic project grant led by Dr. Sheryl Staub-French (Civil Engineering, UBC) with co-investigators Dr. Rachel Pottinger (Computer Science, UBC), Dr. Melanie Tory (Computer Science, UVic), and me is examining a variety of ways that advances in information and communication technology (ICT) can be used to improve construction technology. The grant will have a six-month overlap with the five-year research proposed in this application.

My role in ARTIFACT is largely focused on collaboration technology, and (with Dr. Tory) visualization techniques appropriate for various stages of construction planning and management. Some of this is an outgrowth of a recently completed five-year NSERC strategic network (NECTAR); technology initially developed under funding from NECTAR has been adapted and deployed for use in construction planning and management activities. There has been, and continues to be, a synergistic interplay between the project-specific applied research in ARTIFACT and the more basic research supported by my NSERC Discovery grant.

**NSERC RTI grant: Video processor**

I have submitted an application, with co-applications Dr. Sidney Fels (Electrical and Computer Engineering, UBC) and Dr. Martin McKeown (Medicine, UBC), for funding to upgrade two large wall-sized displays. The existing 4x3 arrays of projectors are currently driven by a now-obsolete cluster of PCs. The cluster runs custom Linux-based software with a proprietary high-speed connection between processors to support multiple displays. This was "state of the art" when it was purchased in 2004. Today, off-the-shelf commodity PCs can produce adequate graphics for twelve projectors. The video processors will provide a dual-DVI interface, compatible with Windows, MacO/S, and Linux (so we are not bound to a single platform). It will also provide smooth blending between the various projectors, eliminating some of the artifacts inherent in a display comprising a mosaic of 12 projectors.

This equipment will support a lot of the research proposed in this application that focuses on large wall-sized displays. It will be shared with the two co-applicants and their students, as well as with other colleagues with whom we collaborate.

**NCE: GRAND**

I am the scientific director for a proposed new NCE on New Media, Animation and Games. This responds to the targeted call for letters of intent by the NCE Program on December 1, 2008. Our letter of intent was accepted on May 7, a full proposal was submitted August 11, and a "site visit" was held in Ottawa on August 24. Announcements of funding will be made in late October or early November, 2009.There are 50 network investigators spanning nineteen universities who participated in the application.

If the new NCE is funded, 75% of my time will be spent as the scientific director and as a researcher in GRAND. I will have a reduced teaching and administrative load in my department to accommodate this. I expect to receive approximately $60,000 per year for research I conduct as a network investigator in GRAND. This is approximately the same amount I received each year over the five years that NECTAR (the NSERC strategic network) was funded. The NCE Program is very clear in specifying that is does ***not*** fund the full costs of research. Network investigators are expected to have other sources of funding, such as Discovery grants, which the NCE Program

leverages through its incremental funding. This is definitely true in my case. Roughly half of the funding for my students, and a portion of the funding for a postdoctoral fellow, is expected to come from this NCE funding, if it is awarded.

The research related to large wall-sized and tabletop displays proposed in this application for an NSERC Discovery grant will be significantly enhanced by complementary multi-university research conducted as part of a project on shared displays that will be funded through GRAND. I expect that some research currently funded under the ARTIFACT strategic grant will continue under GRAND as well.

In addition to the research on shared displays, as scientific director I will be involved in two projects within GRAND that examine how web-based collaboration technology and social networking software can be utilized to increase the effectiveness of the NCE by supporting cross-university and multi-disciplinary engagement in the research. These are outgrowths of my existing research interests, but are largely disjoint from the research proposed in this application, except for some potential application of the ideas under development that relate to structured annotations for co-authored documents.

**Note:** Throughout the application, citations in **[brackets]** refer to entries in the list of references; those in **{braces}** refer to entries in the Personal Data Form 100.

**Objectives of the research program**

The long-term goal of my research program is to gain a better understanding of how to design and implement interactive systems to support particular workflows. Initially my focus was on single-user tasks, such as document preparation, scientific visualization, or entertainment and learning. Over the past decade, the focus has shifted to collaborative versions of these tasks where multiple users, each with different expertise and playing different roles, interact with each other through and supported by technology. This has included both ***same-time*** and ***different-time*** (synchronous and asynchronous) as well as ***same-place*** and ***different-place*** (collocated and distributed) scenarios, but most of my recent work is on synchronous, collocated interaction using large displays (wall-sized and tabletop).

