BrAID: A Portable Device for Real-Time Text Recognition and Braille Output for the Visually Impaired and Individuals With Dual Sensory Impairment

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The ability to perceive the world through vision plays a vital role in daily life. However, over 2.2 billion individuals worldwide live with visual impairments, often resulting in long-term limitations in independence and accessibility. Voice-based assistive technologies, commonly used by visually impaired individuals, often fail in noisy environments or public settings where auditory feedback is impractical. For individuals with dual sensory impairments, the challenges are even more severe. Independent communication and navigation are often impossible without external assistance. Existing braille display systems are typically bulky and prohibitively expensive, leaving many without access to essential text-based information. To address these limitations, we developed BrAID, a compact, real-time text-to-Braille converter designed to support the independence of individuals with visual and dual sensory impairments. BrAID consists of a fingertip-mounted refreshable Braille cell, a palm-sized PCB with an ESP32-based control board, and an ESP32-CAM module. Captured images are processed using a YOLOv11 object detection model to identify key non-textual visual elements such as traffic signs. For text, Google Cloud Vision OCR, selected for its superior accuracy and speed, is used to extract both printed and handwritten content. The recognized text is then optionally translated and displayed in Braille. Reading speed (five adjustable levels) and language settings are configurable via a mobile web interface. BrAID weighs only 114.5 grams, which is over 75% lighter than conventional alternatives that exceed 500 grams. It is also highly cost-efficient, with a total production cost of $78.03, showing a significant reduction compared to existing solutions priced from $500 to $15,000.

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