Face Recognition II

CSE 40537/60537 Biometrics

Daniel Moreira

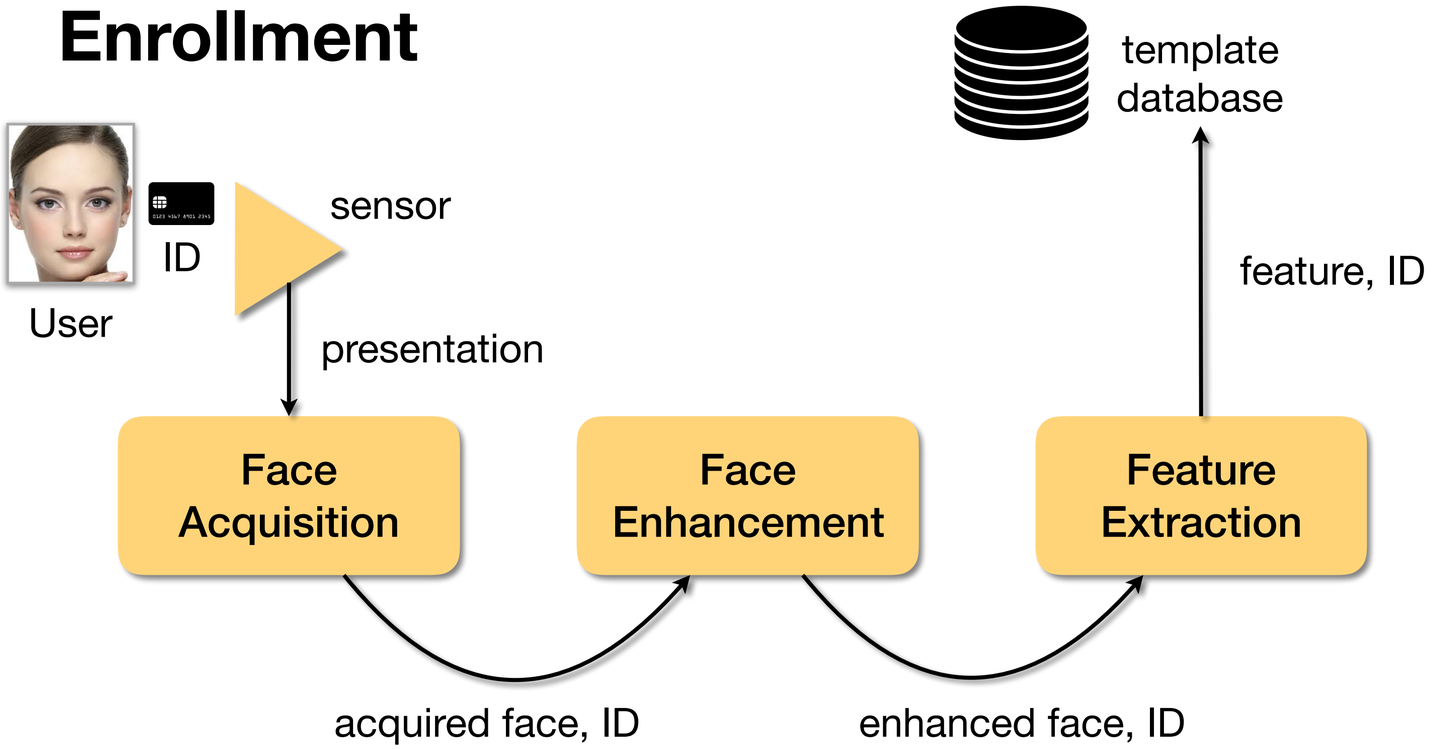
Spring 2020

UNIVERSITY OF NOTRE DAME

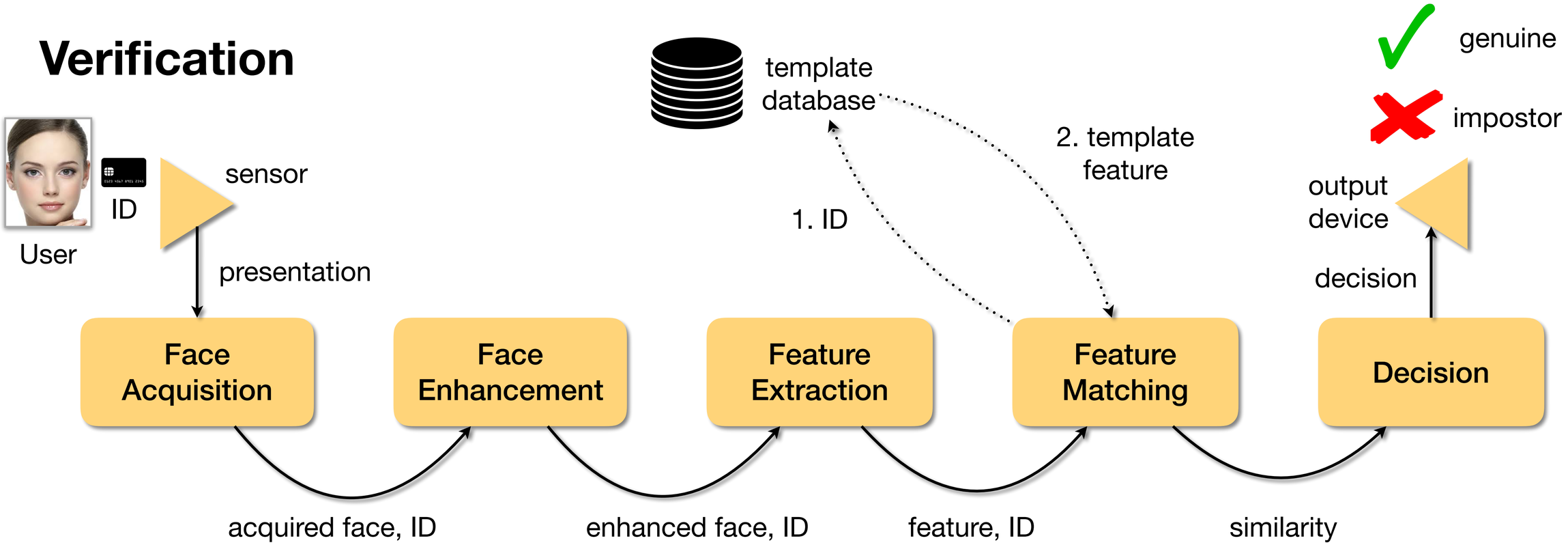
Today you will…

Get to know
Face acquisition and enhancement.

Face Recognition



Face Recognition



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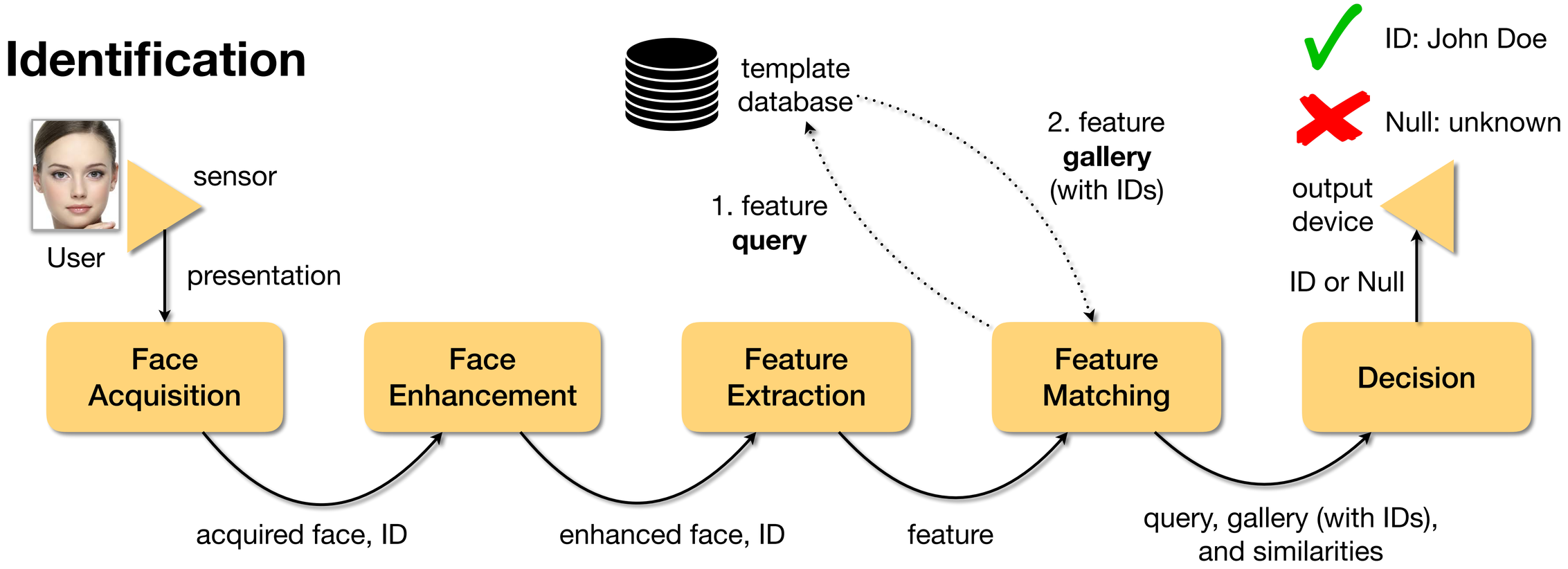
Face Recognition



