INRIA SOPHIA ANTIPOLIS

ICARE

Instrumentation Commande Architecture des Robots Evolués

Program 4a : Automatic Control, Robotics, Signal Processing

Presentation

- **General Orientation**

  Research activities concern the modelling and control of mechanical systems, and more specifically of robotic systems (manipulator arms, mobile robots, flying vehicles, submarines,...) used in the realization of complex tasks interacting with the environment.

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Staff in 2004

- 4 INRIA researchers (E. Malis, P. Morin, P. Rives, C. Samson)
- 6 PhD students (G. Artus, S. Benhimane, M. Fruchard, M. Maya-Mendez, C. Mei, N. Simond)

Research directions

- Nonlinear control and stabilization

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- Perception, navigation and autonomy of mobile robots

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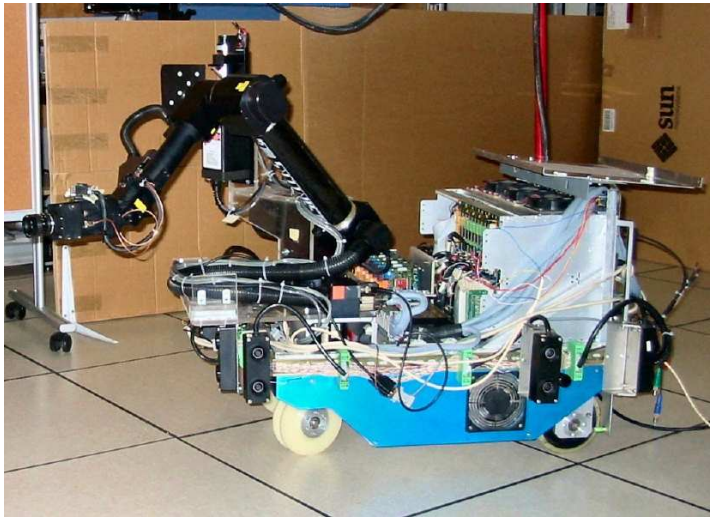
- Nonlinear control and stabilization
- Perception, navigation and autonomy of mobile robots
- Simulation and experimentations (with VISA)

Testbeds for experimentation



Anis : unicycle base + manipulator

Cycab : car base

Nonlinear control and stabilization

- Control of manipulator arms: the task-function approach
- Control of nonholonomic systems (mobile robots, cars,...): time-varying feedback, transverse functions
- Stabilization of critical nonlinear systems (whose linear approximation is not stabilizable)
- Control of legged robots

Stabilization of nonlinear systems

$$\dot{x} = f(x,u)\,, \qquad f(0,0) = 0\,, \qquad f \text{ smooth}$$

locally controllable at $(x,u) = (0,0)$.

2 Possibilities:

Stabilization of nonlinear systems

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1. the linearized system

$$\dot{x} = Ax + Bu, \qquad A = \frac{\partial f}{\partial x}(0,0),\ B = \frac{\partial f}{\partial u}(0,0$$

is stabilizable (e.g. controllable: Rang $(B, AB, \cdots, A^{n-1}B) = n$)

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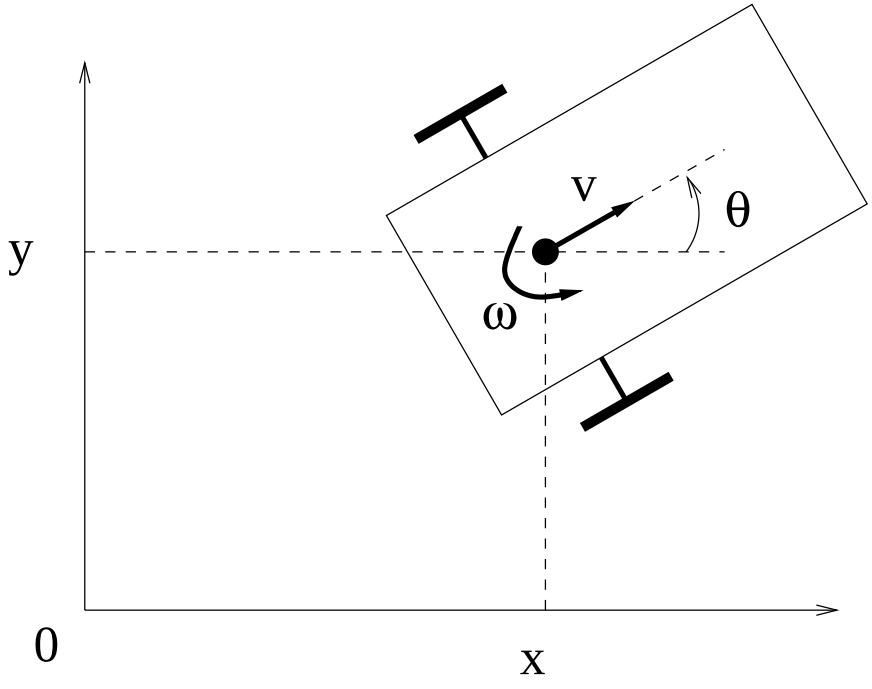
2. the linearized system is not stabilizable: critical system