There are four main threads in my current research that at times intertwine, but also represent important contributions on their own. These are: (1) tools to support collaboration using large shared displays, (2) deployment of virtual and augmented reality techniques to support richer interfaces to information, (3) authoring and presentation tools to take advantage of digital media technology, and (4) exploring the increasing importance of multimodal interfaces, especially involving touch.

**Progress in research**

My research over the past five years has largely focused on collaboration technology: the design and evaluation of interactive systems to support tasks undertaken by groups of people. This is the subset of ***human-computer interaction*** (HCI) referred to as ***computer-supported cooperative work*** (CSCW). Much of my work has been exploring affordances of shared displays in both collocated and distributed environments through new interaction techniques for large wall-sized displays and, more recently, investigations of multi-touch tabletop displays. My expertise lies largely in the domain of interaction techniques. It builds on past work in computer graphics and analysis of algorithms.

By far the largest effort over the past five years has gone into research on ***shared displays*** for face-to-face (collocated) activity in meeting rooms and classrooms. This began when my students and I developed ***Mighty Mouse*** **[1]**, a system to allow multiple users to control each other's desktops (or laptops) while viewing them on shared projection displays. This was further developed through a series of master's theses and doctoral dissertations that have addressed issues such as: (1) what information is to be shared? (2) how might information be better presented to those who are not the owners? and (3) who gets to control which information is seen and why does it matter?

Other approaches to screen sharing, such as the Stanford iRoom **[9]** and tools like VNC **[12],** have an all-or-nothing approach to sharing – if information on a laptop has sensitive information, don't share the screen view; otherwise, let everyone see the entire screen. There are many situations where this does not work, such as when some information on the screen is highly sensitive but not necessary for the current task, while other information is not sensitive but is necessary for the task. This and other considerations led to the idea of ***role-based viewing***, which tailors the display of shared desktops to the needs of the viewer.

In role-based viewing **{12}** the owner of the information sees everything on his/her laptop, but the view seen by others on the shared screen is altered to either hide sensitive information or to augment salient information that might otherwise be hard to understand. An important realization that arose from this work was that the shared secondary display serves a different

purpose than the primary display. Understanding the needs of other viewers, such as being able to see what operations are performed on a spreadsheet, is important. Ordinarily only the owner is looking, so Excel (for example) is optimized to make menu and command selections quick and visually non-intrusive. This means that someone who is watching those actions be performed by the owner finds it difficult to understand what operation is being performed and on what data. MSc student Berry's solution was to change both the temporal and spatial characteristics of operations to provide a better fit between the displayed information and the role each human viewer plays **{12, 30, 33}**.

Building on these two projects and motivated by a belief that large displays provide a qualitatively different experience from desktop or single projector displays, we looked at current limitations of laptops' ability to drive multiple external displays **{28}**. My research team developed a second-generation version of Mighty Mouse called ***Lacome*** (large collaborative meeting environment) that uses standard tools such as VNC to support sharing of multiple desktops on a large wall-sized display **{26}**. This solves a number of problems related to privacy and security, and provides a robust platform-independent mechanism for screen. Two other components were investigated in parallel with this: interaction techniques for large displays where users use body gestures as the primary input technique, PhD student Shoemaker's ***shadow reaching*** **{2, 6, 35, 36}**, and an extensive investigation by PhD student Lanir of how very large displays can be deployed in the classroom with an initial emphasis on tools for instructors, called ***MultiPresenter*** **{3-5, 29, 37}**.

My research on authoring tools continues a longer-term interest in document preparation dating back to the 1970s when I helped develop a then state-of-the-art system that integrated text, diagrams, and equations **[3]**. My most recent work looked at the problem of co-authoring, with a focus on the tight review-revise-redistribute cycle in which multiple co-authors engage during the final phase of developing a document (such as a conference paper during the last two weeks before the submission deadline). The notion of "structured annotations" was introduced to simplify suggestions and changes in a document to make the review and revise tasks easier by grouping annotations in a semantically meaningful way that echoed the workflows of both the annotator and the reviewer-reviser **{11, 32}**.

