ELECTRICAL & COMPUTER ENGINEERING
UNIVERSITY OF MICHIGAN

Hands-free Typing & Text-to-Speech using Eye-Tracking

EECS 452: Digital Signal Processing Design Lab – Fall 2024
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Introduction

Many disabilities (e.g., facial or other muscle paralysis) affect people's ability to use electronic devices, specifically typing. Furthermore, those with facial paralysis often can't speak normally. By using eye-tracking to map eye movement onto a virtual keyboard, users will be able to type out words and sentences, hands-free, and then have it play back via text-to-speech.

Techniques

Pupil Detection: First, we use an open-source Python library called mediapipe [1] to do face landmark detection. These "facial landmarks" are pictured in Figure 2. They are produced by a pre-trained end-to-end neural network. We then select the facial landmarks corresponding to the pupil centers, i.e., two (x,y) pairs of coordinates in the camera image.
Calibration: We use a four-step calibration process that learns a perspective transformation to map the pupil centers to a cursor on the virtual keyboard (Figure 4).
Cursor Output: The perspective transform is applied to the camera feed to map the person's pupil positions to the virtual keyboard in real-time.
Text-to-Speech: Implemented with open-source Python library 'pyttsx3'.

System Setup

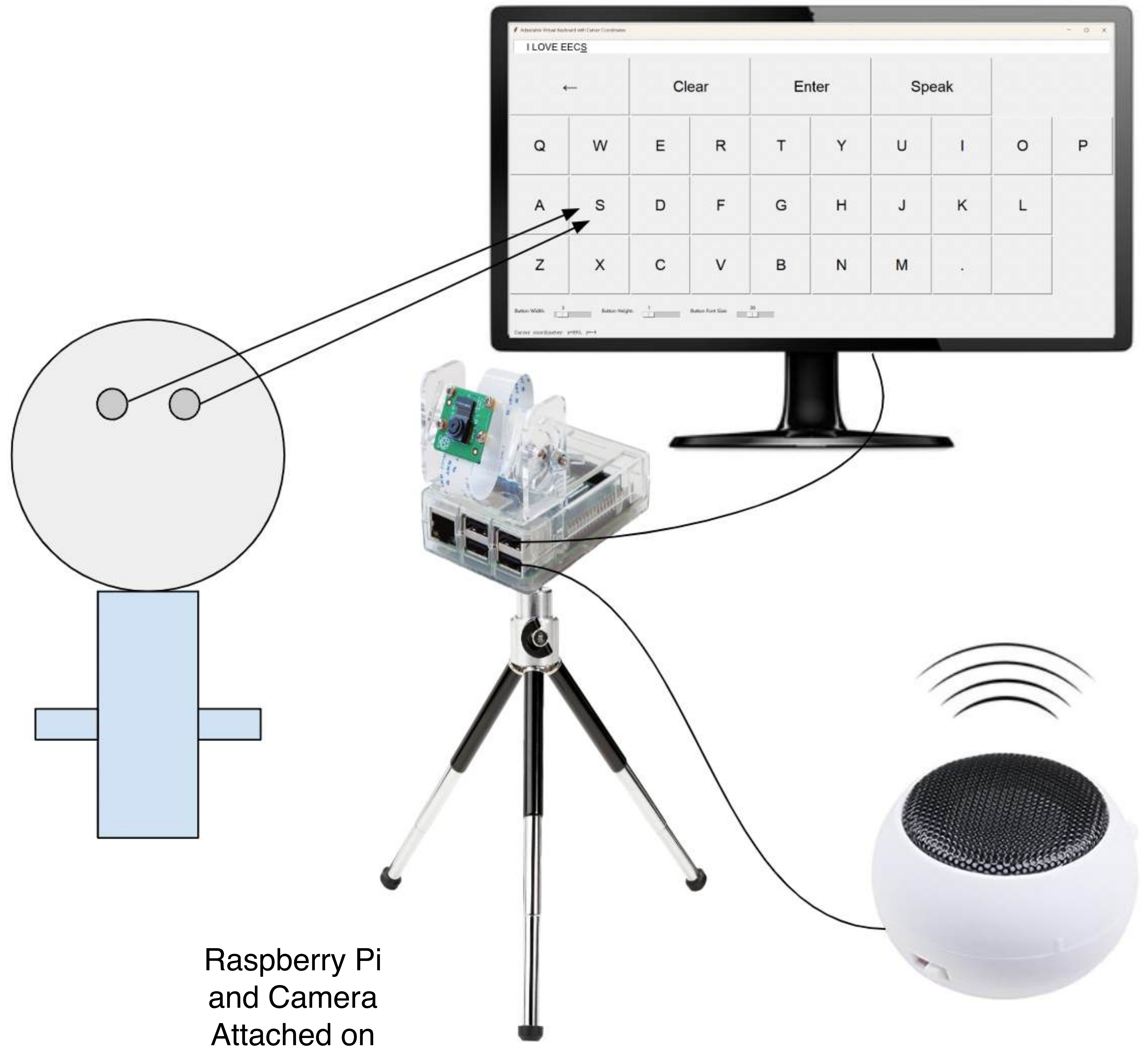


Fig 1: Final System Setup

Fig 2: Facial Landmarks from Mediapipe

