Suspect Identification Based on Descriptive Facial Attributes

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Forensic Identification of a Person of Interest

- Multiple methods for identifying persons of interest in criminal investigations
  - DNA
  - Fingerprint
  - Ballistics
  - Facial information

- While facial information is less accurate than many techniques, it is quite prevalent

- Methods to leverage facial information in criminal investigations are of high societal value

Methods for computer assisted forensic identification:
- DNA
- Latent Fingerprint
- Surveillance Imagery
- Witness Memory
Forensic face identification using imagery

- When surveillance imagery of person of interest exists, face recognition technology may be utilized for identification. However:
  - Image quality often poor, reducing total information available
  - Inaccurate solutions for unconstrained face recognition often make it difficult to leverage such imagery
- Surveillance imagery can be enhanced using forensic sketch artists:

Images from:
Forensic face identification without imagery

- Often no face imagery exists of a person of interest; instead, only face information available is a description from an eye witness
  - For over a century this information has been used to create hand drawn facial sketches of a suspect's description
  - Recent technology advancements have allowed automated searches using face sketches as probe images

Sketch (left) and mug shot (right) of Oklahoma City bomber Timothy McVeigh

Automated sketch recognition system (MSU's FaceSketchID)
Face Sketch Recognition

- Sketch recognition technology facilitates search and retrieval of mug shot and gov’t ID galleries using hand drawn sketches

Limitations of sketch recognition
- Sketch artists are expensive and limited in availability
- Significant amount of time needed to generate a sketch
  - Deploy the artist, interview the witness, draw the sketch, disseminate the sketch
Potential methods to bypass these limitations

- Computer generated facial composites
  - Have been studied in academic setting [1]; support legacy systems
  - Synthesis from attributes, followed by recognition from synthesis complicates the process by adding additional step

- Attribute-based recognition
  - Proposed in this study
  - Allows search directly from witness description
  - Would allow for witness to weight the confidence of descriptions
Attribute-based recognition

- Popular methods emerging in the literature for attribute-based face recognition
  - Seek to encode face image with human interpretable face descriptions
  - Originally proposed for unconstrained face recognition tasks which use protocol with high false positive rates [1]
  - Similarly applied to person re-identification [2]

- Benefits of attribute-based recognition include:
  - Human interpretable feature representation
  - Compact template size
  - Observable in unconstrained conditions
  - Supports many applications

Operational overview of forensic identification using face from description

Proposed Approach

Face Descriptions:
- Thin Face
- Beady eyes
- Thin lips
- Button nose
- Male, White, 20’s

Low Quality Imagery
Eye Witness

Legacy Method:
Media dissemination

Previous Research:
Automated mug shot search

Proposed Approach

Attribute Search System

CCTV Network

Mug shot Gallery

Re-identification from surveillance images
Mug shot identifications

= costly time bottleneck

Attributes manually provided by witness
- Galleries sourced from mug shot databases or surveillance imagery
  - Automated attribute extraction required for galleries

- Outputs of conceptual system are rank ordered *investigative leads*
Defining Attributes: An Artist’s Perspective

- Defined by caricaturist, artist, and EE Professor, Tayfun Akgul
Defining Attributes: An Artist’s Perspective

Artistic images from Tayfun Akgul
Defining Attributes: An Artist’s Perspective

Artistic images from Tayfun Akgul
Holistic Attributes

Gender:

Shape:

Length:

Hair Density:

Note: not all attributes shown.
Eyes Attributes

Buried: 
Almond: 
Line: 

Bent: 
Round: 
Small: 

Note: not all attributes shown.
Eyebrow Attributes

Thickness:

Unibrow:

Orientation:

Forehead size:

Note: not all attributes shown.
Mouth Attributes

Bite:

Mouth:

Asymmetry:

Cheeks:

Note: not all attributes shown.
Attribute Example: Timothy McVeigh (Oklahoma City Bomber)

Mouth width = Small
Broken nose = True
Attribute Example:
Ted Kaczynski (Unibomber)
Attribute Example:
Griselda Blanco (Drug lord)
Automated landmark detection used to align facial components
- Each attribute assigned to a given component (holistic, eyes, nose, etc.)
- Components encoded in LBP histogram representation
- SVM Regressors trained per attribute
- Attributes with three or more values use one vs. all SVR’s
- Outputs are numeric likelihoods for each attribute
Experiment Analysis

- Goal of experiment is to compare accuracy of attribute-based face recognition to baseline approach of sketch-based recognition

- Sketch recognition considered an upper bound:
  - Expert artists used to elicit elaborate facial descriptions from witness

- Can attribute-based approach achieve similar results amateur annotators?

  - 1,196 photographs and hand drawn viewed* sketches
  - Attributes collected via amateur crowd sourced laborers
    - Each photo annotated three times per attribute
    - Average annotation score used
  - Two fold cross validation used for training/testing

* A viewed sketch is drawn while looking at a photograph of the subject

Viewed sketches are highly accurate depictions of photographs

Baseline sketch recognition algorithm:
- MSU’s FaceSketchID [1]
- Mature recognition system that was developed and tuned over a five year time span
- FaceSketchID being integrated in operational environments → optimistic baseline

Sketch Recognition using Attributes

- Amateurs annotators labeled images to yield query attributes
- Attributes from gallery (photographs) automatically extracted
- Attribute extraction algorithm learned on training partition
- Initial algorithm that lacks maturity of well tuned and studied approaches
Experimental Results

- Rank retrieval (CMC) accuracy of Attributes, FaceSketchID and fusion of the two
- Attribute algorithm within same magnitude as the sketch recognition algorithm
  - Affirms research hypothesis
- Fusion of attributes with sketch algorithm actually improve recognition accuracy
Accuracy of different facial components

- Best accuracy from brow, face, mouth and nose
- Relatively low performance from eyes speaks to difficulty in describing such attributes
Humans vs. Attributes

- Annotated 175 mated photograph pairs in FERET with attributes
- Two fold cross validation performed to train automated extraction and evaluate accuracy
- Measured retrieval accuracy across four combinations of gallery/probe for human/machine
- Machine vs. Machine offered highest accuracy
- Speaks to additional applications of attribute-based approach
Conclusions

- Proposed a method for suspect identification using facial attribute descriptions
- Experiments were conducted to compare the proposed attribute-based recognition paradigm to hand drawn sketch recognition
  - In the same order of magnitude as sketch recognition accuracy
  - Fusion with sketch offers highest accuracy
- Future work will examine witness/memory derived attributes, and the use of confidence based matching

Questions?