Kurio:
A Tangible Interactive Museum Guide

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Background

Interactive museum guides have become a popular means to enrich the museum experience by providing additional information pertinent to artifacts on display. To date, the majority of interactive museum guides have adopted a mobile computing approach utilizing visually based personal digital assistant (PDA) applications and or mobile audio devices suited for individual visitors. Despite the availability of rich data, there are several drawbacks to these systems. Research clearly indicates the majority of people visit museums in families or small groups and that current museum guides tend to isolate people and inhibit interaction during their museum visitation experience as they focus on information delivered through the PDA…often to the point that the PDA becomes the focus of the visit. The objective of the Kurio Project is to investigate the potential to reverse this scenario and reinforce the appreciation of the 'real' artifacts while at the same time using innovative technology to enhance the museum visitors' collective experience.

The Kurio Museum Guide was designed for small community-oriented museums

Kurio

Kurio is a museum guide system designed to enhance interaction among family members and small groups visiting a museum. As opposed to more typical museum guides with a backlit display and graphical interface, the Kurio system utilizes tangible interaction, similar to the feedback of the Nintendo Wii. The Kurio system guides visitors through the museum with haptic, audio and visual cues generated by sensor technologies to help correctly identify and differentiate key artifacts as part of a quest to solve a "Museum Challenge."

The Kurio Museum Guide establishes a new paradigm for a family visit to a museum by enriching the learning experience through play while fostering group interaction. The main components of this hybrid system are all connected by a wireless network and include a set of tangible computing devices, a PDA, an interaction table and an autonomous reasoning engine (nicknamed "*Kurio*") that manages the *"Museum Challenge"*. *Kurio* allows visitors to choose from a range of interactive scenarios. In one scenario a family imagines themselves as time travelers whose time map is broken and so they are lost in the present time. In order to repair the time map, family members must complete missions comprised of a series of challenges to collect information from the museum helping to reconstruct the map. The family must use the various tangible components of the interactive museum guide to solve the *"Museum Challenge."* Our goal was to design the museum guide system so the technology would become part of a game narrative, and as such the tangibles were designed as tools that express the storyline and invite playful interaction.

This game-like strategy, supported by the playful design of the tangibles, has proven to significantly enhance visitors' engagement with the physical exhibit and the individual artifacts. In addition there is a noticeable increase in the level of interaction and discussion amongst family members throughout the *Kurio*-lead Museum visit.

Integrating Design, Research, Prototyping & Testing
Kurio is an ambitious design research project that demonstrates the potential to leverage wireless communication in combination with interactive sensor technologies to enhance social interaction and learning in a playful manner. The complexity of developing a fully operational wireless tangible interactive museum dictated the need for a well orchestrated collaborative interdisciplinary design initiative. The project team was lead by three principal investigators at two universities. The overall project lead, Professor Ron Wakkary from Simon Fraser University, headed up the design research initiative, the design development of the museum interaction model and user evaluation studies. Professor Marek Hatala, also from Simon Fraser University, led the design development of the information technology infrastructure including data management, implementation of the wireless communication network and implementation of the AI system to automate the "Kurio" reasoning engine. Professor Jim Budd with the assistance of Professor Bjarki Hallgrimsson at Carleton University led the design and prototype development of the tangible tools. Over the three-year duration of the project there were more than12 students involved in various aspects of the project.

The methodology of research and design undertaken by the Kurio team in this project was multidisciplinary and multi faceted. Researchers from Carleton University and Simon Fraser University collaborated in the early phases of the project to establish the basic research questions. Visits to a variety of museums allowed the Kurio researchers to observe typical interactions in the museum space. Key observations made from these visits allowed the team to develop potential use scenarios. Scenarios explored family interactions in the museum space and provided the canvas to develop potential themes, and possibilities for hardware. Concept development through a variety of media explored the visual aesthetics, and critical-to-function elements of abstract forms as well as literal metaphors that related to the proposed themes. 3D CAD was used to create detailed geometry for rapid prototyping. Final functional prototypes were created with fully functional electronic components and were used for field trials in the Surrey Museum.

The prototype system did not simply emerge but evolved over a period of eighteen months beginning with ethnographic studies of museum visits by small groups and families that helped us immensely. The exploration was not logical problem solving rather practice-based creativity. A combination of evaluative ethnographic research as well as generative participatory design in the early stages, allowed the project to proceed toward a solution focused on creating the best family experience in the museum, rather than creating false assumptions based on technical or commercial limitations. The project underscores how important prototyping is for working in interdisciplinary teams where many aspects of the system have to be developed simultaneously. Complex interactions, and a very broad range of issues have to be resolved to create a truly exceptional experience.

