



Eye-Tracking System Under Different Lighting Conditions

EECS 225B
Class Project Presentation

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Outline

- Eye-tracking System
 - Face Detection
 - Eye Detection
 - Pupil Localization
- Low-light Enhanced Eye-tracking System
 - Low Light Enhancement
- Demo
- Reference

Eye-tracking System

- Input: Image from WebCam
- Resize: 1080x1920x3 to 320x240x3 to reduce the processing time
- Face Detection: Faces within the image
- Eye Detection: Eyes within the face
- Pupil Localization: Pupils within the eye
- Output: Image with annotations on the pupils



Face Detection

1. Haar Cascade
2. HOG Frontal Face Detector + SVM
3. MTCNN
4. DNN Frontal Face Detector

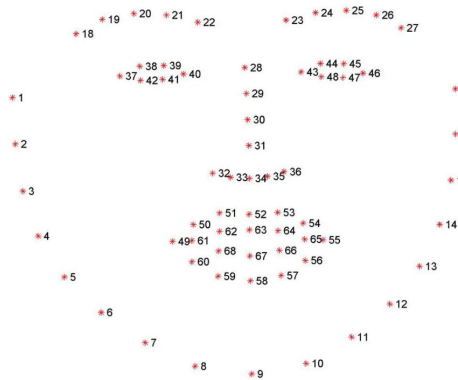


[Table 1.] Face-Detector Comparison (FPS)

Method	HAAR Cascade	HOG	MTCNN	DNN
FPS	1.92	3.79	0.52	9.98

Eye Detection

- 68-facial Landmarks Detector
 - 37-46 points are in interested.



- Blue shades mark the eyes.



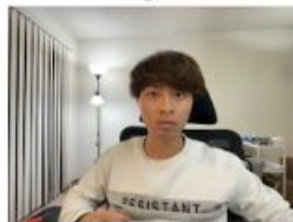
[Table 2.] Face-Detector + 68-point Eye Detector Comparison (FPS)

Method	HAAR Cascade	HOG	MTCNN	DNN
FPS	1.84	3.62	0.61	9.91

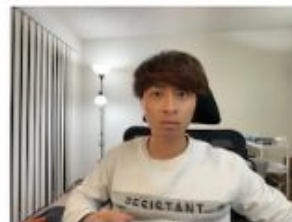
Pupil Detection

- Fill eyes area
- Dilate and segment out the eye area
- Threshold out the eyeballs
- Find the contours of the eyeballs
- Locate the pupil (centroid of the eyeballs)

Original



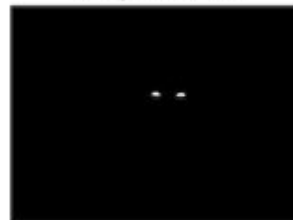
DNN Face Detector



68 Eye Detector



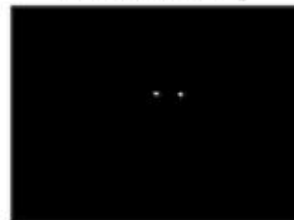
68 Eye on Mask



Segment the eyes



After Thresholding

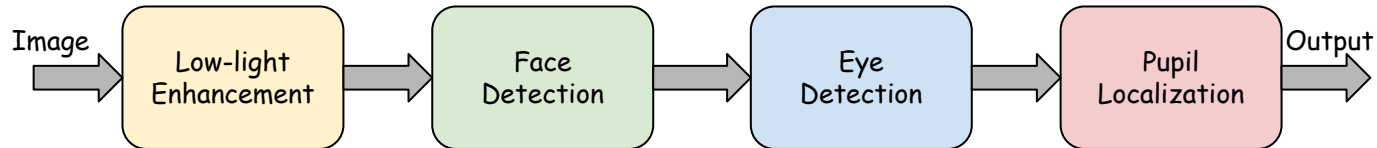


Result



Low-light Enhanced Eye-tracking System

- Input: Image from WebCam
- Resize: 1080x1920x3 to 320x240x3 to reduce the processing time
- **Low-light Enhancement:** Output enhanced image
- Face Detection: Faces within the image
- Eye Detection: Eyes within the face
- Pupil Localization: Pupils within the eye
- Output: Image with annotations on the pupils



