People Locator: A System for Family Reunification

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After a large-scale disaster, many people go missing. Survivors often turn up in refugee camps or hospitals, where information is gathered and stored in a database. The People Locator technology processes this information for family reunification.

In recent years, the US National Library of Medicine, as an information provider and technology developer, has sought to mitigate the effects of mass-casualty events, both natural and deliberate, in the US and abroad. NLM has initiated programs to provide relevant information to first responders and the public, particularly through its Disaster Information Management Research Center (http://disaster.nlm.nih.gov). In addition, research and development projects are under way to design and deploy technologies to track hospitalized disaster victims, improve triage operations, and reunite families.

People displaced or injured during a disaster can lose contact with family and friends. However, they often end up in evacuation shelters or hospitals, which gather and post information so the public can search for missing survivors. To help with this process, the Lister Hill Center, an R&D division of NLM, developed the People Locator (PL). Hospital personnel, relief workers, or family members can enter names, photos, and other information about lost or found people on the PL website, and professional counselors or the public can then search the information.

We first deployed PL during the January 2010 Haiti Earthquake, and it has since been used for several other disasters, including the 2011 Japan Tsunami and New Zealand Earthquake.

The PL System

Figure 1 shows PL's principal components. At its core, a database holds data on missing and found people, which a search engine indexes for efficient searching. There are multiple ways to enter data in the database, and PL can share its data with other repositories with a similar goal. Additionally, the user interface offers multiple views of the data for browsing and searching.

Broadly, PL supports two "flavors" of use: *hospital triage-based* or *community-wide* operation.

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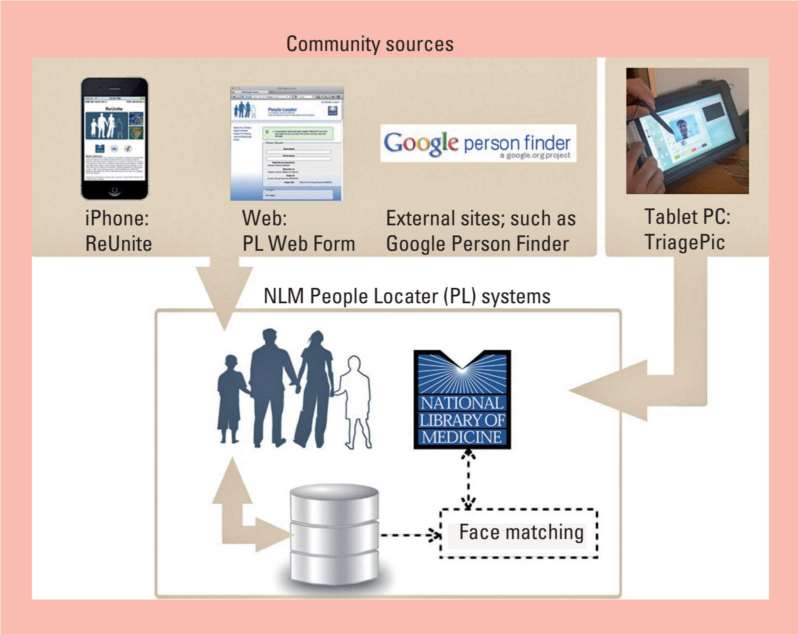

Figure 1. The People Locator (PL) and its data input sources. Research and development efforts seek to improve database searches, including using a combination of text- and image (face)-based matching.

The first aligns with triage procedures and workflow at a hospital for both data input and searching, while the community-wide system lets users upload data from anywhere in a large affected area (such as Haiti and its diasporas in the earthquake's aftermath) and lets the public search that data.

PL offers multiple methods for reporting missing and found people, using

- a (structured) PL Web form;
- a structured form within ReUnite, an iPhone app; and
- unstructured text in the subject line of an email message (not shown in Figure 1).

In addition, data can be imported from other repositories with which PL is interoperable, such as Google's Person Finder. For data gathering at hospitals, NLM offers TriagePic, a Windows-based application for laptop and tablet PCs.

When you enter a missing person's name on PL's search page, it pulls from the database and displays the corresponding photos and descriptive metadata records.

