# Sketch to Photo Matching

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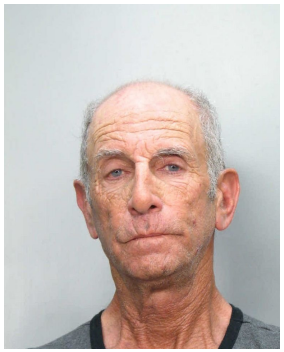
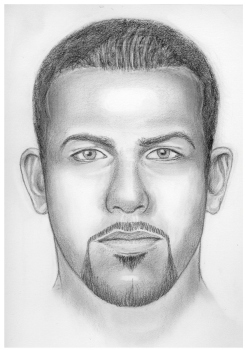
# Motivation

- Many crimes occur in which no facial image of a suspect is available
- A witness or the victim can provide a verbal description of the suspect's face
- This description is used to create a facial sketch (referred to as a composite)





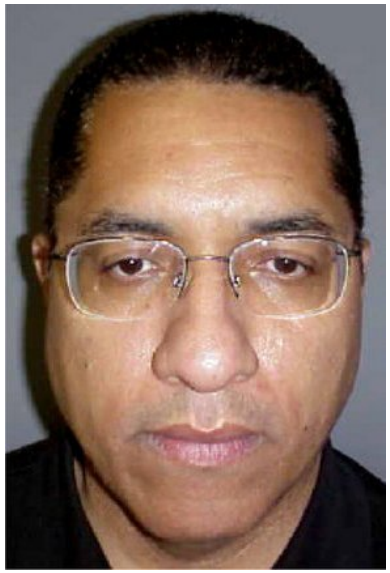
# Example Verbal Description

"The man was about 5ft. 6in. in height, and 34 or 35 years of age, with dark complexion and dark mustache turned up at the ends . . . He had a heavy mustache curled up, and dark eyes and bushy eyebrows. He had no side whiskers, and his chin was clean shaven. He looked like a foreigner."

http://www.forartist.com/forensic/composite/jacktheripper/jacktheripper.htm

# Examples of Composites Today

**Juan Perez** is a detective and artist with NYPD; he creates composites based on victims descriptions. The NYPD produced 273 sketches in 2012.



**Rene Otero** is arrested after the release of a sketch in the sexual abuse case of a 9-year-old girl in the East Village in April 2013.

http://www.nytimes.com/2013/08/19/nyregion/still-finding-value-in-the-vanishing-art-of-police-sketches.html?_r=0

# Examples of Composites Today

**Juan Perez** is a detective and artist with NYPD; he creates composites based on victims descriptions. The NYPD produced 273 sketches in 2012.

**Erika Menendez** is arrested after a sketch was released in December 2013 after a man was shoved in front of a subway train.

http://www.nytimes.com/2013/08/19/nyregion/still-finding-value-in-the-vanishing-art-of-police-sketches.html?_r=0

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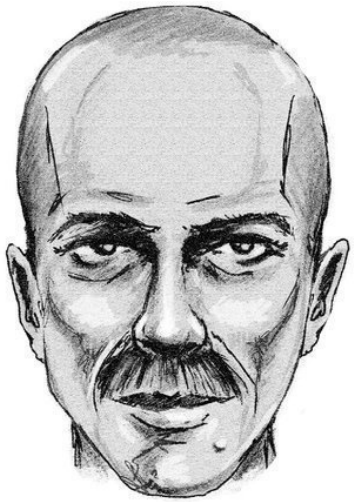
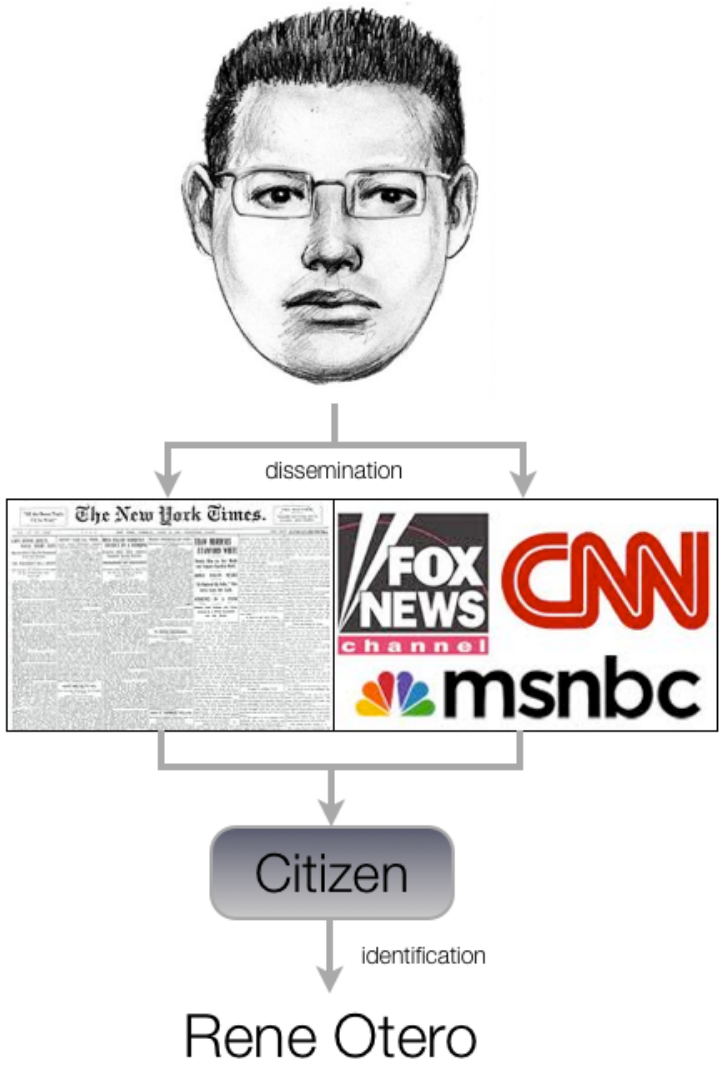


**Steven Papas**' sketch led directly to his identification. He is serving time for kidnapping and sexual assault.

http://www.nytimes.com/2013/08/19/nyregion/still-finding-value-in-the-vanishing-art-of-police-sketches.html?_r=0

