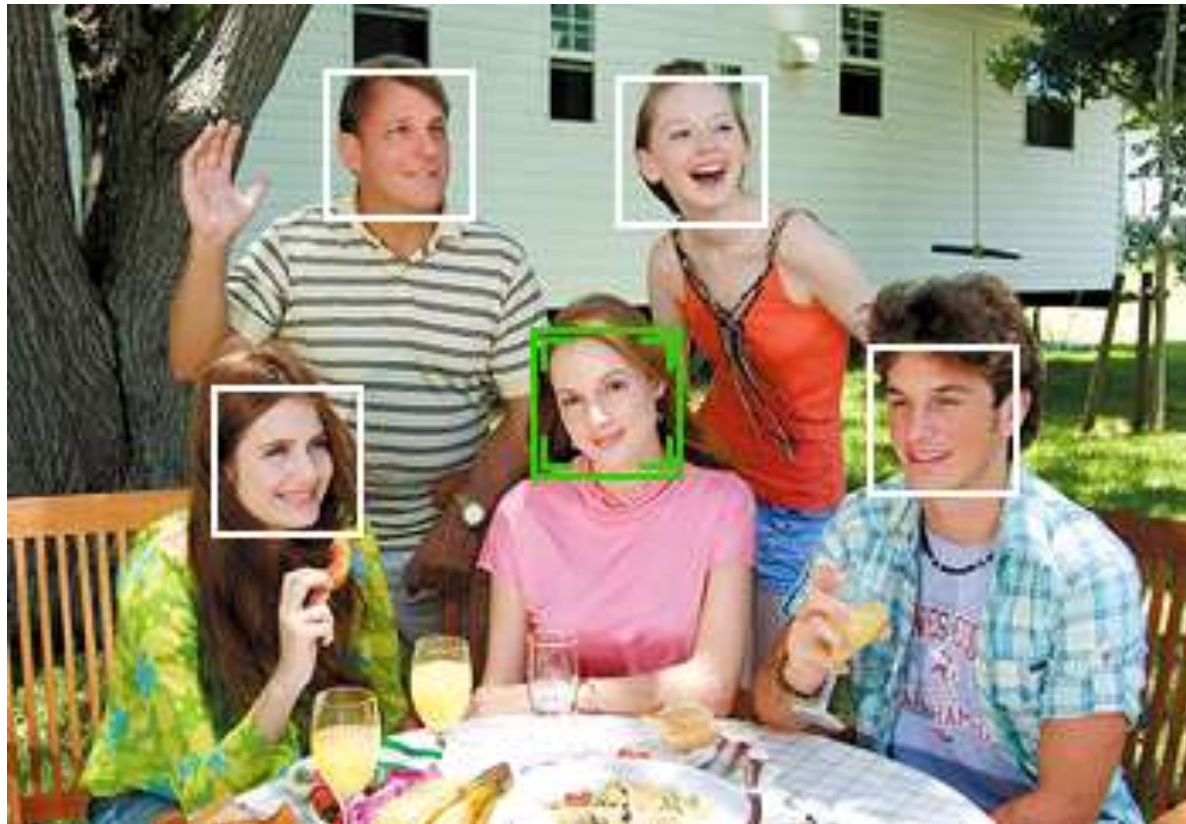




# Viola-Jones Type Face Detection



Jiří Matas

Center for Machine Perception

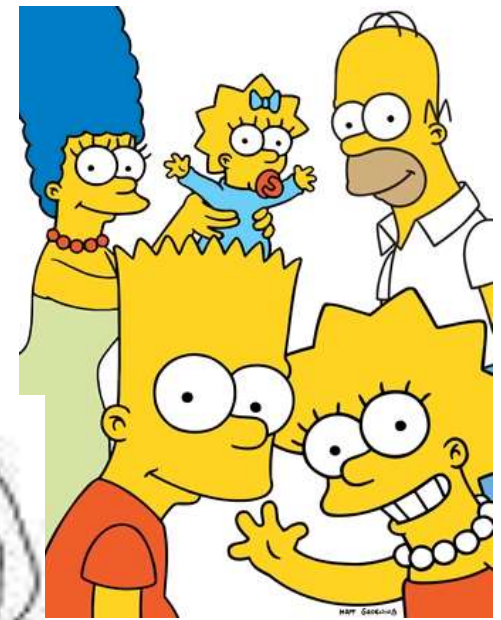
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Czech Technical University, Prague

