Online Vigilance Analysis Combining Video and Electrooculography Features

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Outline

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- Introduction
- System Overview
- Video Features
- Electrooculography
- Conclusion and Future Work

Motivation

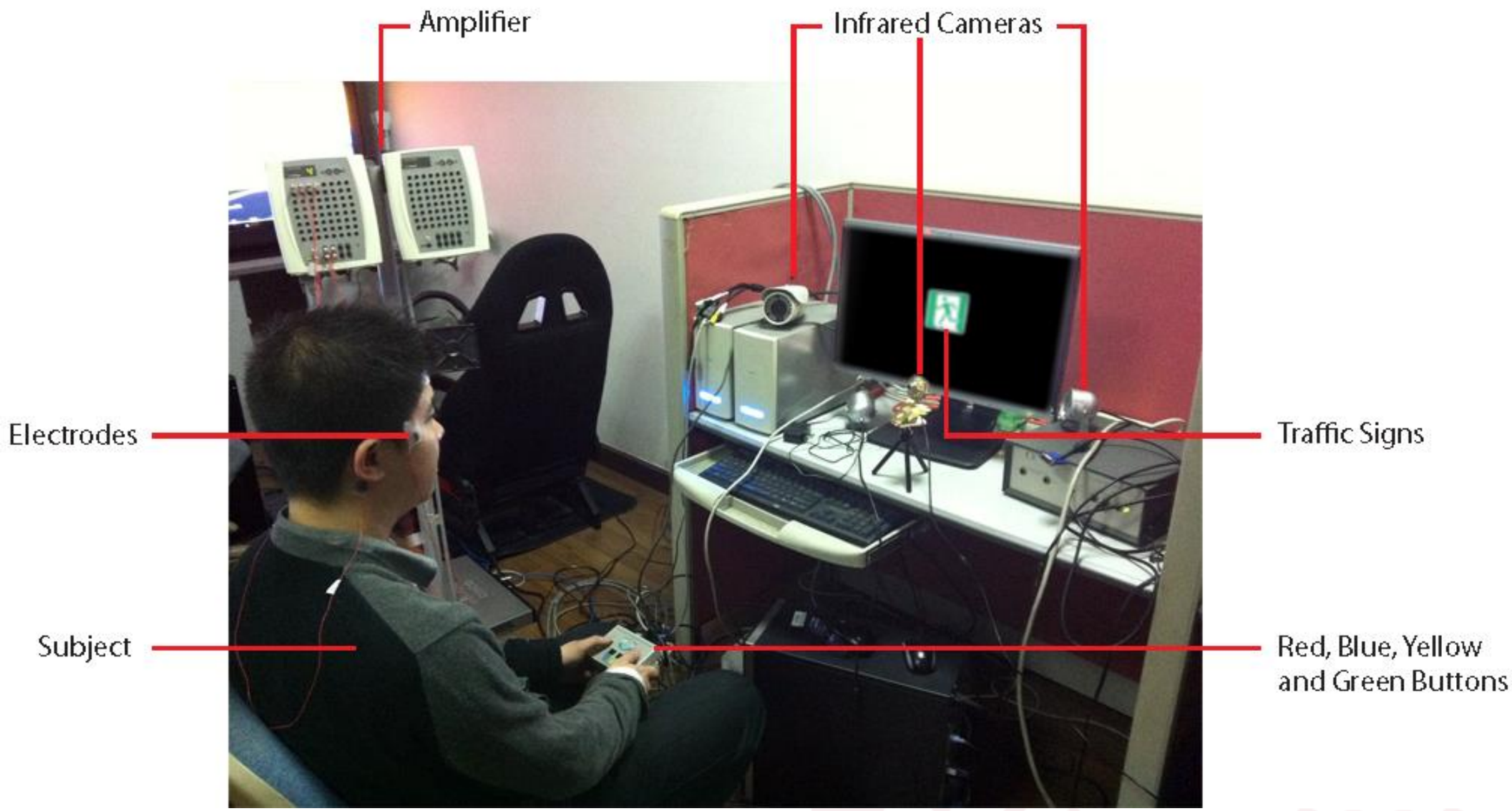
- 600, 000 people die from traffic accidents every year, and
- 10,000,000 people get injured throughout the world.

- 60% of adult drivers – about 168 million people – say they have driven a vehicle while feeling drowsy in 2004 in the U.S. Drowsy driving results in 550 deaths, 71,000 injuries, and $12.5 billion in monetary losses.
- In China, 45.7% accidents on the highway are caused by fatigued driving.

