CEERMA

CENTRO DE ESTUDOS E ENSAIOS EM RISCO E MODELAGEM AMBIENTAL UFPE

SVM Classification for drowsiness detection using eye aspect ratio

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Our focus

Air traffic control towers

Industrial control rooms

Drivers

AUTOMOTIVE 90%

(NHTSA, 2008)

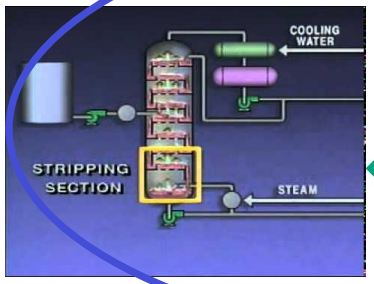
National Highway Traffic Safety Administration

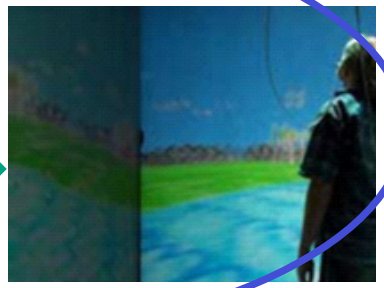
Drowsiness

- Transition between the **awake** and **sleep** states;
- Ability to observe and analyze is strongly **reduced**;
- **Increase** in reaction time. *

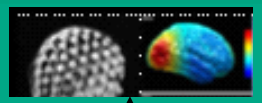
Decision-making in complex systems

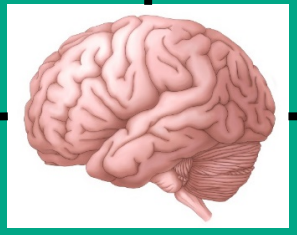
Simulators

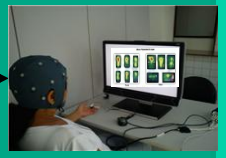




Human Reliability

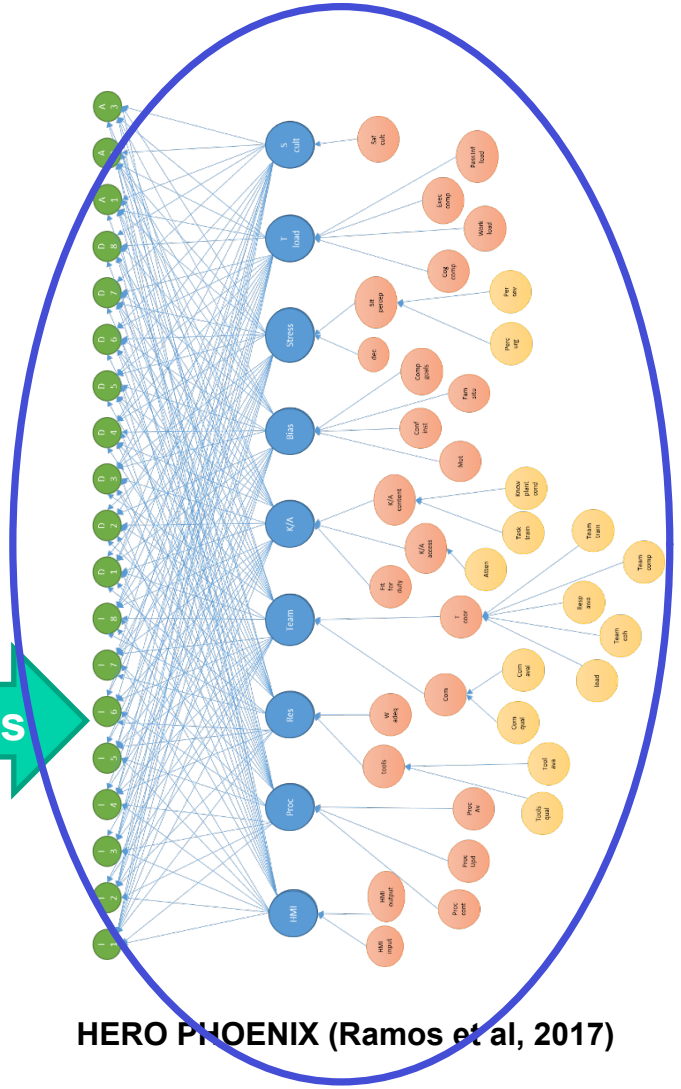






Biological variables from:
Electroencephalogram (EEG)
Electroculogram (EOG)
Electrocardiogram (ECG)

