

# Matching Age Separated Composite Sketches and Digital Face Images

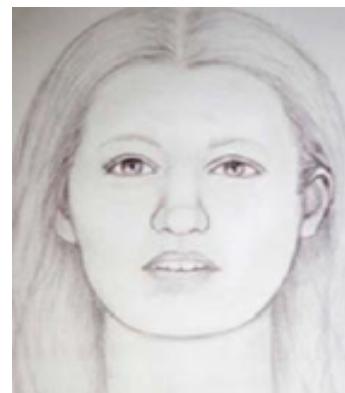
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October 2, 2013

IIIT-Delhi, India

# Facial Sketches

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- Michael Dunahee missing since March, 1991.
- Over the years, police has released many composite sketches to show how he would look as a teen or young adult.
- Gloria Faye Stringer was identified after 37 years [2012] of her death [1975].
- It opened an investigation in her possible murder case.

Michael Dunahee <http://www.cbc.ca/news/canada/british-columbia/story/2013/03/24/bc-michael-dunahee-missing-boy.html>

Gloria Faye <http://www.foxnews.com/us/2012/02/21/body-found-in-texas-river-in-175-identified-as-missing-22-year-old-mother/> 2

# Facial Sketches

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- Terror Hits Home: The Oklahoma City Bombing - Timothy McVeigh caught soon after the bombing



# Several News Around ...

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- Suspect in 1993 Ogden murder cold case arrested (standard.net)
- Suspect arrested in 1996 cold case murder of Rancho Cucamonga Man (cbslocal.com)
- Suspect in 2011 construction site shooting arrested (colletontoday.com)
- Sketch credited for helping to catch murder, rape suspect (kspr.com)
- Delhi rape suspects arrested (timesofindia.com)

# Three Scenarios

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- In law enforcement applications, there can be three scenarios:

- Missing Children (Young Age)



11 yrs.

- Recent Crime (Same Age)



18 yrs.



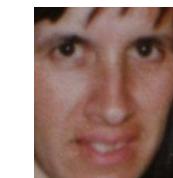
15 yrs.

16 yrs.

- Cold Cases (Old Age)



21 yrs.



35 yrs.

