

## COACHES

# COoperative Autonomous Robots in Complex and Human Environments

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**Partners :** University of Caen Normandie, France

University of Sapienza Roma, Italy

Vrije Universiteit Brussel , Belgium

Sabancı University , Istanbul, Turkey

**Participants:** Agglomeration Caen la mer, Caen City  
Rive de L'orne Mall, Caen  
SME Algorithmica, Italie



- Deploying robots in public areas to assist, guide, and escort visitors
- Visual applications are born:
  - **Guidance and Personal assistance in public areas**
    - **Shop malls**, touristic sites, airport, train stations, **hospitals**
  - Surveillance and patrolling in cooperative way with intervention units (firefighters, police, medical units, and tourist office staff, ...)
- Our target use cases:
  - Caen Rive de l'Orne Shopping Mall in cooperation with Caen city



- Environment monitoring

- Environment modeling
  - **KB event language, 2D/3D visual representation** of the environment
- Rule-based semantic scene analysis
  - **Detecting object, people** behaviors and tracking



- Scene understanding and situation awareness

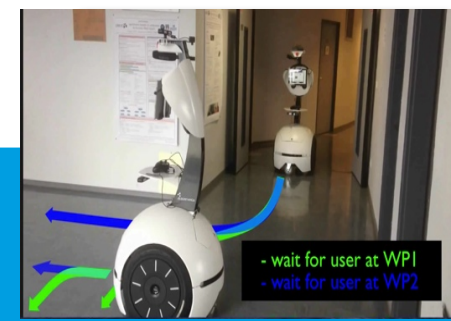
- Human activities Recognition
  - **Human needs and activity** representation
- Situation awareness
  - **Detecting behavior** and **abnormal events**

- Multi-modal short-term human-robot interaction

- From robot to human
  - **Guiding task** : speech, arm pointing, moving to destination, **Information assistance task**: text and maps on the screen
- From human to robot
  - **Requests** of guidance or information: text, speech

- Multi-Robots cooperative planning

- Goal-Based Interaction Decentralized Decision-Making for Multi-agent Planning
- Robust and safe Navigation in populated areas



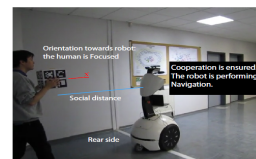
- Advance state of the art of autonomous systems that are able to:
  - Increase the robustness of multi-robot systems in public areas
  - Increase the autonomy of robotic systems that
    - Assess and aware the situation ;
    - navigate safely in crowded environments ;
    - plan and decide collectively ;
    - interact in short-term with humans ;
- Demonstration in a real-world environment
  - Rive de l'Orne Shopping Mall;
  - Lab building;
  - Hospital;



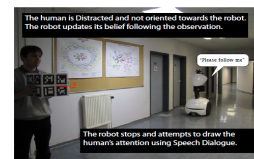
- Ability to
  - navigate in a crowded environment ;
  - detect people ;
  - interact with them ;
  - And, assist them
  - Plan collectively
- Deployment in
  - A shopping mall
  - A center of congress
  - A hospital
  - IAB Forum,



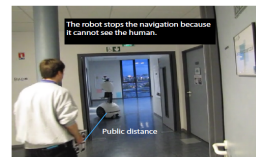
- **Caen Normandie, France**
  - KB reasoning (WP1)
  - Multi-Robots Task Planning
  - Decision-Making (WP4)
- **Sapienza, Rome, Italy**
  - Human-Robot Interaction (WP3)
  - Robust navigation (WP4)
- **Sabancı, Istanbul, Turkey**
  - Multi-KB reasoning (WP1)
- **Vrije, Brussels, Belgium**
  - Image/video processing (WP2)



