Video and Signal Processing for Telecommunication

Structure and Industrial Experience
Department Board

Head of Department

Prof. Matteo Pastorino
Director

Prof. Andrea trucco
Vice-Director

Administrative Officer

Dr. Franco Gabrielli
Administrative Officer

Locations:

**Genoa:** Via Opera Pia 11/A - Via Opera Pia 11 - Via Rodi 1

**Savona:** Via Cadorna 7 (Campus)
Research team, leaded by Prof. Regazzoni, is composed by:

- 7 PhD Students
- 4 Research Grants
- 6 External collaborator
ISIP40 – Expertise

- **Communication and Cognitive Radio Area:**
  - Radio-Mobile Channels Modeling
  - Terrestrial, Satellite and Indoor Communication Systems Simulation
  - Signal Processing for Cognitive Radio Systems
  - Advanced Pattern Recognition, Automatic Decision and Reasoning for Cognitive Radio Systems
  - Signal Processing for Advanced Localization Systems

- **Video Processing and Ambient Intelligence Area:**
  - Advanced Processing Techniques for Video Sequences
  - Advanced Tracking Techniques for Moving Objects through Video Sensing
  - Automatic Context Recognition and Classification for Video-surveillance Systems
  - Automatic Context Recognition and Classification for Smart Spaces
  - Advanced Pattern Recognition, Automatic Decision and Reasoning for Smart Spaces
  - Cognitive Systems modeling for Security Applications
Teaching Activity

- BS courses (TLC): 1 (Tecniche e Sistemi di Trasmissione Fissi e Mobili)
- MS courses (TLC and EO): 5 (Comunicazioni Mobili 1, Elaborazione di Immagini 1, Sistemi di Comunicazione Mobile 1, Sistemi di Telecomunicazione 1, Sistemi Cognitivi per le Telecomunicazioni 1)
- Teaching Activity addressed to high level training courses:
  - PhD course in Sistemi e Servizi Cognitivi per l'Intelligenza di Ambiente e le Telecomunicazioni
  - Courses related to the integrated II° level University Master in “Tecnologie avanzate per Sistemi Intelligenti Integrati” – Security field
    - “Data Fusion” course
    - “Cognitive System for physical security” course
Born in November 2005, Ambient Awareness Lab (A2Lab) joint laboratory is a permanent research partnership between DIBE and the Genoese company TechnoAware s.r.l. for empowering research, education and technological transfer in the field of integrated data and image acquisition and processing systems for Ambient Intelligence.
The joint laboratory context awareness and autonomic network is a cooperation between Telecom Italia and the Department of Biophysical and Electronic Engineering of University of Genova (DIBE)
The joint laboratory Cognitive Radio Laboratory is a cooperation between two DIBE research groups that aims at carrying out research on various aspects (radio transmission and electromagnetism) of the Cognitive Radio discipline.
The joint laboratory SELEX / UNIGE is a cooperation between SELEX and University of Genoa. One of the research groups is a cooperation between ISIP40 and SELEX that aims at carrying out research on wireless WiMAX-based wide-band systems for civil and military applications.
Within the “Distretto Tecnologico per i Sistemi Intelligenti Integrati” financed by Ligurian Region the ISIP40 group participates in the “Physical Security” research line.
Industrial Project Proceeds in the last two years:

- 2005 – 421 KEuro
- 2006 – 629 KEuro
- 2007 – 799 KEuro
- Giu 2008 – 274 KEuro
Video and Signal Processing for Telecommunication

Scientific Activity and Publications
Fourth Generation Wireless Systems

- Terminals should be
  - Multi-modal
  - Multi-standard
  - Reconfigurable
  - Dynamic
  - All-in-one

- Software Radio, Software Defined Radio and Cognitive Radio are developed to answer to such requests
Such new vision is based on terminals which are able to **automatically adapt to the radio environment**

A CR is able to **learn, as a cognitive biological entity**, from past experience

This leads to a terminal **whose physical layer is completely reconfigurable** and able to adapt on the basis of the wireless channel conditions, the traffic on the network or according to preferences / requests of the final user.
By leveraging the expertise within the Group, an approach has been proposed to address some of the issues open CR, involving different levels of the architecture.

