**Strategic Project Grants Progress Report**

**Due Date: June 30, 2013**

**Covers the Period: September 30, 2011 to June 30, 2013**

**Is your personal information below correct? (please enter an “x” in the appropriate box)**

|  |  |
| --- | --- |
|  | **Yes** |
|  | **No** (please make the necessary corrections) |

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**Is the project information below correct?**

|  |  |
| --- | --- |
|  | **Yes** |
|  | **No** (please make the necessary corrections) |

**Project title:** Collaborative Access to Information about Physical Objects via See-Through Displays

**File Number:** STPGP 413142 - 11

**Co-investigator(s):**

**Collaborator(s):**

**Supporting Organization(s):**

M.M. Dahan, IMRIS Inc.

S.B. Borys, Winnipeg Art Gallery

C.M. Mazur, St. Vital Centre

W.K. Kwong, C3A Inc.

**1. Progress Towards Objectives/Milestones**

Using approximately 5 pages, please provide in the box below:

* a brief description of the overall objectives of the research project as awarded;
* the list of milestones as presented in the application and a description of the progress made towards each milestone/objective during the period covered by this report; and
* a description and justification for any deviations from the original objectives and a discussion of the path forward.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Objectives:   * Understanding users’ tasks   + Observational studies   To study the way users currently interact with exhibited objects and their information we followed a two-step process: first, we analysed the way information is currently organized in physical and online exhibition environments. Second, we reviewed the existing literature on musuem visitors and users of digital public displays.  In order to understand the form of information displays for showedcased artifacts, the research team conducted an observational study of various musuems and gelleries in the city of Winnipeg. The study consisted in documenting the ways information is attached to exhibited artefacts ranging from labels and posters to interactive displays (see Figure 1). We visited galleries, collected photographs, and interviewed museum personnel. We coded the photographs and transcripst, and generated cetegories to describe different aspects of an information display. We further extended our analysis of information displays to online galleries, where we extended and refined the previous categories. Seven design dimensions emerged from our analysis: content, supportive content, supportive activity, spatial layout, metadata, label type and display type. These dimensions suggest the content, placement and role the information label plays in the exhibition. For example, a *poster* might suggest longer engament where users are expected to read the details. On the other hand, a carefully-located small legend could highlight a particular part of the exhibited object. The deisgn of a digital replacement to physical labels (as the one we envision with transparent displays) could be guided by the same dimensions.   |  |  |  | | --- | --- | --- | | E:\Projects\STim\Docs\Pictures\Manitoba Museum\IMG_0944.JPG (label) | E:\Projects\STim\Docs\Pictures\Manitoba Museum\IMG_0930.JPG  (posters) | E:\Projects\STim\Docs\Pictures\Manitoba Museum\IMG_0943.JPG  (digital poster) |   Figure : Exemplary information displays for exhibited artefacts.  In the second part, we looked at the existing studies of user interactions in musem and gallery settings and with/around public displays. Our goal was to shed light on the social aspects of technology interaction in such spaces and current state of the art. Based on an extensive review and classification of scientific publications we summarized existing research into conceptual maps as show in Figure 2 and Figure 3. The analysis of existing research highlights the goals and challenges to be addressed when digitally enhancing an exhibit. For example, “user tasks” in relation to a museum visit are understood in three phases: before, during and after the visit. Moreover, there are clear differences in designing technologies for individual visitors or groups. The behaviour of individual visitors can be modelled in terms of user models which can be predined or created real-time. On the other hand, groups of visitors can better benefit from technologies that foster communcation and collaboration.    Figure : Fragment of a conceptual map on technologies for and user interactions in museum environments.    Figure : Fragment of a conceptual map on user interactions with public displays.   * + Classification of interactions   Visitors to a museum or art gallery exhibition, when observed in a long term perspective, follow certain patterns which are influenced by the physical settings, the artwork, the purpose of the visit, among others. Understanding this visit patterns is important in order to better taylor technology development and cover a broad base of potential users. A traditional approach has been to define standard patterns which can be generalized to multiple settings. For example, Falk’s Identity-related Museum Visit Experience Model classifies visitors as:   * *Explorer:* One who visits out of general interest. * *Attraction Seeker:* Generally a tourist, visiting after the museum masterpieces. * *Professional/Hobbyist:* One who is interested in particular topics the museu offers. * *Recharger*: One who visits in order to reflect, rejuvante, and relax. * *Facilitator*: One who visits in order to bring others to the exhibits.   Designing technologies for the *explorer* (quick visits aimed at getting a general understanding of the museum) differs from the design to support the *professional* (extended visits focused on particular items/collections). A transparent-display for a explorer visitor could provide quick facts about the piece and highlight its most intersting aspects, whereas the same transpparent display when designed for the professional visitor should provide extended information about, e.g., the historical context of the artefact and its relevance within it.  Although useful for a general understanding of visitors, these groups are at such high level that cannot tell us much about the local context of use or individual characteristics of the visitor. When more accurate models of the users are needed, reserchers have turned to building dinamic models of the visitors based on intrinsic characteristics (e.g. age, gender, etc) and externally observable behaviors (e.g. visited items, time spent, walking speed, etc). Similarly to the use of standard visitor patterns, the dinammically built user models support content filtering whe the user arrives at a partcular exhibit.  E:\Projects\STim\Docs\AttentionStateMachine\AttentionStateMachine.png  Figure : State machine for an attention-aware transparent public display  Our approach has been not to design for general visitor patterns, or for dinamically generated user models, but rather to design the transparent-display interactions based on the level of interest shown by the user at each particular exhibit. We understand user interaction with an exhibit as a process where the interactive exhibit tries to 1) capture the visitor’s attention, 2) communicate its interactive nature, 3) provoke users to engage, and 4) preserve the user’s engagement. Figure 4 shows our current implementation of this process as a state machine. The nodes represent actions taken by the system like “flash the highlight to attract user attention to the artefact”. The connections represent actions taken by the visitor. As the user moves nearby the artefact, the system interprets such movement as transition of the state machine.  