Video Surveillance

E6998-007

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

Andrew Senior

Rogerio Feris

Ying-Li Tian

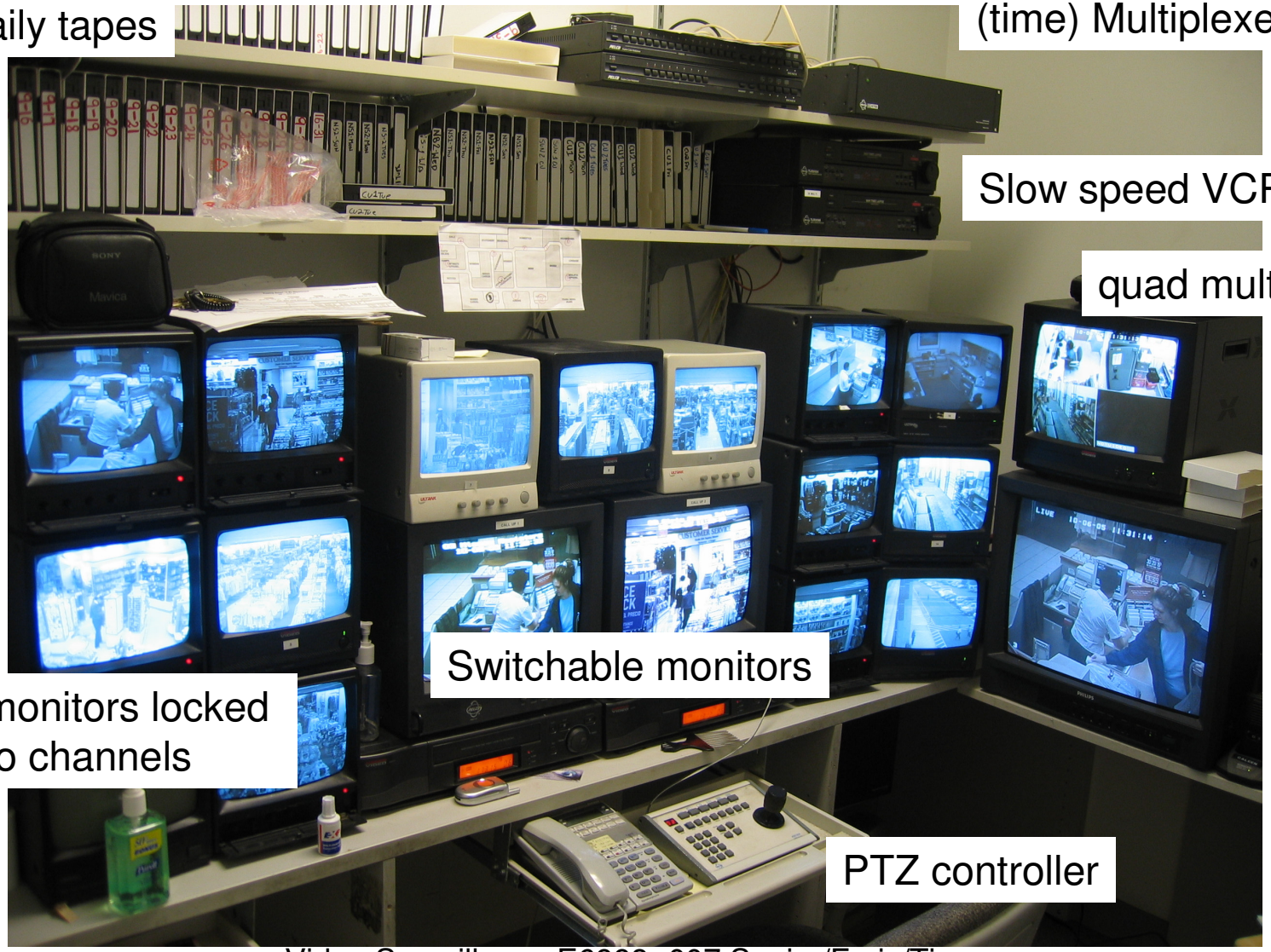
Overview

- 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



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

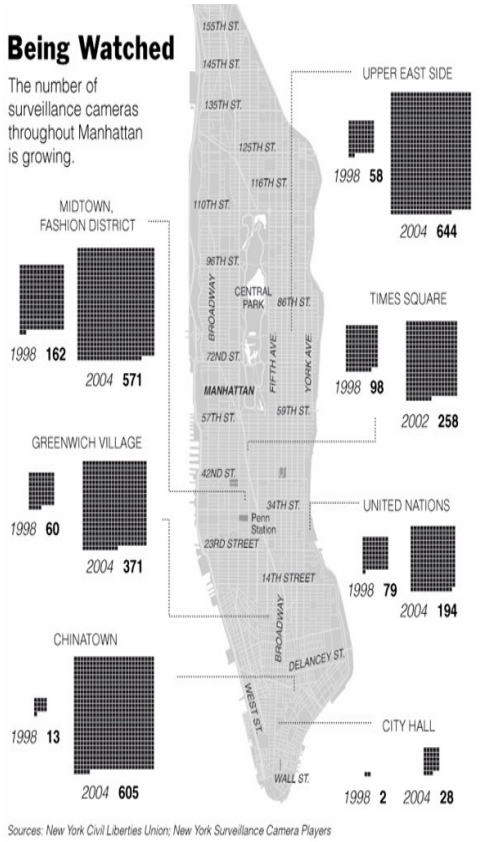
Increasing surveillance

- 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

Upper East Side Cameras

1998→ 58

2004 → 644



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