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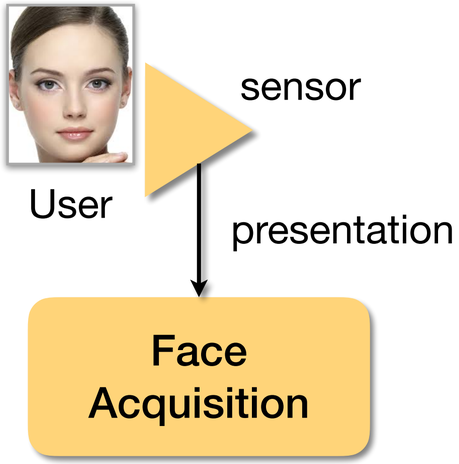
Face Recognition



Acquisition

On-line versus Off-line

https://www.youtube.com/watch?v=BYN4oF_bi4c

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Acquisition

Controlled Acquisition
Right pose, distance and illumination.

https://www.youtube.com/watch?v=BYN4oF_bi4c

https://www.youtube.com/watch?v=-cjoJR3oWcQ

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Acquisition

Controlled Acquisition
Different light wavelengths.

Captures at visible and near-infrared spectra.

Jain, Ross, and Nadakumar
Introduction to Biometrics
Springer Books, 2011

Sony infrared camera.

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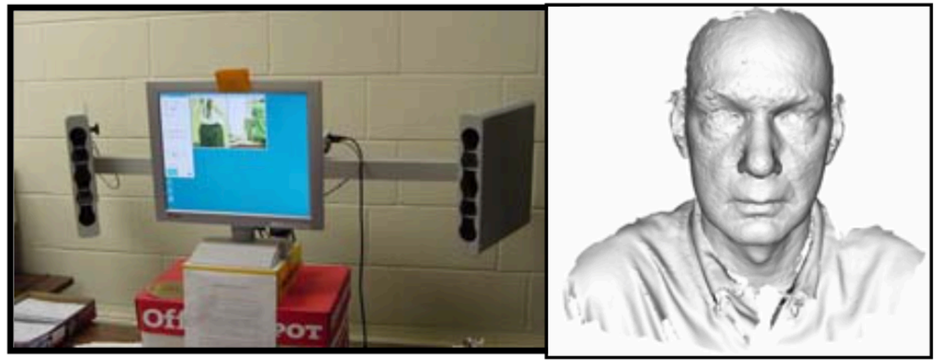
Acquisition

Controlled Acquisition
3D Information

Source:
Dr. Walter Scheirer

Minolta Vivid 900/910



3DMD “Qlonerator”

Acquisition

Unconstrained Acquisition
No illumination control.

https://www.nist.gov/system/files/documents/itl/iad/ig/05771424.pdf

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Acquisition

Unconstrained Acquisition

No distance control.

Jain, Ross, and Nadakumar
Introduction to Biometrics
Springer Books, 2011

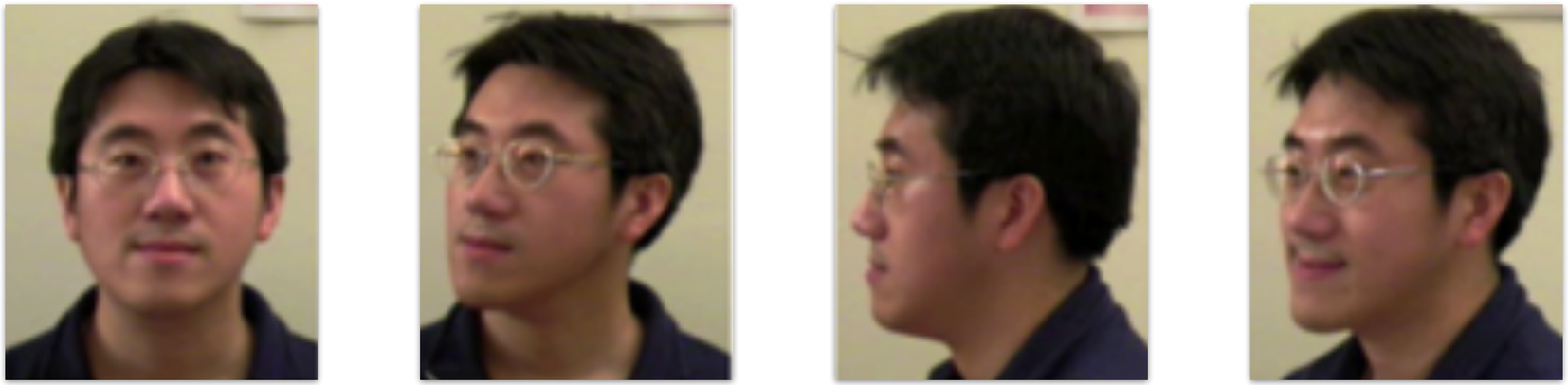
1m

3m

5m

Acquisition

Unconstrained Acquisition
No pose control.



Hsu
Face detection and modeling for recognition
PhD Thesis, MSU, 2002.

