Driver Alertness Detection using Ensemble of Regression Trees and Implemented in OpenCV

CS 512 Final Project Fall 18'

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Problem Statement

- Road Safety
- Preventable accidents caused by...
  - Speeding and Reckless Driving
  - Drunk Driving
  - **Distraction**
  - **Fatigue**

In 2015,

according to the National Highway Traffic Safety Administration,

551

nonoccupants (pedestrians, bicyclists, and others)

killed

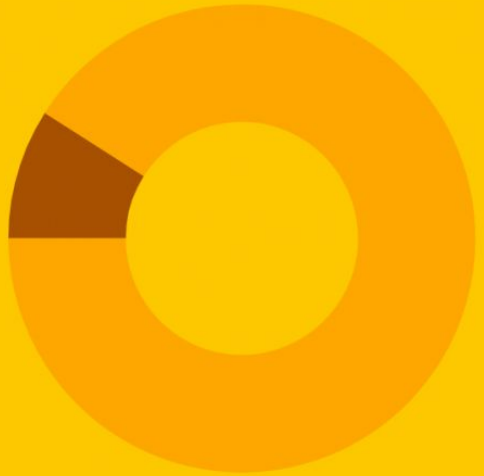
in distraction-affected crashes

3,477 killed

391,000 injured

in motor vehicle crashes involving distracted driving

of 15-19 year olds involved in fatal crashes

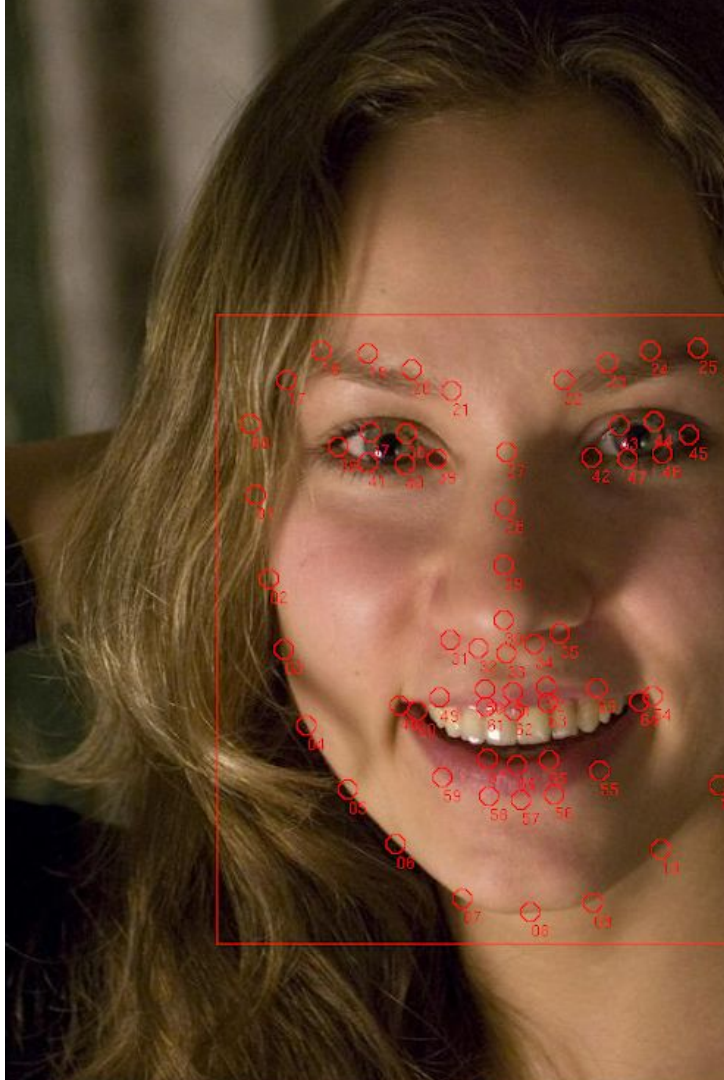


reported as distracted at the time of crash

not reported as distracted at the time of crash

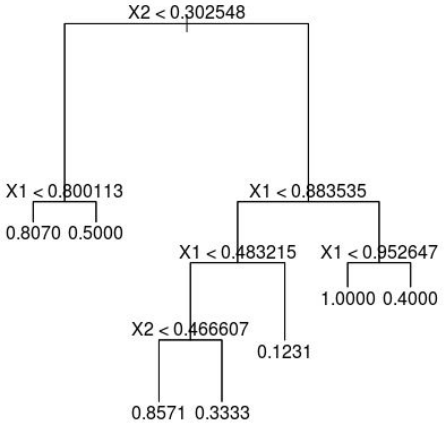
Proposed Solution

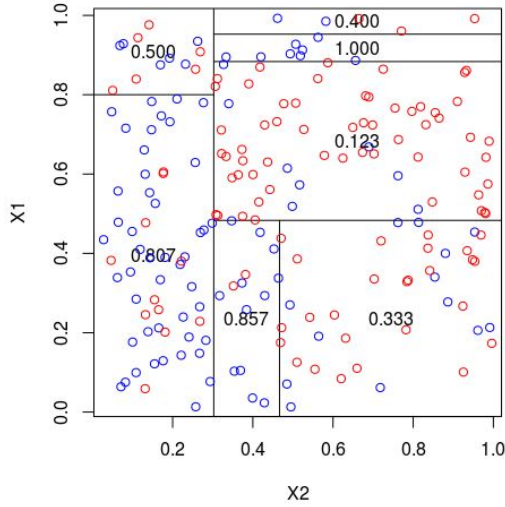
