Portable Refreshable Braille Display

Mingjie Wang, Rajarshi Roy

Introduction

Title: Portable Refreshable Braille Display

Current commercially available electronic Braille readers (aka refreshable Braille displays (RBDs)) are based on piezoelectronics, making them very expensive – prices range from $1,650 to $15,000. Using different technologies, we believe that we can bring down the cost by an order of magnitude. The size of the device can also potentially be decreased, allowing users can carry it in their pockets. All these serve to make the device more accessible to the visually impaired.

Objectives

To create a RBD with small form factor and rechargeable batteries so as to enable portability. Braille dots will be actuated via a cheaper alternative (to be determined via R&D) to piezoelectronics so as to minimize cost. The device will possess removable storage for ebooks, as well as a touch/button-based interface for browsing them. The device will also be able to interface with mobile devices via Bluetooth and a custom application, which will capture text for display in Braille.

Benefits

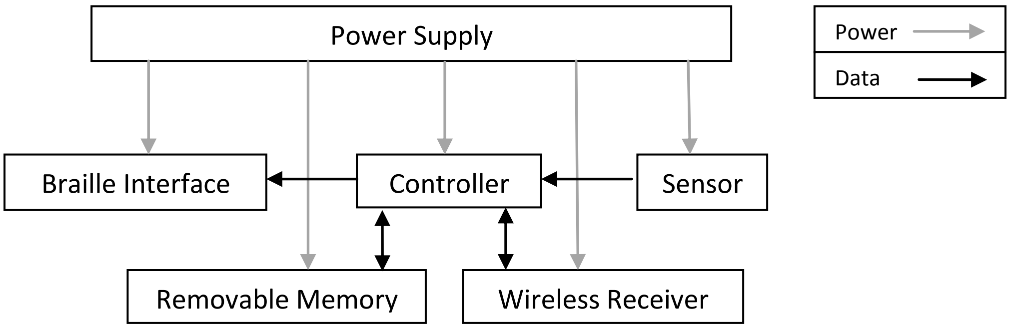
- Portable, allowing users to read Braille on the go.
- Lower cost of ownership – cost hundreds of dollars, instead of thousands.

Features

- Conforms to official Braille size and spacing standards.
- Removable storage for ebooks.
- Interface to browse stored ebooks in Braille.
- Bookmark function.
- Bluetooth connectivity.
- Convert text from mobile devices into Braille for display.
- Scrollable Braille text.
- Rechargeable battery.
- Firmware upgradable via USB.

Design

Block Diagram



Block Descriptions

Power Supply:

- Rechargeable Lithium-Polymer Battery
- Light and compact to keep the device functionally portable
- Meet possible current requirements for mechanical components in Braille interface

Braille Interface:

- Refreshable six dot Braille cells (minimum of two cells)
- The state of each Braille dot will be perceived in the traditional manner (raised or not)
- Braille dot will be actuated electromechanically (we will target to make the Braille cell maintain its state when it is not powered)
- Wired interface to controller board
- Power regulator to use appropriate voltage for Braille actuators

Controller:

- Controls individual Braille Cells and Braille Dots
- Scroll through text data based on feedback by user via sensor
- Store back location in text to memory to retain state while device is turned off
- Process text and scrolling information from wireless devices through wireless receiver
- Send back acknowledgement and position in text back to wireless device

Sensor:

- Optical or capacitive sensors to receive positional feedback from user about scrolling forward or backward in the text
- Both optical and capacitive touch sensors will have dedicated IC chips that can be interfaced to controller board via serial protocols
- Buttons for possible other information such as selection of books

Removable Memory:

- SD card memory that will store multiple text e-books
- Interface with microcontroller via SPI protocol

Wireless Receiver:
- Carry out wireless communication with mobile devices via the Bluetooth protocol
- Will allow functionality such as receiving SMS in Braille

Performance Requirements

- Refresh rate of Braille cells within 0.2 seconds
- Braille cells meet Braille specification of dot diameter (1.5 to 1.6 mm), sub-cell dot spacing (2.3 to 2.5 mm), dot spacing between cells (6.1 to 7.6 mm) and dot height (0.6 to 0.9 mm).
- Can transmit and receive to Bluetooth devices (<1m away) successfully
- Can read and change between .txt files in SD cards 100% of attempts
- Be able to recognize when user wants to scroll forward or backward in text 100% of attempts
- One hour battery life upon continuous scrolling

Verification

Testing Procedures

Power Supply:
- The requirement for this component is that the battery must power the device for at least one hour when continuously scrolling through text. The test setup would be to alter the firmware of the device to simulate sensor data to scroll through text. In this manner, when the device is turned on, the device will automatically scroll through the text. The battery voltage will be measured via an oscilloscope and plotted over time in software such as LabView (Voltage vs. Time Graph). Also, the device will be video-taped during the last 10 minutes of the hour to observe any possible effect on the Braille cell performance by decreasing battery voltage.

- The charging of the battery will also be monitored (Voltage vs. Time Graph) to observe if there is any unusual behavior such as voltage spikes.