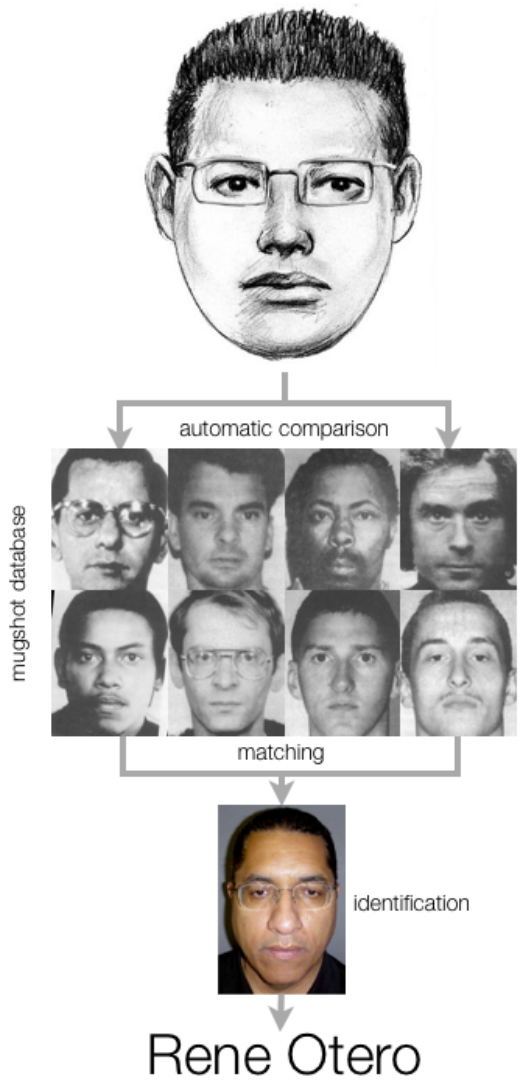
# Current Approach

- Law enforcement agencies disseminate a sketch to media outlets
- Citizens provide information pertinent to the identification and capture of a suspect
- Slow and tedious process
- Fails to leverage resources available to law enforcement agencies (mugshot databases)



# Proposed Approach

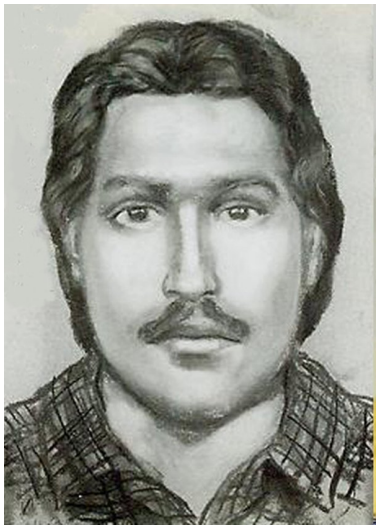
- Match facial composites against mugshots automatically
- Holistic representation (developed by Klare and Jain)
- Component representation (developed by Han et al.)
- Train algorithms using facial composite/mugshot pairs

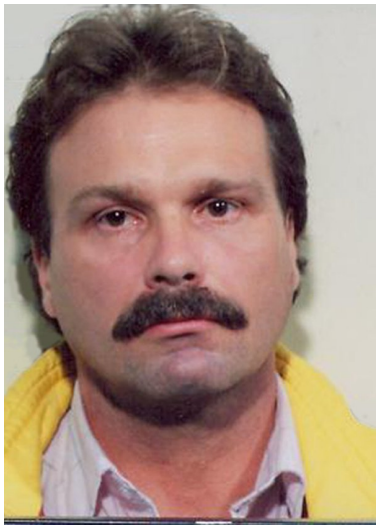


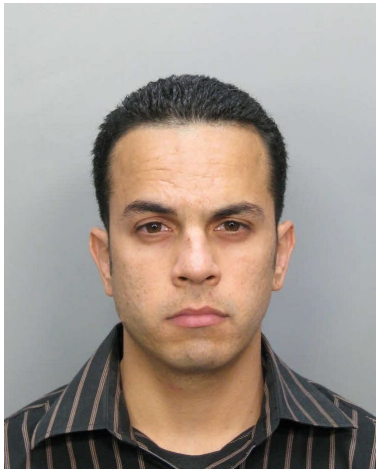
# Composite Types

- Viewed hand-drawn composites
  - Drawn while viewing the photograph
  - Not relevant to law enforcement
- Hand-drawn composites
  - Drawn using the description provided by a witness or victim
- Software-generated composites
  - Created using menu-driven software using description provided by a witness

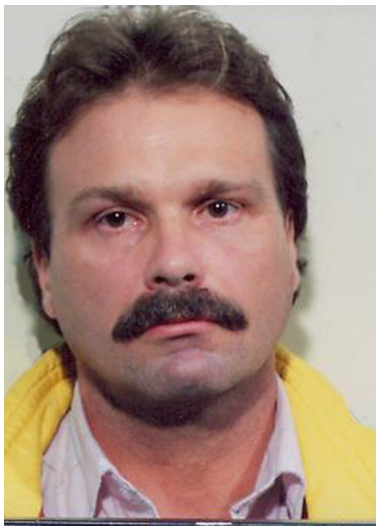
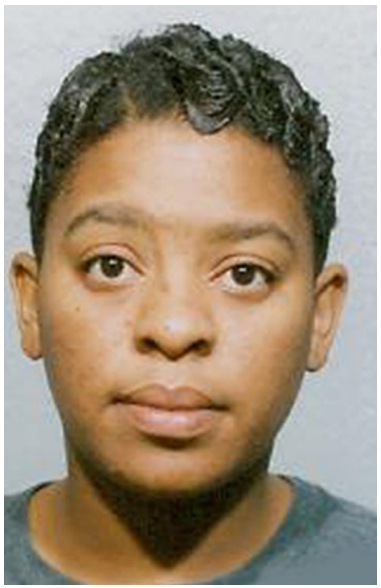
# Hand-Drawn Composites

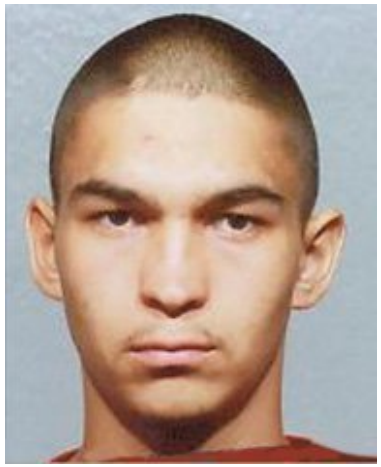






# Software-Generated Composites



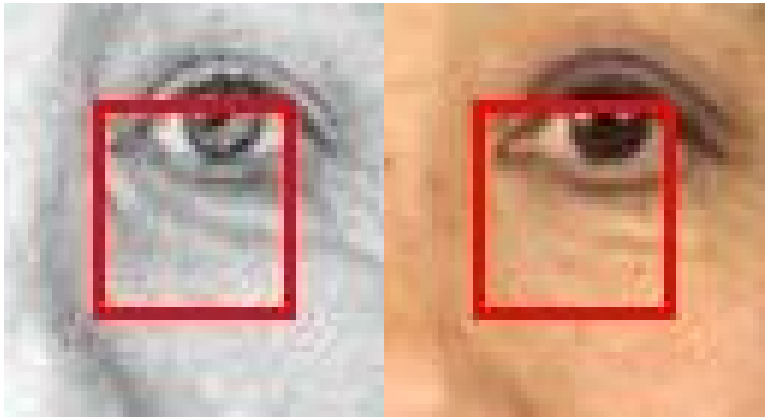
# Alternate Uses for Composites

Can be drawn based on low quality video frames (e.g. from a surveillance video)