- Predict and track facial annotations
- Interpret annotations in to estimations for:
  - Head pose
  - Eye gaze
  - Eye openness
  - Yawning
- Designing a scale (KSS) which tracks:
  - Distraction
  - Drowsiness
- Alert Driver using based on scale



Facial annotation estimation using an ensemble of Regression Trees (Kazemi-Sullivan paper)

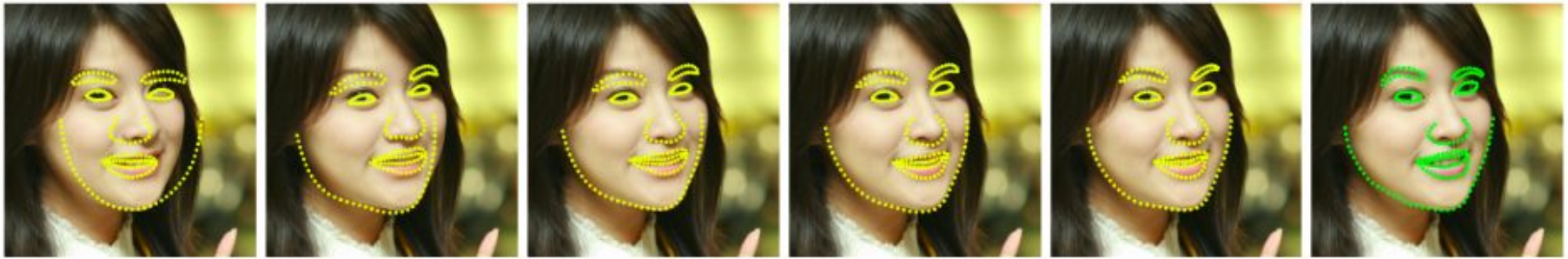
- Detected face first
- Use cascade of regression trees to predict coordinates
- Over many iterations minimizes squared error loss function and
- Uses gradient boosting





Facial annotation estimation using an ensemble of Regression Trees (Kazemi-Sullivan paper)

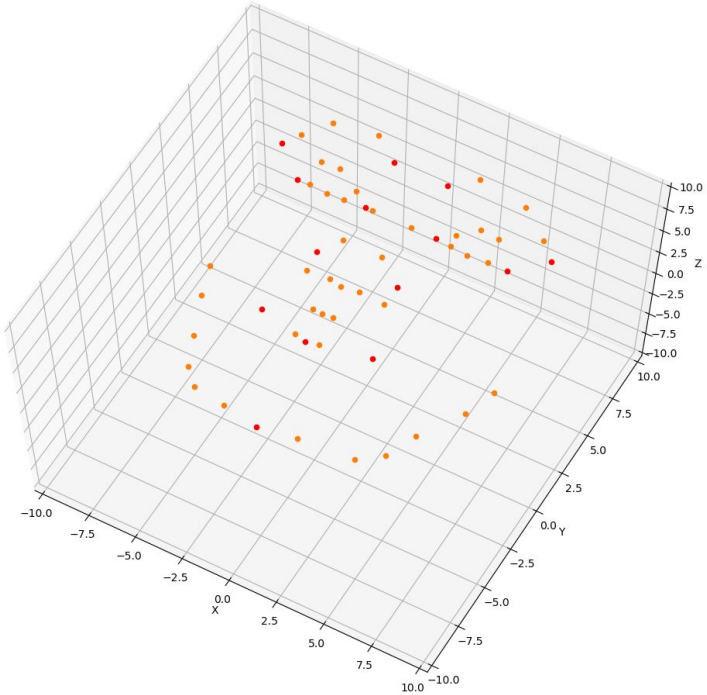
- Great results achieved on the HELEN dataset (2000 training images and 230 for test), and rest 330 were used as the test data.
- average normalized distance of each landmark to its ground truth position was 0.049

