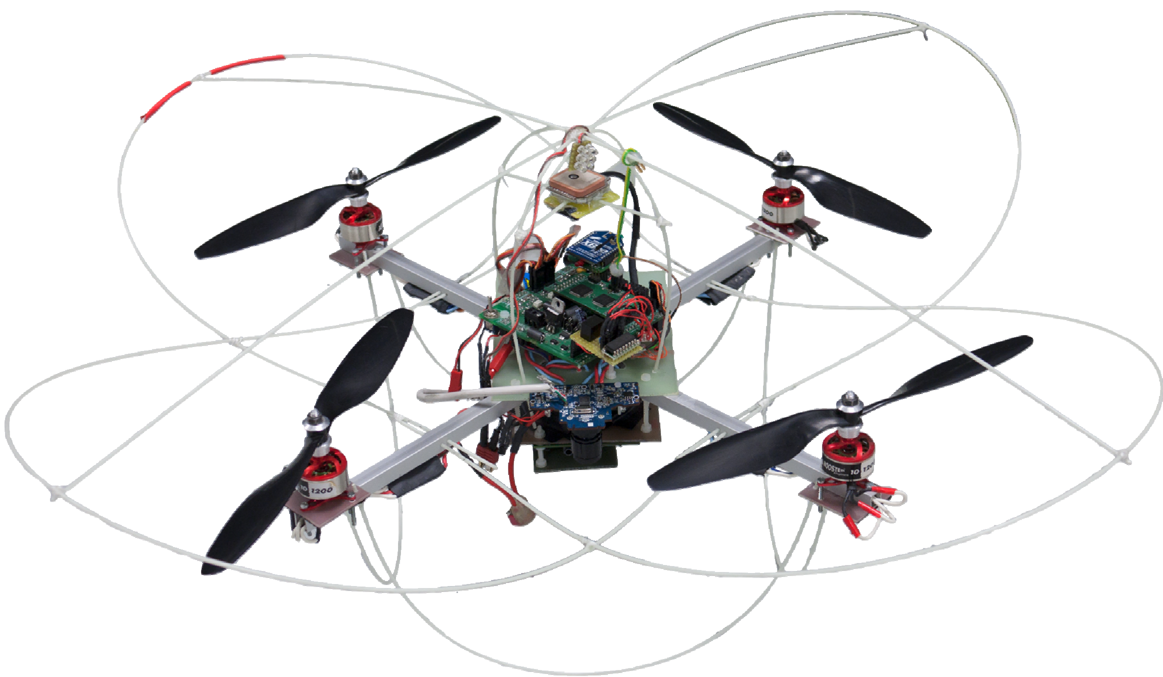
FRANCE STATUS REPORT

30th JOINT COORDINATING FORUM

INTERNATIONAL **A**DVANCED

ROBOTICS **P**ROGRAMME



A Review of R & D in French Industry

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E. DOMBRE & PH. BIDAUD

2010 France Activity-Report-Highlights Summary

Robotics research in France is carried out within up to 60 teams from CNRS, INRIA, and Universities, but also within domain oriented organizations: CEA (Nuclear), CEMAGREF (Agriculture), CNES (Space), IFREMER (Underwater), INSERM (Health), ONERA (Aeronautics). It occupies approximately as many staff researchers as PhD students for a total of up to 1000 people. About 150 PhD theses are supported every year in the various domains related to Robotics.

To better address the scientific and technical challenges posed by modern applications in various fields, the community joins within a "Groupe de Recherche" (GDR) in Robotics, an open national Research Group established by the CNRS in 2007 to foster or strengthen collaborations between research teams and relationships between academics and industry. The Robotic GDR has been renewed in January 2011 after a positive evaluation of its 4-year activity, and on the basis of an update of its scientific objectives. The management has also evolved, namely to account for the fact that interdisciplinarity is growing stronger and becomes a key factor to develop Robotics.

In its new organization, the Robotic GDR drives eight working groups (WG) covering methodological developments, application fields or thematic domains: *Medical robotics* including surgical robotics, assistive technologies, and rehabilitation robotics; *Autonomous vehicles* focusing on aerial robotics and terrestrial robotics; *Advanced techniques in multi-scale manipulation* covering grasping and dexterous manipulation in the macro world, and micro/nano manipulation; *Human-robot interaction* comprising interaction signals, man-robot cooperation, new interaction devices, and ubiquitous robotics; *Advanced design and innovative mechatronics* that emphasizes on methodology of design, robot architectures for the future, innovative technological components, and robotics for process; *Humanoid Robotics*, focusing on design of advanced anthropomorphic structures, modeling and control, optimisation and task planning, and links with living sciences. These six WG continue the activities done in the first four-years of the GDR, and have been presented in detail in the previous Status report. Two additional WG have been created, one on *Control architectures for robotics*, the other on *Robotics and neurosciences*, and are presented in this report.

As indicated in the 2009 Status report, most of the funding comes from the National Research Agency (ANR), created in 2007, through several dedicated calls for tenders, but also form the General Delegation for the Arming (DGA), the so-called Instituts Carnot, and the Interministerial Unique Fund (FUI). The budget of the ANR has been shortened by about 20% in 2010. This reduction is partly due to the launching in Spring 2010 of the "Investments for the future" program by the French government, which has devoted 21.9 billions of € to education and research through several calls. Among them, a so-called EQUIPEX call (1 billion €) is dedicated to provide labs with up-to-date equipments. The Robotics community, through the GDR, has successfully applied to constitute a "National network of robotics platforms" named ROBOTEX, that will be supported over 2 years by 10 millions €. It is structured around five application domains: Production robotics; Mobile robotics; Medical robotics; Micro-nanorobotics; Humanoids robotics and natural interactions. The ROBOTEX initiative is also presented in this report.

Another objective of the GDR is to promote involvement of industrial partners, and to foster collaborative research-industry applications to national and European programs. To this end, a Club of industrial partners has been created (up to 40 motivated small- and large-sized companies - providers of equipments or end-users of robot technologies - have joined the Club so far). In order to better formalize its strategy, the Club has worked on a roadmap, focusing on six domains of activity: Industrial robotics, Military robotics, Service robotics, Medical robotics, Transportation robotics, Robotics for agriculture and environment. To complete the presentation of Robotics in France done last year, this report focuses on R & D activities in industry.

SUMMARY

I) *INTRODUCTION*

In the last report, presented in Toulouse during the 29th JCF, we gave an overview of how is implemented the research policy in France, in particular for Robotics. Then we have listed the projects supported by the National Research Agency (ANR) for funding. Finally, we have described the different research domains addressed by the working groups of the national robotic Research Group (GDR) of the CNRS, which reflect the research done in up to 60 teams in the country. We will discuss the evolutions of the GDR in section II.

In the frame of the "Investments for the future" program launched by the French government in 2010, 21.9 billions of euros have been devoted to education and research through several calls. Among them, a so-called EQUIPEX call (1 billion €) is dedicated to provide labs with up-to-date equipments. The Robotics community, through the GDR, has successfully applied to constitute a "National network of robotics platforms" named ROBOTEX. The network is presented in section III.

Another objective of the GDR is to promote involvement of industrial partners, and to foster collaborative research-industry applications to national and European programs. To this end, a Club of industrial partners has been created (up to 40 motivated small- and large-sized companies - providers of equipments or end-users of robot technologies - have joined the Club so far). In order to better formalize its strategy, the Club of partners has worked on a roadmap. To complete the presentation of Robotics in France done in 2010, this report focuses on R & D activities in industry (section IV).

II) *ROBOTIC RESEARCH IN FRANCE*

Robotic research in France is mainly carried out in laboratories supported jointly by the CNRS (National Center for Scientific Research) and universities. Others public research institutions as CEA, CEMAGREF, INRETS, INRIA, ONERA have also very active research teams in this domain.

Today in France, public research activities in Robotics occupy approximately as many staff researchers as PhD students for a total of up to 1000 people. About 150 PhD theses are supported every year in the various domains related to Robotics. These activities are developed within the framework of up to 60 teams.

Robotic research activities in France are facing major scientific and technical challenges posed by modern applications in various fields. To answer better these challenges, the community joins within a "Groupe de Recherche" (GDR) in Robotics created in 2007 by the CNRS. The GDR has been renewed in January 2011 after a positive evaluation of its 4-year activity, and on the basis of an update of its scientific objectives. The management has also evolved, namely to account for the fact that interdisciplinarity is growing stronger and becomes a key factor to develop Robotics.

