Rapid Object Detection using a Boosted Cascade of Simple Features

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Why

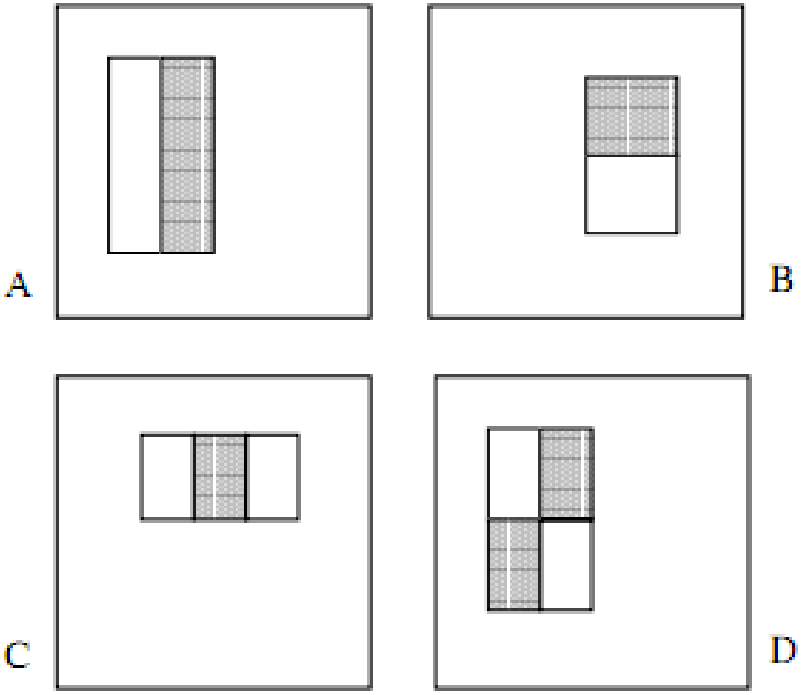
* Features are computed slowly
* Need auxiliary information
* Broad practical applications

Three key contributions

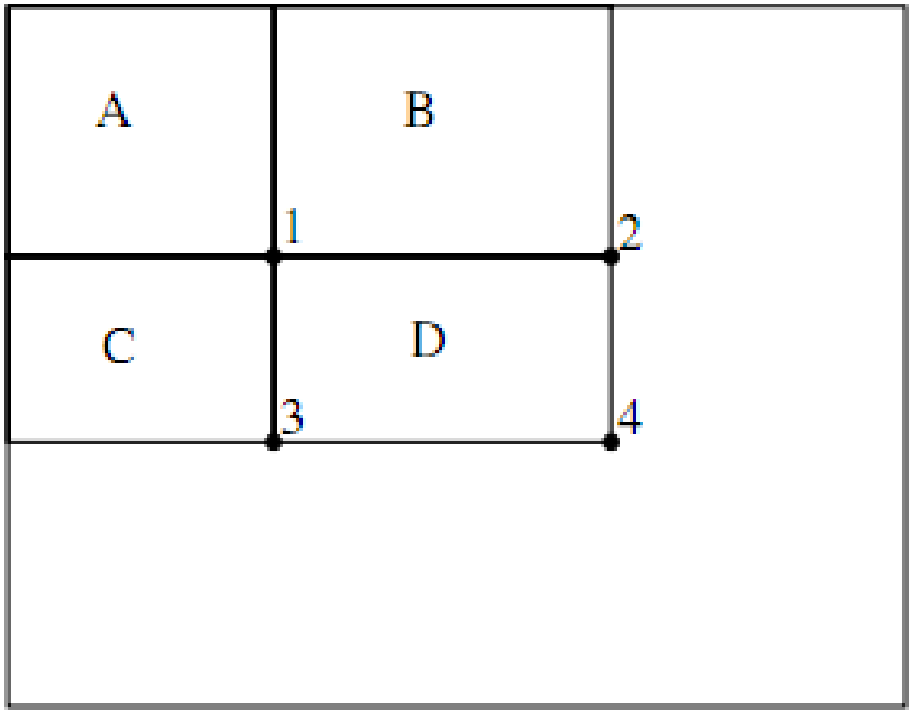
* Integral Image
* AdaBoost
* Cascade Structure