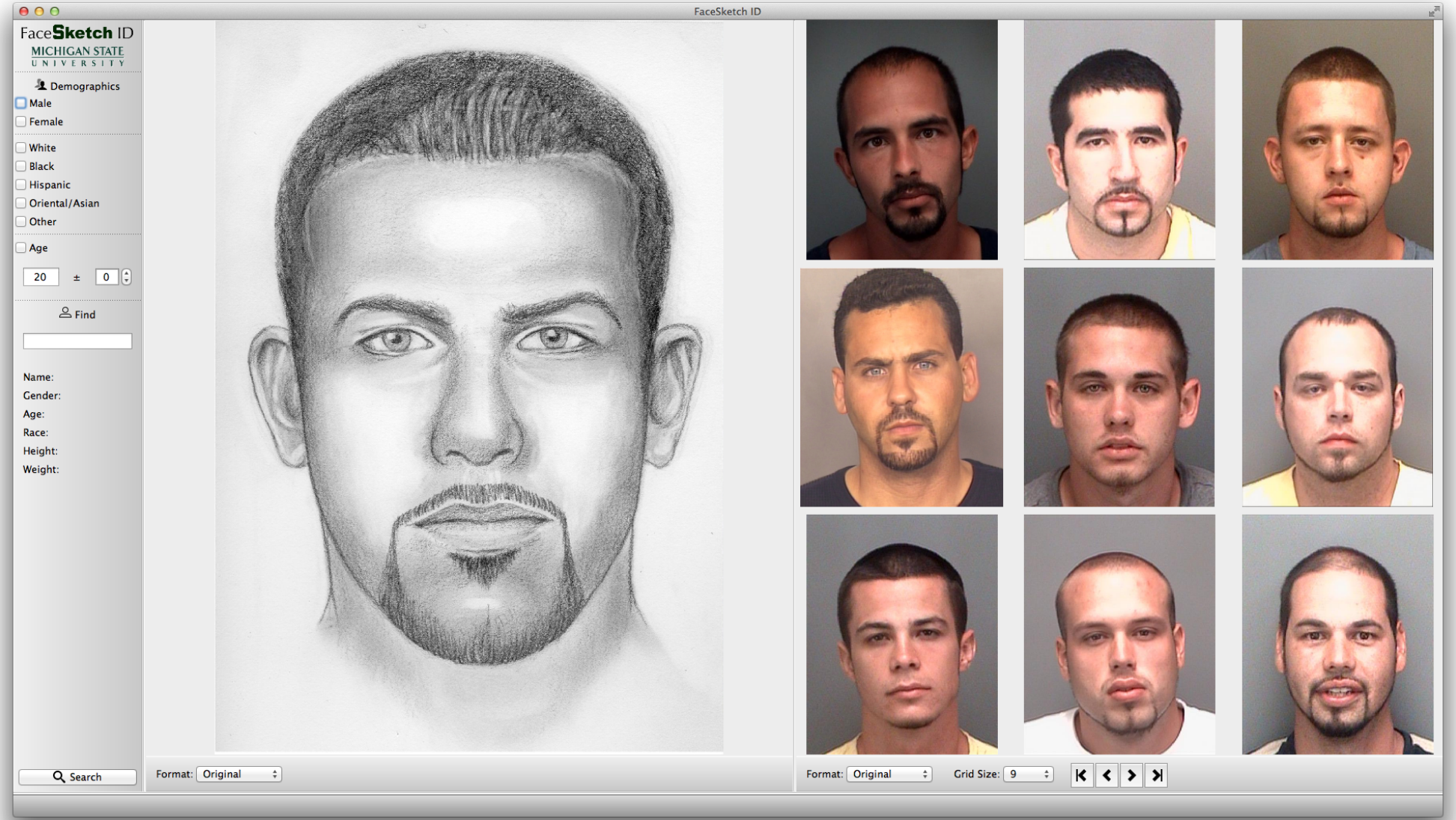
http://losangeles.cbslocal.com/2011/01/15/disabled-woman-says-she-was-victimized-on-tape/

# Challenges in Composite Recognition

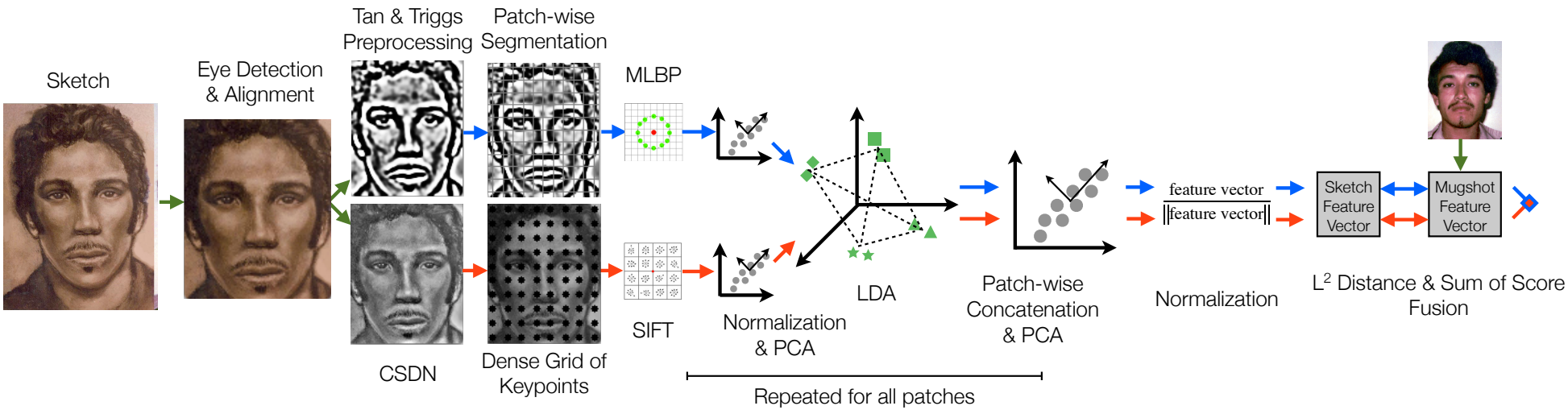
- Inaccurate composites
  - Sketches are drawn from human memory
  - May lead to inaccurate description of the suspect
- Variability in artist skill
- Different image modalities
  - Difficult to compare a composite to a mugshot in terms of pixel intensities
  - The composite has a different "appearance"