The central tenet of our approach is the capture of users’ state and estimation of their attention toward the exhibition. The interface (state machine included) is designed to increase the level of attention toward the exhibit, causing visitors to come close and observe it, but also to encourage them to engage with the interactive content. Succeeding in attracting and engaging visitors has the added benefit of attracting others, a phenomenon observed in other public display installations and termed as the “honey-pot effect”.  Finally, researchers have also point to the different nature of group visits, and how the design goals of for interactive technology should shift focus from information access and interactivity, to support collaboration, discussion, and ecollective understanding of the artefact through the technology. We will extend in this aspect in future iterations of the technology.   * Designing the see-through hardware system   + Single-user support   In designing single-user transparent displays for museum visitors we have followed two directions. First, our ongoing work in creating a large-format erxhibition showcase to contain a small sculpture from the Inuit collection at the Winnipeg Art Gallery (see Figure 5).   |  |  |  | | --- | --- | --- | |  |  |  | |  |  |  |   Figure : Transparent-display showcase for thee Winnipeg Art Gallery  This hardware development includes the actual case, illumination, transparent display and touch and depth sensors. The touch sensor alllows visitors to walk up to the display and interact with its content by touching them directly on the display. The depth sensor allows users to interact with the digital contents from a distance by means of mid-air gestures or natural user interactions. The depth sensor also allows the display to track potential visitors (location, orientation, and face direction) and follow them as they move through the nodes and connections of the attention-aware state machine. A second iteration on the hardware, currently ongoing, makes use of half-mirrors for the side and back walls of the showcase. The half mirrors will preserve the light needed for the display inside the showcase, while enabling users to see the sculpture from other angles as they walk around it.  Our second hardware initiative focuses on a hand-held transparent display to support information access (see Figure 6). Our initial work addresses the hardware challenges of such device (transparency, side detection, double-side input, etc), and proposes a series of interaction techniques to support easier information capture and review. For example, a tPad user can place the device on top of an object in order to image capture it. A tPad can support multiple applications running on each side of the device. We envision many applications of tPads, particularly in the museum environment. For example, a tPad could alleviate the tensions between designing single user and collaborative tools, by dedicating one of its sides to each of this purposes.    Figure : Transparent-display mobile devices called tPads.   * + Multi-user support (fixed zones)   [FUTURE WORK]   * + Multi-user support (variable zones)   [FUTURE WORK]   * Multi-user interactions with see-through displays   + Input styles   We have developed novel tools to support interaction in both fixed and mobile transpranrent-display scenarios. The museum showcase platform uses a depth sensor to support mid-air interactions. In order to improve the creation of mid-air interactions in such a way that require low levels of physical effort we proposed and evaluated a current metric for fatigue called Consumed Endurance (CE). Using CE designers can evaluate the mid-air interfaces they create and improve them so they are less physically demanding, meaning they can be used for longer periods of time. This new metric, CE, is not only necessary for gestural intiractions in transparent displays, but also for other situations where mid-air gestures are used.  For the museum showcase we also developed two novel interaction tools: *binocullar highlights* and the *attention estimator*. Binocular highlights are user-interface components that modify their appearance in order to contain physical objects behind the display. This containement is particularly challenging due to a physical phenomenon called eye-parallax. Eye parallax is the miss-match between the eyes location, so that, a pixel on the transparent display proyects to different objects on the background scene. Our binocullar highlights use track the user’s head and dynamically compute the dimensions of the user-control needed to contain the physical object from the perspective of both eyes. The attention estimator is a software component that estimates the user’s level of attention toward the transparent-display showcase. The component tracks users and computes attention as a function of orientation and movement. The attention estimator is the base for *attention-aware user interfaces* as presented before.  For the transparent-display handheld devices, tPads, we developed a series of interaction techniques unique to such devices. These techniques have a general applicability, with particular advantages for an exhibition scenario such as the possibility to have a museum guide on one side, and collaboration tools on the other. We divide the interactions in four categories: overlay, dual input and output, surface capture and model-based interactions. Our evaluation experiments shows that tPad interactions are not only preferable by users, but also outperfom existing mobile interactions in situation such as multitasking and information capture.   * + Display placement   In the museum showcase scenario, an imporntant aspect, is the capabiliby to spatially align display content between the observer and physical objects behind the display. This requires taking the user location and the part of the physical object to annotate both into account, when deciding the location (pixelX, pixelY) of a user-interface component (e.g. label). As users are tracked with a depth sensor, the relation between the sensor, the user and the object has to be computed. In the best scenario, both object and user change location easily but the sensor remain static. In this case there is a fixed relation between the coordinate system in which the depth sensor captures the user location, and that in which content for the display is created. However, for a museum installation it’s necessary to offer flexibility in the location of the depth sensor. To support this we have created a depth sensor calibration process which determines the relation between sensor, user, and display, facilitating display placement and relocation and generalizible to other scenarios. In our process, the user is asked to physically align his dominant eye with special markers on the display and a calibration item located at the center of the showcase. Comparing the measured user locations to the orientation vectors of the expected locations we perform a minimization search in 3D. Our results find the calibrate the sensor measurements locating the origin of the coordinate system within 1cm of its actual location.   * Validation in the lab and public   + Validation of single-user   [FUTURE WORK]   * + Validation of multi-user (fixed zones)   [FUTURE WORK]   * + Validation of multi-user (variable zones)   [FUTURE WORK] |