Analysis



HERO PHOENIX (Ramos et al, 2017)

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Proposed Solution for drowsiness detection

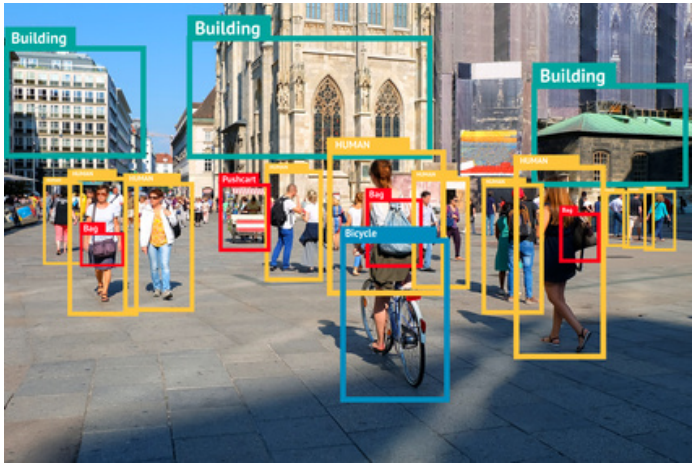
- **Image**-based method;
- **Real-time**;
- Physically **non-intrusive**;
- **Standard** computer camera;
- **Not** computational intensive.

Computer Vision

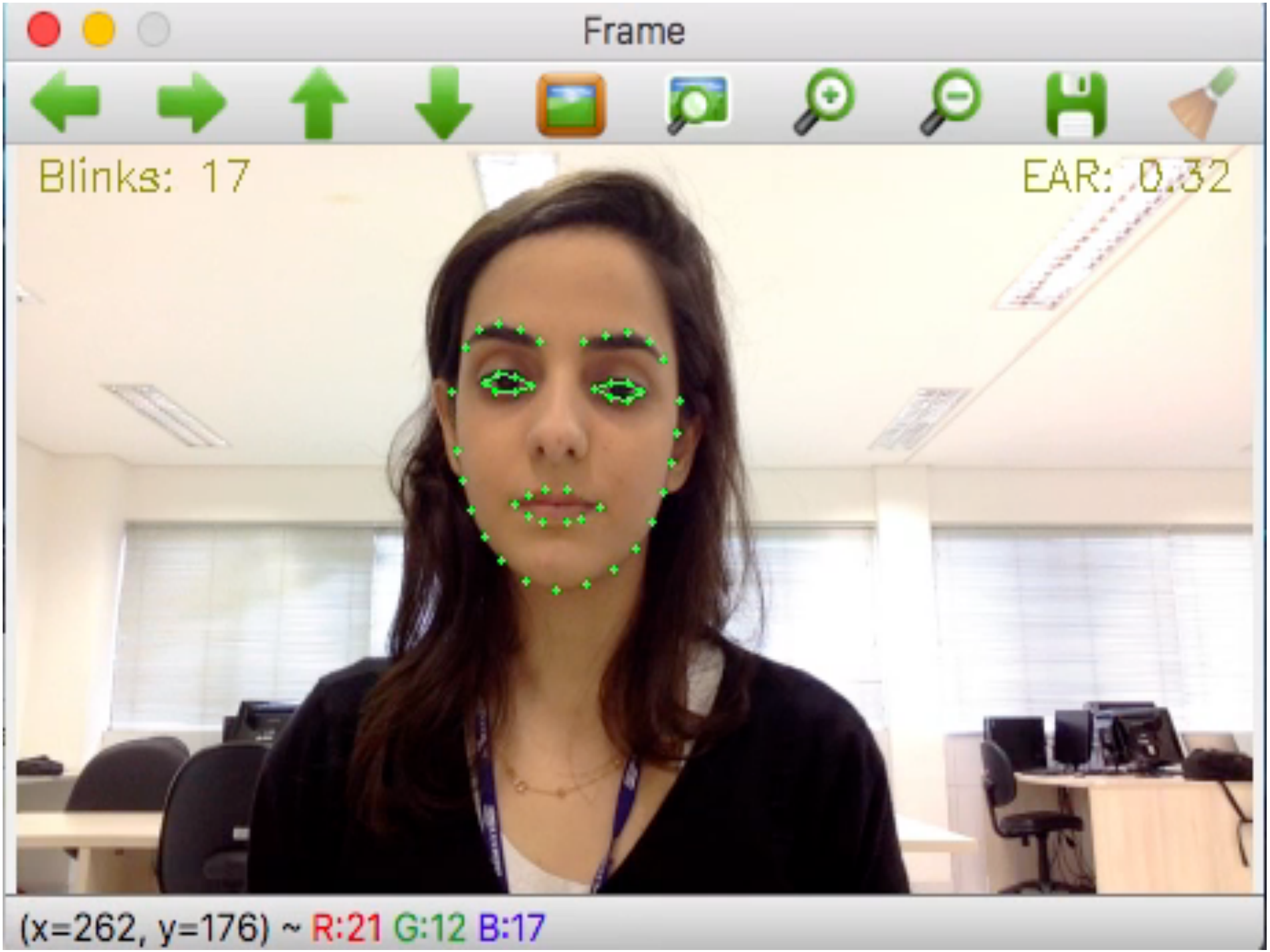
- Studies the **automatic extraction** of information from images and videos[1];