Features

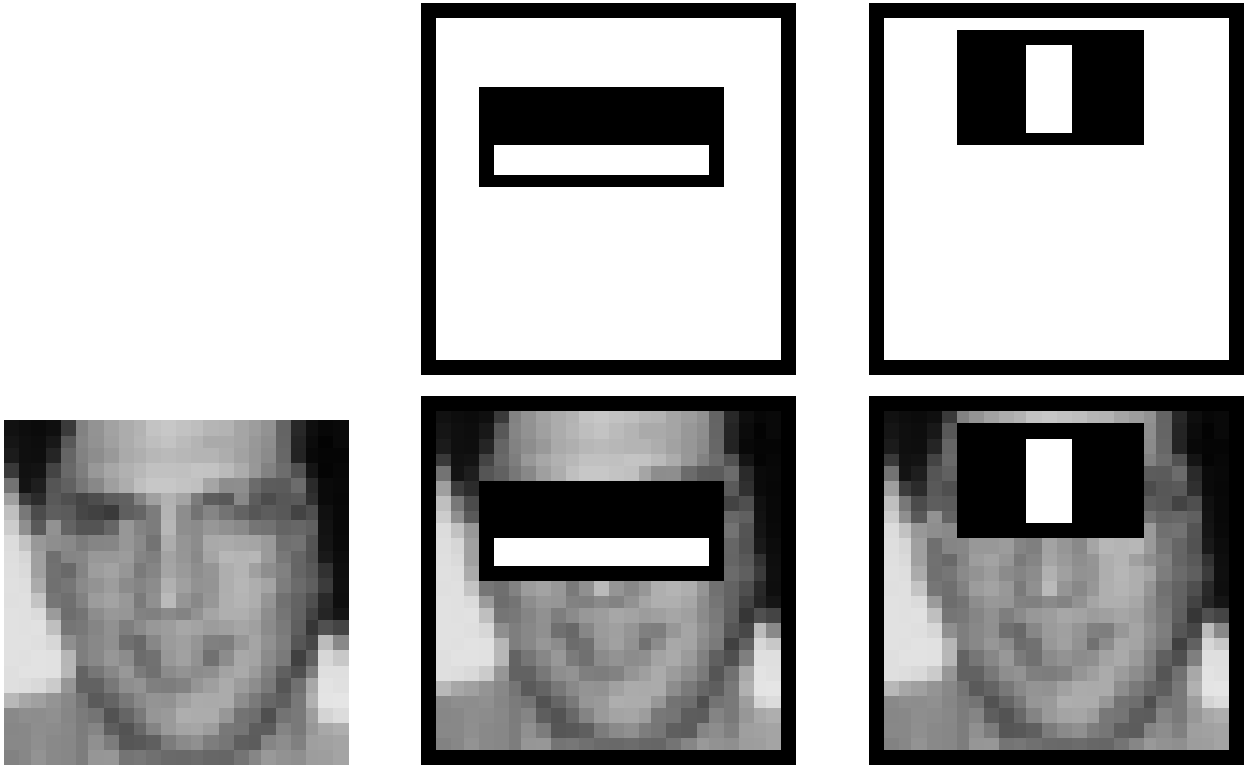
* Haar-like features
* Four kinds of features:



Integral Image



Selected Features



Features of classifier

* AdaBoost

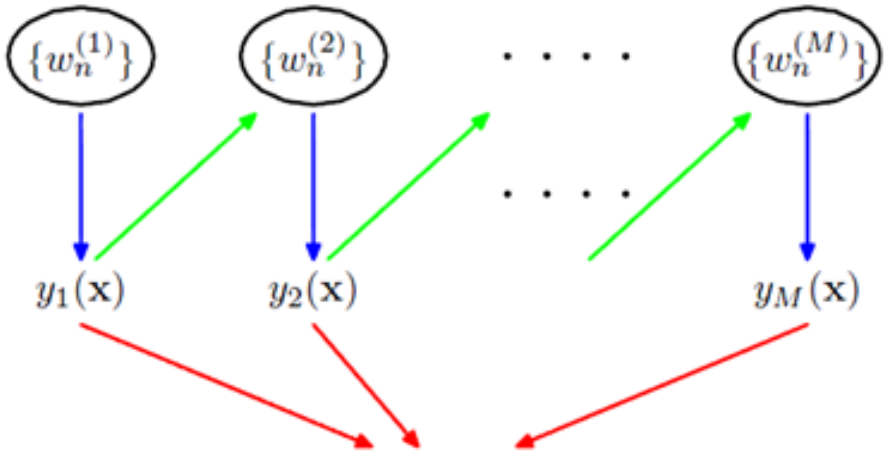
Given the resulution of the detector is 24x24,over 180,000 rectangle features associated witheach image sub-window.