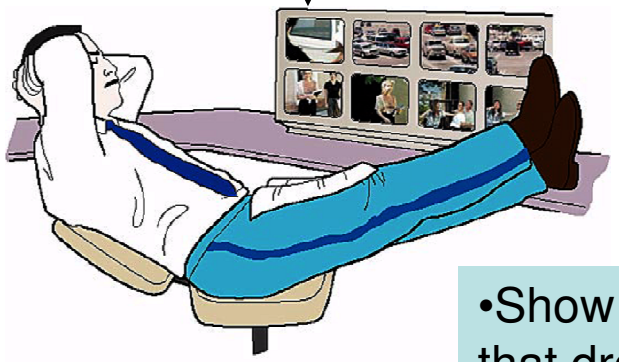


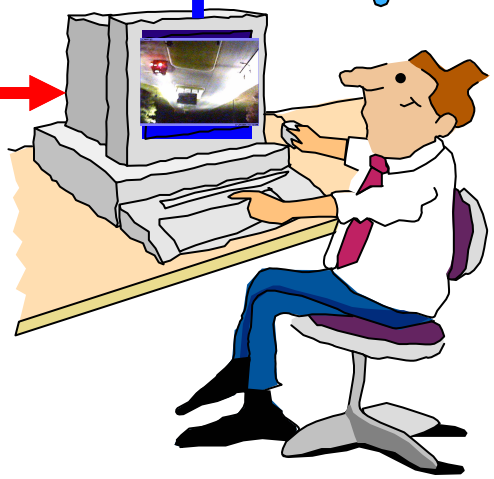
Exhibit 2.5. Monitori video output is a boring task and usually nonproductive in mo even for e motivated employee.

•Show all red cars that drove North on 10 Ave over the last month

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

•Alert – car parked in loading zone > 5 mins

•Unusually low activity on 42nd street.



IBM S3 - Watches video & logs activity

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?

