A General Framework for Cost-Sensitive Boosting

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Overview

- Motivation
- PhD Thesis
- Current work

MOTIVATION

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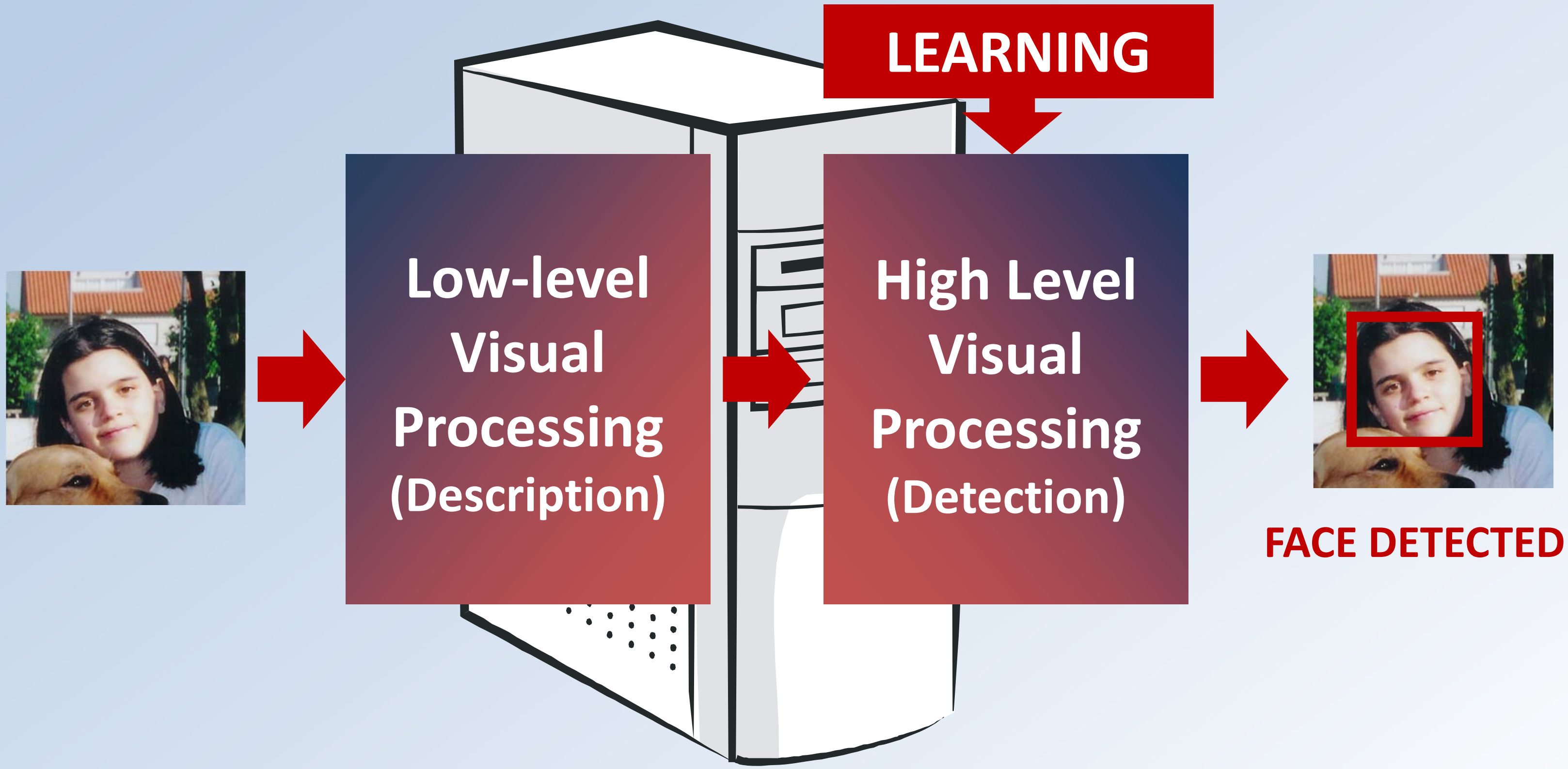
Face Detection in Computers

