Accelerating Face-in-the-Crowd Recognition with GPU Technology

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Outline

- Forensic Face Search
- Face in the Crowd Recognition (FCR)
- Parallel Distributed FCR
- Embedded Face Recognition
- Software Tools for CVPR
- What We Have Learned

Airport  Railway Station  Seaport
Forensic Face Search
Recognising Faces from CCTV

- “The major problem with CCTV biometric evidence compared to DNA and Fingerprints is the inability to match faces to names.”
  - Graeme Gerrard, Former DCC and Co-Chair CCTV Strategy Committee
- Humans can do this task if they are familiar with the person under surveillance, but it is extremely difficult to automate this matching with any degree of reliability.
- This is largely due to the uncontrolled nature of covert photography exacerbated by poor resolution.
- Computer face recognition works remarkably well for passport quality images, but CCTV is much, much harder.
- Need a technology to shortlist suspects from CCTV images
- Aim is for high rank rather than a perfect match
Best Practice Police and Defence Technology
Problem: Matching unfamiliar faces is not as easy as it sounds
Personal Example: Could not find any of my 3 daughters in School Photo of 1000 students

Can recognise with eyecontact iPhone app from LCD screen image!
Our Approach to Face Matching

- Dictionary approach from field of speech recognition
- Very fast approximations, small templates, DCT features, insensitive to alignment, pose, illumination, expression
- Currently robustly matches faces at 12 pixels eye to eye whereas most commercial systems need a minimum of 64 pixels.
Face Recognition Landscape

Misaligned faces and poor resolution images is an Imagus iFaceRec strength.

Performance

Others

Aligned frontal, 100 pixels eye to eye

Ours

High

Quality of Image

Low

Partially aligned, non-frontal, 12 pixels eye to eye

Resolution Limit for Human Recognition
Forensic Face Match System

The LFW Database
- Images gathered off the web
  - Variable
  - Camera
  - Photographer
  - Lighting
  - Pose
  - Expression
  - Age
  - Race
  - Gender
  - Resolution
  - Number of photos (1-245)
- Uncontrolled Gallery
  - 4000 Identities
  - 10000 Images
- Uncontrolled Probe Images
  - 2000 Identities
  - 4000 images
- Good proxy for CCTV surveillance task
- We have also benchmarked on railway CCTV images with fair results
Who?

Results

Face Features Only

Over 4000 persons in database

Full Images
LFW Benchmarks show 80% confidence in just 0.5% of the Database

The system does not do a one-to-one matching, instead it rank orders the entire face database against the probe image.

In 80% of cases the probe is recognised in the top 0.5% of the entire database of 4000 identities and 10000 images.

Now achieves almost 50% Rank 1 matches
Commercial Deployments

- Singapore, Bangkok, Indonesia, Abu Dhabi, ...
- Working on smart phone deployments for Military, Police, and Banking Sector
Face in the Crowd Recognition
From Still to Video

• Need to track individuals and assemble tracklets of face images
• Need to determine how to process tracklets to get best recognition
  – All frames?
  – Best frame?
  – Some frames?
• Want true video enrolment rather than still image
• Integrate and improve identity over multiple frames
• Need to automatically enrol individuals from CCTV as well as to recognise them
IFSEC2011 Award

• IFSEC is the World’s largest security show
• It is held in Birmingham each year
• 25,000 visitors
• 700 companies
• 700 guests at award dinners
• Our technology won the Major Category of CCTV System of the Year for Face Recognition in a crowd
Parallel Distributed
Face in the Crowd Recognition

FOR VIDEOS PLEASE SEE
WWW.IMAGUS.COM.AU
Parallel Distributed Face Search Across a Camera Network

• Recoded in Linux
• Uses Robot Operating System (ROS) from Willow-Garage as distributed middleware
• Scalable to multiple CPUs and GPUs
• Unlimited Cameras and Servers
• Scalable to airports and large infrastructure
• Easily add additional biometrics and other information
ROS: Person Identification in a Crowd
ROS: Cross-Camera Face Match
Embedded Face Recognition
Previous Work in this Area

Dilbert et al., 2005
Sagem Handheld Unit for QPS (Police)

Single handed Operation
Fingerprint Reader
We have added Face Rec
Server Client Operation
Windows CE OS
**IPhone Mobile Application for Field Operations**

- Recognise persons in the field
- Local or remote face database
- Recognition direct from identity cards or LCD monitor

![Application Screenshots](image)
Recent Android Implementation for Defence
Half Lit Face Example

Place icons over left & right eyes
Even .... The Cat Burglar?
Method also works for Dingos
And Gender
iFace Demo Release 5 Nov 2013

iFace Demo Version 1.0.0.1111 (beta) Windows 64 (CUDA enabled)
Software Tools for CVPR Applications
Armadillo

• Written in my Advanced Surveillance Research Group to develop CVPR applications
• Easy Conversion of Matlab to fast commercial C++ code
• Distributed in Ubuntu

Cited in Google Tech talks
42,000 hits per annum
OpenCV

• C++ Library of Standard Computer Vision algorithms
• Some functions are GPU-enabled including face detection
• Face detection rather than recognition is the face-in-the-crowd recognition bottleneck
• We are working on GPU-enabled best practice face detector
OpenCV

• Face detection is the largest processing load in our system – 95% of CPU load
• We specialise in recognition not detection.
• Indeed, our recogniser works on many faces that cannot be detected by our detector
• OpenCV has face detectors based on Haar and LBP cascades.
ROS

- Designed to create robot applications
- Parallel Distributed Middleware
- Transparently Distribute face recognition load to multiple CPUs and GPUs
- Only on Ubuntu Unix, but Windows version is under development
Video Coding 101

• Don’t copy video memory
• Reuse memory segments where possible.
• Use separate heaps / allocators for video frames and small objects.
• Fragmentation will cause more problems than using a buffer bigger than you require.
Stride

• Understand stride – this allows for image cropping without copying memory
• We can pull lots of faces from a single source image without copying any image data, we need only keep a reference to the base frame.
Stride (step), used to allow matrices to use aligned memory.

When passing an image that allows stride, remember you do not have to copy memory to pass a cropped image.

Used in ROI functions in OpenCV.
GPU Acceleration of Detection

• Open CV already has OpenCL and CUDA accelerated Haar cascades, and also CUDA accelerated LBP.
• Enabling CUDA took ~2 lines of changes.
• 1) convert cv::Mat to cv::gpu::GPUMat
• 2) instantiate cv::gpu::CascadeClassifier_GPU
• From 89% cpu usage to 12%!
• Up to 7 video streams per CPU
Multi-Camera Face Recognition Appliance

+ GPU
What We Have Learned

• Database trials are useful but they are only a small part of the story
• You cannot fake bad data by degrading good data – H/T Jim Wayman
• Find problems that match the performance levels you can attain and work in the sweet spot
• Collect your own datasets
• UI design is crucial to user acceptance
Questions

Yes, Mr. Palmer, we here at Mega-Corp did try your "Face Recognition Software," and frankly, it didn't work worth a darn...
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