- Adaptive antennas
- Radio Propagation
- Advanced Signal Processing
- Machine Learning
- Distributed Systems
- Data Fusion
- Behaviour modelling
- Signal interception
- Physical Reconfigurability
- Waveform Adaptation
The Cognitive Cycle

Reconfiguration of the system

Channel and internal state estimation

Data processing to obtain a concise description of the environment

Sensing

Action

Decision

Analysis

E

Reconfiguration policy choice
Knowledge Representation

- Any cognitive entity which is immersed in the physical world has its own inner representation that allows the entity itself to interact with it.
- This knowledge of the physical world is described inside the cognitive entity through **cognitive maps** that link the physical world with the internal representation of the knowledge.
Cognitive Maps

**Perception map:** provides information on how to view the world through every point in space.

**Decision map:** describes the policy of optimal reaction in every point in space.

**Action map:** describes how to implement in the most appropriate way the decision taken at any point in space.

**Analysis map:** allows the cognitive entity to obtain a semantic representation of the external environment.
Example: Cognitive Terminals Map

- In a specific case, namely the mode identification between WLAN and Bluetooth signals in an indoor environment, analysis maps have been used in the process of mode classification by two cooperative cognitive terminals.
Example: distributed classification

- The maps were then used in the classification process of the transmission mode from the cooperative terminals.

- The operational steps are as follows:
  - Listening to radio channel
  - Watching the Companion and extraction of its position
  - Estimate of how to classify the companion through analysis map
  - Distributed Bayesian Classification

From the observation, Bluetooth is detected instead.

However, WLAN is not correctly decided there.

WLAN should be decided.

Bluetooth Source

WLAN 802.11b Source

Bluetooth Source

WLAN should be decided

From the observation, Bluetooth is detected instead

However, WLAN is not correctly decided there

WLAN 802.11b Source
Bio-Inspired Learning: Embodied Cognition

- Which approach to cognition? **Embodied Cognition**
- Approach based on the evolution of biological entities
- The communication system considers internal and external state and evaluates the mutual interactions
- Learning based on autobiographical memories
- Optimization of system performance through genetic algorithms that operate using acquired experience
- Integrated and modular approach to optimize joint and cross-layer system
Smart Antennas

- Smart antennas are intelligent radiating systems that employ an array antenna along with a dedicated chip (DSP or ASIC) for the optimization of the transmission or reception characteristics according to the environmental conditions.
- Example of application to cellular systems: cognitive base transceiver station (CBTS).
- Through a sensing antenna with azimuth scanning, the system captures information on the position and transmission mode of mobile users.
- The analysis of such information allows to make decisions on band allocation, antenna configuration, transmission parameters, etc.
Cognitive Radio and Cognitive Antennas

Advanced techniques for the adaptive and cognitive beamforming

Advances signal processing techniques

Artificial behavioural systems modelling, advanced techniques for the representation of knowledge and learning
In the context of CR a fundamental procedure will be the identification of the standard / modulation present in the monitored environment.

Some of the methodologies tested by the group in this area are:

- Time-Space-Frequency Analysis
- Wigner and Choi Williams Transforms
- Parametric and Non Parametric Classification
- Bayes
- K-NN, Parzen Windows
- Neural Networks
- Support Vector Machines
- Centralized or Distributed Classification
- Stand-alone or cooperative models
- Cyclostationary analysis
- MIMO and Virtual MIMO signal interception
Propagation Models

- The design of high-performance wireless systems requires accurate knowledge / simulation of electromagnetic field in complex environments.
- Different models can be considered for the study of channel, with variable complexity and accuracy: deterministic models for the estimation of path-loss (ray tracing, FDTD, FEM, MOM, ANN) and statistical methods for the estimation of the small-scale fading (Rice or Rayleigh multipath, ...)
- The propagation models are of particular interest for the simulation of the various links radio in complex environments (eg Cognitive BTS in a vehicular case).
Example: Cognitive Cycle for Vehicular Communication