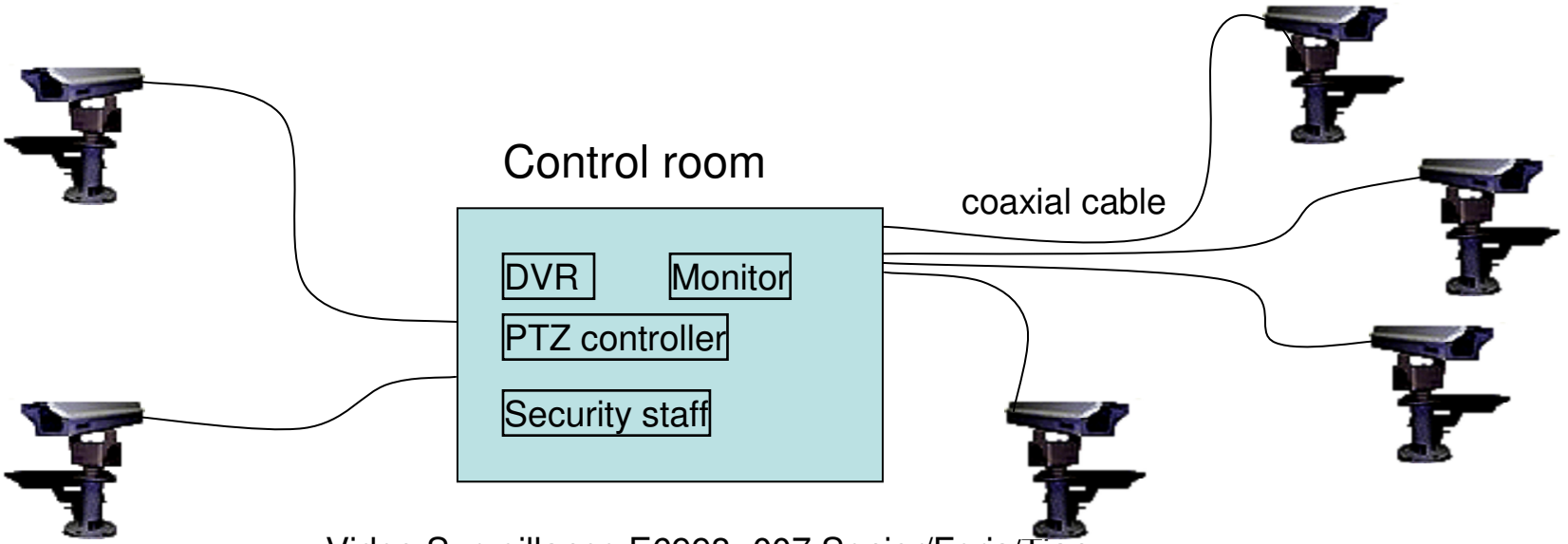
SSS Demonstration

Surveillance architecture

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

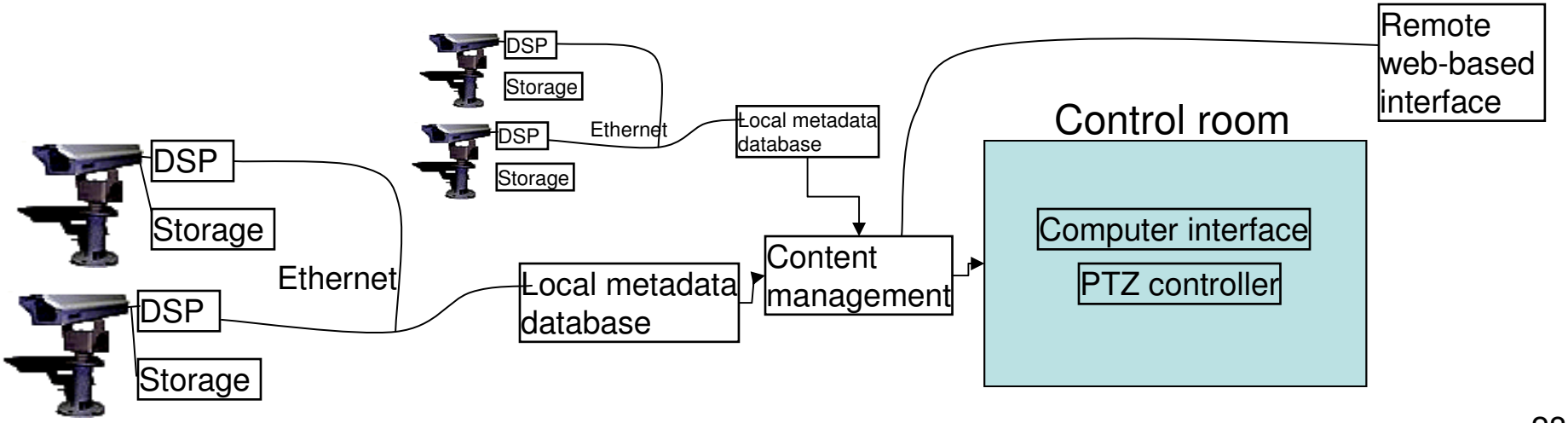
System architecture

- Legacy CCTV systems
  - Analog video, coax cable
  - Central control room contains controllers, recorders, monitors, staff