Weak classifier

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

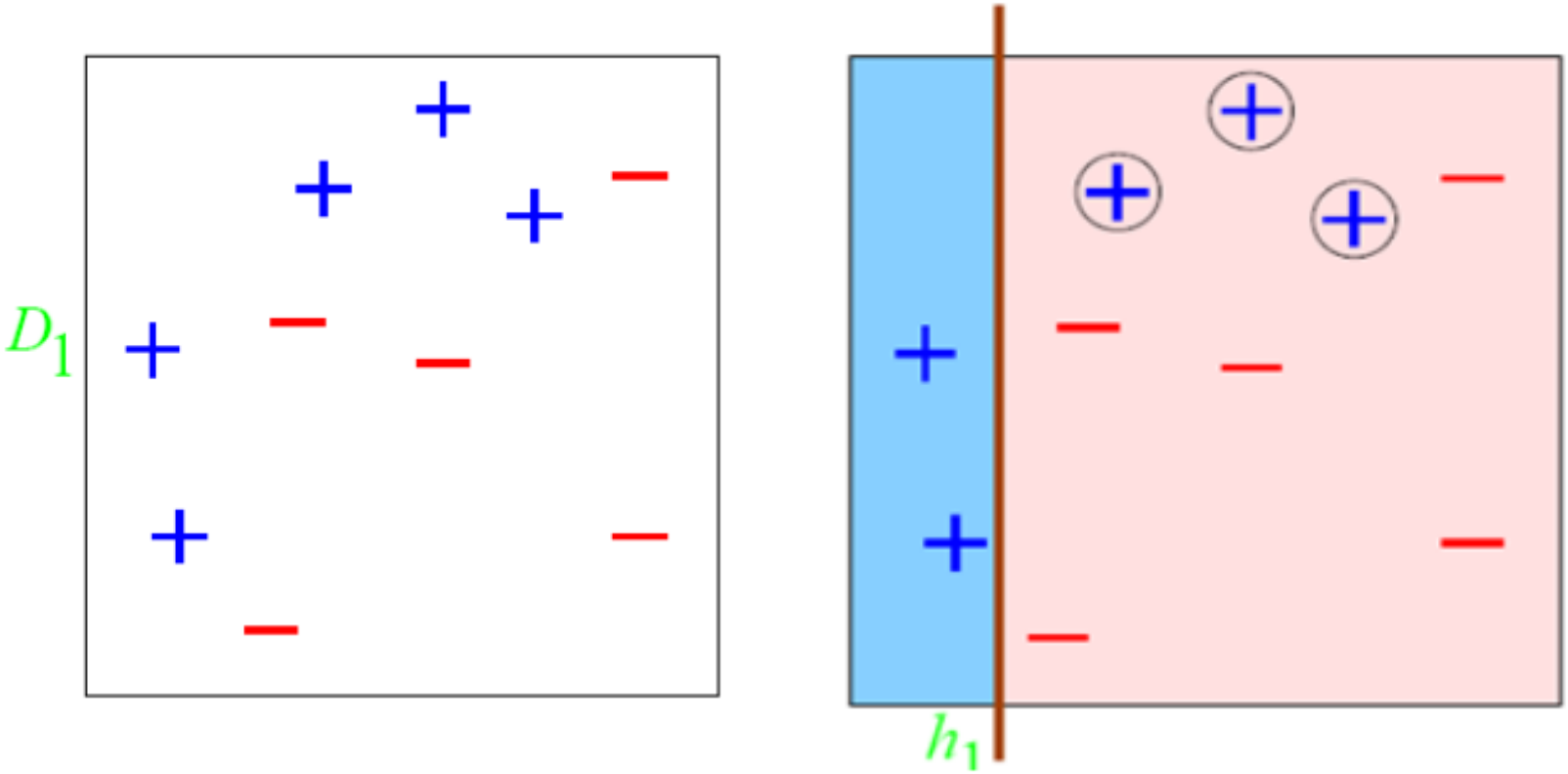
Adaboost classifier

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