- **Sensing**
- **Analysis**
- **Action**
- **Decision**
Cognitive Radio Applications

- Smart Antennas
- Adaptive Beamforming
- DoA

- Cyclostationary Analysis
- Time-Frequency Transformation

- Feature Extraction
- Dynamic link Reconfiguration

- Reinforcement Learning
- SVM
- Artificial NN
- Fuzzy Classifiers
Video Processing and Ambient Intelligence Area
Multi-cue Adaptive Particle filter-based Tracking

- **Particle filter** techniques allows one to perform recursive Bayesian filtering in non-Gaussian non-linear situations.

- **Multiple hypothesis** of the state are propagated in time according to the system transition dynamic and they compared to available observations.

- The state is modeled as the position of a set of corners (point of the image with high curvature) representing the shape of the object to be tracked.

Image: Diagram showing multiple hypotheses and corner observations.
Multi-cue Adaptive Particle filter-based Tracking

- **Local appearance** information (color) of the corner is used to model the motion of each corner by using a Mean Shift tracker.
- The comparison of the motion of each corner with respect to the mean motion of the object is used to take into account object **deformations**, **scale** and **pose changes**.
Model based video object tracking

- Probabilistic Bayesian framework for object tracking
- Corner-based shape model representation of the object
- Local descriptors for enriching each shape element
  - Gradient of each corner
  - Histogram of gradients about each corner
  - Undecimated Wavelet Packet Transform coefficients about each corner
Model based video object tracking -EXAMPLES-
Collaborative Tracking

- Motivation: the contemporary presence of multiple interacting objects can be a source of
  - Identity exchange
  - Coalescence
- Proposed solution: **Collaborative tracking**
  - Trackers are in charge of interaction awareness
  - Probabilistic approach to collaborative estimation of shape and position
  - Based on the *exclusion principle*: an observation can’t have been generated by more than an object
- Results:
  - Improved position estimation
  - Capability to update the target model also during its interaction with other objects
Collaborative Tracking -EXAMPLE-

- Observations must be shared by objects, both for position estimation and model updating.
- Trackers exchange information about their understanding of the scene and in particular:
  - Reliability of the estimated position
  - Information about the ownership of the measurements

Legend
- Solid line: bounding box
- Dashed line: spatial extent of object model
Movement based Tracking

- Motivation: structured background can lead to tracking failure
- Idea: include movement information to improve position estimation and avoid the tracking failure
- Proposed solution: use the information of shape temporal deformation to distinguish the tracked object from the background.

Pro:
- Deformation already computed by the tracking algorithm during the model update
- Easily extended to the case of non-static background
- In case of multiple object tracking, by using a collaborative tracking algorithm, it is possible to consider for the estimation, only the features generated by the tracked object
Movement based Tracking -EXAMPLES-

- Result: a control algorithm has been realized, which, by exploiting temporal deformation information, allows a better position estimation in case of cluttered background.

Legend
- Solid line: bounding box
- Blue dots: observations (corners)
- Red dots: observations used during model reinitialization (only for movement based tracker)
**Video Radio Tracking**

**Video – Radio Fusion**: robust tracking exploiting complementary properties of radio and video signals

- **Video**: greater spatial precision vs. lack of performance in case of occlusion
- **Radio**: lacking spatial precision vs. occlusion robust

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Radio Localization + ”robust” ID (MAC/IP)  
Video Tracking
Video Radio Tracking

Proposed Architecture

Radio Calibration

OFF-LINE

Video Calibration

OFF-LINE

Radio Map

Data Fusion
&
State Estimation

Time recording

Video Map

X

ID
Radio Tracking

Linear - Gaussian Prediction model:  \[ x_k = F_k x_{k-1} + G_k \omega_k \]

Likelihood:  \[ p(z_k | x_k^i) = \prod_{h=1}^{N_{AP}} p(RSS_k^{AP_h} | x_k^i) \]