Database Design

We based the initial design of the PL database and website on the circa 2008 Sahana disaster management system, developed after the Indian Ocean tsunami.[1,2] Following the approach the Sahana developers adopted, PL employs a relational database design centered on "person records" stored in the *person_uuid* table. Each person's report generates two entries in this table—one for the reporter and another for the reported individual.

Many other tables in the system are child tables of *person_uuid*, recording some aspect of these individuals. For example, *person_status* contains information about the health or location of reported people, and *person_physical* records their physical characteristics. The *contact* table saves contact information for both reporters and reported people, so survivors can contact those looking for them and reporters can closely track people for whom they are searching.

Other important tables in the system include the *hospital* table, which associates a reported person with a particular hospital, and the *incident* table, which associates the person with a specific disaster event. The *user* table contains information on all registered PL users, including those who have reported a missing or found person. The *image* table contains information on photos, such as URLs and pointers to where the photos reside in local storage.

As PL evolved beyond the original Sahana functionality, it introduced new tables. For example, one set is for sharing data imported from other family reunification sites via the People Finder Interchange Format (PFIF), an open XML-based standard for exchanging and aggregating missing and displaced person data (http://zesty.ca/pfif). The *pfif_person* and *pfif_note* tables capture records (explained later) from other repositories, and the *pfif_repository* table lists known PFIF repositories—that is, those that are interoperable with PL. The remaining PFIF tables control the automated export and import processes.

Another new PL feature is that Solr, a Java search platform from the Apache Lucene project (http://lucene.apache.org/solr), is used to index and search the PL records. Solr offers better performance and more powerful search-string relevance matching than SQL queries offer. On the downside, it introduces a small delay between the

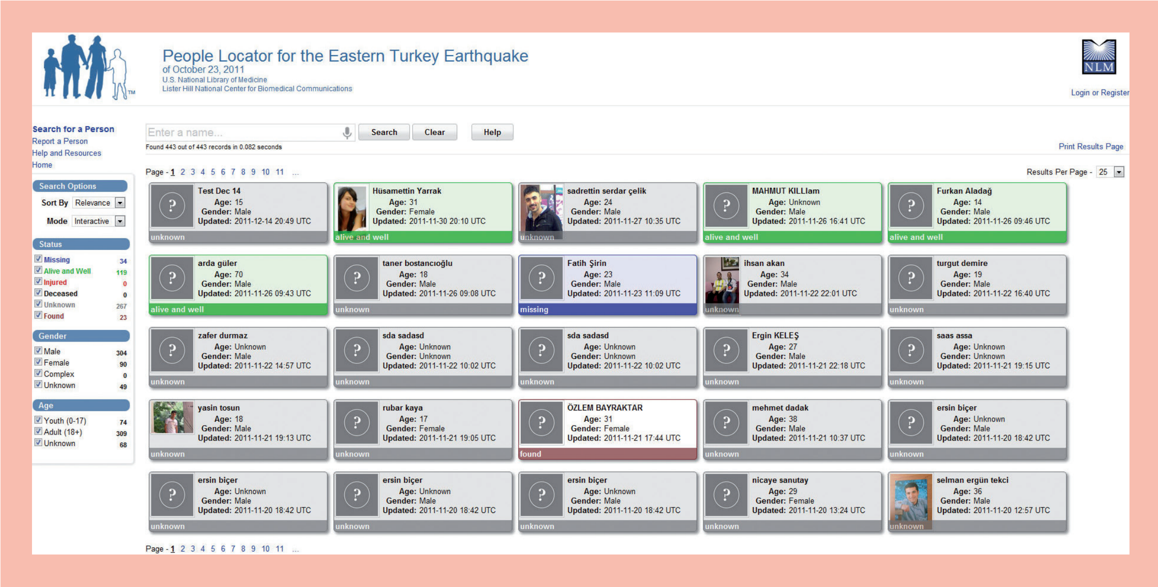

Figure 2. The PL search interface, showing missing person records from the Eastern Turkey Earthquake of October 2011. The default (shown here) is the interactive mode.

time at which people are reported and when they can be queried, because Solr first must index the incoming data.