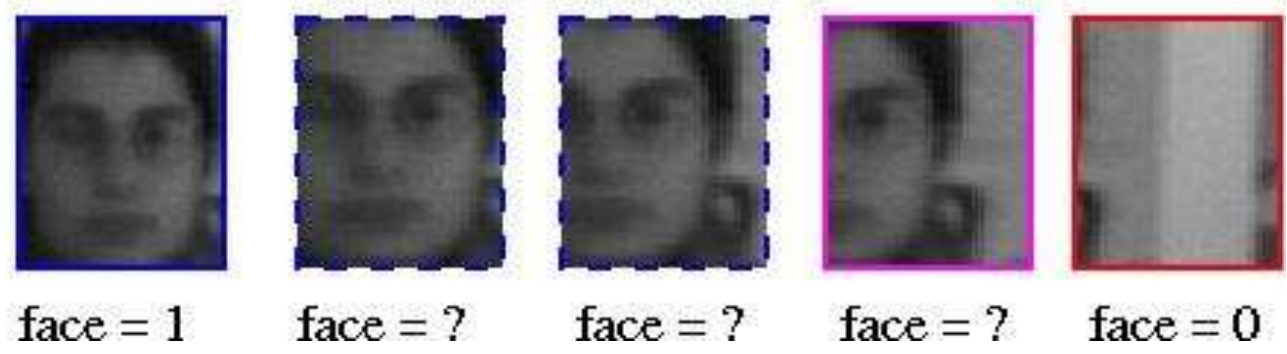
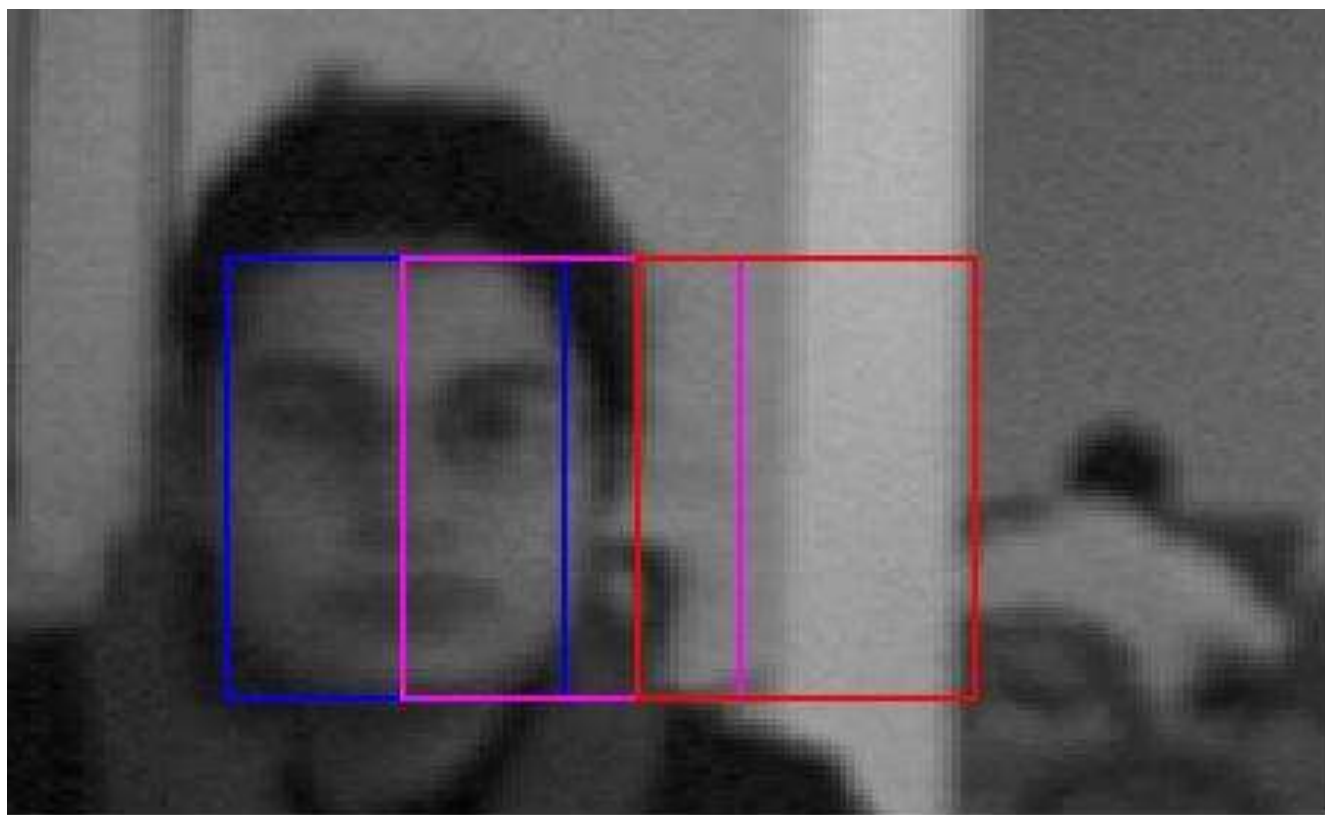
# The task is not simple .... I.