- One of its main goal is to enable computers to reproduce **core functions of human vision**, such as motion perception and scene understanding;

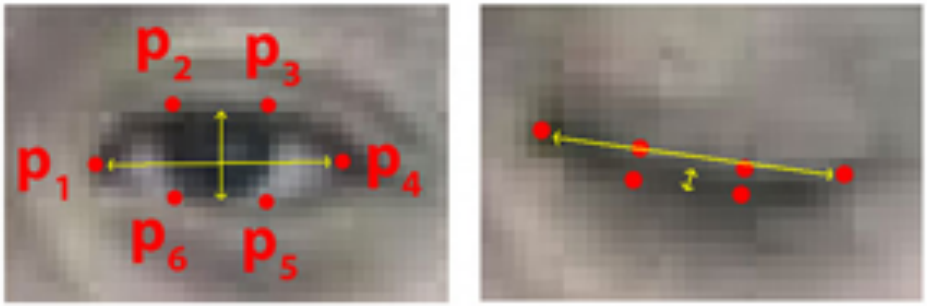
- CV uses three key steps[2]:
  1. Detection of **movement** of objects;
  2. **Tracking** of such objects from frame to frame;
  3. Analysis of object tracks to **recognize** their behavior.



[1]Jan Erik Solem, 2012
[2] Yilmaz, Javed and Shah, 2006


Frame
Blinks: 17
EAR: 0.32
(x=262, y=176) ~ R:21 G:12 B:17

Eye Aspect Ratio



$$EAR^1 = \frac{\|p_2 - p_6\| + \|p_3 - p_5\|}{2\|p_1 - p_4\|}$$

- EAR - The proportion between the **width** and **height** of the eye, based on its landmarks;
- Calculated for **each frame** over the real-time video;
- A **decrease in the EAR** is expected as users close their eyes;
- **Simple**, yet robust metric.

