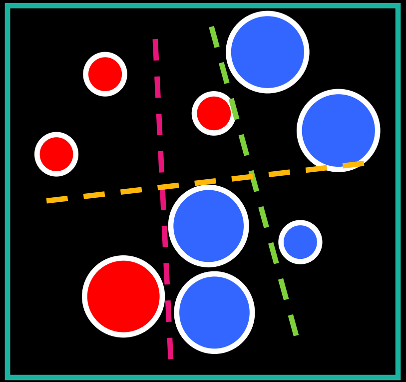
CS4495/6495
Introduction to Computer Vision

8C-L2 *Boosting and face detection*



Generic category recognition: Basic framework

Train

- Build an object model – a *representation*

  Describe training instances (here images)
- Learn/train a *classifier*

Test

- Generate candidates in new image
- *Score* the candidates

Discriminative classification methods

Discriminative classifiers – find a division (surface) in feature space that separates the classes

Several methods

- Nearest neighbors
- Boosting
- Support Vector Machines

Discriminative classification methods

Discriminative classifiers – find a division (surface) in feature space that separates the classes

Several methods

- Nearest neighbors
- Boosting
- Support Vector Machines

Boosting: Training method

- Initially, weight each training example equally
- In each boosting round:
  - Find the *weak learner* that achieves *the lowest weighted training error*
  - Raise weights of training *examples misclassified by current weak learner*

Slide credit: Lana Lazebnik

Boosting: Training method

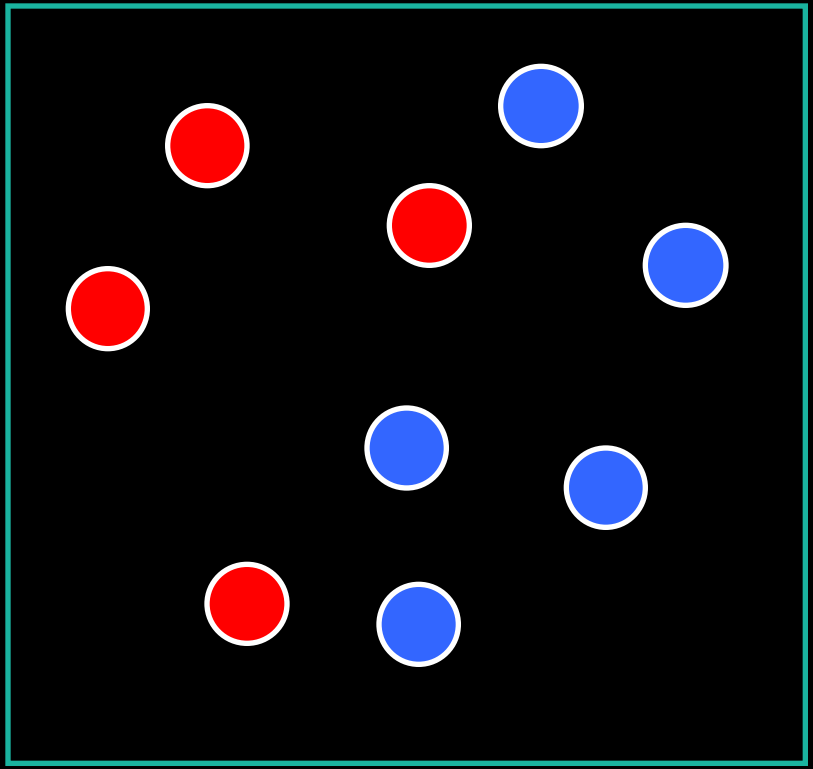
- Compute final classifier as linear combination of all weak learners (weight of each learner is directly proportional to its accuracy)

Slide credit: Lana Lazebnik

Weak learners

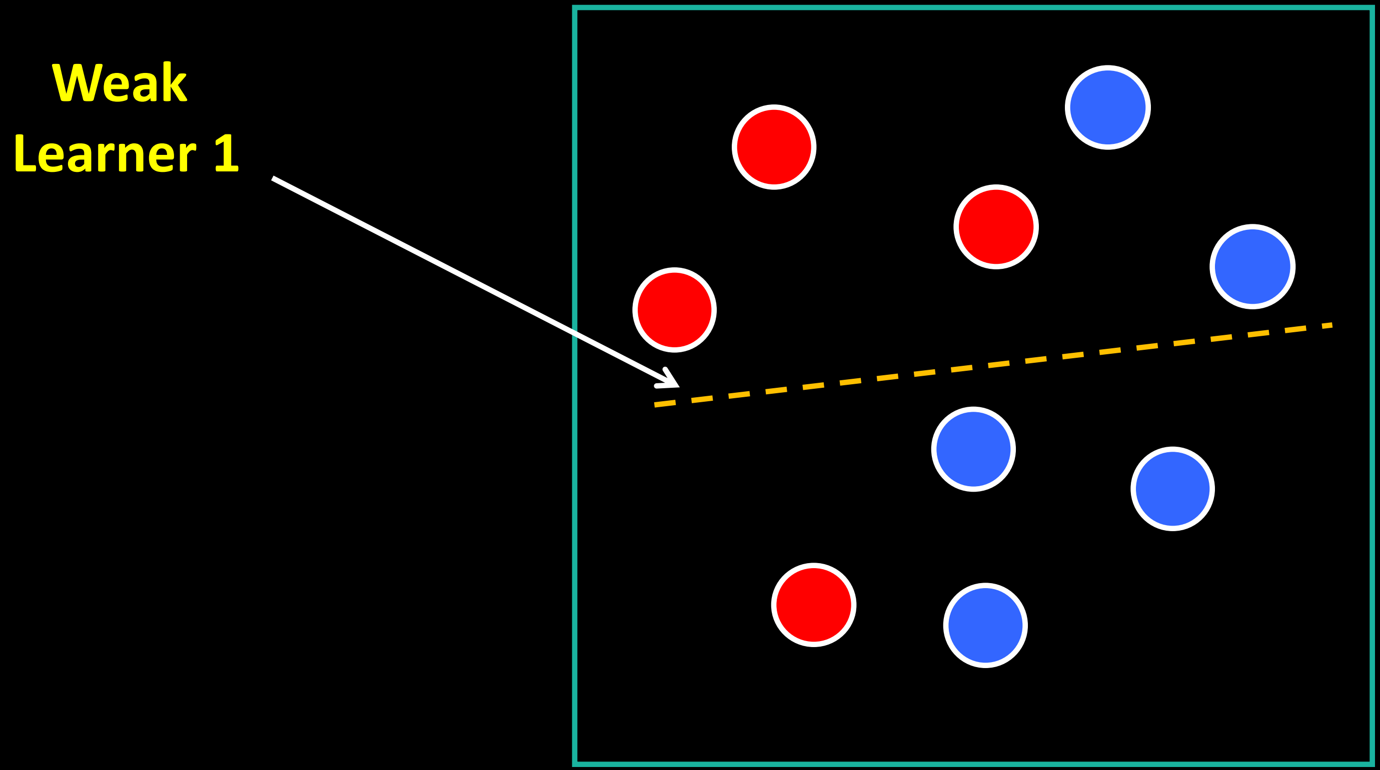
- What is a weak learner?
- Simply, a function that partitions the space
- *Weak* in that it doesn't get the answer right but gives some information over the current errors