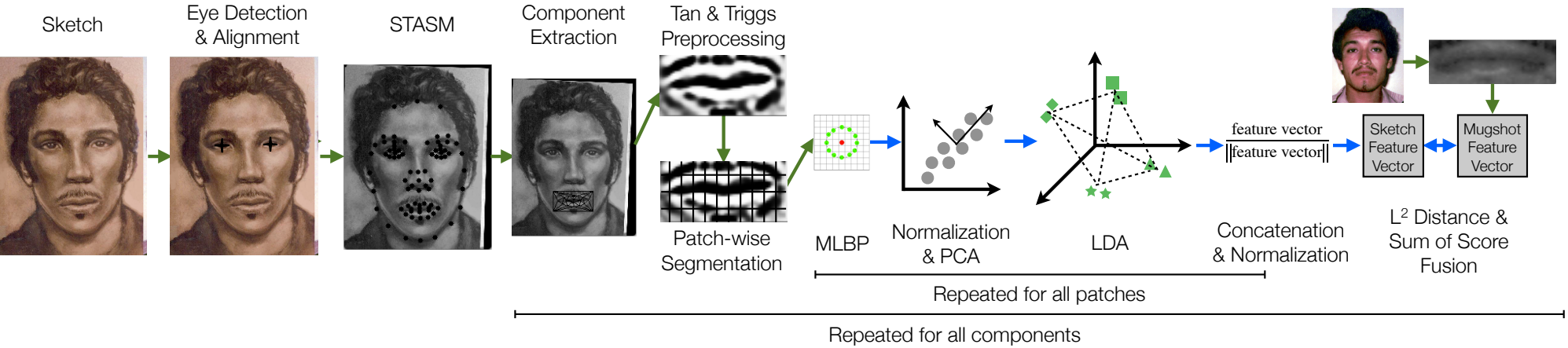
# The FaceSketchID System


FaceSketch ID
FaceSketch ID
MICHIGAN STATE UNIVERSITY
Demographics
Male
Female
White
Black
Hispanic
Oriental/Asian
Other
Age
20
±
0
Find
Name:
Gender:
Age:
Race:
Height:
Weight:
Search
Format: Original
Format: Original
Grid Size: 9

