Rapid Object Detection using a Boosted Cascade of Simple Features

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Why

- Features are computed slowly
- Need auxiliary information
- Broad practical applications
Three key contributions

* Integral Image
* AdaBoost
* Cascade Structure
Features

- Haar-like features

- Four kinds of features:
  - A
  - B
  - C
  - D
Integral Image
Selected Features
AdaBoost

Given the resolution of the detector is 24x24, over 180,000 rectangle features associated with each image sub-window.
Weak classifier

\[ h_j(x) = \begin{cases} 
1 & \text{if } p_j f_j(x) < p_j \theta_j \\
0 & \text{otherwise}
\end{cases} \]
Adaboost classifier

* AdaBoost is a learning algorithm used to boost the classification performance of a simple learning algorithm.
Adaboost classifier
Adaboost classifier
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Adaboost classifier

\[ a_t = \frac{1}{2} \ln\left(1 - \frac{\varepsilon_t}{\varepsilon_t}ight) \]

\[ H(x) = \text{sign}\left( \sum_{t=1}^{T} a_t h_t(x) \right) \]
Principles to define an optimization framework:

i) the number of classifier stages;
ii) the number of features in each stage;
iii) the threshold of each stage
In general:

i) At a given detection rate, deeper classifiers have correspondingly higher false positive rates;

ii) A lower threshold yields higher detection rates and higher false positive rates.
Training Samples

4916 hand labeled faces and non-face subwindows from 9544 images
Experiments and Results

- Speed of the Final Detector:
  - Final detector has 38 layers in the cascade, 6060 features
  - 700 Mhz processor:
  - Can process a 384 x 288 image in 0.067 seconds.
Experiments and Results

- Image Processing
- Scanning the Detector
- Integration of Multiple Detections
Results

This set consists of 130 images with 507 labeled frontal faces.
Conclusions

* The approach is approximately 15 times faster than any previous approach in face detection system.
Do you have any questions?