# What is and is not a face ...



# Errors

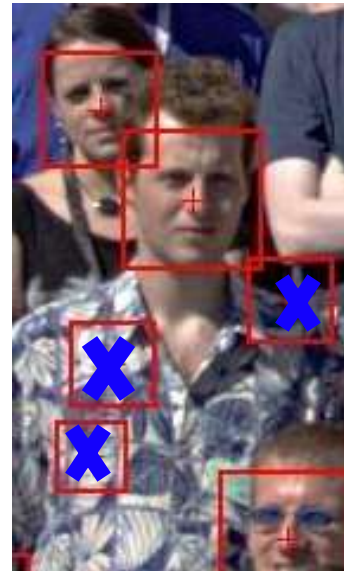


1. false negative
2. false positives
3. localization

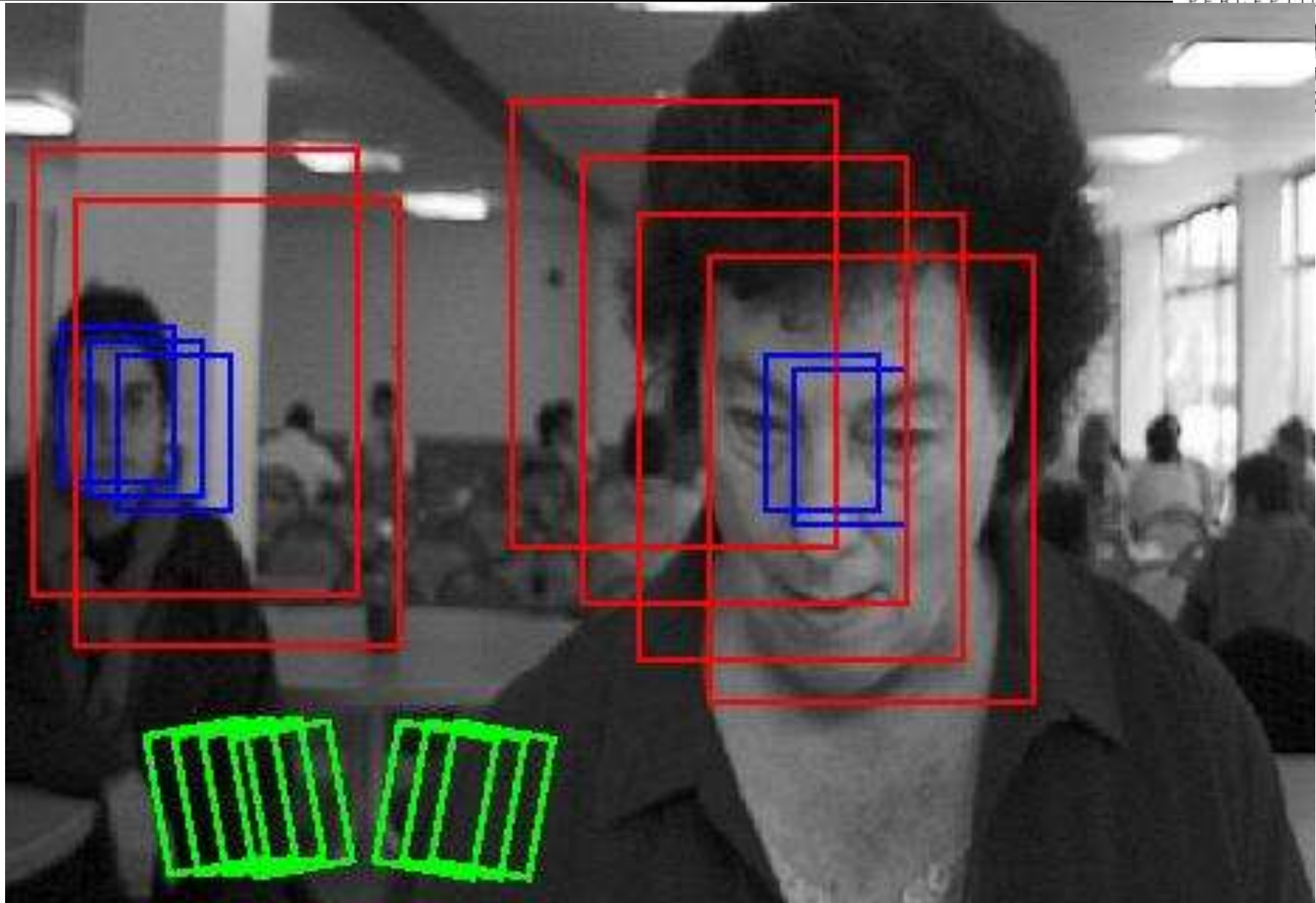


## Problems:

- where is the boarder between 1. + 2. and 3. ?



