Reunifying Families after a Disaster via Serverless Computing and Raspberry Pis

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I. Introduction

Children constitute a vulnerable population and special considerations are necessary in order to provide proper care for them during disasters. After disasters such as Hurricane Katrina, the rapid identification and protection of separated children and their reunification with legal guardians is necessary to minimize secondary injuries (*i.e.*, physical and sexual abuse, neglect and abduction). At Camp Gruber, an Oklahoma shelter for Louisianan's displaced by Hurricane Katrina, of the 254 children at the camp, 36 (*i.e.*, 14.2%) were separated from their legal guardians. It took 6 months to reunify the last children; 70% of the children were with their legal guardian after 2 weeks. Imagine not knowing for 2 weeks (or 6 months) if your children are dead or alive. To exacerbate these natural challenges, during a disaster Internet connectivity is scarse or unreliable.

In this paper, we demonstrate *ReuniFam*, a resilient distributed system built in support of first-responders' family reunification efforts. The front-end of *ReuniFam* runs a web-base interface on raspberry PIs equipped by a touch screen. With another raspberry Pi equipped by a camera as well as with a Unmanned Aerial Vehicle, we collected images and videos that are then being processed with OpenFace [3], an open-source face recognition process. All OpenFace computations are offloaded to a serverless computing platform or to a Docker container to minimize children face recognition time. A central database of images running on an Amazon Web Service database is synchronized with the local raspberry PIs. Our goals are twofold: (1) to demonstrate our low-cost (scalable) prototype for first responder shelters coordination and (2) to show how standard image augmentation techniques may significantly increase face recognition accuracy, when only a small number lost children images is available.

II. System Overview

Disasters constitute a delicate situation especially for children, that need to be quickly identified and protected until they are reunified with their legal guardians. This minimizes other risks, like physical and sexual abuse, neglect and abduction. Research shows that children in such circumstances are often unable or unwilling to give their names or other identifying information [1]. Therefore, they constitute a vulnerable population and special considerations are necessary in order to provide proper care for them during disasters. The events of Hurricane Katrina prove the importance of better solutions to face disaster scenarios.

To minimize the reunification times, we implemented a system for first-responders, that allows families, shelter workers or Unmanned Aerial Vehicle (UAV) to upload images of missing children through a website. After images of lost children are uploaded in a central repository, running on AWS, we offload face recognition computations from a raspberry PI to a serverless computing platform to speedup face matching time of potentially lost children.

Because of the hostile conditions in a disaster, our application allows delay tolerant synchrnoization among the local and the central image repository, as envisioned in our earlier work [2]. When a children face match is found, the location of that individual is updated on a locally stored database. First responders will then receive the name of the individual who is found, along with contact information of their family.

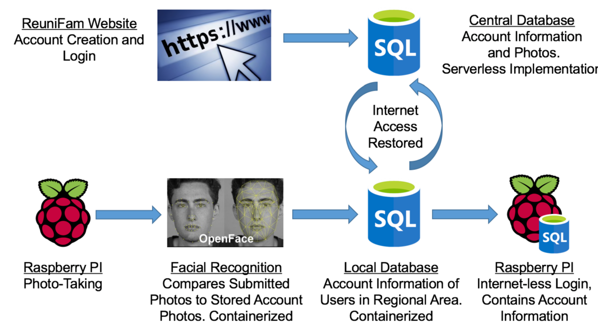

Figure 1: System Architecture for the reunification of lost children with their parents after a disaster.

III. ReuniFam System architecture

The system architecture, shown in Figure 1, is composed by a front-end, composed by a set of two Raspberry Pis,

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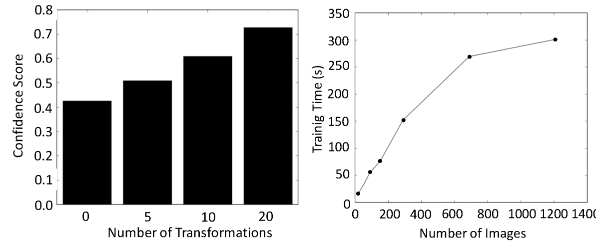
a web interface to query and upload images, and a back-end comprised of a local and a central database. Families or first responders use the Raspberry Pi available at the shelters to create an account online and to log into the ReuniFam website. The account's fields include names, phone numbers and photos of all family members. This information will be stored in a centralized database and each shelter will only receive partitions of the centralized database, based theior geolocation. This is because accounts registered at a shelter need only the information of the nearby area hit by the disaster. Shelter workers may take pictures of victims who are unable to be identified and can upload them with the Raspberry Pi. Also UAV can upload pictures taken by flying over the disaster area. Considering that most network infrastructures rely on cellular or Internet access, unreliable following natural disasters, these pictures are locally stored in a file on the Pi. When the Pi is reconnected to the local ad-hoc network, all photos are uploaded on the server for processing through OpenFace [3], an open-source tool for face recognition. Once OpenFace finds a match between uploades photos and photos stored in the database, it will update the status of that children (or person) in the database as *Found*, along with the individual's current location. First responders will receive the name of the individual who is found, along with contact information of their legal guardian. When the Pi syncs with the database located on the local server, implemented on Amazon AWS, legal guardians can log in to the first responders raspberry Pi to see the status of their family members. Once users log in, a spreadsheet will be displayed showing their family members and their status. Users can also type notes about their family members or update the status of their family members. When the Internet connection is restored, shelters will sync their local databases with the centralized database using a delay-tolerant connection. The backend will then process the received image, and using an efficient facial recognition algorithm, tries to match the received image to stored account images. If there is a match, the location of that individual will be updated in their account on the locally stored database. First responders will receive the name of the individual who is found, along with contact information of their family.

IV. Prototype and Demonstration

Picture taking and front-end. The front end is comprised of a Raspberry Pi, a seven-inch touchscreen, and a picamera. Reliability and cost-effectiveness are the main reasons that led to the choice of these devices. Raspberry Pis are directly connected through a network switch to the backend system for reliable communications. Our ReuniFam software and the interface with the pi-camera, were written in Python and the Graphic User Interface (GUI) was created with the Tkinter library. Our website has been set up so that when Internet connections are restored to the area, families would be able to log into the portal on their own devices to inquire if any information has been released; this prevents camps from being overcrowded with families during the cleanup.



(a) (b)

Figure 2: Tradeoff Accuracy vs Training time: (a) Children face detection confidence score increased using a data augmentation; (b) Time to train Openface increases with the number of training images.

Back-end. The back-end is comprised of a local and a central database. The local database runs OpenFace on a Docker container. OpenFace is trained with images of a person by doing pose detection and alignment, generating embeddings using a pre-trained neural network and by training the classifier. OpenFace is able to find the correct match for a person even when it is trained with merely 3 images. OpenFace outputs the name of the person it believes is a match and a confidence score. This output name is then used to query the database and to find updates about the status of the person $e.g.$, lost or safe.

Even with an adequate number of images, OpenFace's confidence score can be low for people with similar physical features. Moreover, legal guardians may not have many pictures of their lost children. To address the lack of training images we increase the OpenFace's confidence score using Keras, a library implementing a data augmentation technique. Figure 2 (a) shows how the confidence score improves by increasing the number of transformations on an image. The better accuracy of the image augmentation comes at a cost of a training time increase. OpenFace only needs to be trained when images are added to the training classes, so this does not need to happen every time the classification task is run. With over 1000 images, OpenFace takes about 5 minutes to run (see Figure 2 (b)). Finally, the central database runs on Amazon Web Services [4] where queries are run in a serverless environment to provide scalability during emergency response.

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