

Mediterranean Student Days 2017
I3S Laboratory
Signals, Images, Systems (SIS) Team

Leaders: V. Zarzoso & G. Allibert

<http://www.i3s.unice.fr/sis>

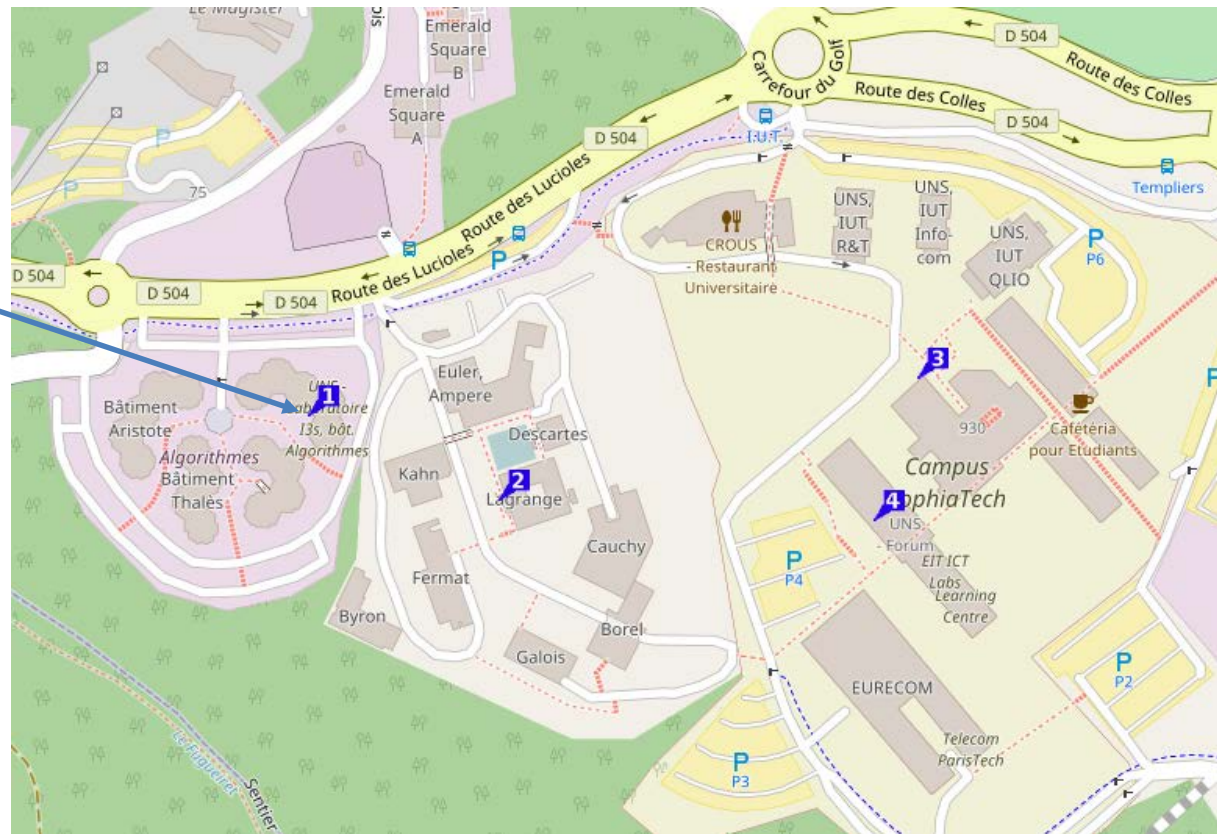
February 28, 2017

Team composition and location

- 30 permanent staff (CNRS, UNS)
- 30 non-permanent members
 - ✓ PhD students, postdoctoral researchers, master interns

- **Location**

- ✓ Les Algorithmes
Euclide-B building
([1] on the map)



Scientific domains

- **Goal:** tackle current societal challenges in
 - ✓ health, well-being, biology
 - ✓ multimedia, future-generation communications and networking
 - ✓ robotics, drones, autonomous systems

