Sketch to Photo Matching

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April 2, 2014
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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).
“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.

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.

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

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

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

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Software-Generated Composites

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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
**Holistic Algorithm**

1. **Sketch**
2. **Eye Detection & Alignment**
3. **Preprocessing**
4. **Patch-wise Segmentation**
5. **MLBP**
6. **SIFT**
7. **Normalization & PCA**
8. **LDA**
9. **Patch-wise Concatenation & PCA**
10. **Normalization**
11. **L^2 Distance & Sum of Score Fusion**
12. **Feature Vector**
13. **Feature Fusion**

**Preprocessing** by Tan & Triggs

**CSDN**

**Repeated for all patches**
Component-Based Algorithm

Sketch
Eye Detection & Alignment
STASM
Component Extraction
Tan & Triggs Preprocessing
Patch-wise Segmentation
Component
Extraction
LDA
Normalization & PCA
MLBP
Concatenation & Normalization
L2 Distance & Sum of Score Fusion
Feature Vector
Feature Vector
Sketch Feature Vector
Mugshot Feature Vector
Repeated for all patches
Repeated for all components

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Performance
COTS Systems Performance Composite vs. Mugshot

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

<table>
<thead>
<tr>
<th>System</th>
<th>Rank</th>
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<tbody>
<tr>
<td>FaceSketchID</td>
<td>1</td>
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<tr>
<td>COTS-1</td>
<td>330</td>
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<tr>
<td>COTS-2</td>
<td>221</td>
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<tr>
<td>COTS-3</td>
<td>5482</td>
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20-30 Black Male
Ranks correspond to a gallery of 100,000 mugshots with the genuine mates after demographic filtering.

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<td>COTS-2</td>
<td>FTM</td>
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<tr>
<td>COTS-3</td>
<td>365</td>
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25-35 Hispanic Female
Ranks correspond to a gallery of 100,000 mugshots with the genuine mates after demographic filtering.

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<td>FTM</td>
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<td>COTS-3</td>
<td>3658</td>
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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.
Ranks correspond to a gallery of 100,000 mugshots with the genuine mates after demographic filtering

<table>
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<td>FTM</td>
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<tr>
<td>COTS-3</td>
<td>4115</td>
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</table>

35-45 Black Male
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.
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)
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.
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
Can we improve the performance of the FaceSketchID System by incorporating the verbal attributes provided by the witness?
Publications
Publications


- S. Klum, B. Klare, H. Han, A. Jain, Sketch Based Face Recognition, IEEE Biometrics Council Newsletter, pp. 4, 2013


Thank you!