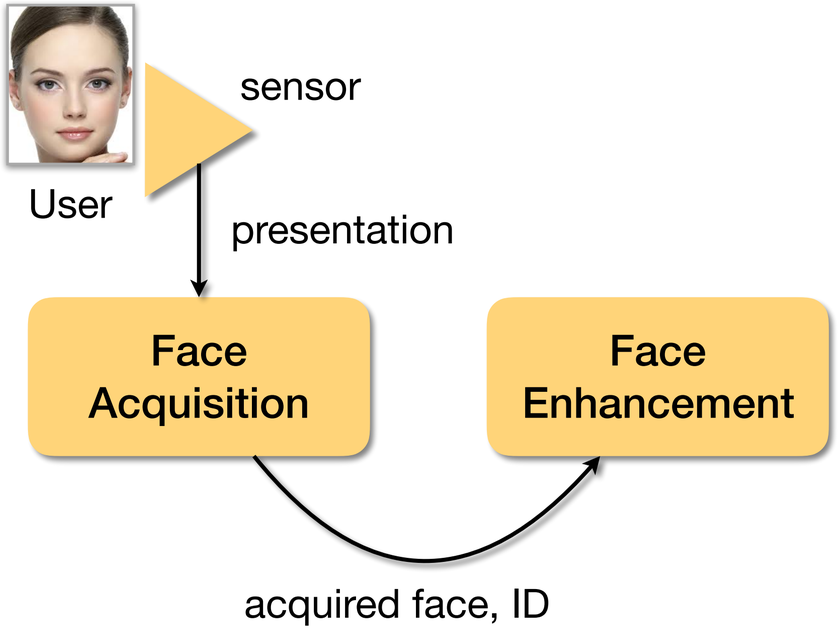
Acquisition

Problems

Presentation Attack

https://www.youtube.com/watch?v=BGgQ9woZQOg

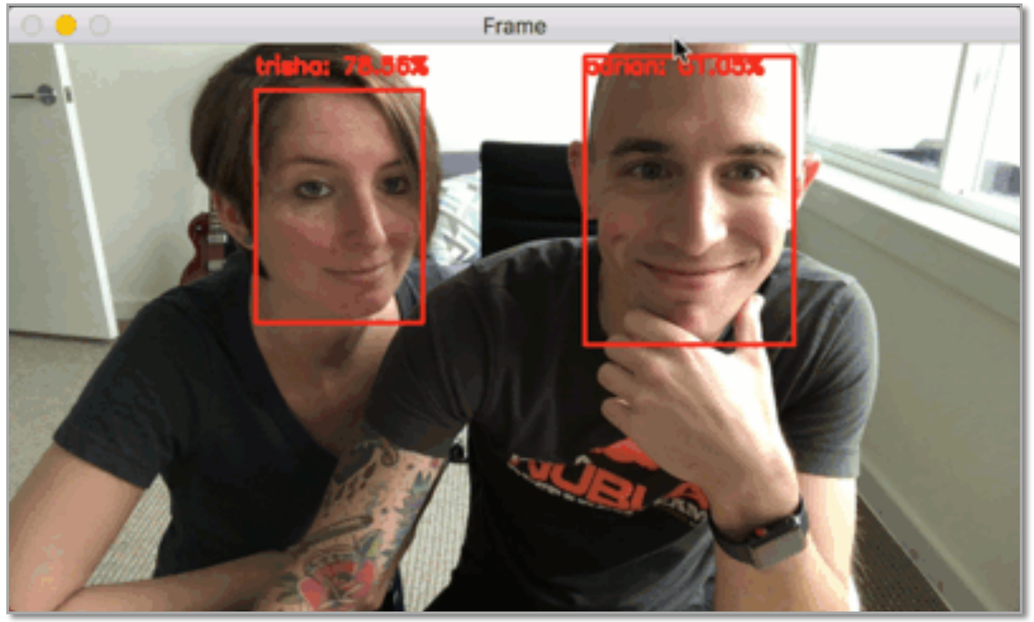
Face Recognition



Enhancement

Face Detection

Goal
Localize faces for segmentation and further recognition.



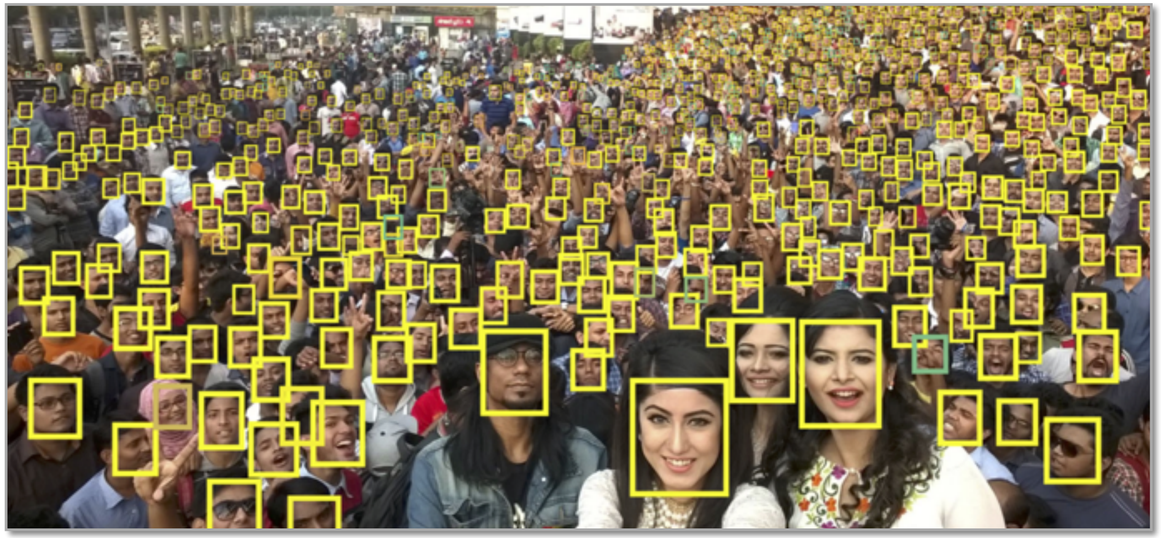
https://www.pyimagesearch.com/2018/09/24/opencv-face-recognition/

Enhancement

Face Detection

Challenges
Megapixel image
Nearly millions of possible locations and scales combined.

False positives should be below 1 in 1 million.



Source: Hu et al., *Finding Tiny Faces*, 2016 (https://arxiv.org/abs/1612.04402)

Enhancement

Face Detection

Methods
Either based on *sliding windows*
or on *regions of interest*.

Enhancement

Face Detection

Sliding Windows
Scans of the image with windows of different scales.

Enhancement

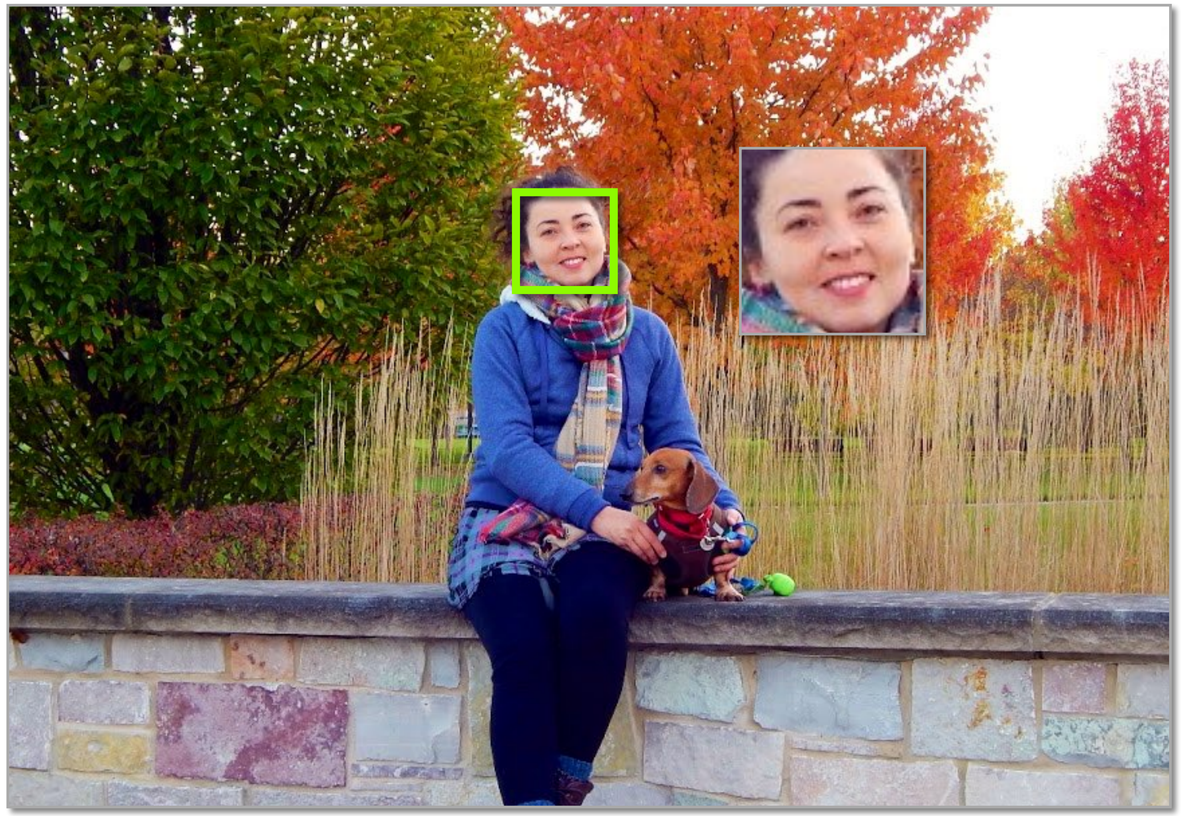
Face Detection

Sliding Windows
Scans of the image with windows of different scales.

Enhancement

Face Detection

Sliding Windows
Scans of the image with windows of different scales.



Enhancement

Face Detection

Regions of Interest
Techniques from Computer Vision or Machine Learning to segment regions.

E.g., Maximally Stable Extremal Regions (MSER[1]) or Deep Local Features (DELF[2]).