- **Tools**
 - ✓ signal and image processing, control, information theory, machine learning

- **5 research axes**
 - ✓ Axis 1: Biological and biomedical signal and image processing
 - ✓ Axis 2: Wireless communication systems and networks
 - ✓ Axis 3: Multimedia coding
 - ✓ Axis 4: Autonomous systems
 - ✓ Axis 5: Observation and modeling



Scientific objectives, challenges, results

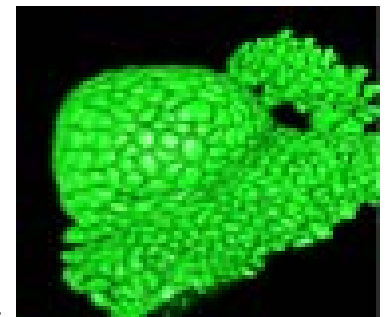
Axis 1: Biological and biomedical signal and image processing

✓ Inverse problems for biology imaging

- Reconstruction algorithms for modern microscopy (TIRF-MA, DIC, superresolution)

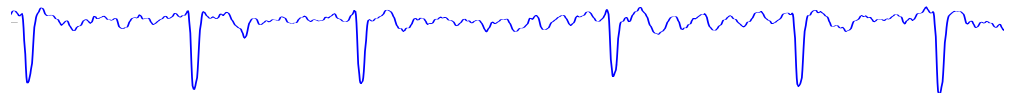
✓ Image analysis

- Developmental biology (CRBM, Inria Montpellier, ENS Lyon)
 - drift compensation in 3D+t microscopy
 - cell segmentation and tracking in morphogenesis
- Aid in therapeutic gesture (General Electric Healthcare)
 - pre-operative CT angiography and live fluoroscopy alignment

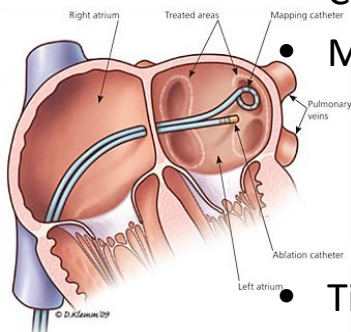


✓ Signal analysis

- Cardiac arrhythmia characterization
- Multi-lead ECG analysis for therapy outcome prediction (ANR JCJC PERSIST)
 - Cardiomyocyte's action potential (Harvard Medical School, USA)
 - ECG interval analysis



- Tissue microperfusion assessment from Laser-Doppler spectra (IBBE, Poland)

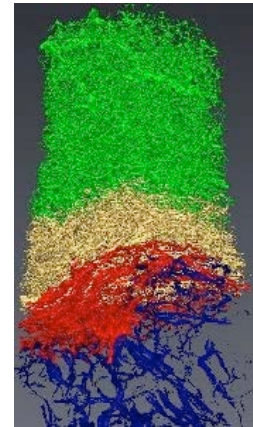


Scientific objectives, challenges, results

Axis 1: Biological and biomedical signal and image processing (cont'd)

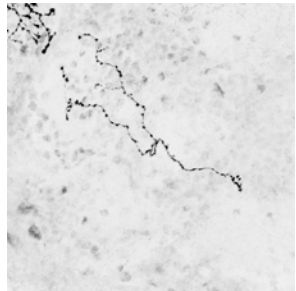
✓ Machine learning

- Segmentation of mammalian neocortex neurons
- Renal cell carcinoma (kidney cancer) classification from vascular network structure
- Characterization of tree-like shapes in biomedical imaging
 - axon morphology in 3D confocal microscopy
- Supervised classification of cells from microscopy imaging (ANR PhaseQuantHD)
 - constrained convex splitting for cytokine concentration in blood



✓ Modeling

- Characterizing mutations in Drosophila brain neurons
- EMG modeling for whole-body vibration effects (LAMHESS)

