Haptic User Interface

Phase II

ECE 480 Design Team 6

For MSU Resource Center for Persons with Disabilities

Team Members:

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Sponsors: MSU RCPD, Marathon Oil, Chrysler, Artificial Language Laboratory
Facilitator: Dr. Virginia M. Ayres

Pre-Proposal

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Executive Summary

The Michigan State University (MSU) Resource Center for Persons with Disabilities is currently conducting research, in conjunction with Marathon Oil, Chrysler, and MSU's Artificial Language Laboratory, for an alternative haptic-user-interface for visually impaired individuals. The devices on the market today are far too expensive for the average consumer and thus make it difficult for blind students to overcome challenges in mathematics and science courses. This device will enable blind students to "see" technical images and graphs from a computer screen and enhance their learning experience overall. ECE 480 Design Team 6 will build upon the past design (Phase I from the Fall 2012 semester) to provide a market equivalent device at a competitive price.

Table of Contents

1. Introduction

1.1 Michigan State University - RCPD

The Resource Center for Persons with Disabilities (RCPD) office was originally created during the 1971-1972 academic semester, with the goal of providing equal access to the University for all students. The RCPD office provides services to MSU students, employees, and visitors to ensure that they have equal access to all MSU services and facilities.

The mission of the RCPD office is to lead Michigan State University in maximizing ability and opportunity for full participation by persons with disabilities.

The functions of the RCPD office are summed up by using the following acronym:

Assess and document disability, academic, and workplace needs
Build and facilitate individual plans for reasonable accommodations
Link individuals with technology, education, and resources
Extend independence through auxiliary aids, disability-related information, and self-advocacy

RCPD at Michigan State values full integration of all persons with disabilities throughout all University programs and services. Further information can be found on the RCPD website https://www.rcpd.msu.edu/.

1.2 Phase I Summary

An initial implementation of the Haptic User Interface (HUI) was developed during the Fall 2012 semester by a prior ECE 480 group, which will be referred to as the Phase I design. Last semester's team designed and built a refreshable HUI, using solenoids. The magnetic force induced by the solenoid on the metal pin is what is responsible for displacing the pins through the casing to display the image the cursor is hovering over. This design was portable and featured rows of pins that would rise to represent portions of an image on a computer screen. The device is driven by computer software designed to open any image in a grayscale format and then allows the user to move the mouse cursor over the image to select portions of the image to be represented by the device.

The technology utilized in this design consisted of custom software, a modern USB interface, AC/DC and DC/DC power converters, as well as microcontrollers and custom-made solenoid circuits.

This design achieved the stated goals of the project, but also presented many opportunities for improvement. The results of the design met with mixed reviews from volunteer blind student reviewers. One of the major opportunities for design improvement involves the pins themselves, which, when driven by the solenoid, vibrates significantly. The users did not enjoy this and stated that it made the image difficult to discern. Additionally, the resolution on the display was fairly low, making it difficult to interpret an image. Lastly, there is significant heat dispersion from the device and the portability could be improved.

The solution reviewed positively as innovative and provides an excellent starting point from which to build upon. Significantly, the group was successful in keeping the cost of the project low; their total cost of design was only $110.

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1.3 Phase II Requirements

The project is currently in Phase II and is intended to build off of the previous team's work. The requirements requested for the current project are higher resolution and non-vibrating pins. The vibration of the display pins on the device was documented to be distracting to the blind individuals testing this product. The addition of more pins, creating higher resolution, for the images will allow the user to discern the image more efficiently.

2. Research Project

2.1 Project Overview

The ECE 480 Design Team 6 for Spring Semester 2013 consists of a motivated group of individuals eager to learn about and help the visually impaired. None of the team members has had any prior experience working with blind individuals, so this design project serves not only as an opportunity to design a useful product, but as a great learning experience overall.

Successful implementation of the cost-competitive refreshable haptic display will enable Jordyn, an MSU sophomore computer science major, and potentially other blind students across the globe like her, to interact and alter drawings and other graphic materials. By allowing the blind to “see” graphs and images in real-time they will have yet another tool to enable them to further their studies. This device will be extremely useful for physics and mathematics materials. The device will be in conjunction with the specificity and needs of the Michigan State University RCPD. It will also take the direct feedback and demands of current blind students and faculty of MSU. Above all else, our goals of the device are for it to be the first commercially affordable device for the average person that is user friendly and productively useful.

2.2 What a Haptic User Interface Device Is

‘Haptic’ refers to the human tactile and muscle movement senses. Tactile feedback is the term applied to sensations felt by the skin. A haptic interface is a computer-controlled device that displays information to a user’s senses. Haptic devices allow the user to feel and perceive objects with which they interact. Haptic user interfaces are input-output devices, meaning they receive an input from the user (i.e. graphic image) and send an output to a device. For our HUI, the output is displayed via a pin-out of the input and the user is able to feel the image displayed on the computer. Through haptic devices, graphical images can be displayed on a computer screen and made accessible to blind persons who currently are deprived of access to standard Graphical User Interfaces (GUIs). These devices enhance the learning experience of blind persons. Blind students who have accessibility to haptic devices are able to access graphical images for mathematics and science based classes.