- MOTIVATION
- PHD THESIS
- CURRENT WORK



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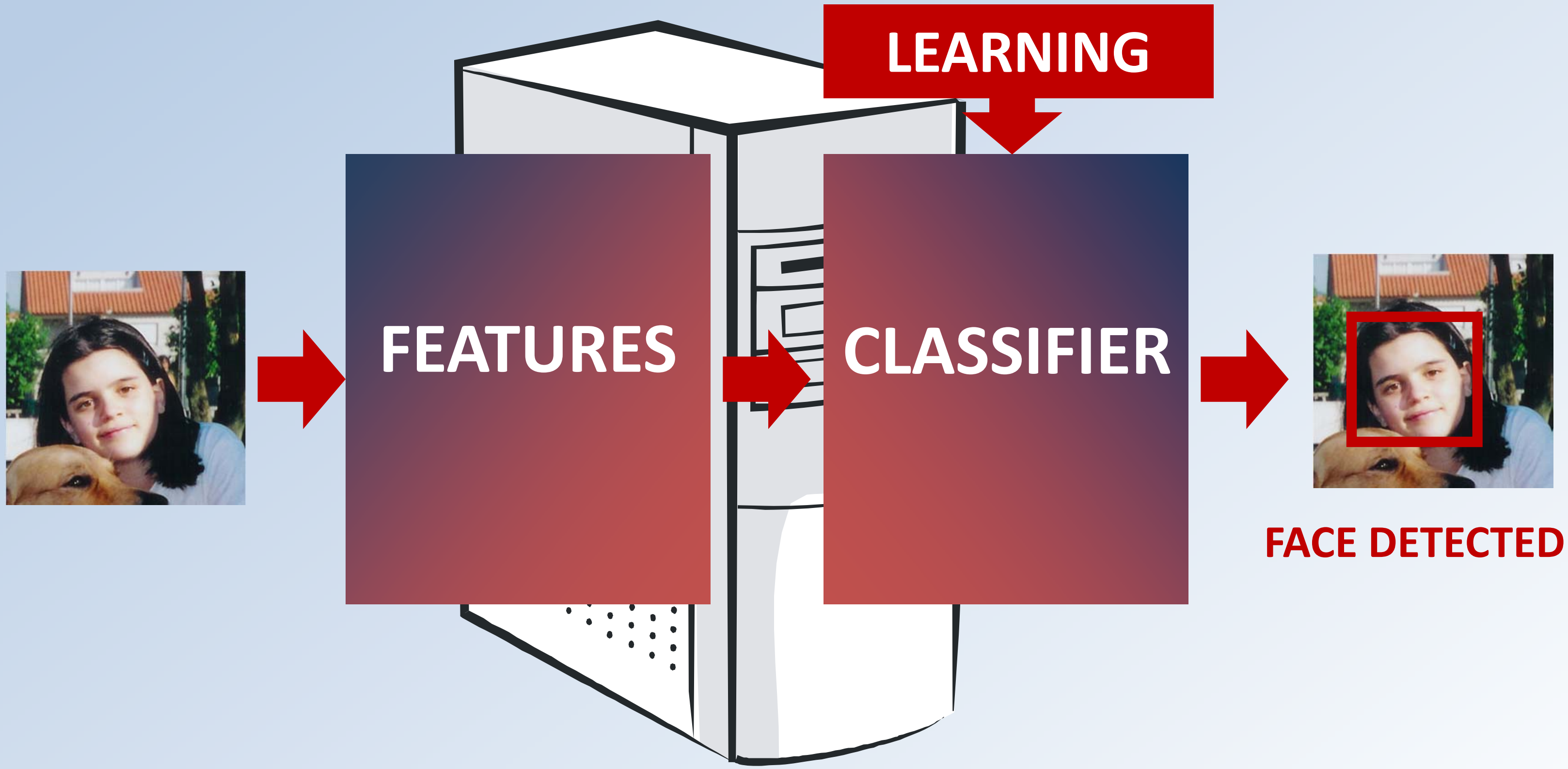

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Reference model

- MOTIVATION
- PHD THESIS
- CURRENT WORK

- **Viola and Jones Face Detector***. They succeeded, for the first time, to detect faces in images in real-time.