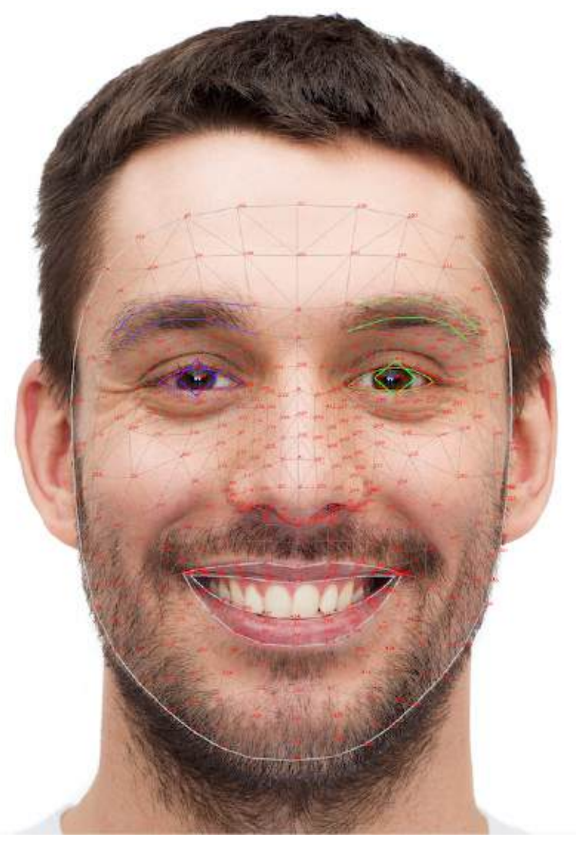
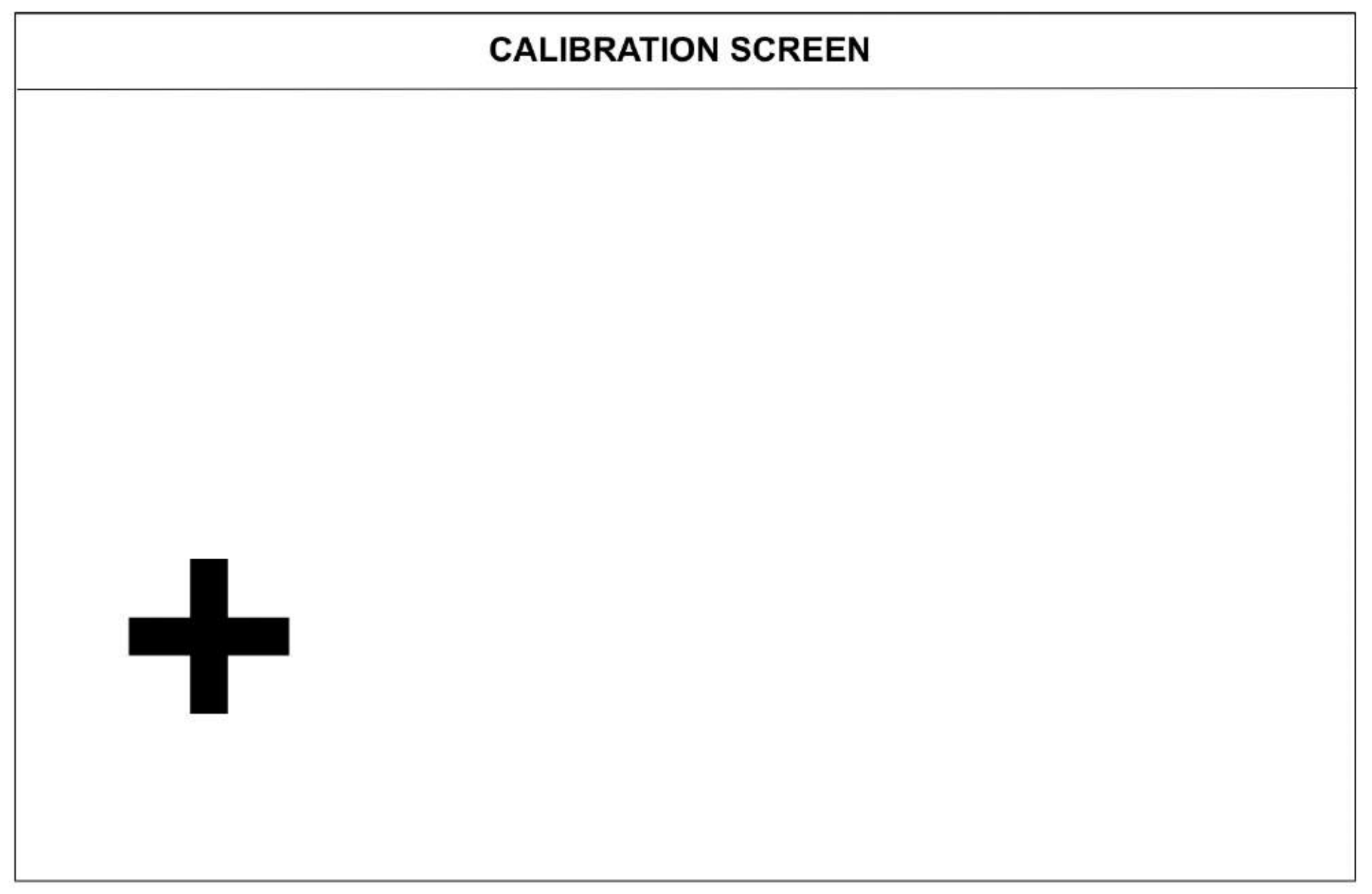


Fig 3: Pupil Positions

Fig 4: Step 1/4 of Calibration



Results

With practice, it takes about 1 minute to type and speak "HELLO WORLD" (hence, 11 CPM). The cursor noise, although we significantly reduced it through filtering, is still present, which increases the typing time.

Conclusion / Future Improvements

Our system provides a relatively cheap (<$100) functional eye tracker, assuming no head or face movement, with some noise. Future improvements include using near-infrared light for better eye measurements, and a higher resolution / framerate camera for less noisy estimates. Also, more advanced (e.g., deep neural network / transformer) models for pupil -> cursor mapping.