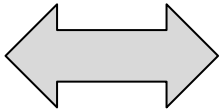


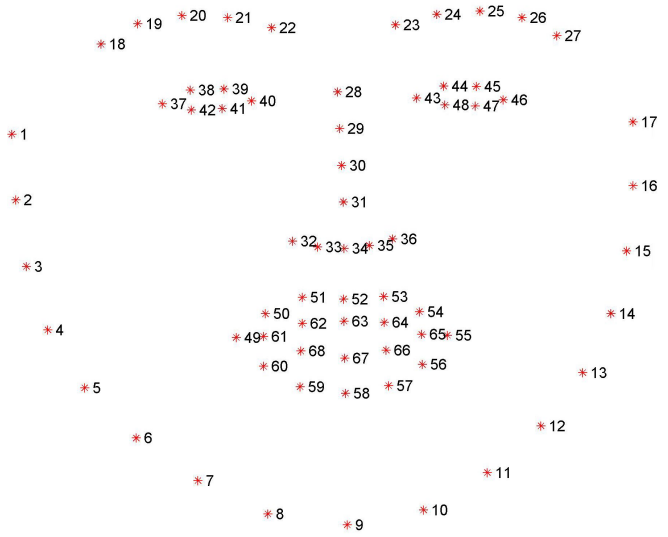
(a) $T = 0$ (b) $T = 1$ (c) $T = 2$ (d) $T = 3$ (e) $T = 10$ (f) Ground truth

Head Pose

- Get 3D object pose using 3D-2D point correspondence







Head Pose

- Euler decomposition of rotation matrix
- Using combined euler angles, to estimate distraction

$$R = \begin{bmatrix} r_{11} & r_{12} & r_{13} \\ r_{21} & r_{22} & r_{23} \\ r_{31} & r_{32} & r_{33} \end{bmatrix}$$

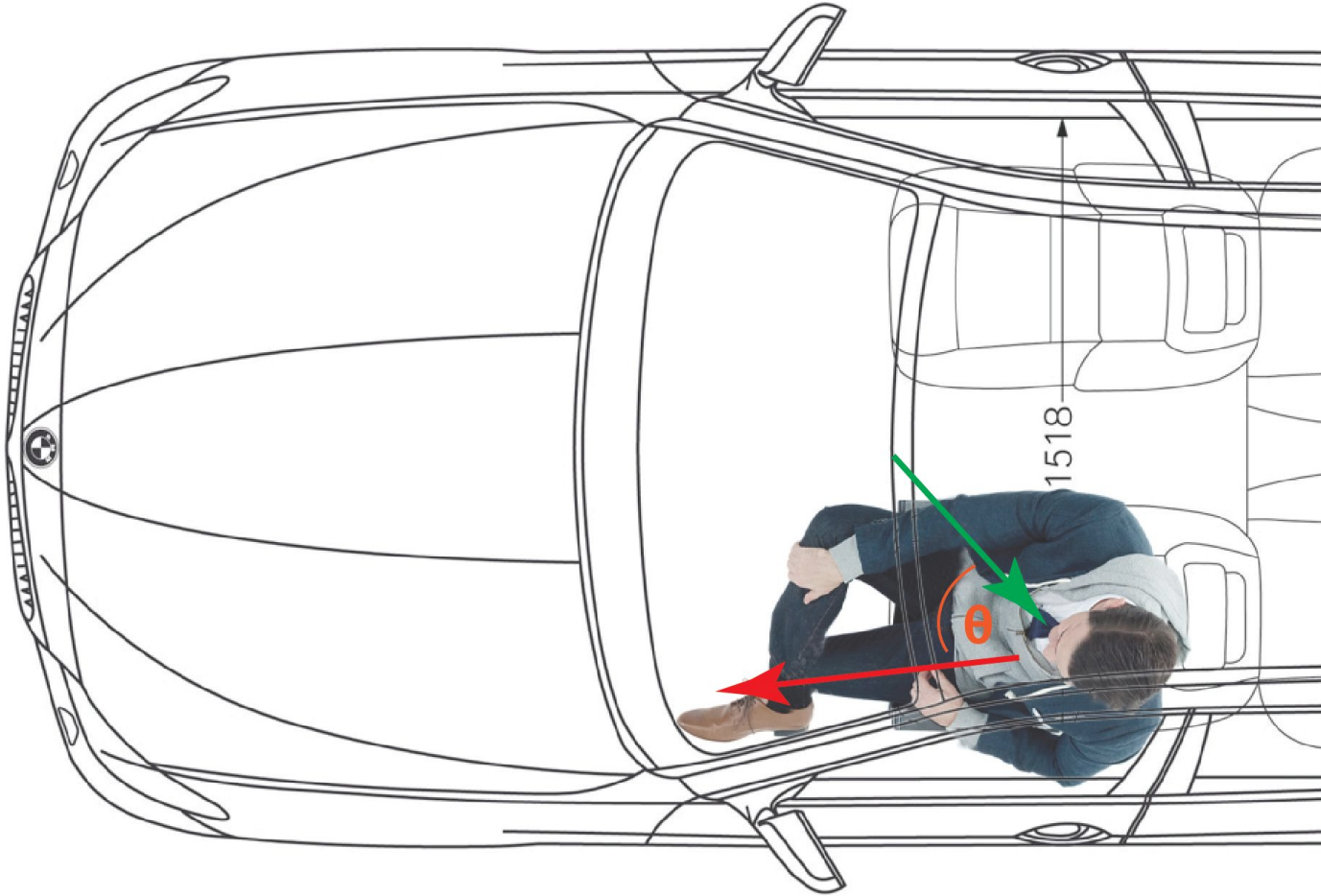
$$\theta_x = atan2\left(r_{32}, r_{33}\right)$$

