iLid: Low-power Sensing of Fatigue and Drowsiness Measures on a Computational Eyeglass

SOHA ROSTAMINIA

ADDISON MAYBERRY

DEEPAK GANESAN

BENJAMIN MARLIN

JEREMY GUMMESON

UMassAmherst

Why Measure Fatigue?

How Do We Measure Fatigue?

Percentage of Eye Closure (PERCLOS)

Blink Duration

Blink Frequency

Why Not Use Existing Technologies?

We need:

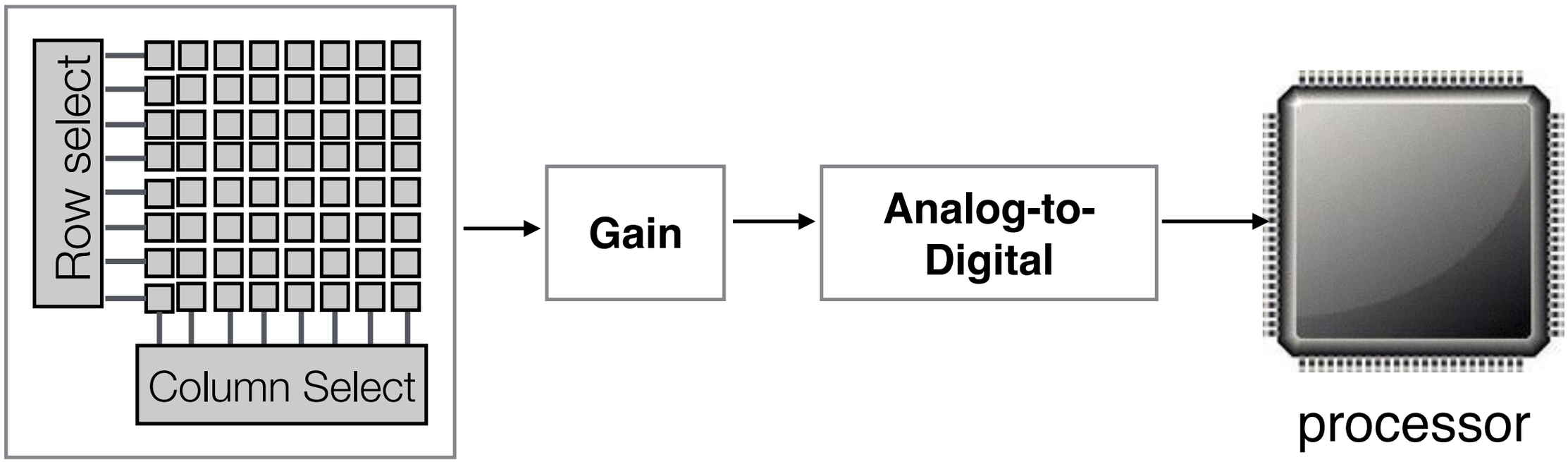
Low-power

Portable

Accurate

Robust

The Challenge for Reducing Power Consumption



imager

processor

Problem: Digitizing and processing too many pixels

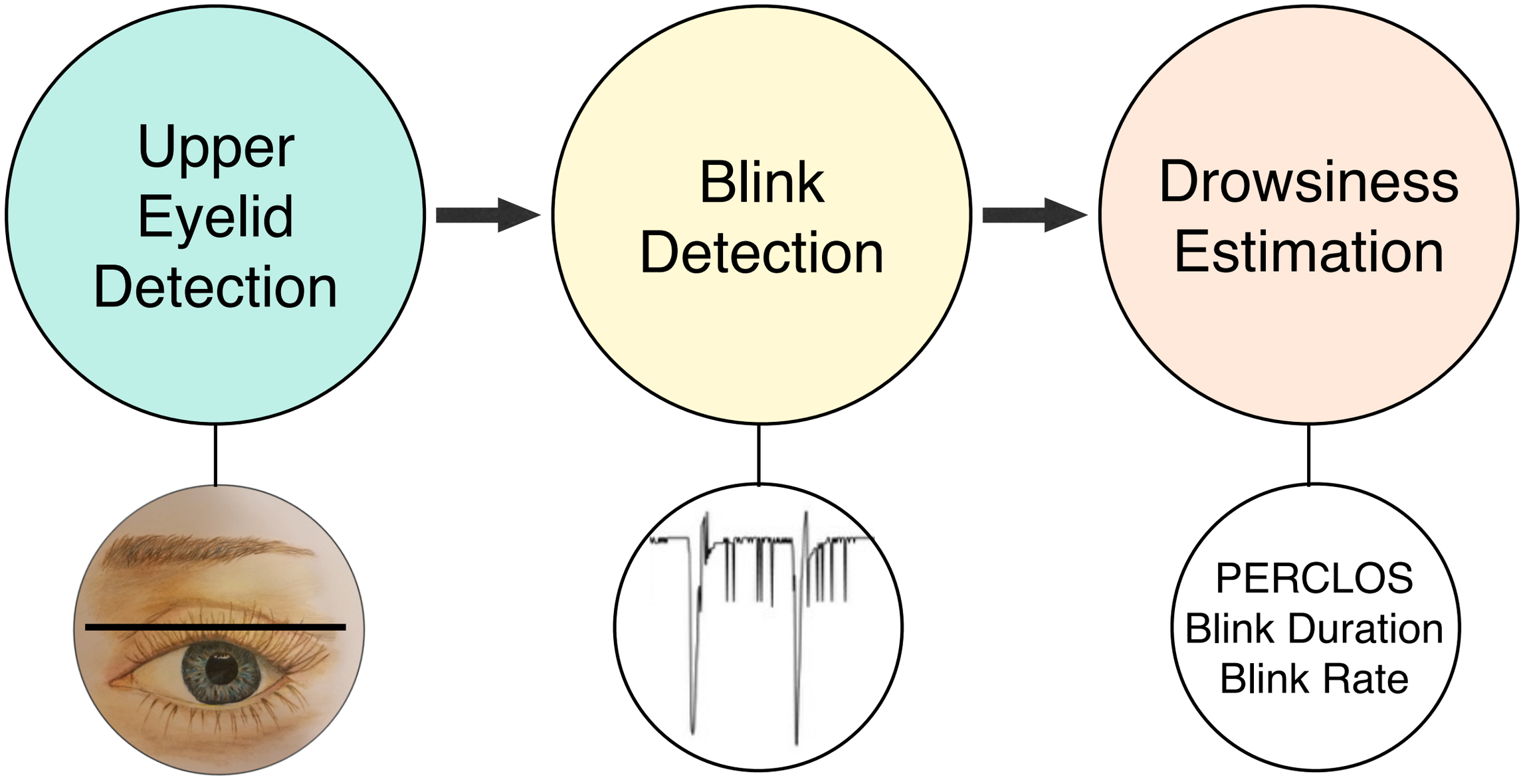
iLid

Contributions:

- Accurate measure of fatigue parameters at low power
- Robustness to lighting, mobility, and other variabilities