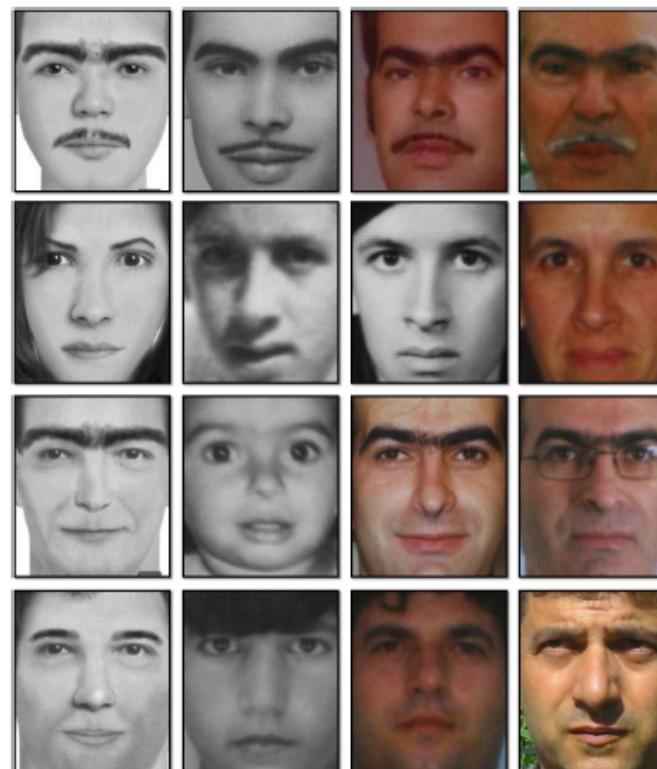


44 yrs.<sub>.5</sub>

# Problem Statement

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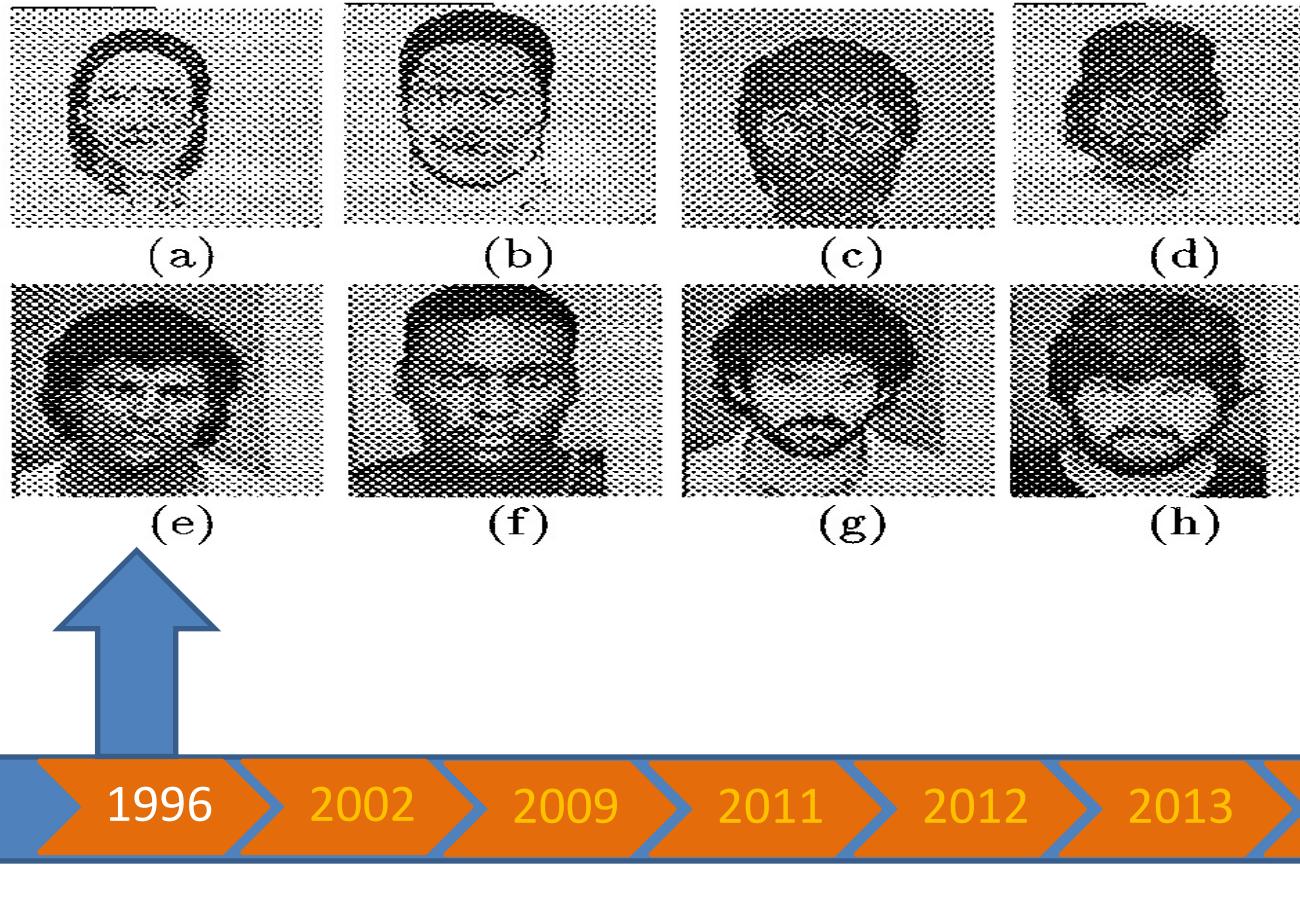
- To match composite sketches with digital face images of different age groups