$$\theta_y = atan2\left(-r_{31}, \sqrt{r_{32}^2 + r_{33}^2}\right)$$

$$\theta_z = atan2\left(r_{21}, r_{11}\right)$$

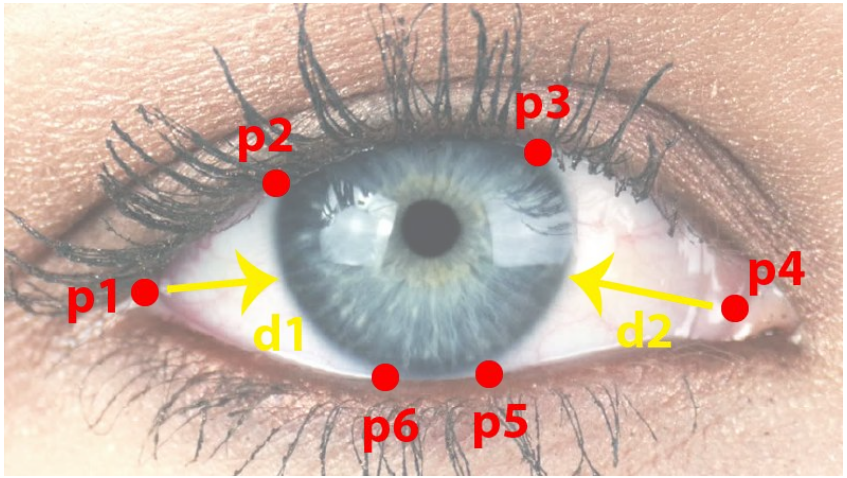
Head Pose

- Camera angle calibration



Estimate Distraction with Eye Gaze

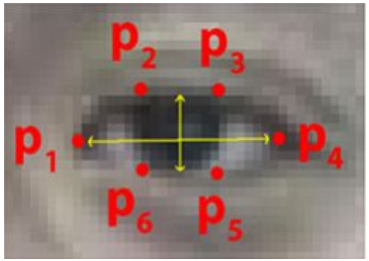
- Use of left and right scleras
- Determine Distraction Over time

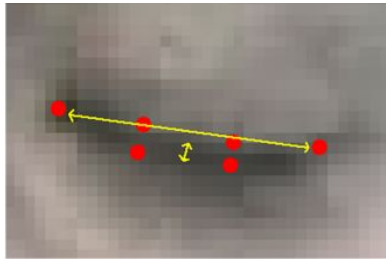


$$d1 = ||(p2 - p6 / 2) - p1||$$
$$d2 = ||(p3 - p5 / 2) - p4||$$

Estimating Drowsy Eyes

- Eye Aspect Ratio





$$EAR = \frac{||p2 - p6|| + ||p3 - p6||}{2 * ||p1 - p4||}$$

Eye Aspect Ratio

- Threshold: 0.25

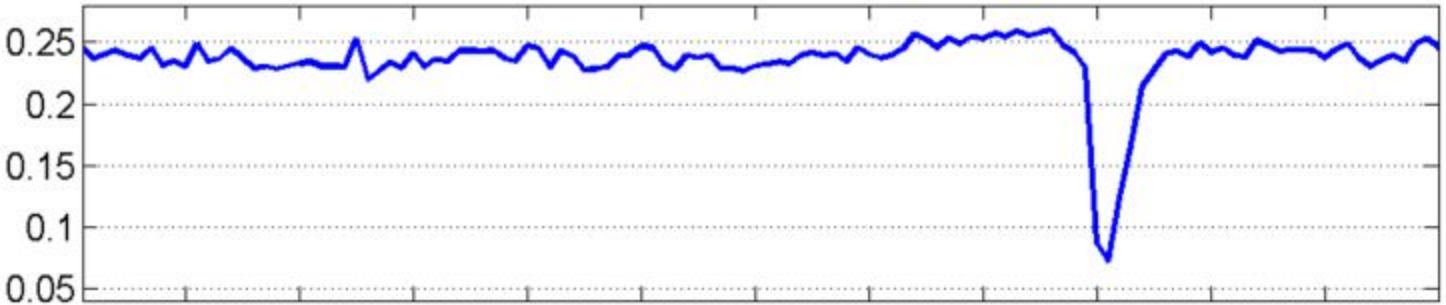
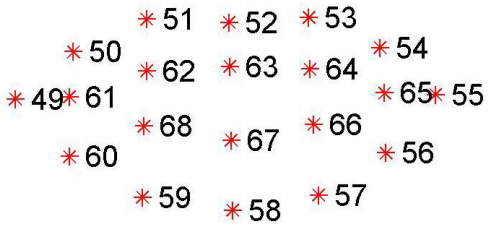