iShadow

Computational Pipeline



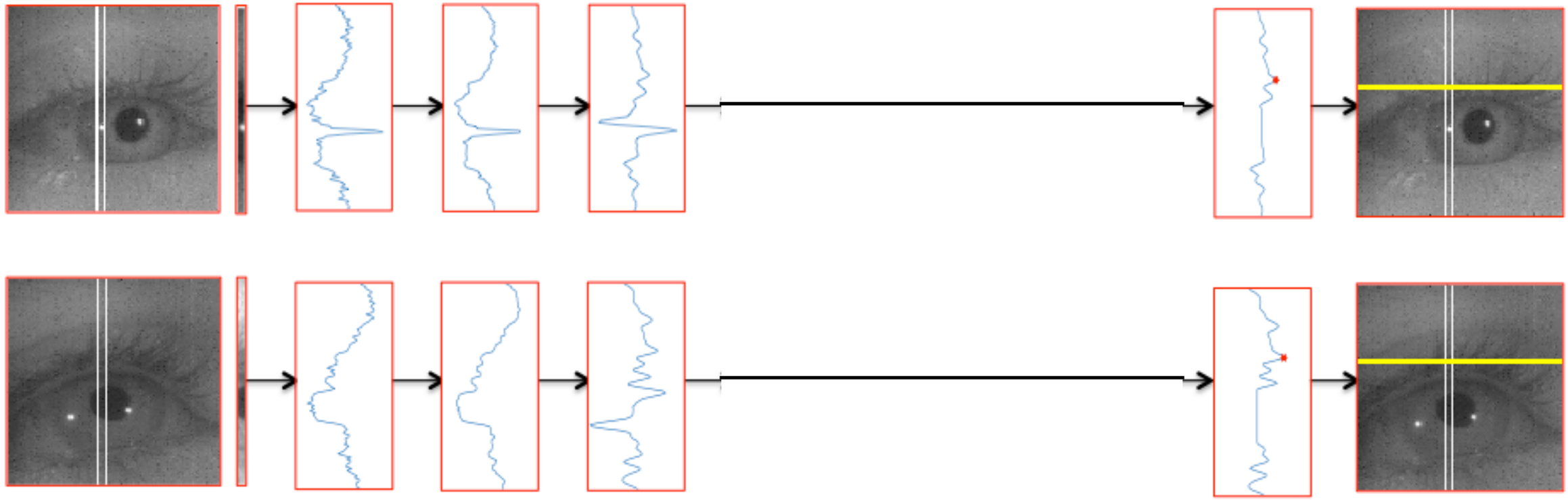
Upper Eyelid Detection

sub-sampling

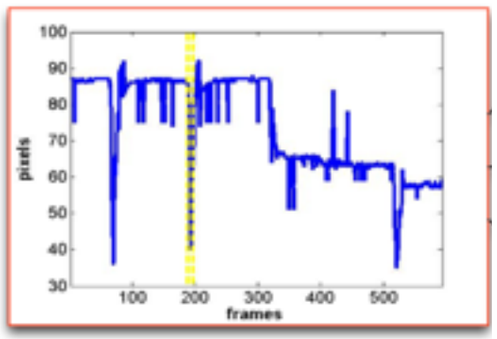
filtering &
edge detection

de-noising

detecting
upper eyelid position



Blink Detection



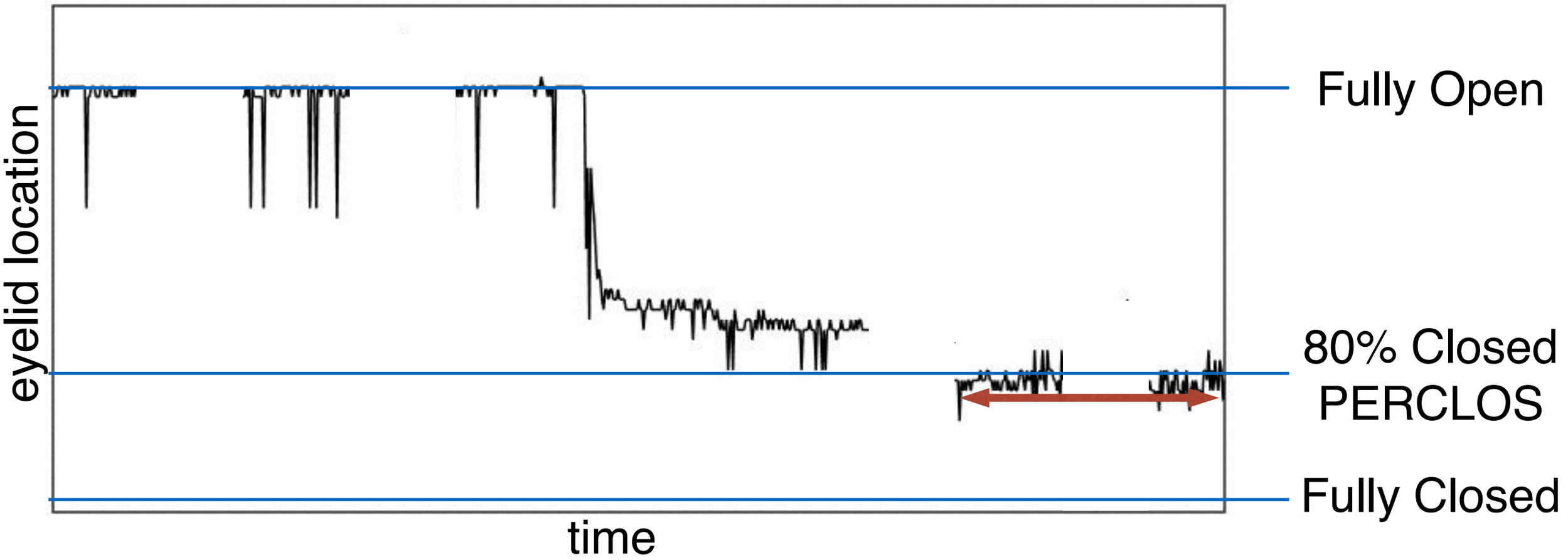
Sequence of Eyelid Positions

Template Matching

Logistic Regression Classifier

Detected Blinks

Drowsiness Estimation



PERCLOS: the percentage of frames when the eyes are more than 80% closed excluding the blinks. (NHTSA 1999)

Evaluation

- Aggregate Results
- Robustness to Variabilities
- Comparison against JINS MEME
- Power Consumption