# Research Progression



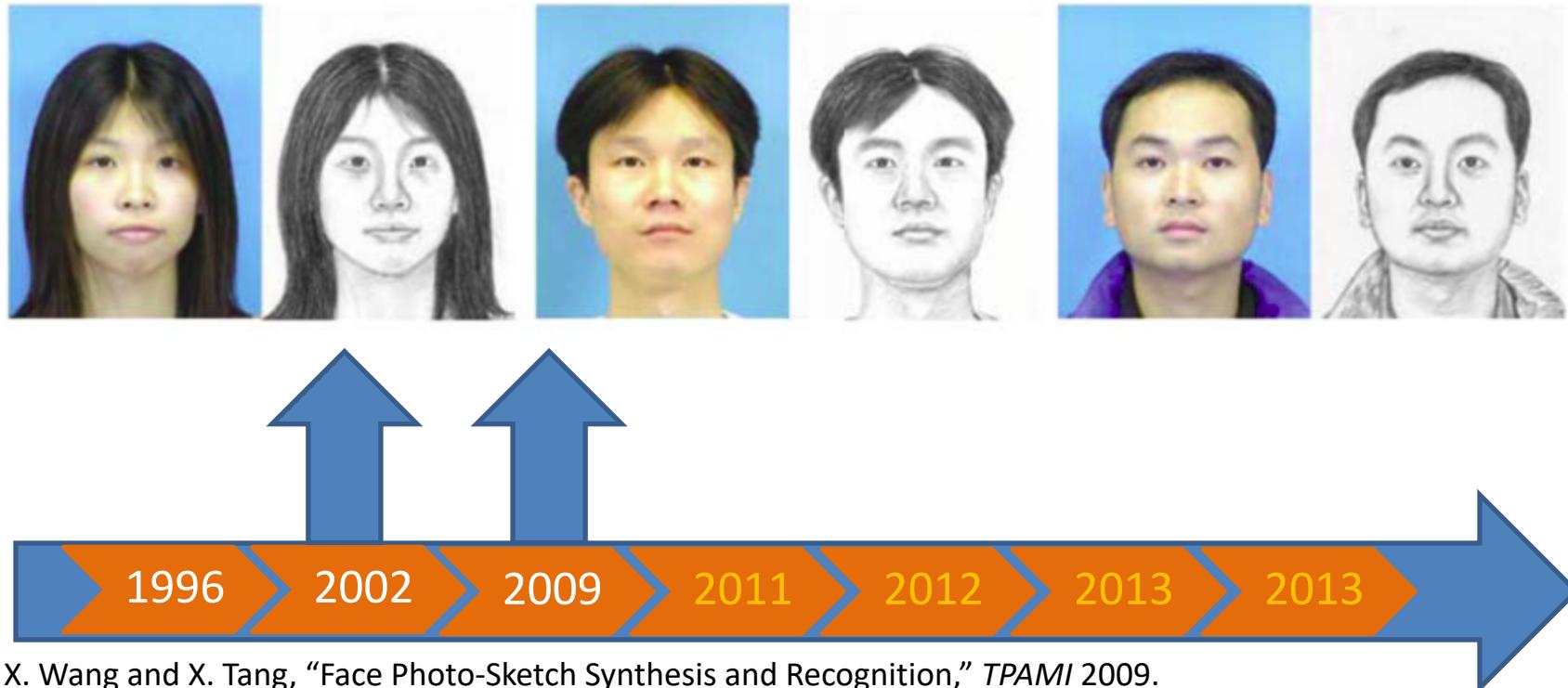
# Research Progression



Uhl, R.G., Jr.; da Vitoria Lobo, N., "A framework for recognizing a facial image from a police sketch,"  
*Proceedings of Computer Vision and Pattern Recognition*, 1996

# Research Progression

Viewed Sketches



- X. Wang and X. Tang, "Face Photo-Sketch Synthesis and Recognition," *TPAMI* 2009.
- Liu et al., "A Nonlinear Approach For Face Sketch Synthesis and Recognition," *CVPR* 2005.
- X. Tang, and X. Wang, "Face Sketch Recognition," *TCSVT* 2004.
- X. Tang, and X. Wang, "Face Sketch Synthesis and Recognition," *ICCV* 2003.
- X. Tang, and X. Wang, "Face Photo Recognition Using Sketch," *ICIP* 2002.

# Research Progression



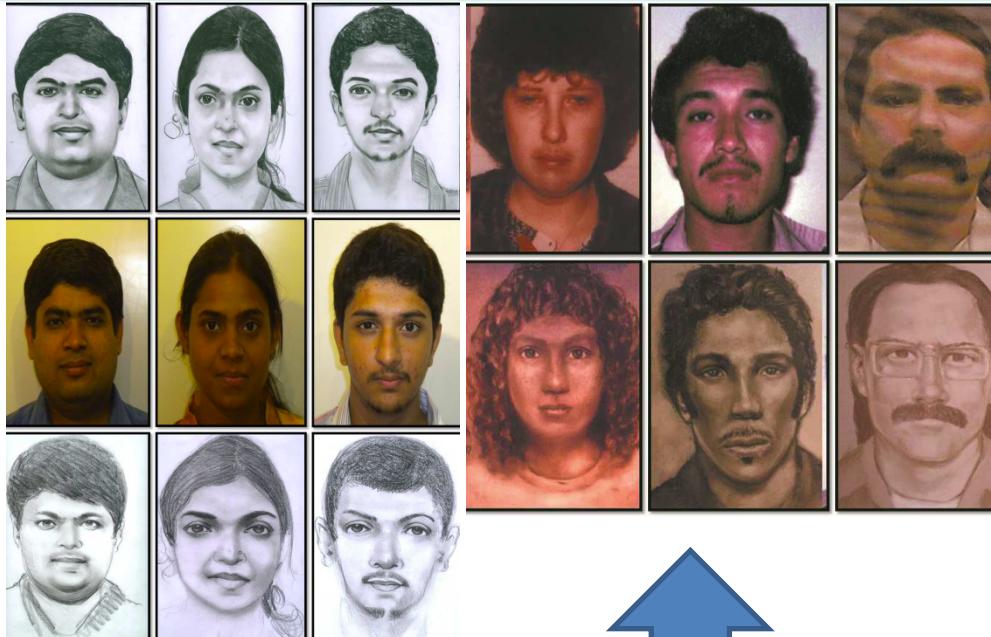
Forensic  
Sketches



B. Klare, Z. Li, and A. K. Jain, "Matching Forensic Sketches to Mugshot Photos", *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 2011

# Research Progression

Viewed  
Sketches



Forensic  
Sketches

Semi-Forensic  
Sketches



H.S. Bhatt, S. Bharadwaj, R. Singh, and M. Vatsa, Memetically Optimized MCWLD for Matching Sketches with Digital Face Images, *IEEE Transactions on Information Forensics and Security*, 2012