Assumption: Independent radio measures between AP

Non linear / non Gaussian Observation Model:

Radio observations:  \[ z_k = (RSS_k^{AP_1}, RSS_k^{AP_2}, RSS_k^{AP_3}, \ldots) \]
Video Radio Tracking

Probability Hypothesis Density (PHD) Filter: target number estimation + state
Evolutionary Image Processing

Tools:
- Genetic Algorithms
- Neural Networks
- NeuroEvolution

Goals:
- Optimal camera placement and real-time orientation
- Background analysis and feature classification
- Shape extraction for tracking and classification
Evolutionary Image Processing -APPLICATION-

GA for Optimal camera placement and real-time orientation

- Inspired by natural evolution
- Population of individuals
  - Individual is feasible solution to problem
- Each individual is characterized by a Fitness function
  - Higher fitness is better solution
- Based on their fitness, parents are selected to reproduce offspring for a new generation
  - Fitter individuals have more chance to reproduce
  - New generation has same size as old generation; old generation dies
- Offspring has combination of properties of two parents
- If well designed, population will converge to optimal solution
Evolutionary Image Processing

Conceptual Algorithm

1. Initialize Population
2. Evaluate Fitness
3. Satisfy Constraints?
   - Yes
   - No: Randomly Vary Individuals
4. Select Survivors
5. Output Results
Performance Evaluation for:

- Bandwidth
- Computational resources allocation
- Events detection
- Ground truth match
Introduction

- Hand-based Human Computer Interface (HCI) should meet the requirements of real-time, accuracy and robustness.
- The purpose of Haar-like features is to meet the real-time requirement.
- The purpose of the cascade of AdaBoosted (Adaptive boost) classifiers is to achieve both accuracy and speed.
- The algorithm has been used for face detection which achieved high detection accuracy and approximately 15 times faster than any previous approaches.
- The algorithm is a generic objects detection/recognition method.
Ada Boost-based Haar Classification

Haar-Like Features

- Each Haar-like feature consists of two or three jointed “black” and “white” rectangles:

  ![Image of basic Haar-like features]

  Figure 1: A set of basic Haar-like features.

- The value of a Haar-like feature is the difference between the sum of the pixel gray level values within the black and white rectangular regions:

  \[ f(x) = \text{Sumblack rectangle (pixel gray level)} - \text{Sumwhite rectangle (pixel gray level)} \]

- Compared with raw pixel values, Haar-like features can reduce/increase the in-class/out-of-class variability, and thus making classification easier.

![Image of extended Haar-like features]

Figure 2: A set of extended Haar-like features.
Ada Boost-based Haar Classification

Application: Cars Multi-Tracking

- Performance evaluation of Haar classifiers through graphic analysis tools (ROC curves)
- Parameters selection in order to optimize the ratio between training time and efficiency
- Training set analysis to extract a set suitable to similar cases
- Testing on heterogeneous “real” video sequences to evaluate trained classifier performance
PTZ Controlling

✓ Two cooperative cameras to achieve high resolution tracking

Wide Field Camera
- Low resolution

PTZ Camera
- High Resolution

Communication Infrastructure
Communication Protocol: UDP

Advantage:
✓ Speed for real time applications
✓ low overhead

drawback:
✓ No guarantee concerning the packet receiving
Context-based content/service adaptation

- Environment Data
- Internal Data

User Profile
- Service Usage
- External Providers

User support
- Services on demand
- Context-based services

Self Decision
- Common Decision with higher levels

ACTION  SENSING  DECISION  ANALYSIS

ACTION  SENSING  DECISION  ANALYSIS
Virtual Guide interaction in terms of Cognitive Cycle decomposition

Context-based content/service adaptation

-EXAMPLE-
Cognitive Surveillance

-IV GENERATION SYSTEMS-

System Architecture

Environment Layer

Interaction with the environment

Network layer

Operator layer

Learning

Analysis

Decision

Action/Comm

HUB

Network access

Local processing layer

modem

ADSL ISDN

Cable modem

UMTS

Interaction with the environment
Technical conditions:
- Integrated smart systems at different scales
- Adaptive ICT systems
- Emulation of intelligent natural systems thanks to neurosciences inspection/recording tools

Advantages:
- Analysis and decision (bio-inspired) theories and techniques, e.g. cognitive cycle
- Systems context adaptivity thanks to learning techniques
- Attention focusing extended to anomalous interaction

Limitations/Problem:
- Not still optimal integration between decision and action levels
- Limited prediction capabilities, only for low level cycles (reflex cycles)
The cognitive cycle will be applied to create processing nodes characterized by smart capabilities (e.g., track a person, identify a specific tag at a gate).