# Viola and Jones suggested Brute-force Search

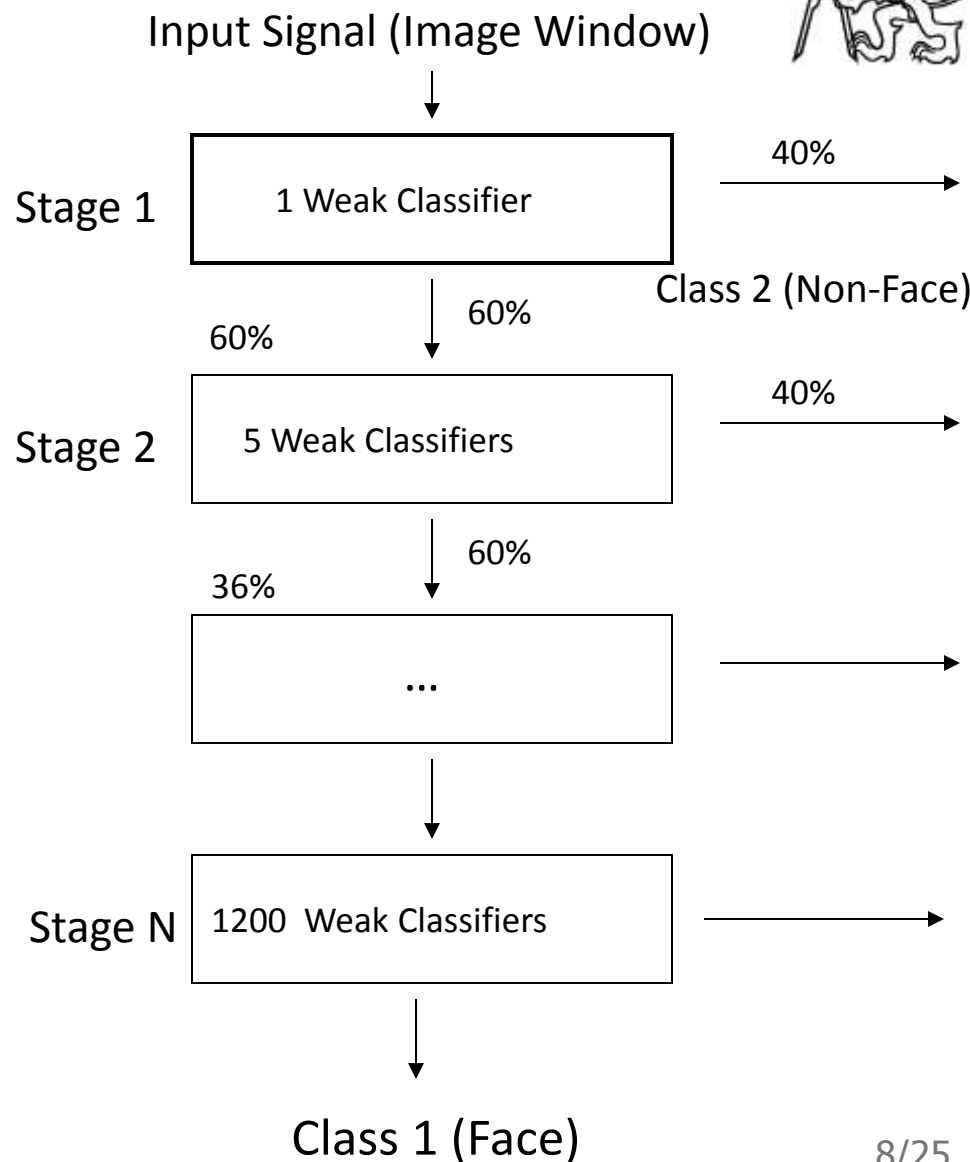


# Viola – Jones (2001)



## Breakthrough #1

- speed depends on negative examples only
- sequential decision making addresses the problem
- .