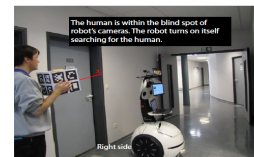
(a) Navigation



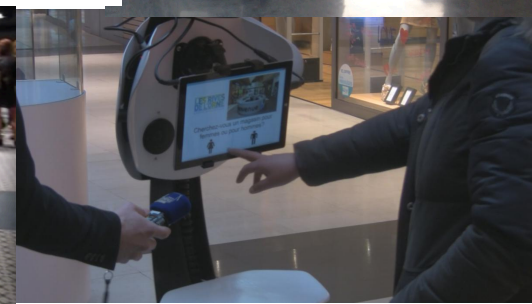
(b) Human distracted



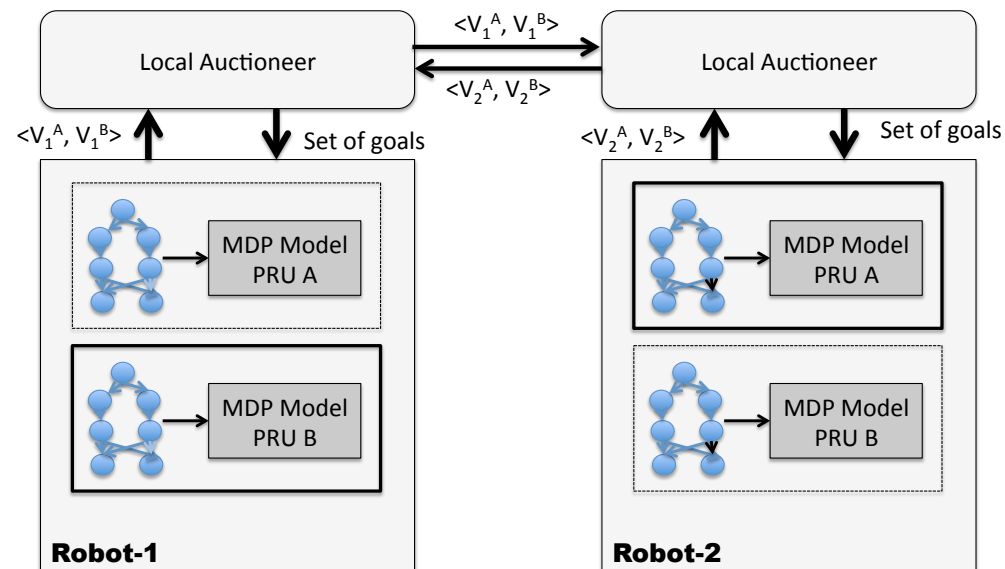
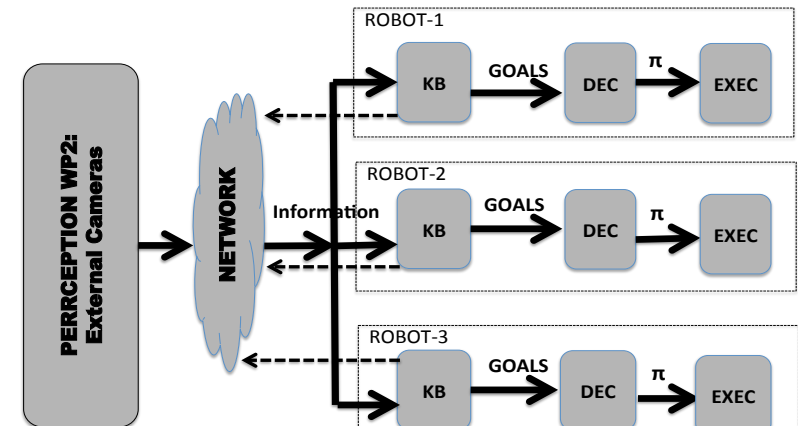
(c) No detection



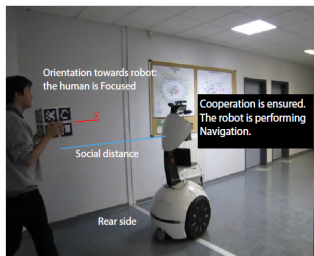
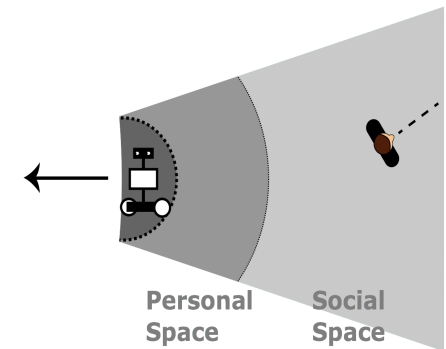
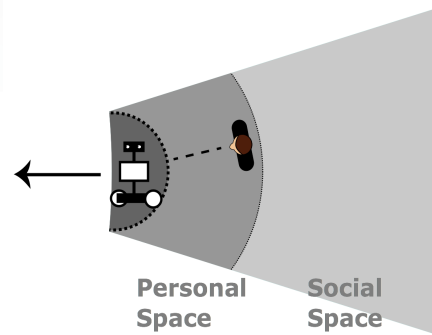
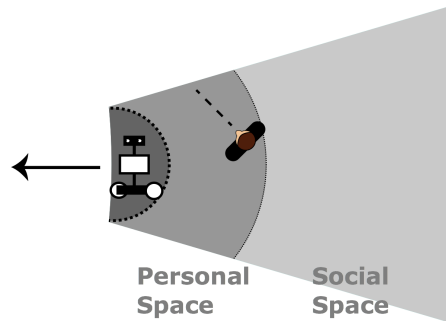
(d) Searching for human