In its new organization, the GDR drives eight working groups (WG) covering methodological developments, application fields or thematic domains:

- **Medical robotics**, including surgical robotics, assistive technologies and rehabilitation robotics. Some examples of topics are Modeling and control; Compact patient-mounted robots; interventional radiology; Transluminal and single port surgery; Design of robot and exoskeleton for rehabilitation;
- **Autonomous vehicles** focusing on aerial robotics (Modeling and control; Visual servo control; Observation and state estimation; Trajectory planning; Design of aeromechanical architectures, sensors and actuators), and terrestrial robotics (Localization and mapping; Scene understanding; Control, multi-robots and platooning);

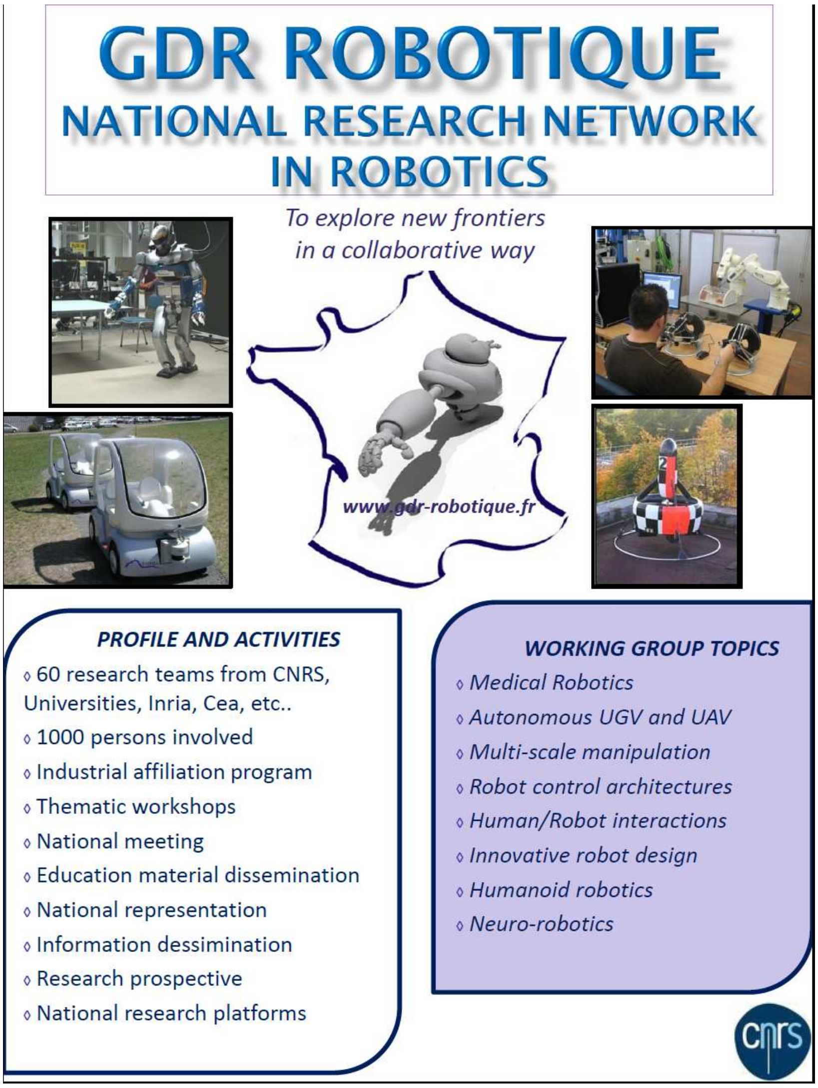
- **Advanced techniques in multi-scale manipulation** covering grasping and dexterous manipulation in the macro world, and Micro/nano manipulation. The scientific issues include Modeling of interaction at the scale at hand; Design and building of dedicated robots; Perception and control; Haptics in the microworld;

- **Human/robot interaction**, Detection, interpretation, synthesis of interaction signals; Robot Interaction with human locally or remotely, sharing or not a given task; New interaction devices (social robotics, BCI); Interaction with and between multi-robot systems (ubiquitous robotics);
- **Advanced design and innovative mechatronics**, with emphasis on Methodology of Design (performance evaluation criteria, multi-objectives optimisation, robust design, bio- inspired design, eco-design); Robot architectures for the future; Innovative technological components (mechanical links, actuators, materials); Robotics for process;

- **Humanoid Robotics**, focusing on Design of advanced anthropomorphic structures; Modeling and control (stability, whole-body motion); Optimisation and task planning (multiple contacts, dynamic stepping over obstacle, jumping and running modes); Links between humanoïd robotics and living sciences (neurosciences, biomechanics, virtual human);

- **Control architectures for robotics**;

- **Robotics and neurosciences**.



The WG "Control architectures for robotics" and "Robotics and neurosciences" are new and are described below. The other WG have been presented in detail in the 2009 France status report.

Concerning the funding of research in France, as mentioned in the 2009 France status report, the main support comes from the National Research Agency (Agence Nationale de la Recherche ANR). Its total budget in 2009 was 820 Meuros (among which 650 Meuros have been dedicated to calls for tenders). In 2010, it has been reduced to 690 Meuros. This 20% reduction is partly due to the launching in Spring 2010 of the "Investments for the future" program that has been mentioned in the Introduction. To the detriment of Robotics research, only few applications to the different ANR calls have been accepted. This has been partly compensated by the acceptation of the ROBOTEX network of robotics platforms that will fund equipments.

Control architectures for robotics

Due to their increasing complexity, present intervention robots, that is to say those dedicated for instance to exploration, security or defence applications, definitely raise huge scientific and commercial issues. Whatever the considered environment, terrestrial, aerial, marine or even spatial, this complexity mainly derives from the integration of multiple functionalities: advanced perception, planification, navigation, autonomous behaviours. These functionalities may be exploited through teleoperation or in an autonomous mode, in a single or multi-robots context to tackle more and more difficult missions. However, robots can be equipped with such functions only if an appropriate hardware and software structure is embedded: the software architecture is hence the main concern of this WG.

As quoted above, the control architecture is a necessary element for the integration of a multitude of works; it also permits to cope with technological advances that continually offer new devices for communication, localisation, computing, etc. Practically, the architecture should be modular, reusable, scalable and even readable (ability to analyse and understand it). As a side effect, such properties should ease the sharing of competencies among the robotics community, but also with computer scientists and control engineering specialists as the domain is inherently a multidisciplinary one.

The CAR WG brings together researchers and practitioners from universities, institutions and industries, working in the field of robot control architectures. This group organizes each year several workshops to expose and discuss gathered expertise, identified trends and issues, as well as new scientific results and applications around software control architectures related topics. Some important topics addressed in the field of robot control architectures include (but not limited to):

- Modeling, programming languages, frameworks,
- Middleware and real-time issues,
- Distribution, verification and validation, and implementation of control architectures,
- Task planning, interaction between planners and other "bricks" of the architecture,
- Robotic architectures: bio-inspired, multi-agent, adaptive, three-layer, etc.,
- Multi-robot coordination, heterogeneous fleet management,
- Adaptive autonomy, human-robot interaction, teleoperation and remote control,
- Networked robots, sensors and actuators.

Neuro-robotics

The robotics research framework significantly widened these last years to neuro-computational sciences and cognitive sciences. On one side, roboticists develop more and more efficient machines, especially in terms of computing power, sensing and actuation capabilities. These robots have increasingly complex mechanical structures and many of them are biologically inspired. However, compared to humans or even much less developed animals, the tasks that can be performed by these robots are still very basic. Most current methods in robotics do not allow to capture the complexity of information to provide robots with a unified multisensory representation of their environment, and make them able to plan and execute their actions autonomously while adapting to change. This limitation motivates an increasing number of roboticists to interact with the neuroscience community in order to identify the neurobiological processes that endow animals and humans with such capabilities.

On the other side, neuroscientist try to understand and model the functioning of the central nervous system (CNS) of humans and animals by using many complementary approaches ranging from electrophysiology and imagery to neurology and psychophysics. In this modeling work, the roboticist can provide valuable elements for interpreting experimental data. Indeed, the theoretical approaches and engineering methods, which were developed for the design of autonomous artificial systems, offer a rigorous framework to structure the thinking of neuroscientists. Besides, the robots can be used as test-beds by offering a way to implement theoretical models on physical systems.

This exchange between the two disciplines also led some researchers to develop interfaces between the CNS and machines. These interfaces range from implanting stimulators, to restore mobility to paralyzed limbs, to the use of various devices allowing to measure the cortical activity in order to control robotic systems.

The objective of the WG "Robotics and Neuroscience" is to gather the researchers involved in this multidisciplinary adventure in order to strengthen their collaborations and lead to new developments by sharing models and techniques from different backgrounds. The WG will be structured around three themes on which the community is already very active: motor control, perception and learning. More precisely, the following research axes have been identified

Motor control

- Understanding the functioning of the CNS of human and animals to control bio-inspired robots,
- Using the formalisms and techniques from robotics to contribute to the modeling of the CNS,
- Design and development of neuro-robot interfaces.

Multimodal perception, integration and internal representations

- Understanding perception within a sensorimotor framework in humans and animals.

Learning

- Understanding and modeling the learning process in humans, especially for motor tasks and action selection,
- Providing robotics systems with learning and adaptation capabilities,
- Improve the mathematical understanding of the learning and adaptation algorithms.

III) ROBOTEX , THE NATIONAL NETWORK OF ROBOTICS PLATFORMS

The French government has decided to invest over 2 years 10 million Euro for equipment of national research platforms in various domains of robotics. This national network of platforms is called ROBOTEX. The main goal of the ROBOTEX is to setup coherent infrastructures of technical equipments in order to:

- Promote scientific exchange and development of collaborative work between academic research teams, companies and end- users, and provide durable and reusable expertise and know–how,
- Give researchers high-level equipments with a facilitated access,
- Increase the visibility of the French robotics academic research and its international impact. It particularly concerns the strengthening of its European scientific leadership, and the

increase of collaborative works with leading European countries as well as at an international level,
- Boost the competitiveness of French companies and open new markets based on robotic technologies.