# Holistic Algorithm



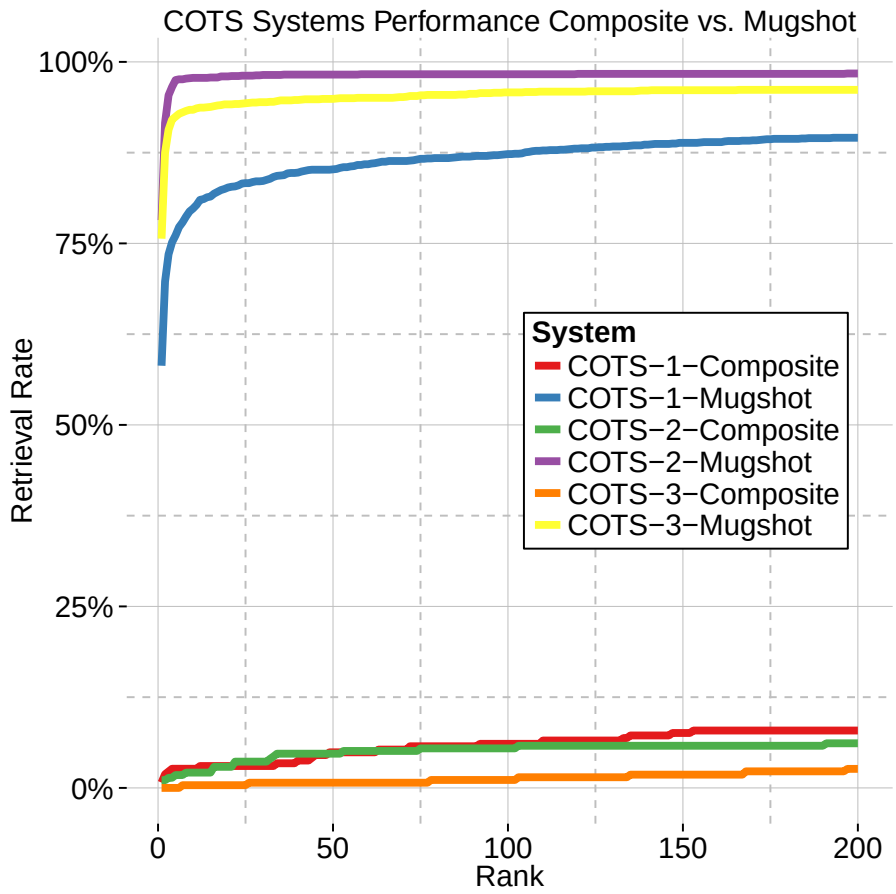
# Component-Based Algorithm



# Performance

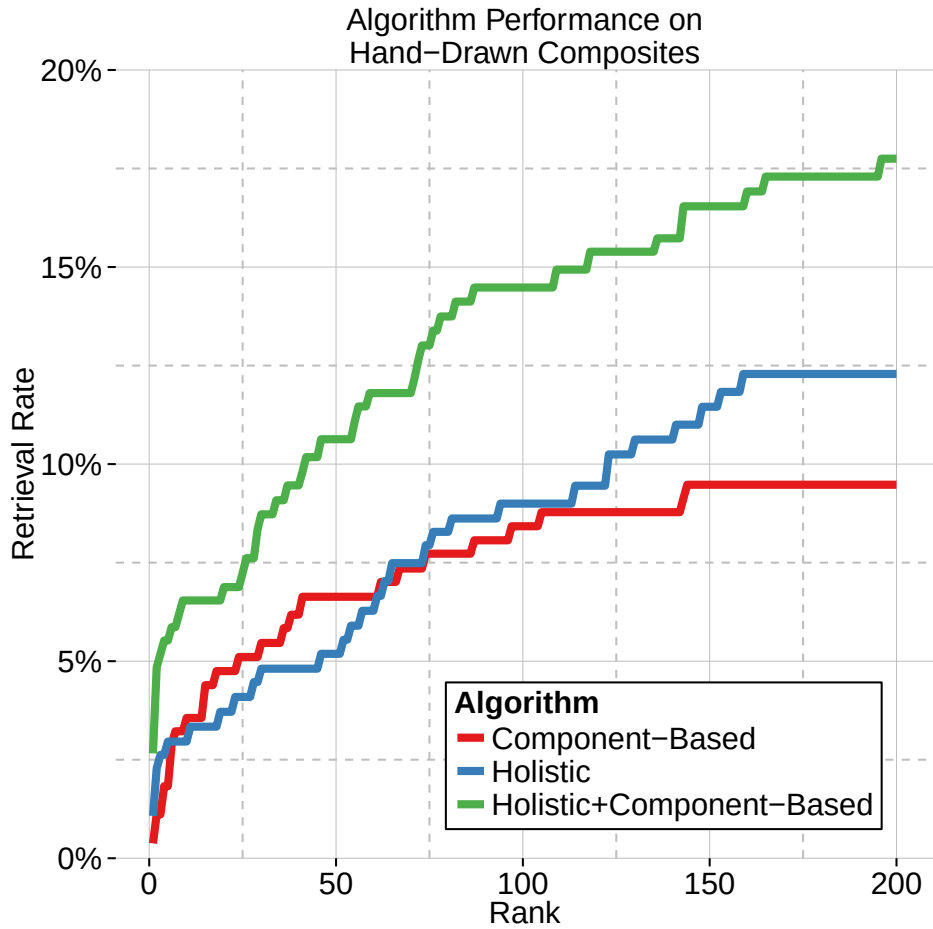
# COTS System Performance

- COTS face matchers perform poorly in the composite to mugshot recognition scenario
- Experiments reflect an enrolled gallery of mated mugshots + 100,000 mugshots from the PCSO database



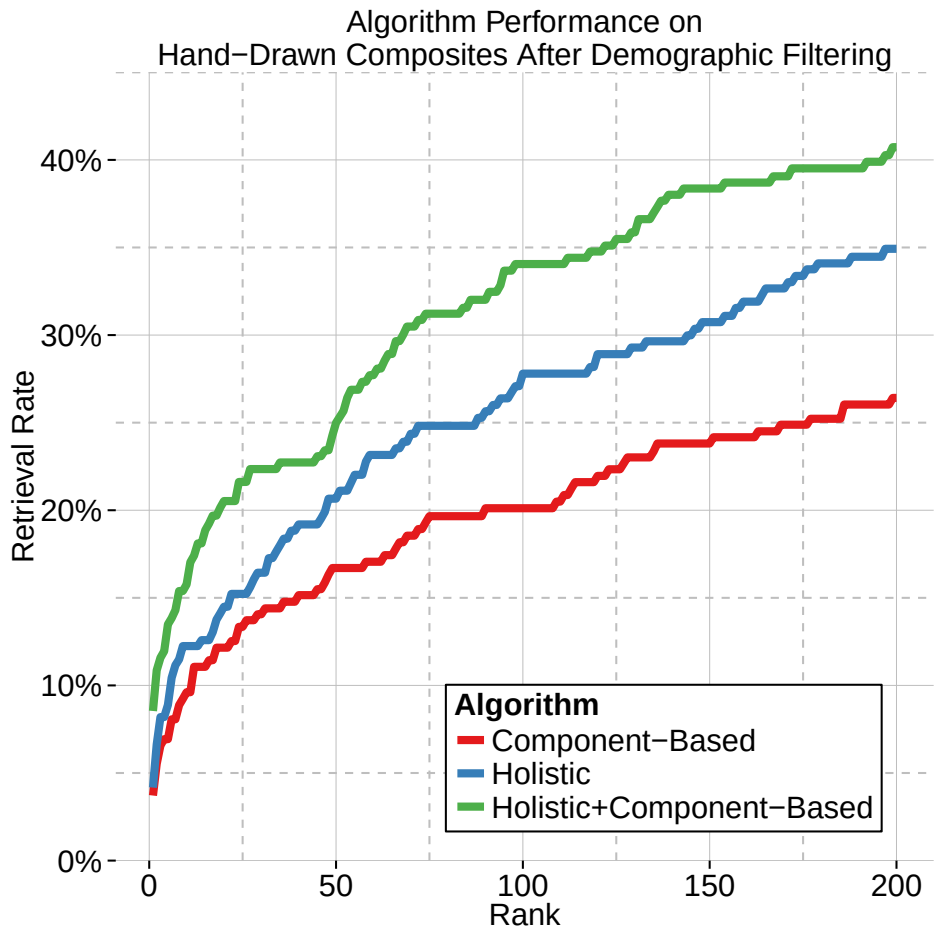
# Performance on Hand-Drawn Composites

- Query set: 265 hand-drawn composites
- Target set: 265 mugshot mates + 100,000 mugshots from the PCSO database
- 5 fold cross-validation (we cannot train the COTS systems, so they are simply testing splits)
- On average, there are about 53 pairs per fold



# Performance on Hand-Drawn Composites After Demographic Filtering

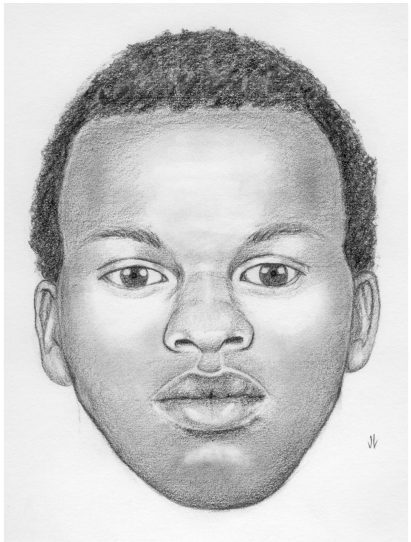
- Same experimental setup
- Subjects in the gallery that are of a different gender or race (white, black, asian, hispanic, other) than the query are removed
- Subjects that fall outside the query's age range are removed



# Retrieval Rank Example: PRIP Dataset

Ranks correspond to a gallery of 100,000 mugshots with the genuine mates after demographic filtering

| System | Rank |
|---|---|
| FaceSketchID | 1 |
| COTS-1 | 330 |
| COTS-2 | 221 |
| COTS-3 | 5482 |



20-30 Black Male

# Retrieval Rank Example: NY Times

Ranks correspond to a gallery of 100,000 mugshots with the genuine mates after demographic filtering

| System | Rank |
|---|---|
| FaceSketchID | 75 |
| COTS-1 | 238 |
| COTS-2 | FTM |
| COTS-3 | 365 |