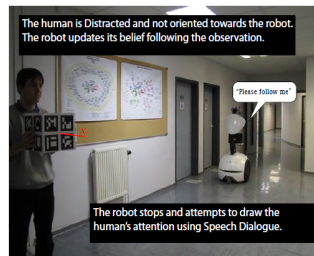
- **Distributed reasoning**
  - Distributed dynamic KB
  - Synchronisation
- **PRU+ hierarchical task Language**
- **Distributed Market-based auction task planning using MDPs**
- **A leader-follower joint planning for joint tasks using a weakly-coupled MDPs**



## • Hierarchical factored POMDPs for Escorting



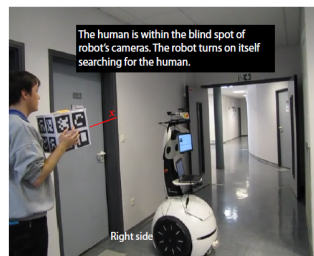
(a) Navigation



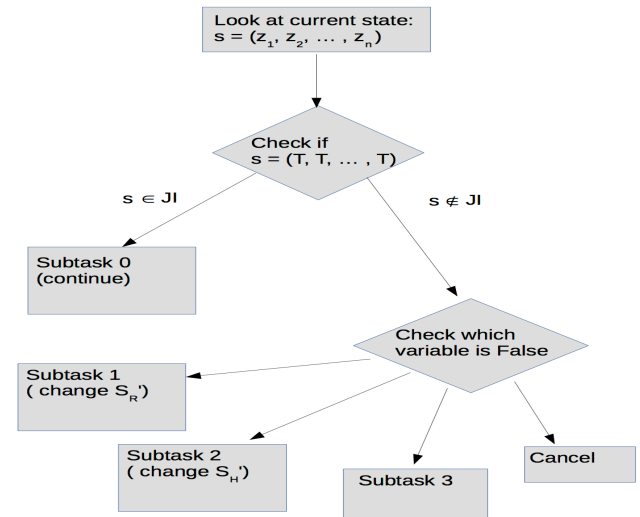
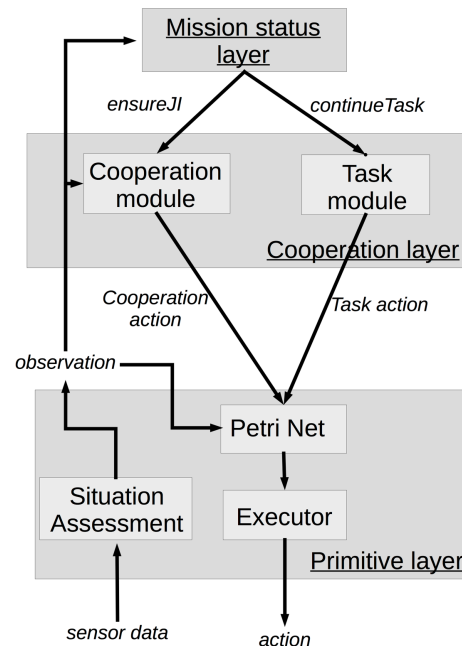
(b) Human distracted



(c) No detection



(d) Searching for human



- **Multiple Knowledge-based representation and reasoning**

- Static and Semantic Knowledge using prolog-like predicate program
- Temporary and dynamic knowledge on the environment
- Temporary and dynamic knowledge on the robot status and goals

- **Static Knowledge on the environment**  
is-a(fastFood, restaurant).  
instance-of(mango, womenDressShop).  
nearby(mango, desgual).

- **Temporary Knowledge on events**

*goal('secure', L) :-*

*unknownObject(X),  
at(X, L).*

*goal('assist', X):-*

*people(X),  
detected(X)*

*goal('escort', X) :-*

*people(X),  
ask\_escort(X).*

- **Temporary Knowledge on status robots and their goals**

*status(idle/Active), current\_task(goal\_id,  
Interruptibility\_level), Activity(robot\_id,  
goal\_id)*



Are you the person guided by my robot colleague?