- One of the milestones in Computer Vision of the last decade.

* Viola, P., Jones, M., 2004. **Robust real-time face detection**. International Journal of Computer Vision 57, 137–154.

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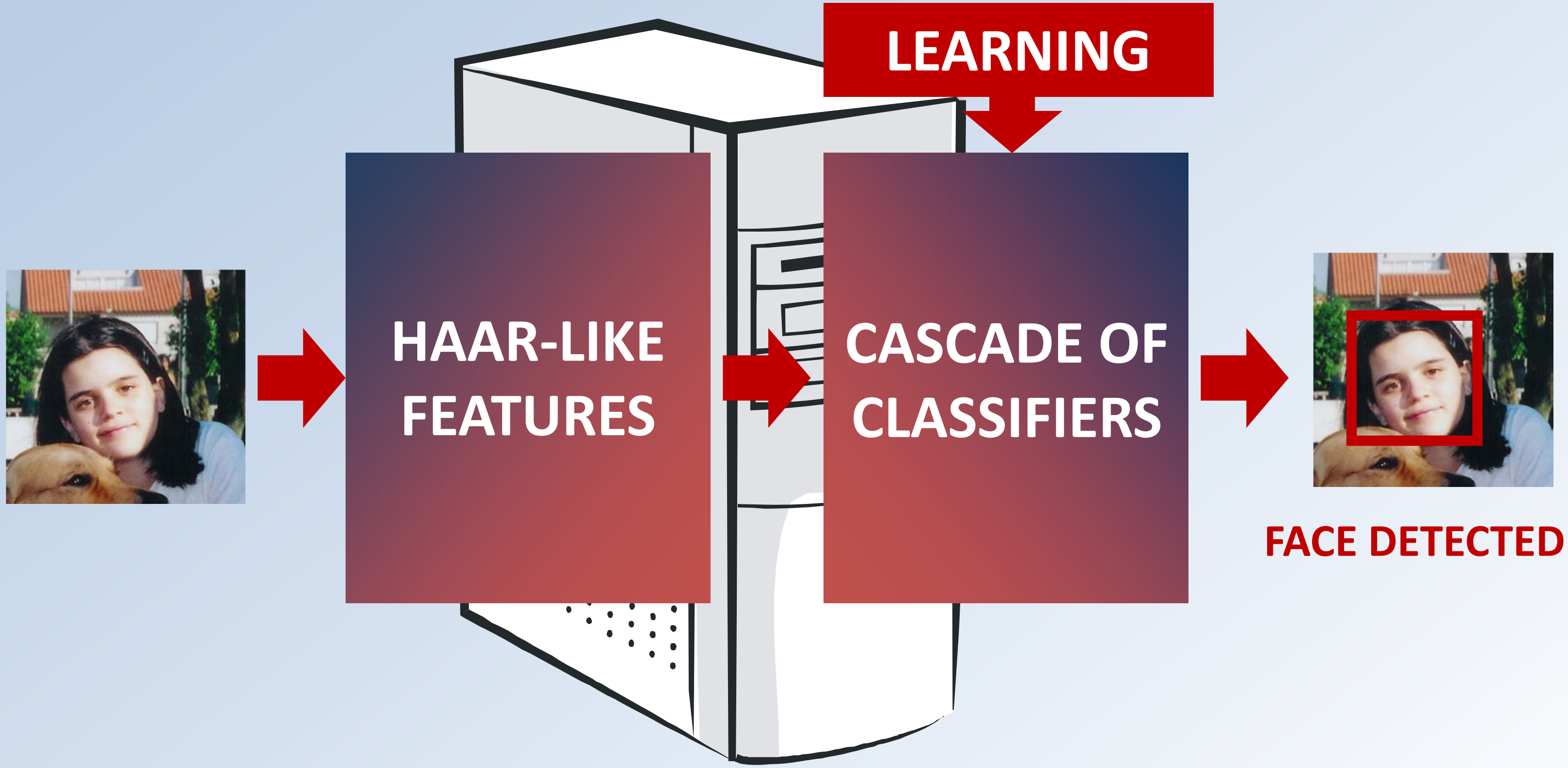
Viola and Jones Detector Framework

