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THE FRENCH AEROSPACE LAB

Adaptive Autonomy for a Human-Robot Architecture

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Plan

Context

A mission operated in the physical world by several agents, including one or several humans

An Authority Sharing problem, with its dynamicity :

- between artificial agents (automatic pilot, UAVs, robots...)
- between artificial agents and human operators

Example of missions :

- Monitoring
- Observations
- Search and Rescue

State of the Art

Adjustable autonomy

- Autonomy : a relationship between entities about an object [Castelfranchi 2003]
- Autonomy : ability of the agent to reduce the need of operator supervision [Goodrich 2001]
- Automation levels [Sheridan 1978]
- Autonomy measure [Huang 2005]

State of the Art

Conclusion

- Autonomy levels are unsatisfying : predefined, not operational or mission specific
- Human operator always considered as a perfect solution, whereas she/he is fallible
- Need of a formal basis for authority sharing : who does what, based on which objective criteria ?

Objectives

Why, when and how should an agent take the initiative ?

- When the environment has changed ?
- When an agent violates established procedures (in particular the human operator) ?
- When an unexpected event occurs ?

Three Main Functions

An Adaptive Autonomy structure based on three core functions :

- Planning
- Situation Assessment
- Authority Sharing

Planning

The planning function :

- Allocates and Schedules tasks between entities in order to reach mission objectives
- Updates parts or totality of the global plan if needed (replanning) in case of disruptive events

Situation Assessment

The Situation Assessment function :

- Constantly analyses the current state of the system
- Predicts the future states of the system
- Detects inconsistencies between predicted states and observed states (conflicts)

Authority Sharing

The Authority Sharing function :

- Identifies conflicts detected by the situation assessment function
- Solves conflicts if necessary with the planning function (e.g. tasks reallocation, temporary solving plan, interaction, etc.)

Basic concepts

Mission basic concepts :

- Resources (including tasks)
- Sources of resources
- Conflict

Resources

An essential concept of the formalization

Resources :

- represent all items needed for the mission accomplishment
- are defined over time.

Examples of resources :

- Physical objects (sensor, fuel, etc.)
- Immaterial objects (pieces of information, logical conditions, etc.)
- Tasks

Resources : tasks

Tasks themselves are resources.

A complex task can be divided into subtasks, which are resources.

Example of a task instanciation :

$$nav1 =< navigating, task, [t_{start} - t_{end}], \\ [(initiated; t_{start})], \{map, navAlgo\}, \{waypointList\}, src >$$

Source

A source defines the producing entity of a resource.

$source =< t_{prod}, e >$

with t_{prod} the production time ;

and e the producing entity.

There are several possible entities :