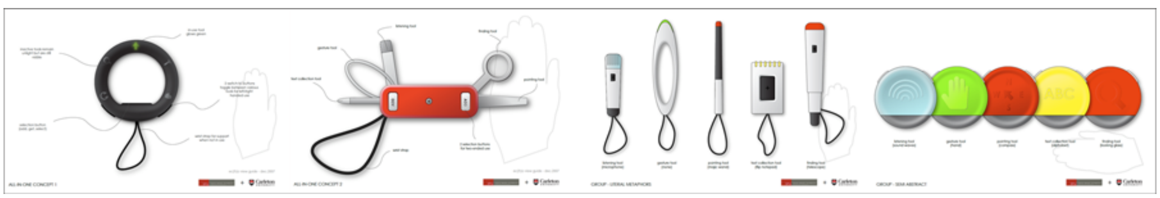
Interviews and observational studies were carried out at museums across the country

Technical Alternatives
Early in the discussions we identified two fundamentally different approaches to building the technical infrastructure. One option would be to install or embed the operational electronics in the exhibit itself. This type of installation would provide available AC power directly to all key elements of the system and support options for either wireless or possibly wired communication between the server and key components of a tracking system. The second option would be to integrate the electronics technology in a package that would either be carried or possibly worn by the museum

visitor depending on the size and weight of the components. This system would necessitate the design of a new, entirely wireless-based systems solution. Based on our investigations we felt it would be possible to create an identical interaction experience from the visitors' viewpoint with either approach. After a lengthy debate concerning the pros and cons of each possible solution we reached a decision that the concept for a new, entirely wireless-based system offered the most significant benefit. The primary deciding factor was the potential to develop a simple and flexible self-contained system that could be installed or retrofitted with minimal disruption to the existing museum infrastructure.

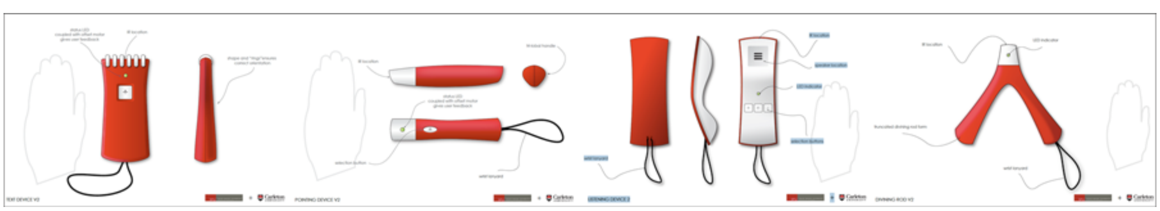
User Engagement in Prototyping Process

During the preliminary research phase interviews and observational studies were carried out at 6 museums of varying size in different locations across the country to provide a broad cross section of contextual sites. In parallel with the ethnographic studies we undertook an assessment of technical options that could potentially support the type of tangible interaction we envisioned. This raised a number of key usability issues. What should this device or series of devices look like? What should they do? And how should they work? Based on the data collected from the ethnographic studies we developed a series of concepts for both individual tools, each with a single specific function and multifunctional tools based on the model of the "swiss army knife." At the same time we explored concept options based on a literal interpretation for each task or function. We envisioned literal objects such as a radio to play back audio versus a metaphoric or symbolic device such as a set of colored pendants with representative icons for different functions.



Preliminary concepts introduced a range of possible design directions

We then ran two series of studies to help us identify how prospective users perceived and/or interpreted the function of this range of generic objects that were meant to allow the museum visitor to identify and select specific artifacts within a museum setting. During these sessions we did not provide any guidance on how the use the different "tools". At the same time we encouraged the participants to explain how they themselves were using the different tools to expedite the artifact selection process. The feedback was very informative and clearly identified an overall preference for the concepts based on literal metaphors with closely matched functions. For example, an object that looked like an oversized laser pointer with a well defined handle was a universal choice for selecting artifacts hanging on walls while few participants "found" a logical orientation for pointing with a circular device.



Second generation design concepts for a set of tethered handheld devices

The next major hurdle was much more complex. How big would the electronics package be? How much power would each device require? How much would each complete package weigh? Since it was not at all clear from the outset of the project that it would be possible to integrate the required technology into a manageable stand-alone handheld package we recognized it would be imperative to evaluate the viability of both a stand-alone handheld package as well as a fall-back option that would include a hand-held device (to facilitate interaction with the museum artifacts) tethered to wearable pack containing the majority of the electronic components - and if we could get it all into one package...would it be usable by both adults and children?