The experimental platforms of the ROBOTEX national network mostly belong to joint CNRS-university laboratories with strong research and development activities in robotics, and having the necessary human resources to give access and provide optimal exploitation of the platforms. This national network links together most of the leading academic robotics research teams in France (Figure 1). It is structured around five application domains:

- Production Robotics,
- Mobile Robotics,
- Medical Robotics,
- Micro-Nanorobotics,
- Humanoid Robotics and Natural Interactions.

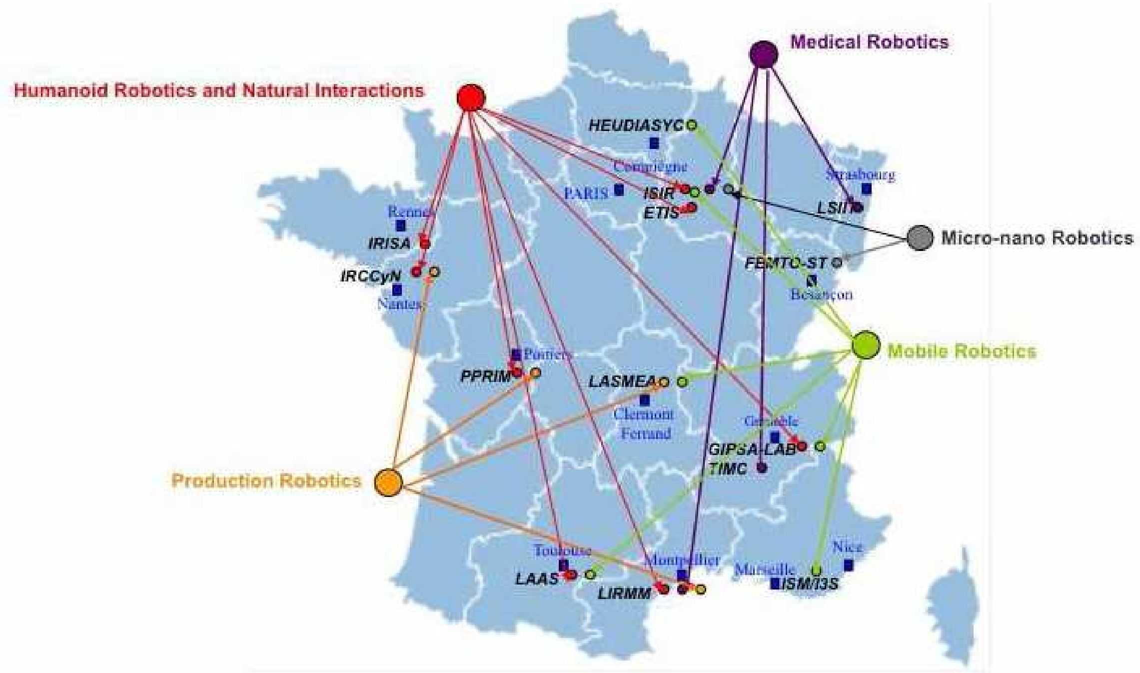


Figure 1. Geographic distribution of the ROBOTEX robotics platforms

The **Production Robotics** sub-network (Figure 2) deals with both industrial challenges and scientific bottlenecks. In industrialized countries there is a growing lack of manpower for tough tasks and a growing need for automation of current manual tasks. However, requirements in terms of robotization in European countries cannot be fulfilled with current robotic systems whose performance are limited by scientific and technological bottlenecks in various fields.

Fro these reasons, the research program of the production robotics sub-network have been organized into three main goals, each of them being linked to both industrial and theoretical issues: (i) DextRob, which addresses mobile and dextrous handling for production robotics, (ii) AccuFast, which aims at performing both high accelerations and high accuracies, and (iii) RoboTool, which is concerned with machining robots.

The four laboratories involved in this sub-network constitute a scientific and technological strength able to compete with Fraunhofer centers and Chinese universities. They have also developed strong relationships with industry and have conducted fruitful collaborative projects. It is the ambition of the Production Robotics sub-network to provide results and know-how which may impact companies such as PSA, Airbus or STX.

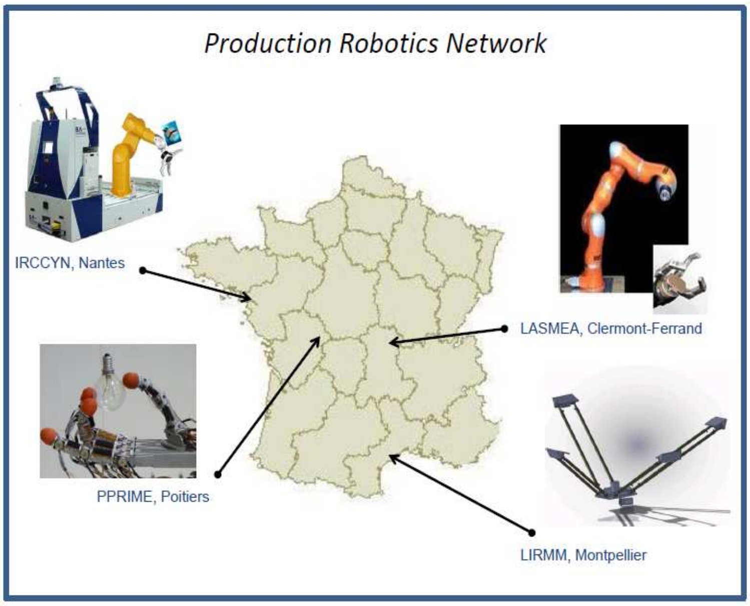


Figure 2. The Production Robotics sub-network

The **Mobile Robotics** sub-network (Figure 3) tackles numerous scientific and technical challenges in order to foster the deployment of dependable robots, with applications for intelligent transportation vehicles, field robotics or micro and mini drones. Besides autonomous navigation, endowing mobile robots with decisional autonomy is a strategic goal, particularly needed for the deployment of multiple robot teams and for addressing the human factor issues. The scientific domains that back up the research activities in mobile robotics on these topics and for which innovations are required span a wide spectrum, that ranges from mechatronics to system science and man/machine interactions, via signal processing, control theory, decision theory, planning and artificial intelligence. In order to achieve actual applications, all these topics must be studied in realistic conditions. For this purpose, the availability of up-to-date experimental platforms and the surrounding technical environment deployed on realistic test fields is essential.

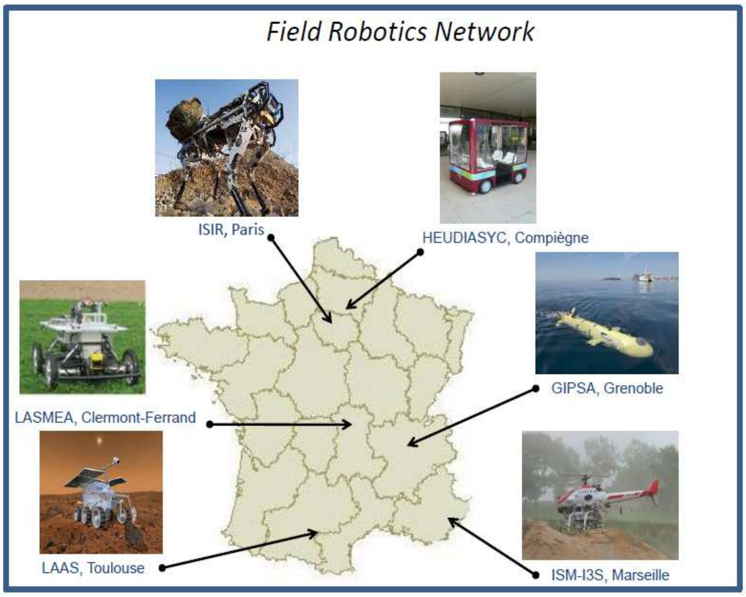


Figure 3. The Mobile Robotics sub-network

Medical Robotics, i.e. the use of a robot to help the clinician during diagnostic or therapeutic actions, started about 25 years ago. Currently, only a few robots have entered the hospital. The reason is certainly complex and multifold, but three main factors emerge quite clearly. Firstly, the design of medical and surgical robots has to be improved to propose lightweight, compact and also low cost robotic devices. Secondly, a large amount of data is available to the surgeon with the increasing number of imaging modalities. Robotic systems should help by efficiently taking into account these multimodal data, for instance by providing safe guidance. Thirdly, clinician-robot interaction can still be largely improved. The Medical Robotics sub-network (Figure 4) will provide unique equipments to allow French teams to work on (i) the development of novel robotic devices, (ii) the development of real-time imaging, planning and robotic guidance, (iii) the development of advanced interaction modes.

More than 70 researchers will be involved, in four different universities. Thanks to the network of clinical partners of each team, a wide range of clinical applications will be studied, with emphasis on endoluminal and single port surgery, interventional radiology and urology. This network of platforms project strengthens translational research between the robotic partners and clinicians, but also allows for the development of industrial collaborations with small French companies such as Koelis or Surgical Perspective.