Low Light Enhancement

1. LIME
2. Dual Illumination Estimation
3. Zero Deep Curve Estimation

[Table 3.] Low Light Enhancement Comparison (sec/frame)

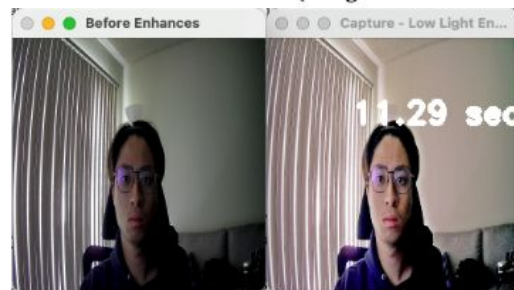
Method	LIME	Dual Illum. Est.	Zero DCE
Sec per frame	0.87	1.75	11.29



[Result of LIME (Image size = 320x240x3)]



[Result of Dual Illumination Est (Image size = 320x240x3)]



[Result of Zero DCE (Image size = 320x240x3)]

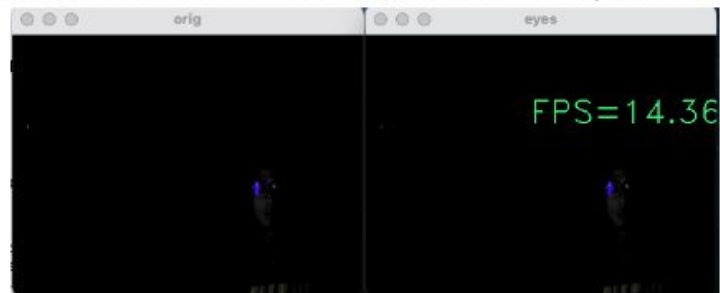
Low Light Enhancement

- DNN Face Detector
- LIME + DNN Face Detector

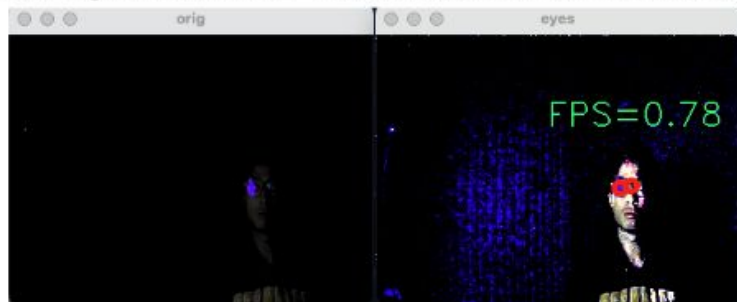
Tradeoff:

Because DNN itself could do well under dim environment. Only when we want to track eyes under extremely low light conditions then sacrifice FPS for the accuracy.

[Result of DNN face detector + 68-facial landmark eye detector]



[Result of LIME low light enhancement + DNN face detector + 68-facial landmark eye detector]



Demo

[Click!]





Reference

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- [5] Q. Zhang, Y. Nie, W. Zheng, "Dual Illumination Estimation for Robust Exposure Correction," arXiv:1910.13688
- [6] X. Guo, Y. Li and H. Ling, "LIME: Low-Light Image Enhancement via Illumination Map Estimation," in IEEE Transactions on Image Processing, vol. 26, no. 2, pp. 982-993, Feb. 2017, doi: 10.1109/TIP.2016.2639450.
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- [8] C. Guo, C. Li, J. Guo, C. Change Loy, J. Hou, S. Kwong, R. Cong, "Zero-Reference Deep Curve Estimation for Low-Light Image Enhancement," arXiv:2001.06826
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