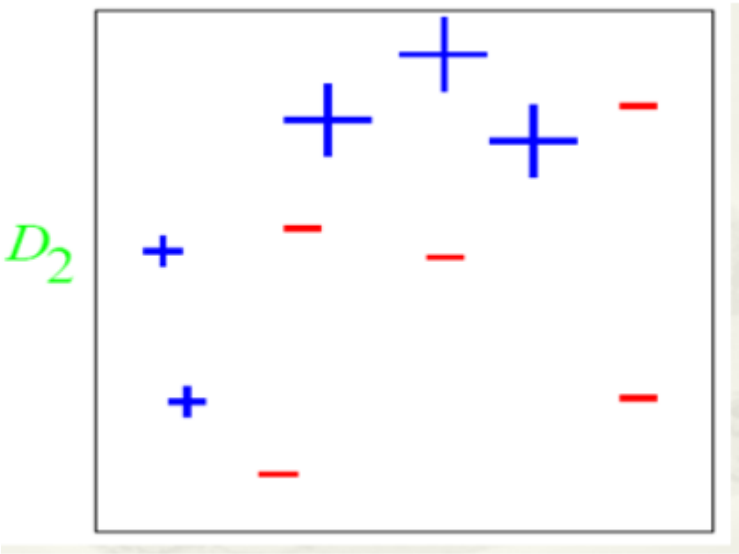


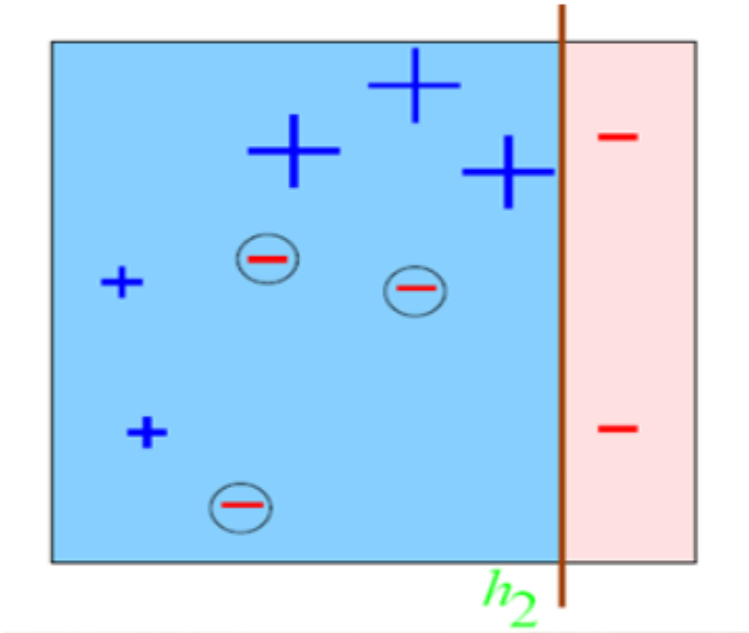
$$Y_M(\mathbf{x}) = \text{sign}\left(\sum_m^M \alpha_m y_m(\mathbf{x})\right)$$