Work on virtual and augmented reality tools **{9}** to support collocated and distributed collaboration, and the use of haptics and other modalities also continue long-term research interests, this time with the goal of enhancing user experience in collaborative settings, not just single-user settings. A just-completed master's thesis by Maksakov **{27}** examined how two users could share a large wall-sized touch screen, each seeing appropriate head-coupled views of a 3D scene that would "blend" to a common view when the users were viewing the same portion of the screen. A laboratory experiment indicated that separate head-coupled views did not adversely affect one user's ability to monitor peripheral activity by another user.

Haptics research co-supervised with Dr. Karon MacLean **{1, 8, 10}** examined the affective nature of touch, both for input and as feedback. I expect to incorporate this into future work on multi-touch tabletops when the appropriate technology exists. (Our studies used specialized equipment developed for laboratory use.)

My research on wall displays has three primary targets: ***meeting rooms*** (work), ***classrooms*** (education), and ***rec rooms*** (entertainment). The Lacome research **{26}** addresses work, MultiPresenter **{3-5, 29, 37}** addresses education, and two research projects funded by Panasonic addressed entertainment by looking at use of large screen displays by families in their homes. The focus in the next few years will be on meeting rooms and classrooms.

**Literature pertinent to the proposal**

There is a rich literature on collaboration technology, especially on large shared displays, dating back almost two decades **[6, 14]**. Winograd's group at Stanford developed the iRoom that included a number of tools to support face-to-face collaboration on both wall and tabletop displays using a combination of built-in computer infrastructure and ad hoc connections to personal laptops and hand-held devices **[9, 10, 13]**. Key issues include understanding the ***social conventions*** and expectations of shared displays **[5, 17]**, how to interact with parts of a large screen that cannot be easily reached through either hand or mouse movement **[2, 4, 16]**, and how to integrate ***personal hand-held displays*** into these environments **[11]**. Han's recent introduction of ***frustrated total internal reflection*** (FTIR) to enable vision-based sensing for multi-touch surfaces **[8]** led to a flurry of research that is just in its infancy.

**Methods and proposed approach**

Good research in HCI requires that a variety of quantitative and qualitative methodologies be used. CSCW especially requires this because of the complex social dynamics often involved **[7]**. Most of my research starts with observations of existing work practices: interviews, field studies, and formative laboratory experiments to establish baseline performance and identify areas of concern. This is followed by an iterative design cycle, often using a participatory design approach (clients are part of the team rather than being simply objects of study). One or more prototypes are then developed, and each is evaluated through a range of informal to formal techniques including deployments in the field, controlled laboratory experiments, and – in a few cases – longitudinal studies. Most projects are done over a number of years, with different graduate students involved in the various steps.

For the next five years I have identified specific projects in the four areas identified above: (1) collaboration using large shared displays, (2) richer interfaces using virtual and augmented reality, (3) authoring and presentation tools, and (4) multimodal interfaces, especially multi-touch interfaces.

My students and I are continuing to work on Lacome and MultiPresenter, with the goal of integrating features from both into systems that fully support group workflow in meeting rooms and classrooms. MSc student Russell MacKenzie has substantially re-designed the architecture for Lacome to fully utilize the cross-platform advantages of Java, and the multiple implementations of VNC **[1]** that exist, each with its own platform-specific benefits. These features will be deployed in MultiPresenter so that instructors can allow students in a classroom to post material on the screen using simple copy-and-paste metaphors or by selecting a portion of their laptop screens, and to navigate through slides and other material on the screen when asking questions.

Research questions to be addressed include privacy and security issues (an extension of the techniques developed earlier by MSc student Berry), turn-taking (the literature suggests different approaches, some student-centric, others instructor-centric, including give-and-take protocols reminiscent of earlier work I did with Inkpen et al. (1997)), and how pointing and selection actions can be displayed in a manner that engages all students, not just the student or instructor who is controlling the screen. Over the next three years we will look at how these tools can be integrated into current classroom environments, and perhaps made interoperable with student response systems such as the ***iClicker*** devices now in use at UBC. We will explore how to use these devices to capture student's interactions with the lecturer's material, expanding on techniques introduced in Abowd et al.'s Classroom 2000 system **[15]**.