[1]Soukupová and Jan Cech, 2016

Support Vector Machines

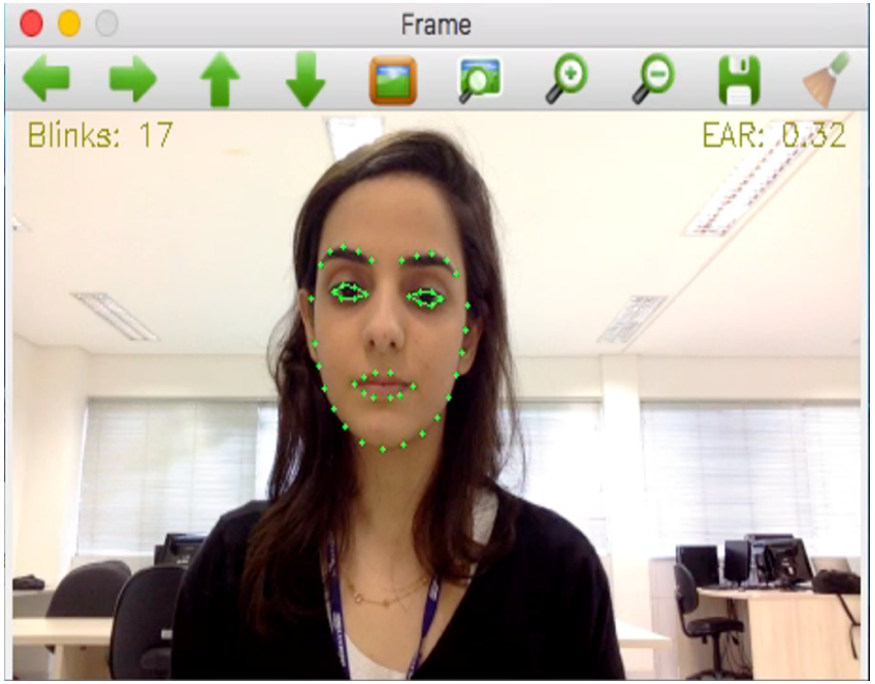
- **Training**:
  - We concatenated 15 consecutive EARs to create a temporal **user's state feature (*x*)**;

- **State classification (*y*)**:

  0 → Open eye;

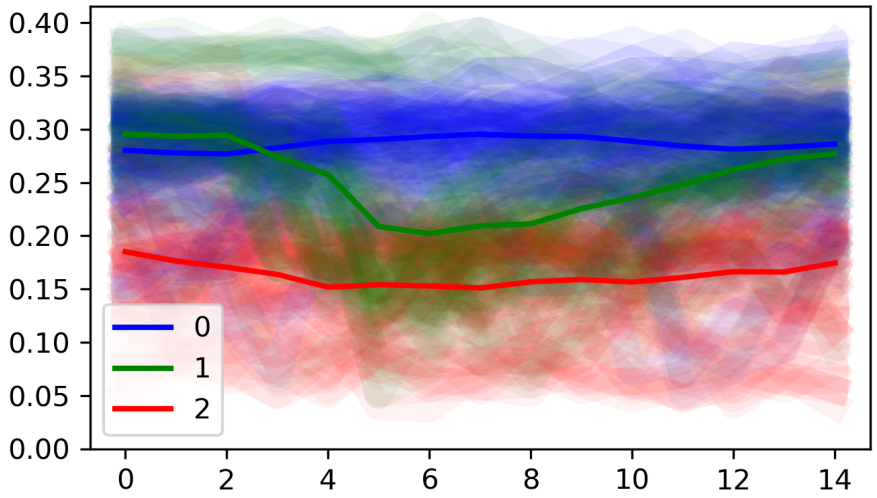
  1 → Blink;

  2 → Closed eye.