# Research Progression



Composite Sketches



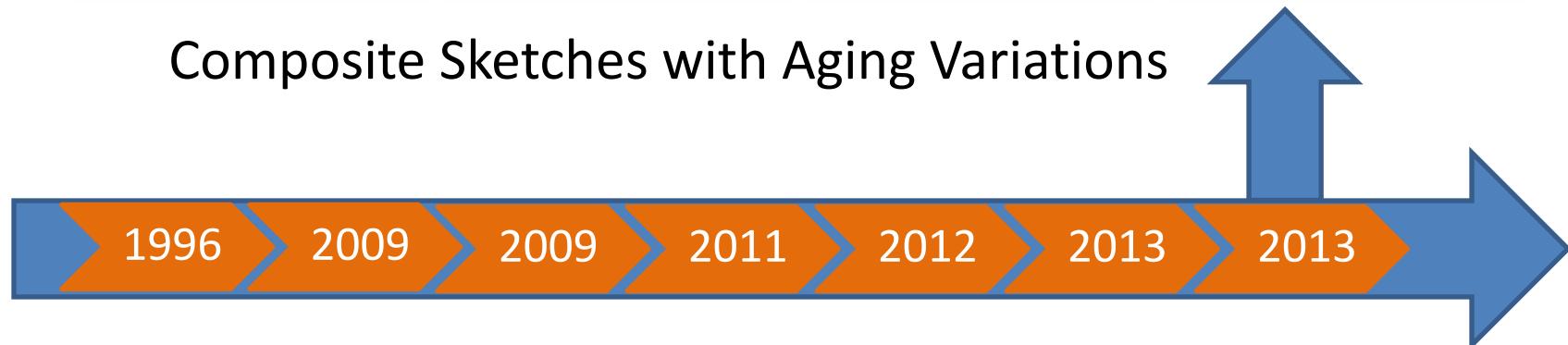
H. Han, B. Klare, K. Bonnen, and A. K. Jain, "Matching Composite Sketches to Face Photos: A Component-Based Approach", *IEEE Transactions on Information Forensics and Security*, 2013.  
S. Klum, H. Han, A. K. Jain, and B. Klare, "Sketch Based Face Recognition: Forensic vs. Composite Sketches", *ICB* 2013.

# Research Progression

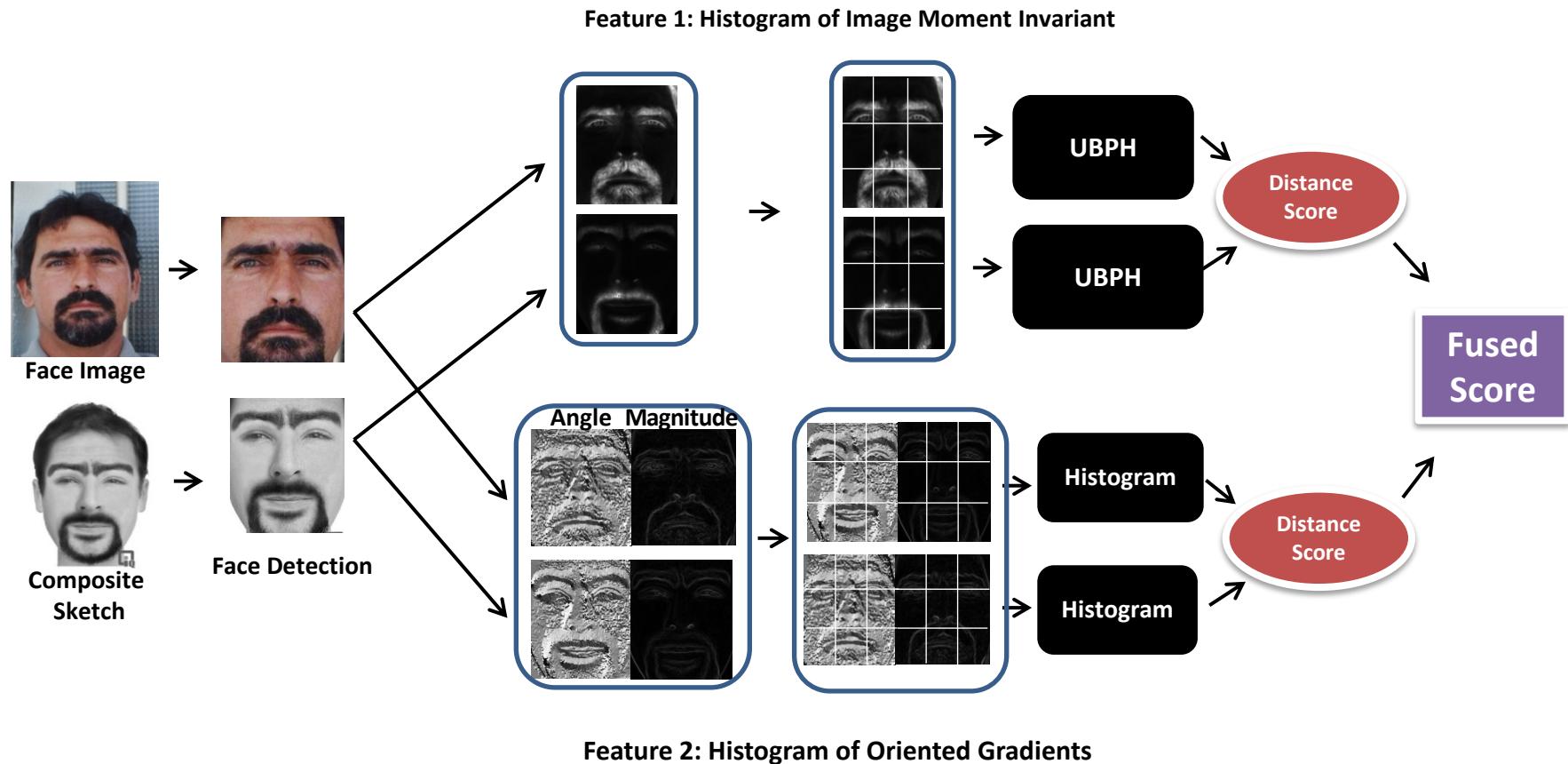
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Composite Sketches with Aging Variations