**2. Research Team**

Please provide an overview of the participation in, and scientific contributions to, the project for each member of the research team (principal investigator, co-investigators, collaborators, company and government scientists, research associates, postdocs, students, etc.).

|  |
| --- |
| Dr. Juan David Hincapié-Ramos (Post-Doctoral Fellow)   * Coordinating the development of hardware and software technologies * Defining the specific objectives leading to reach each of the grant goals. * Coordinating the day-to-day work of master, visiting, and bachelor students. * Literature reviews and analysis of state of the art for all proposed technologies. * Technical architecture for all hardware and software technologies. * Definition of model of fatigue for mir-air interactions in transparent displays. * Experimental design and fatigue-related data analysis for transparent displays. * Definition of the calibration approach for spatial tracking in transparent displays. * Implementation strategy for real-time color correction in transparent displays. * Coordination of collaboration activities with remote collaborators. * Paper writing and scientific dissemination.   Srikanth Kirshnamachari Sridharan (Master Student)   * Profile-based color correction for transparent displays – model, implementation and experiments. * Hardware design and construction for transparent-display exhibition case.   Sophie Roscher (Visiting Master Student)   * Design research for handheld transparent display devices (user-centered design). * Integrating hand-held transparent display devices with paper documents.   Judith Faye Page (Visiting Student)   * Observational study of information display at the Manitoba Museum * Data collection for online galleries (information display)   Xiang Guo (Co-op Student)   * Model of fatigue for mid-air interactions with transparent displays, implementation, and experiment execution. * Three-dimensional spatial calibration for transparent displays. * GUI components (highlights) to handle binocullar parallax in transparent displays. * State of the art of research on the fields of “technological support for museums” and “pervasive public displays”. * Attention metric and attention-aware user-interfaces for transparent display exhibitions.   Paymahn Moghadasian (Co-op Student)   * Experiments for the model of fatiggue of mid-air interactions in transparent displays. * Artificial Inteligence-based approach to hanheld transparent display interactions.   Levko Ivanchuk (Co-op Student)   * Real-time implementations of color correction algorithms. * Model, implementation and experimentation of potential solutions to color-blending in transparent displays. |