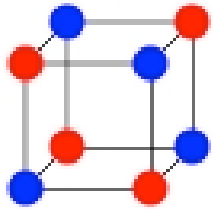


Scientific objectives, challenges, results

Axis 2: Wireless communication systems and networks

✓ Tensor-based signal processing (GIPSA-Lab, L2S, UFC, UNICAMP)

- Tensor-based nonlinear system identification
- Tensor-based MIMO point-to-point and relay cooperative wireless systems
- Constrained/structured tensor decompositions
- Low-rank tensor recovery/completion
- Underdetermined source separation and localization from EEG/MEG signals

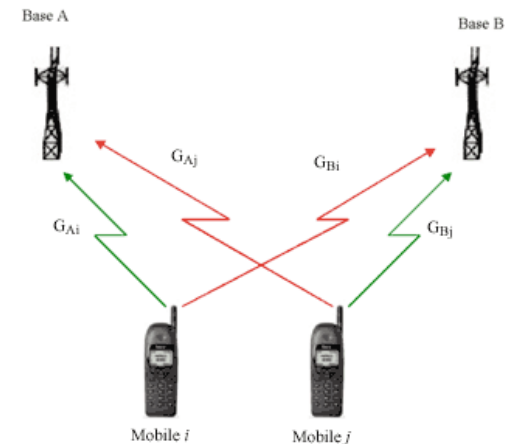


✓ Cognitive radio and MIMO systems (Eurecom)

- Calibration of RF devices in cognitive networks
- Massive MIMO networks

✓ Data-center networking

- Transport-control protocol (TCP) characterization
- Rule compression in software defined network (SDN) switches



Scientific objectives, challenges, results

▪ Axis 2: Wireless communication systems and networks (cont'd)

✓ Network measurement

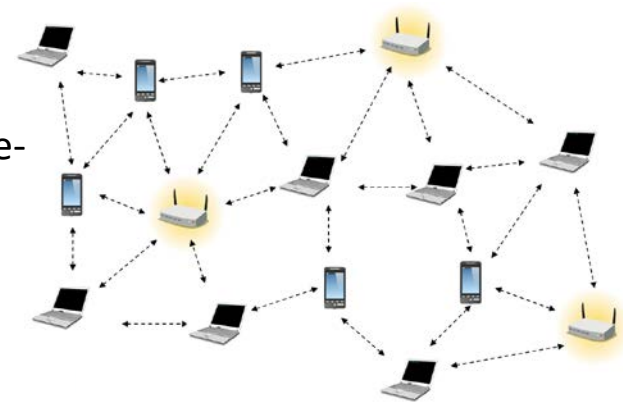
- Detection of network neutrality violations
- Characterization of border gateway protocol (BGP) and security threats

✓ Future-generation networks for video content distribution

- Quality of experience (QoE) modeling in mobile access networks (Orange Labs)
- Routing and caching for video distribution in 5G mobile networks

✓ Mobile social (opportunistic) networking

- Routing policies based on network coding in resource-limited mobile nodes (ANR JCJC TroupWilma)
- Design of reliable transport protocols based on network coding (Inria, Telecom Sud Paris)



Scientific objectives, challenges, results



■ Axis 3: Multimedia coding

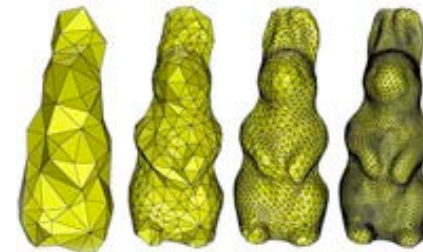
✓ Image and video coding

- Denoising after coding/decoding (CNES, Thales Alenia Space)
 - satellite images of post-Pleiades generation in future CNES space missions
- High-efficiency video coding (HEVC) with bitrate savings (Orange-Labs)

✓ Geometry coding in 3D digitization systems

- Semi-regular meshing and coding in 3D and stereoscopic images
- Efficient massive point cloud coding using depth maps (Cintoo3D)
- Lossless compression of massive hexahedral meshes in geosciences (IFP-EN)