Boosting: Intuition



Slide credit: Paul Viola

Boosting: Intuition



Slide credit: Paul Viola

Boosting: Training method

- In each boosting round:
  - Find the *weak learner* that achieves the *lowest weighted training* error
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Slide credit: Lana Lazebnik

Boosting: Training method

- In each boosting round:
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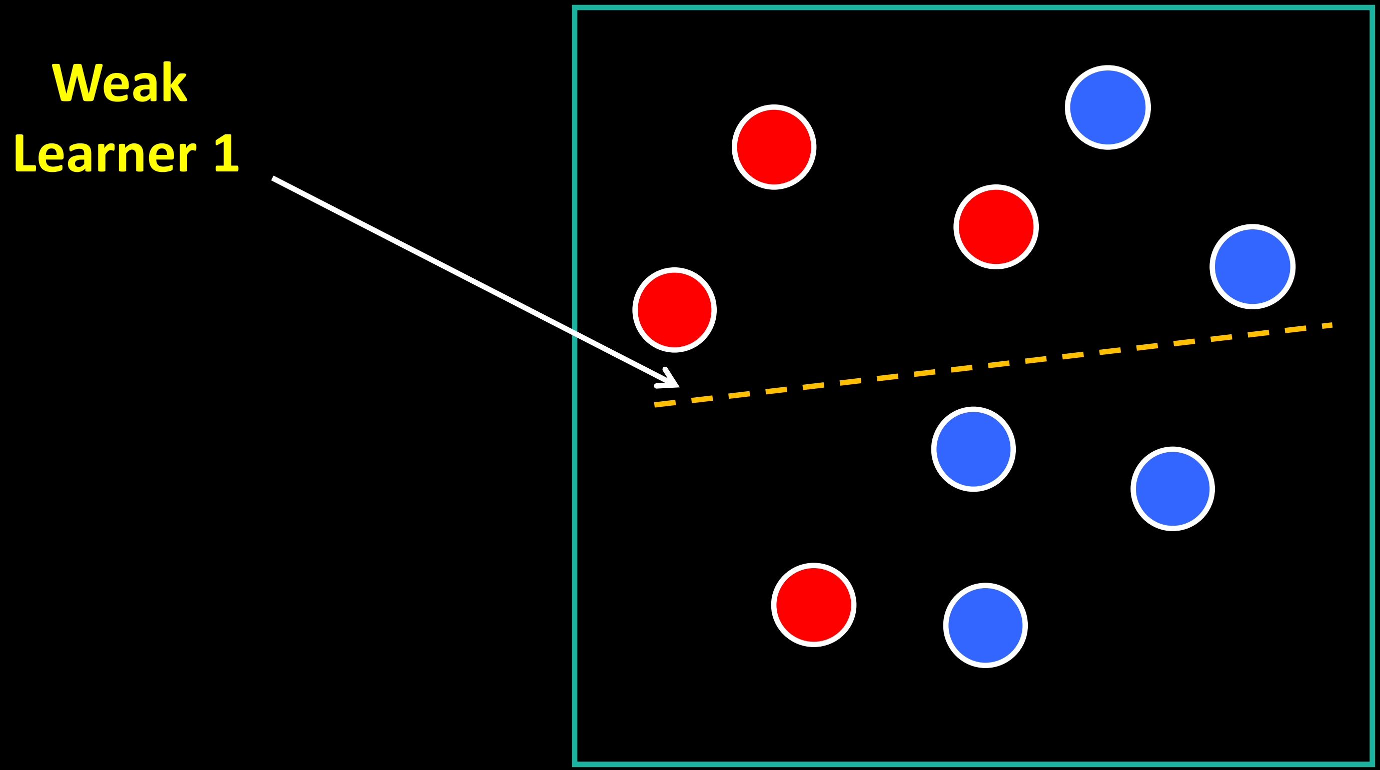
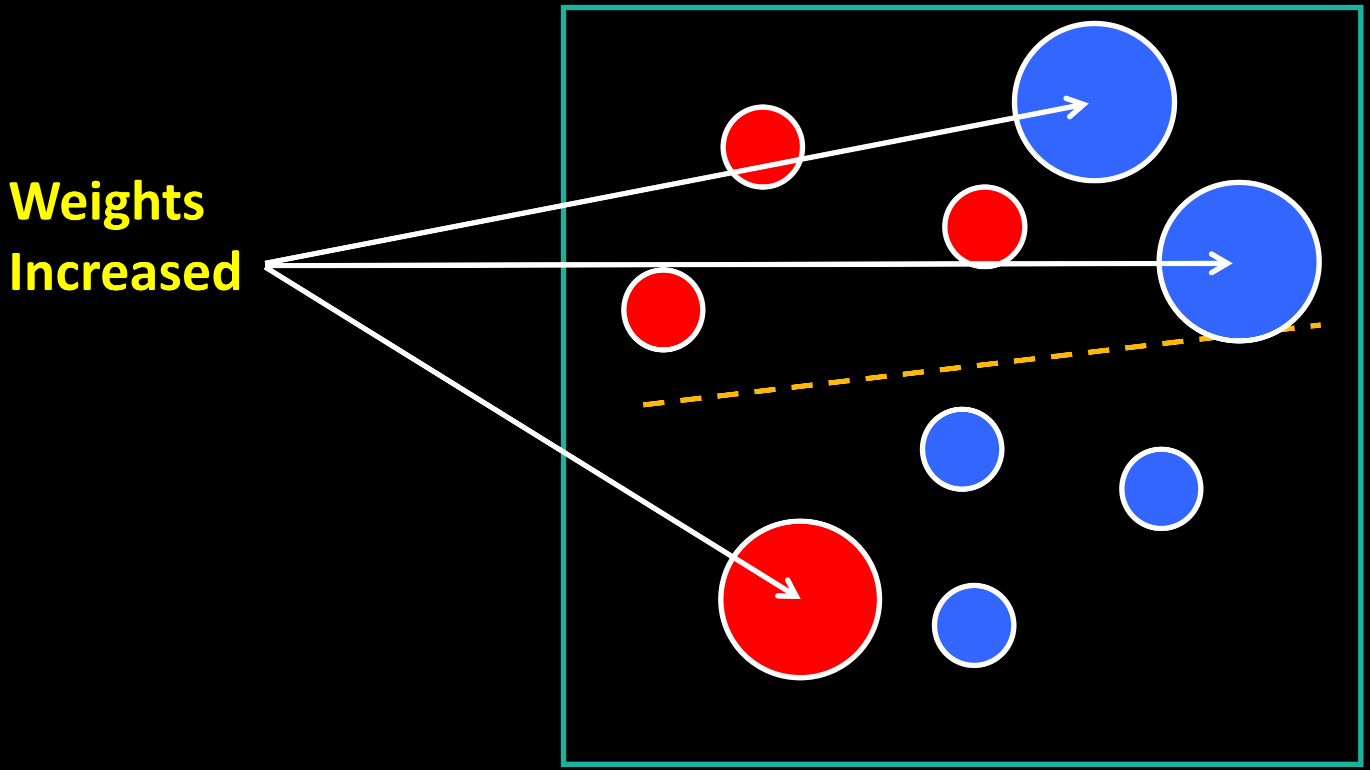
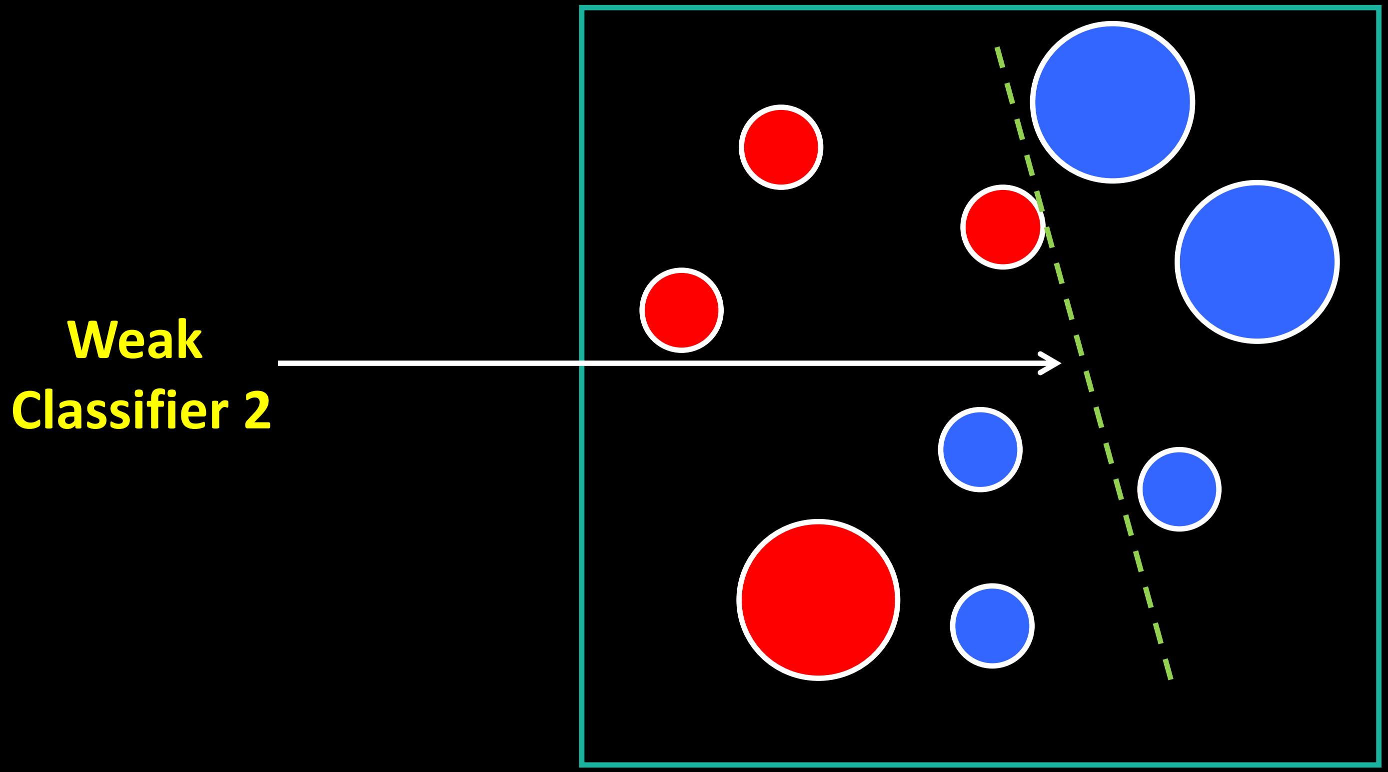
Boosting: Intuition