- It is based on three key ideas…
  - **Haar-like** as features (efficiently computable using Integral Images)
  - **AdaBoost** as learning algorithm
  - **Cascaded architecture** to improve efficiency

Viola and Jones Detector Framework

- MOTIVATION
- PHD THESIS
- CURRENT WORK



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Early stages of the work

- Thorough **study** of the Viola-Jones face detector and related works.
- **Implementation**, from scratch, of our own Viola-Jones training platform.
- Collect **databases** of faces and non-faces, with enough generalization capability.
- **Train** several face detectors, with different parameters.
- Extension to **eye**, **nose** and **mouth** localizers.

PHD THESIS

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First Goals

- Main goal:
  - Detailed analysis on **each of the levels** of the Viola-Jones framework to propose novel improvements, applied to **different object** detection scenarios.

First goals

- We have studied the three main layers of the Viola-Jones framework.

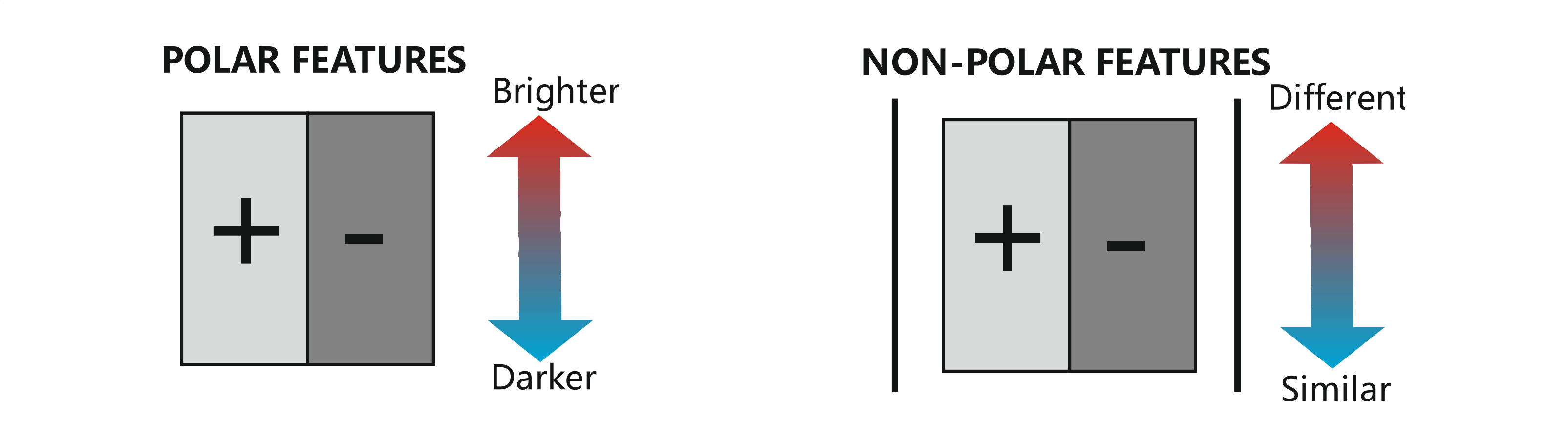
CASCADE ARCHITECTURE

ADABOOST

HAAR-LIKE FEATURES

Development

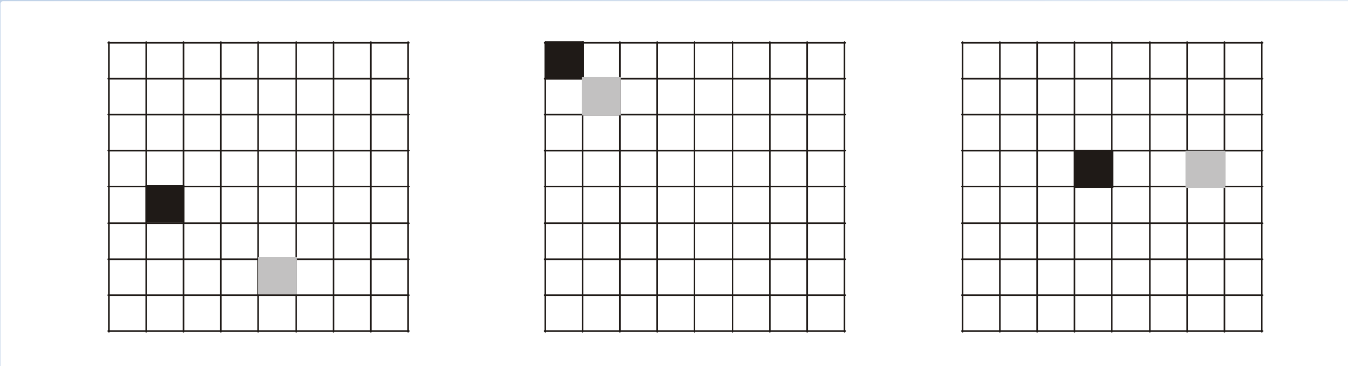
- **Feature Level:** New typologies of features with descriptive or computational advantages.
  - **Polarity invariant features** [1]



