FaceMatch
for Lost Person Finder

approach, architecture,
implementation

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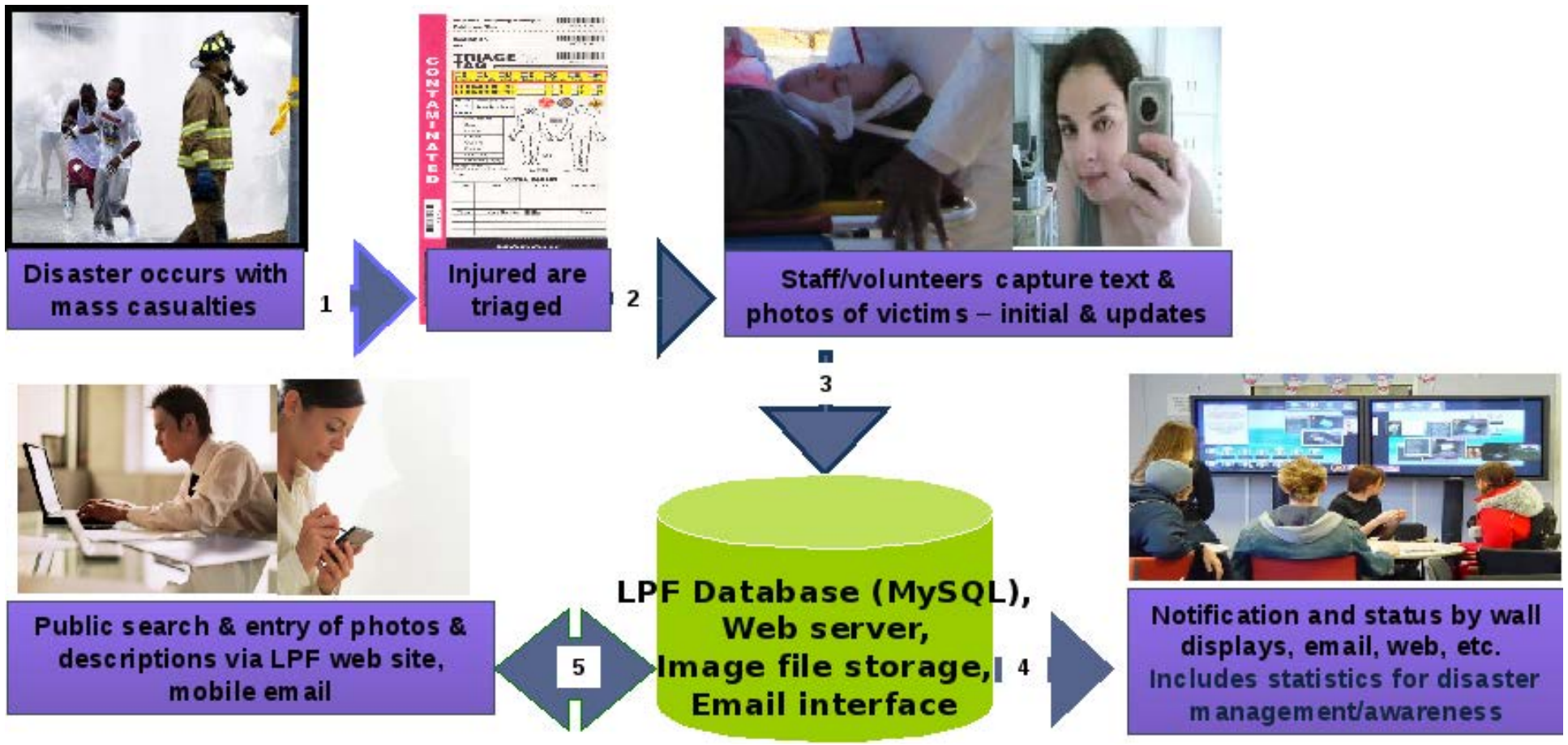
NLM Long Range Plan 2006-2016

- 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

Lost Person Finder (LPF)

R&D of family reunification technologies

- People Locator (PL)
- ReUnite (iPhone app)



