Video Surveillance

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Class 1: Introduction

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Class 1

• Outline
• Introductions
• Surveillance overview
• IBM Smart surveillance system
  – presentation & demonstration
• Surveillance system architectures
• Course structure & grading
• Project ideas
Andrew Senior
http://www.research.ibm.com/people/a/aws/

• Cambridge MA 1990, Ph.D. 1994
  – Offline handwriting recognition with recurrent neural networks
• Speech recognition research LIMSI, Paris
• Post-doc IBM
  – Online handwriting recognition (tablet PCs)
• Research Staff Member IBM
  – Fingerprint classification
  – Face recognition & detection
  – Audio-visual speech (lip-reading)
  – People tracking
  – Smart Surveillance System
Rogerio Feris

http://rogerioferis.com

- MSc. University of Sao Paulo, 2001 (Face Tracking)
- Ph.D. UC-Santa Barbara, 2006 (Multi-Flash Photography)
- Research Internships
  - Microsoft Research, 2001 (Gaze-aware Teleconferencing)
  - Mitsubishi Electric – MERL, 2003/2004 (Non-Photorealistic Camera)
  - IBM Research, 2005 (Multi-view Face Detection)
- Post-Doc IBM, 2006 (Face Analytics)
- Research Staff Member IBM - current position
  - Smart Surveillance System
  - Face Analytics, Object Classification, Abandoned Object Detection
YingLi Tian

• Ph.D. The Chinese University of Hong Kong, 1996 (Shape from Shading)

• Associate Professor, National Laboratory of Pattern Recognition, Chinese Academy of Sciences, China.
  – Lead the Computer Vision and Graphics Group

• Post Doctoral Fellow, Robotics Institute, Carnegie Mellon University, 1998 – 2001 (Facial Expression Analysis)

• Research Staff Member IBM - current position
  – IBM Smart Surveillance System
  – Facial Expression
Video Surveillance
Class 1:
Surveillance Overview

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Overview

• Surveillance technology progression
• Increase of surveillance
• Automation of surveillance
• <Demonstration of IBM SSS>
• Surveillance architectures
Video surveillance technology progression

- **CCTV**
  - Direct video from camera to monitor
- **Analog recording**
  - Record on VHS tapes (running slowly)
  - Time division multiplexing: e.g. 10 channels at 1fps
  - Manual tape changing every day
  - Reuse the tapes every month
  - Pull tapes to investigate incidents
Traditional system

- Daily tapes
- (time) Multiplexers
- Slow speed VCR
- quad multiplexers
- Switchable monitors
- monitors locked to channels
- PTZ controller
Progression: Digital Video recording

- Embedded/Linux/Windows device
  - 4-16-32 channels capture
  - Storage on hard disk
  - Encrypted
  - Access is password protected
  - More configurable
    - Buy bigger hard drives
    - Trade off space: duration/fps/channels/resolution
  - Instant access (from timestamp)
Progression: Networked Video Recorder

- More advanced DVRs may have
  - Network access for control
  - Record from ethernet
  - Better compression for static scenes
  - More configurable
  - Schedules (more detail during the day)
  - Motion detection
    - Alert and “record on motion”
  - Integration of inputs/outputs
    - Record on Infra-red (PIR) sensor
    - Steer PTZ on infrared sensor
  - Still ‘appliances’
Progression:
“Smart surveillance”

• Integrated IT infrastructure
  – Computer keyboard with reconfigurable, multi-monitor interface

• Video analytics
Increasing surveillance

• Rise of video
  – Security concerns
  – Cheaper & more powerful hardware
  – More capability
• “Ring of steel” in London 1990s
  – Response to IRA bombing
  – 4 million cameras in the UK .. in 2002
    • (Norris)
  – Expanding everywhere
Does surveillance work?