2.3 Current Devices Available

Current materials for blind students used to produce graphic images are time consuming and the machines are extremely expensive. The amount of time it takes to transfer these images to paper so the student can feel it through a Braille style layout makes it difficult to produce the multiple images that would be needed for mathematics and science classes. The devices on the market, that implement graphs and drawings virtually are very expensive ($5,000 - $10,000). Figure 2.3a shows the Alva 544 Satellite Braille Display, which costs $6,295. Figure 2.3b shows the PowerBraille Display, which runs from $4,495 - $10,550 depending on the resolution of the device.

Figure 2.3a: Alva 544 Satellite Display

Figure 2.3b: PowerBraille Display

The design of the MSU RCPD refreshable HUI uses different technology than the ones currently on the market. The Phase I device takes a virtual form of an image and allows for the user to feel it via a Braille style pin layout. A software program loads the graphic image, such as a graph from class, and displays it on the pins of the device. The pins are able to continuously move as the user moves the cursor along the image to allow the user to instantaneously feel the image depicted on the graph. Figure 2.3c shows the final product that was created by last semester's ECE 480 design team.

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Figure 2.3c: Last semester's final product

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3. Customer Design Specifications and Objectives

The team's sponsor, Mr. Blosser from the RCPD, has requested that we enhance the functionality of the Refreshable Haptic Graphic Display to better meet the needs of visually impaired students that will use our product. The previous design features met the following criteria:

- Ability to upload images from a computer and convert them to grayscale
- Fast refresh rate
- Portable
- A solution that gave an accurate representation of an image

After getting feedback from the students that used the device, they were impressed with previous design but had a couple concerns. Team 6 asked the testers to provide us with a list of complaints they had regarding the design. Their major complaints were:

- Vibrating pins were distracting and caused difficulty in determining images
- Low resolution

According to Al Puzzuoli, a blind RCPD faculty member who tested out the device, "…the pins trembled perceptibly as I touched them" and "(The pins) were spaced widely enough so that there was not a lot of definition to the images." He concluded that "Both of these issues combined made for a somewhat murky experience."

Phase II of the device must be able to exceed the student expectations and to perform efficiently to avoid their concerns while improving on the past design. The methods currently under consideration to enhance the device are detailed in following sections.

4. FAST Diagram

FAST Diagram is to be included in the final proposal.

5. Conceptual Design Descriptions

5.1 Introduction

Phase II will focus on resolving the two major issues that have been identified: stop the vibrating pins and increase the resolution. To do this we have come up with a three different designs that are outlined below.

5.2 Proposed Design 1 – Increased Solenoids and Pins

The first idea is to include more solenoids and pins in the device. This addresses the resolution issue. The reason for the current poor resolution is due to the fact that the pins are placed farther apart than what a Braille-literate individual is used to feeling. The quickest solution to that problem would be to insert solenoids between two rows of existing solenoids to essentially double the resolution. Figure 5.2a shows the current rows of the device and how they are laid out and Figure 5.2b shows the Design I solution to increase the resolution.

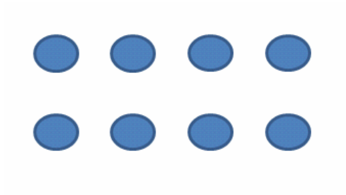


Figure 5.2a: Current rows of the design

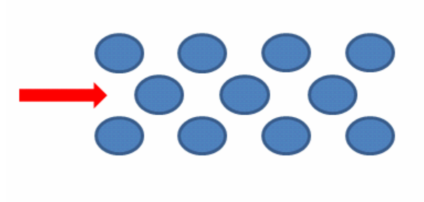


Figure 5.2b: Inserting solenoids between existing rows to increase resolution

5.3 Proposed Design 2 – Smaller Solenoids and Pins

Another design would be to reduce the size of the pins and solenoids. Currently there were 32 solenoids and pins. The proposed design would be to implement an eight-by-eight matrix of pins. Therefore there would be 64 solenoids and pins. In order to fit 64 solenoids inside the device, the diameter of the solenoid would need to decrease from 8mm to either 6mm or 4mm. The problem with the pins being large is that it gave the user a harder time determining the graphic images on the display. By making the pins smaller, it would be similar to the size of Braille dots. The device would be more comfortable and produce a familiar sensation to the user. Proposed Design II addresses the resolution issue and may also positively impact he vibration issue. The pins would not have to protrude as high as they currently do. This would decrease the vibration that occurs when the pins move.