Acknowledgements

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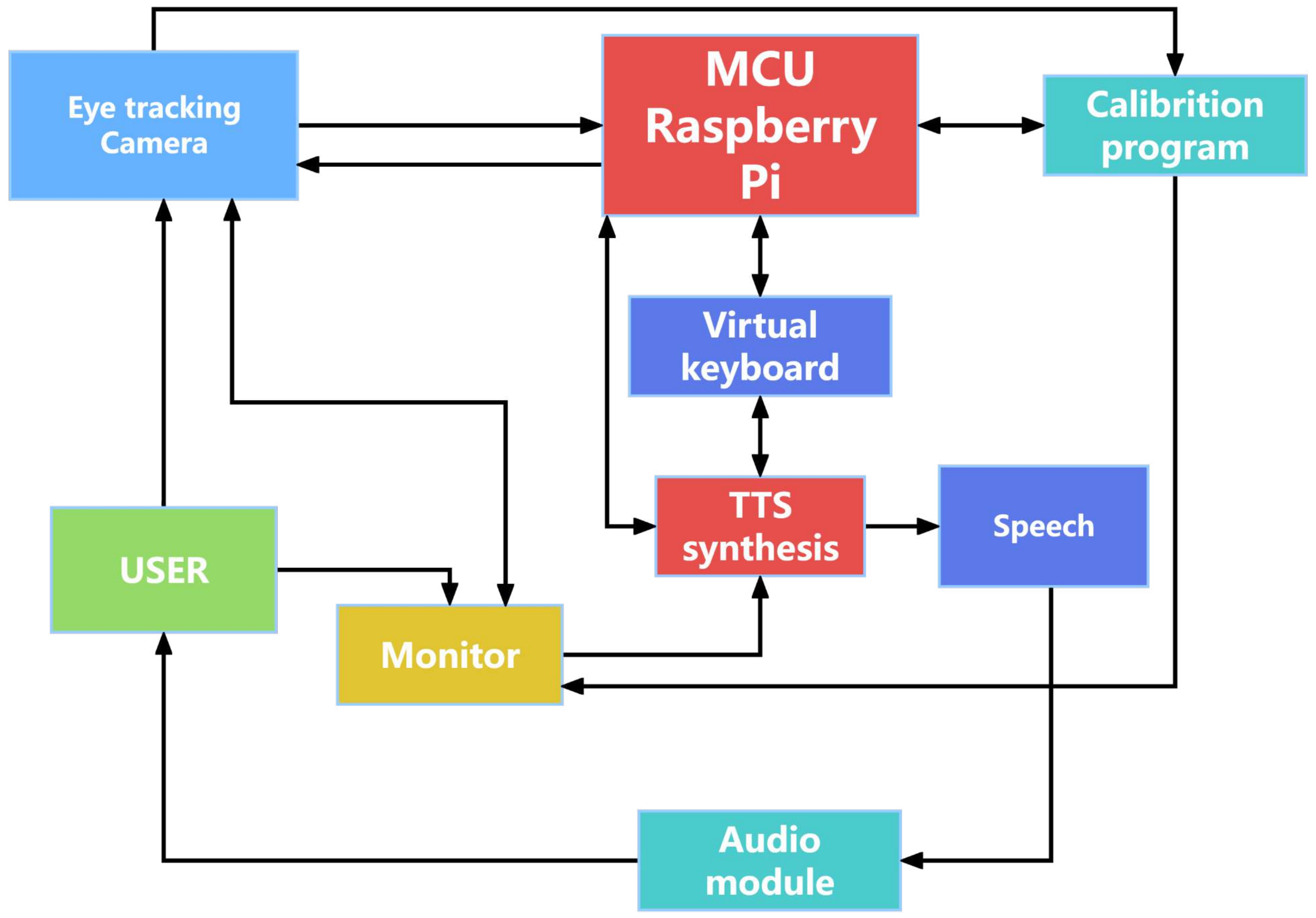
System Architecture


Eye tracking Camera
MCU Raspberry Pi
Calibrition program
Virtual keyboard
TTS synthesis
Speech
USER
Monitor
Audio module