Introduction

	Video	EOG	EEG
Intrusive	Least	Moderate	Most
Accuracy	Moderate, influenced by luminance	Most accurate	Moderate, need to denoise.
Features	Eye movement, yawn state and facial orientation.	Eye blinks, movement and energy.	Delta waves (Slow Wave Sleep) and theta waves (drowsiness)

System Overview

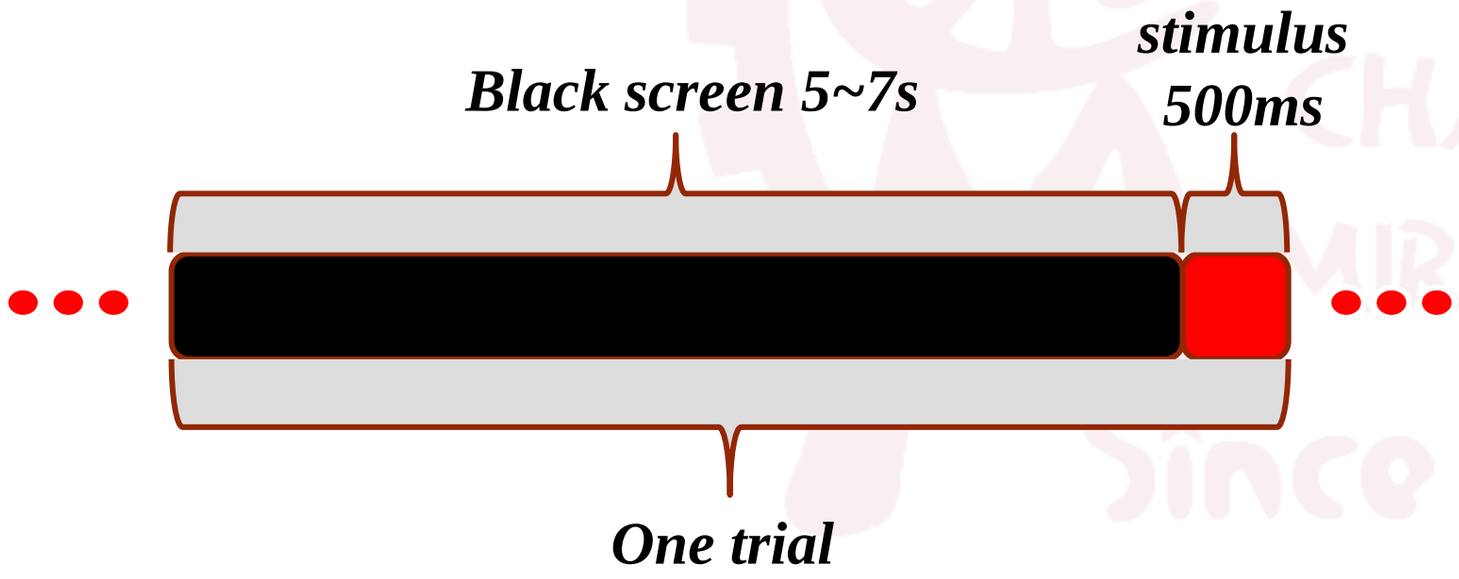


System Overview

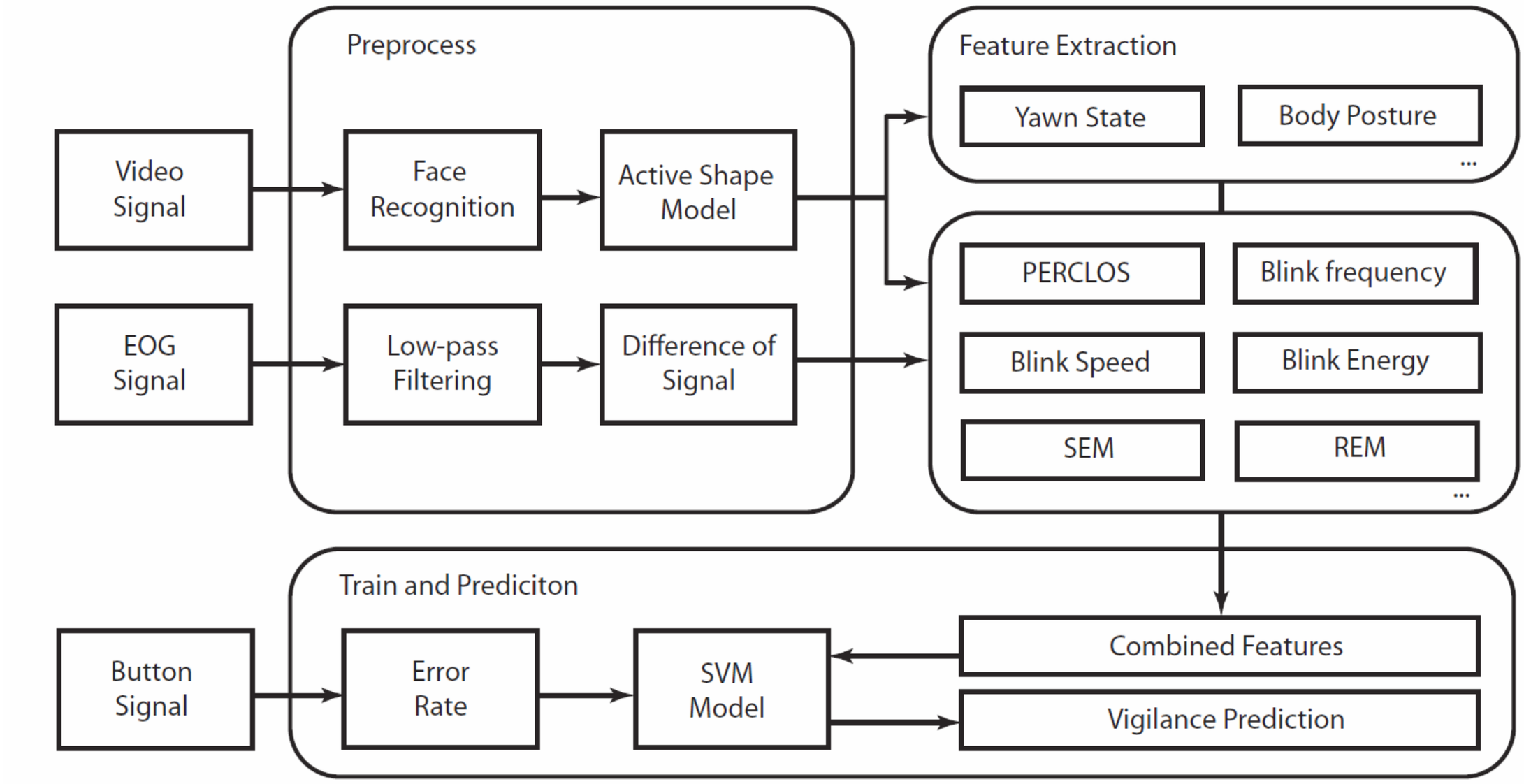
Train

Test

System Overview



System Overview



Visual Features

- Video signals: By infrared cameras, 640×480, 30 frames/s
- Face Detection: Haar-like cascade Adaboost classifier.
- Active Shape Model: Locate the landmarks on the face.

Visual Features

- PERCLOS (percentage of closure): $PERCLOS_e = \frac{\overline{H}_e - H_e}{\overline{H}_e}$

- Blink frequency, etc.:

$$T_{blink} = T_{o2} - T_{c1}; \quad T_{close} = T_{c2} - T_{c1}$$

$$T_{open} = T_{o2} - T_{o1}; \quad T_{closed} = T_{o2} - T_{c2}$$

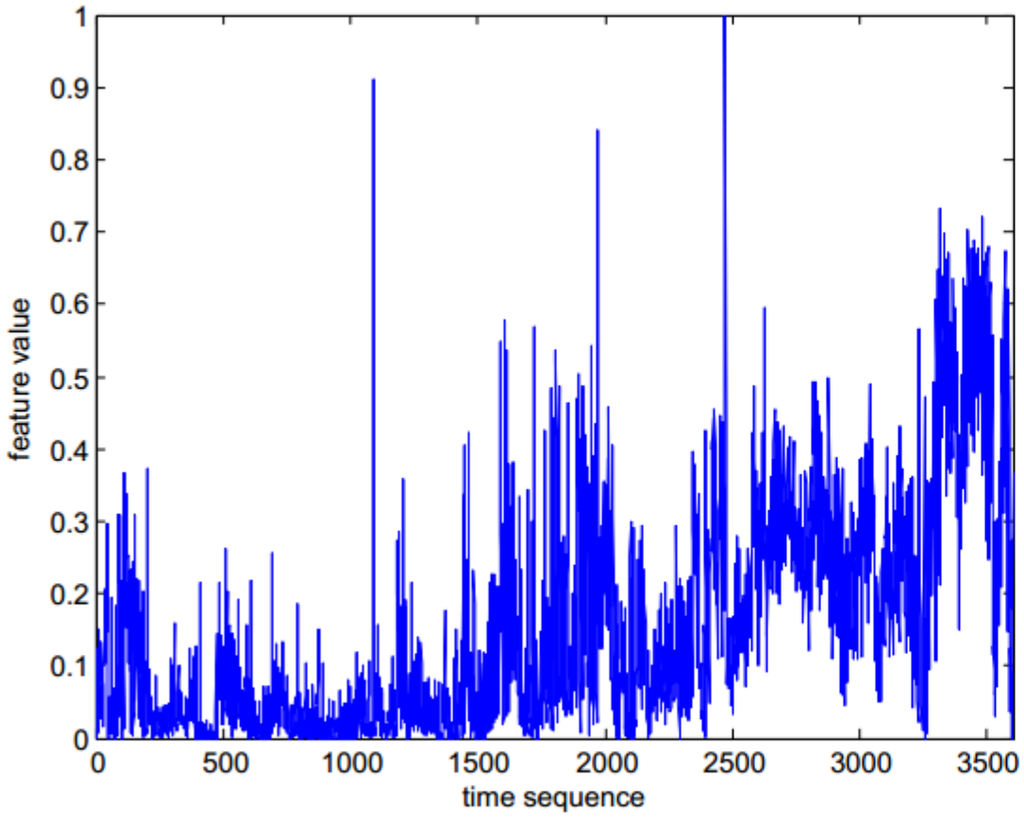
$$S_{close} = \frac{\sum_{i=T_{c1}}^{T_{c2}} D_i}{T_{close}}; \quad S_{open} = \frac{\sum_{i=T_{o1}}^{T_{o2}} D_i}{T_{open}}; \quad E_{blink} = \sum_{i=T_{c1}}^{T_{o2}} V_i^2$$

- Yawn frequency: $Y_i = \frac{\sum_{j=i-w}^{i} (H_j / H_m^k) > C}{w}$

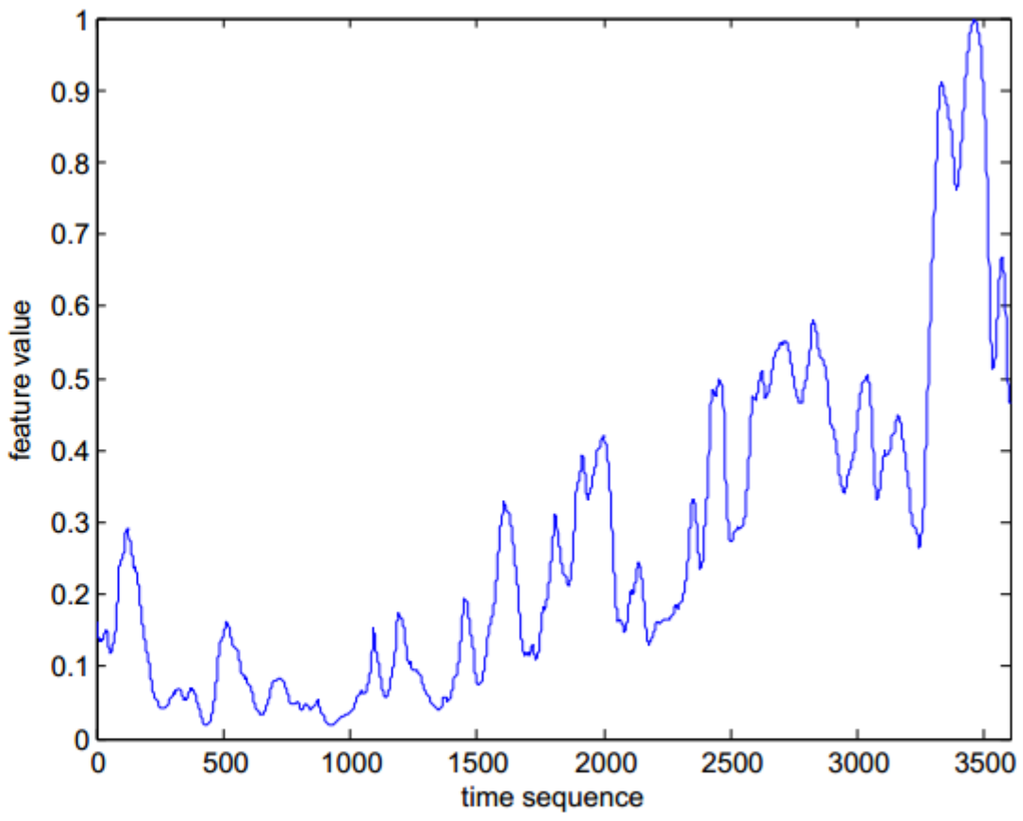
- Body Posture: (By ASM) $\alpha = \frac{D(67,2)}{D(67,12)}; \theta = \frac{D(31,0)}{D(36,14)}; \beta = \frac{D(66,3)}{D(66,11)}$