A very important on-going question is whether using more screen real estate, and the techniques developed by PhD student Lanir for

MultiPresenter, actually lead to better learning outcomes for students. A preliminary study conducted as part of his dissertation research supports evidence in the pedagogical literature that this is the case **{37}**. But more studies are required. These will be pursued in collaboration with colleagues who specialize in assessing educational technology.

A body-centred model for interaction with large screens, especially effective when working at a distance, will continue the shadow reaching work by PhD student Shoemaker. This will employ techniques from virtual and augmented reality to develop "device-less" interaction techniques for use in meeting rooms and classrooms. We will also explore how text input can be accomplished in these situations: there are currently no satisfactory solutions other than specialized gesture-based systems that require substantial learning on the part of users.

MSc student Fernquist is investigating another aspect of body-centred models to determine how knowledge of users' locations around a tabletop display can be used to disambiguate multi-touch input and to tailor the display of information (this continues previous work with MSc student Hancock **{20}**).

**Anticipated significance of the work**

All of my research is reported in the peer reviewed literature, usually appearing first as conference papers – these are the normal venues for fast-breaking research in computer science – and later, in more polished form, as capstone journal articles that often synthesize a number of related projects previously reported at conferences.

My work on collaboration technology has both theoretical and practical importance. A beta version of the MultiPresenter software has been available for download for over a year, with more than a dozen users at UBC (we don't track downloads elsewhere). The Lacome software will be released in Beta form after adequate documentation is prepared. The MultiPresenter software had significant use within classrooms as part of the research for Lanir's dissertation. If it can be integrated into other classroom technology, such as "clickers," I expect this could have a very strong impact on future classroom teaching by providing a middle ground between blackboard-based lectures and PowerPoint-based presentations, both of which have well known limitations.

Much of my research is conducted with industry partners: NECTAR, ARTIFACT, and GRAND all have significant ties with industry that serve to move results from my research to practical application through students who are subsequently employed, or through various types of technology transfer. Research I conduct under Discovery grant funding often is the first step in a chain that leads to these partnerships.

**Training of highly qualified personnel**

The highly interdisciplinary nature of my research provides opportunities for my students to engage in activities that bridge between computer science and other disciplines. Over the past six years collaborations have included research projects with business, civil engineering, education, electrical and computer engineering, fisheries, kinesiology, landscape architecture, medicine, and psychology. In some cases projects are initiated by colleagues in other disciplines, providing an opportunity for computer science students to learn about important problems such as understanding climate change or the many factors influencing fishing policies. In other cases the collaborations arise because the research requires knowledge or skills from other disciplines, such as understanding human hand movement as it pertains to interactions at a distance or pedagogical theories and findings related to classroom presentations and teaching styles.

Students and other trainees are involved in all aspects of my research program. Undergraduate students are engaged as full-time summer interns, usually with the aid of NSERC USRA

funding, and through course projects and directed studies courses. Many of the undergraduates who work in my lab assist with on-going research as part of their Honours thesis or for course credit in COGS 402, a fourth-year course in UBC's Cognitive Systems program in which students are embedded in a research lab. In most cases the undergraduates are paired with graduate students who serve as mentors. This serves a dual purpose: it provides a richer experience for the undergraduates and it develops critical team leadership skills for the graduate students as well as assisting them with their primary research tasks.

A similar system of mentoring exists between PhD students and master's students, and with postdoctoral fellows. A significant change in my research over the past decade has been the inclusion of postdocs in my research team. This has had a very positive impact on my productivity. It has been enabled by two factors: I have been fortunate to have enough funding to partially support postdocs co-supervised with other researchers, and postdoc positions are increasingly part of the normal academic career path for computer scientists, something that was not true a decade ago. During the past six years I have had three postdocs, each of whom played a significant role in supervising graduate and undergraduate students. One now leads a user experience group for a major bank, one is a faculty member in computer science at a Canadian university, and one is just completing a postdoc with me that is co-supervised with a colleague in electrical and computer engineering; she has applied for a research position with a Canadian federal laboratory.