Sharing Data with Other Repositories

To promote wide-scale family reunification, we designed PL to exchange missing person data with other survivor repositories, which is why we use PFIF to share data. PFIF was created in September 2005 in the aftermath of Hurricane Katrina, and Google, Yahoo, and others then adopted it to share missing person data. It saw extensive use again after the Haiti earthquake in January 2010, when Google launched its Person Finder and exchanged PFIF data with our system, CNN, and the *New York Times*.

PFIF data includes *person records* containing identifying information about a person, and *note records* that contain comments and updates about a person's status and location. A typical missing person description comprises a single person record and multiple note records. PFIF has matured since its first use in Katrina to better accommodate the needs of international users regarding postal addresses, personal names, and Unicode. It also includes a mechanism to eliminate ("expire") records, if appropriate.

Our system is equipped to exchange missing person data with any PFIF-compliant repository through regular automated exports and imports. In the aftermath of the Christchurch Earthquake in New Zealand in February 2011 and Japan's tsunami and earthquake in March 2011,[3] we implemented this automated data sharing with Google Person Finder. As a result, missing person data reported on either website appeared seconds later on the other site, letting users around the world report and search the same data using their preferred site.

We used the Google Person Finder data API to share the data (http://code.google.com/p/googlepersonfinder/wiki/DataAPI). We have subsequently implemented part of that API in our system to offer other repositories direct access to our data, which is particularly important when PL might be the only (or first) repository deployed in response to a disaster.

User Interface

Arriving at the PL website, a user first selects a particular disaster event, such as "Haiti Earthquake," and reports on a missing or found person or searches the database. After the user selects the event, a text search box appears. Clicking the search button yields all records collected for the event (see Figure 2). The public can search for a missing person using one of the following:

- a full name or a partial name with a wildcard (for example, "Cath*" will find "Catherine");
- the word "unknown" (to search records lacking names); or
- a blank box, which delivers all records in the repository.

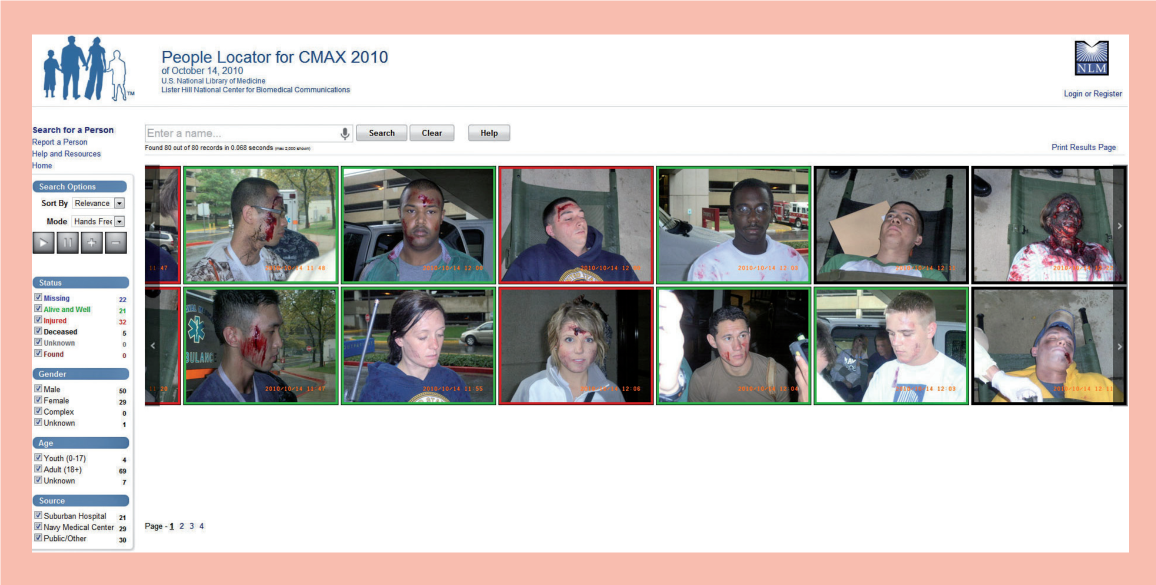

Figure 3. Hands-free mode showing records from the October 2010 CMAX (Collaborative Multi-Agency eXercise) drill, a disaster event exercise held jointly by three neighboring hospitals in Bethesda, Maryland.

