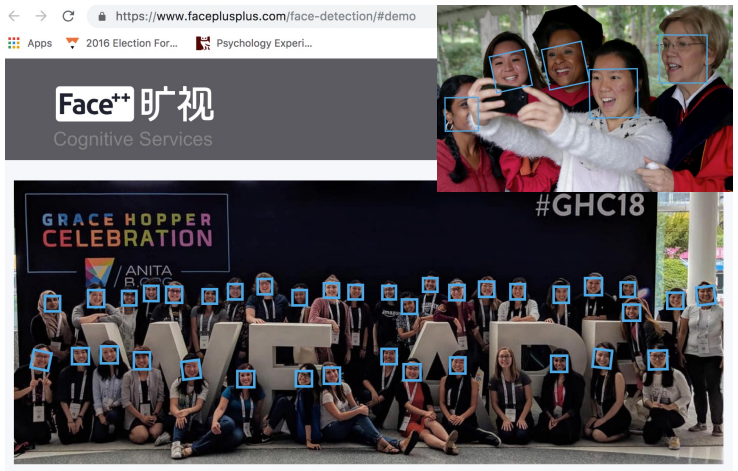
Face Detection



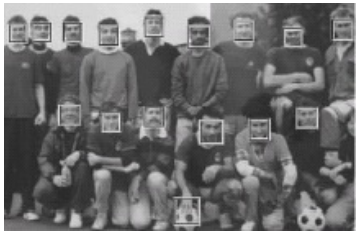
1

Face detection: Viola & Jones

Multiple view-based classifiers based on simple features that best discriminate faces vs. non-faces

Most discriminating features ***learned*** from thousands of samples of face and non-face image windows

Attentional mechanism: cascade of increasingly discriminating classifiers improves performance



1-2

2

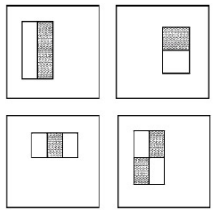
Viola & Jones use simple features

Use simple *rectangle features:*

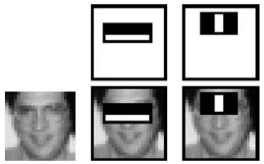
Σ I(x,y) in gray area – Σ I(x,y) in white area

within 24 x 24 image sub-windows

- Initially consider 160,000 potential features per sub-window!
- features computed very efficiently



Which features best distinguish face vs. non-face?



Learn most discriminating features from thousands of samples of face and non-face image windows

1-3

3

Learning the best features

weak classifier using one feature:

$$h(x, f, p, \theta) = \begin{cases} 1 & \text{if } pf(x) < p\theta \\ 0 & \text{otherwise} \end{cases}$$

x = image window
f = feature
p = +1 or -1
θ = threshold

$(x_1, w_1, 1)$ … $(x_n, w_n, 0)$

n training samples, equal weights, known classes

$$C(x) = \begin{cases} 1 & \sum_{t=1}^{T} \alpha_t h_t(x) \geq \tau \\ 0 & \text{otherwise} \end{cases}$$

normalize weights → find next best weak classifier $\epsilon_t = \min_{f,p,\theta} \sum_i w_i \, |h(x_i, f, p, \theta) - y_i|$

AdaBoost

use classification errors to update weights

final classifier

~ 200 features yields good results for "monolithic" classifier

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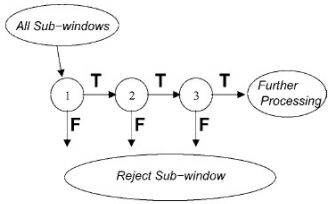
"Attentional cascade" of increasingly discriminating classifiers



Early classifiers use a few highly discriminating features, low threshold

- 1st classifier uses two features, removes 50% non-face windows

- later classifiers distinguish harder examples

- Increases efficiency
- Allows use of many more features

→ Cascade of 38 classifiers, using ~6000 features

1-5

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Training with normalized faces

5000 faces
many more non-face patches

faces are normalized
for scale, rotation

small variation in pose

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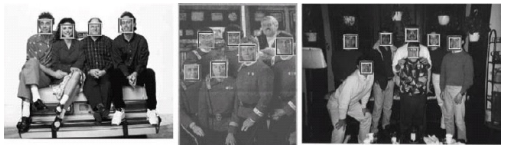
Viola & Jones results



With additional diagonal features, classifiers were created to handle image rotations and profile views

1-7

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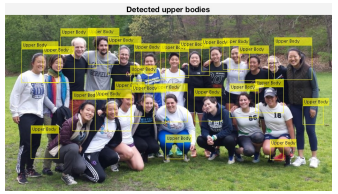
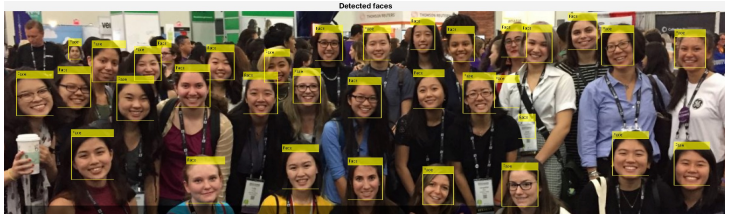
Viola & Jones results
(MATLAB Computer Vision Toolbox)





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