THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY | DEPARTMENT OF ELECTRONIC & COMPUTER ENGINEERING

FPGA-Controlled Single Refreshable Braille Character (LY02a-22)

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Introduction

Overview

Globally, over 253 million people are affected by visual impairment (VI) and depended on visual aids such as braille books and braille displays. However, these products are bulky and expensive which makes availability scarce. Therefore, our project goal is to innovate a solution to address these shortcomings.

A Braille Cell

A Braille Book

Background: The VI rely on braille products to access digital resources.

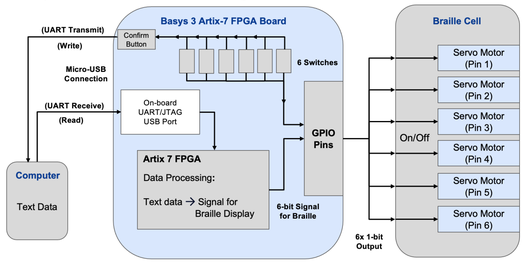
Problem: Existing Braille products are bulky and expensive.

Solution: Single Refreshable Braille Display that is portable and affordable

Objectives

1. Design and manufacture the braille device - a single-celled braille display.
2. Integration of an FPGA with the braille device and establishment of a data connection with a computer.
3. Program the FPGA to receive user input via keyboard and output braille characters via braille display and vice versa, send input from braille device to computer through switches and buttons onboard FPGA.

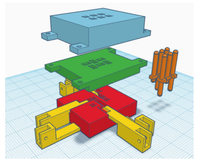
Overall System Block Diagram



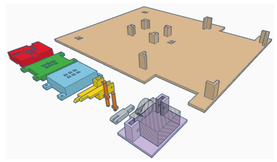
Implementation

Design of the Single Refreshable Braille Display

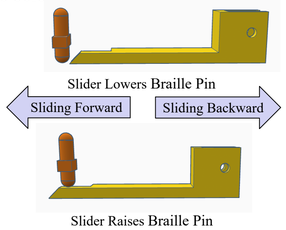
Our design utilizes servo motors and mechanical sliders designed using computer software. A total of 6 servos were adopted, one for each braille pin. Each servo is connected to a slider that, when activated, slides forward and pushes the braille pin upwards and outwards from its within its enclosure. This mechanism is briefly illustrated below in the figure below.



Design Layout of the Braille Cell

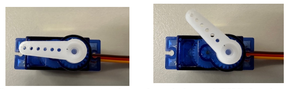


3D Design of all components of the Braille Display.



Integration of FPGA with Braille Display

An FPGA was chosen to be the control system in favor of its high performance in concurrent processing and low latency. Dupont cables connected the servo motors to input/output ports on the FPGA. The FPGA was programmed in Verilog HDL to inject appropriate pulse width modulation (PWM) values to servo motor. The servo motors would rotate to different angles, subsequently retracting or extending their attached armature.



The servo arm rotates based on injected PWM value

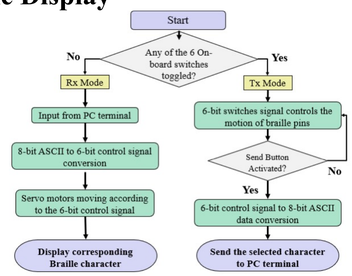
Retracted Servo Armature

Programming the Firmware of Braille Display

In addition to basic controls, additional software is required to support the read and write functions of the braille display. This task involves two sub-tasks:

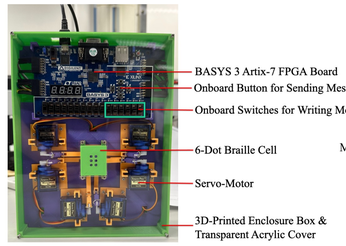
1. Establishment of a serial connection (UART) between the braille device and computer to facilitate the transmission and reception of data.
2. Mapping of ASCII representation of alphabets and numbers to their respective Braille encoder.

A simple flow diagram for this part is shown beside.



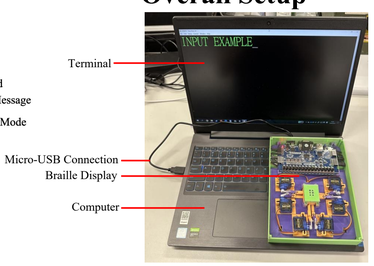
Result & Evaluation

Final Product



Top View of the Braille Display

Overall Setup



Braille Display connected with Computer

Results

Reading Mode

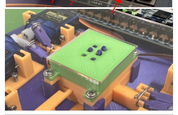
1. Input character "**U**" on the terminal

2. Close-up of the braille cell. The braille representation of character "**U**" is shown.

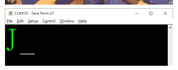
For reference:
Braille representation of character "**U**" and "**J**"

Writing Mode

1. Manipulate corresponding switches to display the character "**J**" on the braille cell.



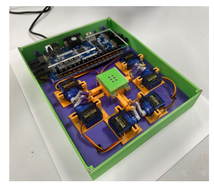
2. Press the confirm button (circled in red)



3. The received character "**J**" is displayed on the terminal program on a computer

Conclusion

We were able to produce a product with an estimated cost of HKD$1900, making it an **affordable, portable, and easy-to-use** braille display. In addition to the device's novel mechanism, it also comes with features such as read and write functions. While our project had achieved desirable results overall, we believe further enhancements could be made through future works such as scaling up the number of braille cells and improving the ergonomics of the device for a more comfortable user experience.



Completed Braille Display