Braille Interface:
- To observe the refresh rate of the Braille cell a simple resistive touch sensor can be used to detect when a Braille dot is raised. Each dot in a cell will be raised from a low position to observe how fast it can be raised. The microcontroller in control board will trigger a start signal separately to initiate a counter (in LabView) and the touch sensor will trigger a stop signal to stop the count.

- Also the mechanical specifications of the Braille cells will be confirmed by measuring the Braille dots and the distance between them using Vernier calipers.

Controller:
- The controller board will be interfaceable to the computer for programming and also testing. Two randomly generated strings will be passed via an SD card and a Bluetooth connection correspondingly. The controller will send the strings back to the computer to check for and discrepancies. A 100% match will indicate working interfaces with removable memory and wireless receiver.
Sensor:

- This test will involve an user and be videotaped for evidence. The user will indicate scroll forward, scroll backward, next ebook, previous ebook signals twenty times. The user will then perform an arbitrary sequence of actions on the device so as to simulate normal usage patterns. The appropriate response from the device must be successful 100% of the times.

Removable Memory:

- As mentioned earlier, reading data from the memory will be tested. Similarly, writing data to the memory will also be tested by passing a randomly generated string to the controller board from a computer, storing the signal in a SD card and then passing the SD card to the computer. A program will check for any discrepancies between the data. And a 100% match would mean a working memory.

Wireless Receiver:

- The wireless receiver will be tested via pinging the device from a mobile device or a computer ten times at increments of 10 centimeters distances between the devices. The (success rate v. distance) graph will be plotted. Success rate must be 100% for all pings within the 1m distance.

Tolerance Analysis

The controller board is the most important block in our design. It does integration of information from the sensors and memory and also controls the Braille interface at a low level. We will be testing this block extensively.

A corner case might arise when the data rate from sensors or buttons arrive too fast for the microcontroller in the controller board or require debouncing. We will probe inputs to observe such cases and test for glitches and jitter in the microcontroller.

Also surrounding components such as resistors, capacitors, oscillators and voltage regulators might be faulty. This might be detected by a not functioning device or damage the microcontroller over time. We will again thoroughly test all components on the board for functionality using an oscilloscope and multimeter.

As mentioned in the testing procedures, we will thoroughly test the interface between the controller and other subcomponent.

Cost & Schedule

Cost Analysis

Labor

Member	$/hour	# of weeks	Hours/week	Total # of hours	Subtotal	Multiplier(x2.5)
Mingjie Wang	$20	12	15	180	$3,600	$9,000
Rajarshi Roy	$20	12	15	180	$3,600	$9,000
					Grand total	$18,000

Parts

Part	Cost/unit	Quantity	Subtotal
HK-282 Ultra-Micro Servo 2.2g / 0.2kg / 0.08sec	$3.99	18	$71.82
Blue Lipo 3.7v 120maAh 14C for Blade MCX/MCX2	$2.47	4	$9.88
ATMEGA328-AU	$3.83	5	$19.15
IC LASER MOUSE SENSOR 18-DIP - ADNS-6000 -	$2.82	2	$5.64
Capacitive Touch Sensor Controller - MPR121QR2	$1.98	4	$7.92
Bluetooth Modem / Breakout to UART serial (RX/TX)	$12.99	1	$12.99
4GB MicroSD Micro SD TF Memory Card+Adapter+Reader	$0.95	1	$0.95
Piano wire (for Braille pins)	$1.43	1	$1.43
Surface mount microSD Socket for Transflash	$3.95	1	$3.95
Custom laser cut chassis from Ponoko	$25.00	1	$25.00
PCB & Misc. parts (connectors, resistors, etc)	$30.00	1	$30.00
		Grand total	$187.91

Total

Grand Total: $18,000 + $187.91 = $18,187.91

Schedule

Week	Task	Member
2/13	- Research for sensors, wireless receiver & battery charging electronics	Mingjie
	- Research for mechanical components (servos), microcontroller & memory	Roy
2/20	- Sign up for Design Review - Finalize and order parts	Mingjie
	- Setup Microcontroller and run test programs - Complete design review	Roy
2/27	- Charging circuit prototyping	Mingjie
	- Interface with one Braille cell working	Roy
3/05	- PCB design	Mingjie
	- Prototype on breadboard the SD card and Memory interface	Roy
3/12	- Individual Progress Report - PCB Design	Mingjie
	- Individual Progress Report - Miniaturize servos and Braille cell form factor and power supply testing	Roy
3/19	- Solder/reflow of PCB components - Testing of Controller Board	Mingjie
	- Prototyping of user interface components such as sensors, buttons, on/off switch	Roy
3/26	- Sign up for Mock-up Demos - Testing of Controller Board	Mingjie
	- Assembly of electronic components for mock-up demo	Roy
4/02	- 3D design of chassis and ordering from Ponoko.com	Mingjie
	- Make Android Demo Application	Roy
4/07	- Power Circuit Testing	Mingjie
	- Testing of Memory and Bluetooth	Roy
4/16	- Final Testing	Mingjie

	- Work on Final Paper	
	- Final assembly of components and chassis	Roy
4/23	- Sign up for Demos	Mingjie
	- Work on Final Paper	Roy
4/30	- Finalize Final Paper	Mingjie
	- Finalize Final Paper	Roy