These nodes will be able to acquire data coming from the environment and from occurring interactions between entities and will take advantage of extended reasoning and analysis capabilities similar to the human operators' one.
A learning phase is present in this kind of systems.

The information so acquired are used to support the operators in the decision and action phases.

The decisional phase has the characteristic to be multilevel.
Low level decisions are taken in an automatic way by the system.

High level decisions are taken by operators in the control room with the support of the system.

In this generation the interaction with operators plays an important role.
The aim is to iterate the system architectures shown before, creating a multilevel architecture.

In this way the spatial perception is augmented.

The data coming to the higher levels are with a higher semantic content.
Cognitive Surveillance

Guard – Thief Scenario

- Detection of the intruder
- Tracking of the intruder
- A cognitive node will activate an operator, describing on his mobile terminal the characteristic of the intruder:
  - Position
  - Weapons detention
  - …
- The operator will be supported in his actions
All the players are modeled through a bio-inspired model.

System acquires information about the interactions between:

- System – Operator (cooperative interaction)
- Operator – Competitor (competitive interaction)

The actions of the system correspond to the messages sent to the operator.
Preventive Transport Security/Safety

- Increasing transport vehicles/infrastructures security/safety level
- Fusion of heterogeneous available data related to
  - External context
  - Vehicle/infrastructure state
  - Internal context

With the aim to:
- Warning: assistance tools able to alert the transport system about future possible dangerous situations
- Debriefing: tools for intelligent a posteriori analysis of situations of interest indexed over automatically detected anomalous interactions
Fixed Sensors for Automotive Applications

**Domain**
- Tunnels Safety
- Traffic Monitoring
- ...

**Objective**
- Vehicles Tracking
- People/Vehicles Classification
- Stationary Vehicles Detection
On-Board Sensors for Automotive Applications

- **Autonomous survival:**
  Communication with external structures is not strictly necessary

- **Subjective perspective:**
  Data are acquired in a driver centered perspective (driver and sensors are placed in similar spatial-temporal positions)

- **Connection with human reaction:**
  Coherence of perception allows easier causal relationship (in space and time) with driver actions to be used for scene analysis
On-Board Sensors for Automotive Applications

- Road detection
- Vehicles detection
- Face detection and tracking
- Vehicles tracking and distance estimation
Example: Speed – Distance Correlation
Distance – Speed correlation for prediction or anomalies detection

- **Internal status**
  - Speed of the vehicle
    \[
    X_p = \text{Speed} \ [m/s]
    \]

- **External status**
  - It depends from the distance between the vehicle and the vehicle before
    \[
    X_C = Kd^2
    \]
  - Where \(d\) is the distance expressed in meter
Distance – Speed correlation for prediction or anomalies detection
Abnormal event detection

The abnormal event detection can be used for two targets:

- **A posteriori analysis**: elaborating data acquired from a “black box”
- **Risk prevention**: alerting the driver about the danger
Speed – Distance: anomaly detection/decision

A threshold has to be fixed

Over the threshold an event is considered normal
Under the threshold an event is considered abnormal

In the particular case it can be noticed that:
- First event: Distance reduction (16-14);
- Second event: Drastic speed reduction (25-15);
- Third event: Regular reduction of the distance (14-12);
- Fourth event: Refining of the speed regulation (15-15);
Book Contributions

Video-Based Surveillance Systems
Computer Vision and Distributed Processing
edited by Paolo Remagnino (Kingston University, London), Graeme A. Jones (Kingston University, London), Nikos Paragios (Siemens Corporate Research).

