ELECTRONICS & DEFENSE

THE CHALLENGES OF MIXED INTERACTIONS FOR AUTONOMOUS MOBILE ROBOTICS

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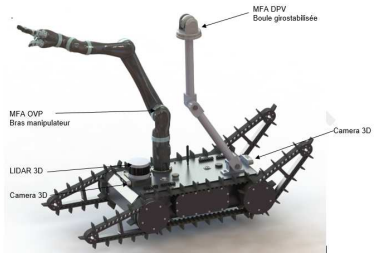
Problems with UAV and UGV in autonomous missions

- Operational Constraints: operation area is segmented, highly heterogeneous, with mission objectives updates, limited resources (communication, energy), uncertainty.
- Autonomous operations with various platforms, ranging from small to large platforms
- Mutiple ways of interacting with robotics, ranging from human-robot teaming (coactivity) to loosely coupled interactions
- Multiple potential operators and platform end-users
- When operator should be in charge? Under which conditions?



Direct Impacts on Human Robot Interactions

- Operational acceptance:
  - Limit impact on doctrine
  - System appropriation
  - Optimized learning curve
  - Robot behavior acceptance
  - Human behavior awareness
  - Robot as a teammate?

⇦ ⇨

- Trust:
  - Robot's environment representation
  - Course of actions (Planning and Scheduling)
  - Mission criticalities:
    - Safety in tasks coexecution / colocalisation
    - Failure modes management
    - Timeliness

➔ *Multiple scientific questions:*
Is shared robot / human mutual awareness achievable?
How to interact with an autonomous robot?

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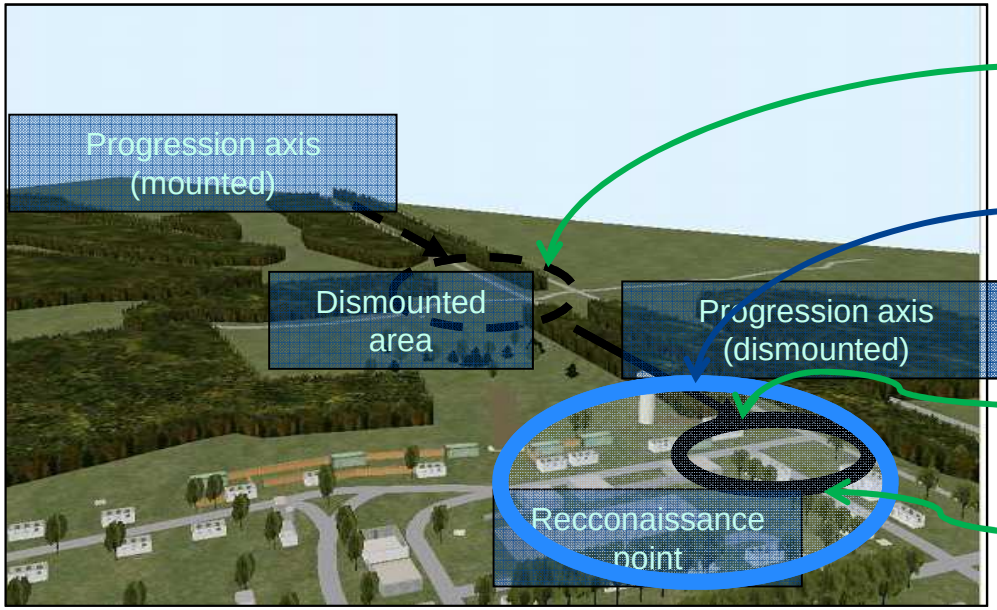
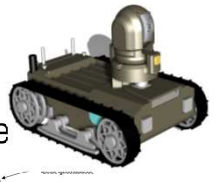
Operationnal Scenario