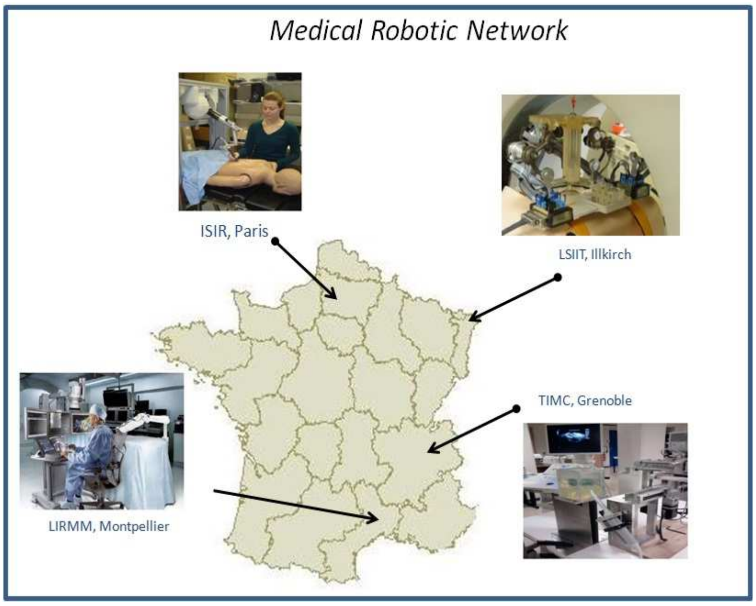


Figure 4. The Medical Robotics sub-network

The **Micro-Nanorobotics** sub-network (Figure 5) focuses on robotic interaction with objects whose size is in a “no man’s land”, i.e. from 100nm to 10µm, between nanotechnologies (1nm-100nm) and micro technologies (10µm-1mm). The exploration of this new scientific paradigm for robotics requires adapted equipment to strictly control the environment using high vacuum chamber, which integrates nanopositionning stages, vision system (Scanning Electron Microscopes, “SEM”) and characterization tools (force sensors). Such equipment adapted to the development of research in nanorobotics will be new in France. It will be a powerful force for the development of nanorobotics and will represent an excellent opportunity to interact with potential external users, industrial (e.g. in the nanotechnology or biotechnology fields) and academia (e.g. in material science). A special attention will be paid to the complementarities of these tools with other equipments (high vacuum or specific gas) in order to be able to create unique clusters.

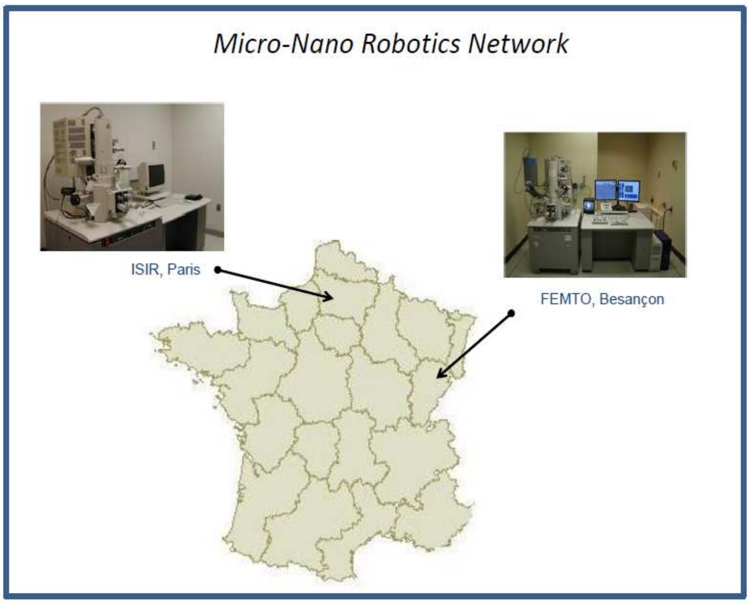


Figure 5. The Micro-Nanorobotics sub-network

The **Humanoid Robotics and Natural Interactions (RHIN)** sub-network is based on a set of complementary equipments allowing for multidisciplinary research works about the synthesis of behaviour of anthropomorphic robots and natural interactions between such robots and human beings. It gathers 8 research teams (around 50 permanent researchers, Figure 6) already involved in joint projects with SMEs as well as large industrial companies. The main objective is the development of autonomous robotic systems with driving and perceptive abilities that are sophisticated enough for personal assistance in professional or private settings. The RHIN sub-network will provide experimental setups for modeling and analysis of the sensory-motor and cognitive functions that are the basic requirements for humanoid robot autonomy and natural human-robot interactions.

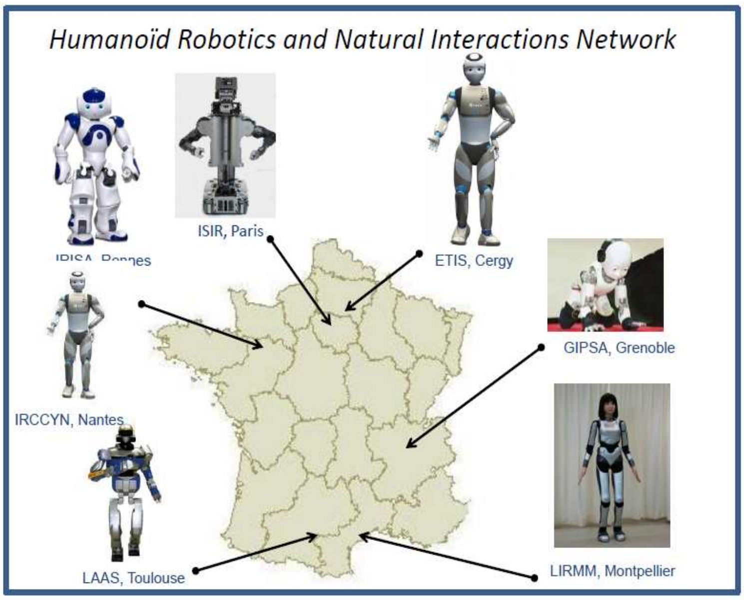


Figure 6. The RHIN sub-network

IV) R & D ACTIVITIES IN INDUSTRY

The Club of industrial partners of the GDR brings together about forty small- and large-sized companies, providers of equipments or end-users of robot technologies. In 2010, the Club has worked on a roadmap, the purpose of which being to inspire the research teams with new applications and technical bottlenecks, to foster collaborative research works, to facilitate the information of the partners about recent scientific breakthroughs, to strengthen the robotic community when lobbying to obtain funds from national agencies, etc. In this section we present the main features of this roadmap.
The main domains of activity may be classified as following:

- Industrial robotics,
- Military robotics,
- Service robotics,
- Medical robotics,
- Transportation robotics,
- Robotics for agriculture and environment.

This classification fits better the French industry compared with the classification proposed in the Strategic Research Agenda of the European Robotics Platform (EUROP) published in 2006 (http://www.robotics-platform.eu/).
The following tables summarize the roadmap of each domain. Another table has been included to mention companies that produce technological hard- or soft-components for Robotics.
Presentation of equipments of a dozen of companies can be found in the Appendix of this document.

Industrial robotics

Three sub-classes have been defined: manufacturing, non-manufacturing, "large" robotics (including robotics for nuclear power plants).

Manufacturing robotics	
Companies	Adept France, Alema Automation, BA Systèmes, BALYO, Bertin, Cyberia, Cimlec Industrie (Gorgé), Fanuc France, Fatronik-Tecnalia, KUKA France, Newtec, PCI, Savoye Logistics, SEA Productique, Snox, Staübli
Products & Services	- Assembly robots - Palletizing robots - Pick-and-Place robots
Objectives	- Automation of dangerous or repetitive tasks - Safety in collaborative tasks (human and robot comanipulation) - Improve flexibility and customization of manufacturing, reduce cycle-times
Societal impacts	- Reduce costs due to walkout - Flexibility of production - Improve companies' competitiveness - Improve conditions of work

Non-manufacturing robotics	
Companies	ALCI, Bertin Technologies, Cybernetix, ECA, Renault Advanced Engineering division, Fatronik-Tecnalia, Robosoft, R&D Tech
Products & Services	- Robots for collection and treatment of waste - Cleaning robots - Robots for inspection and surveillance
Objectives	- Automation of dangerous or repetitive non-manufacturing tasks - Safety in collaborative tasks - Civil protection and security, search and rescue operations
Social impacts	- Reduction of musculoskeletal disorders - Securing of risky operations - Improve companies' competitiveness

"Large" robotics	
Companies	Bertin Technologies, Bouygues, CEA, EDF, Fatronik-Tecnalia
Products & Services	- Tunnel boring machines, sanding robots, construction robots, robots for oil exploration, dismantling robots, glass installation robots, robots to process large surfaces (cleaning, painting, etc.) - Cable robots
Objectives	- Facilitate risky operations and maintaining of installations - Optimization of mining of natural resources - Dismantling of nuclear power plants - Reduction of painfulness of certain tasks, namely in construction
Social impacts	- Reduction of musculoskeletal disorders - Securing of risky operations - Improve security in the nuclear industry

Military robotics

Three sub-classes have been defined to distinguish robots for Land-Force, Airforce and Navy.