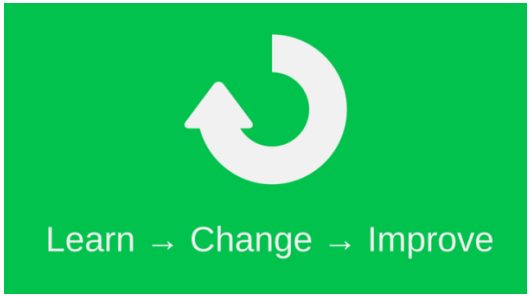
Support Vector Machines

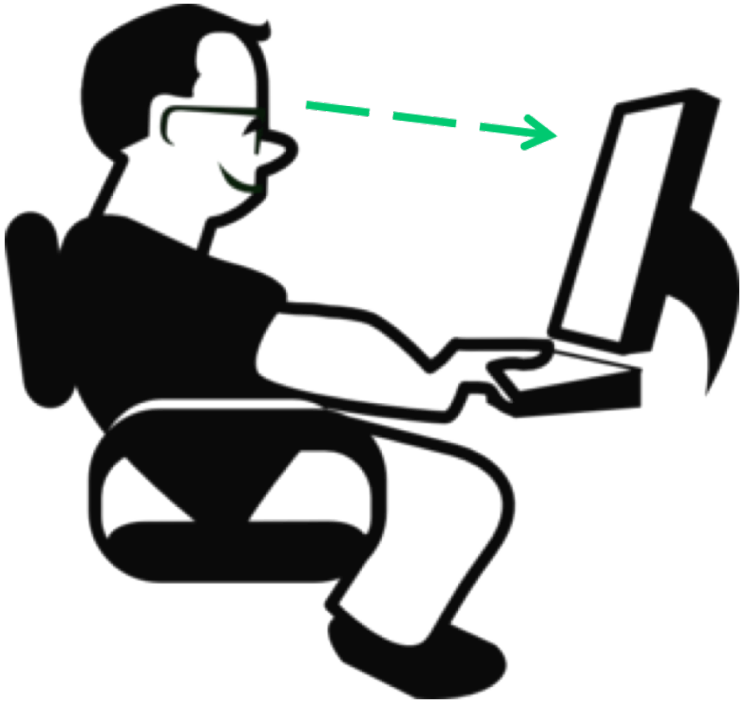
– **Training database**: more than 270 features were created
  - **13** different users;
  - **Natural and abnormal** facial expressions;
  - **Glass** wearing users;
  - **Distinct** head positions.

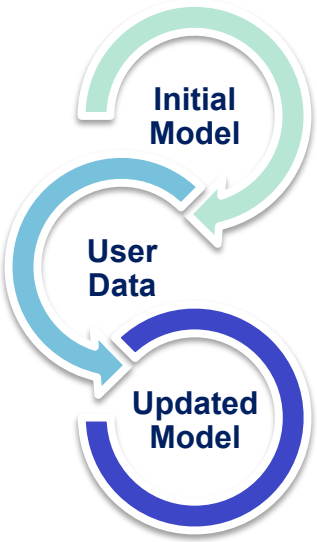


Support Vector Machines

- Personal Feedback







Drowsiness Detection and Warnings

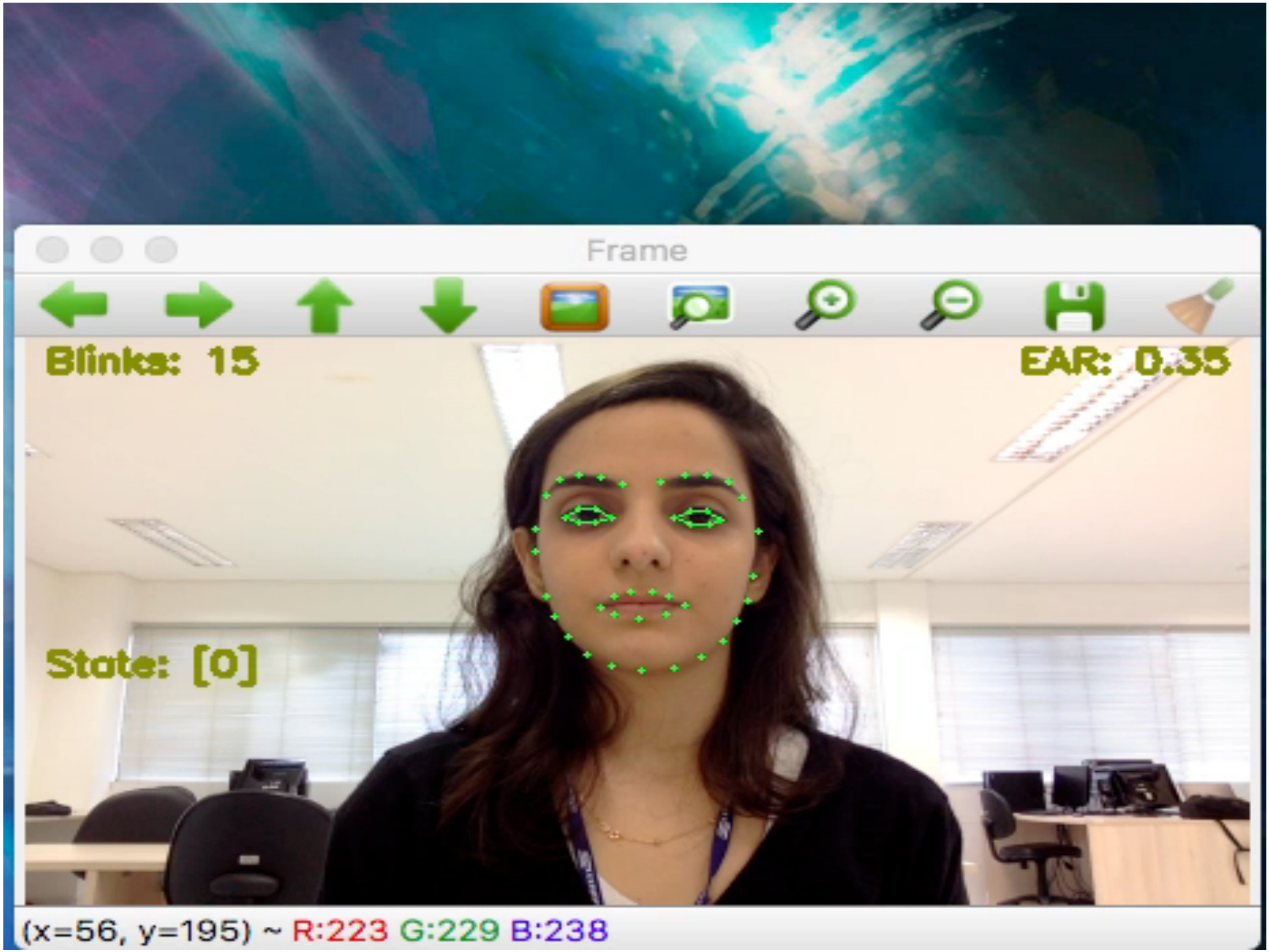
Two different situations were considered as drowsiness states*:

If in a period of 1 minute, the proportion #2/(#1+#2) are greater than 30%; ⇒ ***Many long blinks in a short lapse of time***

If 4 consecutive outputs (i.e. predictions of SVM) are 2 (closed eyes); ⇒ ***Continuously closed eyes***

*Caffier & Erdmann, 2003

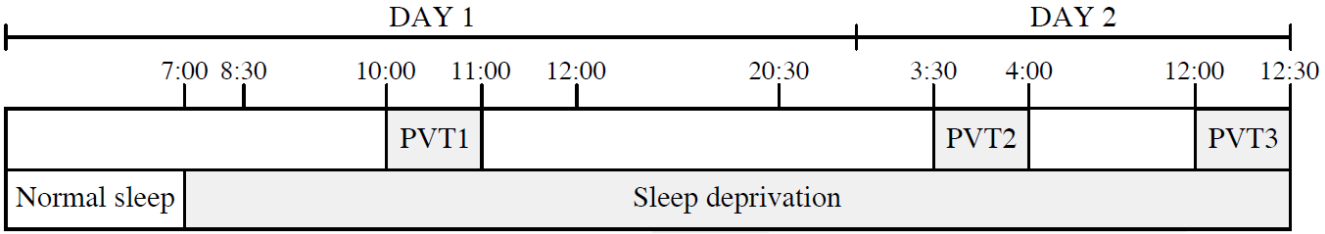
These situations are correlated with the first stages of drowsiness


Frame
Blinks: 15
EAR: 0.35
State: [0]
(x=56, y=195) ~ R:223 G:229 B:238

DROZY Dataset

- Database containing various types of drowsiness-related data for 14 subjects:
  - Eletroencephogram (EEG);
  - Eletroculogram (EOG);
  - Eletrocardiogram (ECG);
  - **Videos.**

- Successive **psychomotor vigilance tests (PVTs)** over two consecutive days under conditions of increased sleep deprivation;



DROZY Dataset

- Totally **different environment** than we trained the SVM model:
  - Camera position;
  - Color;
  - Brightness;
  - Presence of electrodes;
  - Recorded with a different number of frames per second (FPS).