- Point recconnaissance inside a village

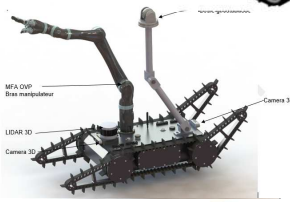


Secure dismounted area with observation robot

Reconnaissance with UAV

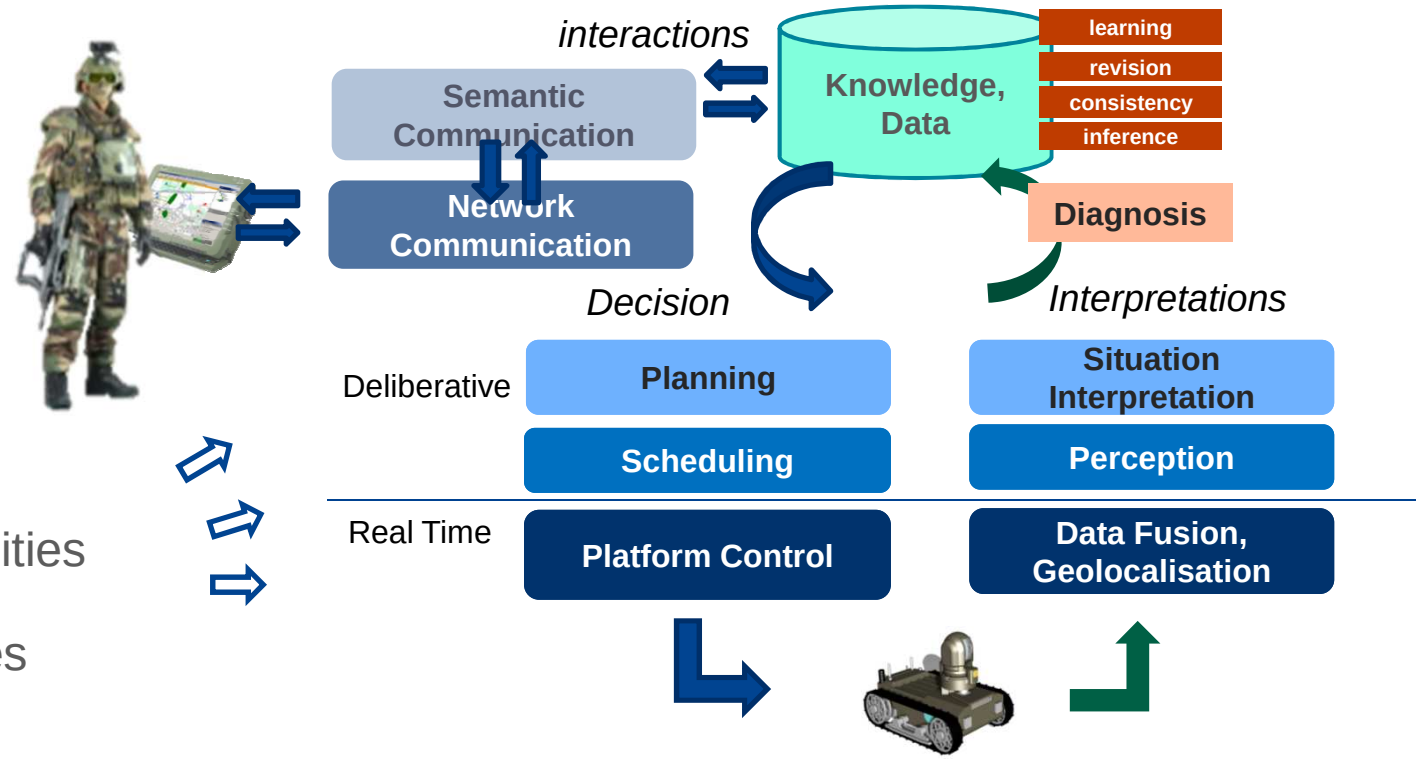


Infiltrate covers and conceale areas



Explore buildings

Multi Agent Architecture Example for Interactions



- Most of functionalities use AI techniques

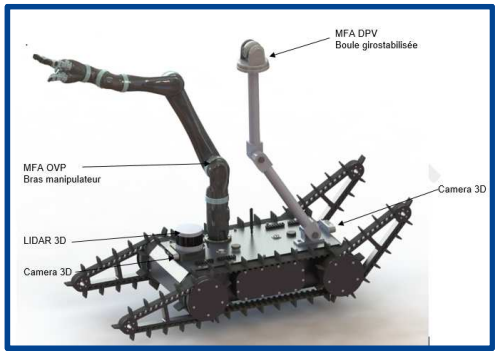
Use cases Example

Contact support and logistic

- **Interactive autonomous mobility**
- **Human/Robot Colocalisation**

Highly Interactive
Co-execution
Dynamic environment

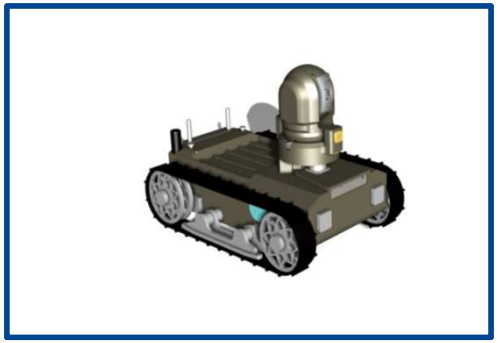
Perimeter Inspection



- **Follow predefined path**
- **Autonomous « routine » observations**

Known environment, propose or decide observations, propose or decide path alternatives