Aggregate Results

16 subjects
5 minutes of watching a video clip
indoor & outdoor

Blink	Precision	Recall	F1 score
Indoor	0.96	0.85	0.90
Outdoor	0.95	0.84	0.89

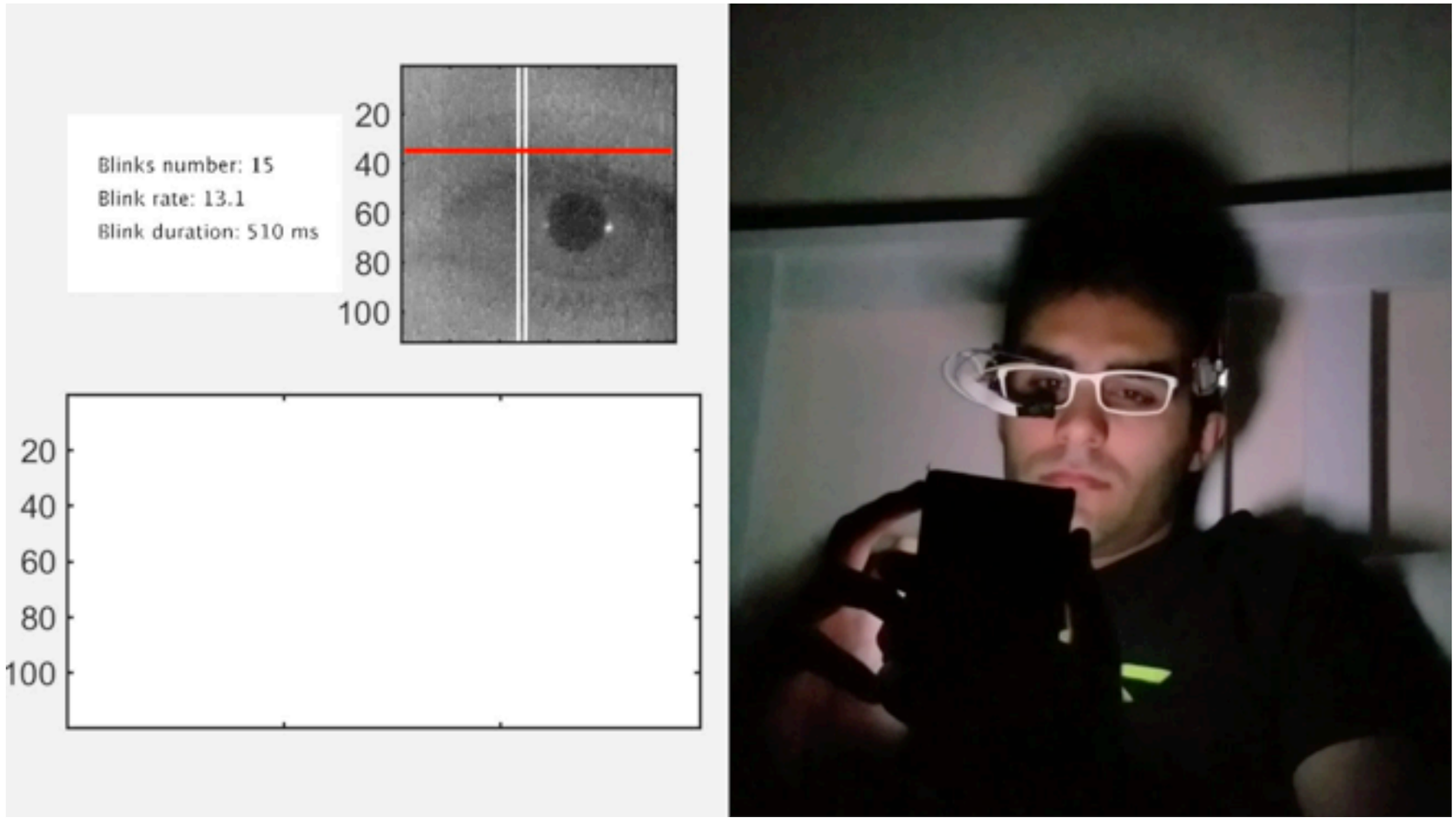
Robustness

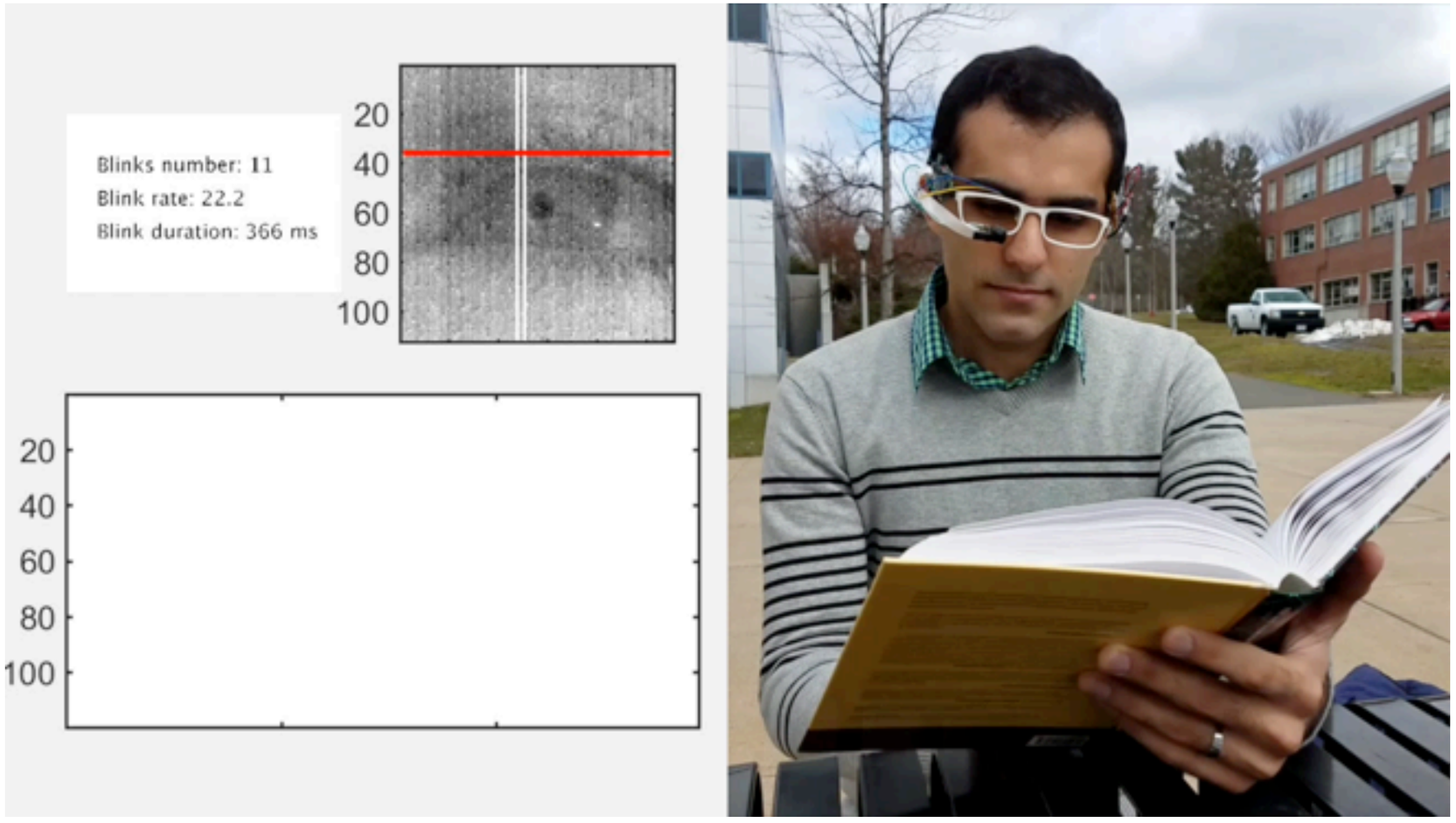
illumination

movement

eyeglass shifts