Linear Dynamic System

$$P(x_t|z_t) = N(x_t|z_t + \bar{w}, Q)$$
$$P(z_t|z_{t-1}) = N\left(z_t\middle|Az_{(t-1)} + \bar{v}, R\right)$$

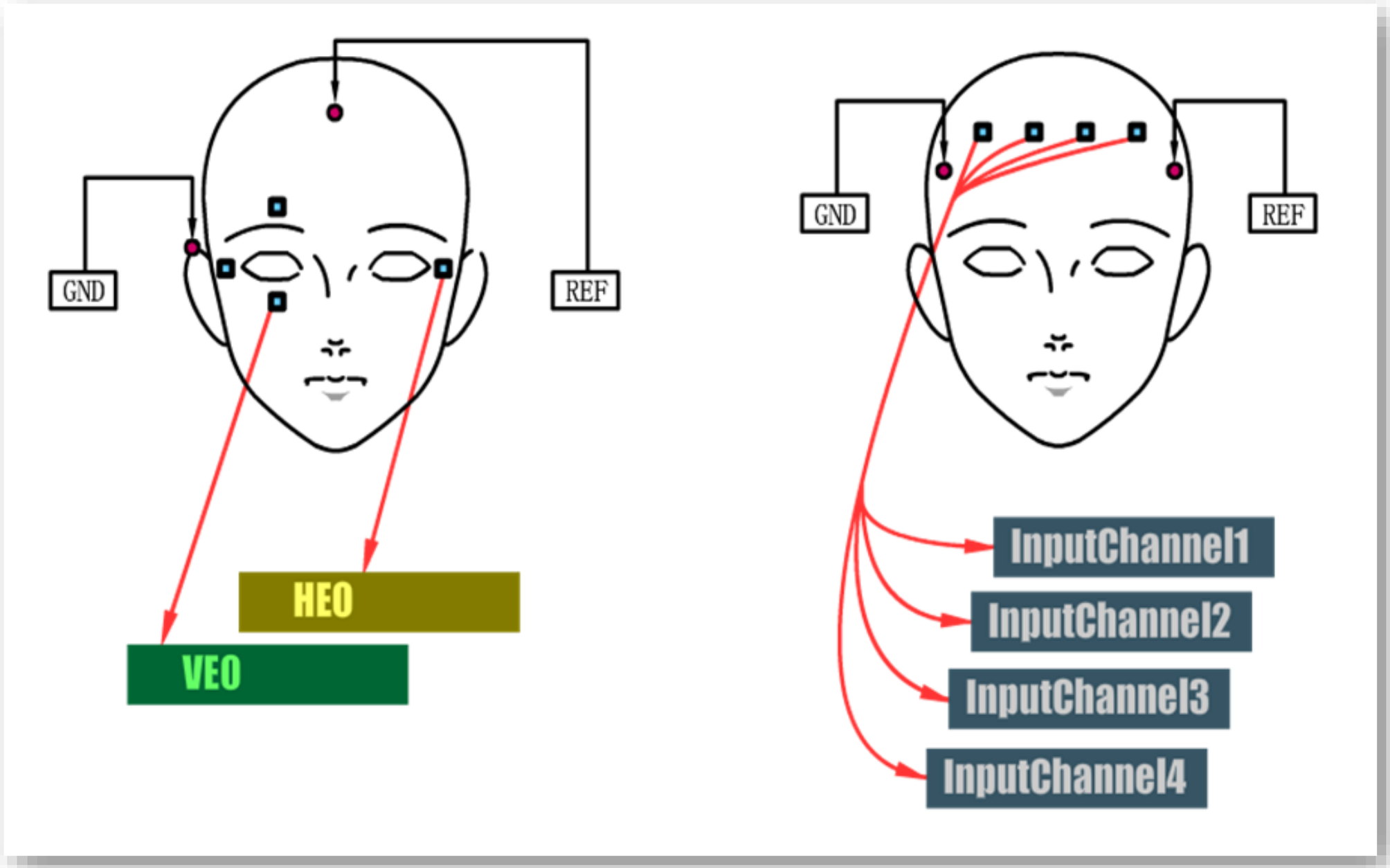


(a) Without LDS



(b) With LDS

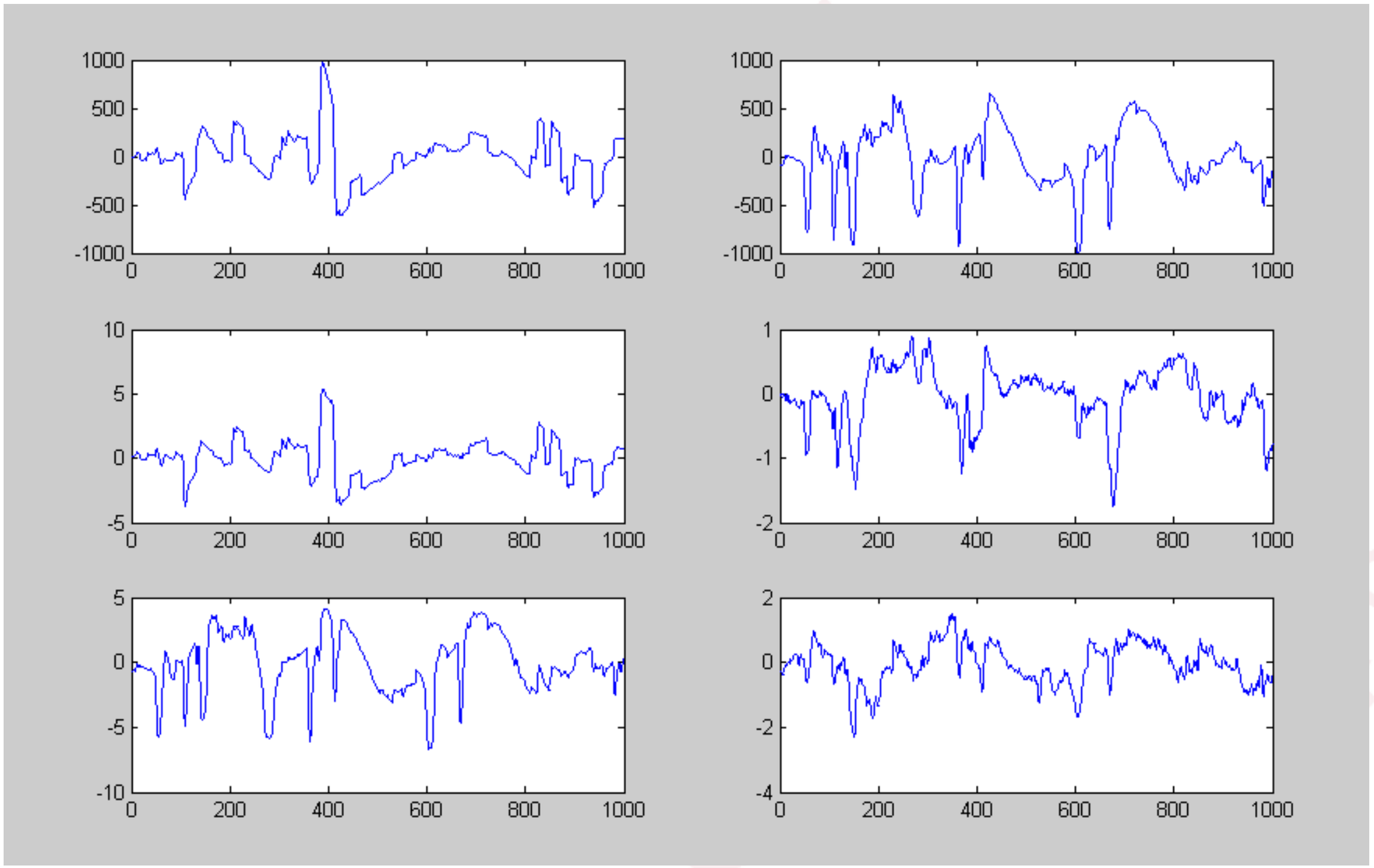
Electrooculography



Forehead Signals Separated by ICA