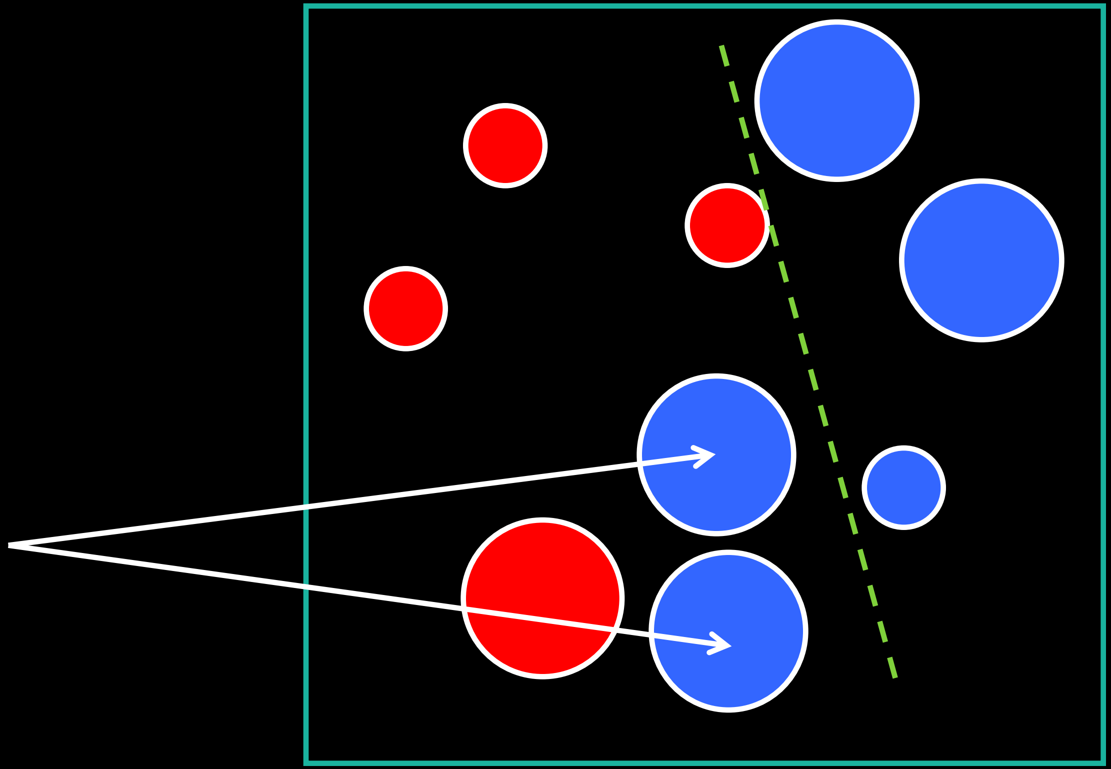
Boosting: Intuition



Boosting: Intuition

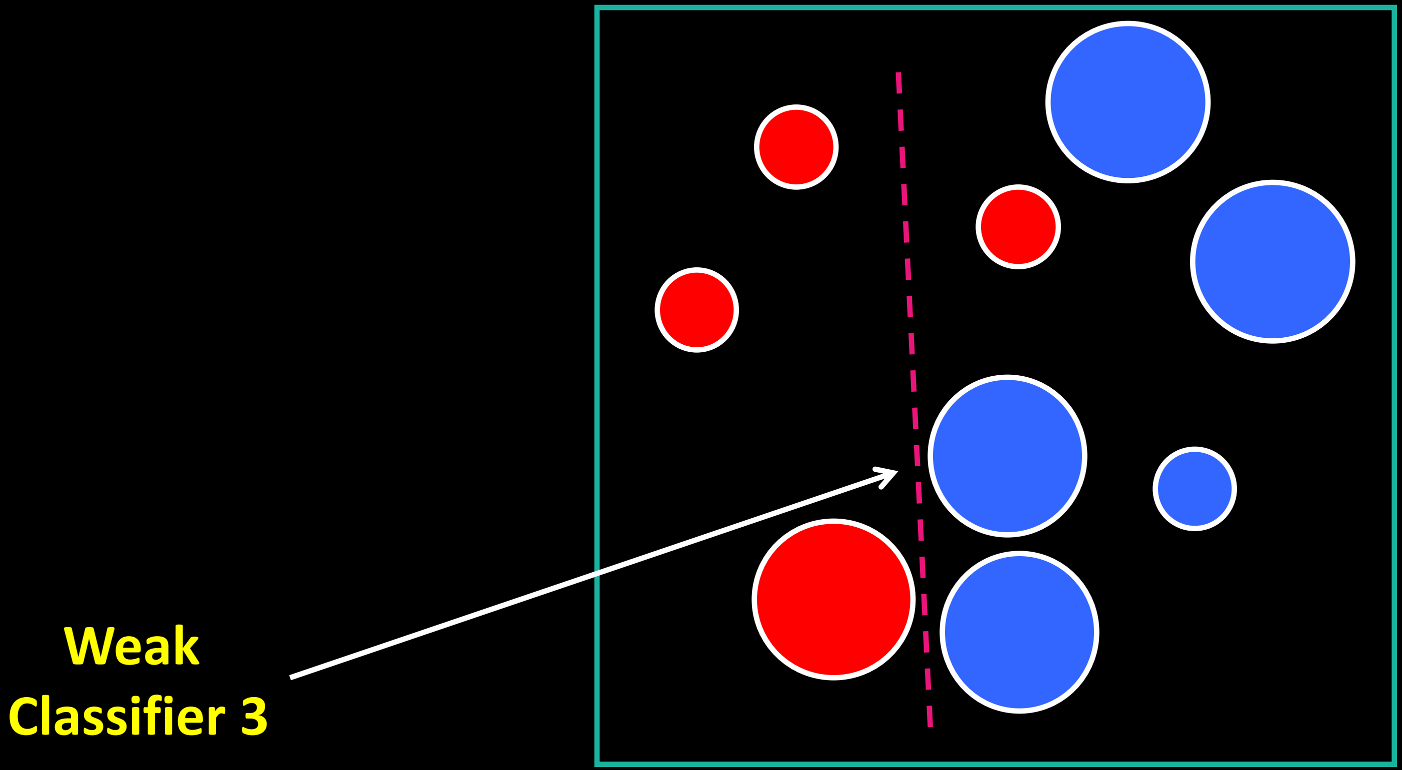


Boosting: Intuition



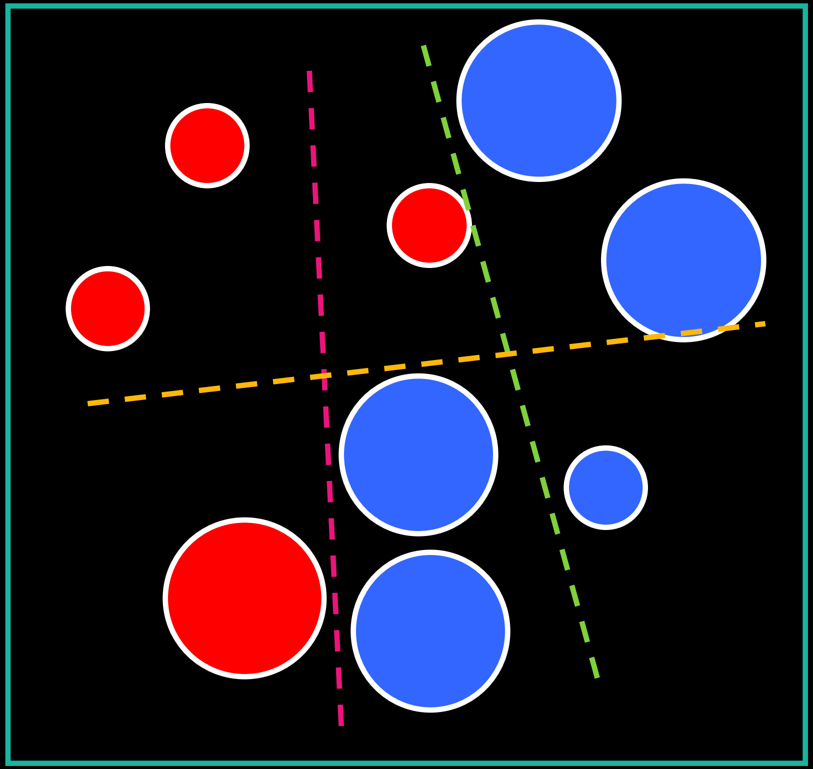
Weights Increased

Boosting: Intuition



Boosting: Intuition

Final classifier is
a combination of
weak classifiers



Boosting: Training

- General: Compute final classifier as linear combination of all weak learners (weight of each learner is directly proportional to its accuracy)
- Exact formulas for re-weighting and combining weak learners depend on the particular boosting scheme (e.g., AdaBoost)

Slide credit: Lana Lazebnik

Viola-Jones face detector

ACCEPTED CONFERENCE ON COMPUTER VISION AND PATTERN RECOGNITION 2001

Rapid Object Detection using a Boosted Cascade of Simple Features

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Abstract

This paper describes a machine learning approach for vi-

tected at 15 frames per second on a conventional 700 MHz Intel Pentium III. In other face detection systems, auxiliary information, such as image differences in video sequences,

P. Viola & M. Jones. *Rapid object detection using a boosted cascade of simple features.* CVPR 2001.

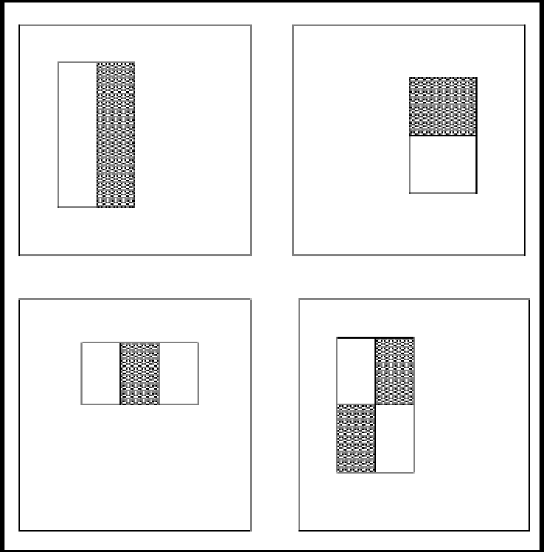
Viola-Jones face detector

Main ideas:

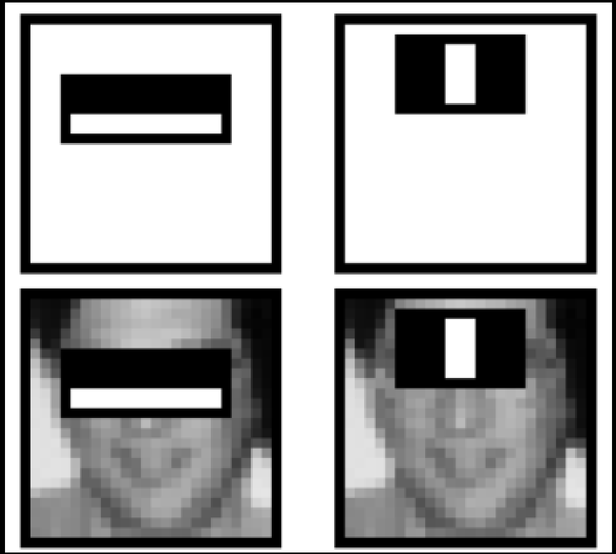
- Represent brightness patterns with efficiently computable “rectangular” features within window of interest

Kristen Grauman

Viola-Jones detector: Features



"Rectangular" filters

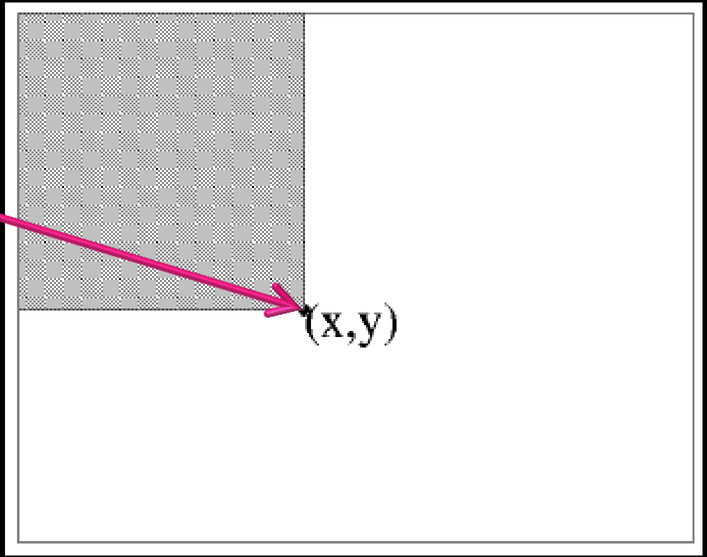


Feature output is difference between adjacent regions

Kristen Grauman

Viola-Jones detector: Integral image

Integral image: the value at (x,y) is sum of pixels above and to the left of (x,y)



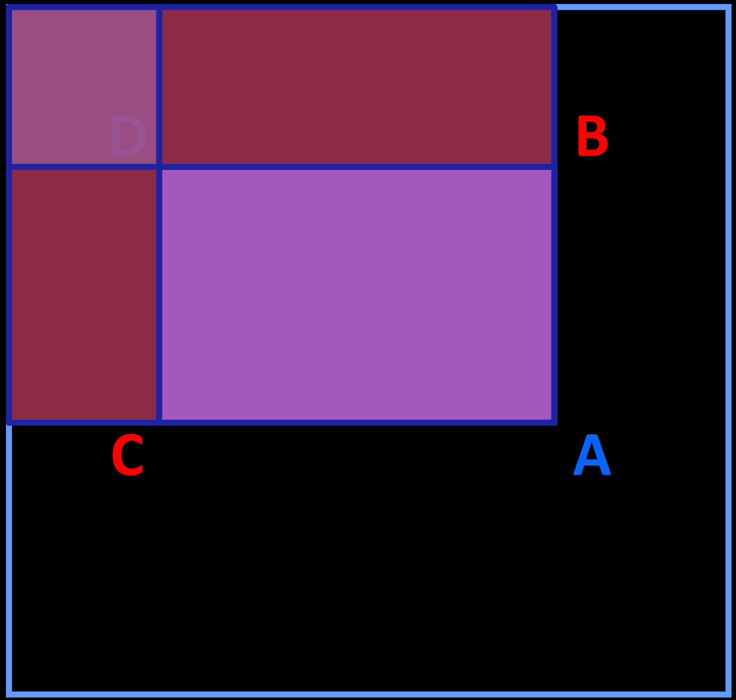
Kristen Grauman

Computing sum within a rectangle

- Let A, B, C, D be the values of the integral image at the corners of a rectangle
- Then the sum of original image values within the rectangle can be computed as:

  sum = A – B – C + D

- Only 3 additions are required for any size of rectangle!



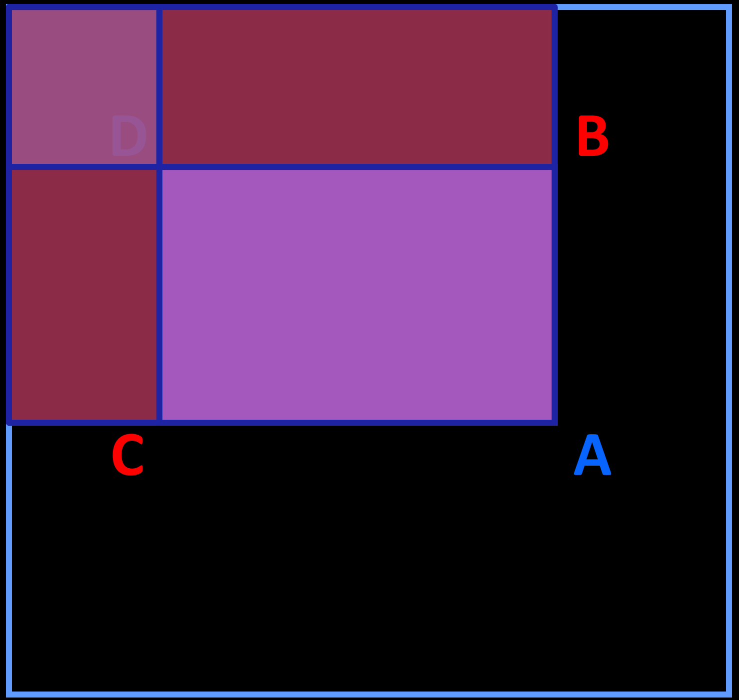
Lana Lazebnik

Computing sum within a rectangle

sum = A – B – C + D

- Only 3 additions are required for **any size of rectangle**!