The system can display search results in three user-selectable modes: interactive (the default), hands-free, or full-screen (the "notification wall"). In all three modes, the user can filter results using checkboxes for gender, age, and status (alive and well, injured, or deceased). The user can also reorder the displayed data according to the time the record was posted or updated or by name, age, or status. Clicking on a retrieved record yields a more complete (but still partial) record, and clicking again displays the full record stored in our system. The user can also print the search results.

Although no login is required for searching, registration is required if the searcher wants to be notified of any future matches or status updates. This follows from the assumption that before someone reports a missing person, he or she is likely to first check whether a report already exists in our system. Registration is a simple process requiring first and last name, desired user name (login ID), email address, and a strong password.

The interactive mode shown in Figure 2 displays results in a row and column layout with a thumbnail photo and the name, age, gender, status and last-updated timestamp. The hands-free mode arranges records as a filmstrip that automatically scrolls from left to right (see Figure 3). The full-screen notification wall does the same thing, but the results occupy the entire screen. This is particularly useful when showing the display to a larger audience—in an auditorium, for example. These latter two modes, which are more suitable when the user needs to review many pictures at once, were designed for emergency-management or counseling staff to rapidly and conveniently view records of incoming patients. Video-player-like controls provide the flexibility to start, pause, rewind, and slow down or speed up scrolling.

Reporting Missing or Found People

Here we provide more detail about the forms for reporting people on the PL website and using the ReUnite iPhone app and about the TriagePic application for hospital-based reporting.

Community Reporting

The PL website and the ReUnite app are suitable for use by anyone, anywhere.

PL Web-based reporting. In addition to searching data, the PL also has a Web-based form for reporting data. As Figure 4 shows, registered users can select the relevant disaster event and provide the requested information, such as the person's name, age (or age range), gender, eye color, skin color, height, weight, and any other distinctive features. They can also indicate where the person was last seen. Contact information they provide is not visible to the public but is available to site administrators to aid in family reunification.

ReUnite iPhone app. As recent events have demonstrated, there is active community participation in the recovery and reunification efforts after a disaster. This was evident from those seeking missing people after the 9/11 terrorist attacks on the World Trade Center in New York City, and more recently after the Haiti Earthquake of 2010 and the Japan Earthquake of 2011. In each instance, people put up signs of those missing on community bulletin boards and other media. Because the PL system provides an electronic bulletin board for reporting on those missing, it needs a variety of easy-to-use data-input mechanisms. So, we decided to exploit the ubiquitous smartphone.

Following the Haiti Earthquake, in a "tiger team" approach, we developed the ReUnite iPhone app (initially called "Found in Haiti"), which is also compatible with the iPod Touch and iPad. The app provides a structured form for reporting missing and found people. Developing the app for the iPhone offered several advantages (some of which would also apply to other widely available devices, such as the Android, Blackberry, or Win Phone):

- ubiquity,
- broad applicability (iPhone, iPod Touch, and iPad devices),
- standardized hardware,
- a powerful software development platform, and
- a uniform distribution mechanism.

From its inception, the app design focused on two key capabilities: reporting missing and found people and searching PL. Also, it was designed for two kinds of users: the layperson and professionals (such as a social or relief worker).

As a model for the layperson, we imagined a mother, looking for a missing family member, using ReUnite to provide that person's name, age, gender, photo, and last known location, and to provide her own contact information for receiving status reports. For the professional, on the other hand, we considered a social worker at a recovery camp, reporting on those who had been found. In this case, the location and health status are known, and the social worker can submit information about the person, including a picture.

ReUnite, highlighted by Apple's iTunes Store as one of its "new and noteworthy" apps, combines all of these desirable characteristics. As Figure 5 shows, it provides an entry form for recording a person's name, gender, age, health status, photo (with tags/annotations), and location (aided by GPS and Google Maps). Also, the text and voice comments fields let the user add helpful information.

The user can also search for records from within the app using the embedded browser. Future enhancements to the app will include improved search and filtering capability, native within-app search, and enhanced interaction with the PL website.