HEO

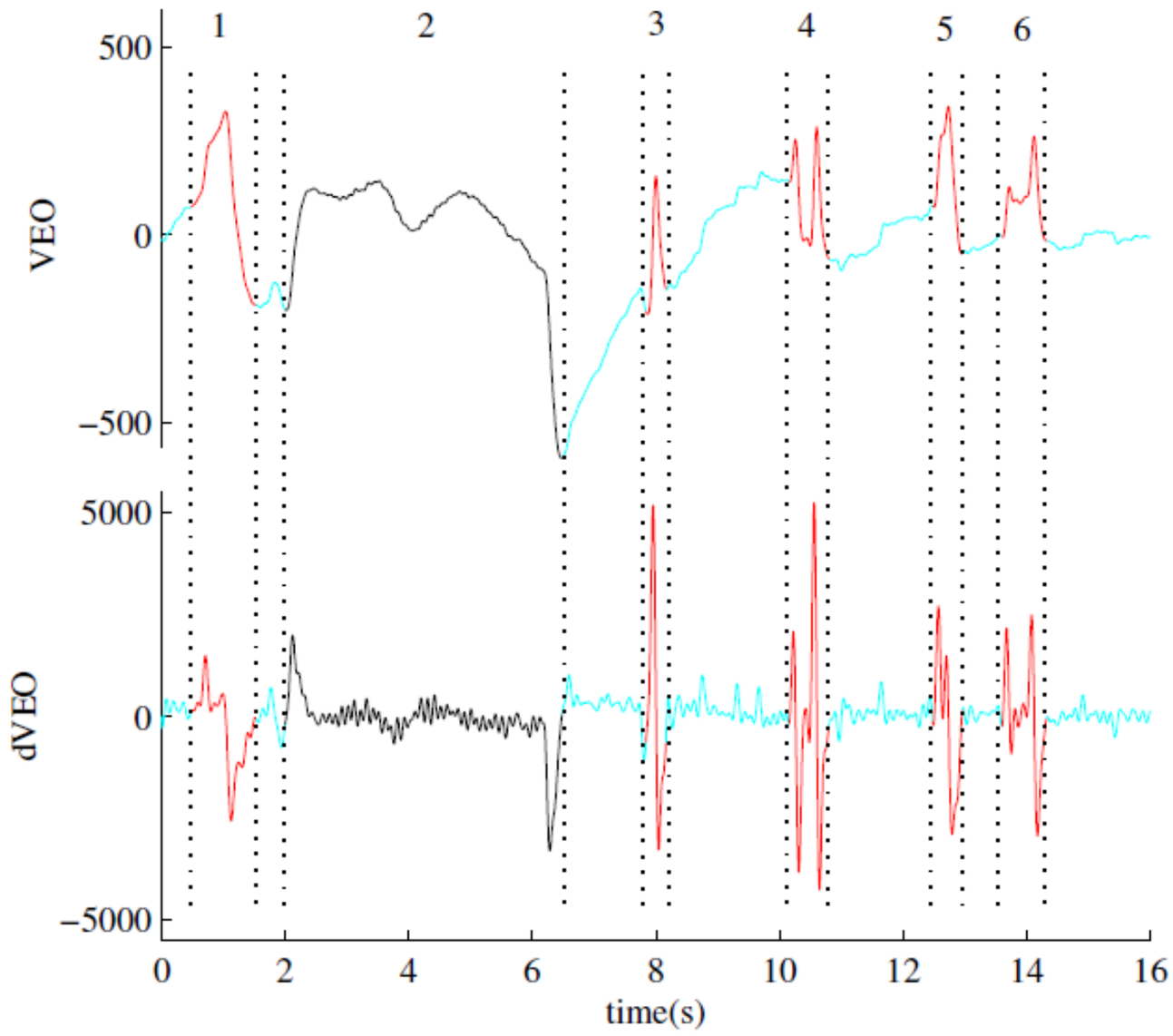
VEO



Electrooculography

- Filter the vertical EOG signal by a low-pass filter with a frequency of 10Hz.
- Adjust the amplitude of the signals.
- Computer the difference of signals for the extraction of eye blinks.
- $D(i) = \big(V(i+i) - V(i)\big) \times R$
  - where V denotes the signal, R as the sampling rate
- Slow Eye Movement (SEM) and Rapid Eye Movement (REM) are extracted according to different kinds of time threshold.
- Fourier transformation: 0.5Hz and 2Hz to process the horizontal EOG.
- The sampling rate: 125Hz, time window: 8 seconds.