[1] I. Landesa-Vázquez, J.L. Alba-Castro. ***The Role of Polarity in Haar-like features for Face Detection***. XX International Conference on Pattern Recognition (ICPR 2010), 23-26 August 2010, Istanbul (Turkey)

Development

- **Feature Level:** New typologies of features with descriptive or computational advantages.
  - **Polarity invariant features** [1]
  - **Quantum features** [2]



[2] I. Landesa-Vázquez, F. Parada-Loira, J.L. Alba-Castro. ***Fast Real-time Multiclass Traffic Sign Detection Based on Novel Shape and Texture Descriptors***. XIII IEEE Conference on Intelligent Transportation Systems (ITSC 2010), 19-22 September 2010, Funchal (Portugal)

Development

- MOTIVATION
- PHD THESIS
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- **Learning Level:** New theoretically motivated asymmetric AdaBoost algorithms.
  - **Cost Generalized AdaBoost** [3]
  - **AdaBoostDB** [4]

[3] I. Landesa-Vázquez, J. L. Alba-Castro. ***Shedding Light on the Asymmetric Learning Capability of AdaBoost.*** Pattern Recognition Letters 33, pp. 247-255, 2012

[4] I. Landesa-Vázquez, J. L. Alba-Castro. ***Double Base Asymmetric AdaBoost.*** Neurocomputing 18, pp. 101-114, 2013

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Development

- **Cascade Architecture Level:** We have designed several changes
  - **Optimal/automatical sizing**
  - **Inter-stage information repechage**
  - **Data source fusion**