DROZY Dataset

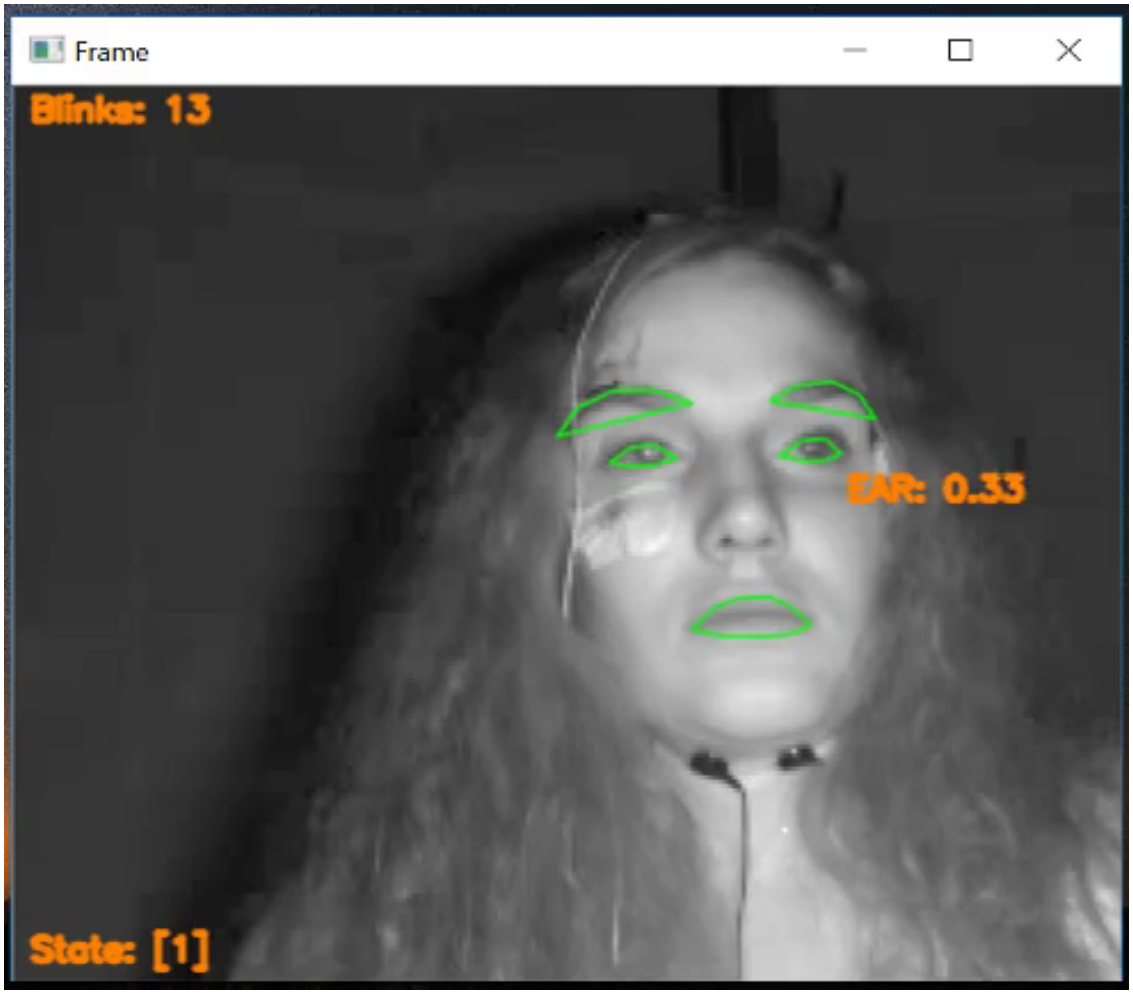
- Subjects filled a **Karolinska Sleepiness Scale (KSS)** form;
- **KSS** is a self-declaration of the level of drowsiness;
- **KSS** is a reliable indicator to measure drowsiness (Kaida et al., 2006).

Karolinska Sleepiness Scale (KSS)	
1	Extremely Alert
2	Very Alert
3	Alert
4	Rather Alert
5	Neither Alert nor Sleepy
6	Some Sights of Sleepiness
7	Sleepy, But No Effort to Keep Awake
8	Sleepy, Some Effort to Keep Awake
9	Very Sleepy, Fighting Sleep

Alert state

Drowsy state

DROZY Results



Subject	PVT1	PVT3
1	0	11
2	0	
3	0	
4		2
5	0	0
6	0	19
7		33
8	0	1
9		26
10	0	7
11		28
12	0	
13		
14		34
Average	0	16.1

Number of warnings

DROZY Results: subject #6

Subj

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