Intelligent Video-Surveillance : from algorithms to systems

Human Activity and Vision Summer School (HAVSS) – Sophia Antipolis / 4th October 2012

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Content

Goal : Very large Video Surveillance systems are emerging today. This presentation attempts to present the needs, the constraints and the evolutions to be taken into account to develop Video Analysis tools suitable to exploit the video data provided by these systems.

Content :

- Thales : involvement in security systems
- Video-surveillance : definition and evolution
- Intelligent Video Surveillance
- Applications
- What is available today ?
- And for tomorrow ?
- Some words about cameras

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THALES - A technology leader providing safety and security

A global company with 67,000 employees and €13 billion in revenues

- We help our customers to:
  - Provide reliable and secure solutions
  - Monitor and control
  - Protect and defend
- In two major sectors

Thales: a reliable, long-term partner with operations in 50 countries

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THALES - A global player

67,000 employees in
50 countries

Global reach, local expertise

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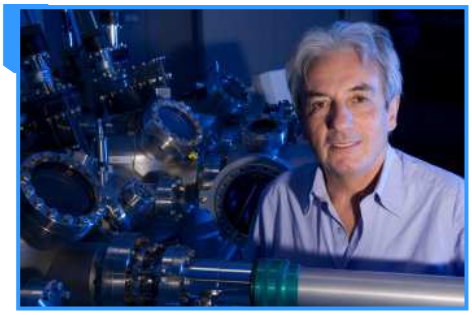
THALES - Innovation: a long-term vision

Strong commitment

- **R&D = approx. 20% of revenues**
- **Key technical domains**
  - Complex systems
  - Hardware (or enabling sensor technologies)
  - Software
  - Algorithms and decision aids
- **Open research**
  - International network of research centres
  - Cooperation with academic and government research institutes worldwide
- **Product policy focused on shorter development cycles and risk reduction**



Albert Fert, scientific director of the CNRS/Thales joint physics unit and winner of the 2007 Nobel Prize in Physics.

Inventing tomorrow's products today

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THALES - Security

Security

- Serving governments, institutional customers and civil operators
- Protecting
  - Critical infrastructures and borders
    - **Airports** (Dubai, Durban, , Doha, …)
    - **Rail transports** (Denmark, Singapore, Dubaï, …)
    - **Cities** (e.g. Mexico City)
  - Critical information systems
  - Sensitive data
- With integrated, resilient solutions

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THALES - Vision Innovation Platform

Backbone : CEA/LIST -THALES joint lab (Vision Lab)

Objectives

- Mature video analytics technologies from TRL 3 to TRL 5-6
- Benchmark and deliver video analytics components at MG with committed performances (incl. scalability)
- Support Design Authority in bids and projects

Platform

- Real time test environment (including indoor, outdoor and specific sensors) – Palaiseau, Singapore, Beijing
- Ground truth data associated with large corpus of videos (international, public, private, protected)
- Proof of concept for various use cases and environments

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THALES - Vision Innovation Platform

Technical roadmap

- **R&T themes**
  - Real time alert against predefined events,
  - Real time investigation (backward and forward tracking) on large network of cameras (fixed or mobile)
  - Investigation with heterogeneous non-synchronized input data
- **Applications**
  - Tracking individuals in crowded scenes with multiple cameras; video summary
  - Crowd monitoring / people sorting: density assessment, people counting, face recognition in a crowd
  - Unusual events recognition, automatic objects recognition, hidden objects detection

Video-Surveillance : definition

Video-surveillance : remotely watching public or private spaces (store, parking lot, airport, ...) using cameras.

two key purposes :

- **Providing human operators with images to analyze the situation, generally : to detect and to react to potential threats**
- **Recording evidence for investigation purposes (forensic)**