25-35 Hispanic Female

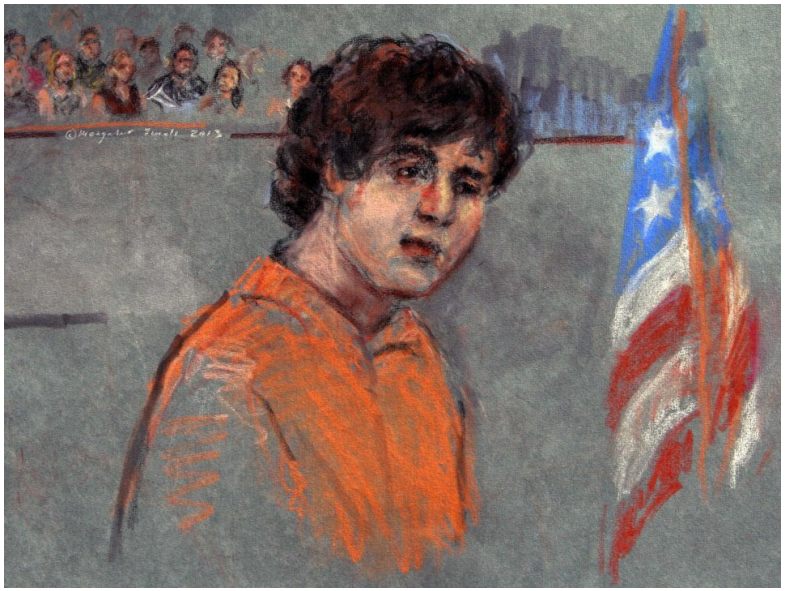
# Retrieval Rank Example: Sequestered Set

Ranks correspond to a gallery of 100,000 mugshots with the genuine mates after demographic filtering

| System | Rank |
|---|---|
| FaceSketchID | 11 |
| COTS-1 | 2052 |
| COTS-2 | FTM |
| COTS-3 | 3658 |

20-30 White Male

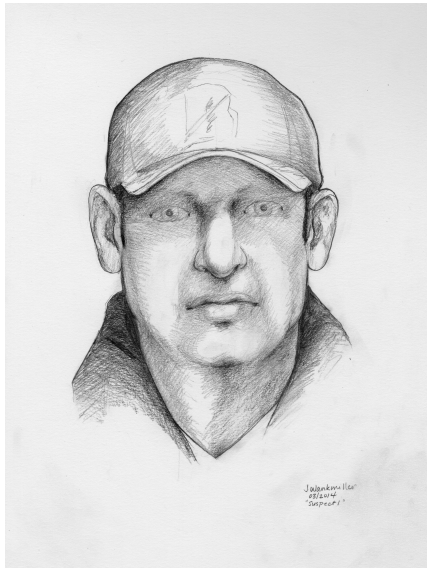
# Retrieval Rank Example: Dzhokhar Tsarnaev



15-25 White Male

The FaceSketchID System is able to match a court room sketch to this image of Dzhokhar Tsarnaev at Rank-88 and Rank-2 before and after demographic filtering, respectively.

# Retrieval Rank Example: Tamerlan Tsarnaev



20-30 White Male

The FaceSketchID System is able to match a surveillance composite to this image of Tamerlan Tsarnaev at Rank-2113 and Rank-20 before and after demographic filtering, respectively.

# Retrieval Rank Example: Active Case

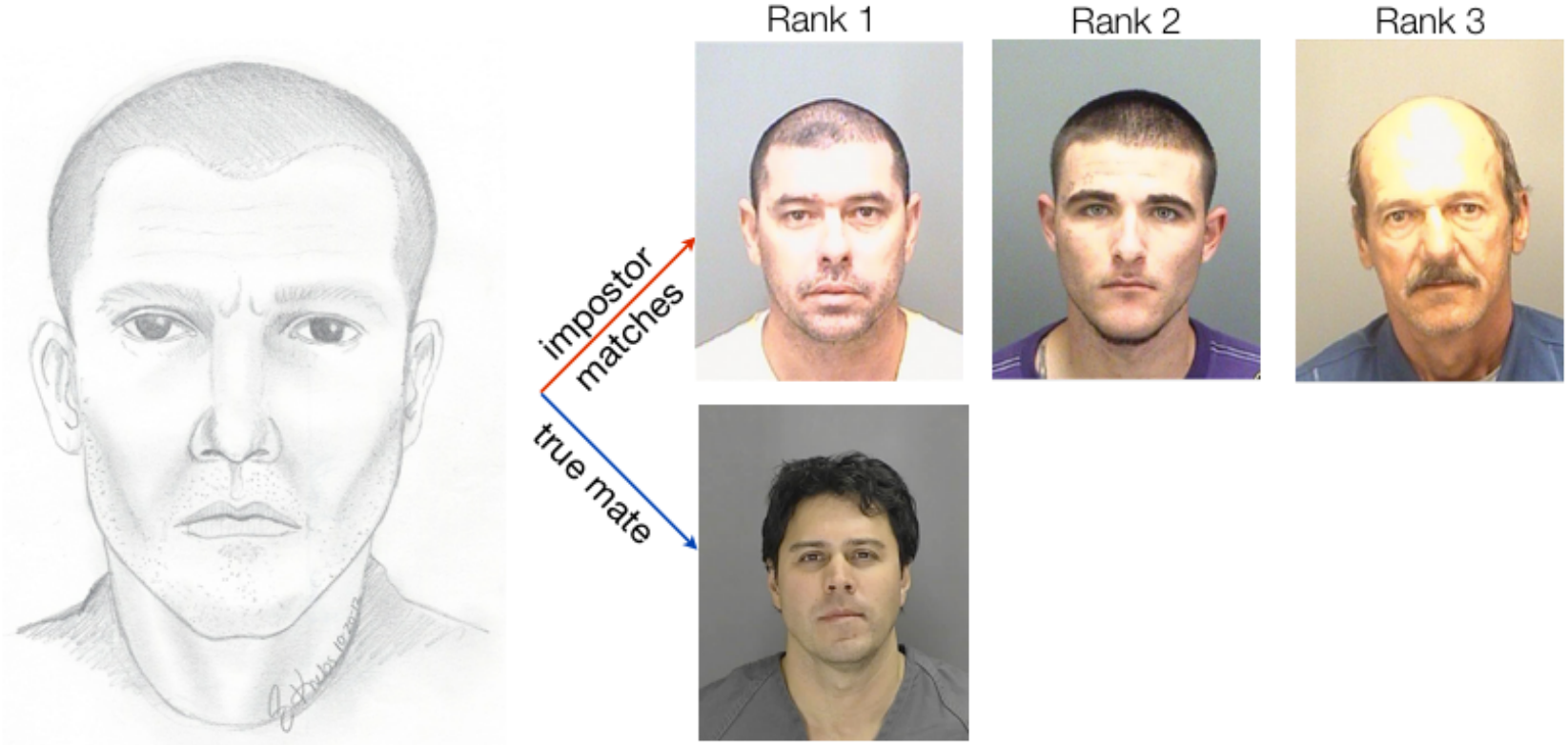
Ranks correspond to a gallery of 100,000 mugshots with the genuine mates after demographic filtering

| System | Rank |
|---|---|
| FaceSketchID | 1297 |
| COTS-1 | 5192 |
| COTS-2 | FTM |
| COTS-3 | 4115 |