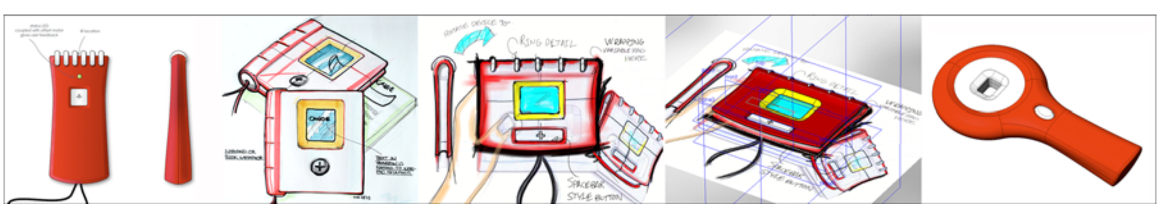
Once we had identified the technical components for the system we ran another series of user tests with family groups in a simulated museum setting to help inform our design decisions and to help validate our assumptions about how we anticipated visitors might respond to the two alternate prototype systems.

The “museum walk-through” used paper prototyping methods with non-functional models

We produced non-functional rapid prototyped models of the two systems based on our nearest approximation of what the final size would be and “walked” our participants through a simulation of the installation. The tethered version of the system with a wearable ‘tech’ pack was designed to meet standard ergonomic and human factors guidelines for size and interface considerations for children. The stand-alone handheld version of the system was sized and weighted to emulate the size and weight of “real” stand-alone handheld devices fully equipped with the electronics that would be required to operate each device within a museum setting.

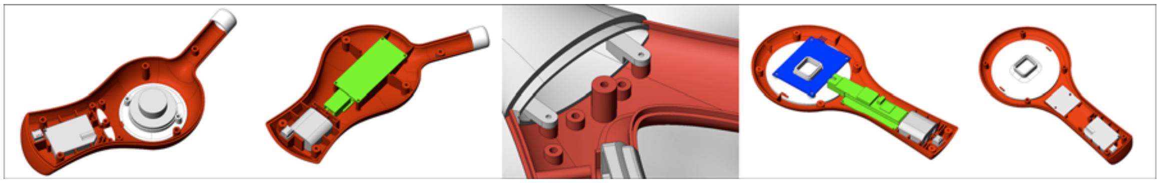

Family groups test non-functional models in a simulated museum walk-through

Many of the children reported the “over-sized” handheld devices to be “big and heavy” but surprisingly there was virtually a unanimous agreement in favor of the “over-sized” stand-alone handhelds. The feedback from this round of studies clearly placed the user experience ahead of functional performance and underscored the perception and play value of a creative solution from the children’s point of view. There were strong indicators that the bright colors and large size of the tangibles were shifting the children’s perception of a museum visitation experience. It would be important that the final series of tangibles be bright and colorful, playful, as well as toy and game-like to balance implication of the size and weight required to house electronic components.


Multiple iterations in the text-reading device reflect the influence of user participation

Design & Development

The design and development of the tangible devices went through many iterations of prototype development. Each device was modeled in 3D with SolidWorks™ and prototyped in ABS on a Dimension 3D printer to assist with ergonomic assessment and usability. One of the primary considerations was the overall size and weight of each device when fully loaded with electronics. Once we had operable electronics we were able to modify and accurately detail our computer models to accommodate the components of a full working wireless system and move into an extended series of user tests fairly early in the process. This process proved invaluable in helping us to advance to a much higher resolution of detail refinement for the final proof of concept field test models.