1. Matas et al. *Robust Wide Baseline Stereo from Maximally Stable Extremal Regions*. BMVC 2002.
2. Noh et al. *Large-Scale Image Retrieval with Attentive Deep Local Features*. ICCV 2017.

Enhancement

Face Detection

Regions of Interest
Techniques from Machine Learning to classify each region as *face or non-face.*

E.g., Support Vector Machines (SVM).

Enhancement

Face Detection

Viola-Jones Detector
First real-time face detector.
Based on sliding windows.

Key Ideas (4)
Haar-like features.
Integral image.
Boosting for feature selection.
Attentional Cascade to reject non-faces.

SECOND INTERNATIONAL WORKSHOP ON STATISTICAL AND COMPUTATIONAL THEORIES OF VISION – MODELING, LEARNING, COMPUTING, AND SAMPLING

VANCOUVER, CANADA, JULY 13, 2001.

Robust Real-time Object Detection

Paul Viola
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201 Broadway, 8th FL
Cambridge, MA 02139

Michael Jones
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This paper describes a visual object detection framework that is capable of processing images extremely rapidly while achieving high detection rates. There are three key contributions. The first is the introduction of a new image representation called the "Integral Image" which allows the features used by our detector to be computed very quickly. The second is a learning algorithm, based on AdaBoost, which selects a small number of critical visual features and yields extremely efficient classifiers [6]. The third contribution is a method for combining classifiers in a "cascade" which allows background regions of the image to be quickly discarded while spending more computation on promising object-like regions. A set of experiments in the domain of face detection are presented. The system yields face detection performace comparable to the best previous systems [18, 13, 16, 12, 1]. Implemented on a conventional desktop, face detection proceeds at 15 frames per second.

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Enhancement

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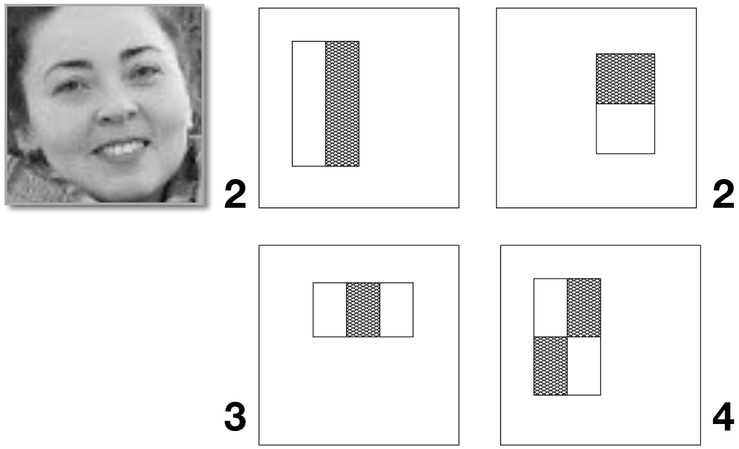
Enhancement

Viola-Jones Detector

Haar-Like Features (1/4)
Binary rectangle filters
used to extract features
from the sliding window.

$$value = \sum pixels\ in\ white\ area - \sum pixels\ in\ black\ area$$

Filter types
2, 3, and 4 rectangles.



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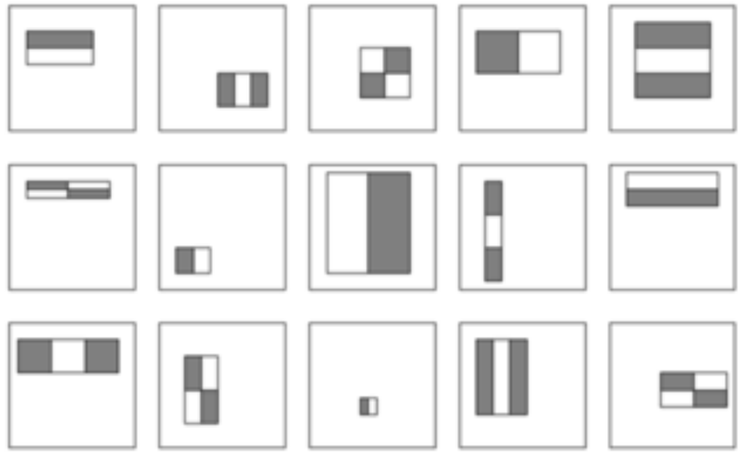
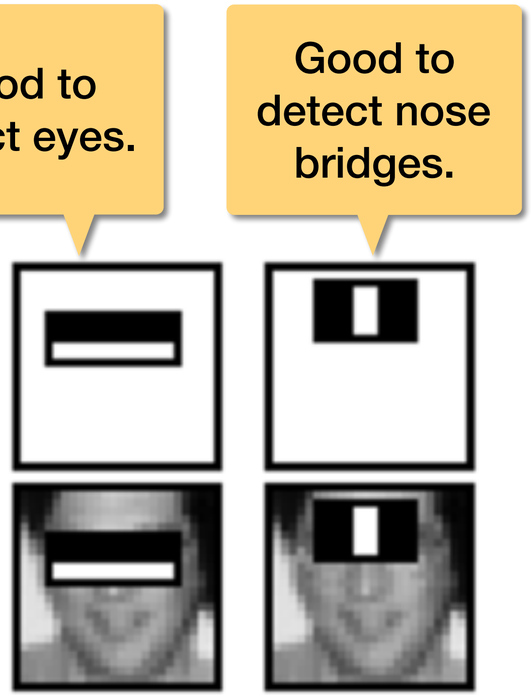
Enhancement

Viola-Jones Detector

Haar-Like Features (1/4)
Take a 24-by-24-pixels window.
The number of possible features is nearly 160,000.





How to apply and how to select features fast?

Enhancement

Face Detection

Viola-Jones Detector
First real-time face detector.
Based on sliding windows.

Key Ideas (4)
Haar-like features.
Integral image.
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Attentional Cascade to reject non-faces.

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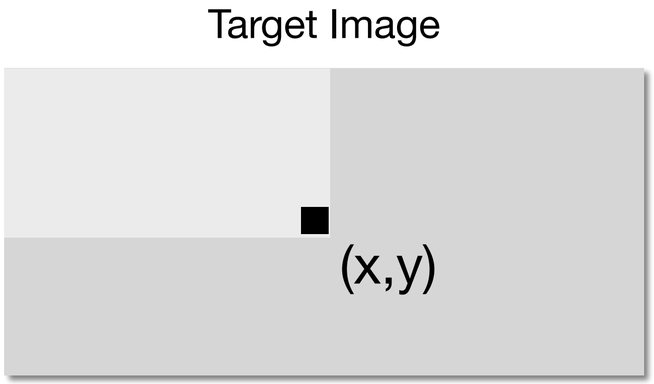
Enhancement

Viola-Jones Detector

Integral Image (2/4)
Solution to apply Haar-like features fast.

Precomputed data structure with the same dimensions of the target image.



Integral Image

Enhancement

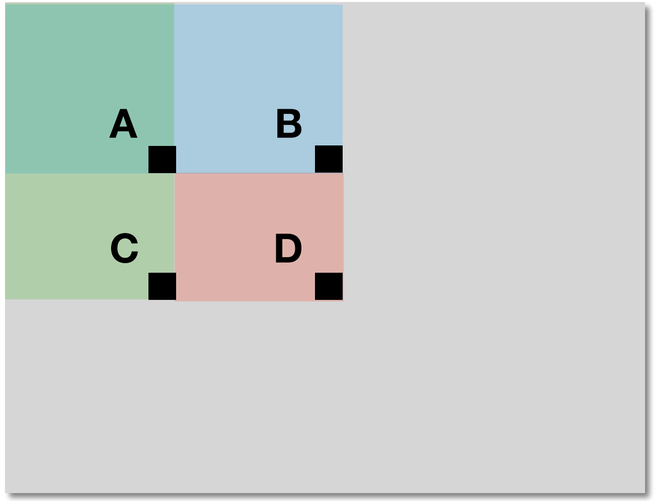
Viola-Jones Detector

Integral Image (2/4)

Remember Haar feature *value*:

$$value = \sum pixels\ in\ white\ area - \sum pixels\ in\ black\ area$$

Integral images allow the computation of the sum of pixel values in any target area in constant time, regardless of the size of the area.



Sum of pixels in red area

$$content = D - B - C + A$$

Only and always 4 accesses.