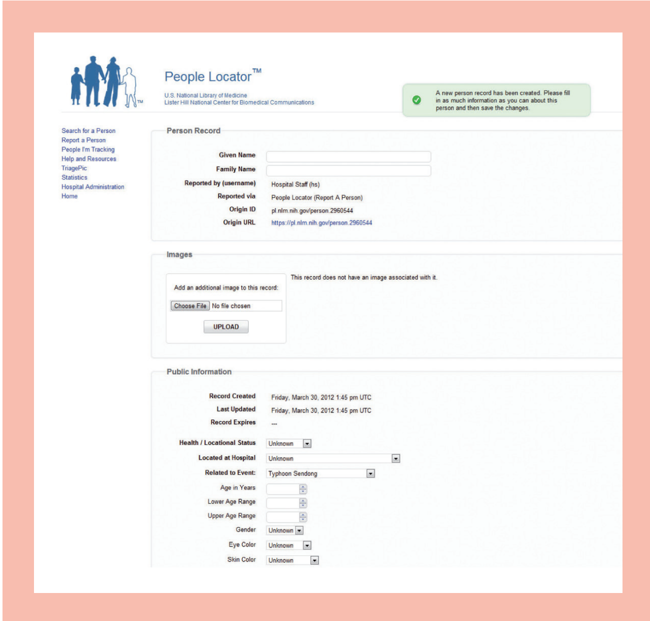

Figure 4. The PL Web form for reporting data. Registered users can select the relevant disaster event and provide the requested information.

Hospital-Based Reporting: TriagePic

The Windows-based TriagePic app can quickly gather photos and minimal information about disaster victims arriving at a hospital and can then forward this data to the PL website for display.

In its first version, hospital staff members took photos with special Bluetooth cameras paired with a laptop hosting TriagePic. When the photographer came within a dozen feet of the laptop, he or she could send a photo to TriagePic, and another staff member would enter related text data. During drill testing, this proved cumbersome and error prone, requiring too much synchronization and verbal relaying between the photographer and data-entry person.

Subsequently, we combined these functions in a tablet computer (or laptop with a webcam) to

