The Hong Kong University of Science and Technology

Electronic and Computer Engineering Department

Final Year Project 2022-2023

FPGA-Controlled Single Refreshable Braille Character

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Abstract

According to the Vision Loss Expert Group (VLEG), an international group of ophthalmologists and optometrists, it is estimated that in the year 2020, over 43 million people are blind, while some other 550 million people are experiencing mild to severe forms of vision impairment. For many of the affected, visual impairment (VI) poses a great challenge and severely restricts the activities one may participate in. For instance, the VI might not be able to learn to read and write properly.

Attempts to aid the VI in such endeavors were first introduced in 1869, when the braille code was invented by Louis Braille. The braille code was then widely adopted to bring literature to the blind. Today, apart from traditional braille products such as braille books and braille displays, innovative technologies such as assistive touch, which are more commonly found on mobile phones, have proved highly useful in this context. As our society advances technologically, with the advent of newer and more advanced accessibility tools such as audio technology and audio books, it is no surprise that many find difficulty in grasping the relevance of the braille system nowadays. That said, the applications for braille are still widespread in our daily lives. Whether it be from public bathrooms to elevator panels; or from ATMs to floor plans, braille can be found in most public facilities and amenities. Additionally, learning braille also boosts one's independence, reducing the necessity of asking for sighted help. There is still much that one might gain from learning braille.

The most traditional way to learn braille is through braille books - physically huge books that consists of "dots" that are embossed onto the pages itself to make up alphabets, numbers, punctuation and others. With the introduction of electronic braille devices, we no longer have to read from bulky braille books but from one that is portable and could be connected to computers smartphones. While there are abundant benefits of electronic braille displays, these devices usually come with a hefty price tag and may not be accessible especially to those in developing countries.

Here, in our final year project, we present our device – the FPGA – Controlled Single Refreshable Braille Character in an attempt to re-produce our own braille display, with similar features to existing braille displays. A Field Programmable Gate Array (FPGA) was chosen for this design to ensure minimal latency for the control of braille pins. Our FPGA model, BASYS 3, offers a wide range of input/output ports, switches, and push buttons, enabling us to prototype a servo motor-based design for our braille display. Six SG-90 motors were chosen to provide the actuation for each of the "dots" in a braille character for its low profile and power consumption.

The actuation mechanism for braille characters is a combination of the motion of servo motor armatures and "sliders", which are small mechanical parts manufactured entirely with 3D printing technology. The principle of our design is a unique "sliding" mechanism. Each of the six braille pins is associated with its own slider. During a "sliding", each of the six braille pins can be independently elevated from its enclosure within the braille cell when the "slider" slides across and vice versa.

In addition to the unique mechanism, the braille system also comes with companion software to provide a seamless user experience to the user. When the braille device is connected to a computer, typing strings of text using the software will allow the user to send that set of text to the braille display. Upon receiving, the braille device would display each of the characters consecutively, one after the other with a controllable time interval in between. Conversely, the braille device also allows the user to send texts from the braille device to the computer. By manipulating the onboard switches, the user can select the appropriate braille character to be sent to the computer. Finally, to enclose all of the components in one single package, an external case featuring dimensions of 16cm X 20.7cm X 3.1cm was manufactured entirely with 3D printing, making our system both lightweight and compact.

In conclusion, our completed braille display prototype was able to accomplish the goals it was conceived for. Both reading and writing functions can be accomplished effortlessly during our testing. While there are many possible future works and improvements to our project, it is our hope this work may provide insights and inspiration to address the accessibility needs of the VI.