Enhancement

Face Detection

Viola-Jones Detector
First real-time face detector.
Based on sliding windows.

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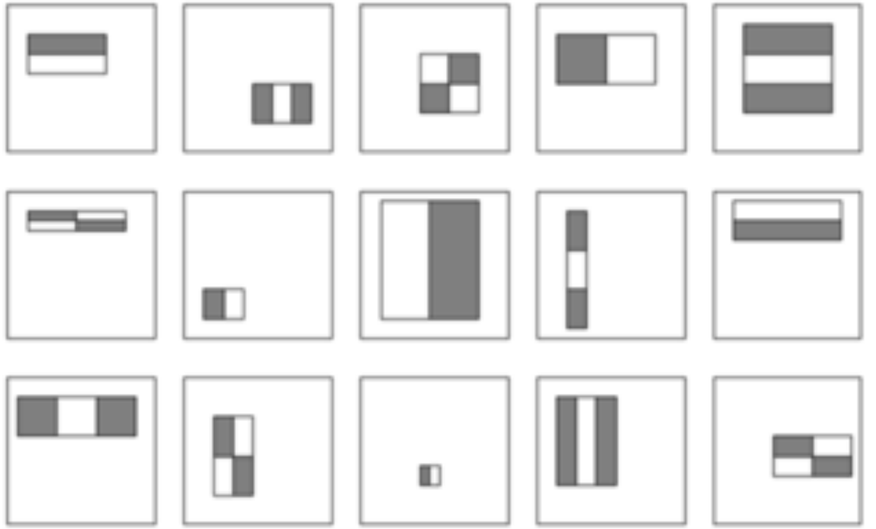
Enhancement

Viola-Jones Detector

Boosting for
Feature Selection (3/4)
Goal: select combinations of Haar-like features that are useful for face detection.

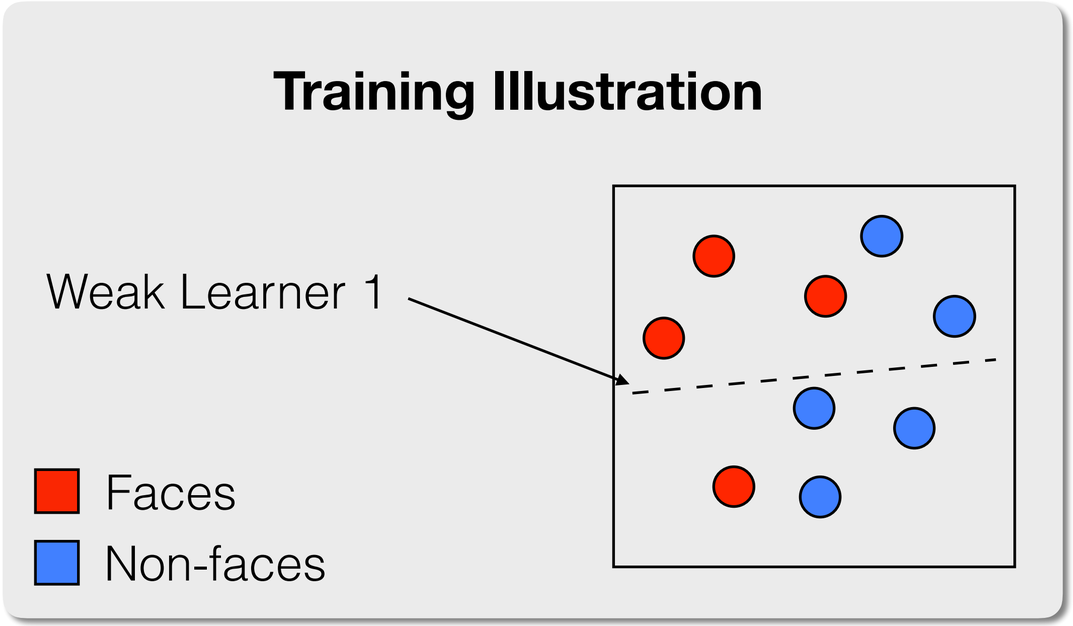


Enhancement

Viola-Jones Detector

Boosting for Feature Selection (3/4)

Solution: *boosting*, a combination of weak classifiers that when learned in sequence and applied together, lead to better final classification.



Source: Dr. Walter Scheirer

Enhancement

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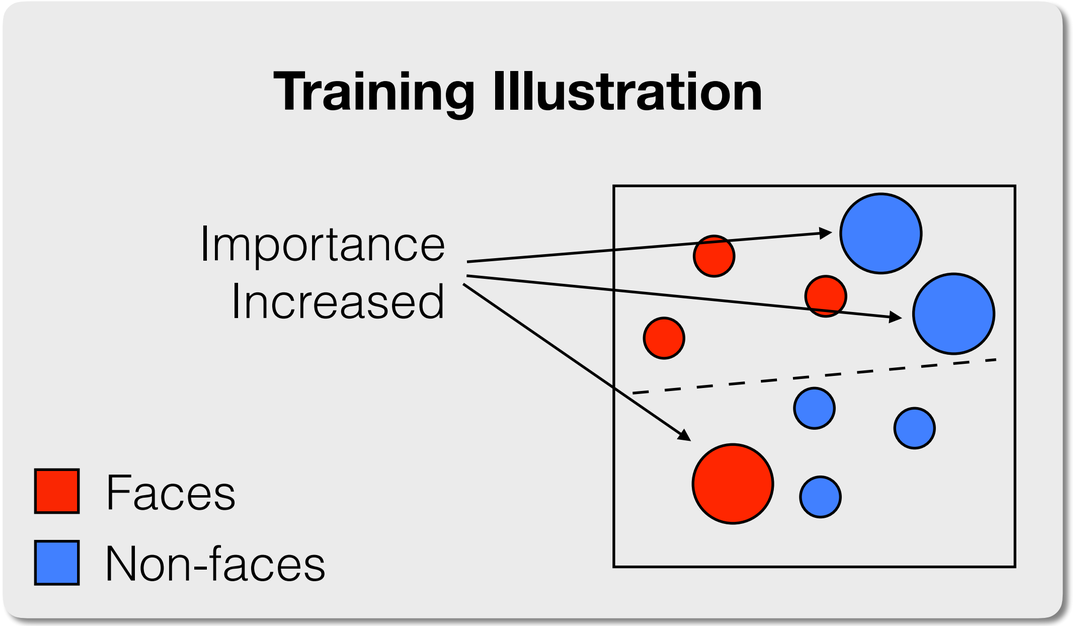

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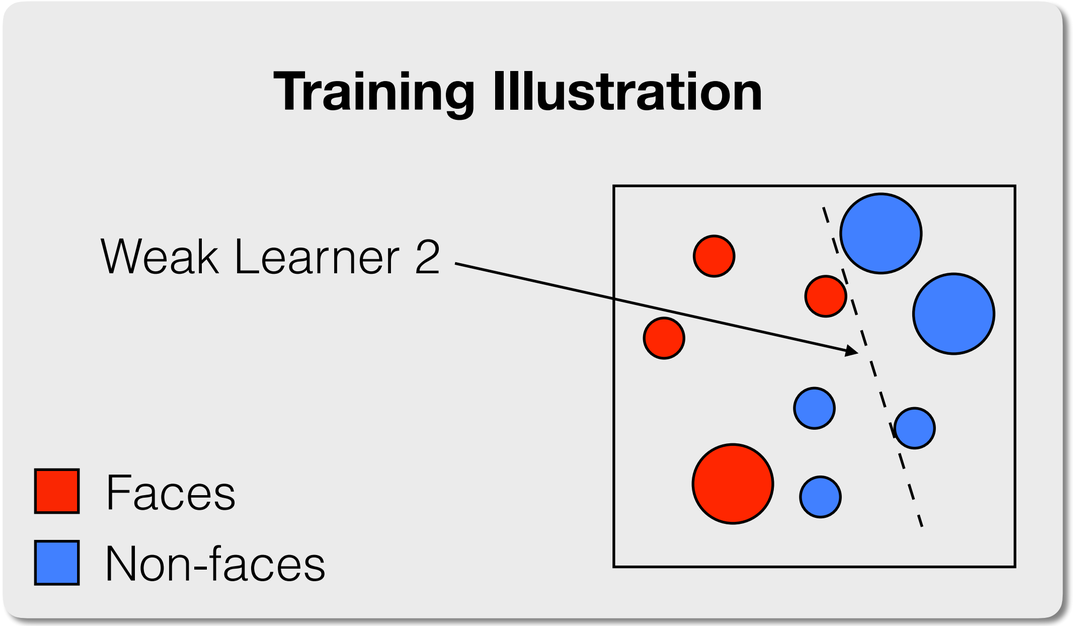