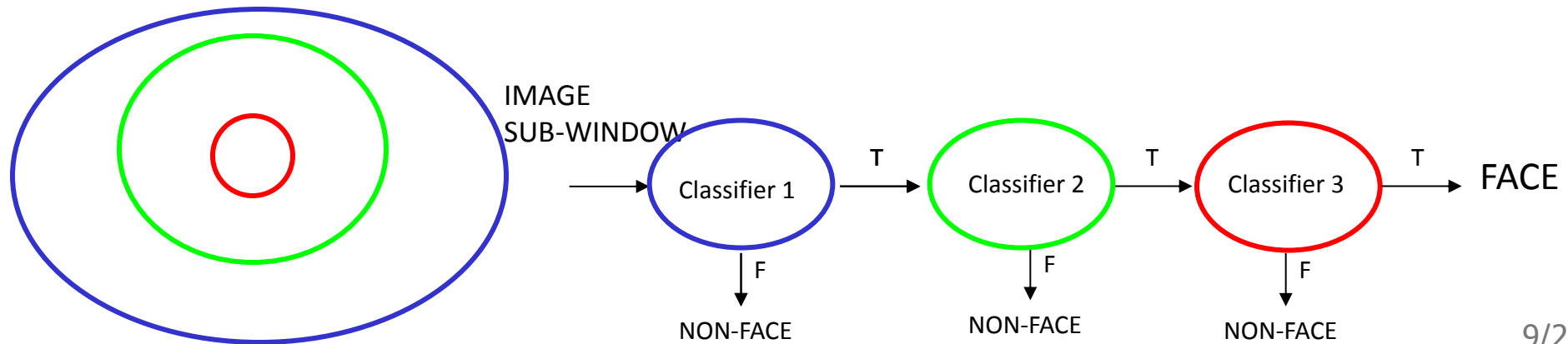
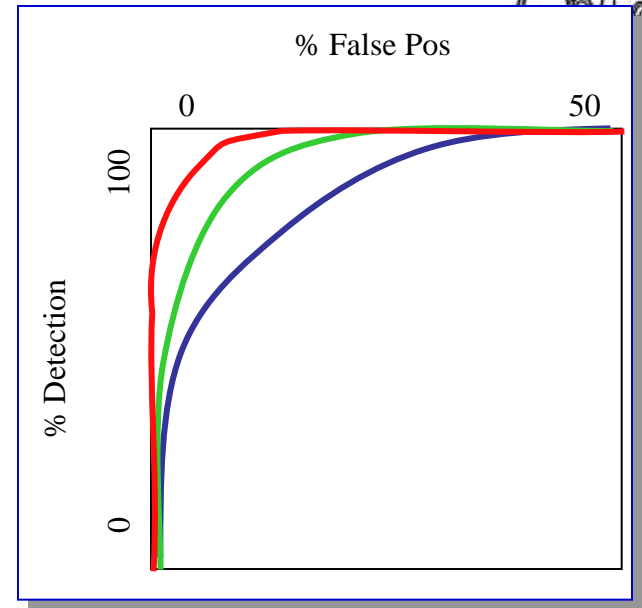




# Viola – Jones (2001)

## Breakthrough #2 - bootstrap

Receiver operating characteristic

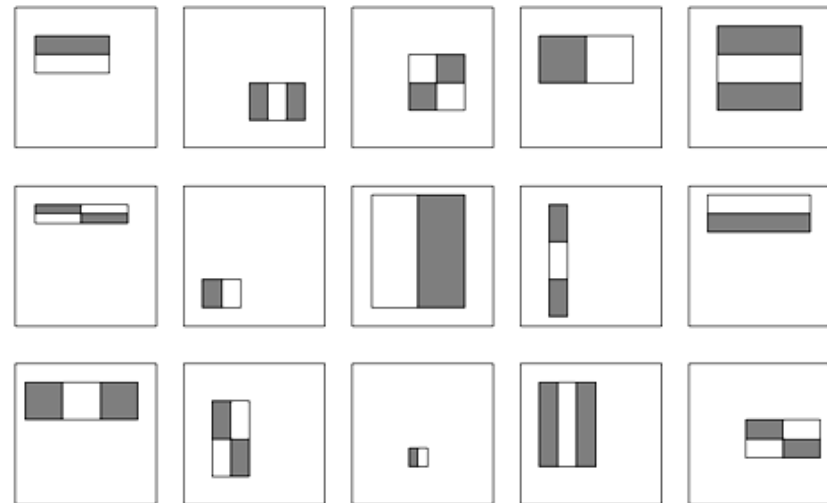
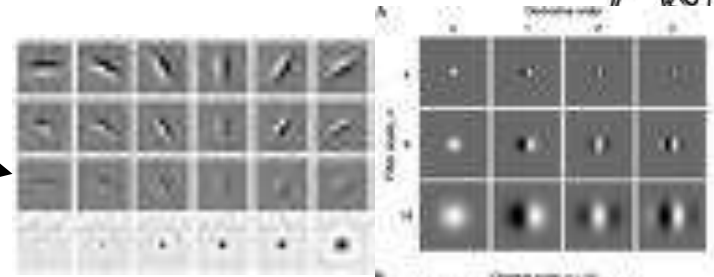