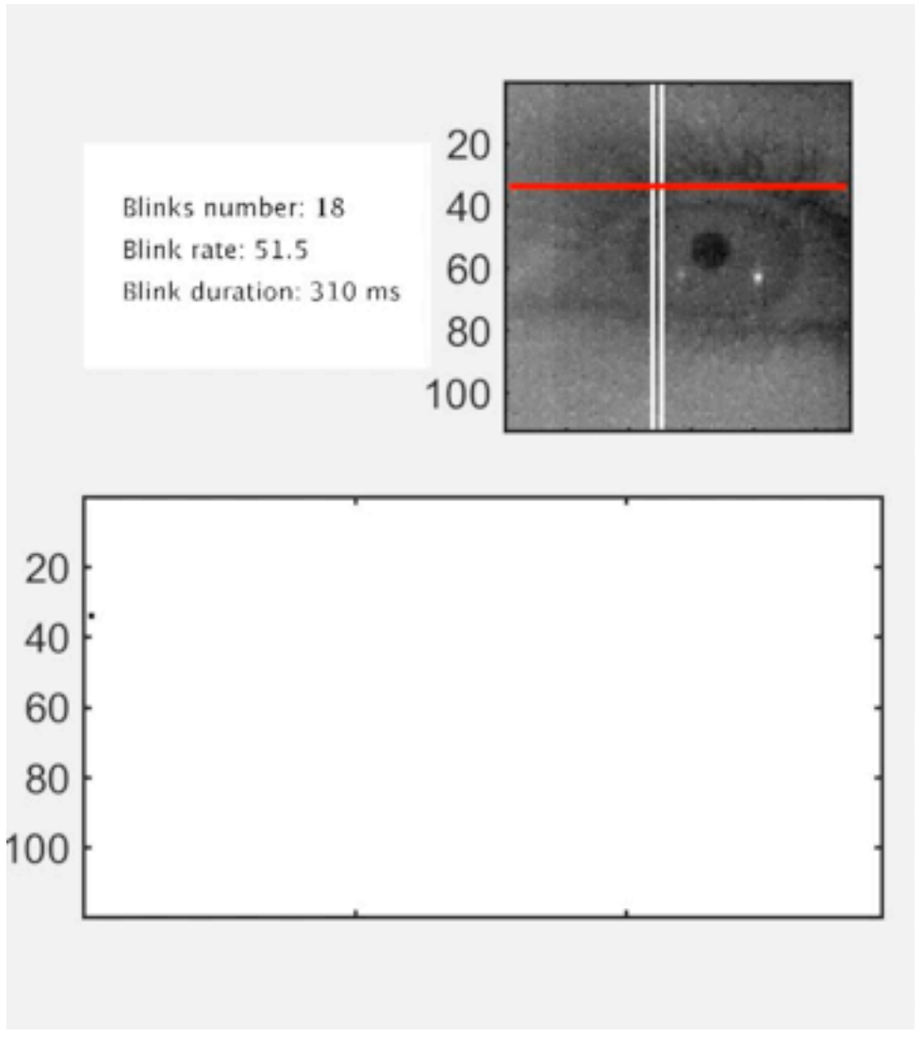
iLid is Robust to Illumination Changes

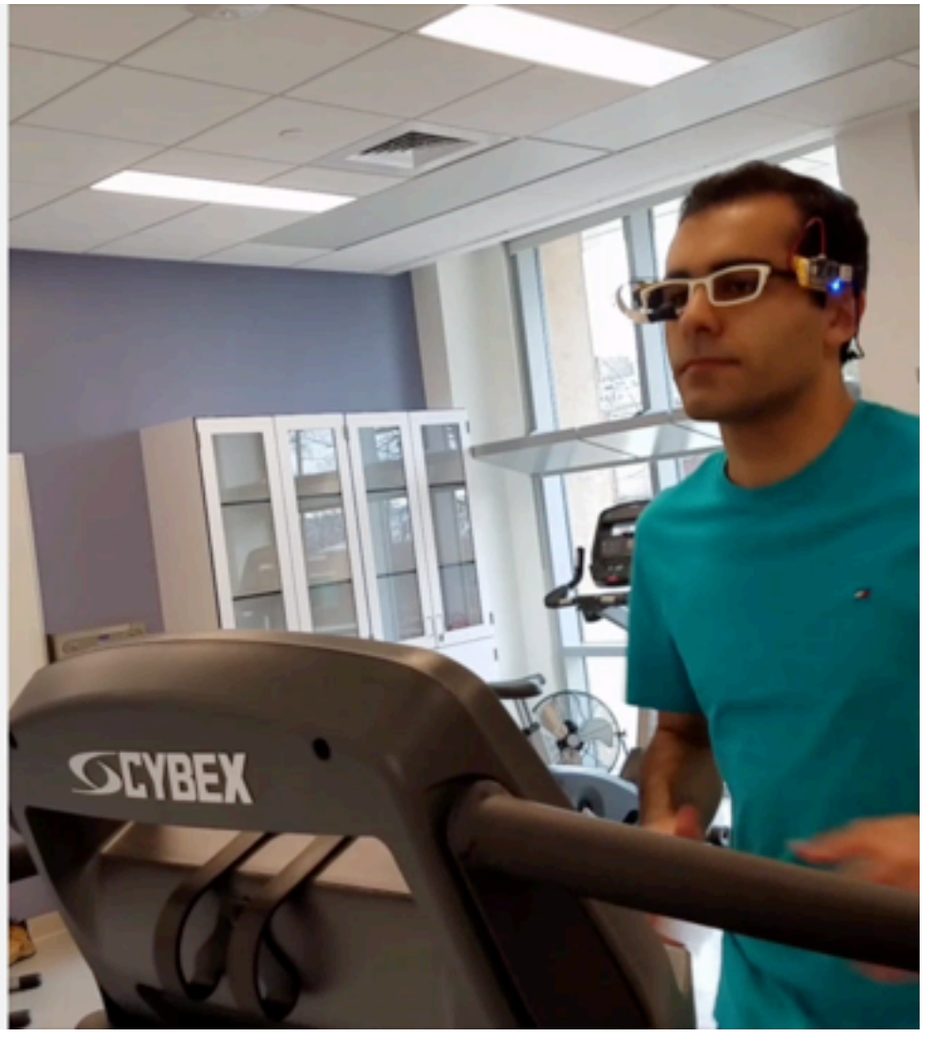