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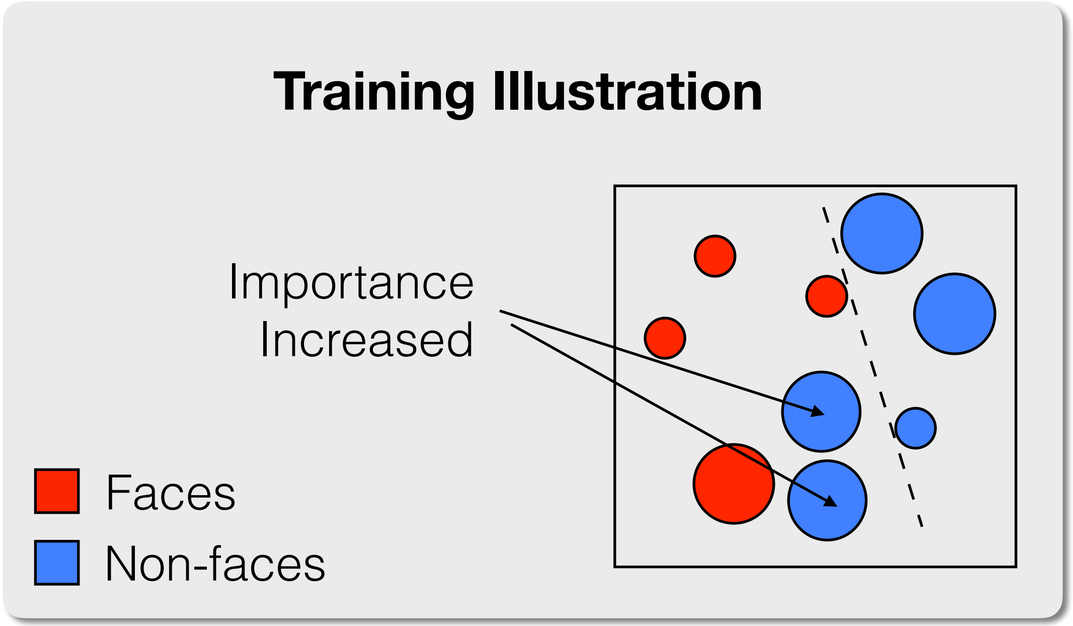

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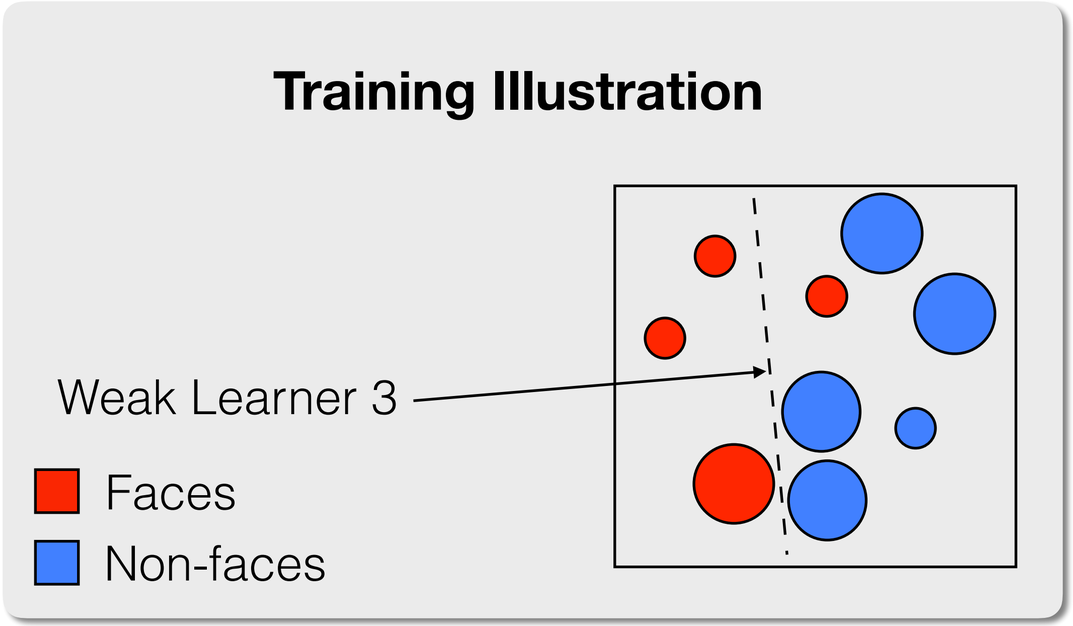

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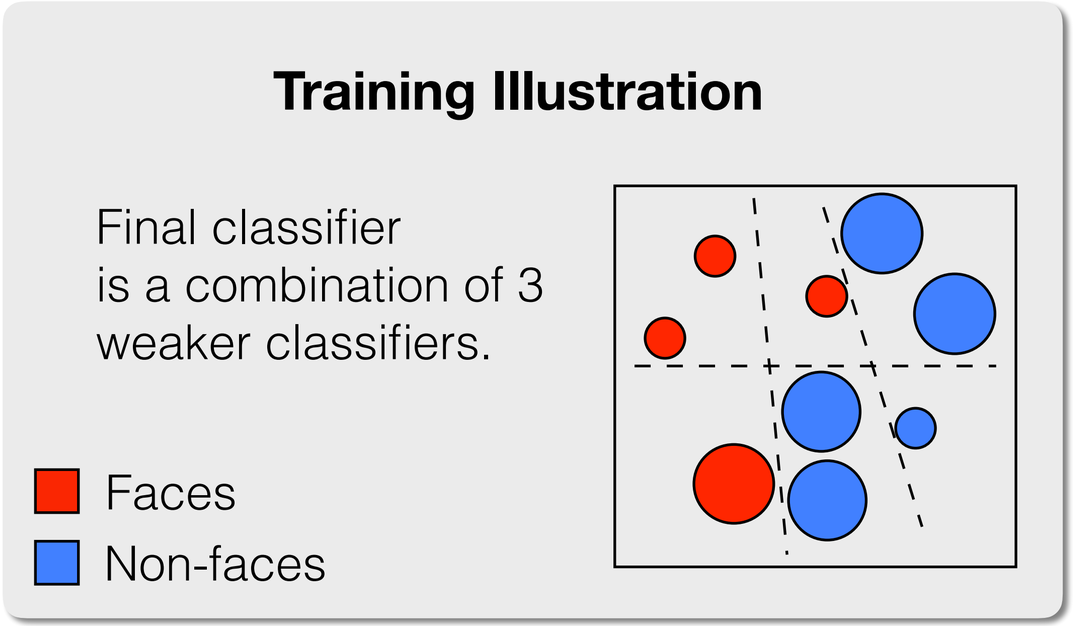

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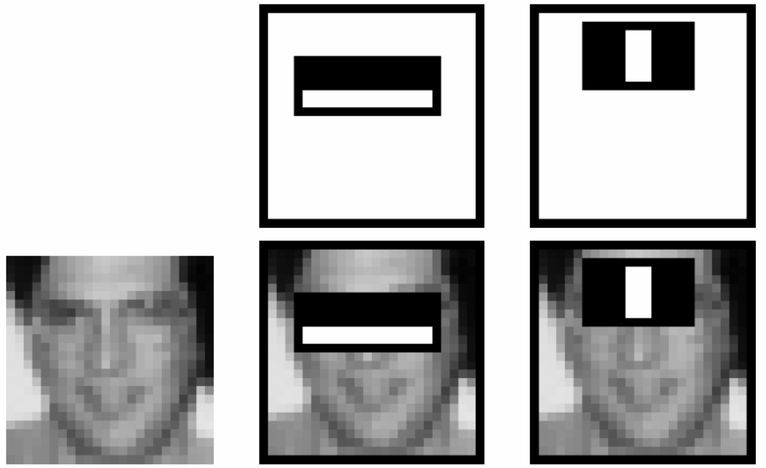
Enhancement

Viola-Jones Detector

Boosting for Feature Selection (3/4)
Possible outcome.