# Proposed Algorithm



Feature 2: Histogram of Oriented Gradients

# Pre-Processing

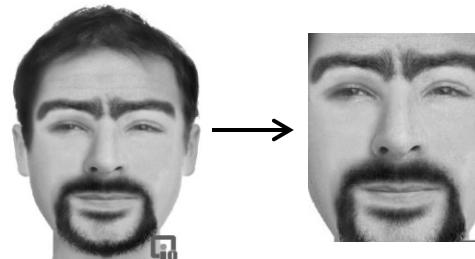
- **VeriLook SDK** by NeuroTechnology
- Face aligned and resized to 224 X 196 pixels
- Conversion to gray-scale



FG - NET



After alignment and resizing



# Image Moment Invariants

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- Image Moment Invariants
  - Alleviate effects of rotation, scaling and translation
  - Used in shape recognition



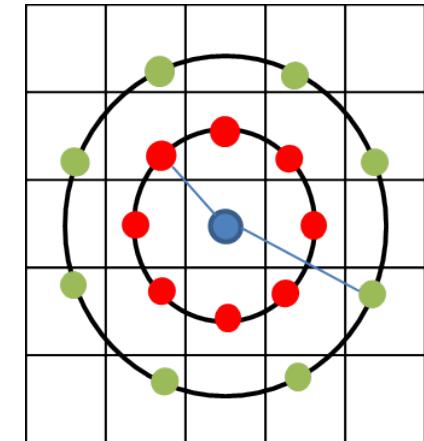
- First Moment Invariant
  - Provides pixel density around the centroid
- Second Moment Invariant
  - Structure of face image invariant to rotation and scaling



# Histogram of Image Moments

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- Image is raster scanned
- Neighboring coordinates with different radius are used – similar to LBP
- Image Moment Invariants are calculated over the neighboring pixels
- Pixel – moments – values whose binary representation has at most two transitions are uniform binary patterns
- Size of histogram is 59 X 1 (i.e. 58 uniform patterns; rest to 59<sup>th</sup> bin)

