FaceMatch for Lost Person Finder approach, architecture, implementation
NLM Long Range Plan 2006-2016

- Bethesda Hospitals Emergency Preparedness Partnership
  - Preparation Through Planning and Research
  - Started in 2004, NLM joined in 2008
- Partnership between
  - National Institutes of Health Clinical Center
  - National Naval Medical Center (NNMC)
  - Suburban Hospital-Johns Hopkins Medicine
  - National Library of Medicine (NLM)
- Over 11 R&D projects started including LPF
  - Patient Information Management
  - Communications
  - Information Access (LPF)
  - Responder Training
- NLM/CEB/LPF: Glenn Pearson, Mike Gill, George Thoma

http://www.youtube.com/watch?v=MJwl7OEfiF0  https://bhepp.org/
Lost Person Finder (LPF)

R&D of family reunification technologies
- People Locator (PL)
- ReUnite (iPhone app)

https://pl.nlm.nih.gov/
LPF: text + image search

web-based system to help re-unite after a disaster
- search LPF database using text (+ image)
- results to desktop or hand-held devices (phones, tablets)
- picture browsing capability

person identification is important
- text modality, e.g. name
- face detection
- face recognition

Some Name

Haiti Earthquake Person Locator

Found in Haiti iPhone App


Interactive Notification

disaster@mail.nih.gov

LPF database & services

Blackberry & other smart-phones (Web/email form)

Person Finder: Haiti Earthquake


https://pl.nlm.nih.gov/
Face Matching

Objective: given person's picture (as a digital photo), find the matched person in NLM/CEB database of pictures.

Challenges

● size of the database HEPL is ~15K images, ~100K records
● pictures may contain 0, 1, 2, … N faces and face-like objects (cats and dogs faces)
● images may be of sub-optimal quality due to
  ○ low resolution, e.g. as taken by older mobile phones
  ○ noise, e.g. from digitizing, compression, watermarking
  ○ under-/over-exposed/colorized
  ○ partially occluded or damaged faces
  ○ presence of duplicates and near_duplicates
● inconsistent in appearance due to facial hair, glasses, jewelry, aging

HEPL images
FaceMatch approach

**Repository**: annotation, browsing, update, clean-up, backup
- detect and group near-duplicates
- cluster images by similarity
- detect faces and triage non-face images
- detect facial features and index by facial features

**Query**: text+image
- text based: name, location, age
- image based: given an input image
  - computer-assisted face/feature selection
  - manual face & facial feature selection
  - parameters: scale, lighting, occlusion
- fusion: e.g. via visual words and SOLR

http://lucene.apache.org/solr/
https://pl.nlm.nih.gov/
Image repository preparation

Haiti Earthquake (HEPL) data-set
● 15K images, mostly color
● rare gray-scale or bi-tonal scans
● low quality images: low resolution, noisy
● ~30% near-duplicates: re-scaled or re-compressed
● some non-face images

Developed image processing tools
● identifying and grouping
  ○ near-duplicates
  ○ no-face images
● prime face/profile detection
● annotation
  ○ name, ID
  ○ age, gender, ethnicity

http://hepl.nlm.nih.gov/
https://pl.nlm.nih.gov/hepl/
Near-duplicates detection and grouping

- many near-duplicates
  - due to multiple postings
  - mostly scaled or re-compressed versions
- task: detect & group, exposing highest quality images
- method: Haar wavelet based IR technique [Jacobs-1995]
  - fast color image matching procedure
  - robust to image noise, scale, compression
  - descriptor: 40 most significant wavelet coefs
- results on HEPL: ~30% near-dups in 15K images
  - near-dup tournament of 15K images in ~5 minutes
  - missing some rotations, crops and blanks
- future work
  - robustness to image transforms and blanks
  - more efficient look-up
Face detection and localization

- critical for face recognition
  - spurious image removal
  - localizing faces for labeling and matching
- detect human faces in near-frontal and near-profile views
- **method**: Haar-like features + boost [Viola-Jones-2001]
- **results** on HEPL: ~25% miss rate (resolution, occlusion)
- OpenCV: GUI for annotation
  - diameter >16 pixels
  - $\pi k/2$ rotation robust
  - principal face/profile
  - image & person ID
  - age, gender, ethnicity
- **future work**
  - occlusion robustness
  - account for skin color
  - detect & use facial features


https://pl.nlm.nih.gov/
Face matching and recognition

- **visual** search for *similar* faces in the repository
  - efficient descriptor indexing + similarity measure
  - few faces of the same subject present
  - robust to illumination, scale and pose

- **methods**
  - Haar wavelet based, like in near-dup detection
  - SIFT and related, e.g. SURF [Bay et al. 2006]

- **results**
  - HEPL: undefined due to image-to-subj as 1-to-1
  - LFW: 76% accuracy

- **future work**
  - hierarchical, going from coarse to fine features
  - dynamically focusing on important features

---

System design

FACEMatcher

Google PF

TriagePic

PL website

RelUnite

External Sources: NLM

PL (Website) http://pl.nlm.nih.gov

“Report a Person” (Sources)

“Current Output”