http://archive.nlm.nih.gov/proj/lpf.php

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

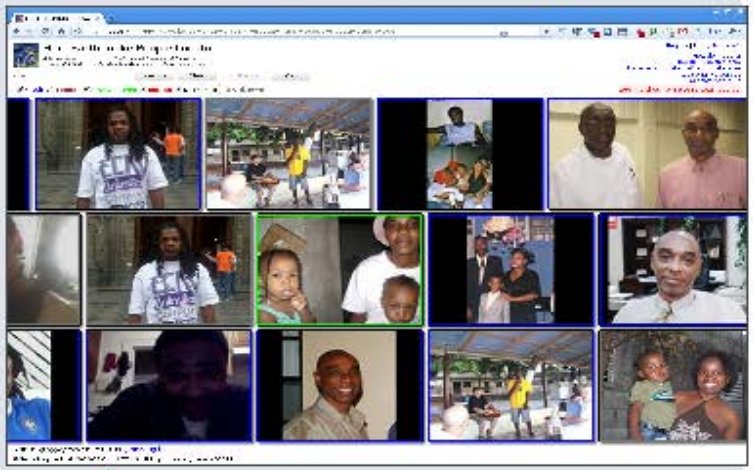
Some Name

Haiti Earthquake Person Locator

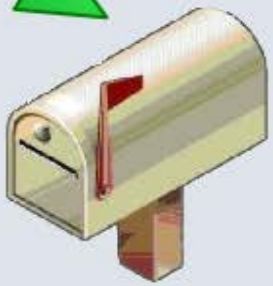
Found in Haiti
iPhone App

http://hepl.nlm.nih.gov

Interactive Notification



NATIONAL LIBRARY OF MEDICINE



disaster@mail.nih.gov

LPF database & services

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

Person Finder: Haiti Earthquake
powered by Google

http://archive.nlm.nih.gov/proj/lpf.php	https://pl.nlm.nih.gov/

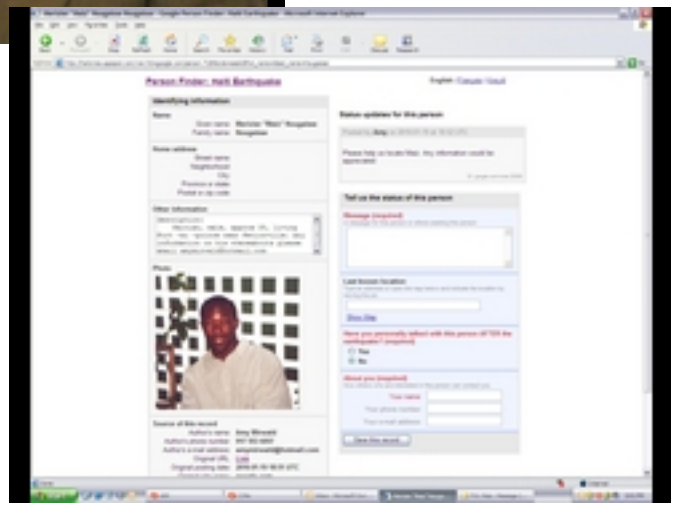
Face Matching

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

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

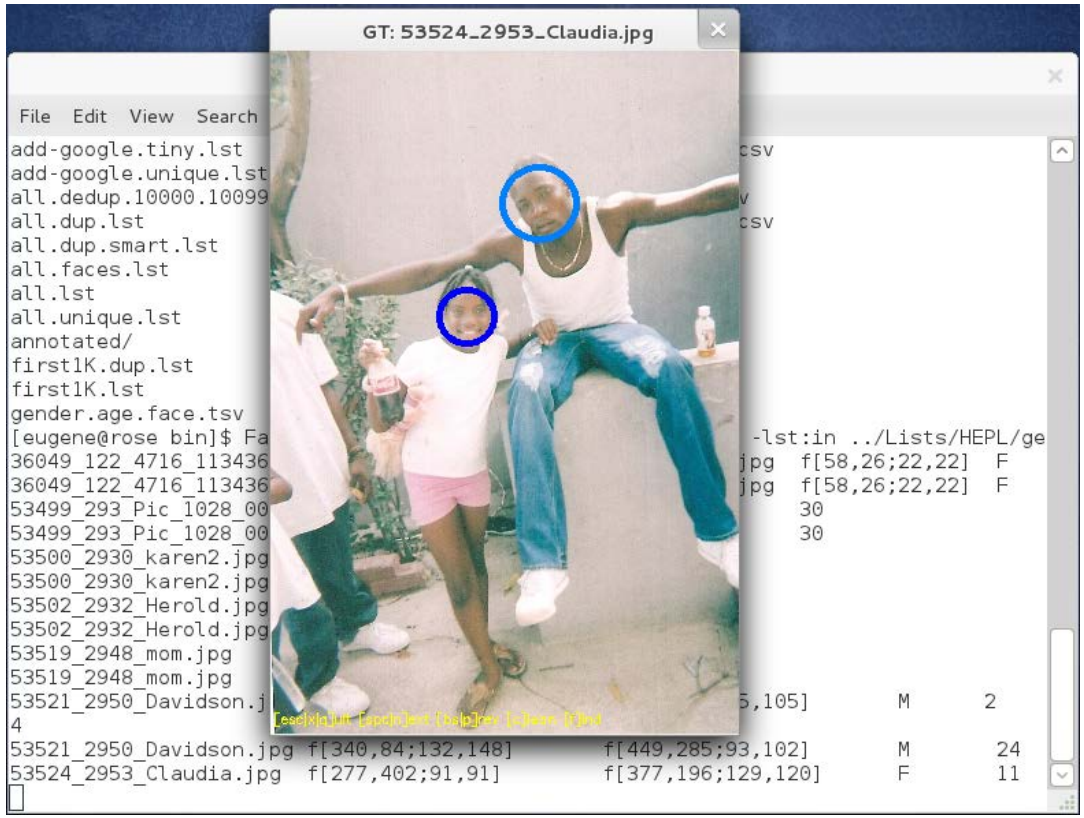
- identifying and grouping
  - near-duplicates
  - no-face images
- prime face/profile detection
- annotation
  - name, ID
  - age, gender, ethnicity