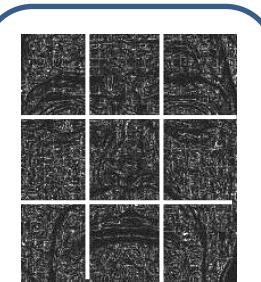


# Histogram of Image Moments

Image Moment Invariants



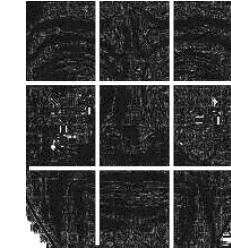
Face Image



Uniform Binary  
Pattern Histogram  
**59 X 1**



Composite  
Sketch



Uniform Binary  
Pattern Histogram  
**59 X 1**

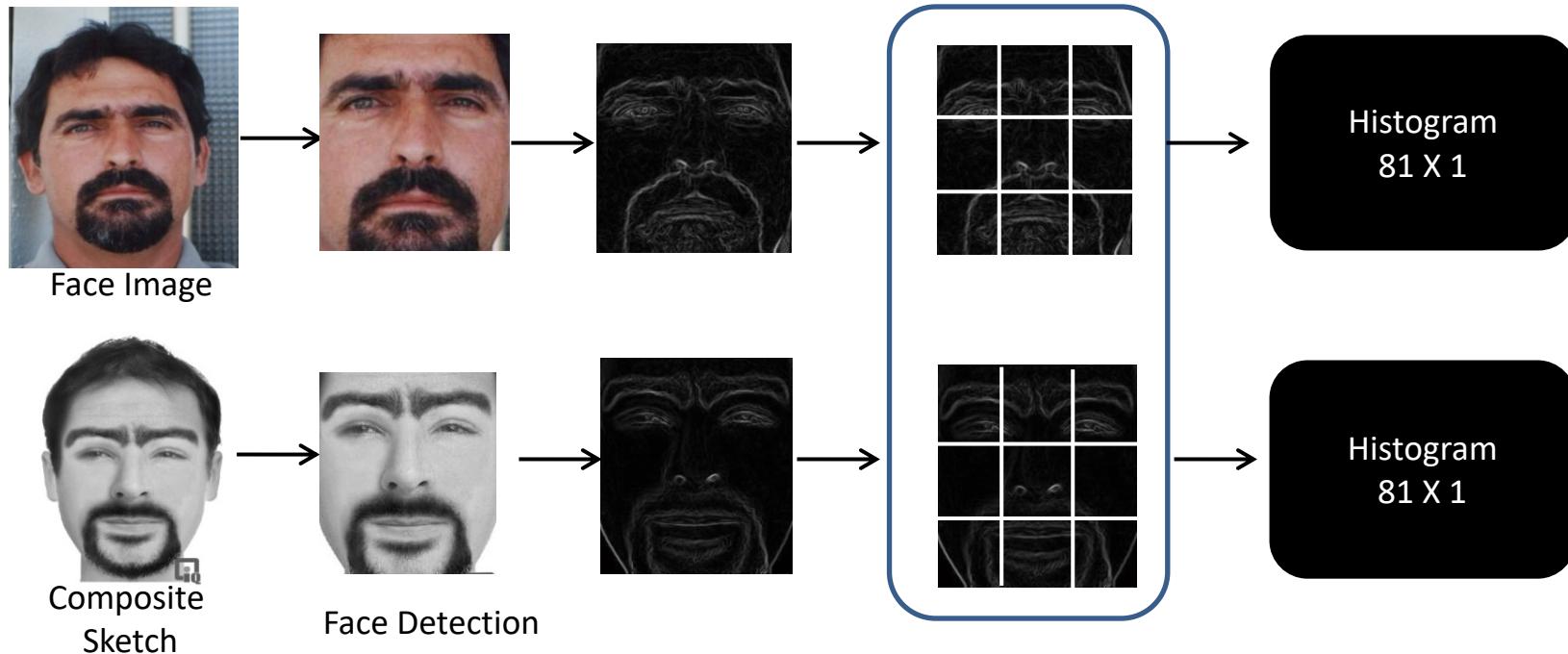
Face Detection

# Histogram of Oriented Gradient (HOG)

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- Image Gradient
  - Shape: Edge information
  - Texture: Intensity variations
- HOG: More weight given to gradient orientations that appear with higher frequency in a local region
- Histogram of Oriented Gradient Size =  $81 \times 1$

# Histogram of Oriented Gradient



# Distance Score

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- $\chi^2$  distance between histograms of each region are calculated

$$\chi^2(x, \xi) = \sum_i \sum_j \frac{(x_{i,j} - \xi_{i,j})^2}{x_{i,j} + \xi_{i,j}}$$

where,  $i$  = region of image and  $j$  = bin number

# Experimental Evaluation

# Database

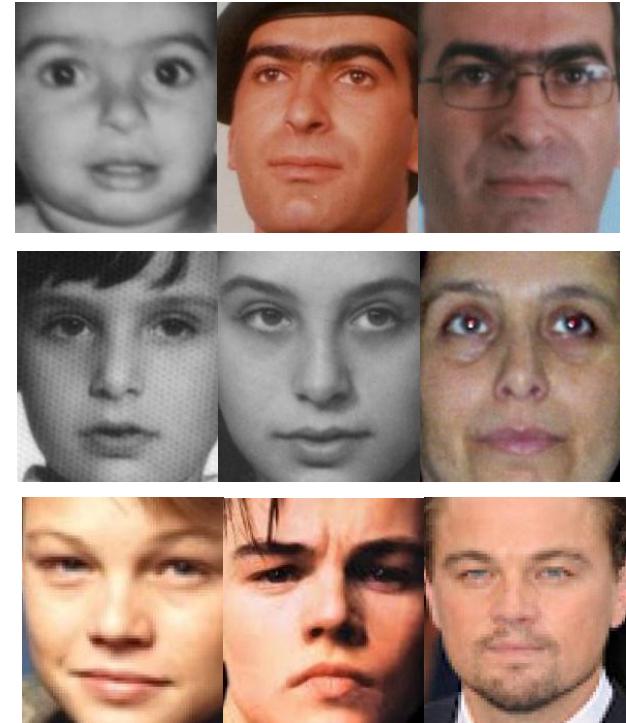
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- **59 Subjects**

- 45 from FG-Net Aging Database
- 14 from FACES Facebook official webpage

- **Age Variation**

- 2 to 65 years
- 10 – 12 age varied images for each subject
- Mean age of probe images in same age group: **25 years**
- Mean age difference between probe and gallery of young age group: **11 years**
- Mean age difference between probe and gallery of old age group: **7.6 years**



# Database

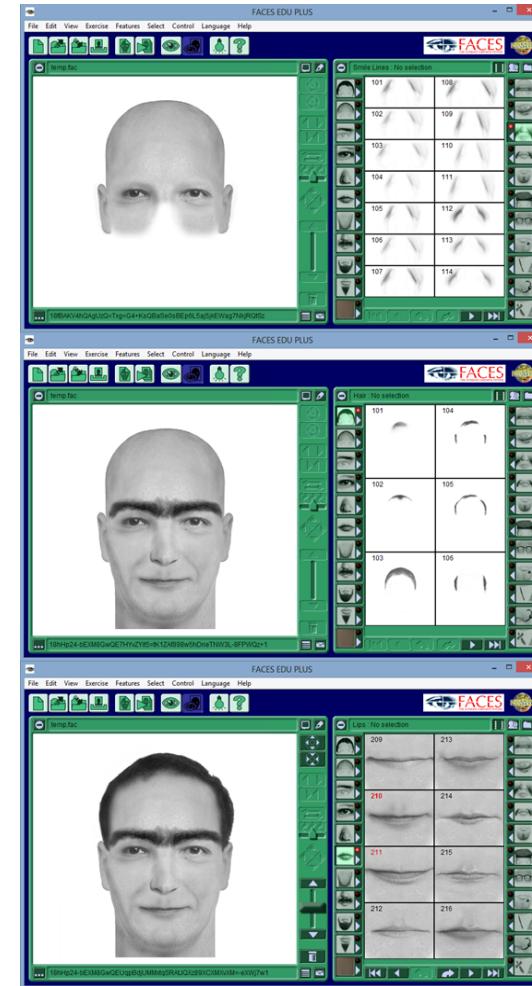
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- Probe: 59 composite sketches
- Gallery: 618 age varied digital face photos – multiple encounter scenario
- Extended Gallery: 4543 digital face images obtained from law enforcement agencies