- operator
- agent
- external world
- procedures

Conflict

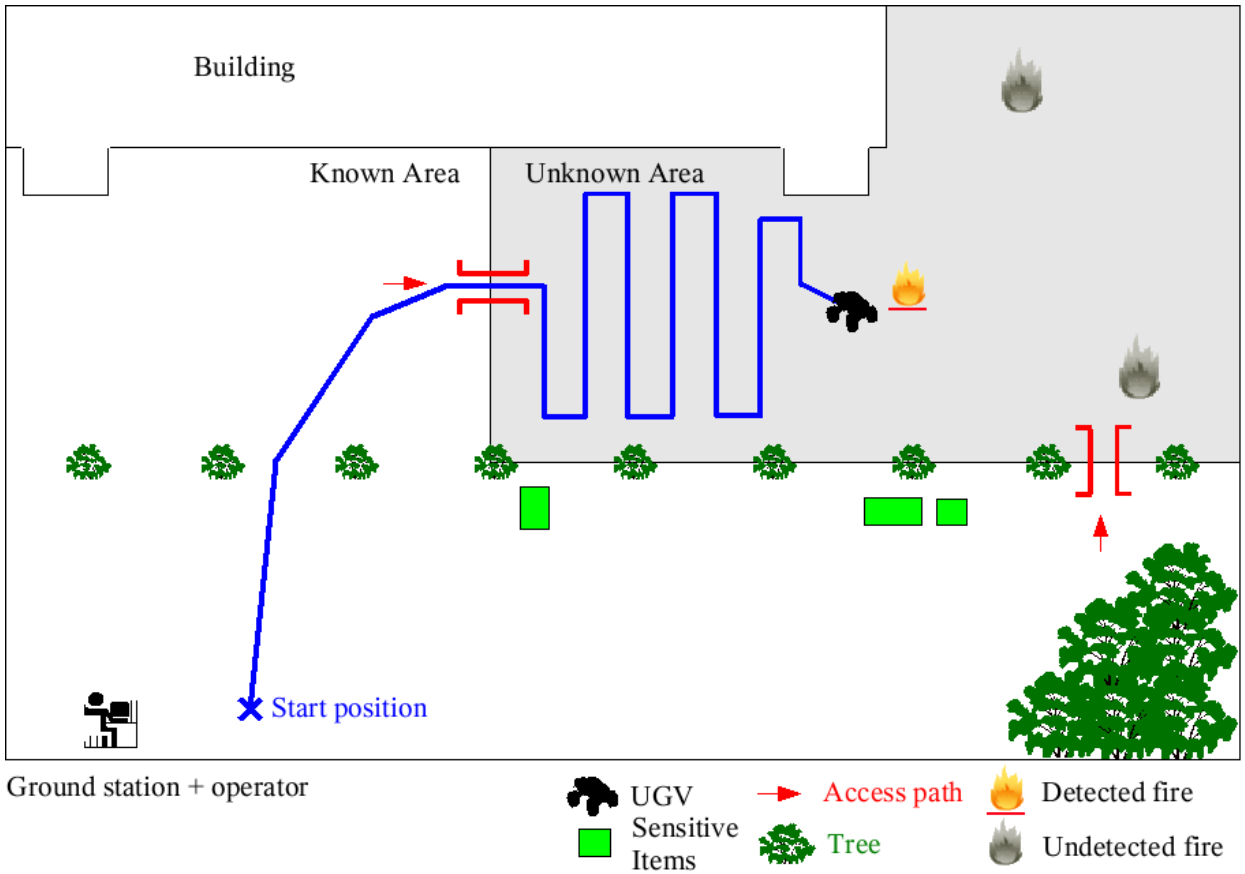
Informal definition :

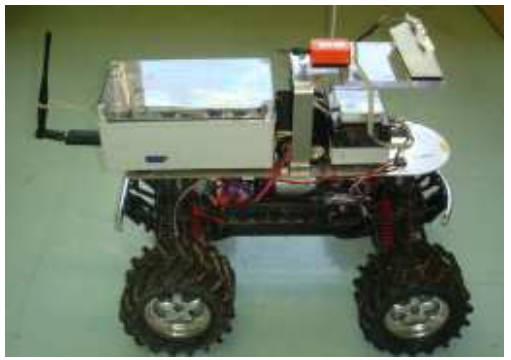
- an observed or predicted inconsistency
- disturbing the predicted execution of the plan
- occuring at the ressource level.

Conflict

Conflict	Operator	Agent	External World	Procedures
Operator	Contradictory orders	Contradictory order	Unworkable order	Violation
Agent	Contradictory action	Failure	Plan inconsis-tency	Violation
External World	Invalidation operator's action	Invalidation agent's plan	-	Violation
Procedures	Procedures' modification	Procedures' modification	Inadapted procedures	Procedures Inconsis-tency

Experimental Setup





- GPS
- Odometry
- Inertial sensors
- Ultrasounds sensors
- Scenic camera
- Procosa

Conclusion

- Resources to model an agent's plan
- Detection and identification of conflicts at the resource level
- Conflict solving
- Authority Sharing $\Longleftrightarrow$ Conflit Detection & Solving

A work in progress :

- Formalization to develop
- Experimentations