Figure: Eye blink event Tereza Soukupova et al. (2016)

Estimating Yawn

- Mouth Aspect Ratio(MAR) - Ratio of height over width of mouth

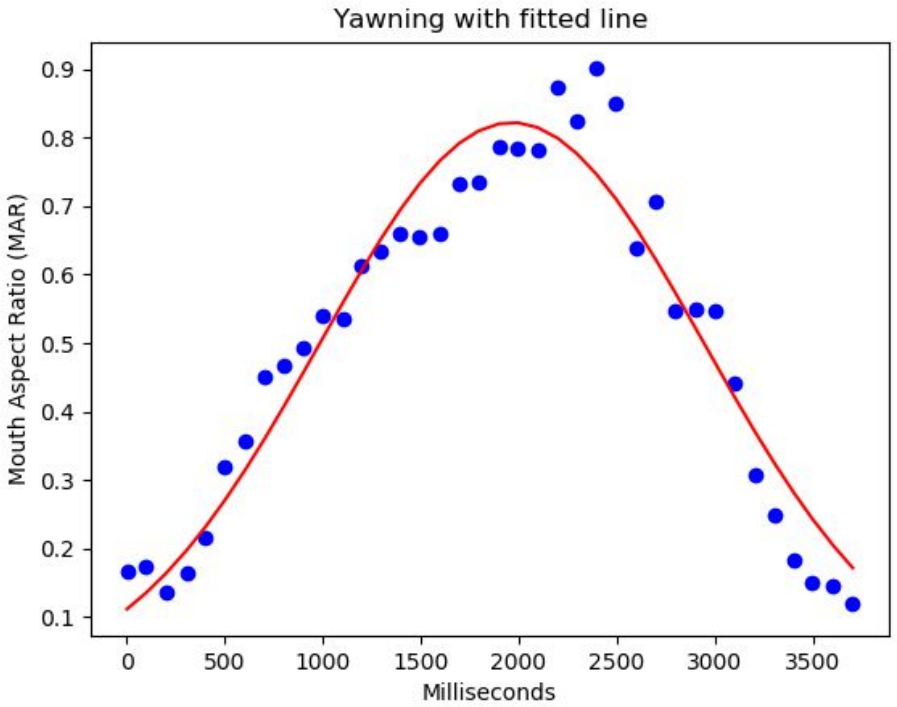
$$MAR = \frac{mean(||p63-p67||,||p52-p58||)}{mean(||p61-p65||,||p49-p55||)}$$



Estimating Yawn

Measuring the MAR

over time to estimate yawn



Karolinska Sleepiness Scale (KSS)

Karolinska Sleepiness Scale (KSS)

Extremely alert	1
Very alert	2
Alert	3
Rather alert	4
Neither alert nor sleepy	5
Some signs of sleepiness	6
Sleepy, but no effort to keep awake	7
Sleepy, but some effort to keep awake	8
Very sleepy, great effort to keep awake, fighting sleep	9
Extremely sleepy, can't keep awake	10

$$dist_{i,e} = \begin{cases} w_e & v_{i,e} \geq \tau_e \\ 0 & v_{i,e} < \tau_e \end{cases}$$

$$drow_{i,e} = \begin{cases} w_e & v_{i,e} \geq \tau_e \\ 0 & v_{i,e} < \tau_e \end{cases}$$