	Young Age	Same Age	Old Age
Probe	59	59	59
Gallery	361	59	198
Extended Gallery	4543	4543	4543
Total Gallery	4904	4602	4741

# Composite Sketch Generation

- Used professional tool **FACES 4.0** by IQBiometrix [8]
- Extensively used by thousands of law enforcement agencies
- More than 4400 options for the facial components
- Composite Sketch
  - Subjects' median age





18 yrs.

# Experimental Protocol

**Experiment 1:** Missing Children (Young age gallery)

Probe: 59 composite sketches

Gallery: 4904 digital face images



11 yrs.



15 yrs.



16 yrs.

**Experiment 2:** Recent Crime (Same age gallery)

Probe: 59 composite sketches

Gallery: 4602 digital face images



18 yrs.

**Experiment 3:** Cold Cases (Old age gallery)

Probe: 59 composite sketches

Gallery: 4741 digital face images



21 yrs.



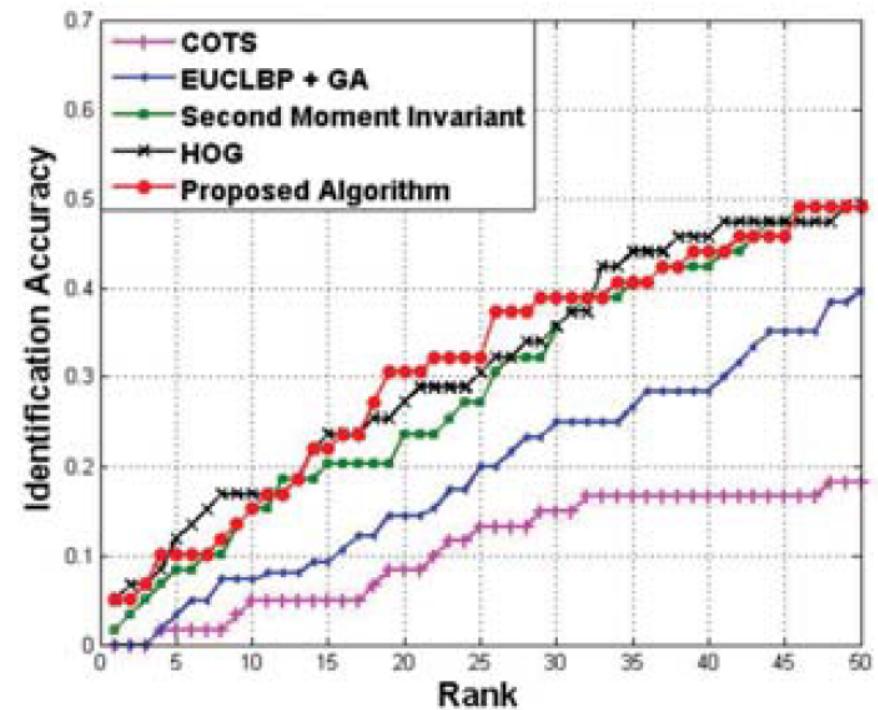
35 yrs.



44 yrs.

