Making Smart Phones Accessible to Braille Users

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***Abstract* — Smartphones are an important tool in modern life, but they are primarily a visual medium. This poses an accessibility problem for the blind and vision-impaired in interacting with the internet-connected world. The ultimate goal of this research is to create a small, lower-cost braille-type screen reader and display for use with smartphones. The device would use a 6x6 grid of piezoelectrically actuated pins being controlled by an application on the phone. Not just text, but images from the phone can be represented on the device. By producing an affordable touch-based screen reader that can also display images from the screen, smartphone accessibility could be improved for those with vision impairments, which ties into the conference theme of smart accessibility.**

Keywords-braille; haptic; smartphone; accessibility.

I. Introduction

Smartphones have become ubiquitous tools in everyday life. These devices, however, are primarily a visual medium, presenting a challenge for those who are blind or sight-impaired. While electronic braille screen-reading devices exist on the market, they are designed to display text and can be cost-prohibitive at over $500 [1]. The goal of this research is to develop such a device for smartphone use that would be more affordable and display images as well. The device will consist of a smartphone app that connects to a microcontroller to actuate a 6x6 grid of piezoelectrically actuated pins.

Braille and haptic displays have shown themselves to provide great benefit to blind people. Many devices have been developed and tested to help visually impaired people navigate the world independently, such as in the case of Amemiya [4] where the research demonstrates its use within the deaf and blind communities of Japan as a portable wayfinding device. In this case the importance of portability is demonstrated as it pertains to the usability of braille devices in everyday life. Beyond portability it demonstrates the ability for those without sight to use touch as a viable way to interpret the world around them. It is with the understanding of other contributions within the haptics realm that we intend to focus on the user within our research.

Work on this research was started as part of an unpublished master's thesis by Jason Blood at Weber State University and continued by Professor Dhanya Nair [2]. This research was eventually passed on to our team. At the time we received the project, an Android app had been developed which connects to a USB development board (Microchip Technology dsPIC33E); this app would take a screenshot of a portion of the phone's screen, convert it to a bitmap, and send it to the dev board over a USB connection. This setup is shown in Figure 1.

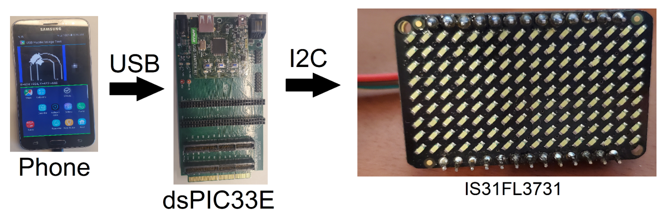

Figure 1. Initial electronics design

This dev board would display the image on a mono-color LED array (Adafruit IS31FL3731) controlled through an I2C (Inter-Integrated Circuit) connection to stand in for the pin array for initial testing. This setup had two problems. First, the dsPIC33E was an older design, and, for its feature set, was more costly and cumbersome than more recent microcontrollers. Second, the board's I2C connection was unreliable, leading to only portions of the LED array being updated at times.

In Section 2, we will describe our current progress on improving and updating the electronic hardware for the device and its accompanying application. In Section 3, we will describe the progress on designing the pin grid to eventually replace the LED array. In Section 4, we will conclude and describe our next future steps on this work.

II. Electronics and Android Application Progress

In order to solve the problems involving the microcontroller with the design we received, we have been working to replace the dsPIC33E with an ESP32. The ESP32 is a more recent microcontroller with extensive support available and a much lower cost (approximately 1/12 the cost to us). In addition, the ESP32 supports a Bluetooth connection. This would allow the device not to need to be physically tethered to the phone. Further,

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Bluetooth connections are easier to develop on the app side due to the API and smartphone support being geared more toward Bluetooth peripherals than USB peripherals. This new design is shown in Figure 2.

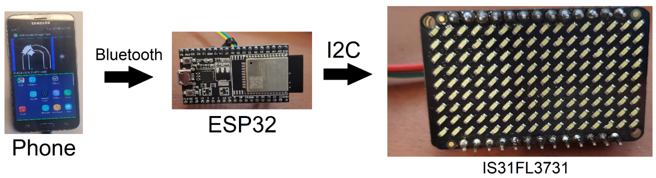

Figure 2. New electronics design

At this time, the app has not been updated to the new design, but using a basic Bluetooth terminal emulator, we are able to send images over Bluetooth to the device to display an image now reliably. Our immediate next step for this would be to update the application to communicate with the new microcontroller.

III. Pin Grid Design Progress and Methodology

To ensure this design's viability in the real world, we are looking to conduct tests using samples and interview schools for the blind to ensure that the implementation of our haptic system fulfills the needs of the blind. The first question we need to answer for this is whether the spacing of the pins is comfortable to read. To test this, we have 3D-printed example 6x6 matrices with different designs and different spacings using measurements from braille standards to stay within the usual parameters followed in everyday braille characters [3]. For these measurements specifically, we are investigating the maximum and minimum values presented in the given ranges, as the difference in millimeters is already small. By 3D printing the models, we can accurately present braille, as seen in Figure 3, and present a final outline of a design without having the design completely present.

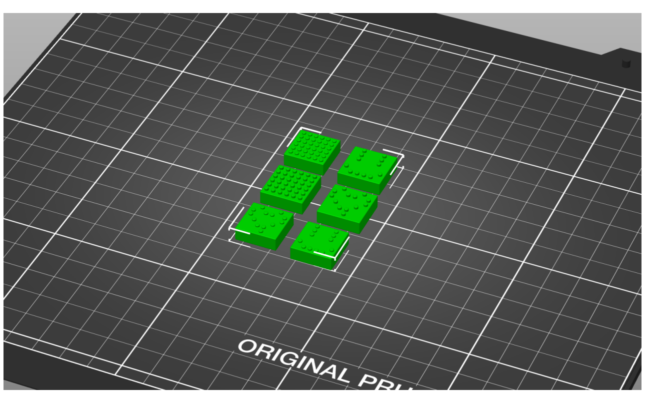

Figure 3. Models of braille matrix designs for testing in the PrusaSlicer software.

This allows a proof of concept and an opportunity for revision before the design is created to ensure minimal problems. Second, it is important to take into account the user in such a design, as without understanding its flaws, we can not offer the best solution. To solve this problem, we plan to gather suggestions on how to make this haptic system work most to their benefit. This will make sure that our design fits the best with the lives of those it is looking to help.

IV. Conclusion and Future Work

Given the progress outlined above, our next steps are developing the haptic board that will have actuated pins and be 3D printed to the specifications determined through the discussion with the blind. This will replace the LED matrix itself but utilize its driver board, which should provide the control signals for actuating the pins in the new matrix. Further testing would also be necessary to ensure its functionality and reliability. Testing with this finished device by blind or visually impaired people will be necessary to test if the device provides greater accessibility to smartphones through displaying images on a portable pin grid.

Acknowledgment

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References

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