BrailleSense: Real-Time Digital Text to Braille Converter

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1 Problem Statement

Braille literacy is critical for the independence and education of visually impaired individuals. However, many current solutions for converting digital text to Braille are expensive and inaccessible to those in need. The goal of this project, "BrailleSense," is to create an affordable and portable device that converts text into Braille in real time. The device will provide a practical and accessible solution for visually impaired individuals, allowing them to read any form of text content on the go. According to the World Health Organization (WHO), over 285 million people worldwide are visually impaired, and many rely on Braille for reading and writing. Current refreshable Braille displays, which can convert text to tactile Braille characters, are prohibitively expensive for many users, with prices often exceeding thousands of dollars. Furthermore, these devices tend to be bulky and limited in functionality, restricting their usage in real-life scenarios like reading from mobile devices or computer screens. This project seeks to provide some remedy to the lack of access to devices that also translate physical texts - like those in books or on signs - into Braille.

2 Literature Survey

The development of Braille displays using piezoelectric actuators and microcontroller systems is explained profoundly [1]. It highlights the challenges of ensuring tactile accuracy and the need for lightweight, portable devices. It is relevant for understanding hardware components for Braille-based devices and the limitations of current systems in terms of power consumption and refresh rate.[2] The details about converting digital images of text into Braille using OCR-technology is explained here. It introduces methods to enhance image processing for better text recognition and translation to Braille, addressing the issues of translation speed and accuracy. [3] The cost effectiveness and a portable design is a major issue for such devices and that is discussed and handled in (Johnson, L., & Smith, R. A portable, low cost Braille Reading device) reducing production cost. The review covers various Braille interface technologies, analyzing current trends in mechanical and electronic Braille displays and claims that future research should aim at improving actuator materials and enhancing the durability and tactile sensitivity of refreshable braille displays [4].

3 Deliverables

A functional prototype that can *at least* take in images and extract characters – either by fully ingesting a word and separating out that word into characters or processing into characters directly through the use of some stochastic algorithm (or other method that is less computationally impactful, but most probably through a computer vision based ML algorithm), and then output some Braille-encoded character to a skin-contact actuator in a dynamic manner.

Individual deliverables:

- Text ingestion
    - Camera → OCR Algorithm
        - low resolution camera (low enough to accurately read a printed word, but not too high to significantly increase processing power/camera quality requirements)
        - The algorithm first extracts the text from the image.
        - The algorithm identifies what the text contains and outputs a letter or number (or punctuation).
- Text processing algorithm
    - A CNN or similar extracts and identifies characters with high accuracy
    - Trained on some external dataset of letters.
    - This dataset should be printed letters, *however* there is potential in also training the algorithm on some handwritten characters.
- Processing
    - Processing can probably be done through an Arduino or some other prebuilt circuit with ad-hoc programming.
    - The processor does not need to have high computational power to process *only* letters, even when running an OCR-trained algorithm
        - If the computer has some low-power GPU or vector core, processing becomes less of an issue.
        - Buses do not necessarily need to be high-speed or throughput, they just need to be fast enough to input some analyzable file from the camera as well as output either a single character or character array to the actuator.
- Actuator
    - The actuator should receive some packet of Braille data and output a physical change in the device that allows the user to feel/read the letters output by the algorithm

4 Topics covered in Class

1. SPA Paradigm
    a. The robot follows this paradigm by the following mapping:
        i. Sense: The robot "senses" text and produces some positive feedback to the user to produce some sensory feedback
        ii. Plan: The robot plans for, "motion" that is provided by the user
        iii. Act: The robot acts upon its surroundings upon camera-contact (and activation) with text that it can identify and actuates the result
2. HAAT (Human Activity Assistive Technology) model
3. Tactile Sensors
4. Deep Neural Networks.
5. Control Systems
6. Human Experimental methods
7. User interfaces
8. Economic and Social considerations
9. Ethical and regulatory considerations
10. Autoencoders (Tentative)

5 Plan of Action

Week 1- 2: Hardware Design and Procurement (10/15/2024 - 10/22/2024)
Deliverable: Hardware schematic, BOM (Bill of materials)

Week 3-4: Software and Prototyping (10/23/2024 - 10/29/2024)
Deliverable: Basic software that converts text into Braille and hardware prototype setup

Week 5-6: Testing and Refining Prototype (10/30/2024 - 11/6/2024)
Deliverable: Working prototype and feedback for initial testing

Week 7-8: User Testing and Optimization (11/7/2024 - 11/14/2024)
Deliverable: Refined and user-friendly version of BrailleSense

Week 8-9: Final Touches and Documentation (11/15/2024 - 11/22/2024)
Deliverable: Comprehensive project report and video

Week 9-10: Presentation (11/23/2024 - 12/6/2024)
All members present the project and submit the final report, working prototype, detailed documentation, challenges and outcomes, final project video

6 References

[1] Chhabra, Y., & Khanna, P. (2016). **Braille Display for the Visually Impaired using Actuators and Microcontrollers**. *International Journal of Advanced Research in Computer Science and Software Engineering*, 6(6), 300-305.

[2] De Silva, P., & Fernando, C. (2018). **Real-Time Text to Braille Conversion Using Optical Character Recognition**. *IEEE International Conference on Industrial and Information Systems* (ICIIS), 345-350.

[3] Johnson, L., & Smith, R. (2020). **A Portable, Low-Cost Braille Reading Device: Design and Evaluation**. *Journal of Assistive Technologies*, 14(3), 200-210.

[4] Meng, L., & Zhang, T. (2021). **Braille Interface Devices: Current Trends and Future Directions**. *IEEE Transactions on Haptics*, 14(2), 133-145.