- Recordings frequently used for evidence
  - And for TV news broadcasts
- Deterrent effect on crime
  - Or a “balloon” displacement effect?
- “Force multiplier” is indispensable
- Is it cost-effective?
Video Surveillance

• Manual surveillance impractical
  – Increasing number of channels
  – lack of attention span
  – Increasing “situational awareness” needs
Video surveillance automation

• Have computers watch the video
  – Scalable
    • More channels: just buy more servers & licenses
      – Cheaper than people
      – People still have to deal with the (false) alarms
  – Indexing
  – Real-time alerts
Video Surveillance vs Automated analytics

Why is this car parked here? We should change our security policy

IBM S3 - Watches video & logs activity

- Show all red cars that drove North on 10 Ave over the last month
- Alert – car parked in loading zone > 5 mins
- Unusually low activity on 42nd street.
Commercial Use

• A huge growing field
• Major commercial market for computer vision
• Hundreds of companies doing analytics
Application domains

• Security & Operations
  – Public sector: city streets, airports, train stations
  – Secure facility protection
• Retail
  – “Loss” prevention
  – Understanding shopper behaviour
• Casinos
• Museums
Security

• Indexing everything that happens
  – For forensic investigation, after-the-fact
  – What happened?
  – Who did what?

• Instant alerts
  – Warning staff of “indicator behaviour”

• Watchlist of faces
Retail

- Loss prevention
  - Leads investment- already have “asset protection” departments, with cameras, DVRs
  - Manual tracking of “suspicious” people
    - Steering “Pan-Tilt-Zoom” (PTZ) cameras
  - Recording events for forensic investigation
  - Deterrence is as important as actually catching people
  
  - Need to automate the task & deal with specific “threats”
Retail

• Future applications
  – Operations
    • Monitoring queues
    • Counting customers
    • Measure “conversion rates” customers:sales
  – Marketing
    • Segmenting customers
    • Triggering direct marketing
Casinos

• Detect, record & index cheating/suspicious behaviour
• Find “valued customers”
• Banned or “watchlist” customers
Questions?
SSS Demonstration
Surveillance architecture

- Legacy systems architecture
- Future systems architecture
- Video sources
- Analytics (software) architecture
- Variations
System architecture

• Legacy CCTV systems
  – Analog video, coax cable
  – Central control room contains controllers, recorders, monitors, staff
Future system architecture I

• All IP
  – Possibly wireless (though that is subject to attack)
  – Possibly independent of data network for QOS needs
  – All data encrypted
  – Convergence of IT & security departments
  – Convergence of physical and electronic security
  – Central, dynamic, computer-based control
  – Increasingly automated
Future system architecture II

- Video storage and processing at the camera
  - DSP encodes, encrypts and interprets video
  - DSP on same wafer as imager
  - Video is not transmitted except when someone needs to view it
- Metadata in distributed clustered content manager
Video sources

• Analog cameras (NTSC/PAL)
  – To frame-grabber on computer
  – Via encoder box (e.g. Axis analog→IP)
  – Constrained ~ 640x480, 30fps
  – Control line for PTZ
  – Coax cable. Maybe multiplexed onto fiber optic

• IP cameras
  – Images direct to ethernet
    • Control over resolution, rate, compression
  – PTZ control over ethernet
  – Power over ethernet (1 cable)

• IR/Thermal, multispectral…
Analytics architecture

• A series of “modules”
• Our system uses a publish-subscribe architecture
  – Communication through a metadata queue
  – Modules are largely independent and using common protocols to allow recombination
Modularized video analytics

- Data (image) acquisition
- Object detection
  - Background subtraction
  - Motion-based
  - Model-based detection
    - Face, pedestrian, vehicle
- Tracking
- Alert detection
- Classification
- Colour indexing
- Recognition (faces, license plate…)
- Behaviour analysis
- Communication
Variations

• Steerable cameras
  – Pan, tilt & zoom
  – Very common in legacy systems
  – Less used in automation
    • Guarantee constant coverage
    • Analytics are easier with static cameras

• Mostly we assume static cameras
Variations

• Interacting cameras
  – Track from one camera to another
    • Overlapping or with gaps

• Other sensors
  – Increasing range of options
Course structure & grading