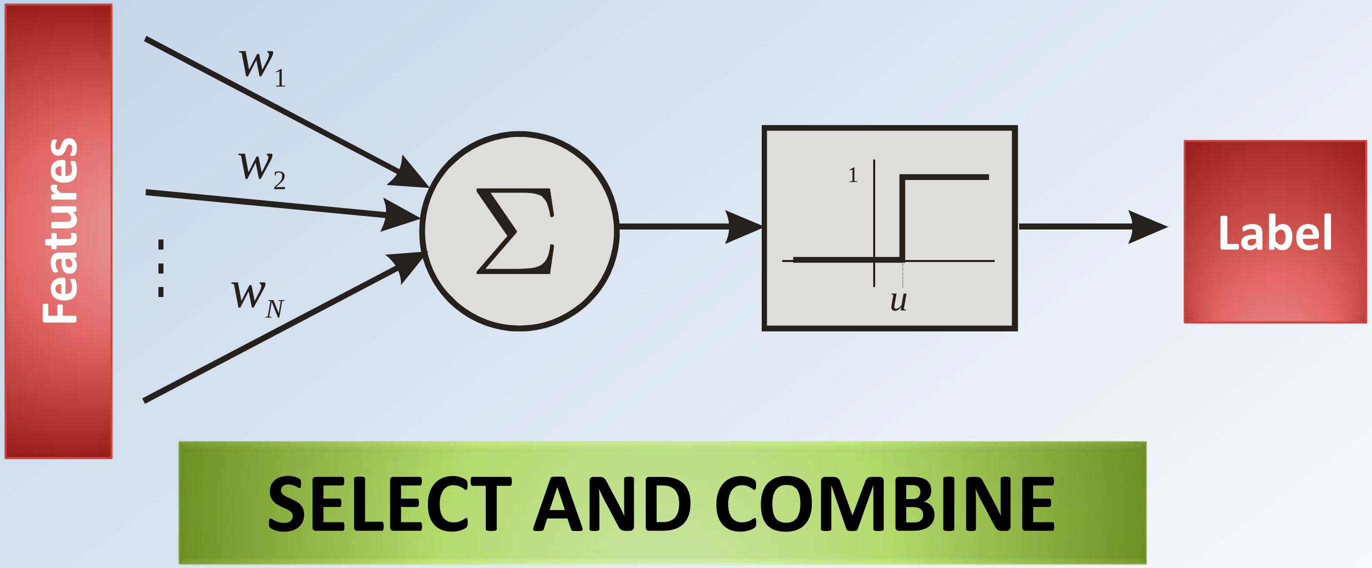
Final focus

- Most of our efforts have been focused on the **Learning Level,** the most theoretical part.

- Final title : ***"A General Framework for Cost-Sensitive Boosting"***

AdaBoost

- AdaBoost is a learning algorithm which selects **weak classifiers** from a pool, and combine them into a final **strong classifier**.



AdaBoost

- AdaBoost is a learning algorithm which selects **weak classifiers** from a pool, and combine them into a final **strong classifier**.

$$\underbrace{H(x)}_{\text{Strong Classifier}} = sign\left(\sum_{t=1}^{\overset{\text{Selection}}{T}} \underbrace{\overset{\text{Weak Classifiers}}{\alpha_t h_t(x)}}_{\text{Combination}}\right)$$