iLid is Robust in Mobile Settings

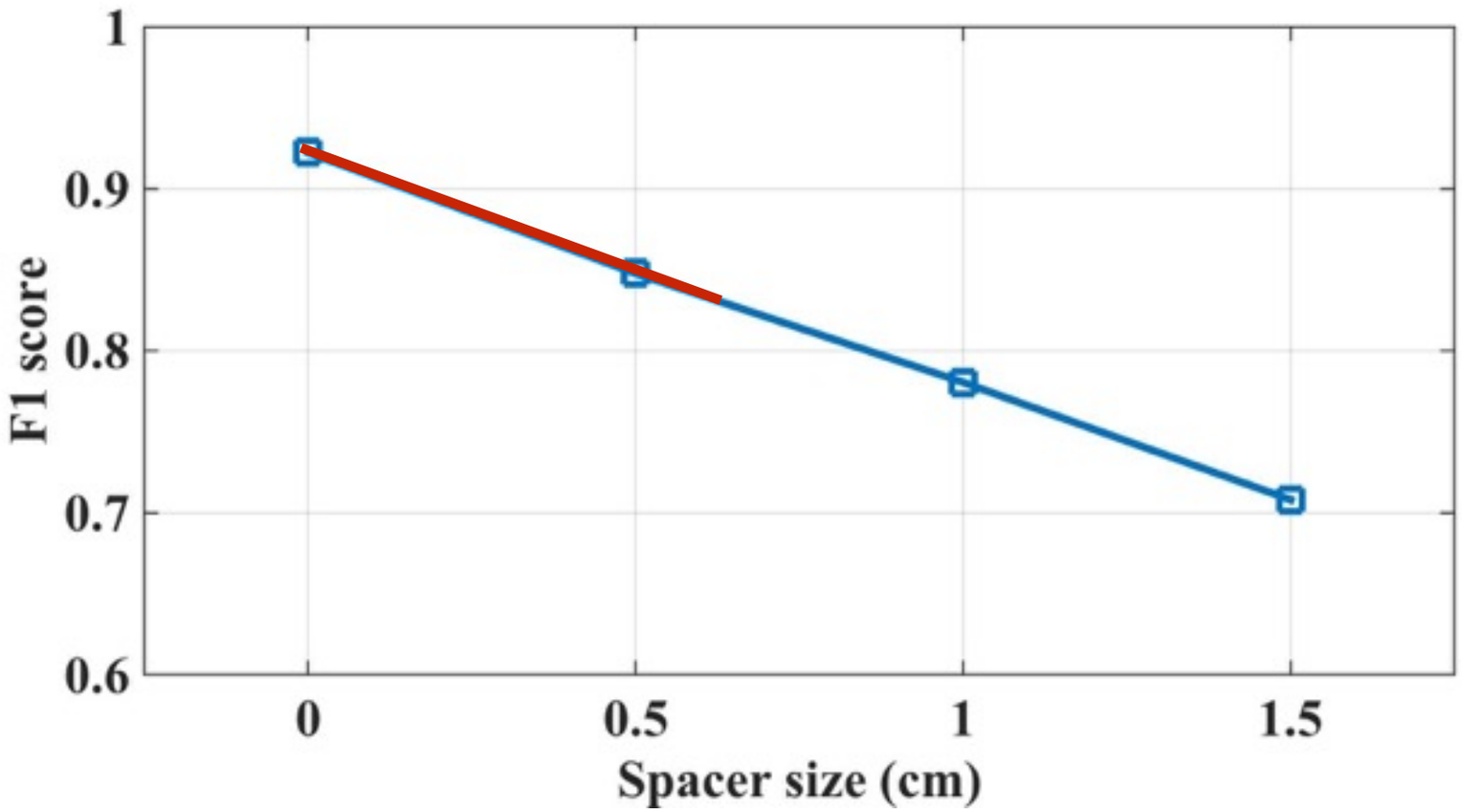
5 subjects
5 minutes of eye video
watch a video clip vs. walk on a treadmill