Text Searcher

PL DB
Image IDs

Image + Text

FaceMatch Web Service

“FaceMatch” Service Host

“Face” Match

“Whole Image” Match

Compute Whole Image Descriptor

Compute Face Descriptor

Compute Face Descriptor

Face Loc

Face Descriptor

Q_i

Q_wi

QQi

Qi

Q_i

Qi

Swi

Sfi

Query Image

Query Image whole descriptor

Query Image face descriptor

Whole Image similarity

Image face similarity

Image + Text

Web services talk to PL getting SOLR test matches

Poll AND Notify new images

Face Match Lists

<ImageID,Swi>

<ImageID,Sfi>

Face similarity list

Note: ImageID not unique i.e. multiple face candidates/image

FUSION

TEST/UL/SCRIPTS Result Collector Evaluator

Date: NOV 16, 2011
By: Girish Lingappa, Frank Flannery
Reviewed by: Dr. George Thoma, Sameer Antani, Eugene Borovikov, Michael Gill

PL Source path
Facematch data index path
Query path
FaceMatch sub-system

- add a visual modality to the search
- whole image features for near-duplicate detection
- face features for face matching
- indexed to efficiently answer queries
- results ordered by the descending similarity
- output optionally fused with the text query results
Implementation

Core library
- core coding in portable C++
- open data formats, e.g. XML or plain text
- open-source libraries, e.g. OpenCV, OpenMP
- platform-independent, e.g. Linux, Windows, Mac
- maintainable front-middle-back-end pieces
- documentation: user's, developer's, TRs

Web service
- main-stream platform: Windows.NET
- exposing task-level functionality: ingest, query, erase
- COM/ATL wrapper to the core library
- garbage-collected environment, C# coding
- thread- and process-level parallelism
- integration into LPF
Plans

**Short-term:** desktop based
- flat file based repository
- set of executable utilities
- limited GUI

**Mid-term:** migration
- integration into LPF as web service
- more accurate face matching
- text+image queries

**Long-term:** cloud based
- live web-based repository
- service based back-end
- web-based front-end
- mobile device support
Face/feature detection improvements

- using color in various color spaces
- skin color modeling
- hierarchical feature spaces
- top-down vs. bottom-up approaches
- beyond Haar-like features, e.g. pixel-, stat-, shape-based
- 3D head pose estimation
- other learning techniques, e.g. SVM, ANN
- incremental learning

https://pl.nlm.nih.gov/
Face ID/recognition improvements

- accounting for gender, age, ethnicity
- combining multiple descriptors
- compressed sensing
- boosting very large feature sets
- using biology/psychology inspired features
- more precise feature localization, e.g. LBP, density-based
- 3D head and face modeling
- robustness to occlusions
Face ID via large feature sets

UMCP

- rich set of feature descriptors (~70K)
- partial LS for multi-channel feature weighting
- tree-based discriminative structure
- robust to varying conditions
- claim to outperform state-of-the-art on FERET and FRGC

Extensions

- alternative indexing, e.g. fuzzy hashing
- experiments with color spaces
- trying with additional descriptors, e.g. Haar and SURF
- testing on HEPL and other NLM sets

W. Schwartz et al, _Face identification using large feature sets_, IEEE 2011

https://pl.nlm.nih.gov/
Robust faces/objects classification

Caltech
● using natural image stats
● biologically inspired filters
● un-supervised learning
● natural image patches
● visual attention + sparse coding = significant features
● claimed ~93% accuracy using 1 training instance

Extensions
● different color spaces, gray-scale, even bi-tonal
● smart histogram EQ and adaptive thresholding
● trying Haar wavelet and SURF descriptors
● testing on HEPL and other NLM sets

C. Kanan & G. Cottrell, Robust classification of objects, faces, flowers..., CVPR
https://pl.nlm.nih.gov/
Text+image fuzzy search

- visual and text fuzzy search complement each other
- **image**: uncontrolled environment, varying quality
  - primary face
  - estimates of age, gender, ethnicity, location
  - characteristic marks, e.g. birth spots, missing teeth
- **text**: multi-lingual, free-form
  - likely name
  - indication of age, gender, ethnicity, location
  - description of characteristic marks
- **Lehigh**
  - image features => semantic descriptions
  - ontological reasoning
- approximate matches, ranked results
- smart result lists merge
- optional relevance feed-back

Ed Kim et al, Finding VIPs - A visual image persons search, ICME 2011
http://edwardkim.net/
Summary

• need: enhance query capability in Lost Person Finder
• goal: text+image search
• large repository, e.g. HEPL ~100K records, ~15K images
  ○ annotation with rich meta-info, e.g. face, age, gender
  ○ robust near-duplicate image detection and removal
  ○ face detection and identification
• current
  ○ text: name, age, gender, location, etc. - needs extension
  ○ image: face/profile detection, matching - needs work
• future
  ○ text+image fusion, e.g. via semantic descriptors
  ○ video+audio search
  ○ cloud computing + mobile device support
• collaboration with academia & industry
Questions

- Why not use available web resources, e.g. face.com?
- How can we better focus on important facial features?
- Would this focus improve recognition/ID performance?
- Many vs. few features? high vs. low resolution?
- Color spaces: bi-tonal, gray-scale, color? which color?
- Is occlusion+pose+light+expression handling hopeless?
- What about age, gender, ethnicity clustering?
- Is doing FaceMatch on a mobile platform practical?
- Is doing all that in video easier or harder?
- Will text help or hurt? natural vs. synthetic languages?
- Any URLs, references?
- Anything I forgot?