Robotics for Land-Force	
Companies	Thalès, Sagem, Nexter Systems, Robosoft, R&D Tech
Products & Services	- Surveillance and reconnaissance robots, combat robots, robots for logistics, for demining - robots to protect critical infrastructures
Objectives	- Protection and assistance of the soldier in operation - Medical evacuation
Social impacts	- Limit casualties - Maintain employment in the country - A test-bed for academic research - Number of potential technology transfers for civil applications

Robotics for Airforce	
Companies	Cassidian, Bertin Technologies, DCNC, EADS, Cyberia, Dassault Aviation, Flying robot, MBDA, Parrot, Sagem DS, SYSNAV, Thalès
Products & Services	- UAV (Unmanned Aerial Vehicle) for surveillance, for combat - UAV to protect critical infrastructures
Objectives	- Border surveillance - Airspace surveillance - Rescue operation (earthquake, fire, etc.) - Support of ground operations - Battlefield robots
Social impacts	- Maintain employment in the country - A test-bed for academic research - Number of potential technology transfers for civil applications

Robotics for Navy	
Companies	ECA, Thales Underwater Systems (TUS), DCNS
Products & Services	- ROV (Remotely Operated Vehicle) - AUV (Autonomous Underwater Vehicle) - USV (Unmanned Surface Vehicle)
Objectives	- Surveillance of underwater space - Underwater defence - Surveillance of seas
Social impacts	- Maintain employment in the country - A test-bed for academic research - Number of potential technology transfers for civil applications

Service robotics

Again, three sub-classes have been defined: domestic robots, educational robots, recreational robots.

Domestic robots	
Companies	Aldebaran, Gostai, Mindscape, Robosoft, Robopolis, Wany Robotics, Withings,
Products & Services	- Household robot (mower, vacuum cleaner, pool cleaner, etc.) - Surveillance robot - Robotic aids for disabled, smart walkers, robot pet, robot companion
Objectives	- Discharge people from their domestic chores - Home surveillance - Monitoring of lonely old persons - Cognitive assistance of lonely old persons
Social impacts	- Improvement of quality of life - Development of service networks - Securing of lonely persons - Strengthen relationships with remote family or medical environment

Educational robots	
Companies	Aldebaran, Gostai, Festo, Meccano, Planète Sciences , POB Technology, Robopolis, Robosoft, Wany Robotics, Wifibot
Products & Services	- Educational robots and simulators - Various learning softwares
Objectives	- Introduce robotics early in education (high school, even elementary school) as a mean to attract students in engineering cursus
Social impacts	- Increase interest of students for scientific and technical studies - Increase technological competitiveness of the country

Recreational robotics	
Companies	Aldebaran, Dialonics, Kuka, Meccano, Mindscape (Violet), Parrot, Planète Sciences, POB Technology, Robopolis, Robosoft, SYROBO, Wany Robotics
Products & Services	- Robots for leisure - Robots for hobbyists - Robots for amusement parks
Objectives	- Robotic platforms for domestic entertainment - Software for robotic platforms - Guides for museum, for company visit
Social impacts	- Highlight and protect French culture - Support and develop employments in the "digital content" industry

Medical robotics

This class includes robotics to assist people and robotics to assist surgeons, or more widely medical doctors.

Robotics to assist people	
Companies	Aldebaran, Fatronik-Tecnalia, Haption, ISIS Robotics, Magellium, Robosoft
Products & Services	- Manipulation aids - Mobility aids, smart walkers - Robots for rehabilitation and training
Objectives	- Improve quality of life of disabled and elderly people - Increase personal independence - Cognitive stimulation of the elderly - Automatic individual transport vehicle
Social impacts	- Benefit for the patient and his/her family - Lower costs for welfare services - Face the challenges of ageing population - Keep patient at home

Robotics to assist doctors	
Companies	Adept, Aesculap, AS2I, BA Systèmes, Collin, Endocontrol, General Electric Medical Systems SCS, ISIS Robotics, KOELIS, Medtech, Praxim, Robosoft, Stäubli, SurgiQual, Variants
Products & Services	- Robots for surgery (orthopedics, neurosurgery, MIS, microsurgery) - Robots for diagnosis (tele-echography) - Robots for therapy (interventional radiology, radiotherapy)
Objectives	- Transcend human limitations - Single port and Natural Orifice Transluminal Endoscopic Surgery (NOTES) - Remote surgery (battlefield, ocean, space) - Robotized instruments, micro and nanorobots
Social impacts	- Benefit for the patient: less invasive, more precise surgery and therapy - Increase safety of interventions

Transportation robotics

Transportation robotics	
Companies	Apojee, Dassault Aviation, Induct, Valeo, Robosoft
Products & Services	- Intelligent vehicles and platoon of vehicles - Aerial drones and navigation strategies - "Last kilometre" driverless shuttles
Objectives	- Autonomous vehicles in the city to control the traffic flow - Autonomous freight systems - Assistance to air traffic control - Inclusion and control of drones in air traffic
Social impacts	- Less pollution - Better safety and traffic density regulation in private and public transportation - Multiply by 2 air traffic while increasing safety - Availability of "last kilometre" transportation systems

Robotics for agriculture and environment

Robotics for agriculture and environment	
Companies	Claas France, Lattitude, Lelly, Renault Agriculture
Products & Services	- Automation of existing agricultural machines (tractors, harvesters, etc.) - UAV for inspection of fields and agrochemical treatments - Treatment and picking of vegetables and fruits
Objectives	- Design dedicated small mobile robots rather than multifunction heavy machines - Use of fleet of small mobile robots - Improve accuracy of guiding in outdoor environments - Management of soil and forestry
Social impacts	- Reduction of agricultural inputs (fertilizer, pesticide, etc.) - Improve competitiveness - Reduction of accidents

Technologies for Robotics

Technologies for Robotics	
Companies	Acapela, As An Angel, Autocruise, CRIIF, Effidence, Festo, Gostai, Haption, Intempora, Kineo, National Instruments, Prolexia, Py Automation, Robopec, Robosoft, Spirops, Symétrie, Viametris, Voxler, Vocally, Wifibot
Products & Services	- Software and midlleware - Services, programmation platforms, simulation tools - Sensors and actuators - Design of dedicated robots - Integration of robotized cells
Objectives	- Develop new components for sensing - Develop new actuators - Fill the gap between robot providers and end-users
Social impacts	- Develop industrial activity

VII) CONCLUSION

As shown in the 2009 Status Report, France is quite active in the field of Robotics research. The present report is focused on the R & D in the French industry. Companies are present in most of the robotics domains. Several of them are startup and have been created to exploit recent advances of research labs.

In 2010, the Robotic community received substantial fundings to invest for equipment and develop experimental platforms in the frame of the so-called ROBOTEX national network. Besides, the activity of the national Research Group (GDR) in Robotics is still growing, and interdisciplinary links with neurosciences has been developed.

ACKNOWLEDGMENT

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APPENDIX

This appendix collects the description of products of a dozen of French companies:

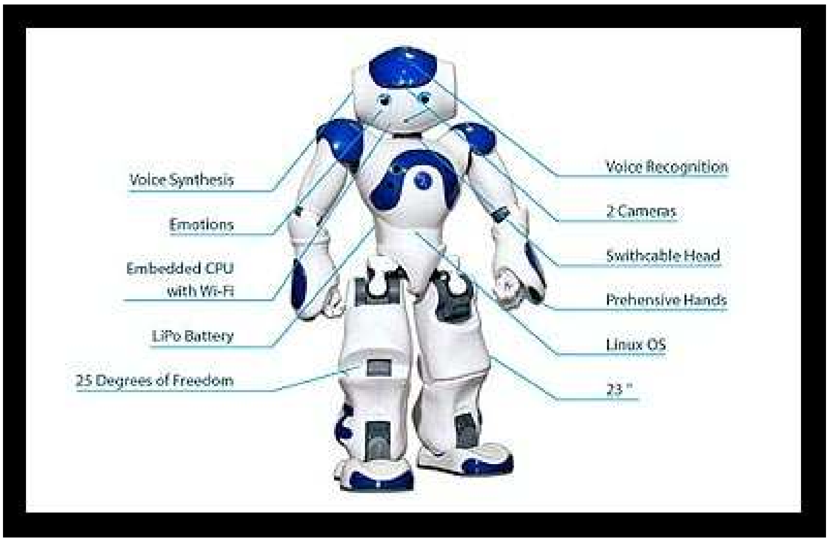
- Aldebaran Robotics,
- AssistMov,
- B.A. Systèmes,
- ECA,
- EOS Innovation,
- Gostai,
- Haption,
- Induct,
- Robopec,
- Robosoft,
- Wany.

The goal is to highlight some examples of advanced technologies that have been developed, sometimes in the frame of collaborative projects together with academic partners, sometimes with their own R&D facilities only.