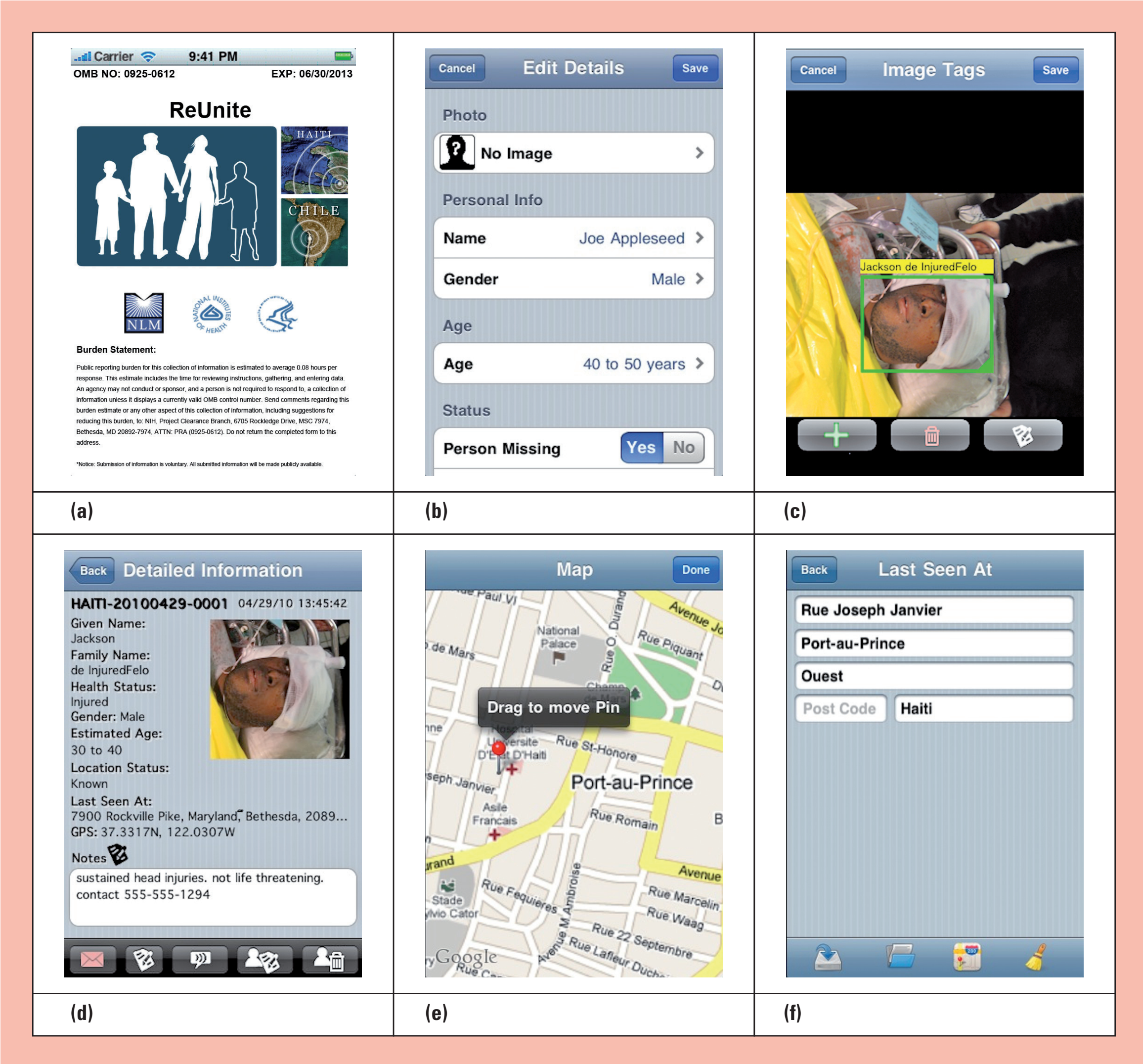

Figure 5. Screen shots of the ReUnite iPhone app: (a) initial screen, (b) form for recording person information, (c) image capture and tagging capability, (d) summary information, (e) mapping feature that uses GPS to identify (f) geographic and postal information.

let a single staff member perform the following functions:

- take the photo;
- enter a mass-casualty ID;
- record the gender, note whether the person was an adult or child, and enter a name if time allowed; and
- route the patient to a hospital zone for treatment (color coded as green, yellow, or red, depending on severity of injury).

TriagePic then immediately sends this information to PL. It could also email the data to designated recipients.

In a recent region-wide exercise, called Capital Shield 2012, we successfully fielded two Motion Computing CL900 tablet computers with TriagePic at Suburban Hospital (see Figure 6). Each tablet runs Microsoft Windows 7 Professional, is finger-touch sensitive, and has a digitizer pen and two built-in cameras. This proved considerably more successful than the first approach. The collected data was transmitted to PL through the hospital's enterprise Wi-Fi network. Each photo is JPEG-compressed, speeding up the Wi-Fi transmission while retaining good quality. Compression is a frequent requirement of wireless telemedicine applications.[4]

TriagePic works best with this tablet in a "landscape" orientation. To use the rear-facing three-megapixel camera, the user must carry (not dock) the tablet. Hospital staff liked the tablet's

(a) (b)

Figure 6. TriagePic in use. (a) A staff member using a tablet computer during the Capital Shield 2012 Drill at Suburban Hospital, part of Johns Hopkins Medicine, in Bethesda, Maryland, and (b) the TriagePic interface.

optional holder, which has elastic hand straps on the back and a shoulder strap. When docked, users can enter text with a physical keyboard. Otherwise, they use a Windows 7 virtual keyboard or the digitizer pen equipped with handwriting recognition. TriagePic exploits the finger-touch feature in the tablets for nontext entry—for example, via enlarged checkboxes to specify gender and adult or child.

Future Steps

Challenges remain in several areas. For retrieval, we intend to explore search-by-face matching and multimodal (text and image) search strategies.[5] We are also working on strategies to notify the public and relevant government and emergency response organizations through SMS text messaging and social media outlets (Twitter, Facebook, and Google+). We aim to advance interoperability with other disaster mitigation sites through common data formats and data retention policies.