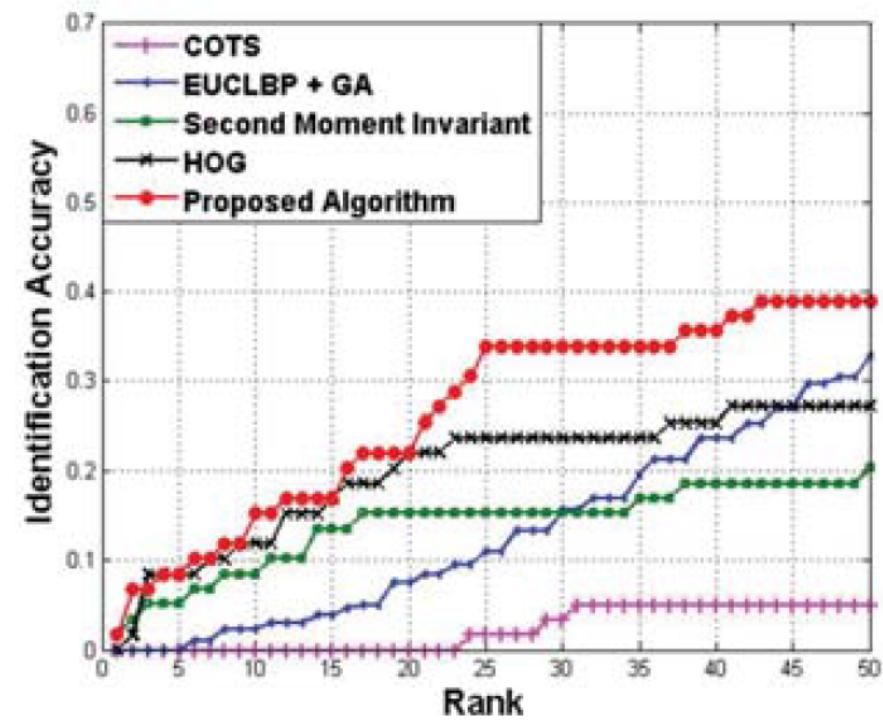
# Results – Young Age Group

Algorithm	Rank – 50 Accuracy
COTS - VeriLook	18.3 %
EUCLBP + GA [6]	39.6 %
Second Image Moment	49.2 %
HOG	49.2 %
Proposed Approach	<b>49.2 %</b>



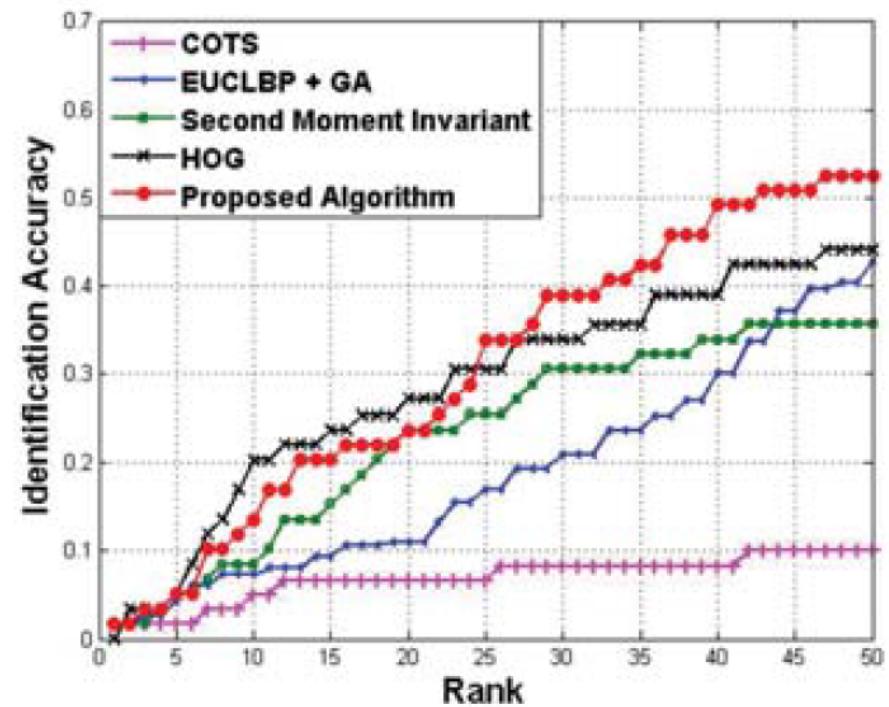
# Results – Same Age Group

Algorithm	Rank – 50 Accuracy
COTS - VeriLook	5.0 %
EUCLBP + GA [6]	32.6 %
Second Image Moment	20.3 %
HOG	27.1 %
Proposed Approach	<b>38.9 %</b>



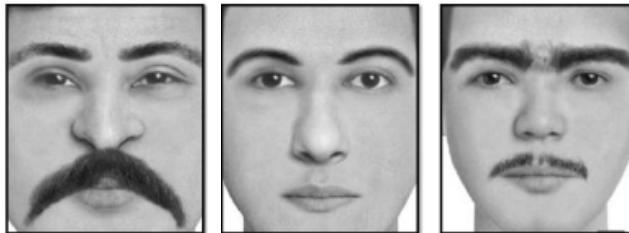
# Results – Old Age Group

Algorithm	Rank – 50 Accuracy
COTS - VeriLook	10.0 %
EUCLBP + GA [6]	42.7 %
Second Image Moment	35.6 %
HOG	44.1 %
Proposed Approach	<b>52.5 %</b>

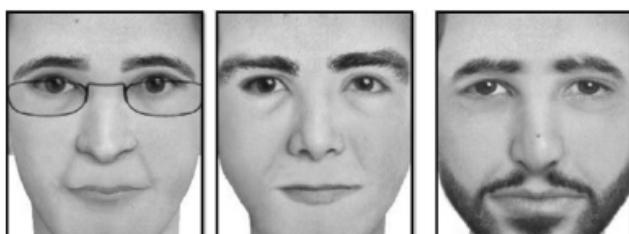


# Analysis

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Sample cases in which the proposed algorithm perform correct recognition



Sample cases in which the proposed algorithm fails to recognize face images



# Future Work

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- Incorporating craniofacial growth in young age group
- Learning best weights for fusion
- Increasing the size of database and incorporating soft biometric information

# Thank you.

Questions?