First two selected features.

This combination is enough
to lead to perfect True Positive Rate,
but poor False Positive Rate.

All faces are detected as positive, but many non-faces are detected as positive too.

Whenever this classifier says an object is not a face (rejection), it is probably right.

Enhancement

Face Detection

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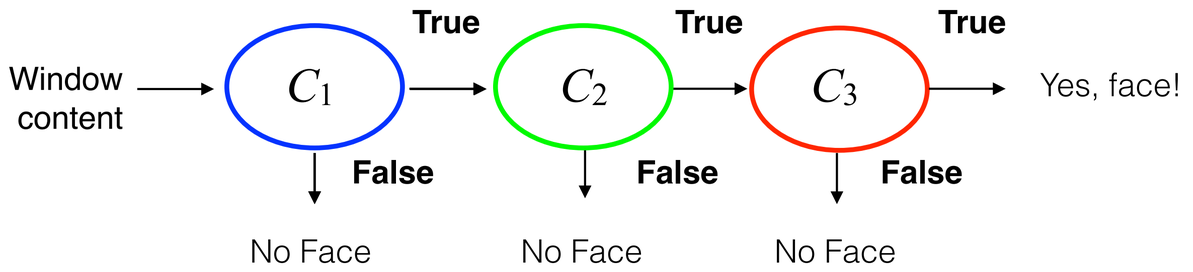
Enhancement

Viola-Jones Detector

Attentional Cascade (4/4)
Make a cascade of different classifiers that are good at rejecting faces.

Start with simpler and faster classifiers.



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Enhancement

Viola-Jones Detector

Results

Jain, Ross, and Nadakumar
Introduction to Biometrics
Springer Books, 2011

clean background

cluttered background

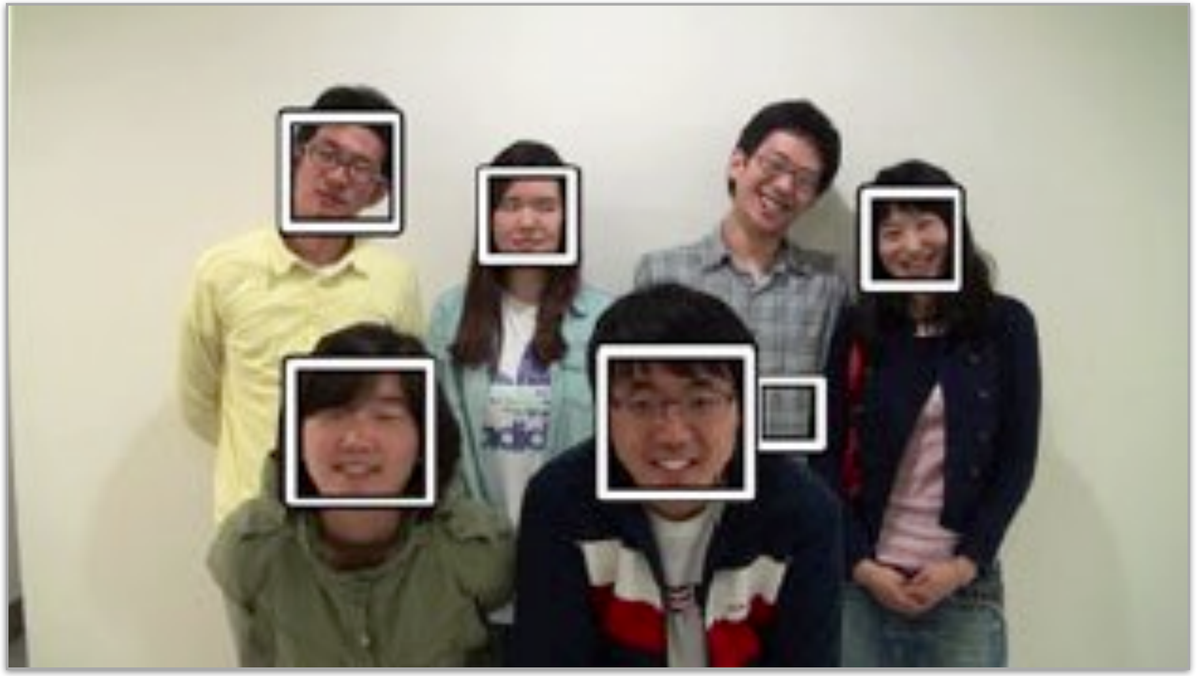
tilted head

upside down

Enhancement

Viola-Jones Detector

Results



Jain, Ross, and Nadakumar
Introduction to Biometrics
Springer Books, 2011

Enhancement

Face Detection

Attack
Non-live faces and some special patterns may be used to trigger the face detector on purpose.

If it happens too often, it will flood the system.

https://www.theguardian.com/world/2019/aug/13/the-fashion-line-designed-to-trick-surveillance-cameras

Enhancement

Face Detection

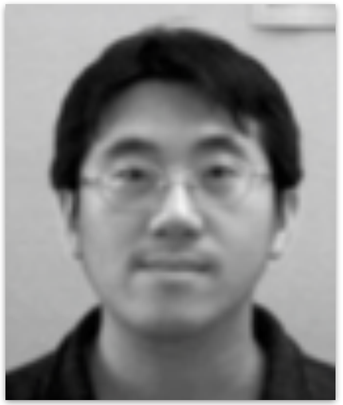
Attack
Make-up can be used to hinder detection.

https://twitter.com/glichfield/status/925425702194810882

Enhancement

Face Alignment

Goal
Make template and sample faces be in similar poses, to make further description and matching easier.



template

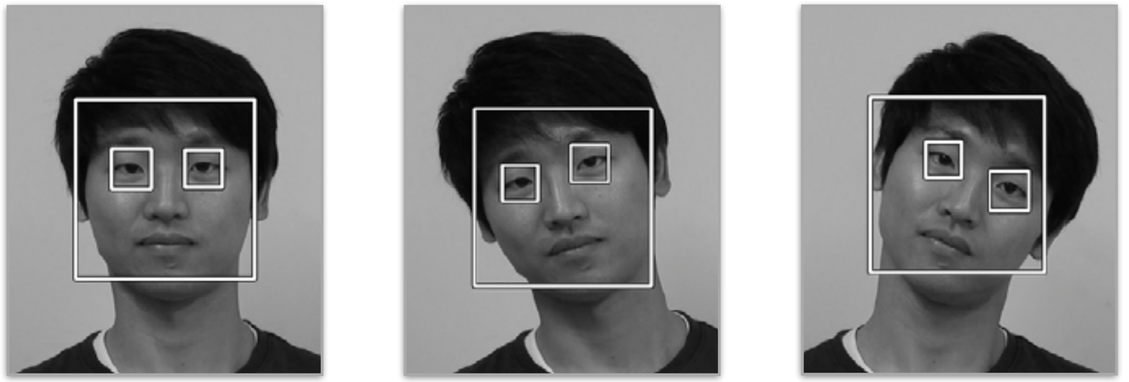
sample

Enhancement

Face Alignment

Detection of Face Landmarks
E.g., position of eyes.