Advanced Video-Based Surveillance Systems
edited by Carlo S. Regazzoni (University of Genova, Italy), Gianni Fabri (Italtel S.P.A, Milano, Italy), Gianni Vernazza (University of Cagliari, Sardinia, Italy)

Multimedia Video-Based Surveillance Systems Requirements, Issues and Solutions
edited by Gian Luca Foresti (Computer Science Dept., University of Udine, Genoa, Italy), Petri Mähönen (VTT, Technical Research Center of Finland and University of Oulu, Finland), Carlo S. Regazzoni (University of Genova, Italy).

Multisensor Surveillance Systems
edited by Carlo S. Regazzoni (University of Genova, Italy), Gian Luca Foresti (Computer Science Dept., University of Udine, Genoa, Italy), Pramod K. Varshney (Dept. Electrical Engineering and Computer Science, Smith College, Syracuse University)
Prof. Carlo Regazzoni has been **guest editor** of the following Special Issues:

**PROCEEDINGS of the IEEE**
*Volume 89, n.10, October. 2001*

**THIRD GENERATION SURVEILLANCE SYSTEMS**
with G.L. Foresti (University of Udine, IT) and V. Ramesh (Siemens Corporate Research, USA)

**IEEE Signal Processing Magazine**
*Volume 22, number 2, March 2005*

**SURVEILLANCE NETWORKS: LOOK WHO’S WATCHING**
with K. N. Plataniotis (University of Toronto, Canada)

**Eurasip Journal on Image and Video Processing**
to appear in 2008

**VIDEO TRACKING IN COMPLEX SCENES FOR SURVEILLANCE APPLICATIONS**
with A. Cavallaro (Queen Mary Univ., U.K.) and F. Porikli (MERL, USA)
Publications


Publications

Organized Conferences

IEEE - ICIP 2005
International Conference on Image Processing

IEEE - NSIP 2003
Workshop on Nonlinear Signal and Image Processing

Conference on Advanced Video-based Surveillance Systems

IEEE - AVSS 2009
Conference on Advanced Video-based Surveillance Systems
Agreements
Agreements

Cagliari               Trento                   Udine           Verona

Kingston University

University of Tampere

The University of Reading

University of Aalborg

University of Illinois at Chicago

University of Sydney

University of Toronto

University of Maryland

University of Syracuse

University of California at San Diego
vIdeo and Signal Processing for Telecommunication

Projects and Partnerships
The project, financed by Italian Ministry of University and Research (MIUR), foresees the study and design of an integrated Software/Hardware system for realizing an intelligent info-mobility network with high reconfigurability.
Project R.F.I. – GSM-R

- Project, started in 2004 and ended in June 2006, consisted in an hardware/software evaluation of the ERTMS/ETCS system for high speed railway lines.
- Evaluated components:
  - Ansaldo Ground Segment
  - Alstom Ground Segment
  - Ansaldo On-Board Segment
  - Alstom On-Board Segment
Marconi-Selenia

- UAV data link study.
- Goal of the project was to provide a State-of-the-Art about available UAV communication technologies.
- Evaluation of system requirements was performed in order to define a communication architecture useful for UAV communications.
Goal of the project “Studio sull’impiego integrato di tecniche multimodali per la localizzazione ed il tracking di mezzi mobili e persone in ambienti indoor e outdoor” was to evaluate the usage of multimodal location systems in indoor and outdoor framework and scenarios.

Role of ISIP40 was to evaluate the integration between WLAN and Video based location systems.
DAVID experiment (CNIT, ASI and Italian space industries)

Goals:

- **W band** (60-95GHz) usage exploration, in order to transmit multimedia contents with very-high **bit-rate** (100Mb/s) from a ground station to a Low Earth Orbit regenerative satellite
- Overcoming the limits on transmission capacity and service continuity imposed by signal propagation drifts
**PRIN SHINES**

- **Satellite and Hap Integrated Network and Services (SHINES),**

- **Goal**: definition of the role of satellites and High Altitude Platforms (HAPs) in the evolving scenario of new communication systems (Applications and Performances).