Video-Surveillance : definition

Domains

- City surveillance
  - Streets, places, public buildings, car parks
- Public transports
  - Train / Metro / Bus / Airports / Harbors
  - Infrastructures, platforms, vehicles
- Road Traffic monitoring
- Public events management
  - sport, pilgrimages, fairs, celebrations, demonstrations, ...
- Industrial sites and infrastructures
  - factory, warehouse, pipe-line, nuclear site, ...
- Defense, Border surveillance
- Maintenance of critical sites
- Commercial centers
- Health - Assistance to the person

Video-Surveillance : definition

Missions (list of examples is far from being exhaustive) :

- Security : protect against crime and terrorism
  - Protect ATM (suspect behaviors, robbery
  - Detect fighting
  - Investigate and gather legal proofs
- Safety : protect against accidents
  - Detect Over crowding
  - Detect slip and falls
  - Detect people on rails, on roads
  - Detect Incidents / dangerous behaviours on roads (AID)
  - Detect Smoke / fire
- Law Enforcement : Protect against vandalism and fraud
  - Detect vandalism and fraud
  - Detect illegal parking,
- Marketing

Video-Surveillance : evolutions

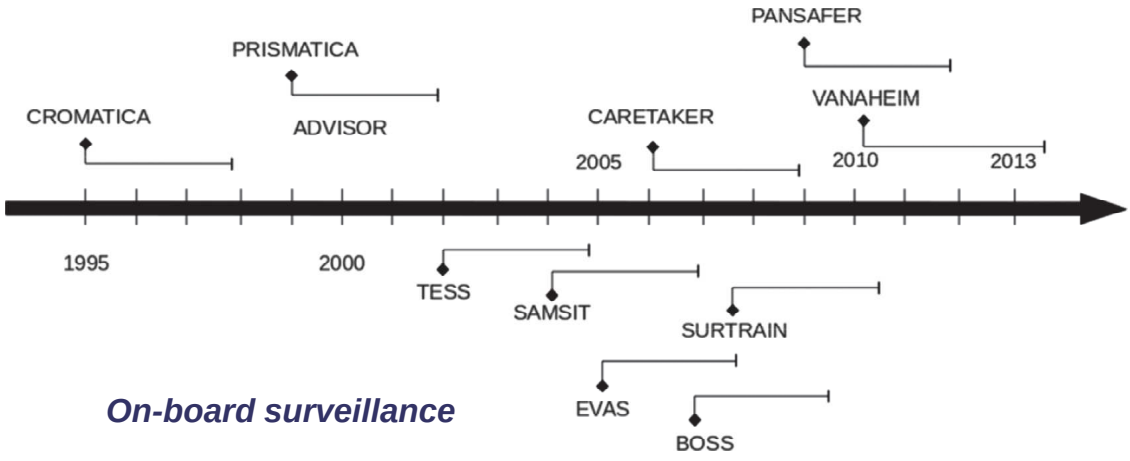
3 major phases :

- **1970's : Beginning of development**
  - Analogue systems, video tapes
- **First boosting during 1990's**
  - Highly pushed by digital technologies (DVRs)
- **Huge expansion of Video-Surveillance after early 2000 events :**
  - governments have made personal and asset security a priority in their policies.
  - Deployment of large CCTV systems : several thousands cameras
  - Major research domain and commercial market for computer vision :
    - Many collaborative funded projects,
    - Many scientific international workshops / seminars / papers …
    - Hundreds of companies created
  - Enabled by evolution of technologies (networks) : digital images, compression, use of IP, …

Video-Surveillance : evolutions

- **Example : Collaborative projects in transport domain (EU / F)**

On-board surveillance



On-board surveillance

Source : Intelligent Video Surveillance Systems, Chapter 2 : Focus on transport system (S. Ambellouis and J.L. Bruyelle), to be issued by end 2012, publisher : ISTE/WILEY

(French version (Outils d'anlyse vidéo) : publised by Hermes)

Why Intelligent Video-Surveillance ?

Issues :

- The number of cameras is continuously increasing
  …. not the number of security agents
- Human limitations :
  - Human operator cannot maintain an acceptable level of attention for long time
  - Sifting through large collections of surveillance videos is tedious and error prone for a human investigator.