Jain, Ross, and Nadakumar
Introduction to Biometrics
Springer Books, 2011



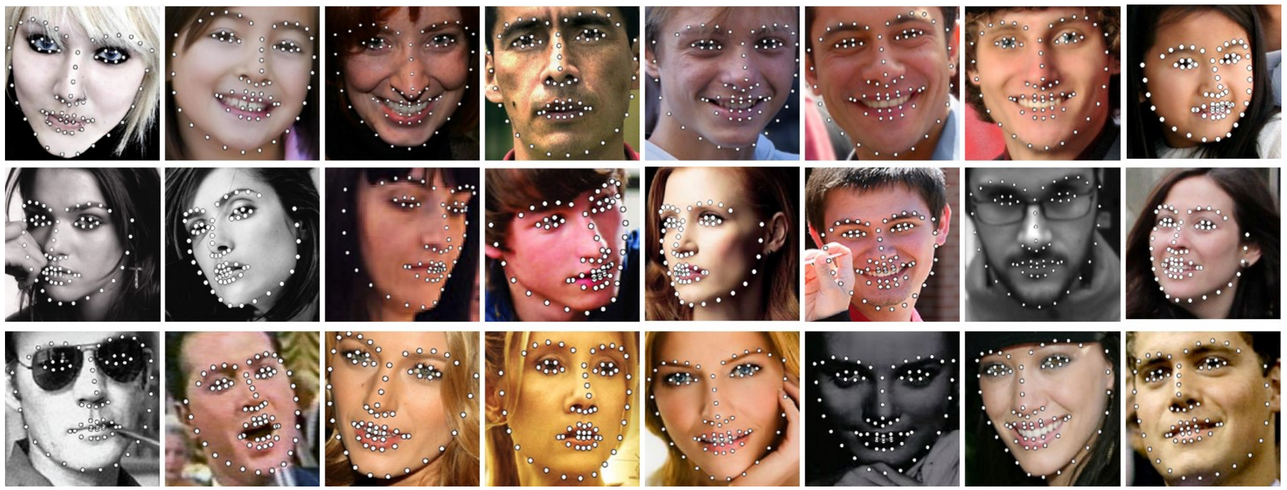
Possible solution: eye detection using Viola-Jones approach.

Enhancement

Face Alignment

Detection of Face Landmarks

There are better solutions in the literature, using deep neural networks, for instance.

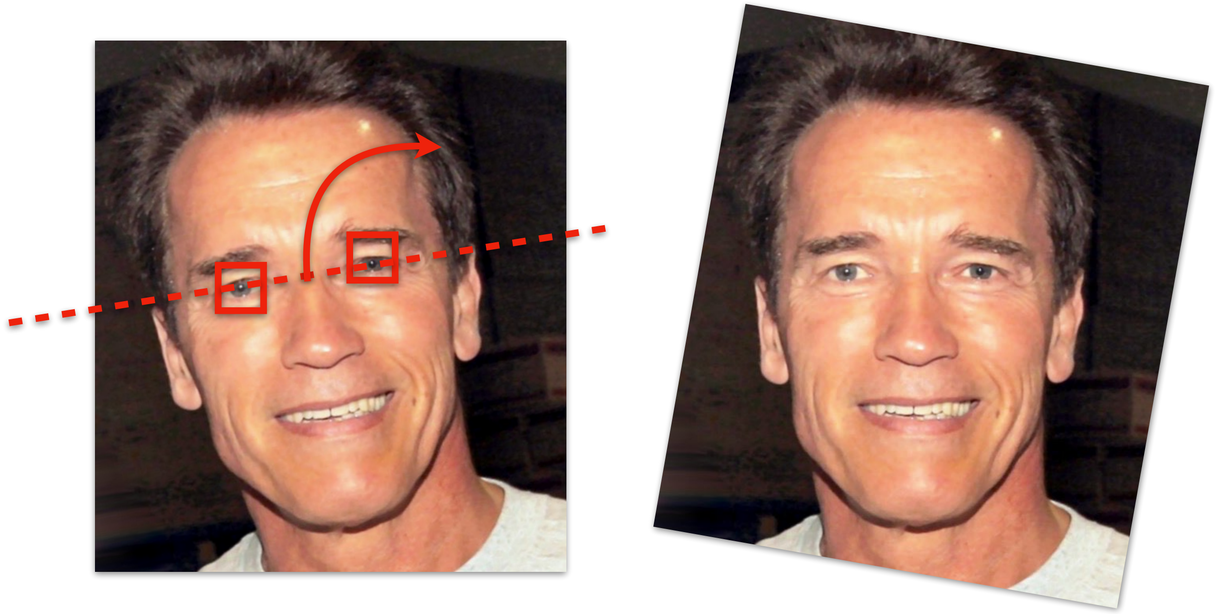


Zhang et al.
Facial Landmark Detection by Deep Multi-task Learning
ECCV 2014

Enhancement

Face Alignment

Landmark Alignment
E.g., make the positions of the eyes horizontally aligned, by rotating the face image.



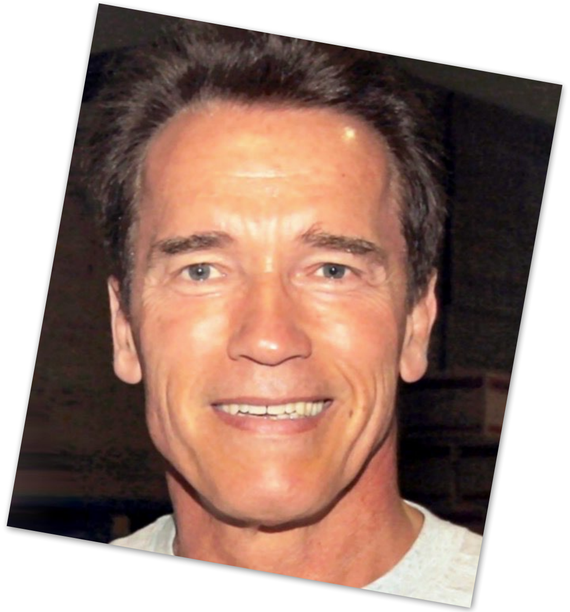
http://www.bytefish.de/blog/aligning_face_images/

Enhancement

Face Alignment

Cropping
Make a tight crop of the face, to remove background.

Keep eyes, nose, and mouth.



http://www.bytefish.de/blog/aligning_face_images/

Enhancement

Face Alignment

More Severe
Pose Variations
Naïve approach will not work.

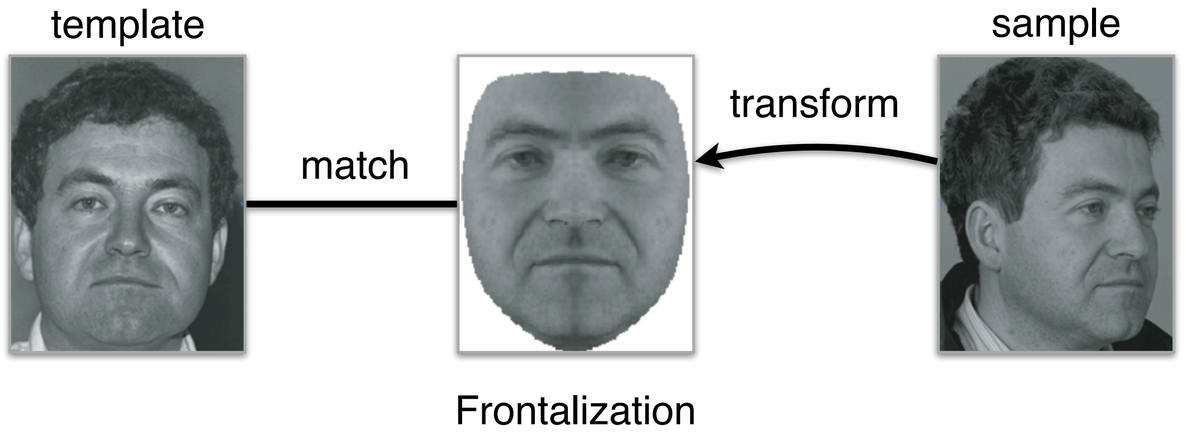


Enhancement

Face Alignment

More Severe Pose Variations
Alternative approaches.
3D information will help to do frontalization.

Yi et al.
Towards Pose Robust Face Recognition
CVPR 2013



Enhancement

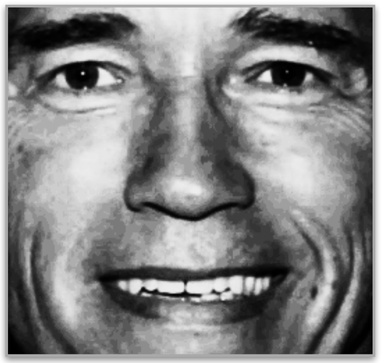
Illumination Correction

Simplest Solution
Color histogram equalization.

Alternatives
Photometric normalization, illumination modeling, etc.

Original

Grayscale



Equalized

S’up Next?

Face Description and Matching

Acknowledgments

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Thank you, professors, for kindly allowing me to use your material.

https://engineering.nd.edu/profiles/aczajka
https://www.wjscheirer.com/

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