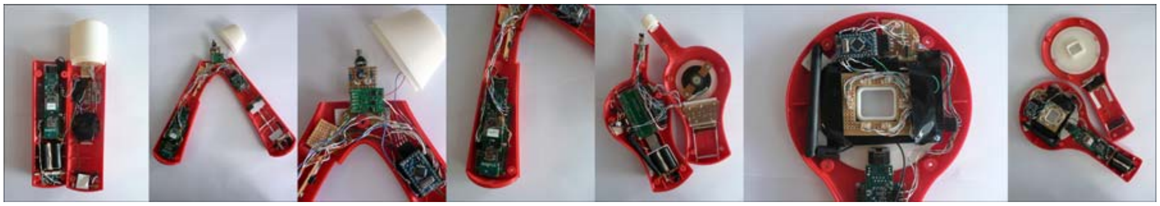


Assembly details of SolidWorks™ files for Rapid Prototyping

As opposed to more typical museum guides with a backlit display and graphical user interface, the Kurio system utilizes tangible interaction, similar to the feedback of the Nintendo Wii. The Kurio system guides visitors through the museum with haptic, audio and visual cues to help correctly identify and differentiate key artifacts as part of a quest to solve a "*Museum Challenge*." At the outset of the visit a family selects one of a number of Museum Challenges that requires them to correctly identify a series of artifacts to help them solve the mystery quest. The group leader is then assigned a PDA that "talks to" *Kurio* while each of the other family members is assigned a different tangible device. Next, *Kurio* assigns individual tasks via the PDA that are delegated by the group leader. As family members wend their way through the exhibit each of the tangibles illuminates when it is in close proximity to selectable artifacts. The visitor then has to read and/or examine each selectable artifact and choose the most appropriate item by depressing a button on the tangible. Depending on which tangible the visitor happens to be holding the device will respond by illuminating a different colored light, vibrating or emitting a sound to acknowledge that their choice has been transmitted to the group leader's PDA. When each set of tasks is complete the family members congregate to discuss the next set of tasks or to discuss additional clues if someone has been unable to find or correctly identify a particular artifact.

The primary innovation of the hybrid system is the set of four tangible computing devices. The tangibles serve as the means of collecting information and knowledge from within the museum. We designed four tangibles. The first is known as the *pointer*. It is reminiscent of a flashlight and is used by pointing at museum artifacts you want to select. The second tangible is the *reader* that is shaped like a magnifying glass and is used for collecting text from didactic displays. The third tangible is the *listener* for hearing audio files in different locations in the exhibition space. It resembles an old portable AM radio or walkie-talkie. The fourth tangible is the *finder* that is used for finding locations in the museum like particular display areas. It is shaped like a divining rod for dowsing water.

In addition, a PDA called the *monitor* is used to coordinate family members as they work through each task and to support them in completing missions and challenges. The PDA application monitors each family member's progress with challenges, assigns new challenges and redistributes the tangibles among the family members. The application displays the items collected by the tangibles in the form of puzzle pieces. The *monitor* allows visitors to keep or discard items collected by tangibles. A tabletop display provides families with awareness of the game state such as how far along they are in completing missions, completing the time map, and which challenges were successfully completed and which were not. Family members can review the information collected in a graphical format on the tabletop along with the time map to see if it meets the challenge or, if not, what the best answers are.



Each handheld device contains a full wireless computer + a combination of sensors

We chose radio frequency identification (RFID) and infrared (IR) technologies for tangible sensing. The *reader* incorporates an RFID reader in its shell. The RFID tags are passive tags on plastic chips that are attached to graphical icons and readable by the *reader*. The *pointer, listener*, and *finder* utilize IR sensors that detect IR beacons. In each case we had to shield and direct the IR sensors within the tangibles to create better accuracy The IR beacons are enclosed in small plastic cases powered by a small coin-cell battery. They are programmed on a compact microprocessor and flash an eight-bit identification code every second.

Initially, we explored several approaches to sensing for the tangibles including active RFID, vision systems and even gesture tracking with accelerometers and magnetometers, but in preliminary tests the IR beacons proved more reliable. Both the RFID and IR technologies were chosen for their reliability, relative ease in implementation, and the low cost in tagging objects in the museum. This approach proved very flexible in adding and removing content. The RFID tags are fastened to didactic displays and the IR beacons are placed next to or on artifacts with artifact-safe adhesive.

Details of the operational handheld devices and interaction table used for field-testing

Field Testing, Analysis and Assessment

In our field test evaluation, families tested Kurio in a local history museum. The number of participants was 25 parents and children, or 8 families. Each user session consisted of the families completing a sample "Museum Challenge." This was preceded by a short tutorial on the system and a brief interview and questionnaire on previous experiences with museums and technologies. Following the session, participants completed questionnaires and a semi-structured interview. The analysis and assessment of the field trials validate the overall success of the prototype system. The studies show that the design of the tangibles in particular integrates well with the rest of the system by providing playful and responsive interaction that is quickly picked up by participants of all ages.

User Feedback

The overall impressions of the experience with Kurio were positive.