Name of the system: NAO Humanoid robot

Company: Aldebaran Robotics
www.aldebaran-robotics.com

System description:
The **NAO Humanoid Robot from Aldebaran Robotics** is a companion, assistant and research platform. If the full-size personal butler is still a vision of the future, ALDEBARAN's robots will already provide a perfect platform to deliver a range of daily services. With 25 degrees of freedom (DOF), NAO is capable of executing a wide range of movements (walking, sitting, standing up, dancing, avoiding obstacles, kicking, seizing objects, etc.) The Nao Robocup Edition has 21 DOF while the Academics Edition has 25 DOF, since it is built with two hands with gripping abilities. However, the figure of 25 for DOF is technically misleading, as each leg has a general "HipYawPitch" axis of movement that amounts to 1 DOF for the pelvis. All versions feature an inertial measurement unit and four ultrasonic sensors that provide Nao with stability and positioning within space.
Nao also features a powerful multimedia system, including four microphones, two speakers and two CMOS cameras, for text-to-speech synthesis, sound localization and facial and shape recognition, amongst various other abilities. The package includes a dedicated programming software called *Aldebaran Choregraphe*, and Nao is also compatible with Microsoft Robotics Studio, Cyberbotics Webots, and Gostai Urbi Studio. Equipped standard with an embedded computer and wifi connection NAO is fully autonomous and can establish a secure connection to the Internet to download and broadcast content. Fitted with two speakers and several microphones, NAO has a quality sound system to play music. It is equipped with a voice recognition system that locates where the sound is coming from, so that he can turn his head towards the speaker or origin of the sound. He has a text to speech function so he can interact with its environment verbally by pronouncing any text sent to him, messages, e-mail, books, newspapers, etc.
Nao is being introduced on the market as the ideal introduction to robots and aspires to eventually become an autonomous family companion. Finally, with more sophisticated functions, it will adopt a new role, assisting humans with daily tasks. Featured with an intuitive, dedicated programming interface, "Choregraphe", the entire family will be able to enjoy the robotic experience. Full of new and advanced technology, the NAO robot will also satisfy the most demanding techno-addict's expectations.



Aldebaran Robotics: NAO

Name of the system: IsiMove

Company: AssistMov
www.assistmov.fr

System description:

IsiMove is a robotic solution with biofeedback primarily for balance and spinal cord rehabilitation; and also for neuromuscular and orthopedic rehabilitation, muscular reinforcement for athlete, and prevention of fall in elderly. This system includes four actuated degrees of freedom (3 rotations and 1 translation) and four three axes force sensors, one for each leg and arm. The device is able to destabilize the patient postural system in various controlled ways. Furthermore, by measuring in real time the position of the patient's center of pressure, IsiMove adapts the rehabilitation process to the patient's actual performance, maintaining exercise both achievable and challenging.
Coming with a vast array of rehabilitation games, the patient can visualize its improvement in real time and session after session, during the whole rehabilitation process. With its practical assessment tools, the physiotherapist can focus more on patient's interactions. Also including dedicated rehabilitation exercises database for neuromuscular, orthopedics injury, elderly and sport.
This robotic solution improves the posture rehabilitation process by making it much simpler to achieve, more efficient and more fun for the patient. With 4 active rotations, IsiMove is a dynamic and versatile platform with no match on the market and represents a new generation of rehabilitation tools, enabling real time exercise adjustment.

Main characteristics and performances:

IsiMove's workspace is defined as follow: +/- 15° tilt angle on X & Y; +/- 180° vertical rotation and +/- 15cm horizontal translation. And it maximum velocity is: 30°/s for the tilt; 1 rev/s for the vertical rotation and 1m/s for the translation. Each joint is independently controlled in position, velocity and force with an error less than 2% of it full range.
The two force sensors located on the platform can measure independently the centre pressure for the left and the right leg within a resolution of 0.5mm. The two other sensors, located on frame's handle, can measure three components of the user's hand forces with precision of 0.2kg.
The middleware software is an open platform with tools and programming library that can be used to easily create new rehab protocol, develop a customized application and new virtual reality rehab game. It also offers the capability to remotely share applications and data between therapists.

AssistMov: IsiMove

Name of the system: ROBMARKET

Company: B.A. Systèmes
www.basystemes.com

System description:

- Industrial Automated Guided Vehicule (AGV) and robotic Arm (6 DOF) which allows working in hostile environments in total autonomy.
- AGV guidance with Laser triangulation system
- Robotic arm with visual recognition and servoing
- Modular system which allows dissociating the tool from the AGV (patent)

ROBMARKET is the result of a French cooperative research project with public research centers (CNRS, INRIA, CEA).

Application domains:

- Nuclear industry (in nuclear radiation environment).
- Construction / order preparation / industrial assembling (Reduction in MSD-type diseases)
- Aluminium production (Improvement in hard working conditions +60°C)
- Milling long piece with specific robot

Main characteristics and performances:

TECHNICAL SPECIFICATIONS	
Capacity	1 000 kg at 600 mm
Lifting height	From 0 to 3 m
Guidance system	Laser
Communication	WIFI 802.11.a
Empty weight with battery *	1 525 kg
Maximum speed	2 m/second
Load lifting speed	120 mm/second
Safety device	Laser scanner
Autonomy	8 H


B.A. Systèmes: ROBMARKET

Name of the system: USV INSPECTOR

Company: ECA
www.ecagroup.com

System description:

INSPECTOR is a flexible remote controlled surface platform capable of carrying out a large range of missions and tasks in following domains:

- Mine Warfare, Mine Countermeasures (MCM),
- Littoral and inshore hydrographic operations,
- Coastal and Port Security,
- Intelligence, Surveillance and Reconnaissance (ISR),
- RNBC detection & localisation,
- Structure and Hull inspection,
- Very Shallow Water surveying and inspection,
- Fleet training.

Main features of INSPECTOR are:

- Multi task and reconfiguration capabilities,
- High navigation accuracy and repeatability,
- Great permanence at sea,
- High level of availability and operational effectiveness,
- Crew-safe operations.

The hull and the propulsion have been specially studied to fulfil the requirements of the missions:

- High speed for transit,
- Station keeping and accurate flight path for seafloor survey and inspection,
- Low draught for very shallow water (VSW) operations,
- High sea state survivability for offshore constraints.

Main characteristics and performances:

Structure:	Aluminium Rigid Hull
Length overall (LOA):	8.3 to 9.2m
Beam:	2.95 m (2.5m in transport configuration)
Draught:	0.6 m
Weight:	4900 kg full load
Propulsion:	2 x turbo diesel + hydrojets
Speed:	> 30 kts
Endurance:	> 20 h at 6kts
Operating modes:	Fully Automatic – Remotely Controlled or Manual modes
Sea State operations:	up to SS4 (survivability SS5)
Navigation Approval:	Div222 Cat3

ECA: USV Inspector

Name of the system: e-vigilante

Company: EOS Innovation
www.eos-innovation.eu

System description:

e-vigilante is a moving and stand-alone robot dedicated to watch warehouses and wide storage areas. It prevents from intrusions or alerts in case of emergency (fire, waterleaks). When an anomaly is detected, e-vigilant informs the safety agent through videotransmission. Then, the agent takes the control of the robot in order to qualify precisely the alarm and to act consequently.
Easy to use, e-vigilant is a reliable and evolutive modular robotic platform. Thanks to its modularity, the robot is a multipurpose tool loaded with various sensors and cameras to detect anomalies. In addition, E-vigilante integrates dissuasive tools as well such as dazzling flash and strident alarms and it also can communicate through speakers.
E-vigilante is the perfect tool to add value to the existing watching systems and it upgrades the prevention process, thanks to its mobility and high reactivity.

Main caracteristics and performances:

- Remote controlled
- Dissuasive ressources
- Multi-purpose detector
- Night vision
- Stealth
- Autonomy: minimum 10 hours
- Height: 25 cm
- Width: 25 cm
- Length: 50 cm
- Weight: 55 Lbs
- 2 front wheels, 1 free rear wheel

EOS Innovation: e-vigilante

Name of the system: e-one

Company: EOS Innovation

www.eos-innovation.eu

System description:

Eos innovation was present at the Robotics in Lyon, and he brought us e-one.
It is a modular and scalable platform that can adapt to the needs of professionals. Equipped with various sensors and cameras, e-one is a mobile base that can ship to may technologies to best meet specific expectations. In its first version designed especially for the security field, it will conduct patrols on their own and will alert you if a problem occurs. With its interactive features, it can also be a guest host of a new genus. Easy to use, e-one is a service robot that is able to respond to the problems of remote monitoring and security of premises effectively. e-one is also working on new schools so that, in the near future, improving the lives of elderly and disabled in their homes or in specialized centers.
As you can see from the photo at right, e-one has a relatively small size, 60 cm. It is equipped with a camera and a pico projector resolution. For audio, it has 2 speakers and 2 microphones omnidirectional. Finally, for the movements of the robot, there is 8 and 4 ultrasonic sensors infrared sensors.

Main characteristics:

Height: 60 cm, Width: 40 cm, Depth: 35 cm
Weight: 8-10Kg
2 front wheels
A rear idler
Battery life: Minimum 4 hours
1 high resolution camera
1 hight resolution fish eye video camera
1 high resolution videoprojector
2 high quality speakers
2 omnidirectionnal microphones

EOS Innovation: e-one

Name of the system: Jazz

Company: Gostai

www.gostai.com

System description:

Jazz is based on the concept of mobile telepresence: the robot stands in a remote location and serves as your personal avatar. You connect on the robot from a web browser on a PC. You can move the robot, see through its camera, listen through its microphone, talk through its loudspeakers, turn its head to see around.

