Micro Actuator Array for Braille Text Generation

Sumati Singh, Matan Winstok, and Kyle Nova

Consultant: Dr. John Saad

WATERLOO ENGINEERING

UNIVERSITY OF WATERLOO

Introduction

Research Objective

Over the past decade electronic devices have increasingly been paired with touchscreens to give a purely visual feedback to users who provide tactile inputs. One group of people left behind in the touchscreen revolution are the visually impaired. Our objective is to create a low-cost refreshable braille display which could be incorporated into existing touchscreen devices.

Background

Braille text uses small protrusions arranged in block cells in order to represent each letter of the alphabet (Figure 1). Current refreshable braille solutions use piezoelectric materials or pneumatics to produce the necessary actuation [1]. These solutions are extremely expensive, bulky, not portable, and require external power sources. In order to address these issues, the proposed method of actuation is electromagnetic using an array of permanent magnets and solenoid coils [2].

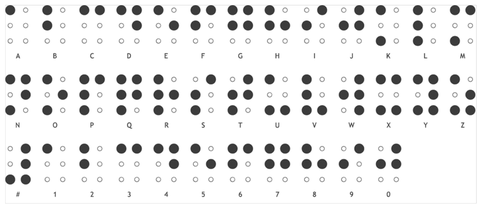


Figure 1: Braille alphabet

Methods

Solenoid coils were hand wound using 38 AWG magnetic copper wire. Each solenoid has a total of four layers comprised of about 80 windings per layer which gives high magnetic force while maintaining low current. The diameter of a solenoid was chosen to match the 1mm diameter of the permanent neodymium (NdFeB) magnets, which were chosen to closely resemble standard braille dimensions [1]. A low-density polyethylene (LDPE) film was chosen for a flexible surface layer that allows the user to feel the protrusions in the 'on' state and also retract the magnets back to the flat 'off' state. The Arduino IDE was used to write custom code to convert an English character input to the correct tactile braille output.

Results

- 35mA of current was necessary to lift each magnet
- Each coil could receive up to 80mA of current from the 5V Arduino output
- The magnet is actuated by a great enough distance to be felt by a human finger
- Heat-shrink tubing was used to provide stability to the coil and the magnet inside
- Each solenoid coil has one wire leading to the 5V terminal and the other leading to the ground (Figure 2)

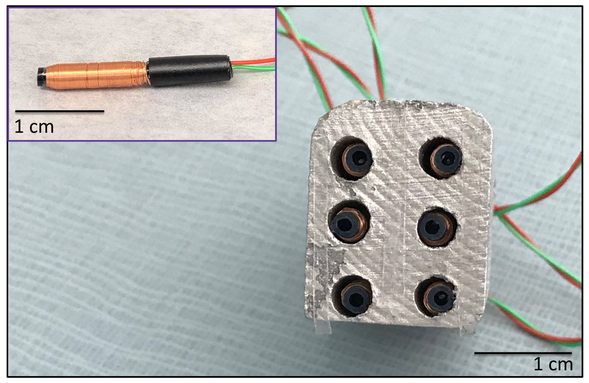


Figure 2: Solenoid array with inset of single coil

The circuit was designed to:

- Provide each pixel in the array its own dedicated 5V terminal (Figure 4)
- Give the user control over each pixel individually
- Allow each braille letter to be formed by selecting the required pixels to be in the 'on' state
- Connect all pixels to a shared ground terminal

Figure 3: Braille array showing the letter O

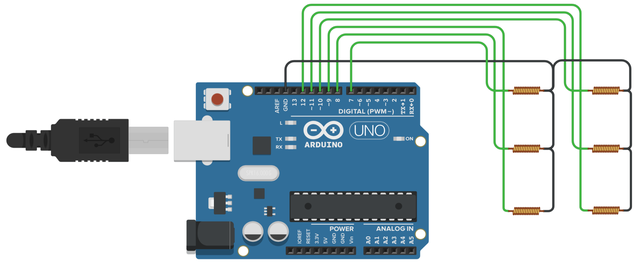
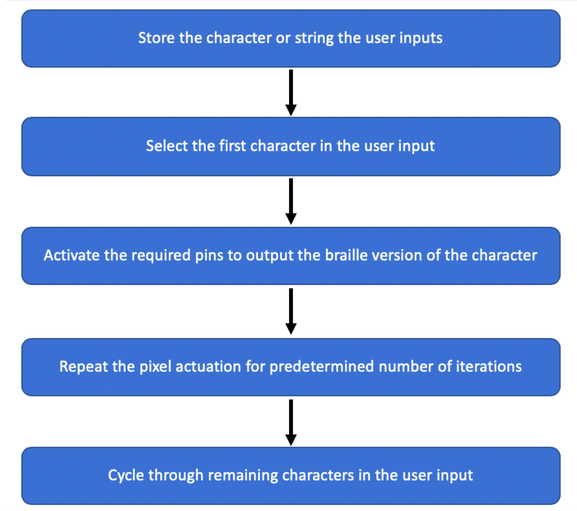


Figure 4: Circuit diagram of actuator array



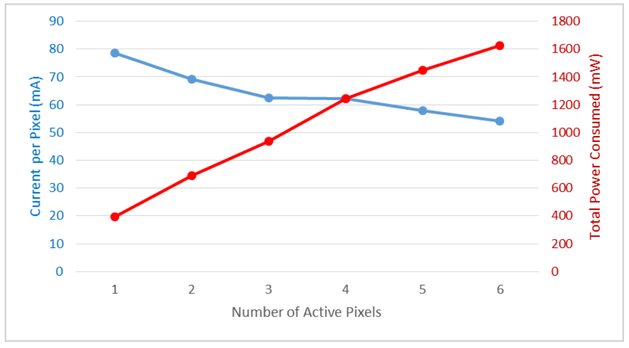


Figure 5: Current output and power consumption

- When all 6 actuators are active simultaneously, the current through each coil does not significantly decrease
- Total power required is less than what can be output from a touchscreen device via USB-C (Figure 5)

Conclusion

Discussion/Conclusion

- Solenoid micro actuators can provide switch-like control to a braille pixel array
- Each actuator can be felt by a human finger and the braille array can be read in a similar fashion to traditional braille text
- The power requirements are low enough that the circuit could be interfaced with a small mobile device
- Limiting factor in scaling down the array to sub-millimetre sizes is the interaction between adjacent actuator magnets

Future Work

- The base material can be selected to reduce the interaction between adjacent actuator magnets
- The flexible membrane layer should be optimized by changing the thickness to provide more consistent actuation and improve user experience
- A custom PCB should be fabricated to replace the Arduino currently being used in order to set desired current outputs and decrease overall size
- Size of the braille array can be increased to display multiple letters simultaneously

References and Affiliations

References

[1] N. Runyan and D. Blazie, "The continuing quest for the 'Holy Braille' of tactile displays", Nano-Opto-Mechanical Systems (NOMS), 2011.

[2] J. Strequea, A. Talbi, R. Viarda, P. Pernoda, and V. Preobrazhensky, "Elaboration and Test of High Energy Density Magnetic Micro-Actuators for Tactile Display Applications," Procedia Chemistry 1, vol.1, no.1, pp. 694-697, September 2009.

Acknowledgements

We would like to thank Dr. John Saad for providing our team with valuable advice and lab resources, Jenn Coggan for support in materials purchasing and lab resources, and Krunomir Dvorski for his technical help in assembling solenoid coils.