⇒ **Manual surveillance becomes impractical**

→ **Needs for "situational awareness" to assist people:**

- in surveillance tasks:
  - the computers watch the video and produces real-time alerts
- In post-analysis tasks :
  - by Indexing video with metadata to ease research
  - By offering video analysis-based exploration tools

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What is available today ?

Simple applications : environment is not too complex and/or well mastered

- Intrusion detection
  - Presence of somebody in a forbidden zone
  - Somebody enters a protected area through forbidden way
- Automatic Number Plate Recognition
- Detection of abnormal behaviors (mainly loitering)
- Counting (people, vehicles, lorries, …)
- Abandoned luggage (not crowded scenes)

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What is available today ?

Involved technical functions

- Detection of Motion / Change / Objects (eg head, face, silhouette, number plate)
- Tracking
- Object Classification (people / Car / Lorry / …)

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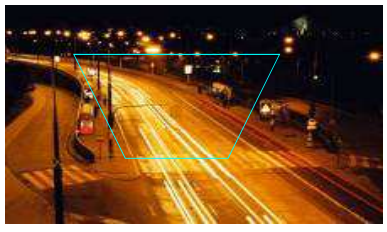
What is available today ?

Which enables following applications:

- Road / Tunnel Traffic Management - AID
  - Stopped vehicles
  - Wrong Way
  - Pedestrian Detection
  - Debris Detection
  - Smoke & Fire
- Car park access control
- Free flow systems on motorways using multiple sensors
- Detect intrusion on protected sites (“sterile zones”)

Example: Citilog



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What is available today ?

Some solutions are proposed for following applications:

- Detect intrusion on protected sites
- Detect people crossing / jumping / going / falling on rails
- Surveillance of tube doors closing (in station doors, wagon door)
- General railways protection (cars blocked on a level crossing)

But : there is no large scale deployment of these solutions at the time being

And for tomorrow ?

Extend the domain of application of existing techniques

- More variability in considered scenes
- More complex scenes (crowd, activity)

Facilitate their deployment

- Simplify configuration of algorithms
- Automatic or weakly assisted camera calibration
- Assess the needs for calibration (=> measure calibration error)
- Master sensitivity to scene/acquisition parameters (scene complexity, orientation, resolution, ….)

Extend scalability

- Processing architectures (GPUs ?)
- System / network architecture (distributed system ?, processor virtualization, cloud computing, edge computing)

And for tomorrow ?

Develop and validate new applications

- **Crowd monitoring**
  - Detect crowd formation / dispersal
  - Count people, Estimate density
  - Detect stampedes
- **Automatic detection of abnormal / unusual behaviour**
  - Individual / group / crowd levels
  - Already some solutions at research level (eg IDIAP) and COTS (e.g. iCetana)
- **Track all objects across network of cameras**
  - In relation with map of monitored area
  - To detect events / record metadata / present a synthetic situation map
- **Track an object across a network of cameras**
  - Object « Re-identification » (object signature, face recognition, gait analysis ?)
  - Track in crowded scene
- **Tools for post-analysis (e.g. Video Synopsis)**

And for tomorrow ?

Example: Video Synopsis

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And for tomorrow ?

Validate functionality and Evaluate dedicated solutions:

- **Validate the functionality**
  - Simulate the function embedded in the system
  - Train the operators to use such functions
- **Test candidate solutions (algorithms) with representative data**
  - Simulation including synthetic image generation
  - Test bed in true environments

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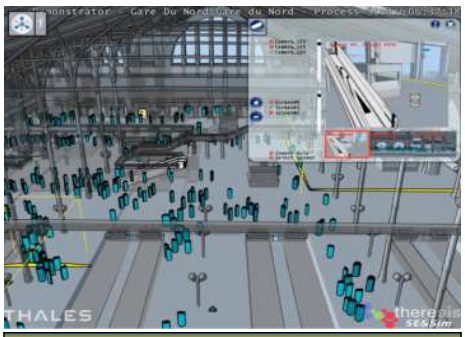
And for tomorrow ?