Electrooculography

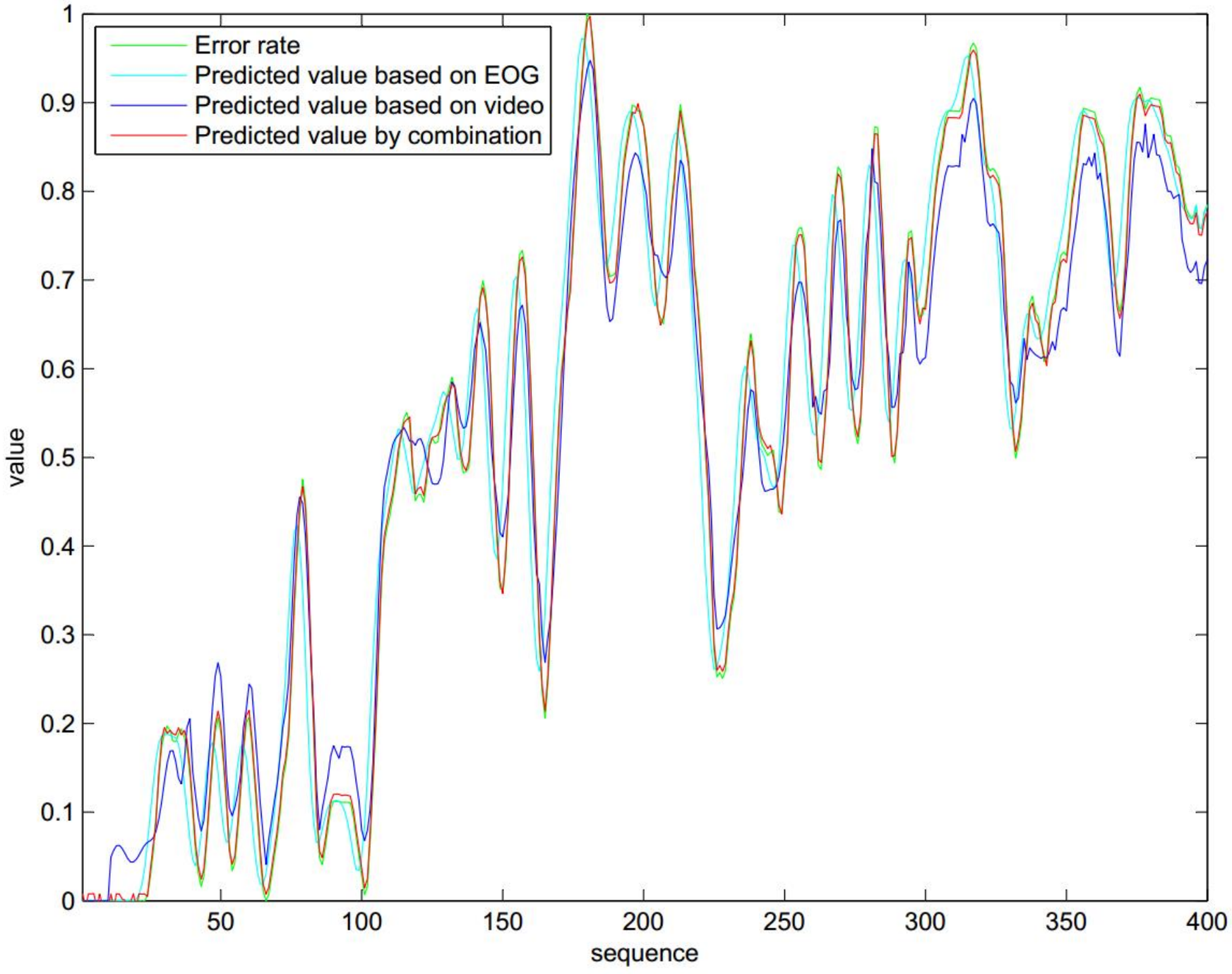


Conclusion

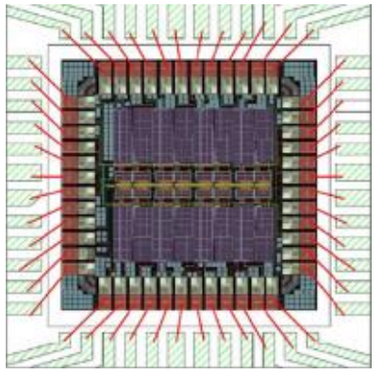
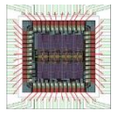
Table 1. Squared correlation coefficient and Mean squared error of regression result

Subject	Video-based	EOG-based	Combinination
1	0.731/0.0256	0.843/0.0136	**0.852/0.0117**
2	0.778/0.0129	0.892/0.0064	**0.919/0.0170**
3	0.750/0.0151	0.866/0.0148	**0.882/0.0111**
4	0.750/0.0175	0.929/0.0091	**0.937/0.0045**
5	0.756/0.0170	0.809/0.0051	**0.921/0.0072**
Average	0.752/0.0882	0.88/0.0098	**0.898/0.0089**

Conclusion


Error rate
Predicted value based on EOG
Predicted value based on video
Predicted value by combination
value
sequence
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
50
100
150
200
250
300
350
400

Future Work

- Smaller EOG chip:  to 

- Comprehensive feature: depth information and grip power.

- Robustness and stability:

  Various luminance, moving car, actual environment…

Thank you

BCMI: We are family!

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