Eye Pupil Detection Using Open CV And Python

Johnal Dsouza[1] Abdullah Abdullah[1] Kristof Van Laerhoven[1]

University of Siegen[1]

Introduction

The purpose of this project is to detect the position of the pupil in an image or video, thus enabling ubiquitous eye-tracking applications such as Gaze Estimation, Human-Computer-Interaction, Advanced Driver Assistance. Accurate pupil detection is crucial as errors in detection can degrade the performance in its respective applications.

Our project proposes a method for robust real time pupil detections using computer vision techniques with improved accuracy and detection speed which can be integrated into embedded architectures.
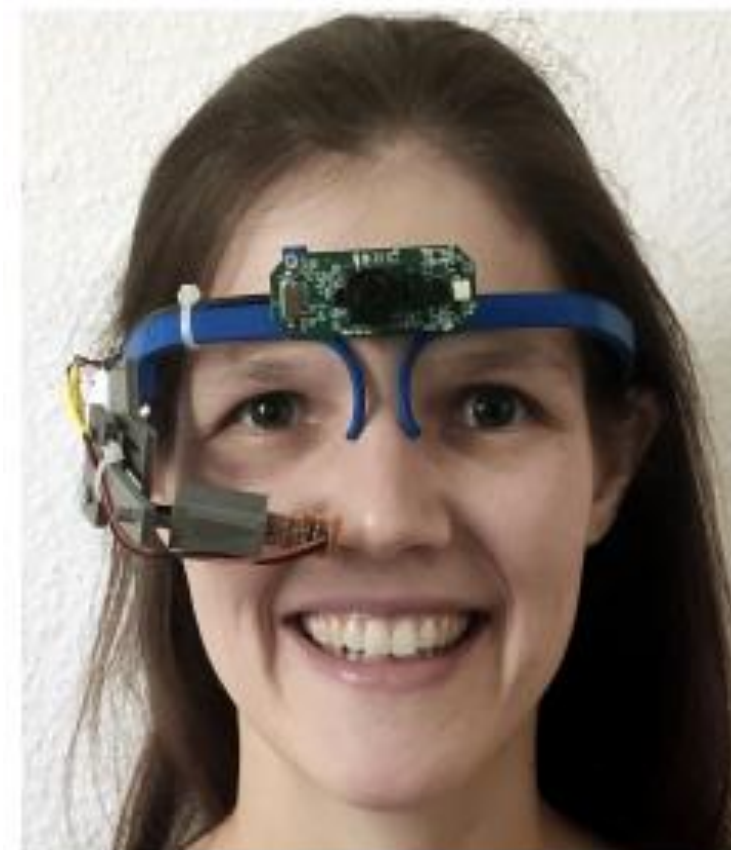
Previous Work

[1] presents an embedded system for real-time pupil detection on a wearable device, along with a pupil detection pipeline using edge analysis.

While [2] is a novel algorithm for robust and fast pupil detection in real-world environments based on ellipse evaluation of a filtered edge image.

Code:
https://github.com/JohnalDsouza/Robust-Pupil-Detection-Algorithm.git

Methodology

- Selecting a region of interest (ROI) from the input source and convert it to grayscale and perform CLAHE contrast enhancement.
- Utilization of both Median and Gaussian blurring effectively reduces noise, providing improved edge detection using Canny algorithm resulting in overall faster processing speed, contributing to more accurate and efficient pupil detection. Morphological closing operation closes the gaps between detected edges, improving contour detection.
- The detected Contours are filtered based on certain area and circularity criterias and only the best circular contour based on circularity is considered as a potential pupil candidate.
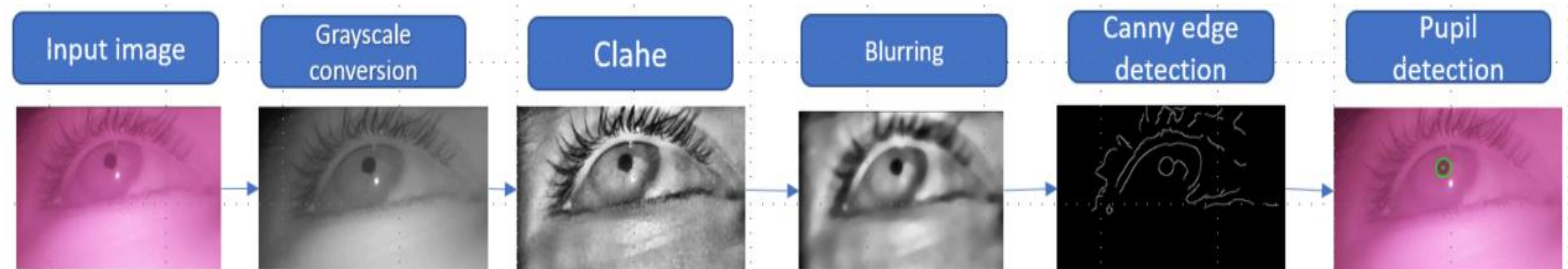
Results

Our method was evaluated on two new hand-labeled dataset consisting of approx. 1500 images. The achieved results are mentioned in the table. The incorrect detection were usually caused when the pupil looks at the very extremes corners of the eye. The measured run-time was 9.24ms per image on a intel i7-10750H CPU (2.60GHz)

	Dataset 1	Dataset 2
Accuracy	88.53%	72.75%
F1 Score	93.91%	84.25%
Precision	98.81%	97.62%
Average FPS	150.04	149.27

Conclusions

The proposed Eye Pupil Detection algorithm provides a reliable solution for various ubiquitous eye-tracking applications due to its high precision, reasonable accuracy and faster speed.

References:
[1] Raj, A., Bhattarai, D., & Van Laerhoven, K. (2023). An Embedded and Real-Time Pupil Detection Pipeline. *arXiv preprint arXiv:2302.14098*.
[2] Fuhl, W., Santini, T. C., Kübler, T., & Kasneci, E. (2016, March). Else: Ellipse selection for robust pupil detection in real-world environments. In *Proceedings of the ninth biennial ACM symposium on eye tracking research & applications* (pp. 123-130).