Project Title
An Interactive Talking Campus Model at Carroll Center for the Blind

Final Report

Funding organization
Noyce Foundation
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30 April 2009
**Executive Summary**

This Final Report documents activities and outcomes for a research and development project under funding from Robert Noyce Foundation. This work was done between September 1, 2008 and April 30 2009, and represents the collaborative effort of three organizations: The Carroll Center for the Blind in Newton, MA; the IDEA Center at the University of Buffalo College of Architecture; and Touch Graphics, Inc. of New York City. A grant in the amount of $15,000 was used to cover project costs, including materials and supplies, staff, consultants, travel and overhead.

![Figure 1: A close up view of some of the buildings and landscape features as they appear on the finished talking campus model.](image)

The model is now installed and operational at the Carroll Center, and staff and clients are carrying out a 30-day informal evaluation of its features and functions. A more structured usability study will occur in June of this year, and the results of that process will form the basis of an article documenting findings of this evaluation. The article will be submitted to journals and other publications that focus on universal design, exhibits, assistive technology, and cartography. Our long-term ambition is to commercialize processes and technologies developed here, and to begin creating installations of this type for outdoor and indoor environments. This new product will serve as a natural extension to the company’s current products and services. We anticipate generating new orders for talking tactile models and sculptures, hopefully starting with the National Mall Universal Display planned for installation at...
the Smithsonian Information Center in the Castle in Washington, D.C. (pending funding approval), a place where millions of US and foreign tourists go each year to plan their visit to the nation’s capital. This exposure could generate further awareness of our system, and may lead to additional new business for the company.

Progress towards goals

The collaborating organizations have successfully implemented the research plan that was described in the project proposal, dated October 27, 2007 (see Appendix A for the original proposal document). Tasks carried out included the following:

- Materials research, leading to development of a new process for producing low-cost, durable and attractive models that are capable of determining where on their surface they are being touched, and then reporting that information to a computer.

- Documenting buildings, roads, sidewalks, bus stops, and other landscape elements at Carroll Center through a combination of on-site measurement, photography, and internet-based resources such as Google Earth (figure 2).

Figure 2: The Carroll Center as it appears in an aerial view taken from Google Maps. The red box indicates the area depicted on the talking model.
• Constructing a detailed volumetric computer model of the Carroll Center campus using AutoCAD and 3D Studio Max and other computer programs (see figure 3).

• Outputting the computer model as a collection of miniature buildings and landscape “tiles” that could be pieced together to create a scale replica of the campus (figure 1 and cover image). This work was done using a Z-Corp Z-printer 450 color 3D Printer. This machine is owned by the University of Buffalo School of Architecture, and was made available to the project by the IDEA Center.

• Designing a simple electronic device (figure 4) capable of harvesting information on touches by observing changes in capacitance on a series of electrically conductive parts connected to the sensor device by thin coaxial cables. It is not necessary to actually physically come into contact with the electrode to register a touch. We discovered that reliable touch detection can occur even when a 1/8” inch thick layer of (non-conductive) material encases an electrode.

• Mounting individual 3D prints of buildings and landscape tiles on a pedestal to create a scale model of the campus rendered in color and textures that could be explored both visually and tactually (by touching).

• Creating a computer application in Adobe Director that permits students, staff and visitors at the Carroll Center to interact with the model by touching parts to hear descriptions, as well as to get overview information about the Center’s layout through various combinations of touching, looking and listening. A simple three-button user interface allows users to navigate menus and make selections.
Evaluation

While no formal evaluation of the talking campus model was planned as part of the Noyce-funded research project, we recognize the importance of carrying out well-designed usability studies for any new method or device that is intended to form the basis of a replicable system, especially if individuals with differing preferences and capabilities are expected to use the system. We will work with the IDEA Center staff to develop protocols and data collection tools for an on-site evaluation scheduled early June, one month after the system began service in the lobby of the Carroll Center Tech Center. This one-month shakedown period will allow us to fine tune the model’s touch sensing behavior and program function. The three partner organizations will work together to recruit 6 to 8 participants with limited prior knowledge of the campus to explore the model for 10 minutes. Then, they will be questioned about this experience in a short interview, prior to being escorted on a short tour of the grounds. The participants will be encouraged to verbalize their process of orientating themselves to an unfamiliar environment. Informal questioning and conversation both during and after the outdoor walking exercise will seek to reveal the extent to which learning of spatial configurations and relative distances and directions between landmarks improves after exposure to the interactive talking model. Our purpose is to evaluate whether, and to what degree, interactive way-finding systems like the Carroll Center Talking Campus Model promote better comprehension of relatively unfamiliar outdoor environments. We speculate that other environments, especially places that serve the blind and visually impaired, could benefit from incorporation of public amenities of this type, and so these findings will be significant to our plans to develop opportunities for creating similar installations for a variety of organizations and audiences.