iLid is Robust with Eyeglass Displacements

5 subjects
5 minutes of watching a video clip
spacer sizes: 0.5, 1, and 1.5 cm



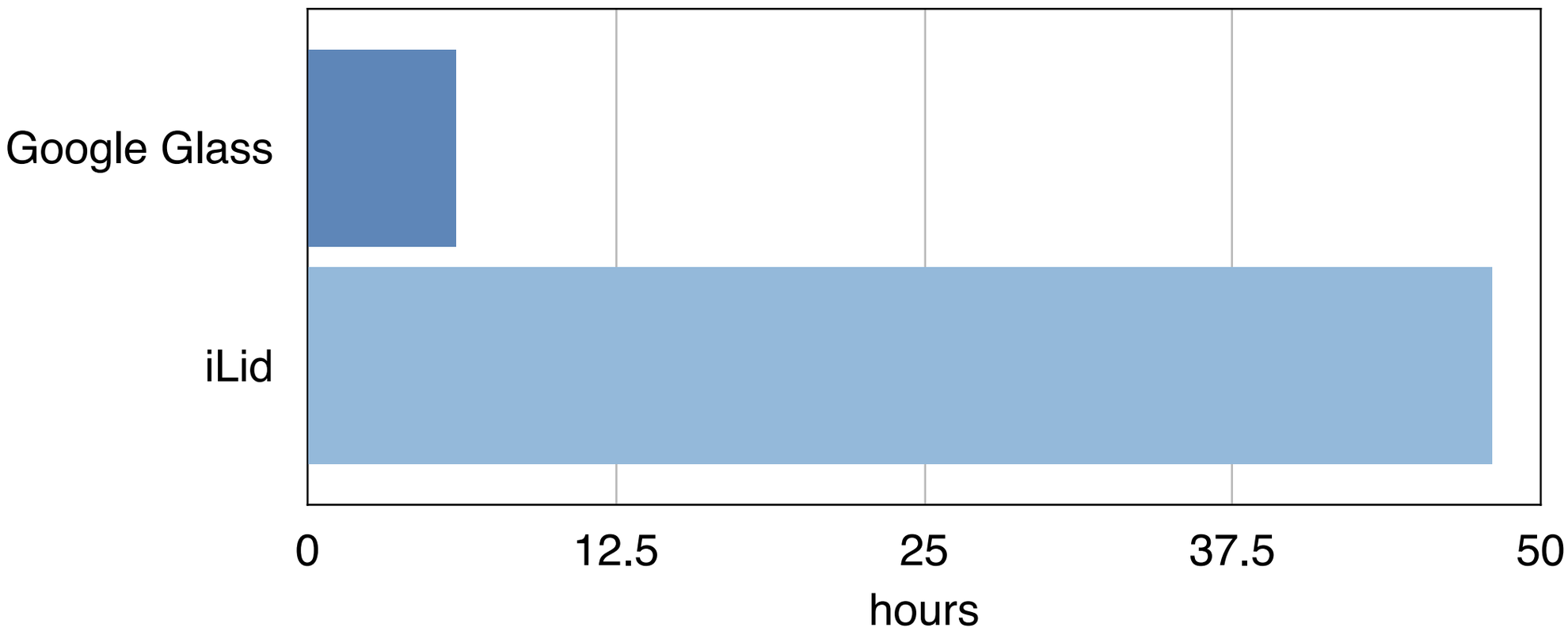
Blink Detection

Comparison against JINS MEME

Power Consumption

Frame rate = 100 Hz

Power consumption = 46 mW



iLid has low power consumption even at high frame rates of 100Hz

Conclusion

- iLid can obtain fatigue and drowsiness detectors in real-time and under natural environments.
- iLid is robust to user mobility, lighting conditions and eyeglass shifts.
- iLid has wide applicability and can enable fatigue sensing in domains ranging from transportation safety to cancer fatigue.

Thanks & Questions?