5.4 Proposed Design 3 – Magnetic Latching

This design would consist of an array of magnetic bars that could create an eight-by-eight matrix (64 pins). The higher pin matrix addresses the resolution issue. The use of magnetic bars will allow the pins to latch when in use, instead of constantly moving up and down. This addresses the vibration issue. The bars would have small holes drilled in them in order to allow the pin to glide up and down as needed. In order to raise the pin when needed (i.e. to feel the graphic image output from the computer) a pulse needs to be sent to both bars. Therefore two consecutive pulses are sent to the device from a power source.

These pulses then charge the bar; setting the polarity so the magnet is attracted to the bar. This allows for the pin to protrude the surface and the user to feel the graphic image. The latch effectiveness of Proposed Design III has been tested by our RCPD collaborator/sponsor Mr. Blosser and been shown to be satisfactory.

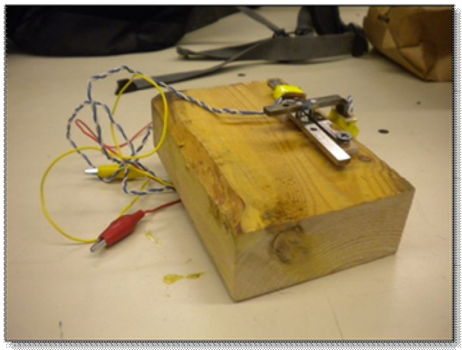


Figure 5.4a: Prototype

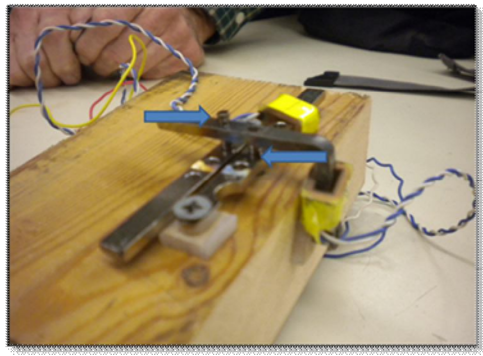


Figure 5.4b: The magnets are polarized and latch effectively

6. Proposed Design Solutions

6.1 Conceptual Design Initial Selection

After several discussions with our sponsor, Mr. Blosser, Design Option III was selected for initial investigation. The latch design, implemented by the magnetic bars, would allow higher resolution and eliminate the vibration that currently exists with Phase I HUI, therefore meeting the Phase II design requirements and addressing the two major issues identified by users.

6.2 Testing and Implementation

Mr. Blosser assisted in the design and creation of the Design Option III magnetic latch prototype. He demonstrated the latching device's ability to raise the pin when pulses were sent and drop the pin when the polarity was reversed. The current prototype is very basic and only demonstrated the use of one pin. Team 6 then performed additional tests of the single pin prototype. To test the prototype we used the power supply provided in lab and connected two banana-to-banana connectors to the ports of the power supply. We clipped one of the alligator clips of the prototype to one of the banana ends. Then to complete the circuit we briefly touched the other alligator clip to the banana connector. This momentary pulse consistently raised the pin. Alignment issues between the pin and the hole were identified and resolved.

Mr. Blosser stated that he ordered magnets that have a smaller diameter online and would like to implement those in the next prototype with eight-by-eight array of pins. The smaller magnets would be the shape of the pin and enable an eight-by-eight array design. Decreasing the diameter of the magnets will decrease the distance between the pins. This reduction will establish a device that is competitive with the resolution of existing products. Also it would be consistent with how Braille is written. Braille characters are close together, so the reader is able to read in a fluid motion.

Testing the eight-by-eight array prototype that will raise multiple pins when specified will insure that the magnetic field of each pin will not interfere with others. If this problem arises, shielding the pins will eliminate this issue

The second stage of testing involves the creation of software that is necessary for a working device. Code will need to be written in order to send the pulses to the magnetic bars. Some of the current code will be altered to support this device, while other portions will remain the same and be used. Rigorous testing of the altered code will need to be completed. That will insure that the user interface is still functioning properly.

The third stage of testing must occur after rigorous second stage testing. The design must be tested with several different graphic images to insure proper functionality. Current blind students will participate in testing and assess the device. Corrections will be made to reflect more positive reviews from testers.

Once the third stage of testing is completed without any unexpected behavior, and with all system parameters meeting design specifications, eight-by-eight design prototype will be implemented and any scale-up issues identified. The final prototype will undergo refinements and final packaging to prepare it for presentation at design day.

7. Risk Analysis

8. Project Management Plan

8.1 Team Member Roles

Every member of the ECE 480 Design Team 6 will have both a technical role that is subject to change, as well as an administrative role determined by Dr. Grotjohn. Though these technical and administrative roles exist, it is up to the team as a whole to work together toward a common goal to guaranty success. Some minor technical roles have yet to be decided at this time. These minor technical roles will be assigned as there need arises. ECE 480 Design Team 6 will work collectively to ensure each member's individual tasks are met.