Infiltration



- **Progression in conceal and covers**
- **Environment analysis**

Unknown environment
Retrieve data to the operator
May require assistance

High processing power ⟸ ⟹ Low processing power

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Interactions modalities

- Towards conversational agent example

modalities

Validation dialogue control

Robot Execution Controler

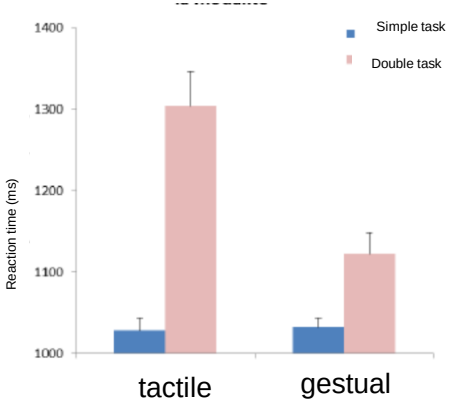
Navigation Plan

Gestual

Speech Recognition

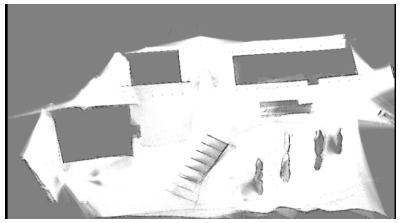
Brain Computer Interface

Reaction time according to modality

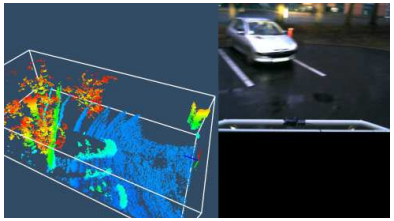


Environment representation: interactions based on data

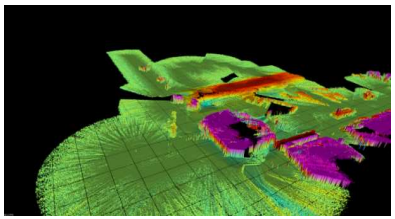
- **Simultaneous Localisation and Mapping (SLAM) 2D:**
  - **Hector, Cartographer, gMap**
  - **Limited structured environment indoor / outdoor**
- **Obstacle map 3D, dense, with semantic information**
- **SLAMD 3D**
- **Environment reconstruction 3D + images**



Poor data,
Highly interactive <u>for mobility</u>
Risks:
System lost, teleoperation



Medium data,
Real Time, no or limited interactions
Risks: safety



Rich data,
Highly interactive <u>for missions:</u>
Risks: operator overload

Machine Learning

- Reinforcement
- Representatior level

High processing power ⟸ ⟹ Low processing power

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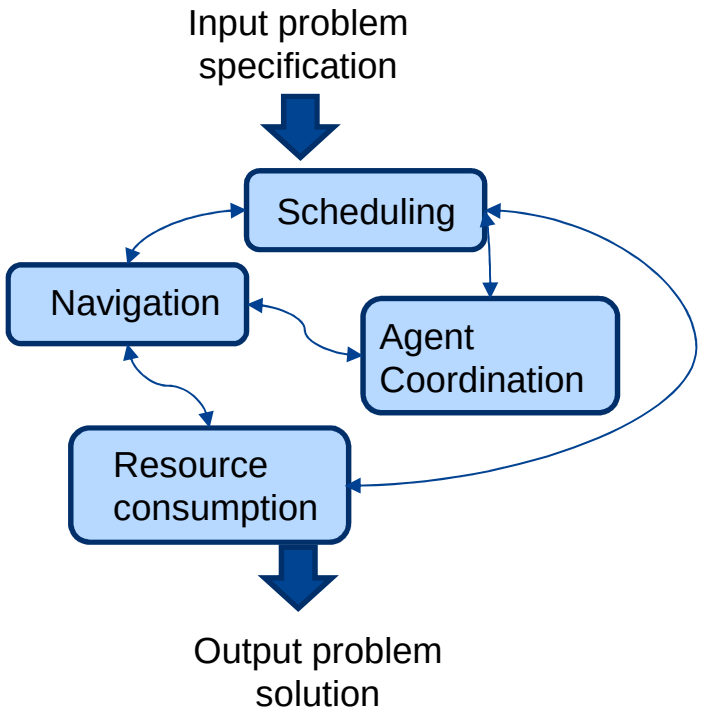
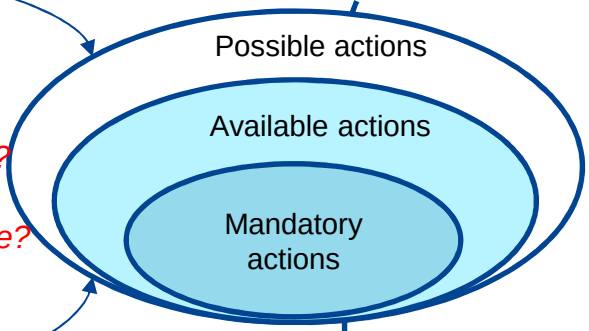
Decisions: Multiple Model Processing in AI