Avoid scaling images
→ scale features directly for same cost



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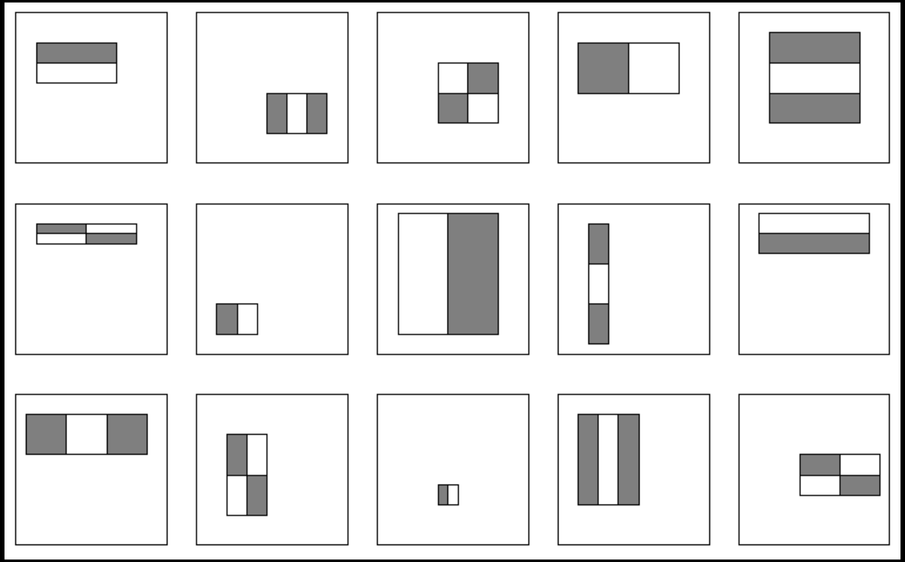
Viola-Jones detector: Features



Considering all possible filter parameters – position, scale, and type:

180,000+ possible features associated with each 24 x 24 window

Which subset of these features should we use to find a face?

Use AdaBoost – both to select *informative* features and to form the classifier

Kristen Grauman

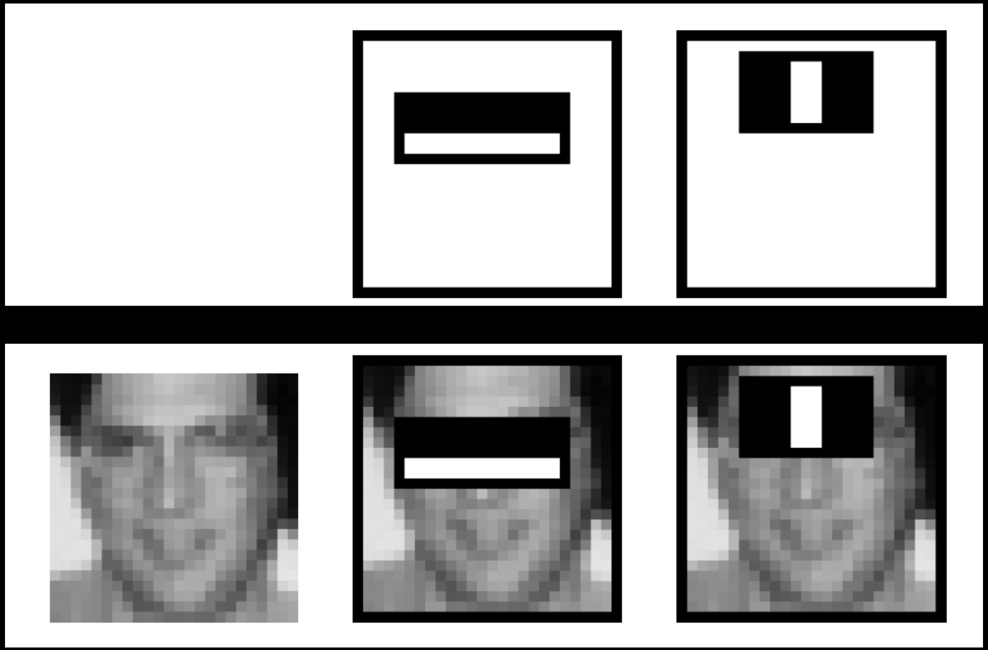
Viola-Jones face detector

Main ideas:

- Represent brightness patterns with efficiently computable “rectangular” features within window of interest
- Choose discriminative features to be weak classifiers/learners.

Kristen Grauman

Viola-Jones Face Detector: Results



First two features selected

Viola-Jones face detector

Main ideas:

- Represent brightness patterns with efficiently computable “rectangular” features within window of interest
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Kristen Grauman

Viola-Jones face detector

Main ideas:

- Use boosted combination of them as final classifier
- Form a cascade of such classifiers, rejecting clear negatives quickly

Kristen Grauman

Viola-Jones face detector

Main ideas:

- Use boosted combination of them as final classifier
- *Form a cascade of such classifiers, rejecting clear negatives quickly*

Kristen Grauman

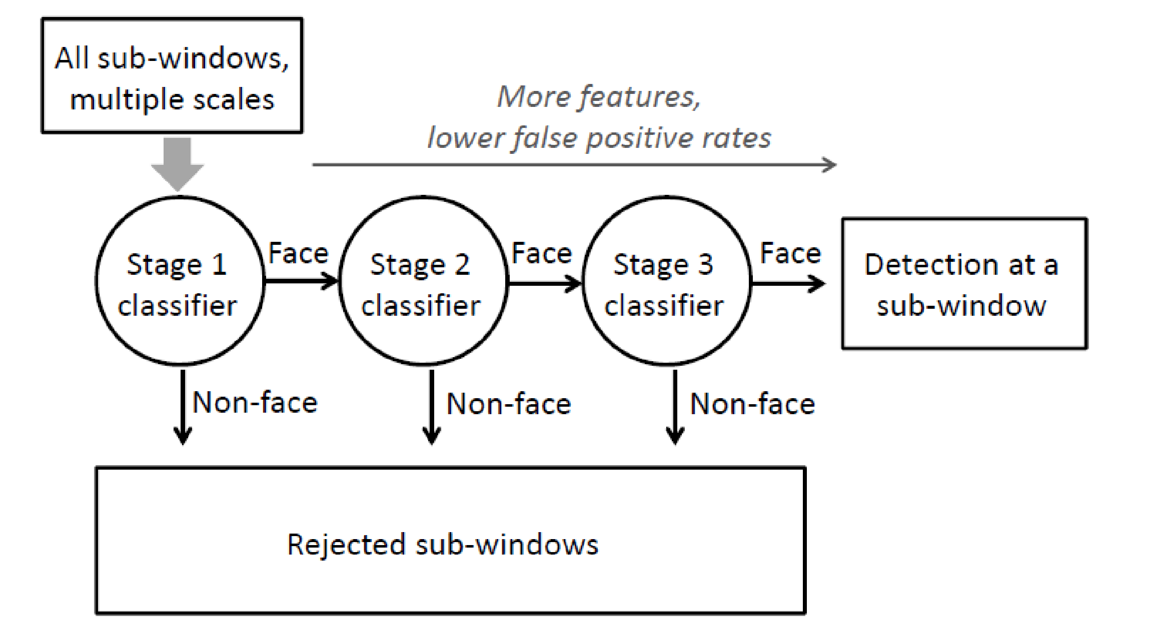
2^{nd} big idea: Cascade…

- Even if the filters are fast to compute, each new image has a lot of possible windows to search
- How to make the detection more efficient?

2nd big idea: Cascade...