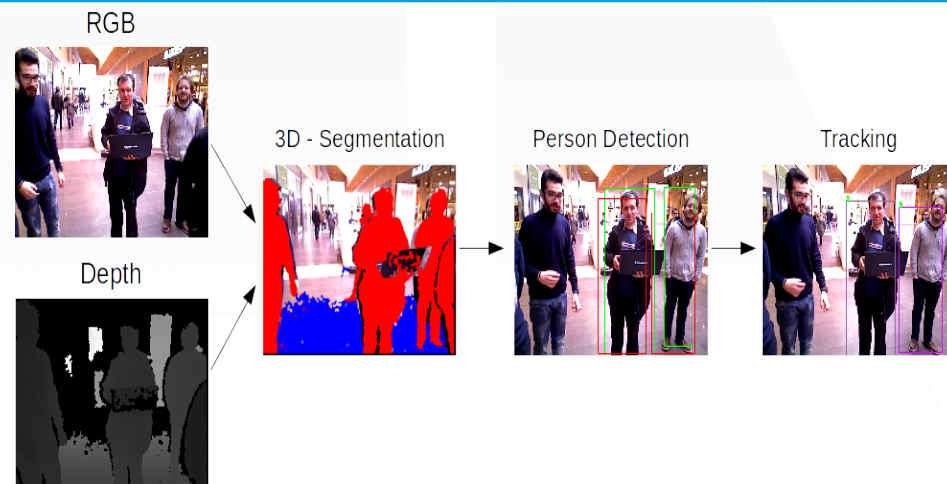
- **Image/video processing**

- Face detection
- People detection and tracking

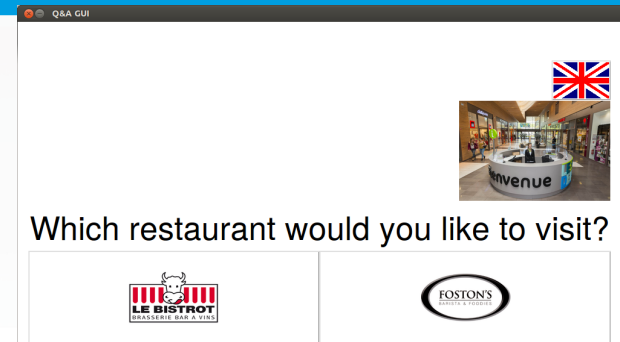
- **Event detection**

- Behavior people understanding : Particle filter methods for articulated objects

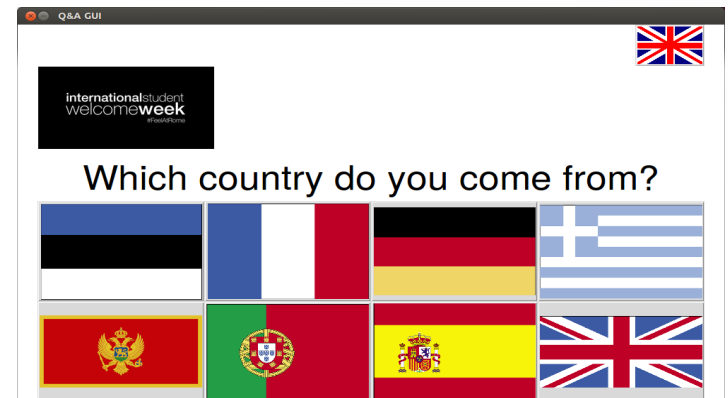
- People approaching
- People surrounding the robot
- People going away



- Multi-modal short-term human-robot Interaction
  - Developing a simple language for defining interaction template
- Human intention estimation
  - Estimating the behavior through the moving
  - Dialogue
    - goal('escort', X) :-*
    - people(X),*
    - ask\_escort(X).*

