Pupil Detection on Images

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Objective: This thesis proposes an algorithm for pupil detection on eye images and videos. Different image-processing algorithms are combined and their performance is evaluated on the Labeled Pupils in the Wild (LPW) data set of near-infrared (NIR) video streams. The goal is to find a robust and effective combination of methods for precise pupil localization.

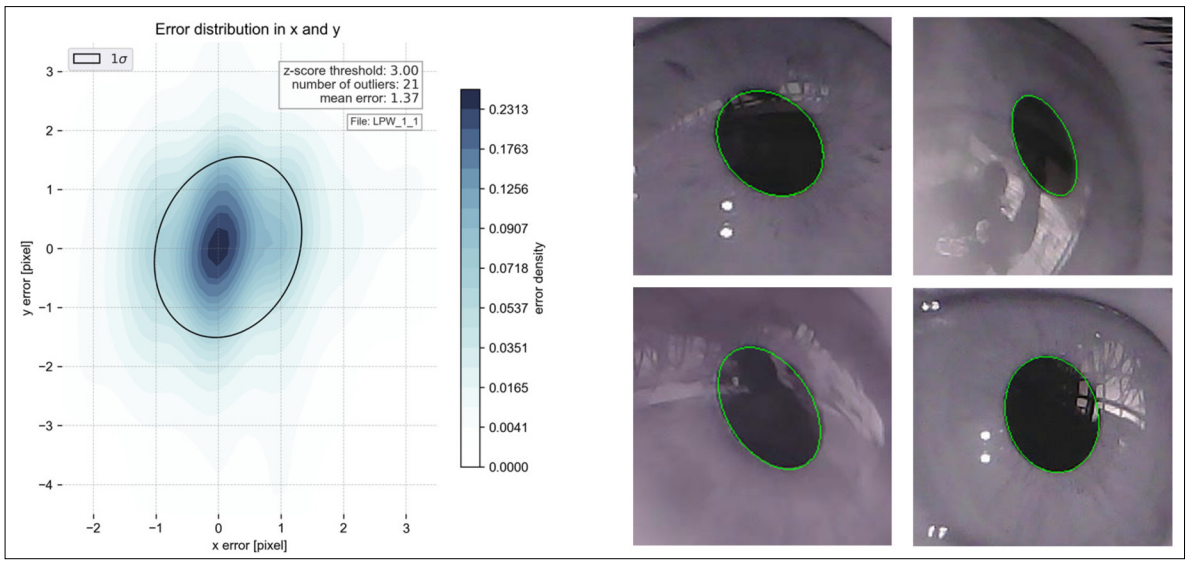
Approach: The data set is analyzed and challenges are discussed. The proposed image processing pipeline is composed of two parts: (a) the pupil localization on a frame, and (b) the fitting of an ellipse to the pupil's boundary. In part (a), thresholding, edge detection, and Haar-like features are compared. Part (b) contrasts contour segmentation, RANSAC and active contouring. Performance measures of the algorithms are evaluated for the image data set and discussed for different levels of image noise and corneal reflections.

Result: The best performing pupil detection algorithm is based on a Haar-like feature method. The pixel with the strongest response is considered to lie inside the pupil. This location is then used as a seedpoint to determine an initial contour inside the pupil. The iterative ACWE method is then used to identify the pupil boundary. The result is a binary mask of the pupil area. The contour of this mask provides the input to a RANSAC algorithm for finding the best ellipse, while ignoring outliers caused by corneal reflections. The ellipse provides a close approximation to the true pupil parameters on the LPW dataset's images.
The algorithm operates at 1.3 fps with a mean error of 1.4 pixels for a 2000-frame video, achieving a 98.9% success rate. The Performance varies based on noise levels.
The developed pupil detection algorithm will be used in a subsequent work to automatically and thus efficiently label large datasets of critical video streams. These will be used together with data augmentation to train a highly reliable AI-based eye tracker.

Experimental setup of the LPW data set to record the eye area.
Source: arXiv:1511.05768

Active contouring without edges, the red dot is the location of the best response from the Haar-like feature.
Picture from LPW with own overlay

Result of the evaluation of the algorithm over 2000 frames (left) with solutions for the pupil approximation (right).
Pictures from LPW with own overlays



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Subject Area
Image Processing and Computer Vision