$$KSS_{i,k} = \frac{\sum_{j=i-k}^{i} dist_j + \sum_{j=i-k}^{i} drow_j}{2k}$$

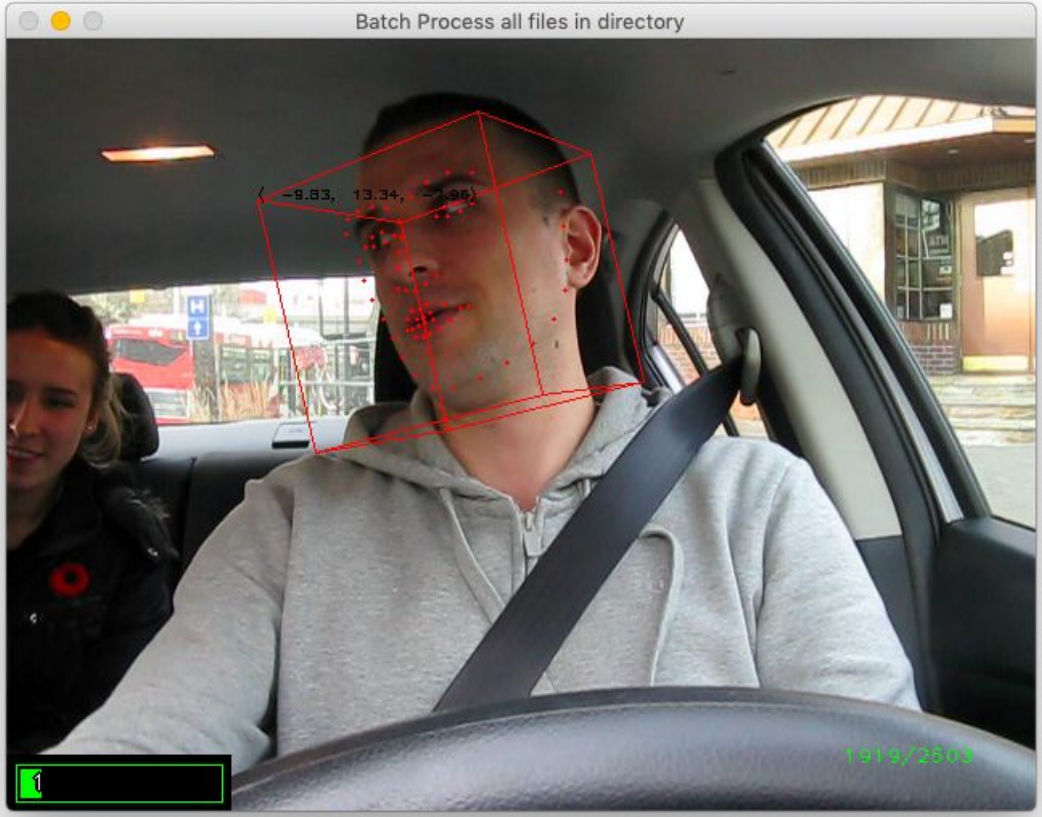
Results

Comprehensive Application including

- Distraction Alert
- Drowsiness Alert
- Alertness Scale Combining Both

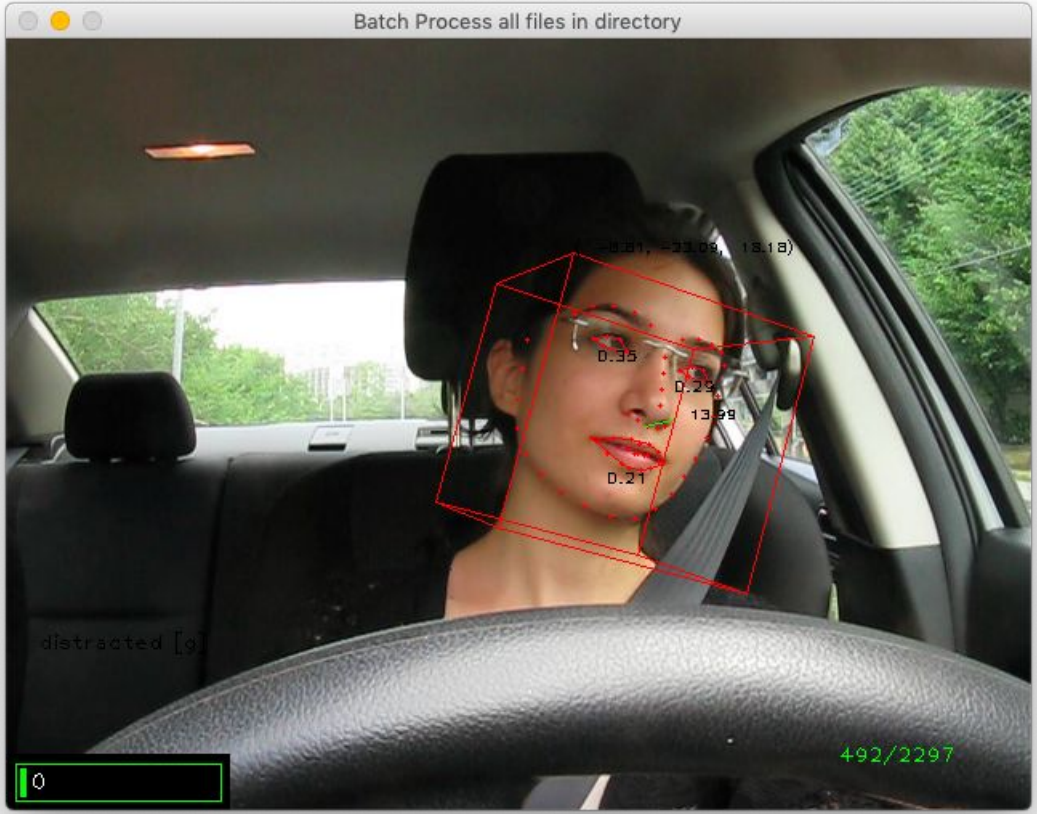
Testing

Head Pose Estimation:



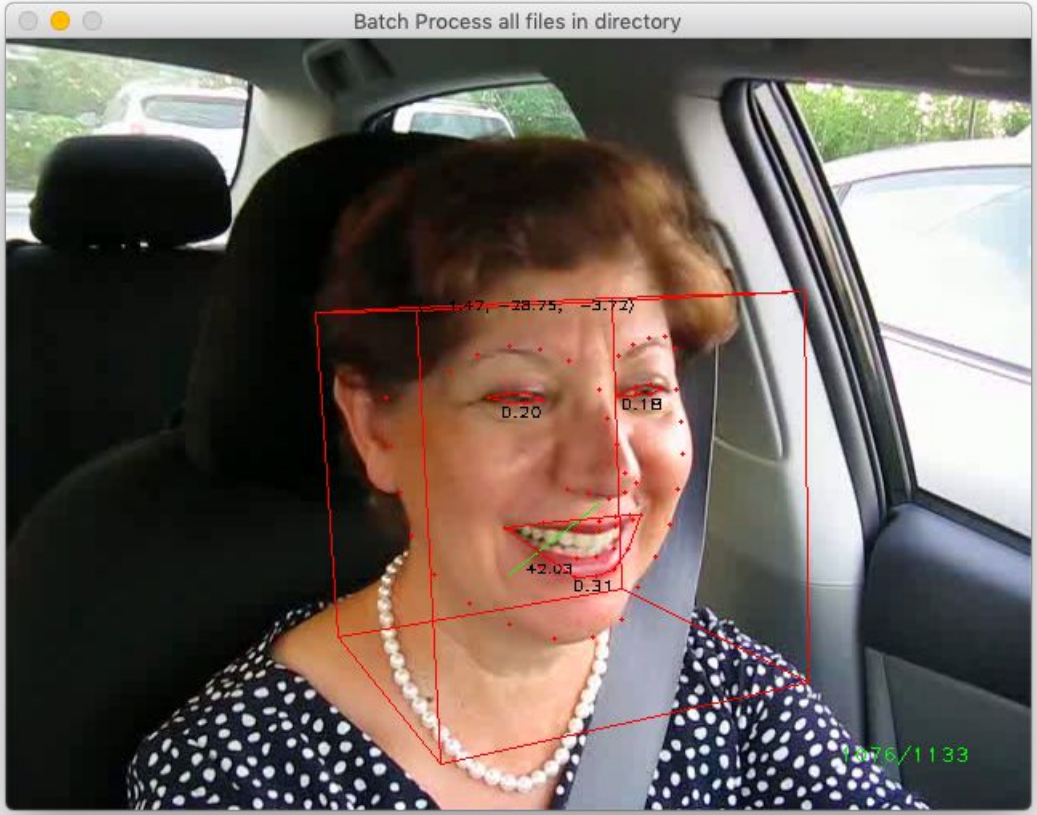
Testing

Gaze Estimation



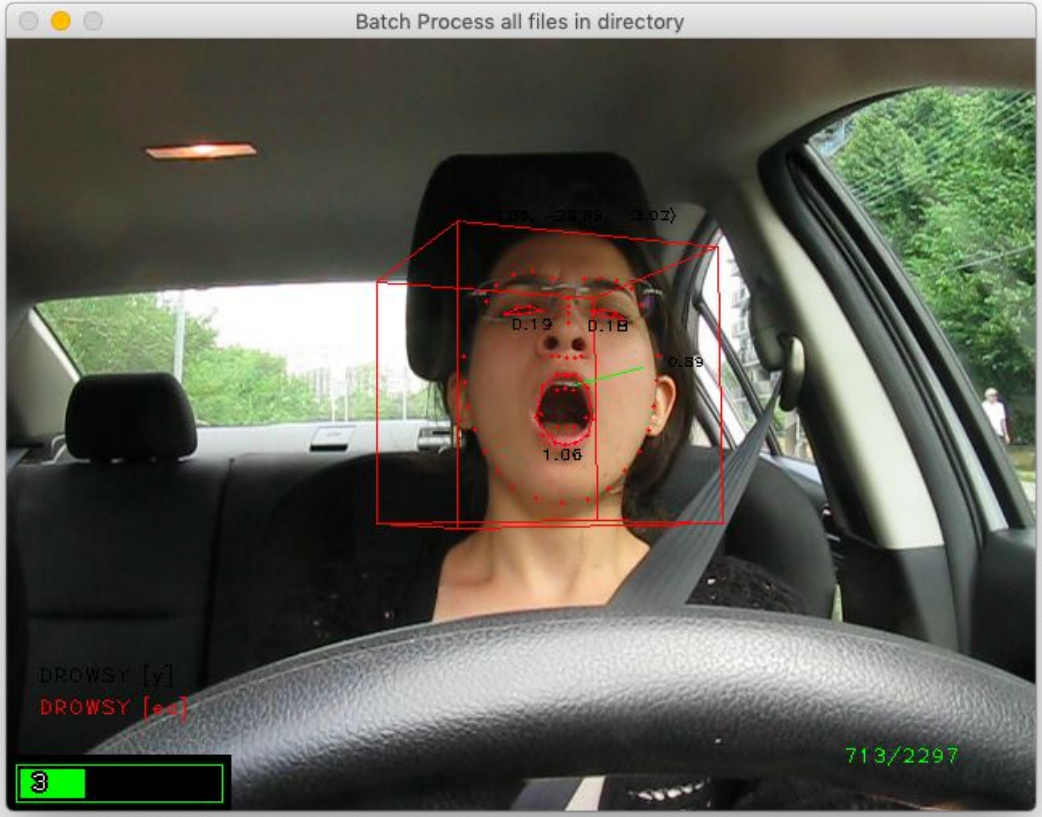
Testing

Eye Openness Estimation



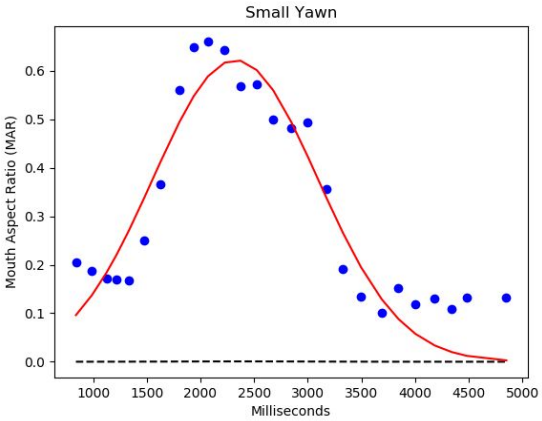
Testing

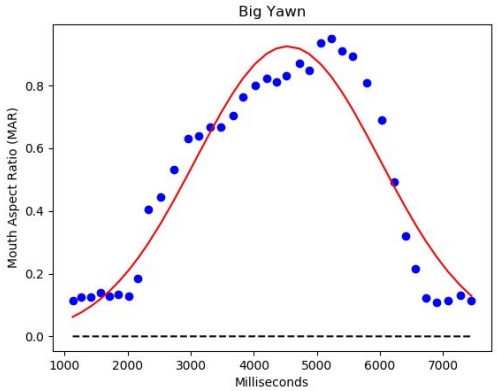
Yawn Estimation

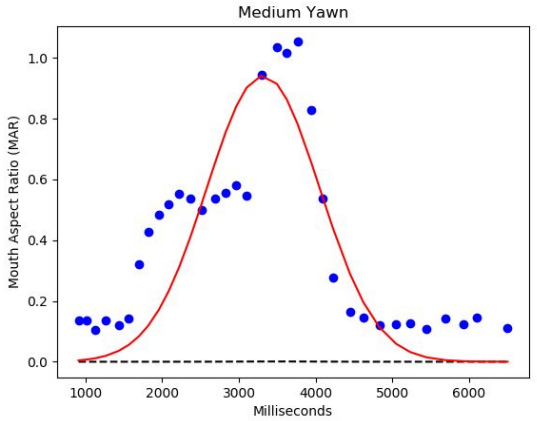