It is extremely easy to control the robot: you simply click on the real-time image displayed on the interface by using the 3D pointer to indicate the place the robot should go.

This gives you the unique ability to be almost physically present in a distant place without bearing the inconvenience of physical presence: travelling expenses and time, wide areas to cover, risk of human presence.

Jazz is typically useful for businesses with distant production sites. Without traveling, a production manager or any expert can talk directly to the operators on the production lines, visit the factory, and check that test procedures are well implemented... This is just an example and applications of mobile telepresence are countless.

One version of Jazz is more specifically targeting security applications. In that case Jazz allows you to check the situation when an alarm is triggered without taking any risk. Still another security version can patrol autonomously and send alerts whenever it detects a suspicious situation. This avoids watchmen to cover very wide areas for instance.

Main characteristics and performances:

- 1m-high robust robot. Wide angle camera with night vision, powerful loudspeakers.
- Autonomous (Indoor localization technology with a telemetric laser) / controlled behavior (Wifi connected)
- Rotating head with LCD screen
- Movement and people detection
- Gostai point and click control interface
- 5h hour autonomy in operation. Automatic docking station with 4 IR sensors
- Elegant design and engaging
- 16 ultrasonic sensors to avoid collisions
- Core 2 duo processor. Running Linux and Urbi for easy and fast programming.

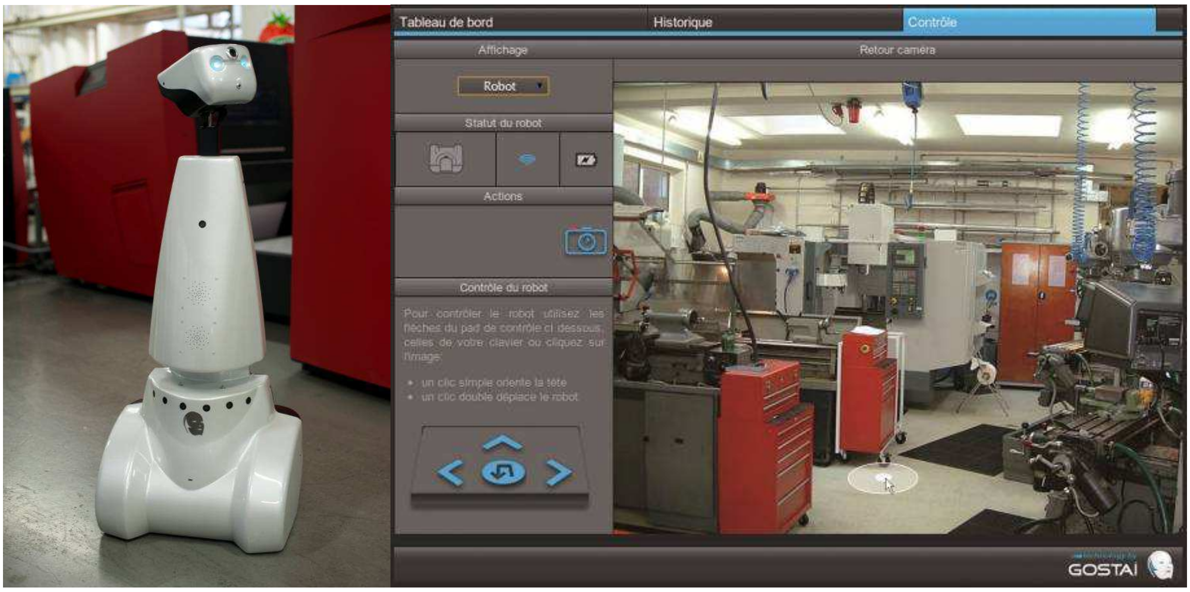


Tableau de bord
Historique
Contrôle
Affichage
Retour caméra
Robot
Statut du robot
Actions
Contrôle du robot
Pour contrôler le robot utilisez les flèches du pad de contrôle ci dessous, celles de votre clavier ou cliquez sur l'image
un clic simple oriente la tête
un clic double déplace le robot
GOSTAI

Gostai: Jazz

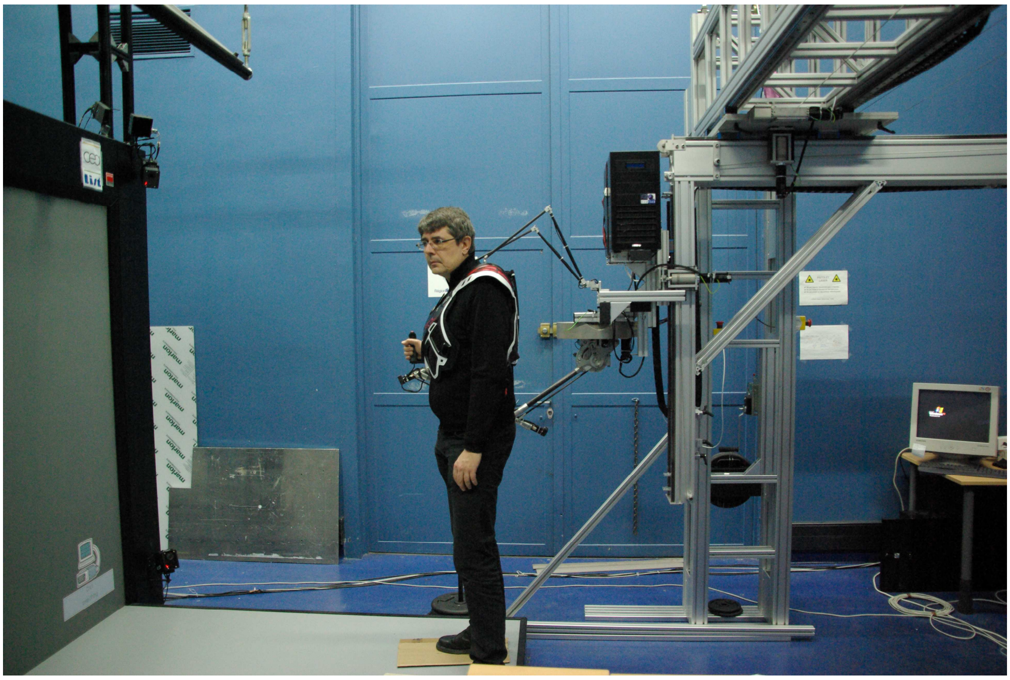
Name of the system: BOOM 3D

Company: HAPTION

www.haption.com

System description:

BOOM 3D is an articulated boom (3 prismatic joints) which follows a human operator and carries two haptic devices (e.g. Virtuose 6D35-45) for left and right hand interaction inside a very large volume. All 3 axes are back-drivable thanks to the use of capstan drives. User safety is ensured through the use of mechanical brakes which stop the movement in case of excessive torque. A proximity sensor (mechanical, optical or other) keeps the end-effector within safe distance of the users' back.
The motors are only used only to move the joints (compensate residual friction and inertia), not to resist during the delivery of force feedback by the haptic devices. Instead, the brakes are used to resist to the force applied by the user. The brakes' activation is purely mechanical, no control system is required. Thank to this design, BOOM 3D is intrinsically safe. The performances are adapted to the characteristics of the haptic interfaces and to the size of the immersive environment. The stiffness has been optimized in order to be compatible with the simulation of rigid contact.
The target application is natural physical interaction with a virtual environment inside a large workspace (at least 3 x 3 meters with 2 meters height). Use cases are assembly, manufacturing and maintenance simulation in the industry and in the navy, remote operation in nuclear facilities.



BOOM 3D in operation with one haptic device Virtuose 6D35-45 (right side)

Name of the system: Cybergo

Company: Induct
www.induct.fr

System description:

CYBERGO is a rotobized transportation system which is part of the new modes of urban and green mobility. It can transport up to 8 persons.
CYBERGO is a complement to traditional public transport (metro, tram ...). It is dedicated to the last mile from a station, the pedestrian town centers, university campuses, etc. It is partner with urban electric vehicles MODULGO and functions of car sharing.
This concept was developed by INRIA since 1990 and has been featured in several European cities within the European projects CityMobil and CityNetMobil.
The CYBERGO implements new technologies in the field of robotics in the automotive propulsion and is 100% electric.
CYBERGO is equipped with sensors including laser range finders and cameras and a set of functions developed by INDUCT enabling it to move autonomously and safely, without any specific equipment infrastructure (even though the current regulation imposes its use on reserved lanes).
This robotized vehicle uses either batteries or lithium-polymer solution Numexia, which allows ultra rapid charging by induction in 15 seconds during stops (when boarding and alighting passengers), enabling continuous operation of CYBERGO (without return to Base Station).
CYBERGO provides a service economically and ecologically.

The computer system management and monitoring controls the implementation of a variable number of shuttles CYBERGO according to demand. It does not move a bus with 40 seats to carry three people!

Induct: Cybergo

Name of the system: REETI

Company: Robopec

www.robopec.com and www.reeti.fr

System description:

Reeti is a PCBot which combines the worlds of a home theater PC (htpc) and communicative robotics. Its body embeds a full home theater PC (audio 5.1, hdmi, blu-ray, …). Its head fully animated with 15 motors expresses its emotions through postures and facial expressions. Reeti can also hear (two microphones) and see (two HD cameras).