**3. Training**

Please list **each** trainee (Undergraduate Students, Master’s Students, Doctoral Students, Postdoctoral Fellows, Research Associates, Technicians …) on a separate line in the table below providing: a) the number of years they have been on the project, b) the percentage (%) of time each type of trainee spent on this project, and c) the percentage (%) of funding from this strategic grant. If a trainee is fully paid from other sources, enter “0” in the “% of funding from this grant” column. Insert additional rows if necessary. (DO NOT INCLUDE PERSONAL NAMES.)

|  |  |  |  |
| --- | --- | --- | --- |
| **Specify type of trainee (e.g. M.Sc., Ph.D. etc)**  **(one trainee per line)** | **(a)**  **Number of calendar years on the project** | **(b)**  **% of research time spent on this project** | **(c)**  **% of salary from this grant** |
| Post-Doc Fellow (JDHR) | 1.5 | 100% | X |
| Master Student (SKS) | 1.5 | 100% | X |
| Visiting Master Student (SR) | 0.5 | 100% | X |
| Visiting Student (JFP) | 0.2 | 100% | X |
| Co-op Student (XG) | 0.8 | 100% | X |
| Co-op Student (PM) | 0.4 | 100% | X |
| Co-op Student (LI) | 0.4 | 100% | X |
|  |  |  |  |

**4. Dissemination of Research Results and Knowledge and/or Technology Transfer**

4.1 Please provide the number of publications, conference presentations, and workshops to date arising from the research project supported by the grant in the table below.

**Publications, Conference Presentations, etc.**

|  |  |
| --- | --- |
|  | None to date |

**- OR -**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Number of publications, presentations…** | | |
| **Status** | **Refereed**  **Journal Articles** | **Conference**  **Presentations/**  **Poster** | **Other (including Technical Reports, Non-Refereed**  **Articles, etc.)** |
| **Accepted/Published** |  | 1 |  |
| **Submitted** |  | 2 |  |

4.2 Please provide the bibliographical reference data for the above publications, conference presentations and workshops under the corresponding headings. For publications, specify whether submitted, accepted or published.

**Refereed Journal Articles:**

|  |
| --- |
|  |

**Conference Presentations/Poster:**

|  |
| --- |
| **[PUBLISHED]**  Sridharan, S.K., Hincapié-Ramos, J.D., Flatla, D.R. and Irani, P. 2013. **Color correction for optical see-through displays using display color profiles.** In Proceedings of the 19th ACM Symposium on Virtual Reality Software and Technology (VRST '13). ACM, New York, NY, USA, 231-240. DOI=10.1145/2503713.2503716 <http://doi.acm.org/10.1145/2503713.2503716>  **[SUBMITTED]**  Hincapié-Ramos, J.D., Roscher, S., Büschel, W., Kister, U., Dachselt, R. and Irani, P. 2014. **tPad: Rich Interaction with Transparent-Display Mobiles.** Under review for the SIGCHI Conference on Human Factors in Computing Systems (CHI '14).  Hincapié-Ramos, J.D., Guo, X., Irani, P. 2014. **Consumed Endurance: A Metric to Quantify Arm Fatigue of Mid-Air Interactions.** Under review for the SIGCHI Conference on Human Factors in Computing Systems (CHI '14). |

**Other (Including Technical Reports, Non-Refereed Articles, etc.):**

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* 1. **Patents and Licences**

Please provide in the table below the **number** of patents (filed and issued) and licences to date arising from the research project supported by the grant in the table below. (Provide details in 4.4.)

|  |  |
| --- | --- |
|  | Not applicable |

**- OR -**

|  |  |
| --- | --- |
|  | None Yet Filed/Issued |

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| --- | --- | --- | --- | --- | --- |
|  | **Number of Patents** | | | | |
| **Description** | **Canada** | **U.S.** | **EP** | **Other** | **Totals** |
| **# of Patent Applications Filed** | 1 |  |  |  |  |
| **# of Patents Issued** |  |  |  |  |  |

|  |  |  |
| --- | --- | --- |
| **# of Licences** |  | **(Provide details in 4.4.)** |

4.4 Please provide details (titles, patent application number, patent number…) about the above listed patent applications, patents, and licences under the corresponding headings.