Key insight: *almost everywhere is a non-face*

- So... detect non-faces more quickly than faces
- And if you say it's not a face,
  be sure and move on



1. Form a *cascade* with really low false negative rates early
2. At each stage use the false positives from last stage as “difficult negatives”

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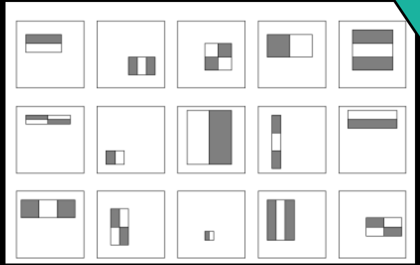
Viola-Jones detector: Summary

Faces

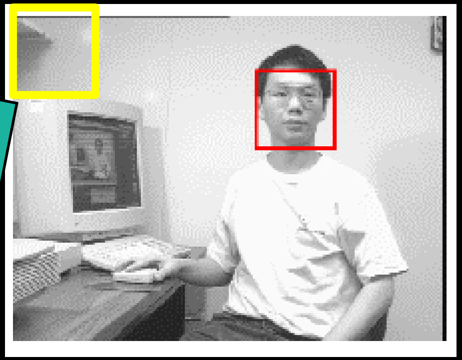
Non-faces

Train cascade of classifiers with AdaBoost



Selected features, thresholds, and weights

Apply to each subwindow



New image

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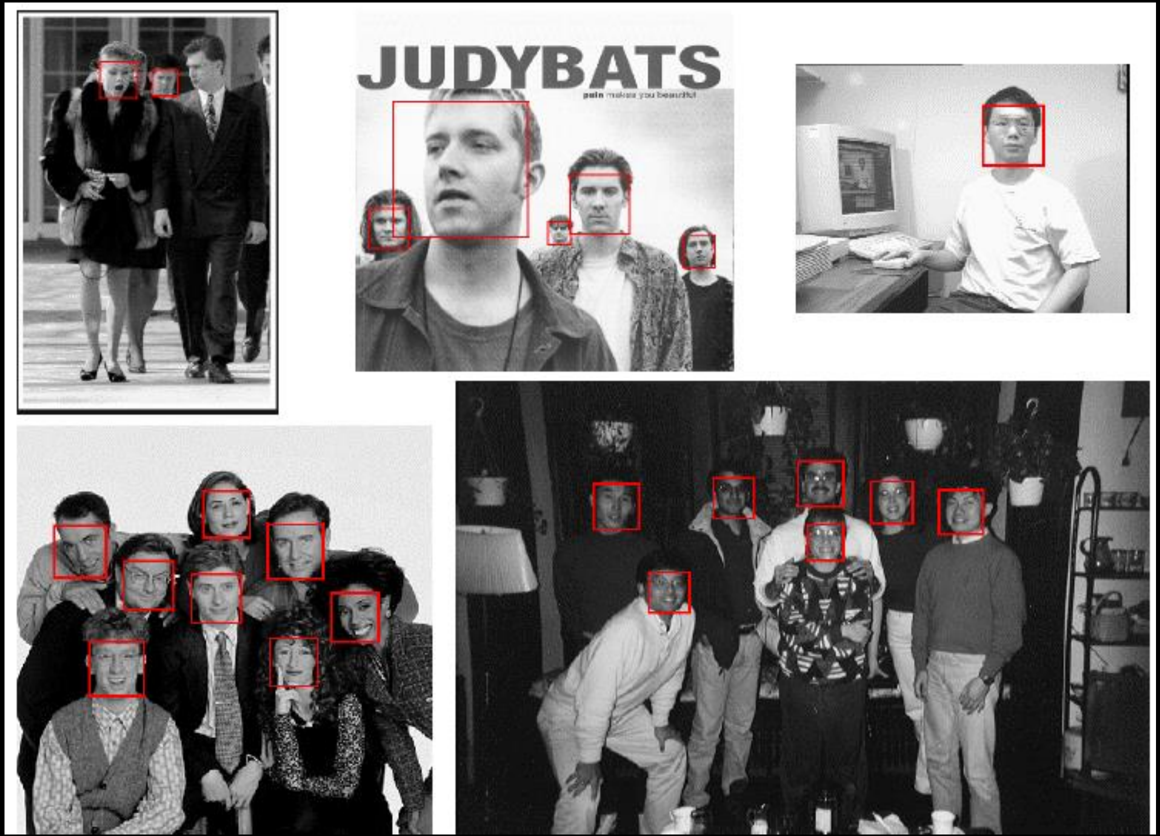
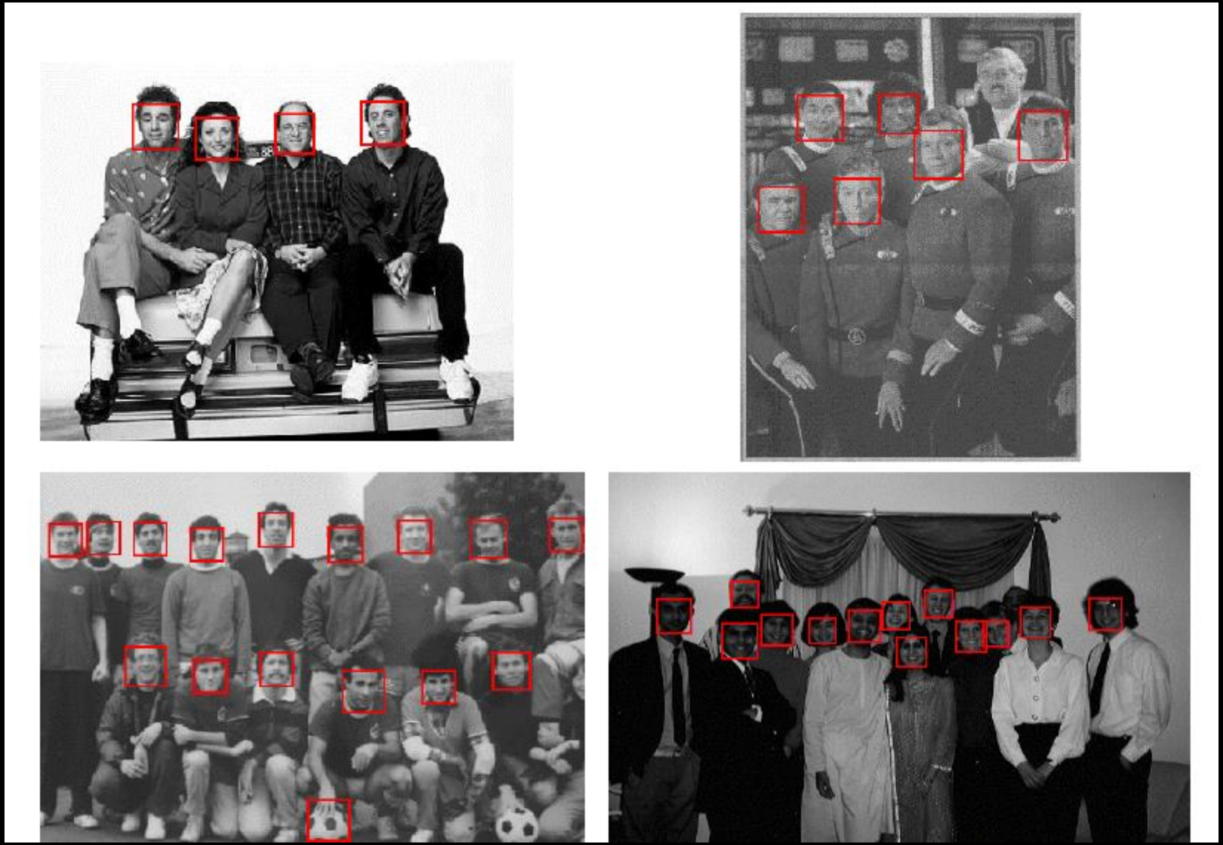
Viola-Jones detector: Results