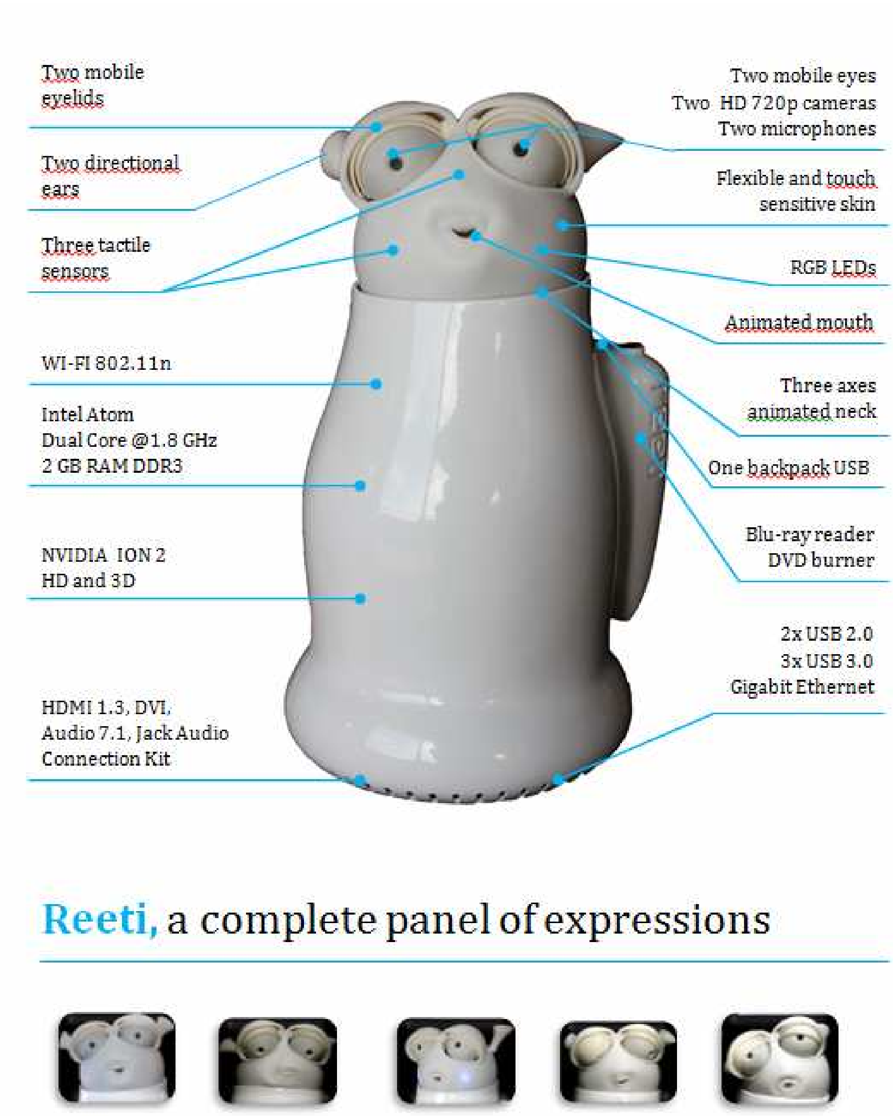
A user friendly interface, available on iphone or ipad, allows you to build your own animations and to launch a whole bench of applications. Connected to the web, Reeti receives emails, read RSS feeds and broadcast on Facebook.

Reeti is an open development platform. Besides applications already available, develop your own project. A scalable and configurable artificial intelligence allows customization.

Main application domains are:

- Research laboratories and developers : develop new applications or integrate your applications with Reeti expressive interface (AI, man machine interaction, robot assisted therapy, sociology, psychology, …)
- Teachers: Innovative tool to teach the sciences and the technologies in a fascinating and applied way
- Firms and professionals organizations: Reeti makes your stands and your reception center attractive and original
- Home users: PC, funny robot, communicative and connected object, video surveillance, … Reeti gathers all these functions in the same advanced design object

Main caracteristics and performances:


Two mobile eyelids
Two directional ears
Three tactile sensors
WI-FI 802.11n
Intel Atom
Dual Core @1.8 GHz
2 GB RAM DDR3
NVIDIA ION 2
HD and 3D
HDMI 1.3, DVI,
Audio 7.1, Jack Audio
Connection Kit
Two mobile eyes
Two HD 720p cameras
Two microphones
Flexible and touch sensitive skin
RGB LEDs
Animated mouth
Three axes animated neck
One backpack USB
Blu-ray reader
DVD burner
2x USB 2.0
3x USB 3.0
Gigabit Ethernet
Reeti, a complete panel of expressions

Name of the system: Kompaï the robot

Company: ROBOSOFT

www.robosoft.com

System description:

Kompaï is a robot designed to assist dependent persons at home. This robot can speak, understand what we say to it, find its way around the house and, with just a word, access all Internet services. Kompaï is intended to help dependent persons in their daily lives. It is a mobile and communicative product. Somewhat like a dog, it has its "basket", which is the recharging dock that it heads back to when its batteries are low. Equipped with speech, it is able to understand simple orders and give a certain level of response. It knows its position within the house, how to get from one point to another on demand or on its own initiative, and it remains permanently connected to the Internet and all its associated services.

Main characteristics and performances:

Thanks to the robuBOX-Kompaï based on Microsoft® Robotic Developer Studio, Kompaï R&D already integrates most of the basic needed functions for a true robot companion. The aim of Kompaï R&D is to allow developers to spend as little time as possible creating existing tools and rather develop new behaviors and a real “added value”. Kompaï R&D is even delivered with some Open Source code to make easier first developments.

Extra hardware such a various sensors or any specific devices can be added into Kompaï R&D, thanks to its connectivity.

› Dimensions: 450 x 400 x 243 (L x W x H)
› Payload: 30 kg
› Weight: 25 kg, including batteries
› Max speed: 1 m/s
› Li-ion batteries
› Odometry
› Laser range finder
› Cameras
› Ultrasonic sensors (rear and front)
› Infrared sensors

More information at: http://www.doc-center.robosoft.com/Kompaï_home_page

Kompaï Facebook account: http://www.facebook.com/pages/KompaiTheRobot/115097121860721

ROBOSOFT: Kompaï

Name of the system: RobuROC6

Company: ROBOSOFT

www.robosoft.com

System description:

With exceptional obstacle crossing and unmatched off-road performances compared to its size, the robuROC6 offers a real solution for reconnaissance, monitoring and safety operations while minimizing human risks. The highly innovative concept of customized loads allowing adaptation to the context opens multiple application fields. Thus, equipments such as video cameras, transmission systems and sensors can be very easily installed on the robot to match missions it will have to carry out.

Thanks to its integrated control technology based on the robuBOX™ and its open architecture, the robuROC6 offers integrators an efficient tool to develop custom-solutions for very complex applications.

Main characteristics and performances:

› IP 65
› Length: 1500 mm / Width: 780 mm (including wheels) / Height: 500 mm
› Weight: (including batteries): 160 kg
› Step clearance: around 25 cm (climbs standard stairs)
› Max Speed: 13km/h
› Max slope: 45°
› Max Payload: Around 100 Kg

ROBOSOFT: RobuROC6

Company: WANY ROBOTICS
www.wanyrobotics.com

System description:

PekeeII is a full game of mobile robots for scientist or educational applications which take advantage from a modular and robust conception. Thanks to its huge modularity, this robot can be equipped with more than 40 different embedded sensors like temperature sensor, light sensor, microphones, compass, gyrometers, various cameras (CCD, CMOS, Stereo, Thermal…), various telemeters (laser, US, IR), various 3D sensors (Microsoft Kinect, Visio 3D+ system, …), absolute indoor localization system, GPS, …etc. It can even be equipped with embedded arms (1 or 2) and/or outdoors locomotion system. This robot is running with an embedded PC with Microsoft Windows or with Linux. All the robots of the Pekee II line of products benefit from the same software architecture and the same API. The robot is also directly programmable in C#, C++ but also in Matlab and is fully compatible with ROS.

Main characteristics and performances:

387mm diameter, 225mm maximum height and a weight of 12kg maximum (including embedded PC and battery), 2 drive wheels, Maximum Speed 50cm/s (fast ratio gearbox) or 25cm/s (slow ratio gearbox), Carrying Handle, Programmable architecture based on a Mitsubishi 16bits Microcontroller, 24Mhz, 128KB Ram; Firmware updatable via internet, TypeA USB connector, Embedded User Interface (8 buttons- 8 Leds 5 of which are user definable, programmable graphical back-lit LCD black&white screen 128x64pix); 2 DC 12V powerful motors, 2 Highly accurate odometers (255560 tops per wheel cycle), over current detection and security with accessible signal for software, 360° bumpers; 12V 7A/h battery NimH, integrated quick charger with accessible signals for software (current voltage, charging in process, end of charging); 96 pins connector (DIN41612 TypeC) allowing the user to have full control of all robot's digital and analogical signals coming from the robot.

Wany: PEKEE II