Face Photo-Sketch Synthesis and Recognition

Signal and Image Processing Laboratory
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Project Overview

- Automatically generate sketches from face photos and vice versa.
- A new approach towards face recognition via this system – Transform to same plane, meaning, photos into sketches / sketches into photos and compare the two.
- Locate a face photo from a data bank based on a query sketch – Useful for security purposes.
Image Generation

- Divide the photo into small overlapping patches.
- Compare input patches to corresponding patches in a database which contains face photos and sketches of people.
- Select K number of best matching photo and sketch patches to compose a new image.
- Face recognition by using any recognition technique desired while the compared photos are in the same plane.
The Theory Behind The System

- Use Markov random field to model images. Each patch in the photo is a node in a graph thus creating a graphical model represented by an undirected graph.
- Non adjacent nodes are conditionally independent given all the others.
- Each node conditionally independent in all others given it’s neighbors.
- Two subsets of nodes are conditionally independent given a separating subset.
- Exploit the above MRF properties to create a new image using Belief propagation.
- $x =$ sketch/photo to synthesize.
- $y =$ input photo/sketch.
BP – Belief Propagation

\[
p(x_1, \ldots, x_N, y_1, \ldots, y_N) = \prod_{i} \Psi(x_{i-1}, x_i) \prod_{j} \Phi(x_j, y_j),
\]

\[
\Psi(\tilde{x}_{j,i}, \tilde{x}_{j,\hat{i}}) = \exp\left\{ -\|d_{j,i} - d_{j,\hat{i}}\|/2\sigma_c^2 \right\}
\]

\[
\Phi(\tilde{y}_j, y_j) = \exp\left\{ -\|\tilde{y}_j - y_j\|^2/2\sigma_c^2 \right\}
\]

- Belief propagation – a statistical inference method used to determine which patch from the K possible patches should be selected for the generated photo.
- We estimate a scene \( x \) from an image \( y \).
- \( x \) and \( y \) are divided into patches.
- Each patch is a node in the Markov graph.
- BP is used to determine which piece from a photo pieces bank belongs where in the computer generated photo.
The System

Preprocessing → Patch Matching

Selecting Patches for sketch (MRF) → Sketch synthesis
Results: Photo → Sketch synthesis

Original photo

Artist sketch

One layer averaging

One layer min.

Two layers averaging

Two layers min.
Results: Photo → Sketch synthesis

- Original photo
- Artist sketch
- One layer averaging
- One layer min.
- Two layers averaging
- Two layers min.
Results: Sketch → Photo synthesis

- Artist sketch
- Original photo
- One layer averaging
- One layer min.
- Two layers averaging
- Two layers min.
Results: Sketch → Photo synthesis

- Artist sketch
- Original photo
- One layer averaging
- One layer min.
- Two layers averaging
- Two layers min.
## Results – Face Recognition

- Artist sketches vs. synthesized sketches on two different sets of databases:

<table>
<thead>
<tr>
<th>Synthesis Method</th>
<th>Total %</th>
<th>Total recognitions</th>
<th>Correct recognitions (2st place)</th>
<th>Correct recognitions (1st place)</th>
<th>Average Correlation</th>
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Conclusion

- Results:
  - Offers a new, innovative approach for face-sketch recognition.
  - Good face recognition results.
  - Produces good synthesized image outputs.
  - The output quality is dependent of DB used in the system and chosen parameters. (patch size, number of patch candidates etc.).
  - Relatively high time and computation resources consumption.