- **ISIP40 Role:**
  - Identification of the present communication system for a possible physical reconfigurability
Virtual Immersive Communication

Goal of the Virtual Immersive Communications (VICOM) project was to study and develop techniques, protocols, and applications for Immersive Virtual Tele-presence.
Primary goal of REOST was to identify obstacle present on railway lines through a long-range view. It’s hence possible to alert driver in time to avoid dangerous collisions.
INMOVING

INtelligent MOBILE Video Environment

(IST 2001-37422)

- Creating a toolkit that allows a general and modular solution for mobile video-related applications

- Demonstrating the usage of toolkit for the development of versatile applications.

- Testing applications with different end-users

- Realizing market analysis in order to verify the commercial applicability of the proposed solution
Goal of the project was to analyze a situation of potential interest through the usage of an augmented perception obtained by multiple cameras.

A **personalized** communication between System and User allows to exchange secure information.
Watcher

**Watcher:** Widefield scene Analysis of object Trajectories, people Counting and Heterogeneous Event Recognition

- Automatic Video-Surveillance Systems:
  - Parking areas monitoring
  - Traffic fluxes control
  - Recognition of abandoned objects
  - Recognition of non-permitted trajectories
This project deals with the theme of distributed video-surveillance; its goal is the development of a cooperating multiple-camera system able to gather information, at different resolution levels, about people and interacting objects.
The project aims at exploiting computer vision techniques together with data fusion and scene understanding algorithms to provide the driver (be it a train or a road vehicle driver) with an additional active safety tool.
Distributed and heterogeneous architectures for multi-sensor surveillance systems. (Prot. N. 7280/297 MIUR)

The aim of this project is to realize a distributed automatic monitoring system for extended environments through an heterogeneous multi-sensor architecture.
Pose Estimation of human subjects

- Standing
- Squatting
- Sitting
- Lying

Security Oriented
- Detection of abnormal behaviours
- Detection of subjects in forbidden areas

Service Oriented
- Detection of emergency situation (a subject faints)
Ski Performance Analysis

- Goal of the project is evaluate skier performances and detect potentially dangerous behaviours.
Sport Events Analysis

- Goal of the project is to develop an integrated HW and SW system for video recording and for image indexing applied to sport events.
Context Awareness for Automotive Applications

Objective:
- Extract contextual information about traffic status and driver behaviour for enhance telecommunication services

Approach:
- Analysis of driver attention and of traffic status by video processing algorithms
- Communication and retrieval of relevant contextual information to/from a remote database

- Carriageway Detection
- Face Tracking
- Vehicles detection
Partner: Selex Communications

Title: Development and simulation of time-frequency synchronization algorithm for WiMAX in high mobility environment

Goal:
- Develop novel algorithm for the environment of interest
- Implement the proposed algorithm in a software
- Performance analysis
Baseline WiMAX

- Partner: Selex Communications
- Title: R&D for a Broadband Wireless product
- Team: 5 employers
- Goal:
  - Develop Physical and MAC layers for the system
  - Implement the proposed layers in a simulator
Context Awareness

- Role of ISIP40 is to develop video processing and context analysis algorithms to analyze human behaviour in an office for personal communication services.

  - **BUSY Profile**: during a meeting calls tagged as family ones are blocked.
  - **EMERGENCY Profile**: automatic call after detecting of an anomalous event.
SINTESIS
Sistema INTEgrato per la Sicurezza ad Intelligenza diStribuita

Learning / Multisensor Data Fusion / Robustness

- **Application field**: Homeland security
- **Participants**:
  - Elsag
  - Selex-Comms
  - Selex-SI
  - Ansaldo Signal
  - University of Genoa – DIBE
The aim is to realize an innovative structure based on the concept of “Network Centric Operation” which is adapt to optimize:

- Distribution
- QoS
- Time critical processes

The cognitive cycle will be applied to create processing nodes with reason capability similar to the human operators one, but with a more efficient analysis capability.
vIdeo and Signal Processing for Telecommunication