Organizational Results

We view interactive orientation and way-finding systems like the one demonstrated in this Noyce Foundation-funded project as an important part of our overall business strategy. There are good reasons to believe that this technology fills a need in the market, and that business opportunities could emerge for a very low capital expenditure:

Figure 3: The touch sensor device. Each USB device is capable of reporting on touches to up to ten individual parts. To produce a model with more than ten parts, multiple units are used.
• The TouchSensor device that we developed and deployed publicly for the first time at the Carroll Center project is a low cost, very simple electronic device that can be manufactured overseas for $10 per unit. One unit is needed for every 10 model parts; so, a model that has 200 discrete touch channels would require 20 units, all connected to a USB hub, and a single PC to run the program that interprets the touches and plays back appropriate audio. The sensor unit could be offered commercially to other interactive model developers and other potential end users and resellers, if we determine that this would not diminish our competitive edge.

• Our method for making touch sensitive models with the required properties was shown to be practical and effective. The final specification calls for printing hollow buildings that are then filled with low melting temperature metal alloy (also called Wood’s metal). These metal cores are connected via individual shielded cables to the touch sensor devices, which measure capacitance for each part and return a value to a computer housed in the model’s base. Individual thresholds are set in software, so that the model can be adjusted to maximize sensitivity while reducing cross-channel interference that can lead to spontaneous talking by the model when it is not being touched. Hardware potentiometers for each touch measurement channel permit further tuning. Other techniques were successfully demonstrated for capturing touches on flat portions of the model where it was not possible to create cavities that could be filled with metal; instead, roadways, parking lots, and small features like bus stops were made with shaped sheet metal pads under the 1/8” thick hard shell of the 3D print. These pads were then each connected to the sensors via coaxial cables. The Carroll Center model includes 16 different zones and two touch sensor devices. This approach is scalable to achieve models of any size and complexity.¹

• The 3D prints appear to be durable and easy to maintain. They are integrally colored rather than surface coated, so the colors will not rub off after extended exposure to people touching it, even in outdoor installations. The method calls for impregnating the finished 3D prints with a hard, clear epoxy shell. We have yet to see any breakage to model parts, including quite small elements like the tiny gazebo visible in figure 1. If parts do break off, or if buildings or other features change over time, model parts can be unscrewed from below and removed, and new ones added, since each building and landscape tile is a separate 3D print.

• 3D printing is a maturing technology; equipment is getting cheaper and processes and materials are getting better. A suitable 3D printer for producing model components now costs $40,000, an amount that would be quickly amortized after only a few projects.

• Speech synthesis has improved dramatically, and very naturalistic voices are cheaply available for voicing text-based content, such as place names and descriptions. With an internet connection to the model’s computer, it becomes easy to continuously update descriptions, and to link to web-based data such as bus schedules, office occupants, etc.

¹ The USB protocol permits connection of up to 255 individual devices to the computer. This means that it would be possible to create a model with over 2,000 individual touch-sensitive locations.
Budget

Project expenditures were approximately as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electronics and wiring</td>
<td>$1,200</td>
</tr>
<tr>
<td>Supplies and Materials</td>
<td>$1,000</td>
</tr>
<tr>
<td>Fabrications</td>
<td>$800</td>
</tr>
<tr>
<td>Consultants</td>
<td>$5,000</td>
</tr>
<tr>
<td>Staff</td>
<td>$5,000</td>
</tr>
<tr>
<td>Travel</td>
<td>$1,000</td>
</tr>
<tr>
<td>Overhead</td>
<td>$1,000</td>
</tr>
</tbody>
</table>

Total $15,000

Conclusion

Work carried out under this Noyce Foundation grant has allowed the collaborators to create a scalable system for producing touch-sensitive talking models and sculptures. Potential customer for future installations include universities, government and performing arts complexes, hands-on science and technology centers, hospital complexes, public transportation hubs and many other public spaces. Durable, visually attractive low-cost models can be produced with existing 3D printers, and touch sensitivity can be added by simply adding conductive metal cores, and wiring each part back to custom sensor devices connected to an ordinary PC. The results of an upcoming evaluation will be shared with the field via publication and conference presentation, thereby stimulating additional activity in this area. Most importantly, this Noyce Foundation grant allowed us to produce a working demonstration of our concepts, so that we can observe its effectiveness with actual users and make incremental improvements. With the Carroll Center model in place and operational, potential customers like the Smithsonian Institution will see that installations of this kind are both practical and effective, and that many people, including those with disabilities, find them intuitive, engaging and helpful.
**Project Collaborators**