All of my students participate in a weekly research seminar, the Interaction Design Research Group (IDRG). The focus is on reading and discussing relevant papers from the HCI literature over a broad spectrum of topics, not just those directly related to my research program. IDRG is also used as a venue to rehearse conference presentations and to gain feedback on work that is being submitted for publication. A few times each year we invite HCI-related researchers from other departments to present overviews of their research to gain an appreciation for methodologies and research approaches in other disciplines. I co-lead IDRG with my colleague, Dr. Joanna McGrenere, with participation from three to five other faculty researchers and their students, depending on the topics under discussion. This gives students an opportunity to develop critical analysis skills and gain experience presenting and critiquing their own work and that of others.

In addition to experience working in multidisciplinary teams and learning about the research literature, most of my students attend international conferences to gain insights and inspiration from leading researchers in the field of HCI. This also provides an opportunity to exchange ideas with students from other universities and other countries. Subject to available funding, I encourage each of my graduate students to attend one research conference every year. Often they serve as student volunteers, which enriches the experience for them and also provides reduced or waived registration fees and sometimes subsidies for meals and accommodations. Many of my doctoral students participate in doctoral symposia and workshops associated with conferences, which provides further, more focused opportunities for them to seek advice from top researchers in their particular areas of interest. Travel is increasingly costly. Leveraging university travel funding for graduate students who present their work at conferences, student volunteer subsidies from conferences, and opportunities to participate in research consortia meetings such as for the NECTAR strategic network over the past five years and for the proposed GRAND NCE over the next five years makes it possible to provide these opportunities for students. The payback from this investment can be seen in a higher success rate for student publications and students' development of their own peer network within their fields of interest.

**Note:** Throughout the application, citations in **[brackets]** refer to entries in this list of references; those in **{braces}** refer to entries in the Personal Data Form 100.


1. BOOTH, K. S., FISHER, B. D., LIN, C. J., AND ARGUE, R. (2002). The "Mighty Mouse" multi-screen collaboration tool. In *Proc. UIST '02*, 209-212.
2. BAUDISCH, P., CUTRELL, E., ROBBINS, D., CZERWINSKI, M., TANDLER, P. BEDERSON, B., AND ZIERLINGER, A. (2003). Drag-and-Pop and Drag-and-Pick: Techniques for accessing remote screen content on touch and pen-operated systems. In *Proc Interact'03*, pp. 57-64.
3. BEATTY, J. C., CHIN, J. S., AND MOLL, H. F. (1979). An interactive documentation system. In *Proc. SIGGRAPH '79*, pp. 71-82.
4. COLLOMB, M., HASCOËT, M., BAUDISCH, P., AND LEE, B. (2005). Improving drag-and-drop on wall-size displays. In *Proc. Graphics Interface 2005*, pp. 25-32.
5. CRABTREE, A., HEMMINGS, T., AND RODDEN, T. (2003). Social construction of displays, *Public and Situated Displays: Social and Interactional Aspects of Shared Display Technologies* (eds. O'HARA, K. ET AL.), Dordrecht: Kluwer Academic Publishers, pp. 170-190.
6. ELROD, S., BRUCE, R., GOLD, R., GOLDBERG, D., HALASZ, F., JANSSEN, W., LEE, D., MCCALL, K., PEDERSEN, E., PIER, K., TANG, J., AND WELCH, B. (1992). Liveboard: a large interactive display supporting group meetings, presentations, and remote collaboration. In *Proc. SIGCHI* '92. ACM, New York, NY, pp. 599-607.
7. GRUDIN, J. (1994). Groupware and social dynamics: eight challenges for developers. *CACM 37*, 1 (Jan. 1994), pp. 92-105.
8. HAN, J. Y. (2005). Low-cost multi-touch sensing through frustrated total internal reflection. In *Proc. UIST 2005,* pp. 115-118.
9. JOHANSON, B., FOX, A., AND WINOGRAD, T. (2002). The Interactive Workspaces Project: Experiences with Ubiquitous Computing Rooms. *IEEE Pervasive Computing* 1, 2 (Apr. 2002), pp. 67-74.
10. MORRIS, M. R., CASSANEGO, A., PAEPCKE, A., WINOGRAD, T., PIPER, A. M., AND HUANG, A. (2006). Mediating Group Dynamics through Tabletop Interface Design. *IEEE Comput. Graph. Appl.* 26, 5 (Sep. 2006), pp. 65-73.
11. MYERS, B. A., STIEL, H., AND GARGIULO, R. (1998). Collaboration using multiple PDAs connected to a PC. In *Proc. CSCW '98*, pp. 285-294.
12. RICHARDSON, T., STAFFORD-FRASER, Q., WOOD, K. R., AND HOPPER, A. (1998). Virtual Network Computing. *IEEE Internet Computing* 2, 1 (Jan. 1998), pp. 33-38.
13. RUSSELL, D. M., STREITZ, N. A., AND WINOGRAD, T. (2005). Building disappearing computers. *CACM* 48, 3 (Mar. 2005), pp. 42-48.
14. STEFIK, M., FOSTER, G., BOBROW, D. G., KAHN, K., LANNING, S., AND SUCHMAN, L. (1987). Beyond the chalkboard: computer support for collaboration and problem solving in meetings. *CACM 30*, 1 (Jan. 1987), pp. 32-47.
15. TRUONG, K. N., ABOWD, G. D., AND BROTHERTON, J. A. (1999). Personalizing the capture of public experiences. In *Proc. UIST '99*, pp. 121-130.
16. VOGEL, D. AND BALAKRISHNAN, R. (2005). Distant freehand pointing and clicking on very large, high resolution displays. In *Proc. UIST '05*, pp. 33-42.
17. XIAO, Y., LASOME, C., MOSS, J., MACKENZIE, C. F., AND FARAJ, S. (2001). Cognitive properties of a whiteboard: a case study in a trauma centre. In *Proc. Seventh Conference on European Conference on Computer Supported Cooperative Work*, pp. 259-278.

