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Computational Infrastructure for Law Enforcement

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Crime and violence have reached intolerable levels in the United States.

The purpose of this project was to establish a connection between the needs of the law enforcement community and the capabilities and solutions offered by LLNL's advanced computer technology. In this project we planned to demonstrate the leverage of enhanced computational infrastructure for law enforcement by demonstrating the face recognition capability at LLNL in a pilot project. The project specifically implemented (1) a face finder module extending the segmentation capabilities of the current face recognition so it was capable of processing different image formats and sizes and (2) create the pilot of a network-accessible image database for the demonstration of face recognition capabilities. The project was funded at \$40k (or an equivalent of 2 man-months) for a feasibility study. It investigated several essential components of a networked face recognition system which could help to identify, apprehend, and convict criminals. This report describes in detail the purpose, results, and achievements of the project.

Purpose:

To research a case law enforcement officers spend a sizeable percentage of their time reviewing and researching crime related evidence such as albums of mug shots or photographs of crime scenes. The pilot implementation of our fully networked face recognition system would free officer's for the street by saving work time during the investigation of a crime. System operation was planned to be simply that an officer would submit a mug shot sample for a query over a secure internet connection (encryption) and receive in the ideal case matching results without further interaction. Our feasibility study addressed some interface challenges for networked face recognition (basic matching functionality, JAVA implementation) and the issue of finding a face in an image and normalizing the aspect and size of the image for the classification algorithm (face finder component). A full system pilot for our investigated functionality will also have to address the scalability of the recognition algorithm to large databases (>1000 faces) and secure network connectivity.

Results and Achievements:

1. We surveyed several image types and some existing public databases available for benchmarking of face recognition systems. The national institute of standards (NIST) is proposing a standard for face recognition images as it already exists for fingerprints. The chosen basic JPEG format has some disadvantages for automated face recognition due to potential artefacts. GIF, TIFF, and other formats offer alternatives. The project was added to the list of test sites for the FERET database created by the Army Research Laboratory, currently with 1200 faces the largest publically available database for the testing of face recognition systems. We started testing our system on the NIST face database, which contains a subset of 130 persons with highly varying, multiple images. The NIST database is currently acknowledged as very difficult for existing face recognition systems. By invitation we contributed a chapter surveying the state of the art in face recognition to the handbook of Pattern Recognition and Computer Vision. The presented knowledge of the face recognition application area is based on the expertise collected during this LDRD project.

2. We established a collaboration with the Sacramento Sheriff's office which is starting the development of its own local mug shot database and could serve as a testbed for automated identification with face recognition. The law enforcement community has invited our project to the Command School in California (classes and discussion panel) offering the potential for alternate access to local mug shot databases in police departments. We continue after the end of the project in our collaboration. The National Institute of Justice (NIJ) and ANSER (Analytical Services Inc.), a nonprofit organization, have asked us to help in supporting of the Center for Missing and Exploited Children (CMEC) with the potential of funding Laboratory research at a level of more than one full time employee. The experience with our online pilot and the internet ready technology investigated in this LDRD project was crucial for the acceptance of our technical expertise and collaboration in the new project.

3. Our project focused on the implementation of several essential components of a networked recognition system: interface, face finder, and operation on a standard database.

a) KEN Online is our web page which is connected to an online recognition system (see also the publication reference). A user can submit images which are either stored in a database or matched to the database of stored face images. Within a short time the user receives recognition results in form of a ranked list of recognized faces. The system provides us also with the opportunity to collect experience with system usage and statistics for our algorithms. The system has an automatic image converter stage which converts from over a dozen image formats automatically to the TIFF format currently implemented in the recognition system. Fig. 1 shows an entry page of the online system. The system is based on perl scripts interfacing several modules: the face recognition program, ImageMagick (an automatic image converter), and an SQL database for textual metadata accompanying the images. The system keeps the originally submitted image as reference and creates as standard size greyscale frame which is fed into the recognizer.

Fig. 1. Online Description of our recognition system based on wavelets and elastic matching.

b) During the inception of our online pilot system the JAVA language started to become attractive due to its industrial support and cross platform capabilities. We implemented a JAVA interface for our recognition system. The interface can run on any platform providing the JAVA virtual machine run time environment including within a web browser across the internet.

Fig. 2. JAVA interface for face recognition system.

c) In addition to interface issues we investigated a new form of generalized, local symmetry measure as features for face detection. The system is derived from a generalized symmetry detector presented in the Ph.D. thesis of Reisfeld. Facial symmetry appears to be an attractive, robust feature to detect faces and their orientation within an image. We extended Reisfeld's work to operate on a image resolution pyramid and applied our extended technology to frontal mug shots. The first segmentation results on a database as difficult as the NIST database are encouraging. The local symmetry detection may offer significant advantages on cluttered and noisy background by providing robust features. Time was too short to collect sufficient test results for a publication within the feasibility study. Since the work on our face finder and testing on the NIST and FERET databases is continuing and may lead to a patent or journal publication we do not want to disclose detailed information on the symmetry measure at this time.

Fig. 3. Face Finder based on symmetry detector: (a) original (1000x1000 pixel greyscale image, (b) second level of resolution pyramid with facial symmetry features detected, and (c) cropped and scaled output of the face detection stage.

Publications

- Test system for online recognition, KEN Online under <http://www-iscr.llnl.gov/KEN/KENOnline>, UCRL-MI-122528.
- KEN face recognition with silicon retina preprocessing, UCRL-MI-123621.
- Contribution of a survey chapter on face recognition to the "Handbook for Computer Vision and Pattern Recognition", UCRL-JC-126414.

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