→ **Cintoo3D** startup company



✓ Bio-inspired image processing

- Retina-inspired image coding scheme (Inria)
- Dynamic retina-inspired filtering (4G-SGME)
- Statistical detection and classification based on time-encoding (COBRA, ENCODIME)

Scientific objectives, challenges, results

■ Axis 4: Autonomous systems

✓ Feedback control of aerial robots

- Unified nonlinear control strategy incorporating aerodynamic forces
 - spherical body shapes
 - axisymmetric body shapes
 - airplanes

✓ Sensor-based control

- Image-based visual servo control
- Bio-inspired UAV landing on moving platforms based on optical flow

✓ Sensor fusion and invariant observers

- State (position, velocity, orientation) estimation in symmetric systems
 - highly robust, computationally simple algorithms based on Lyapunov design



Scientific objectives, challenges, results

■ Axis 4: Autonomous systems (cont'd)

✓ Visual simultaneous localization and mapping (SLAM)

- Novel methods for accurate, real-time robot localization and high-quality 3D scanning using low-cost sensors (e.g., Microsoft Kinect)
 - sensor calibration
 - camera tracking
 - real-time 3D reconstruction
 - dense alignment, superresolution

→ PiXmap startup company

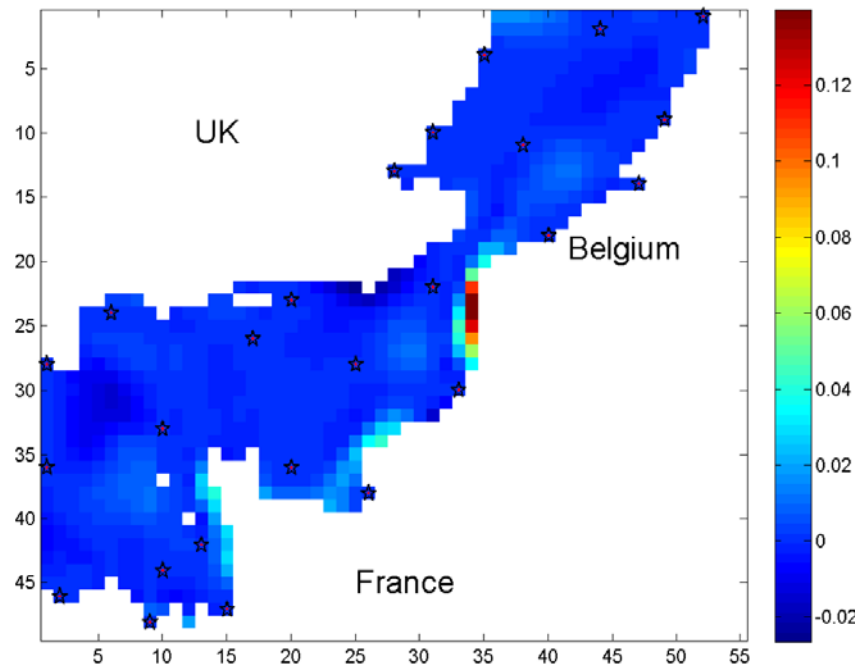


Scientific objectives, challenges, results

■ Axis 5: Observation and modeling

✓ Design of computer experiments via Gaussian processes

- New criteria for semi-parametric or nonparametric designs (GdR MASCOT-NUM, ReDICE)
- Accurate prediction over entire experimental domain and precise estimation of covariance of Gaussian random field (ANR DESIRE)



Scientific objectives, challenges, results

■ Axis 5: Observation and modeling (cont'd)

✓ Design of optimal experiments (DOE) for parametric nonlinear models

- Acceleration of DOE algorithms
- DOE algorithms on compact sets with guaranteed convergence
- New generalized design criteria with efficient optimization