**SEND ONE ORIGINAL ONLY DO NOT PHOTOCOPY**

# APPENDIX A (Form 101)
## Environmental Impact



Complete this Appendix if you have checked the "YES" box under Certification/Requirements on page 1, Form 101. Include activities that will take place in Canada **and/or abroad.** This information will assist NSERC in determining whether a screening is required under the *Canadian Environmental Assessment Act.* (See the "Requirements for Certain Types of Research" in the NSERC *Program Guide for Professors*.)

| Family name of applicant | Given name | Initial(s) of all given names | Personal identification no. (PIN) |
|---|---|---|---|
| Booth | Kellogg | KS | **Valid** 10455 |

Name of applicant's organization
British Columbia

Title of proposal
Collaboration technology and multi-user interfaces

Name of other participating organizations (if applicable)
(none)

**Name of Location (Please complete an additional copy of Appendix A for EACH location at which research will be undertaken.)**
The University of British Columbia

1. Main characteristics of the location (i.e., physical description & coordinates)

Some of the research will take place in classrooms and meeting rooms that are not formal research laboratories or offices.

***Continue on page 3 of this Form (if necessary).***

NOTE: There is a potential to generate several Appendices A. **Please ensure that all Appendix A pages are numbered consecutively in the space provided in the upper right corner of the form. IF YOU FORESEE THE NEED FOR MORE THAN 3 (THREE) APPENDICES A, PLEASE CONTACT NSERC'S ENVIRONMENTAL ASSESSMENT UNIT BY TELEPHONE AT (613) 992-3612 OR (613) 995-8079, OR BY E-MAIL AT enviro.assess@nserc-crsng.gc.ca.**



The information contained in this form will be used by NSERC to determine any potential environmental effects.
(See the "Requirements for Certain Types of Research" in the NSERC *Program Guide for Professors*.)



Canada

**PROTECTED WHEN COMPLETED**

| Personal identification no. (PIN) | Family name of applicant | **Page 2 of 2** (Total Appendix A *only* ) |
|---|---|---|
| 10455 | Booth | |

## APPENDIX A (Form 101) CONTINUED

2. Principal activity(ies) and activity component(s).

Informal testing and formal field studies (deployments) of technology developed in the research will be conducted in classrooms and meeting rooms at The University of British Columbia.

***Continue on page 3 of this Form (if necessary).***

3. For each principal activity and activity component, list the environmental elements affected and provide a description of those effects.

No environmental elements will be affected beyond what would occur for research conducted in a laboratory or office setting.