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

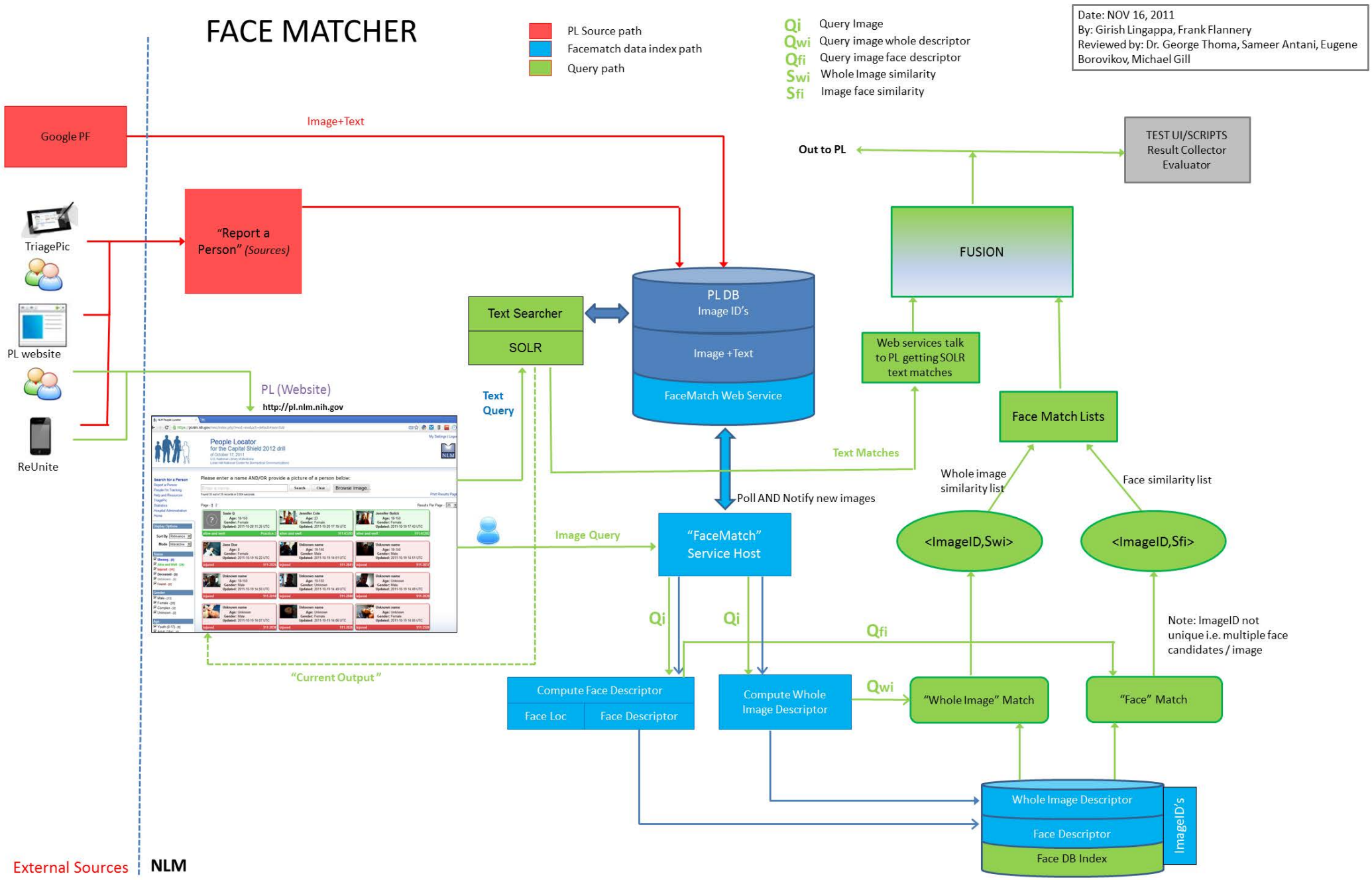
- critical for face recognition
  - spurious image removal
  - localizing faces for labeling and matching
- detect human faces in near-frontal and near-profile views
- **method**: Haar-like features + boost [Viola-Jones-2001]
- **results** on HEPL: ~25% miss rate (resolution, occlusion)
- OpenCV: GUI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