✓ Nonparametric density estimation with region-censored data

- Prevention of hyperbaric decompression sickness (DGA/DGCIS SAFE-DIVE)
 - maximum entropy estimation of biophysical parameters
 - parametric model for risk of decompression sickness



fr.wikipedia.org

✓ Model-free designs

- Geometric criteria for point selection over domain of interest
 - improved Morris method for input variable characterization (ANR DESIRE, MDSC)
 - new randomized cross-validation method for curvilinear designs resulting from robotic environmental observation (EU DRONIC)

Scientific production (2011–2016)

		Number	Per FTE
Doctoral supervision	Defended PhD theses	50	2.5
Publications	Peer-reviewed international journals	150	7.5
	Peer-reviewed international conferences	239	12
	Invited conferences	29	1.5
	Books, book chapters	17	0.9
	Edition of proceedings, books, special issues	5	0.3

■ Journals

- ✓ Automatica, IEEE Magazines, IEEE Transactions, Nature Neuroscience, Neurocomputing, SIAM Journals, The Annals of Statistics,

Scientific production (2011–2016)

		Number
Industrial transfer	Patents and APP-issued software	10
Projects	European	3
	ANR	11
	Public grants	16
	Industrial grants	23
	International grants	9

- **Total contracts: 5.5 M€**

Team highlights

■ Prizes and Awards

- ✓ French Academy of Science Michel Monpetit prize 2013
- ✓ Knight of the Legion of Honor 2015
- ✓ International Statistical Institute elected member
- ✓ Polish Academy of Sciences acknowledgement medal 2015
- ✓ Institut universitaire de France 2013-2018

■ Best paper awards

- ✓ Information Processing in Computer-Assisted Interventions 2015
- ✓ Differential Geometry in Computer Vision for Analysis of Shapes, Images and Trajectories 2015
- ✓ IEEE TENCON 2015
- ✓ IEEE Intelligent Robots and Systems (IROS) 2013
- ✓ IEEE Summer School on Biomedical Signal Processing 2011

Team highlights

- **Editorial boards of international journals (Associate Editors)**
 - ✓ Control Engineering Practice
 - ✓ Digital Signal Processing
 - ✓ EURASIP Journal on Image and Video Processing
 - ✓ IEEE Transactions on Aerospace and Electronics
 - ✓ IEEE Transactions on Neural Networks and Learning Systems
 - ✓ IEEE Transactions on Robotics
 - ✓ IEEE Transactions on Wireless Communications
 - ✓ SIAM Journal on Imaging Sciences
 - ✓ Statistics
 - ✓ The Annals of Statistics

Team highlights

■ Industrial transfer

✓ Cintoo3D startup (2013)

- Surface and 3D data streaming and visualization solutions
- Award winner at *Concours national d'aide à la création d'entreprises de technologies innovantes 2013*



✓ PiXmap startup (2014)

- Real-time 3D localization and mapping for robotics
- Award winner at *Concours national d'aide à la création d'entreprises de technologies innovantes 2014*



■ Industrial impact

✓ Wavelet -based imaging system (Axis 3 – Multimedia coding)

- Pleiades generation of CNES satellites

✓ Modeling, control and observers for unmanned vehicles (Axis 4 – Drones)

- Novadem, Skybotix, CEA, Bertin Technologies, Cybernetics, Thales Group, Dassault Aviation, IBM