***Continue on page 3 of this Form (if necessary).***

4. Mitigation measures.

No special mitigating measures will be required.

***Continue on page 3 of this Form (if necessary).***

Natural Sciences and Engineering Research Council of Canada | Conseil de recherches en sciences naturelles et en génie du Canada

**SEND ONE ORIGINAL ONLY DO NOT PHOTOCOPY**

# APPENDIX B (Form 101)
## *Canadian Environmental Assessment Act*
## Pre-Screening Checklist

Complete this Appendix if you have checked the "YES" box under Certification/Requirements on page 1, Form 101. Include activities that will take place in Canada **and/or abroad.** This information will assist NSERC in determining whether a screening is required under the *Canadian Environmental Assessment Act.* (See the "Requirements for Certain Types of Research" in the NSERC *Program Guide for Professors.* )

| Family name of applicant | Given name | Initial(s) of all given names | Personal identification no. (PIN) |
|---|---|---|---|
| Booth | Kellogg | KS | **Valid** 10455 |

Name of applicant's organization: British Columbia

**Applicants are responsible for verifying whether permits are required for any of the activities listed below. Please indicate yes (Y), no (N) or unknown (U) by checking the appropriate box for EACH of the listed activities.**

| Y | N | U | DESCRIPTION OF ACTIVITY |
|---|---|---|---|
| | | | **Part 1. - Determination of Physical Work under the CEAA** |
| | X | | Does any phase of the proposal involve the **construction, operation, modification, decommissioning, abandonment or other activity** in relation to a built structure that has a fixed location and is not intended to be moved frequently? |
| | | | **Part 2. - Determination of Assessable Activities under the CEAA** |
| | X | | Activity takes place in a National Park or National Nature Reserve in Canada |
| | X | | Activity takes place on First Nation lands |
| | X | | Activity takes place in the North (Yukon, Nunavut, or the Northwest Territories) |
| | X | | Activity takes place in or within 30 metres of the right-of-way of a power line, a natural gas line, or a railway line |
| | X | | Activity takes place in or adjacent to a water body, resulting in harmful alteration, disruption or destruction of fish habitat (including the removal or damaging of aquatic vegetation) |
| | X | | Destruction of fish other than by fishing |
| | X | | Sampling or prospecting for ores or minerals |
| | X | | Disposal of a prescribed nuclear substance other than in a laboratory equipped for such disposal |
| | X | | Deposit of a deleterious or other substance into the environment (in the earth, air, or water) |
| | X | | Any kind of remediation of contaminated land |
| | X | | Deposit of oil, oil wastes or any other substances harmful to migratory birds in waters or in areas frequented by migratory birds |
| | X | | Killing or removal of migratory birds, their nests, eggs, or carcasses or other physical activities that may require a permit or other authorisation under the *Migratory Birds Regulations* or *Migratory Bird Sanctuary Regulations* |
| | X | | The removal or damaging of vegetation and/or the carrying on of agricultural activities or the disturbance or removal of soil in a wildlife area that requires a permit under section 4 of the *Wildlife Area Regulations* under the *Canada Wildlife Act* |
| | X | | Physical activities that are carried on in Canada and that are intended to threaten the continued existence of a biological population in an ecodistrict, either directly or through the alteration of its habitat |
| | X | | Establishment or operation of a field camp in a single location that will be used for 200 person-days or more within a calendar year |
| | X | | Seismic surveying involving more than 50 kg of chemical explosive in a single blast; or marine or freshwater seismic surveying, if during the survey the air pressure measured at a distance of one metre from the source would be greater than 275.79 kPa (40 lbs/sq in) |



**PROTECTED WHEN COMPLETED**

Version française disponible

Canada

**SEND ONE ORIGINAL ONLY DO NOT PHOTOCOPY**

| Personal identification no. (PIN) | Family name of applicant |
|---|---|
| **Valid** 10455 | Booth |

**APPENDIX B (Form 101) continued**

Are any authorizations, permits, or licences required to undertake any activity for any phase of the proposal? If **yes**, list them below, along with the name of the issuing agency(ies). If **no**, please state "None required" and submit this page with the rest of your proposal.

Behavioural Research Ethics Board approval for research involving human subjects



**PROTECTED WHEN COMPLETED**



Canada