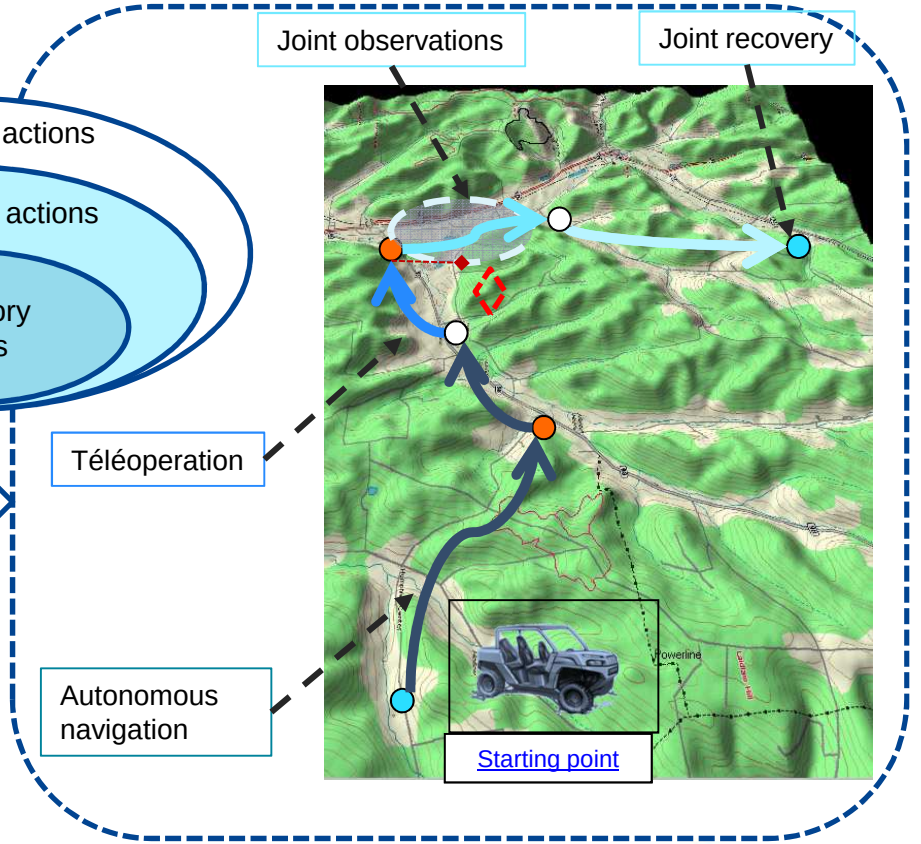


- **Multiple Models for the Problem** ⇨ Model-based interactions
- **Decide relaxations (e.g. mission objectives)** ⇨ Model-based interactions
- **Multiple solving method (Branch and Bound, A* and co..), Search algorithms** ⇨ Interact with Choice points
- **Data presentation** ⇨ Modality problem

Human-Robot Interactions based on mixed initiative

Achievable?
Performable?
Available?
Coexecutable?





Principle:

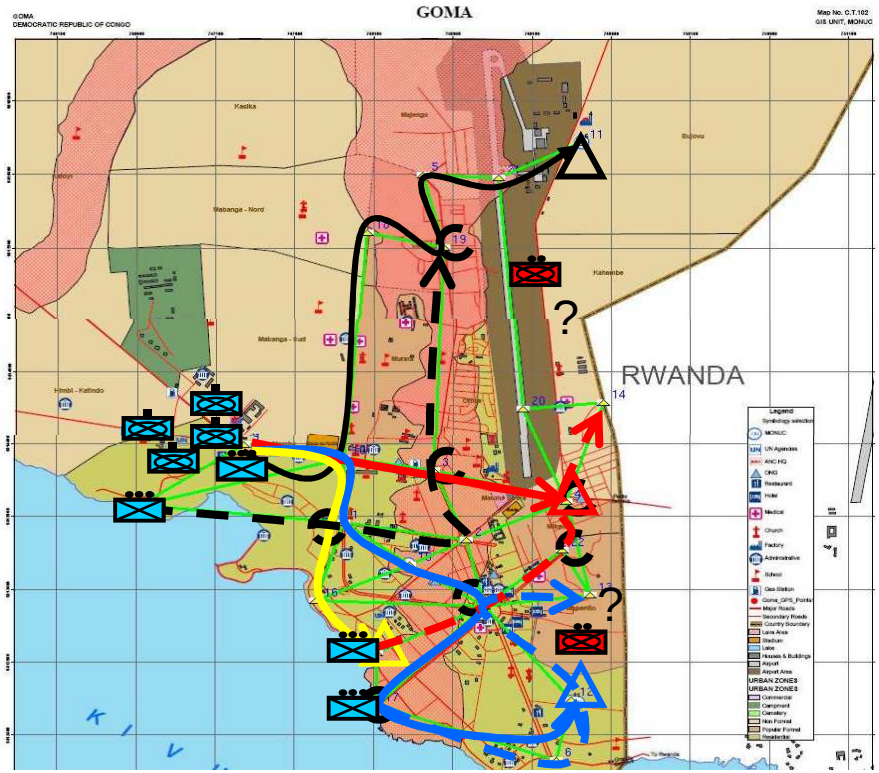
- Tasks can be dynamically allocated to humans or vehicules
- Choices are made on-line
- Insertion in a hierchical organisation

State of the art:

- KAoS, SAFRAN Patents

Benchmark exemple: support UNO in GOMA and secure town

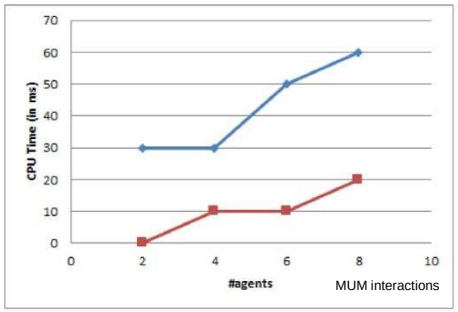
- Battalion level scenario, wargaming, sampling snaphot of situations
- Multiple interactions between man and robots are deduced from OPORD and FRAGO
- Plan and (re)-schedule functionality with uncertainty
- Each robots represent all other agents activities.



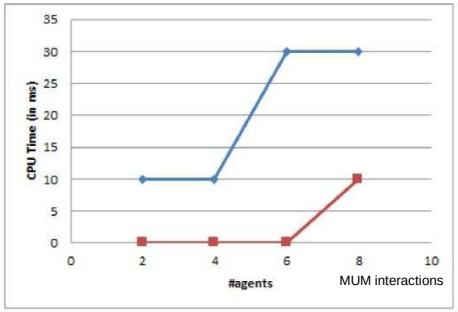
Automatic Uncertainty Management vs Interactions

The total CPU time (blue) is the sum of the certainty CPU time (red) plus uncertainty one.

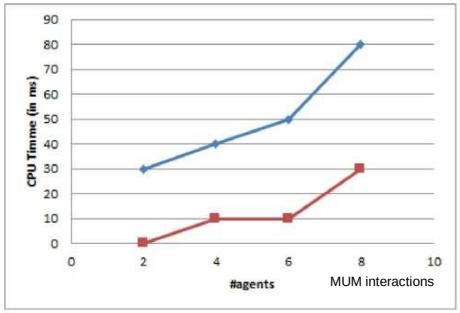
- Four real operational situations, stressed with temporal uncertainty
- Multiple mixed interactions man-robots
- Plan recovery with AI !
- Workshop SPARK - ICAPS2018



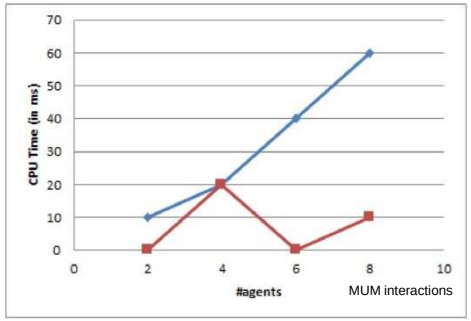
Recon village after flooding.



Suspect sites inspection



Reinforce UN in GOMA.



Secure humanitarian area, for civilian rescue

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Conclusion

- Environment representation: interactions depends on available processing power
  - Small robots will require more interactions
  - Overconstrained by energy and communications (in adversarial environments)
- Decision, planning and scheduling: multiple interactions possibilites. Engineers must take advantage
- Dependence to environment / missions:
  - Emergent Modalities, with combinations
  - Task allocation (machine or human)
  - Deal with uncertainty!