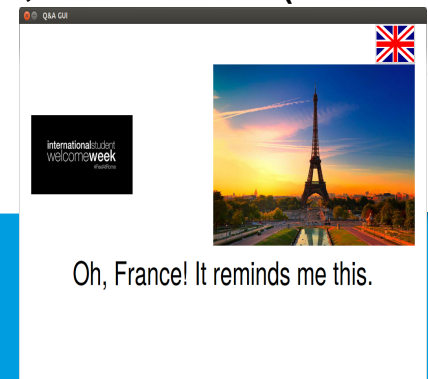


`ask<whichActivity, {shop, restuarant}>`



`ask<ComeFrom, "country", GetCountries(Continent)`

`state <ShowInfo, Country>`





## Published : 1 journal and 6 conference papers

1. Xuan Son Nguyen, Abdel-Ilhah Mouaddib, Thanh Phuong Nguyen, Laurent Jeanpierre "Action Recognition in Depth Videos Using Hierarchical Gaussian Descriptor", International Journal of Multimedia Tools and Application, accepted and published in 2018
2. Valerio Sanelli, Michael Cashmore, Daniele Magazzeni, and Luca Iocchi. Short-Term Human Robot Interaction through Conditional Planning and Execution. In Proc. of International Conference on Automated Planning and Scheduling (ICAPS) 2017
3. Eugenio Sebastiani, Raphaël Lallement, Rachid Alami, and Luca Iocchi. Dealing with On-line Human-Robot Negotiations in Hierarchical Agent-based Task Planner. In Proc. of International Conference on Automated Planning and Scheduling (ICAPS) 2017
4. L. Jeanpierre, A.-I. Mouaddib, L. Iocchi, M.T. Lazaro, A. Pennisi, H. Sahli, E. Erdem, E. Demirel, V. Patoglu. COACHES: An assistance multi-robot system in public areas. In Proc. European Conference on Mobile Robots (ECMR), 2017.
5. Paola Ferrarelli, María T. Lázaro and Luca Iocchi. Design of robot teaching assistants through multi-modal human-robot interactions. In Proc. of International Conference on Robotics in Education (RiE) 2017
6. Yusuf Izmirlioglu and Esra Erdem: Qualitative Reasoning about Cardinal Directions using Answer Set Programming. AAAI 2018:
7. Yusuf Izmirlioglu, Bahadır A. Pehlivan, Misra Turp, Esra Erdem: A general formal framework for multi agent meeting problems. ICRA 2017: 1299-1306

## Submitted : 2 conference papers

1. Fabio-Valerio Ferrari, Laurent Jeanpierre and Abdel-Ilhah Mouaddib, Multi-level POMDP Framework for Human-Robot joint activities, (*Under submission*), 2018
2. Abdel-Ilhah Mouaddib, Laurent Jeanpierre, "A practical distributed reasoning and planning for multi-robot systems", submitted, 2018



Are you the person guided by my robot colleague?

- **Software developed during the project and released as open-source**
  - **thin\_navigation ROS package:** localization and navigation modules for dynamic environments developed within Task 4.1 - [https://bitbucket.org/ggrisetti/thin\\_navigation](https://bitbucket.org/ggrisetti/thin_navigation)
  - **PNPgen library:** library for plan generation from PRU domains developed within Task 4.1 - <http://sites.google.com/a/dis.uniroma1.it/petri-net-plans/pnp-generation>
  - **thin\_mapper ROS package:** offline 2D mapping for dynamic environments developed within Task 1.1 - [https://bitbucket.org/ggrisetti/thin\\_mapping](https://bitbucket.org/ggrisetti/thin_mapping) (upon request)



- **Polyclinique saint-martin (private hospital), Caen:** a demonstration to assist people to find a doctor or a unit care and new capabilities of the robot are under discussion like transporting goods medicines, ...
- **Relais science, science, culture and innovation, Caen:** a partnership between relais sciences and our group to develop demonstration at their modern and high tech building with many and reconfigurable facilities. A demonstration of smart home and robots is under discussion.
- Luca locchi “Conditional planning for Human-Robot Interaction”, **PlanRob Dagstuhl Seminar 15-20 gennaio, 2017, Dagstuhl , Germany.**
- Luca locchi "Short-Term Human Robot Interaction through Conditional Planning and Execution", **ICAPS 2017**
- Luca locchi "Dealing with On-line Human-Robot Negotiations in Hierarchical Agent-based Task Planner", **ICAPS 2017**
- Abdel-Ilhah Mouaddib, **Smart City event** organized by Caen City, “ Robots in public space”, 2017
- Abdel-Ilhah-Mouaddib and Laurent Jeanpierre, **Google French Tour**, December 2017, Caen
- **Coaches.greyc.fr** the web site of the project is maintained and up to date with new results and demonstration (pictures, video, publications, ...).



- A multi-service multi-robot system and programmable services;
- A software for service multi-robot and independent from the physical platforms;
- Possible deployments in different environments;



**LES RIVES  
DE L'ORNE**  
SHOPPING & LOISIRS



Au revoir et merci pour votre  
participation