SELECT AND COMBINE

Asymmetric Learning

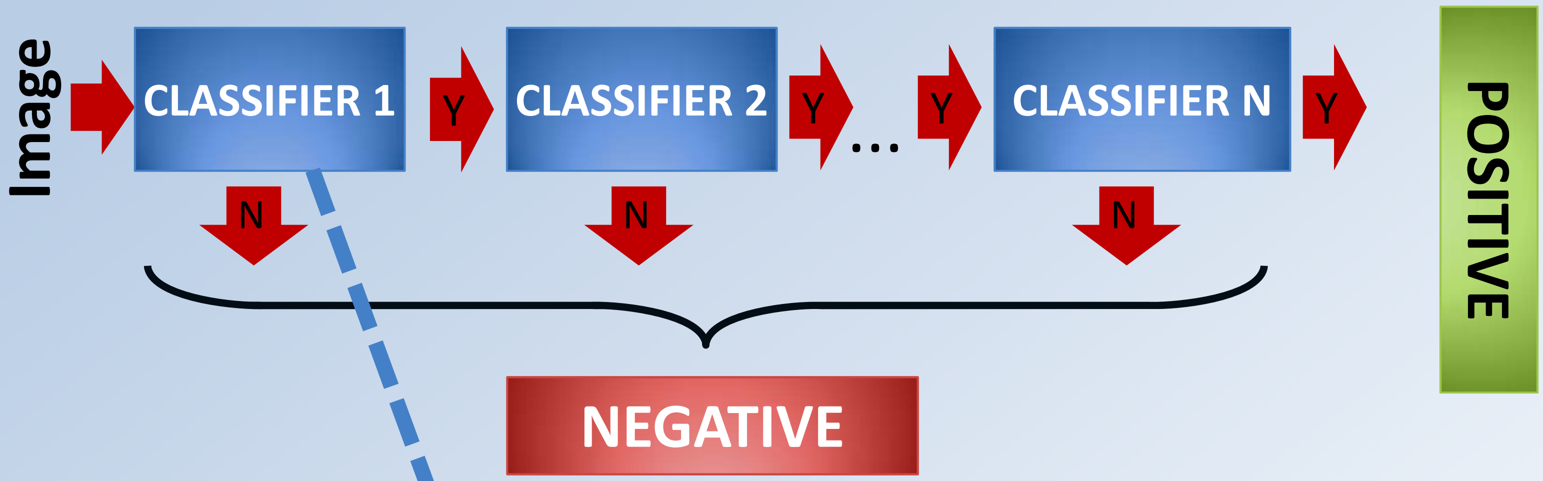
- **Object detection** in images is a paradigmatic **asymmetric problem**:
  - Positives are extremely **scarce** and valuable.
  - Negatives have a huge **variability** compared to that of positives.
  - To be feasible (real-time), negatives must be **rejected** as soon as possible.

Asymmetric Learning in the Viola-Jones Framework

- However, as originally stated, **AdaBoost** is a **cost-insensitive learning algorithm**.

- In the Viola and Jones framework, the threshold of every boosted classifier of is modified ***"a posteriori"*** (after training) to get an asymmetric result → **Non-optimal solution**.

Viola-Jones Strategy



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

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

Asymmetric AdaBoost variants

- Several "asymmetric AdaBoost" variants have been proposed in the literature…
  - AdaCost
  - AsymBoost
  - AdaC1, AdaC2, AdaC3
  - CSB0, CSB1, CSB2
  - Cost-Sensitive AdaBoost

Heuristics
No theoretical guarantees

Too complex

Our proposals

- We have followed two different ways:
  - **Cost-generalized AdaBoost**
  - **AdaBoostDB**

Cost-Generalized AdaBoost

- Several papers claim that, AdaBoost remains being cost-insensitive even when initialized with an uneven (asymmetric) weight distribution.

Cost-Generalized AdaBoost

- We have **refuted that afirmation**, proving [3] theoretically and practically, that **asymmetric weight initialization** is **an effective way to reach boosted cost-sensitive behaviors**.

- It preserves **all the theoretical guarantees** of original boosting, but for asymmetric problems.

AdaBoostDB

- Another way is defining a **Double-Base exponential bound** (different base for different classes), and minimize it.
- It can be modeled by a polynomial, and allows a **very efficient** search method.
- Results are equivalent to “Cost-Sensitive Boosting” but **200 times faster**.

CURRENT WORK

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Current Work

- We are **writing** a final **comparative framework** of all cost-sensitive boosting algorithms in the literature with **Cost-Generalized AdaBoost** and **AdaBoostDB**.

- Defense of the PhD scheduled for the beginning of 2014.

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Thank you for your attention!!

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