Adaboost classifier

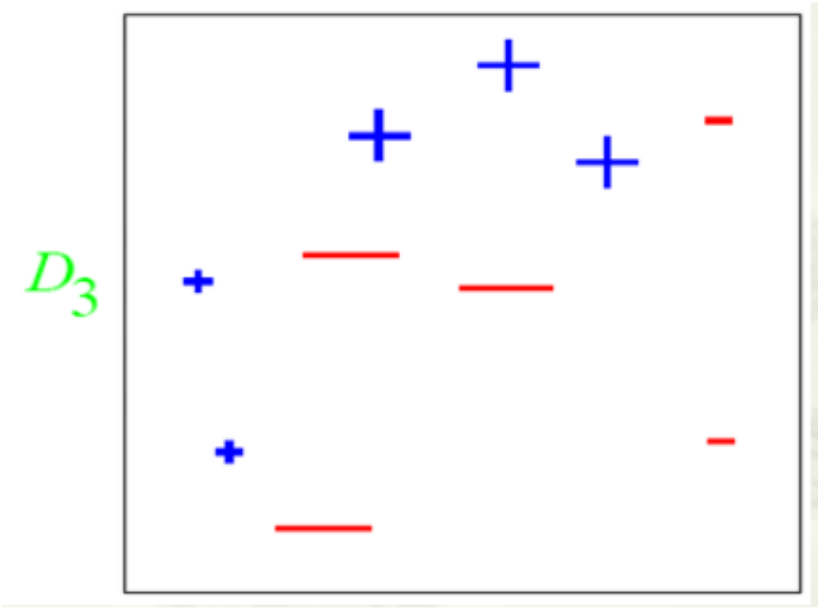


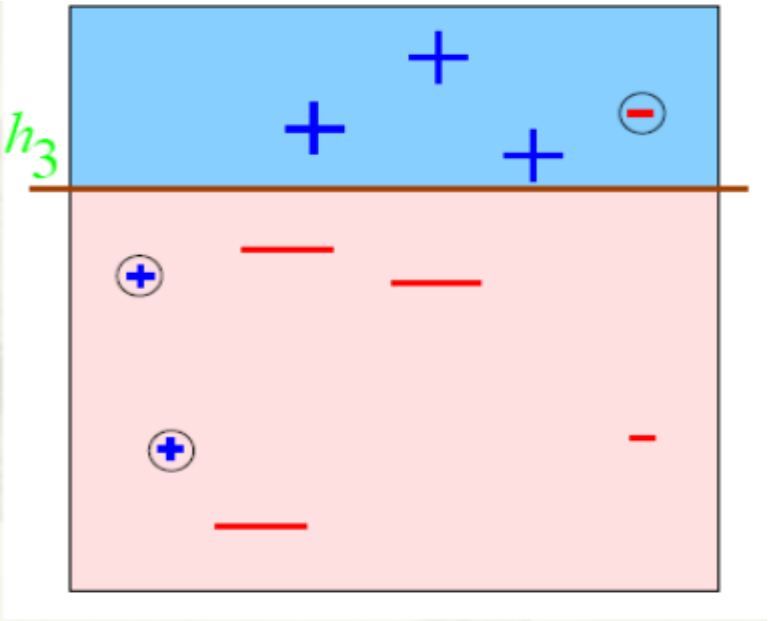
Adaboost classifier



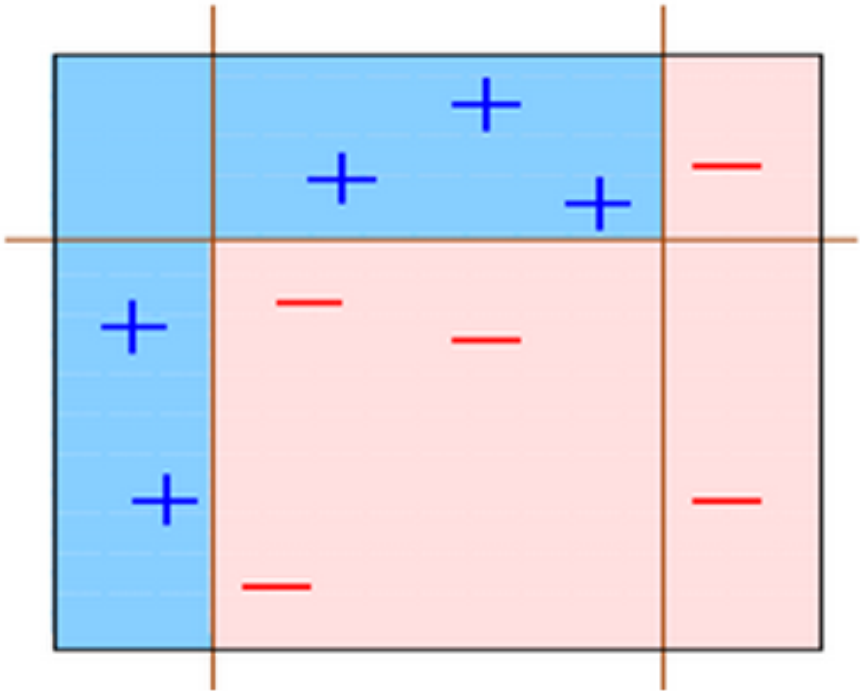


Adaboost classifier





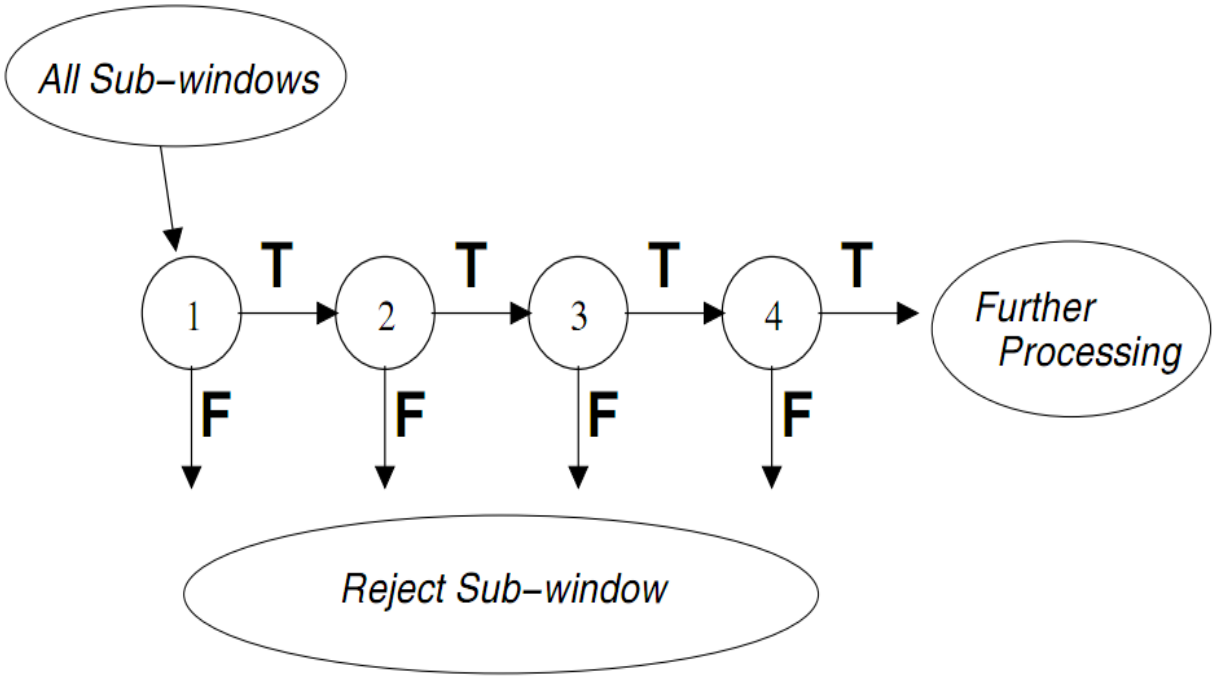
Adaboost classifier



$$a_t = \frac{1}{2} In(\frac{1-\varepsilon_t}{\varepsilon_t})$$

$$H(x) = sign\left(\sum_{t=1}^{T} a_t h_t(x)\right)$$

