FaceMatch: a visual search system for family reunification during disasters

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Introduction
The objective of our system (FaceMatch) is to provide a fast and robust visual search capability for those who are looking for missing people in the aftermath of calamities, natural or otherwise. We propose a Single-Image-per-Person (SIP) approach to face image matching using an ensemble of weighted face image descriptors, taking advantage of their matching strengths. FaceMatch utilizes many visual features including color, texture and shape to provide robust face detection, matching and image near-duplicate detection capabilities. To test our system, we considered several well-known benchmark face image collections. Our results are comparable to, and in some cases, better than those of leading open source and commercial systems, especially for low quality images, which is usually the case in disaster scenarios.

Face Detection
A reliable face detector is necessary for any face matching application, as it determines the locations and sizes of human faces in digital images. Our FaceFinder achieves this goal via:
- haar-like gray-scale features
- major 30-degree rotations
- color skin mapping in RGB, HSV, Lab spaces
- color based landmarks (eye, nose, mouth) detection
- artificial neural net (ANN) landmark verifier
- correcting mirror rotations using eye line

Description
An image data-set may contain many near-duplicate images due to multiple postings of the same photograph rescaled or recompressed. Such near-duplicates need to be identified and grouped. Each group would be represented by the highest quality image. We solve this by:
- color wavelet descriptor: scale- and compress-robust
- real-valued distance in \( [0, 1] \), with 0 – perfect match
- tight threshold for near-duplicate detection
- champion selection: highest resolution, lower compression
- using 128 × 128 YIQ color images: gray-scale compatible

Near-Duplicate Detection

Challenges
- low quality, suboptimal lighting
- pictures may contain 1 or more faces
- face-like objects (animal/carnival faces)
- presence of duplicates and near-duplicates
- face images may be hard to match due to:
  - partially occluded or damaged faces
  - presence of facial hair, glasses, jewelry
  - person natural aging
- source photograph degradation

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Experiments
Detect near-duplicate images in our data

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Near-duplicates</th>
<th>Near-duplicates 5:1</th>
<th>Near-duplicates 1:5</th>
</tr>
</thead>
<tbody>
<tr>
<td>CalTech</td>
<td>548,634 images</td>
<td>1.0 ± 0.0</td>
<td>1.0 ± 0.0</td>
</tr>
<tr>
<td>ColorFeret</td>
<td>2,662 images</td>
<td>0.99 ± 0.00</td>
<td>0.99 ± 0.00</td>
</tr>
<tr>
<td>PeopleLearner</td>
<td>128,632 images</td>
<td>0.98 ± 0.01</td>
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</tr>
</tbody>
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ViolaJones + SkinMap + Landmarks

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<tr>
<th>ViolaJones + SkinMap + Landmarks</th>
<th>Skin color from annotation</th>
<th>Estimate color models: ANN or histogram</th>
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Combiner module

- map input features to ANN
- apply kernel to ANN
- generate weight vector
- re-weight features
- take weighted sum
- output match score

Landmark detection

- eye/mouth maps derived from luma/chroma bands
- major peaks are landmark candidates
- false positives eliminated by ANN landmark verifier

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Applications
- FaceFinder (FF) outperforms some commercial detectors: 512 images of celebrities
- Base Viola-Jones face detector misses about 50% of PL faces.
- The face detection module improves a gray-scale face detector with the skin/landmark detection

Conclusion
We provided query-by-image capability to the PEOPLE LOCATOR (PL)® system, evaluated several state-of-the-art systems on existing data-sets and developed tools for image annotation and near-duplicate detection. The detection module improves a gray-scale face detector with the skin/landmark detection.