35-45 Black Male

# Unsuccessful Matches

For unsuccessful matches (retrieved at a Rank greater than 1000), the mugshots retrieved at a low rank often look more like the sketch than the true mate



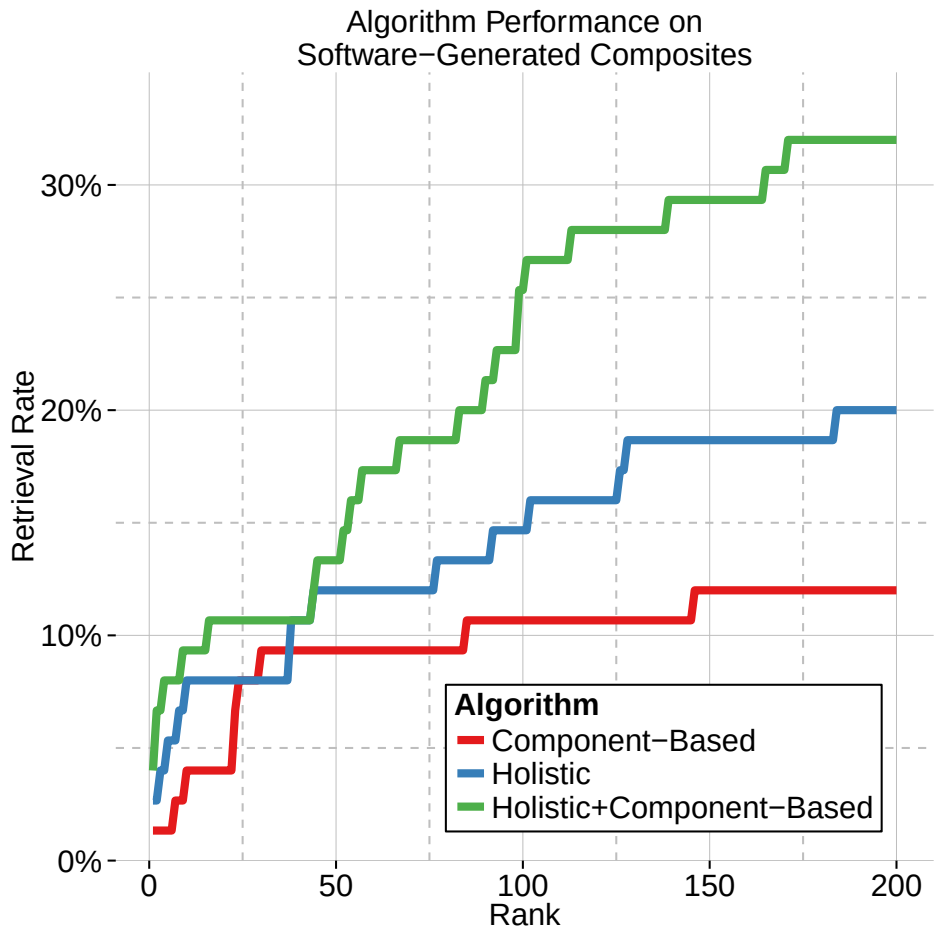

http://www.mlive.com/news/detroit/index.ssf/2012/10/sketch_released_of_suspect_in.html

# Unsuccessful Matches

There are also cases where both the genuine match and a significant number of impostor matches look like the composite

# Performance on Software-Generated Composites

- Query set: 75 software-generated composites
- Target set: 75 mugshot mates + 100,000 mugshots from the PCSO database
- FaceSketchID System is trained on 1800 viewed hand-drawn composites (from the CUHK-VHDC database)