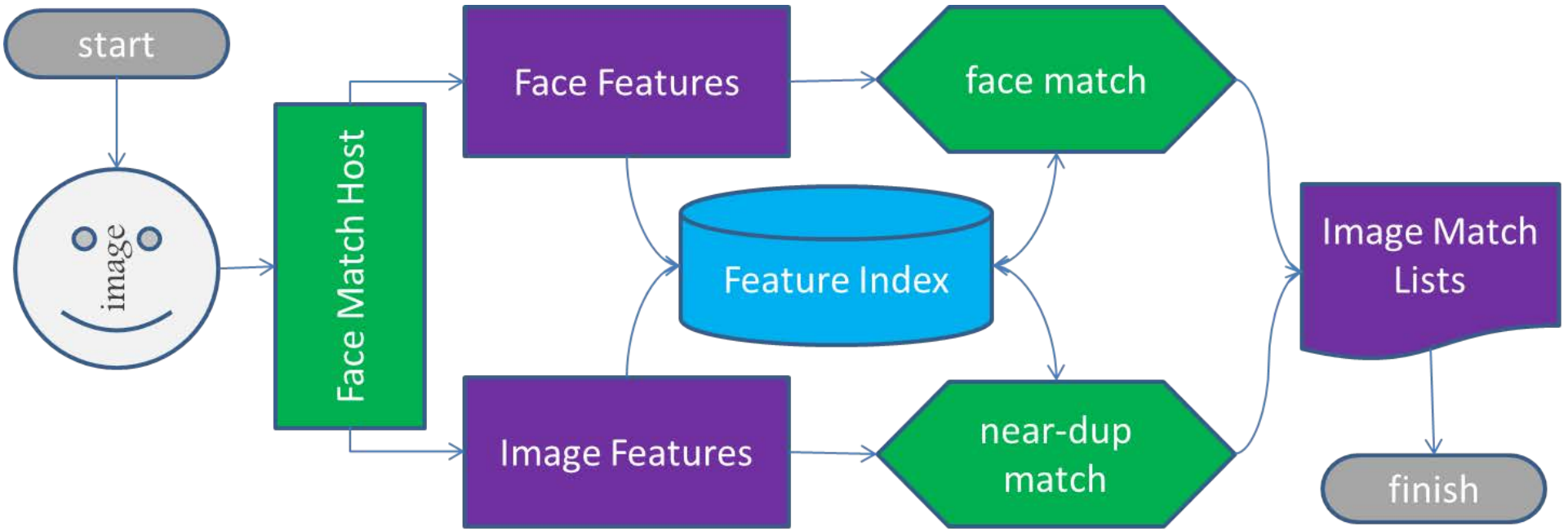
Face matching and recognition

- **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



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

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

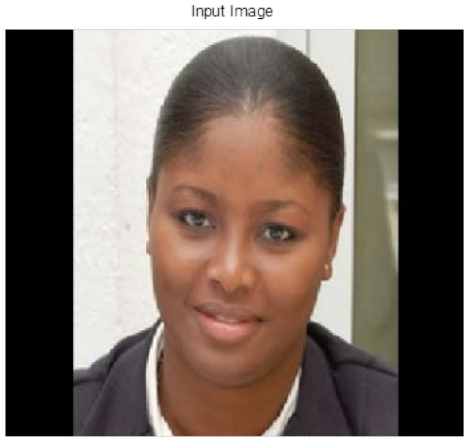
UMCP

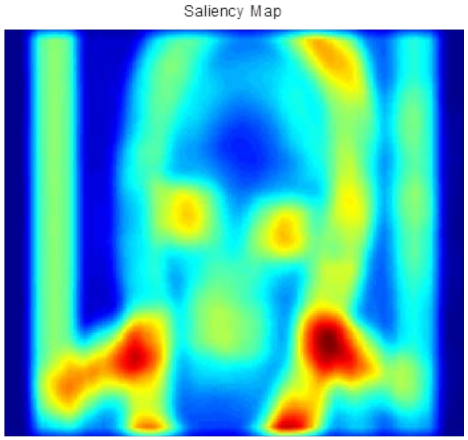
- rich set of feature descriptors (~70K)
- partial LS for multi-channel feature weighting
- tree-based discriminative structure
- robust to varying conditions
- claim to outperform state-of-the-art on FERET and FRGC

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

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

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

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?