Collaborations

- Local and national



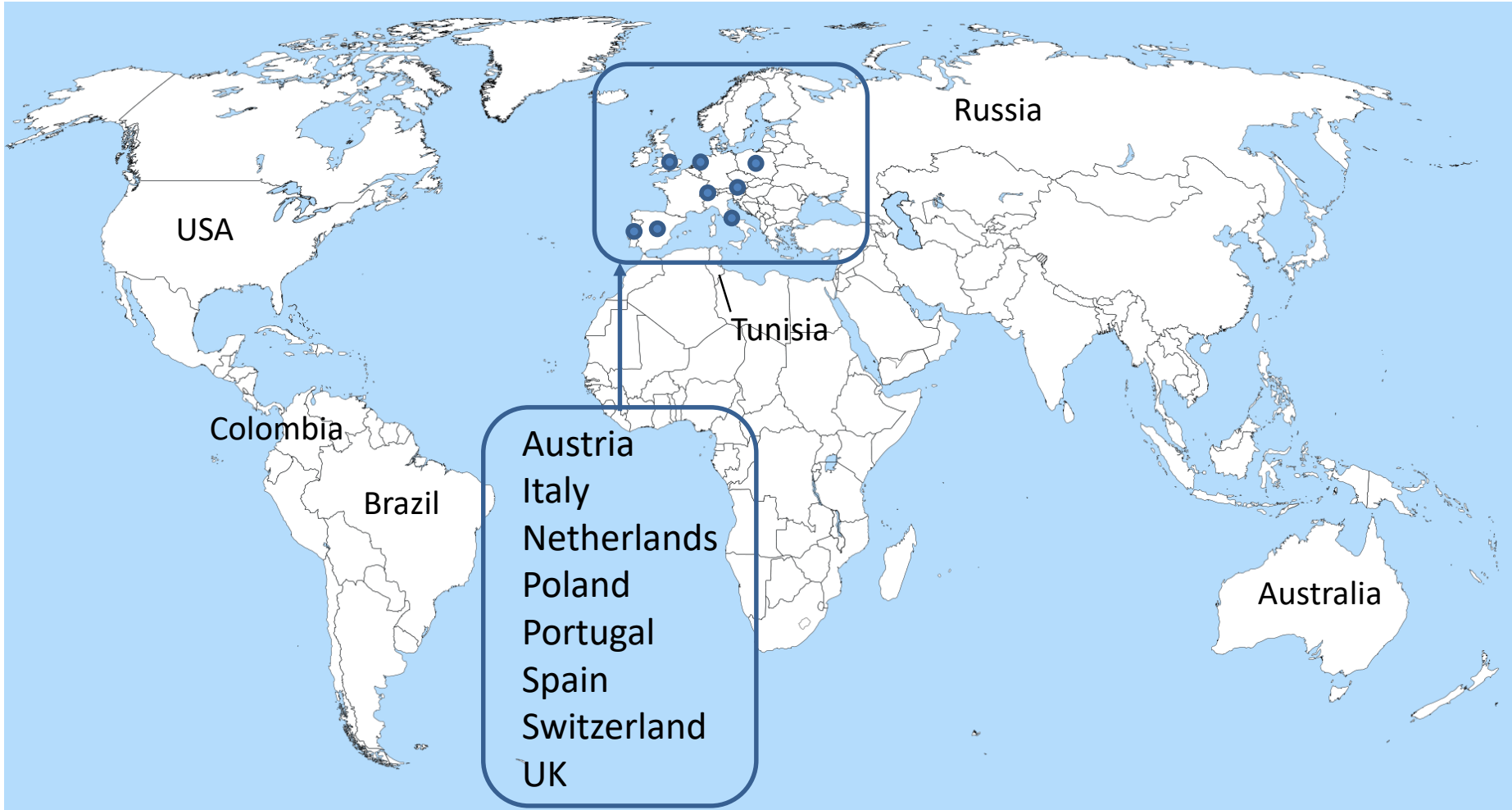
Labex

- SIGNALIFE: 1 thesis
- UCN@Sophia: 3 theses

IBV
LJAD
CHU Nice
IPMC
Inria Sophia
CHPG Monaco
LAMHESS

Collaborations

■ International



cartograf.fr

Main collaborative research projects

■ European projects

- ✓ **FP7 Dronic [Strep]** Unmanned surface vessel for algae control
Alseamar, LG Sound (Netherlands), VITO (Belgium), Septentrio (Belgium), U Ljubljana (Slovenia), Cyprus Ministry of Agriculture, Scottish Waters (UK)

- ✓ **FP7 TUAV [Echord]** Teleoperation of unmanned aerial vehicles
Skybotix

- ✓ **H2020 Comanoid** Collaborative humanoids in aircraft manufacturing
Airbus, Inria, DRL (Germany), Univ. Rome 1 (Italy)