# Viola – Jones (2001)

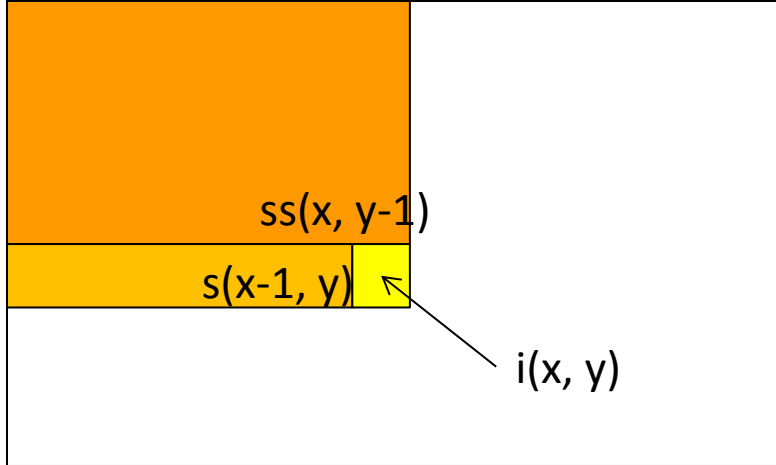


## Breakthrough #3

- Fast features
- Gabor filters approximated by piecewise constant functions - Haar wavelets,
$$\psi(t) = \begin{cases} 1 & 0 \leq t < \frac{1}{2}, \\ -1 & \frac{1}{2} \leq t < 1, \\ 0 & \text{otherwise.} \end{cases}$$



# Fast calculation of Haar wavelets



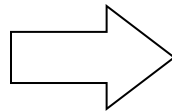
row sum :  $s(x, y) = s(x-1, y) + i(x, y)$

Integral image :  $ss(x, y) = ss(x, y-1) + s(x, y)$

MATLAB: `ss = cumsum(cumsum(double(i)), 2);`

Image

0	1	1	1
1	2	2	3
1	2	1	1
1	3	1	0

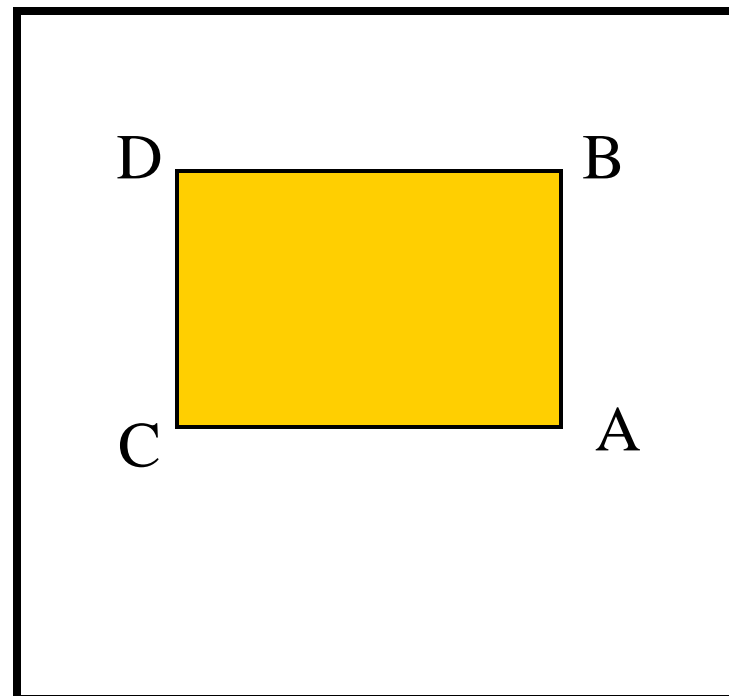


Integral image

0	1	2	3
1	4	7	11
2	7	11	16
3	11	16	21

# Fast calculation of Haar wavelets

- values at A,B,C,D are read out from the integral image
- Sum of the intensities within the rectangle is equal to:  
$$\text{sum} = A - B - C + D$$
- Each rectangle requires 3 addition/subtraction operations!