Physical Security
oriented Applications
Detection and Tracking

Detection:
- Statistical histogram based Change Detection
- Gaussian Mixture model
- Gradient-based Change Detection

Tracking:
- Mean Shift
- Non Linear Shift Estimator (NLSE)
- Multicue Adaptive Particle Filter-based tracking
Fixed Camera Tracking in complex background
Fixed Camera Tracking in complex scenes
Fixed Camera Tracking in crowded scenes
Movement based Tracking

Legend

- Solid line: bounding box
- Blue dots: observations (corners)
- Red dots: observations used during model reinitialization (only for movement based tracker)

With movement info

Without movement info
PTZ Controlling
PTZ Controlling – Fixed+PTZ Camera
Tracking on moving camera

Collaborative Tracking
Moving Camera

Mean Shift Tracking
Moving Camera

MAPT Tracking
Event Recognition

- Detection of moving subjects in the scene
- Detection of the action performed by the subjects
- Focus of attention and, if necessary, alarm signal dispatch
Graffiti Detection

Special thanks to TechnoAware for Demo Video
Shop Window People Counting
Abandoned Objects Detection
Pose Estimation
Ambient Intelligence and Situation Awareness

- Context-based and personalized to user services
- Operators support to perform surveillance tasks
- Analysis of driver attention and of traffic status by video processing algorithms
- Communication and retrieval of relevant contextual information to/from a remote database
Virtual Guide
Virtual Guide

VICom Project
Guard-Intruder Scenario

Operator – Competitor (competitive interaction)

- Image grabbing
- Subjects detection
- Map position detection
- Context analysis and Learning
- Low level automatic Decision
- Guide message dispatch
Guard-Intruder Scenario
On Board Sensors: Examples

- Carriageway Detection
- Vehicles detection
- Face Tracking
On-Board Sensors: Camera + Canbus
Fixed Sensors: Vehicles Tracking and Direction Detection
Fixed Sensors: Motorway Vehicles Tracking and Speed Evaluation

17:53:25: Car transit: 96 kmh
17:53:47: Car transit: 101 kmh
17:55:54: Car transit: 105 kmh
Fixed Sensors: Queue Detection

Rain

Night

Light and Shadow
Example: Tunnel Vehicles Tracking

- High Robustness to car lights

Special thanks to Aitek for video sequences
Example: Tunnel Vehicles Tracking and Stationary Vehicles Detection

Special thanks to Aitek for video sequences
Example: Obstacle Detection on railway lines
Interactive Applications for Cultural Sites

Video and Signal Processing for Telecommunication
Introduction

- Interactive systems developed for Parque Explora museum of Medellín, Colombia (Interactive Museum)
- Worldwide trend of using interactive applications based on innovative interfaces and image processing algorithms
- Different levels of complexity
Interactive Tropical Forest
Interactive Tropical Forest

Green Screen + Projectors

Projection area + Cameras

Green Screen + Route
Interactive Tropical Forest

- People are projected inside the virtual space.
- Virtual objects interact with people:
  - Waterfall
  - Butterflies
  - Birds
  - Fishes
  - Water level
- Audio 5.1 to increase scene reality appearance.
Animal Eyes

- Animals look directly in people eyes
- The system detects the visitor’s face (spatial position) and sets the position of animal eyes
- Realistic photo render

LCD TV + Camera + Audio 2.1
People see themselves like carved in the stone

Projector + Camera
Floor Pong

- Up to 4 people play using their feet to move the bar

Projector + Camera UV + Audio 2.1
Catch the Sentence

- Users stop the falling letters using their shadow to find the hidden sentence

Projector + Camera
Billiard

- Real billiard stick
- Virtual Balls and Table

Projector + Camera + Audio 2.1
Draw the Photo

- This application allows to add hairs, glasses, mustaches, etc. In the photo
- It works even if the user moves his face through a real time face tracking

Monitor + Camera + TrackBall + Button
Thanks for Attention