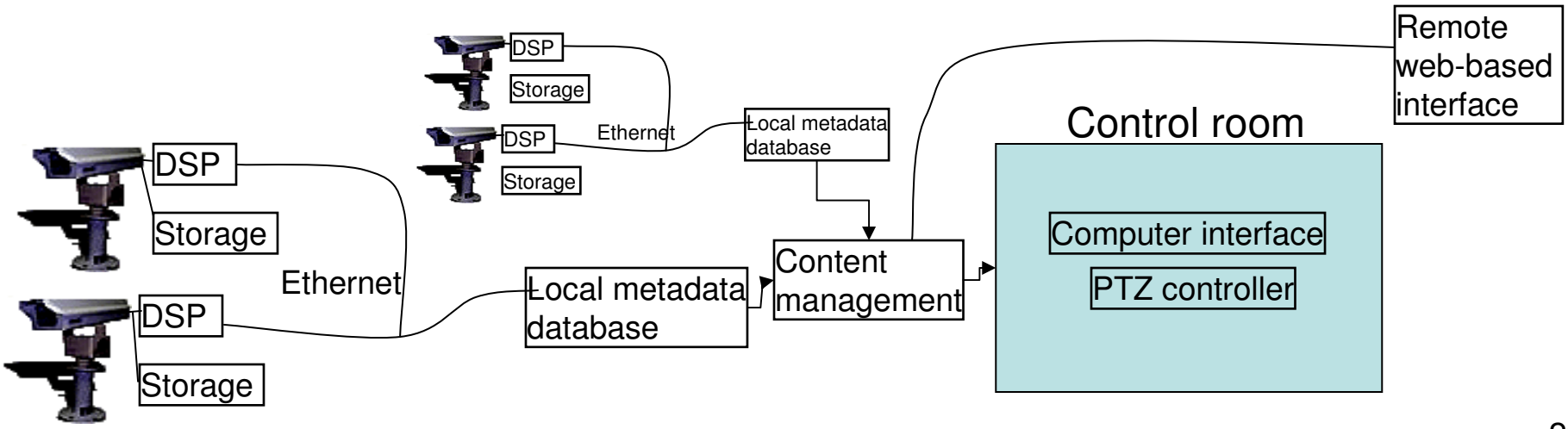
Future system architecture I

- 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

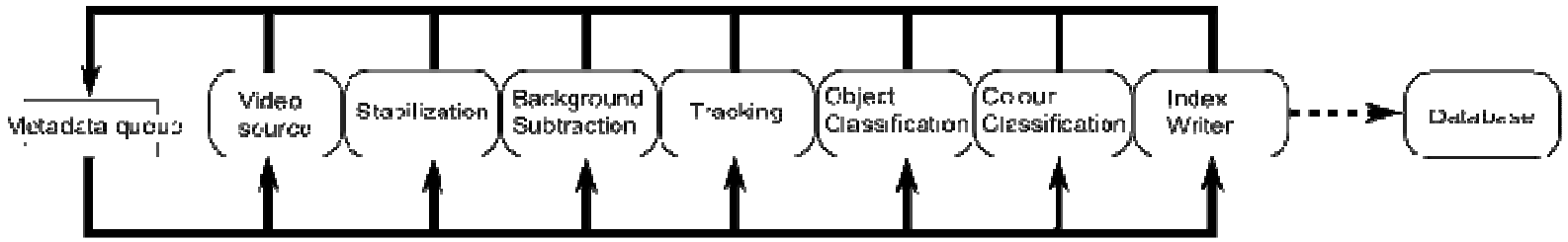


Video sources

- 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