Testing

Yawn Estimation







Testing

KSS

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Average KSS: 0.74
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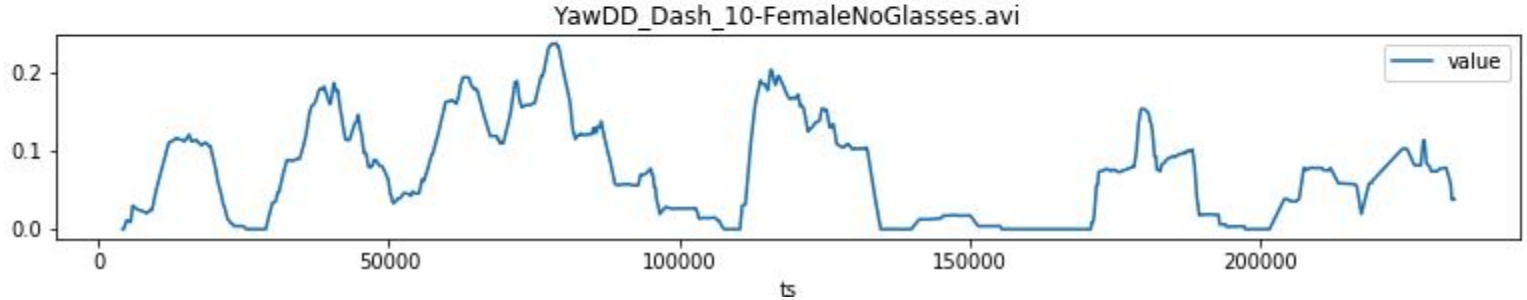

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