**Patent Applications Filed:**

|  |
| --- |
| **Serial Number:** 61/887,039 **Title:** Color Correction for Optical See-Through Displays Using Display Color Proﬁles  **Serial Number:** XXXXXXXX **Title:** XXXXXXXXXXXXXXXXXXXXX PLEASE ADD GORILLA ARM XXXXXXXXXXXXXXXXXXXXXX |

**Patents Issued:**

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**Licences: (licencees, exclusive/non-exclusive…)**

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4.5 Describe how the results achieved to date are being transferred to the user sector and the prospects for their commercial/industrial exploitation or their use by other sectors (e.g., revising or formulating policy or regulations).

**Prospects for the Transfer of the Results to the User Sector**

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**5. Problems Encountered**

Identify the main problems encountered during this instalment of the grant from the list below (select all that apply):

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| --- | --- | --- |
| X | Technical or scientific problems | |
|  | Problems with direction of research or findings | |
|  | Equipment and facilities | |
|  | Staffing issues (including students) | |
|  | Funding problems | |
| X | Partner withdrew from project | |
| X | Partner interaction issues | |
|  | Other (specify) |  | |

**- OR -**

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|  | No problems occurred during this instalment of the grant |

Briefly describe the main problems identified above and the steps taken to resolve each one.

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1. **Collaboration with Supporting Organizations**

6.1 Who initiated this strategic project?

|  |  |  |
| --- | --- | --- |
|  | The university researcher | |
|  | The industry partner (if applicable) | |
|  | The government partner (if applicable) | |
|  | Other (specify) |  | |

6.2 In what way were the partners directly involved in the project (select all that apply)?

|  |  |
| --- | --- |
|  | Partners were not involved in the project apart from their financial and/or in-kind contributions |
|  | Partners were available for consultation |
|  | Partners provided facilities |
|  | Partners participated in the training |
|  | Partners received training from university personnel |
|  | Partners discussed the project regularly with the university team |
|  | Number of meetings during the period covered by this report:\_\_ \_ |
|  | Partners were involved in the research |

6.3 Describe the partner’s involvement and comment on the collaboration.

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6.4 Was any cash committed to this project?

|  |  |
| --- | --- |
|  | Yes |
|  | No |

6.5 Was any in-kind committed to this project?

|  |  |
| --- | --- |
|  | Yes |
|  | No |

6.6 If any cash or in-kind was committed, please enter the amounts below, along with the amount of cash and in-kind that has been received (if any) to date. If no cash or in-kind was received, please enter “0”. Where cash or in-kind was not committed enter “n/a”.

|  |  |  |
| --- | --- | --- |
|  | **Amount Committed** | **Total Amount Received to Date** |
| **Cash** |  |  |
| **In-Kind** |  |  |

6.7 Describe the in-kind received and explain variations between commitment and actual cash and in-kind contribution if applicable.

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**7. Financial Information**

The purpose of this section is to provide additional project-specific detail; it cannot be substituted with a Statement of Account (Form 300).

Please provide the following financial information:

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Amount remaining in grant account as of June 30th:

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| --- | --- | --- | --- | --- | --- | --- |
| Budget Item | Budget for Year 1 | Actual Expenditures | Budget for Year 2 | Actual Expenditures to date in current grant year | Projections from now to September 30 (current year) | Planned Expenditures for the Next year of Support |
| **Salaries and Benefits** | | | | | | |
| Students |  |  |  |  |  |  |
| Postdoctoral fellows |  |  |  |  |  |  |
| Technical/professional assistants |  |  |  |  |  |  |
| Other (specify) |  |  |  |  |  |  |
| **Equipment or Facility** | | | | | | |
| Purchase or rental |  |  |  |  |  |  |
| Operation and maintenance costs |  |  |  |  |  |  |
| User fees |  |  |  |  |  |  |
| **Materials and Supplies** | | | | | | |
| Materials and supplies |  |  |  |  |  |  |
| **Travel** | | | | | | |
| Conferences |  |  |  |  |  |  |
| Field work |  |  |  |  |  |  |
| Collaboration/consultation |  |  |  |  |  |  |
| **Dissemination Costs** | | | | | | |
| Publication costs |  |  |  |  |  |  |
| Other (specify) |  |  |  |  |  |  |
| **Other (specify)** | | | | | | |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| **Totals** |  |  |  |  |  |  |

Please provide detailed explanations for any deviation in the current period and in the budget for the coming year. (Note that deviations from the budget of greater than 20 per cent require pre-approval from NSERC.)

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