8.1.1 LeRonn Wilson

TBD Technical Role / Project Manager

(Technical responsibilities)

It is Mr. Wilson's responsibility as team manager to coordinating meetings, facilitate communications with the facilitator, sponsor and team, and maintaining the GANTT chart.

8.1.2 Bin Tian

TBD Technical Role / Document Preparation

(Technical responsibilities)

Mr. Tian's is responsible for the preparation and coordination of all written documents as well as all final editing of every document. It is also his responsibility to organize and maintain the team documentation portfolio.

8.1.3 Eric Bell

TBD Technical Role / Website Management

(Technical responsibilities)

Mr. Bell is responsible for the upkeep of the website so all interested parties may look at documents related to the design project.

8.1.4 Kristen Kirchhoff

TBD Technical Role / Presentation Preparation

(Technical responsibilities)

Ms. Kirchhoff is also responsible for managing the preparation and execution of any material to be presented. The presented material will be coordinated via power point slides and prepared for using effective and engaging presentation techniques.

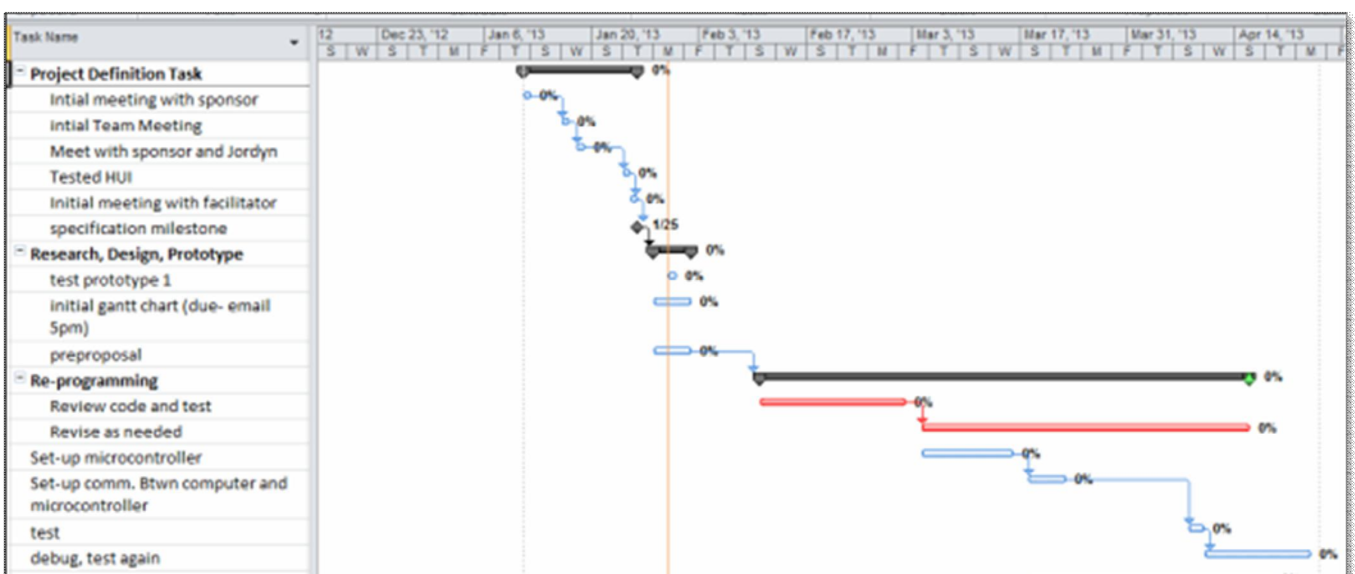
8.1.5 James Hunter

TBD Technical Role / Lab Coordinator

(Technical responsibilities)

Mr. Hunter is responsible for ensuring the cleanliness and orderliness of the laboratory. He is also responsible for checking out any items from the ECE shop and putting in orders for parts.

8.2 GANTT Chart



9. Budget

The budget is still under development and will be discussed in the final proposal.

10. References

[1] Gillespie, Richard B., and Sile O'Modhrain. "The Moose: A Haptic User Interface For Blind Persons with Application to the Digital Sound Studio." Center for Standord University: Computer Research in Music and Acoustics, Oct. 1995. Web. 18 Jan. 2013.

[2] MacLean, Karon. "Haptics and the User Interface." *Haptics and the User Interface*. Georgia Tech, n.d. Web. 15 Jan. 2013.

[3] Miller, Tim, and Robert Zeleznik. "Haptic User Interfaces." *Haptic User Interfaces*. Brown University, n.d. Web. 28 Jan. 2013.