■ Bilateral programs

- ✓ **France-Brazil CNRS-FUNCAP, COFECUB-CAPES**
Tensor modeling in communications and biomedical engineering
Supelec, Eurecom, CNAM, GIPSA-Lab
Federal Universities of Ceara, Santa Catarina, Rio de Janeiro

- ✓ **Other countries: Australia, Colombia, Italy, Poland, Russia**

Main collaborative research projects

■ ANR projects

- ✓ **DESIRE [Intl White]** Designs for spatial random fields
 JKU Linz (Austria)
- ✓ **DIAMOND** Image deconvolution in N-dimensional optical microscopy
 Pasteur Institute, MIPS Lab U Haute Alsace, LIGM U Paris-Est, INRA
- ✓ **DIG-EM** Geometric approach to ascidian morphogenesis
 CRBM, Inria
- ✓ **HMOVE** Vesicle detection and tracking
 IBV
- ✓ **MOTIMO** Seminal motility imaging for automated fertility assessment
 Inst Math Toulouse, INRA, Inst Méc Fluid Toulouse, IMV Technologies, LJAD
- ✓ **PhaseQuantHD** Quantitative phase imaging
 Phasics Palaiseau, TIRO (UNS, CNS, CAL)



Main collaborative research projects

■ ANR projects (cont'd)

- ✓ **RNAGRIMP** Modeling of ARN assembling by genomic screening
IBV, U Paris V
- ✓ **Robotex [Equipex]** National network of experimental platforms in robotics
LAAS, IRISA, Heudiasyc, LASMEA, ...
- ✓ **SCAR [ASTRID]** Sensory control of aerial robots
ISIR Paris 6, CAS Mines Paristech
- ✓ **TroupWilma [JCJC]** Transport and routing protocols in adhoc networks
- ✓ **PERSIST [JCJC]** Catheter ablation outcome prediction in atrial fibrillation
CHPG Monaco

Main collaborative research projects

- Industrial contracts

4G-SGME	Airbus	AMD Micro Device
Aseta Nanographics	Bertin Technologies	BF-Systèmes
Cintoo3D	CNES	Cybernetix
EDF R&D Chatou	ETSI	Galderma
Intel	LMDC	L'Oréal R&D
Orange Labs	PGMO	Thales Group
Trident Media Guard		
General Electric Medical Healthcare		
Institut Français du Pétrole – Énergies Nouvelles		

✓ 10 CIFRE contracts

Some perspectives

▪ Transversal topics

✓ Inverse problems

- Electrocardiographic imaging (ECGI)
- Image reconstruction for superresolution microscopy
- Massive MIMO systems

✓ Optimization

- Non-convex / mixed integer networking problems (with COMRED-Coati)
- Discrete dynamic systems for network coding (with MDSC)
- Optimization of submodular functions for sequential design (with MDSC)

✓ Machine learning

- Disease diagnosis and personalized therapy from signal / image analysis (with SPARKS)

✓ Tensor decompositions

- Analyzing multimodal, multidimensional, incomplete datasets
- Multiscale modeling of physiological phenomena (e.g., cardiac arrhythmia)

✓ Bio-inspired approaches

- Feature extraction, classification
- Image and video coding
- Communications, control



Interested?

- **For further details, please contact:**
 - ✓ **Axis 1** Biological and biomedical signal and image processing
 - Xavier Descombes **xavier.descombes@inria.fr**
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 - ✓ **Axis 2** Wireless communication systems and networks
 - Guillaume Urvoy-Keller **urvoy@i3s.unice.fr**
 - ✓ **Axis 3** Multimedia coding
 - Marc Antonini **am@i3s.unice.fr**
 - ✓ **Axis 4** Autonomous systems
 - Tarek Hamel **thamel@i3s.unice.fr**
 - ✓ **Axis 5** Observation and modeling
 - Luc Pronzato **pronzato@i3s.unice.fr**
- **... or the team leaders:**
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