Cascade Structure



Cascade Structure

* 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

Cascade Structure

* 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

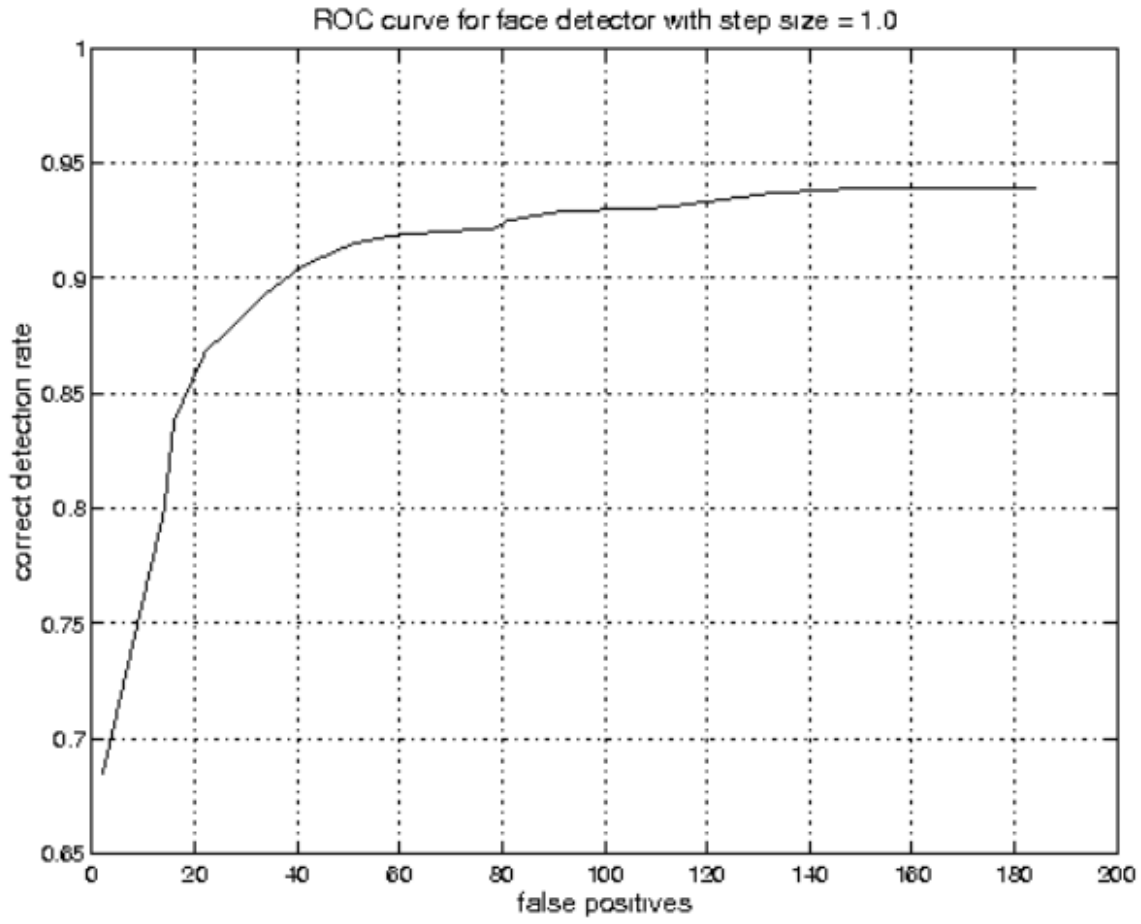
Experiments and Results

* 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

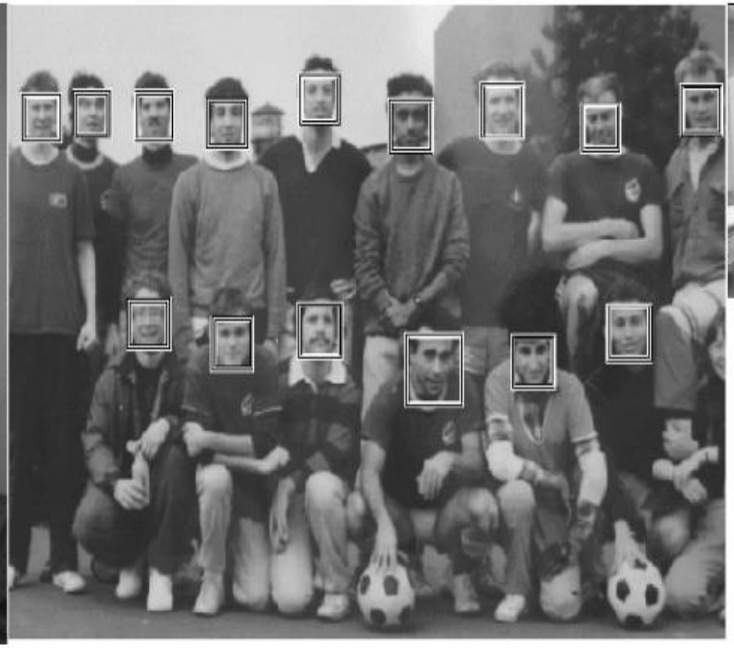
* Image Processing
* Scanning the Detector
* Integration of Multiple Detections

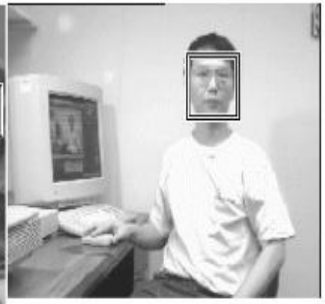
Results



This set consists of 130 images with 507 labeled frontal faces

output





Conclusions

* The approach is approximately 15 times faster than any previous approach in face detection system.

Do you have any questions?