- In semi-structured interviews following the field trials, a child responded: "*I feel that like I absorbed the information, instead of just reading and skimming over it and leaving…you actually had to look at it, and it was more fun to read it and look at it, than to just read it and be like "oh this is interesting" and leave."*
- In another exchange a child remarked: "*you can actually do things, like you just don't look at*

things or watch movies or something, but you find stuff..." The parent responded: "*Exactly, the physicality of it because it's interactive…the fact that all the senses were, you know, you could maybe move, gesture, listen, read, point, you know…there was physical stuff.*"

Field testing fully operational prototype system installed in a community museum

Potential Benefits of the Kurio Museum Guide

Kurio is a proof of concept only – it is not intended for production at this point in time. The Kurio project does, however, clearly demonstrate the potential to utilize new sensing technology to create tangible user interfaces to actively engage families and small groups in exploring a museum exhibition in much more depth in an entertaining and playful way than has previously been possible and may eventually lead to new commercial applications.

The results of the Kurio Project support the intended goals to foster social interaction and learning among family members and small groups visiting the museum. Our design strategies to combine playful design and tangible interaction with game-learning and hybrid systems hold up well under the scrutiny of the analysis. We see three distinct positive implications for museum visitors based on the design strategies we pursued:

- *Closing the social gap:* There is a noticeable increase in the level of interaction and discussion among family members – young and old - throughout the Kurio-lead Museum visit.
- *Naturalizing technology:* The wireless handheld tangibles allow freedom of movement and support the use of natural gestures to identify and select individual artifacts whether they are located on the walls, in display cases or in the midst of a diorama.
- *Shifting to exploration and discovery:* The game-like strategy supported by the playful design of the tangibles has proven to significantly enhance visitors' engagement with the physical exhibit and the individual artifacts.

From a curatorial perspective, interactive museum guides in the past focused on information access and richness. The move toward playful design and tangible interaction creates the opportunity to design learning activities with interactive technology that are based on personal exploration and discovery rather than information retrieval and retention. This motivates learning and enhances the social and collaborative experience. In addition, from an operational standpoint, one of the major considerations in the museum environment related to the installation and operation of a typical interactive museum guide is the infrastructure cost to retrofit a technologically intensive system together with reconstruction and exhibition down time to install the system and/or implement changes. Continual technological advance and system or exhibit updates also compound cost and rework. The self-contained wireless design of the Kurio system eliminates the need for any infrastructure change and only requires that small transmitters be installed in the exhibit space.

Lessons Learned

Our strategy to leverage the diversity of strengths in the design team through a simultaneous approach to multiple aspects of the overall research and design initiative have led to a much more idealistic solution from the perspective of the end user than might have otherwise been possible. By focusing on the opportunity to "follow the evidence" and learn from users our strategy underscores the importance to validate any assumptions we might make about the operation of the system or details of each device through ethnographic observation, user studies, workshops and field trials. As a result, we made a deliberate effort to visualize and explore potential directions that might have easily been dismissed earlier in the process for technical or logistical reasons. For example, the decision to investigate an entirely new “wireless” approach to the system seemed far beyond our technical capabilities at the outset of the project…but the potential benefits from the user perspective were readily apparent. In a similar fashion, all of the ergonomic data suggested the size of enclosure required to house all of the wireless electronic components would result in a very heavy, oversized “tool” for adults that again seemed to be out of the questions for small children. To deal with these potential design dilemmas, we decided to pursue a two-pronged approach to the technical development and simultaneously test the viability of both an “oversized” self contained wireless system as well as a more compact handheld device tethered to the electronics carried in a fanny pack. The ensuing iterative prototyping and field-testing process was crucial to decisions in the design development. The colorful, oversized and heavy, self-contained wireless “tools” proved to be a hit with the children. If we had not followed through this development to an advanced prototyping stage it is highly unlikely we would have fully recognized the implications of the “play factor” in the design of the tangible devices and the final solution might have taken a very different direction.

The iterative prototyping process and the extensive use of rapid prototyped models also helped us learn much more. During this project we were able to produce a greater range of concept alternatives with immediate hands-on feedback during our user studies while the benefit of the RP models was of even more significant during the detail development and resolution of technically complex operating details during the field trials.

In summary, the net result of the collaboration led to the development of an easy-to-use, dynamic solution that goes far beyond the initial expectations of everyone involved in the project. We anticipate the lessons learned from this project will now be leveraged to develop more creative solutions in future applications of interactive technologies.

Note

Earlier this year the Kurio Project received a Gold Award in the Concept Category at the IDSA Northwest Design Invitational for 2009.

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