# Viola – Jones (2001)

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CENTER FOR MACHINE  
PERCEPTION



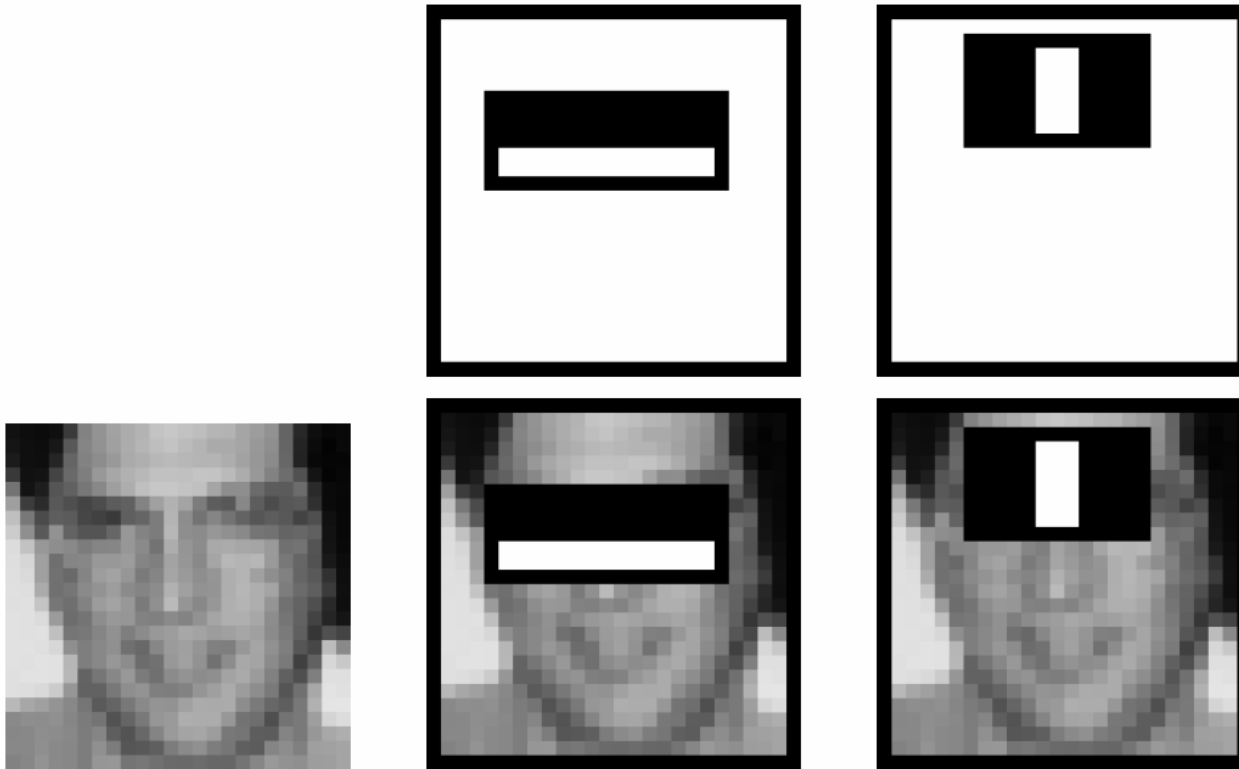
## Breakthrough #5

- 

**AdaBoost** (Schapire a Freund, 1997) used for training the classifiers

# Adaboost Detector

- Selected features:



The two features have 100% detection rate and 50% false alarms



Thank you for your attention.