Steven Landau, Principal Investigator (Touch Graphics)
Heamchand Subrayan, Design and Production (IDEA Center)
Edward Steinfeld, Project Advisor (IDEA Center)
Zachary Eveland, Hardware Engineer (Touch Graphics)
Justin Hjortshoj, Fabrication and Testing (Touch Graphics)
Jeanice Bainnson, Project Management (Touch Graphics)
Dan Gieschen, Programming and Media (Touch Graphics)
Padma Rajagopal, Orientation and Mobility Consultant (Carroll Center)
Eric Gasper, On-site System Oversight (Carroll Center)
Rachel Rosenbaum, Project Advisor (Carroll Center)

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**Figure 5:** The Carroll Center for the Blind is a residential rehabilitation facility for newly blind children and adults. The campus is in Newton, MA, a suburb of Boston.
Appendix A: Original grant proposal

An Interactive Talking Model for the Carroll Center for the Blind

Grant proposal submitted to the Noyce Foundation
24 October 2007

Blind and low vision individuals require overview information prior to traveling independently in new environments. Touch Graphics, Inc. is a ten-year old company that specializes in design and implementation of imaginative and effective way-finding systems that provide exactly the kind of information that visually impaired people need. These systems take a variety of forms, from simple booklets of raised line maps for transit systems and neighborhoods; to cell phone museum guides that allow visitors to trigger personalized attractor sounds from destinations to which they want to travel; to three-dimensional models that users touch to hear audio descriptions of any part (see figure 1). Since our audience is very small, we rely on government grants and other non-commercial sources to finance our research and development operations.

Figure 1: Left, a visitor to the New York Hall of Science navigates on the exhibit floor using her cell phone and the Ping! system. Right, the Rocket Park Talking Touch Model.

The company maintains a relationship with the Carroll Center for the Blind in Newton, Massachusetts, where students use the Talking Tactile Tablet, a Touch Graphics product, as part of the Center’s braille literacy program. The campus at Carroll consists of a collection of buildings and exterior spaces connected by pathways. When new students arrive for orientation, they are taken on a tour to familiarize them with the layout. A better way for new students to learn the campus configuration could be to invite them to explore a three-dimensional interactive campus model similar to one that we are developing for the Smithsonian Institution (in collaboration with the Rehabilitation Engineering Research Center on Universal Design at the University at Buffalo, see figure 2). The model will be made of cast resin that has
been coated with paint mixed with silver particles. When users touch the model, their body will share its electrical charge with a building or other feature. A sensor will detect a change in capacitance in the part has been touched, and send a signal to a computer, which will then play back a prerecorded audio clip describing that part. If contact with the part is maintained, the computer will proceed to play orienteering information that includes directions for traveling to the selected destination. In addition to this simple form of interaction, the model will also include an index that allows users to scroll through an alphabetical list of all destinations shown, and then select one to have his or her hand let to that place on the model through a process of incremental audio coaching. By this means, a blind or low vision individual will be able to independently explore the campus in safety, to mentally prepare a route prior to traveling.

Figure 2: A rendering of the National Mall Universal Display, now in development for the Smithsonian Information Center at the Castle in Washington, DC.

We request a grant of $12,000 to pay for the design, fabrication and installation of a talking touch model of the campus of the Carroll Center. The proposed system would be given to the Center as a gift, and could include a plaque indicating that funding was provided by the Noyce Foundation. The work of creating the model will take six months, and we are prepared to begin immediately. Additional details about the project or an itemized budget can be produced on request.

Contact: Steven Landau, President and Founder
Appendix B: Overview and way-finding scripts for the Carroll Center Talking Campus Model

Overview 1
The Carroll Center for the Blind, located in Newton, Massachusetts, is a private, non-profit agency which serves persons of all ages who are blind or visually impaired. The Carroll Center campus includes five main buildings. To learn about each of these, please touch the model.

Overview 2
The Carroll Center serves the needs of blind and visually-impaired persons by providing rehabilitation, skills training, and educational opportunities to achieve independence, self-sufficiency, and self-fulfillment and by educating the public regarding the potential of persons who are blind and visually-impaired.

Overview 3
Established in 1936, the Center has pioneered innovative methods for blind persons to gain independence in their homes, in class settings, and in their work places. New and evolving technologies, combined with time-tested adaptive methods, individualized instruction, and personalized therapies developed by the Carroll Center staff, have provided thousands of blind and vision impaired persons with diverse opportunities for success and independent living.

Main1
Main Building

Main2
Layout: The Main Building has three floors plus a basement. On the first floor are general gathering places and classrooms. The second floor has more classrooms and administrative offices. The third floor includes spaces for personal management classes, including a kitchen and library, and more administrative offices.