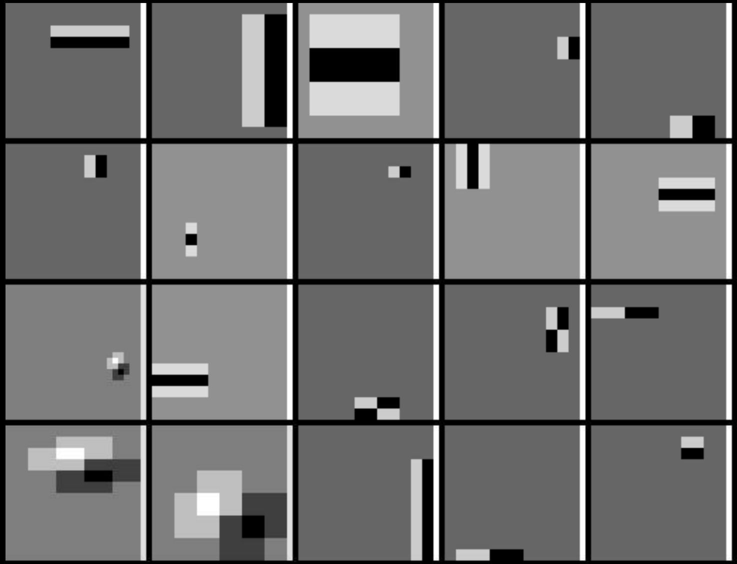
Viola-Jones detector: Results



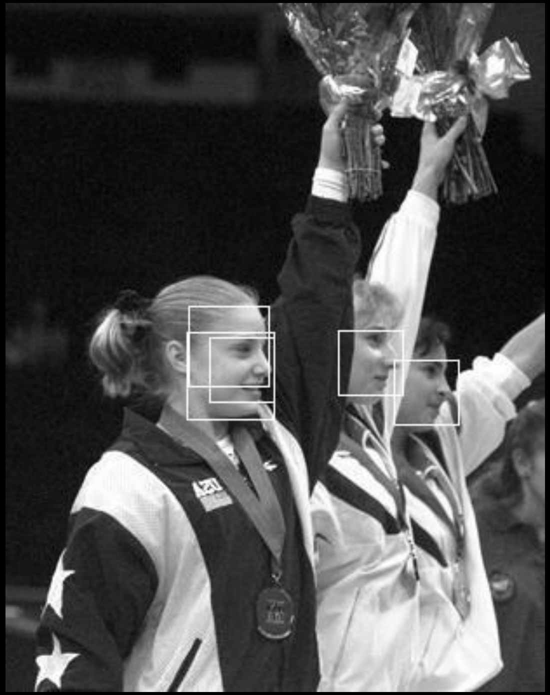
Viola-Jones detector: Results

Detecting profile faces?

Can we use the same detector?

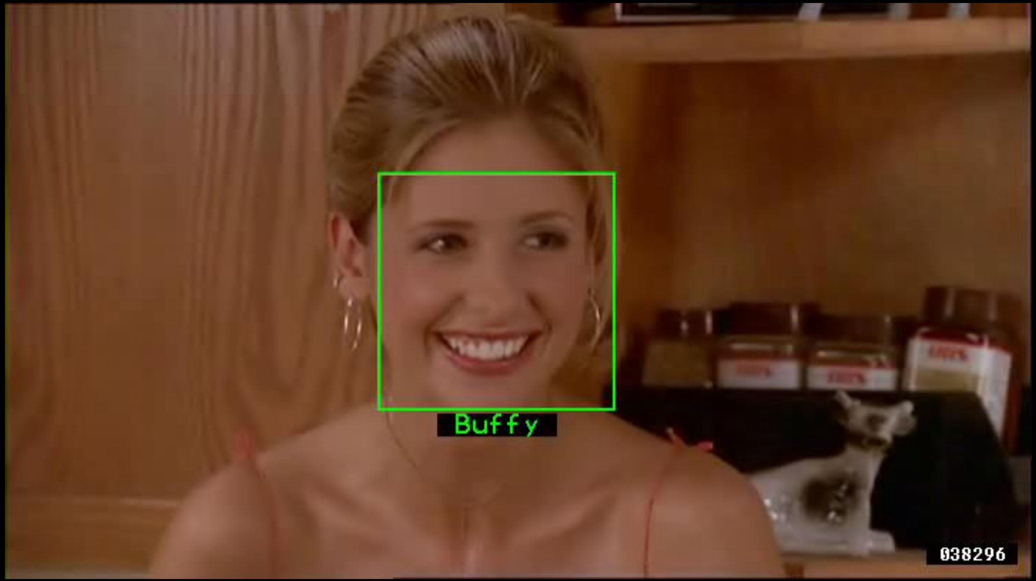


Viola-Jones detector: Results



Paul Viola, ICCV tutorial

Example using Viola-Jones detector



Frontal faces detected and then tracked, character names inferred with alignment of script and subtitles

Everingham, M., Sivic, J. and Zisserman, A.
"Hello! My name is... Buffy" - Automatic naming of characters in TV video. BMVC 2006.

Google now erases faces, license plates on Map Street View

By Elinor Mills, CNET News.com
Friday, August 24, 2007 01:37 PM

Google has gotten a lot of flack from privacy advocates for photographing faces and license plate numbers and displaying them on the Street View in Google Maps. Originally, the company said only people who identified themselves could ask the company to remove their image.

But Google has quietly changed that policy, partly in response to criticism, and now anyone can alert the company and have an image of a license plate or a recognizable face removed, not just the owner of the face or car, says Marissa Mayer, vice president of search products and user experience at Google.

"It's a good policy for users and also clarifies the intent of the product," she said in an interview following her keynote at the Search Engine Strategies conference in San Jose, Calif., Wednesday.

The policy change was made about 10 days after the launch of the product in late May, but was not publicly announced, according to Mayer. The company is removing images only when someone notifies them and not proactively, she said. "It was definitely a big policy change inside."

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- Report: Amazon may again be mulling Netflix bu
- Mozilla maps out Jetpack add-on transition plan
- Google begins search for Middle East lobbyist
- Google still thinks it can change China

Consumer application: iPhoto 2009

http://www.apple.com/ilife/iphoto/

Lana Lazebnik

Consumer application: iPhoto 2009

Things iPhoto thinks are faces

Lana Lazebnik

Viola-Jones face detector: Summary

Key ideas:

- Rectangular features and integral image
- AdaBoost for feature selection
- Cascade

Training is slow, but detection is very fast

Really, really effective….

Boosting (general): Advantages

- Integrates classification with feature selection
- Flexibility in the choice of weak learners, boosting scheme
- Complexity of training is linear in the number of training examples
- Testing is fast
- *Easy to implement*

Boosting: Disadvantages

- Needs many training examples
- Often found not to work as well as an alternative discriminative classifier, support vector machine (SVM)
  - Especially for many-class problems

Lana Lazebnik