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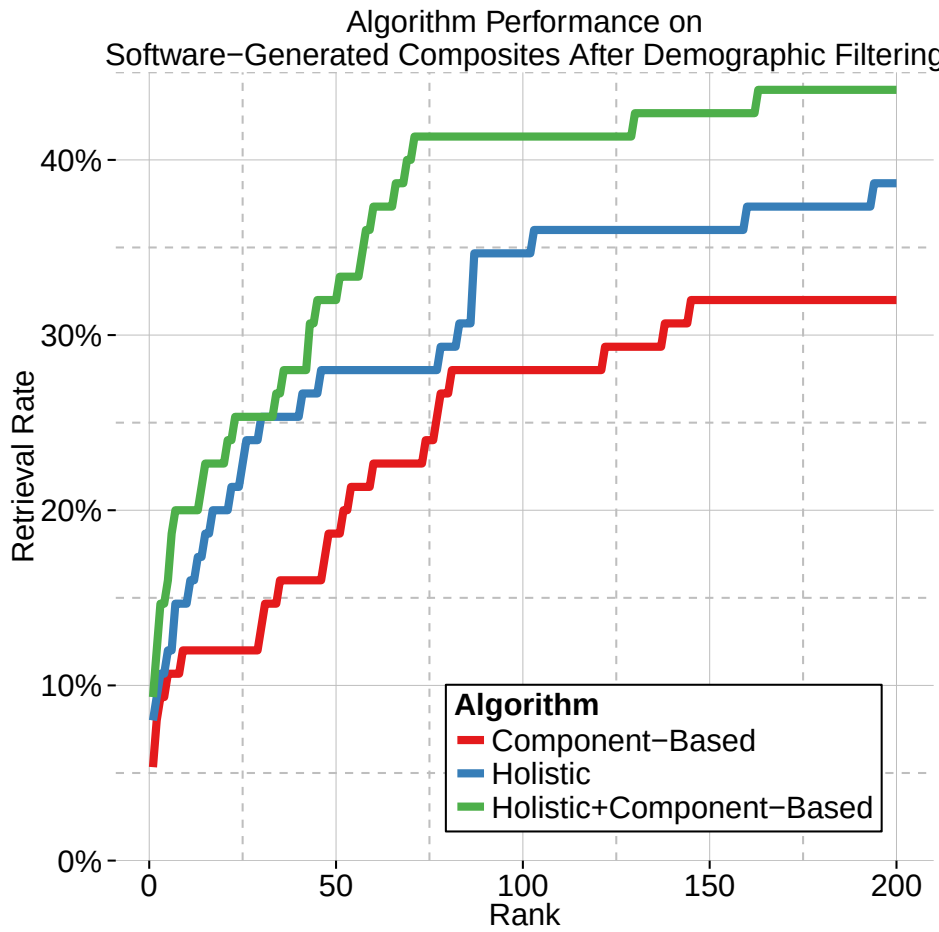
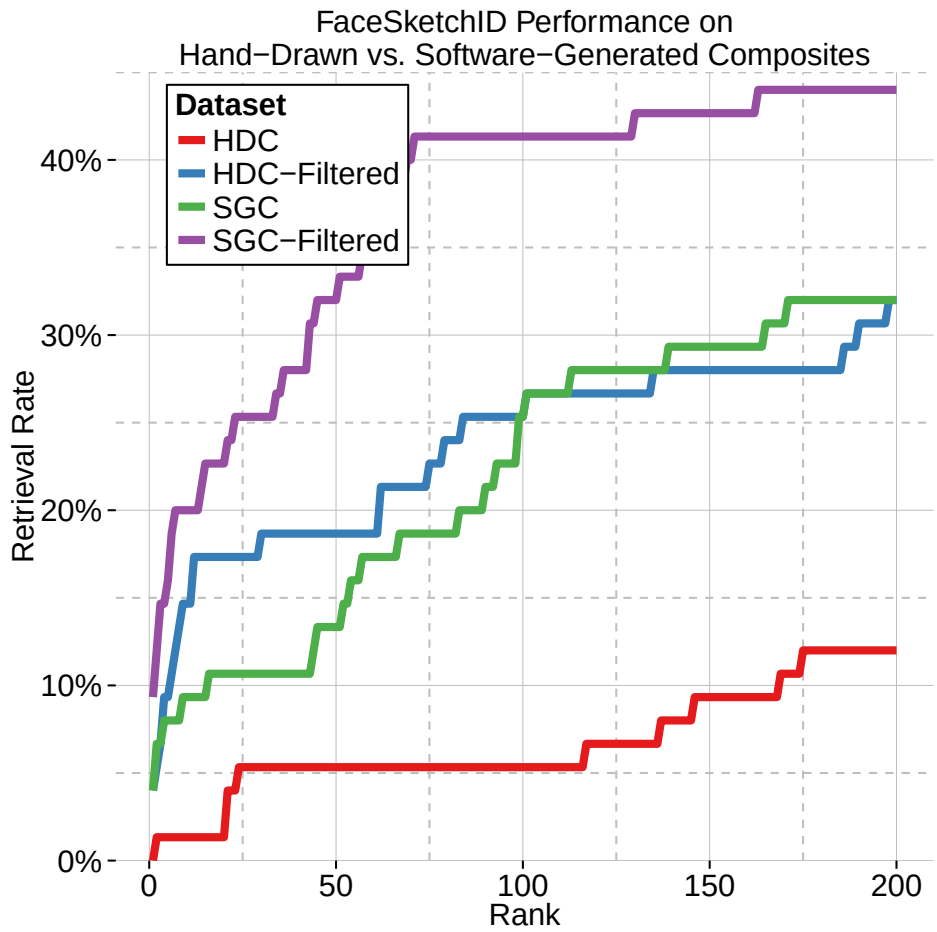


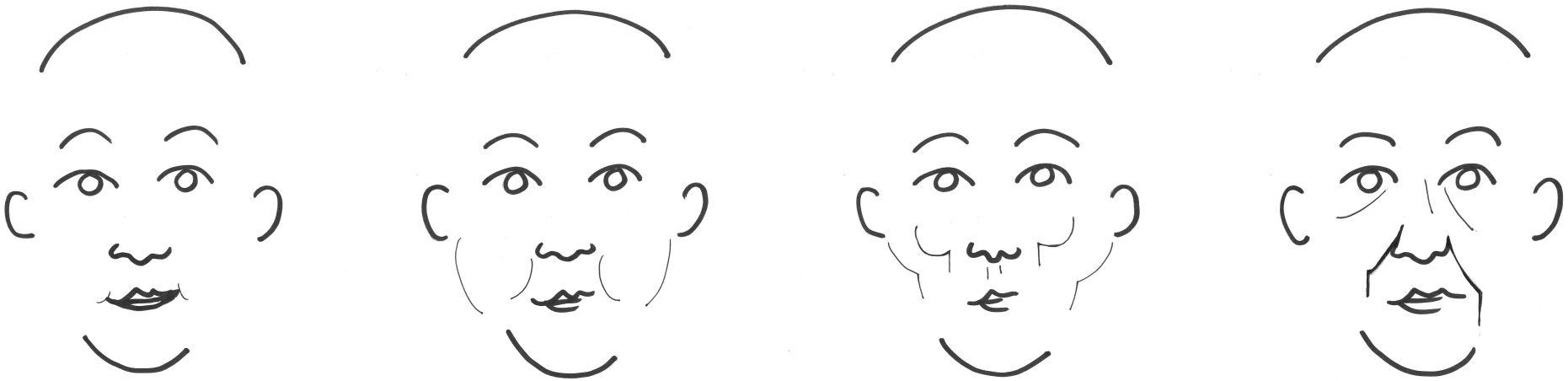
# Performance on Hand-Drawn Composites vs. Software-Generated Composites

- Which modality results in the best performance?
- Comparing a set of 75 hand-drawn composites and 75 software-generated composites that have the same mugshot mate
- Published in ICB 2013 proceedings



# Future Work

# Attribute-Based Face Recognition



Can we improve the performance of the FaceSketchID System by incorporating the verbal attributes provided by the witness?

# Publications

# Publications

- S. Klum, H. Han, B. Klare, A. Jain, The FaceSketchID System: Matching Facial Composites to Mugshots, IEEE Transactions on Transactions on Information Forensics and Security (TIFS), Under Review
- S. Klum, B. Klare, H. Han, A. Jain, Sketch Based Face Recognition, IEEE Biometrics Council Newsletter, pp. 4, 2013
- S. Klum, H. Han, A. Jain, B. Klare, Sketch Based Face Recognition: Forensic vs. Composite Sketches, International Conference on Biometrics, 2013
- J. Klontz, B. Klare, S. Klum, E. Taborsky, M. Burge, A. Jain, Open Source Biometric Recognition, Biometrics: Theory, Applications and Systems, 2013

Thank you!