Main3
Entering and exiting: There are three doors into the Main Building. Coming from the Tech Building and the dorms, you will use the east door. From St. Paul’s Building or Centre Street, you will use the west door. From Rader Hall and Sargeant Street, you will use the north door.

TechCenter1
Tech Center

TechCenter2
Layout: The Tech Center has two floors. On the first floor are computer labs, the auditorium, and staff offices. The second floor includes more staff offices and a conference room.

TechCenter3
Entering and exiting: There are two doors leading into the Tech Center. From the Tech Center Parking lot, use the South door. From the Main Building, Rader Hall and Sargeant Street, use the North Door.
TechDorm1
Tech Dorm

TechDorm2
Layout: The Tech Dorm is physically connected to the Tech Center. The Tech Dorm has one floor, including kitchen, bathrooms, and guest rooms.

TechDorm3
Entering and exiting: There are two doors leading into the Tech Dorm. The Tech Dorm can also be accessed via a door connecting directly to the Tech Center.

StPaulsBuilding1
St. Paul's Building

StPaulsBuilding2
Layout: The St. Paul's Building has two floors. On the first floor are staff offices and classrooms. There are dorm rooms on the second floor.

StPaulsBuilding3
Exiting and entering: There are two doors leading into the St. Paul's building. From the Main building and Centre Street, use the South Entrance. There is an emergency exit and staff entrance on the West side of the building.

Raeder Hall1
Raeder Hall

Raeder Hall2
There are three floors plus a ground level. First floor: lobby, kitchen, Rose room, and a library. Second floor, dorm rooms and bathrooms. Third floor, dorm rooms and bathrooms. (note: the elevator does not serve the third floor).

Raeder Hall3
Exiting and entering: There are two ways to enter Raeder Hall. From the Main Building, Tech Center or St. Paul's building, enter Raeder Hall by passing through the gazebo and through the south entrance. Note, the south entrance is the main entrance, but for wheelchair access, use the East entrance (Rose room entrance). The east entrance (rose room entrance) is accessible to wheelchairs. Raeder Hall has three other emergency exits.

PottingShed1
Potting Shed

PottingShed2
There is only one floor, and one door. The potting shed is used for storage and maintenance purposes. The potting shed is located near the south side of the Tech Dorm.

Condo1
Condo building

Condo2
The condo building is on the campus, but is not part of the Carroll Center.

Private Houses1
Private Houses

Private Houses2
There are three private houses at the intersection of Center Street and y. These houses are not part of Carroll Center.

Center Street1
Center Street

Center Street2
Center street runs north and south, and is a very busy street. To the South, Center Street leads to Newton Center, and to North it leads to Newton Corner, the Mass Pike and Watertown. There is two-way traffic on Center Street. The intersection with Sargent street is a lighted intersection. There is audible pedestrian signal at the intersection. Continue pressing to hear what the audible signal sounds like.

Center Street3
<insert audible signal>.

Sargent Street1
Sargent Street.

Sargent Street2
Sargent Street runs along east west along the north side of the Carroll Center campus. It is not busy as Centre Street. The name of this street changes from Sargent to Cobot on the west side of centre street. On the North side of sergeant street are private houses. To the west, Cobot street leads to Newtonville, and to the east, Sargent Street leads to Brighton. The intersection with Center street is a lighted intersection. There is audible pedestrian signal at the intersection. Continue pressing to hear what the audible signal sounds like.

Sargent Street3
<insert audible signal>.

Bus Stop1
Bus Stop

Bus Stop2
Carroll Center is served by the 52 bus, which runs between Watertown yard and Dedham mall. During rush hours, the bus runs about every 30 minutes, and about every hour at other times.

Bus Stop3
For more detailed information about schedules and fares, please call MBTA at 617-222-3200. There are bus stops on both sides of the Center Street, and are marked by metal sign poles. Tactile markings have been placed on the bus stop poles.

**techParking1**
Tech Center parking lot

**techParking2**
Tech Center parking lot is the largest car parking area, and is located to the south of the tech center.

**techParking3**
nil

**EastParking1**
East parking lot.

**EastParking2**
The east parking lot is East of the tech center.

**EastParking3**
nil

**RaederParking1**
Raeder Hall parking lot

**RaederParking2**
There is a small parking lot east of the Rose room in Raeder Hall.

**WestParking1**
West Parking

**WestParking2**
The west parking lot is close to the main entrance, located between St. Paul’s and the Main building.

Other landscape features of interest
An audible sculpture with bells and globes is to the North of the Tech Center
The gazebo is a small structure with a pitched roof and benches where you can sit. You pass through the gazebo on the way to the main entrance into Raeder Hall down some flagstone steps.

**Neighbors**
Country Day School is on the Opposite side of Centre Street.
Boston College Law School is on the opposite side of centre street.