Example for system simulation

SE-STAR

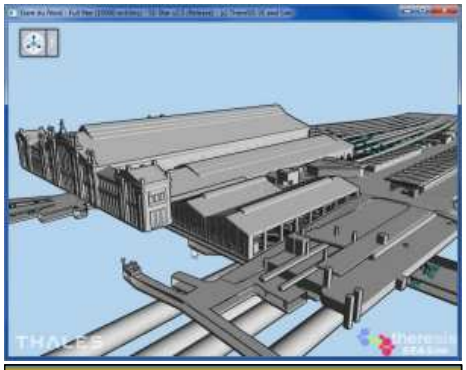
(Thales)



Passenger flows simulation

CCTV Operator Training (VR)

Equipments and people Simulation



Critical Infrastructure Simulation

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Cameras

Constraints :

- **Costs :**
  - Unitary costs : trade-off between cost and performance
  - Global cost : minimize the number of cameras
    → PTZ (Pan, Tilt, Zoom)
    → Wide FoV, High Definition
  - Deployment (Cabling, Interfaces, Encoders, Power Supply)
- **Time coverage : 24/24 , 7/7**
  - Day / Night capacities
- **System integration : Cameras are system components using existing networks:**
  - Evolution from analogue to digital, IP interface
  - Communication bandwidth is limited : needs for image compression
  - Inter-operability / inter-changeability
    - standardisation actions (ONVIF, PSIA)
    - Compression standards (H264)
    - Communication protocoles (RTP, RTCP, RTSP)

Cameras

Image Formats :

- **Many formats are available (TV and multi-media worlds)**
  - On-going: Evolution to Megapixel : HD (1MPx) and Full HD (2Mpx)
  - Tomorrow : evolution to « Multi-Megapixels » (> 16 Mpixels) ?
- **Megapixel formats may be used to :**
  - Provide resolution for recognition / identification tasks :
    - Automatic Number Plate Recognition
    - Face / IRIS recognition
  - Enlarge the FoV (-> panoramic, fish-eye)
  - Implement a « digital PTZ » function
    - Low resolution to detect
    - High resolution to identify

Example : Antares

- Thierry Midavaine: ANTARES, A New Land Situational Awareness System, OPTRO 2012-008,, Paris, France / 8–10 Feb 2012

- Designed for military applications
- Very wide field of view " supra fish eye" 360°x 210°
- Very high resolution : 5.5 M Pixels
- Low Noise (less than 2e-)

- **Other existing products (eg immervision)**

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Smart Cameras :

- **Goals**
  - Process images before degrading them for compression
  - Get rid of network bandwidth limitations by delivering only pertinent information (metadata, areas of interest)
  - Digital PTZ
- **Solutions :**
  - Video-surveillance cameras with embedded « VMD » (Video Motion Detection)
  - Camera + DSP-based compression board
    - Dedicated processors (Da Vinci, Mango DSP, …)
    - Compression + video analysis
  - Cameras with integrated UC
    - Computer with Linux , possibly with co-processor (FPGA, ASIC)
    - Enables the user to integrate high level algorithms

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News Images

- **Thermal cameras**
  - Day/night capacity,
  - Uncooled micro-bolometer technology, now affordable for civilian applications
  - Resolution complies with video-surveillance needs (today : 640 x 480, near future : 1280 x 1080)
- **SWIR cameras**
  - Day/night capacity (outdoor)
  - Coupling with eye-safe laser
  - Better vision through fog and dust
- **3D sensors**
  - Technologies : structured light patterns, Time of Flight, Stereo-Vision, pushed by video games (e.g. Kinect) and Automobile
  - Short range : few meters
  - Applications : access control (gates), counting

Scene measured in the 1.4–1.8 µm spectral band on a moonless night (© Onera 2010

Thank you for your Attention