There are opportunities for hospital-focused improvements as well. For example, the system could be considered for routine ER use, not just disaster response, if it had privacy and security enhancements—for example, it would have to comply with the US Health Insurance Portability and Accountability Act (HIPAA).[6] It would also benefit from integration with other hospital systems, such as real-time patient trackers using RFID/IR tags.[7]

Face Matching and Photo Deduplication

We want to extend the search technique to image queries. A family member should be able to send in a photo of a loved one and get the top (say, five) most similar pictures in the database. This face matching requires efficient techniques for extracting image features (shape, color, texture) and requires annotated and validated (ground truth) datasets.

Ongoing research has resulted in a prototype for face location and identification using tools in OpenCV (Open Source Computer Vision library, http://opencv.willowgarage.com/wiki). The prototype locates faces using the method Paul Viola and Michael Jones proposed,[8] and it computes face descriptors using speeded up robust features (SURF).[9] It indexed localized faces by computing these SURF descriptors and considered those within a threshold similarity score to be similar.

A related problem concerns the same photo appearing multiple times in the database, possibly because several people sent it in during a

Potential Partners for Disaster Information Exchange

In the US, the American Red Cross provides a "Safe and Well" website and coordinates with other entities through a shelter network (https://safeandwell.communityos.org/cms/index.php). To complement the National Center for Missing and Exploited Children, the US Federal Emergency Management Agency (FEMA) attempted a National Emergency Family Registry and Locator System for adults (https://egateway.fema.gov/inter/nefrils/home.htm). Furthermore, information about missing people brought to the police is disseminated through the FBI's National Crime Information Center 2000 system.

Traditional patient transport and tracking systems include the military's Transcom Regulating and Command & Control Evacuation System (https://www.trac2es.transcom.mil) and the Department of Health and Human Service's (DHHS) Joint Patient Assessment & Tracking System (http://teams.hhs.gov/jpats). We're particularly interested in the emerging Tracking Emergency Patients/Clients protocols[12] supported by FEMA and DHHS (www.evotecinc.com/TEP[TEC]), which should allow exchange of messages among emergency managers at the local, state, and federal level, using the Integrated Public Alert and Warning System's open and private networks.

The US State Department is also involved in international responses, as is the UN Office for the Coordination of Humanitarian Affairs. Important sites include the International Committee of the Red Cross's Family Links, and Missing.Net of Foundation Casques Rouges.

disaster event. Eliminating these duplicates would reduce the search space, thereby improving performance. We investigated several methods and developed a C++ prototype to index the image collection based on the Haar Wavelet (http://en.wikipedia.org/wiki/Haar_wavelet) image descriptors, retaining positions and signs of only the most significant coefficients. Measuring the matching distance between photos and grouping those below a threshold distance gives sets of near duplicates.

Challenges in this area include low-resolution photos, typical of those from cell phones; faces that are occluded with clothing or hair; and variations in pose and ambient lighting.

Notification and Data Exchange Strategies

The use of social media in disasters for notifications, reunification, help requests, situational awareness, and general emergency management is becoming increasingly important,[10,11] and there are several potential partners for disaster information exchange (see the sidebar).

We seek to notify as many interested parties as possible using multiple channels when we deploy PL during a disaster event. So, we plan to build in automatic notifications via social networking sites (such as Twitter and Facebook), SMS, the Integrated Public Alert and Warning System (IPAWS, www.fema.gov/emergency/ipaws) listservs, email lists, and other avenues. We need to develop standardized message creation and distribution strategies, integrate them into the system, and evaluate these strategies to determine their effectiveness.

Family reunification technologies have enormous potential to provide relief to distraught family and friends searching for lost individuals. However, as recent disasters have shown, although missing people might be identified in hospitals and camps, few tools exist or are sufficiently maintained to provide search capabilities to the public. Instead, people often resort to pinning handwritten notes, describing their dear ones, on bulletin boards and street corners. Our project aims to fill this void by deploying PL for large-scale disasters, developing tools and technologies to improve reporting and search capabilities, and supporting interoperable standards for data exchange with other organizations that might be aiding in similar efforts. IT

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