Example

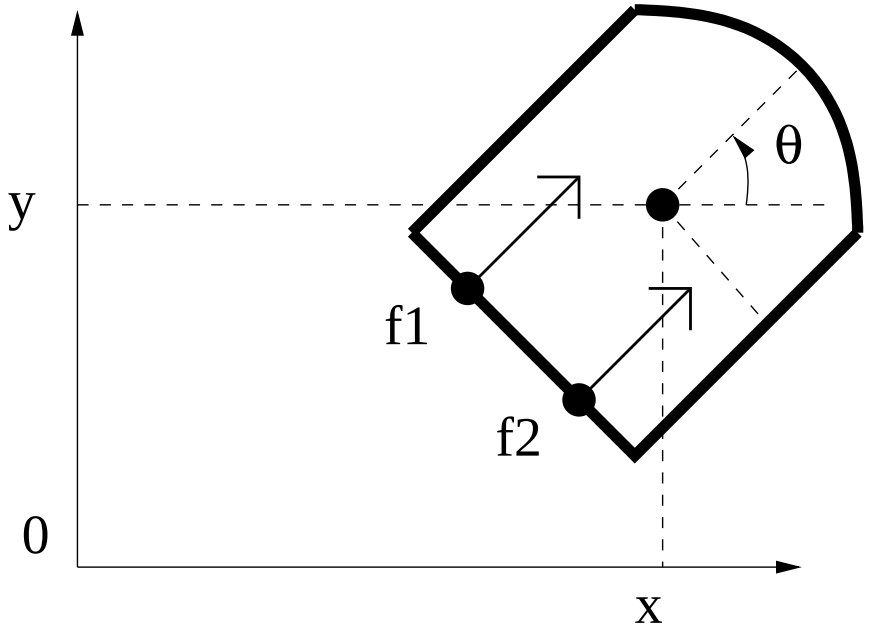
- Non-holonomic systems (unicycle)



State: (x, y, θ), Control v, ω

Example (continued)

- Under-actuated mechanical systems (slider)



State: $(x, y, \theta, v_1, v_2, \omega)$, Control f_1, f_2

Main control objectives

- Trajectory stabilization: “find feedback laws $u(x, x_r, t)$ that stabilize reference trajectories $x_r(t)$”.

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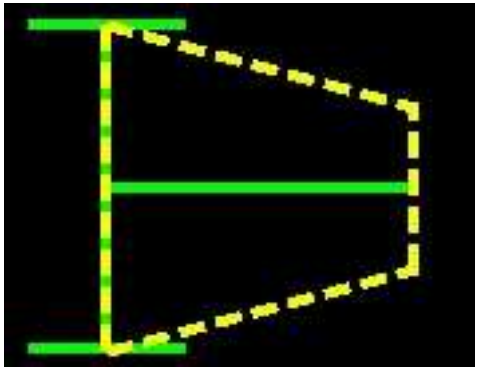
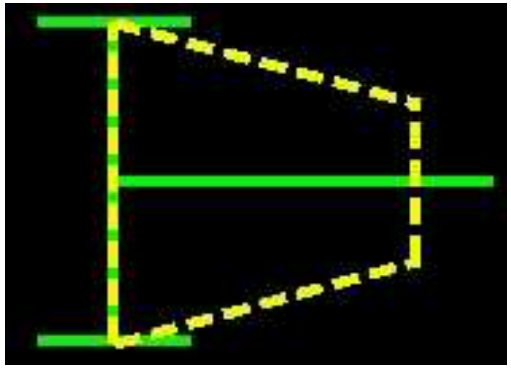
  - analyze the effects of model uncertainties
  - design feedback laws with good robustness properties
- Tools: linear and nonlinear control techniques, differential geometry

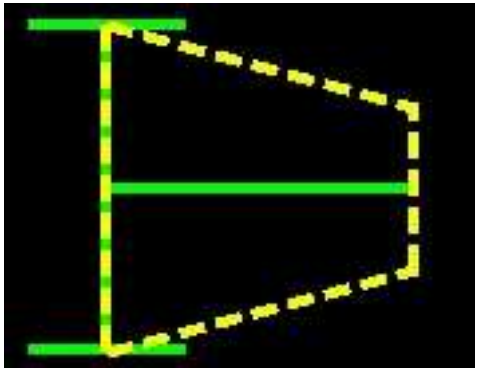
Simulation results



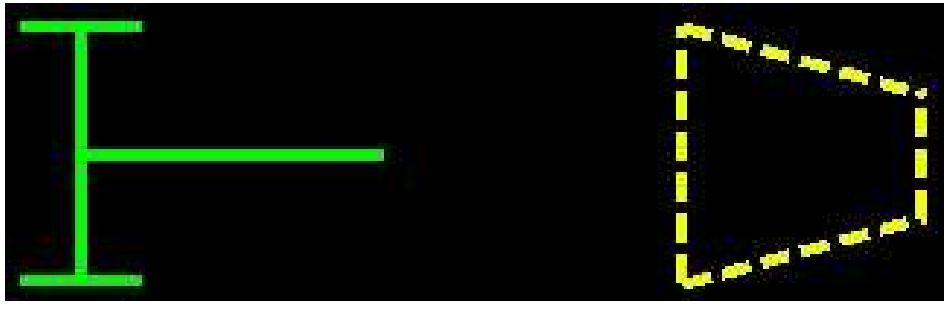
Unicycle : ϵ grand



Tricycle : ϵ grand



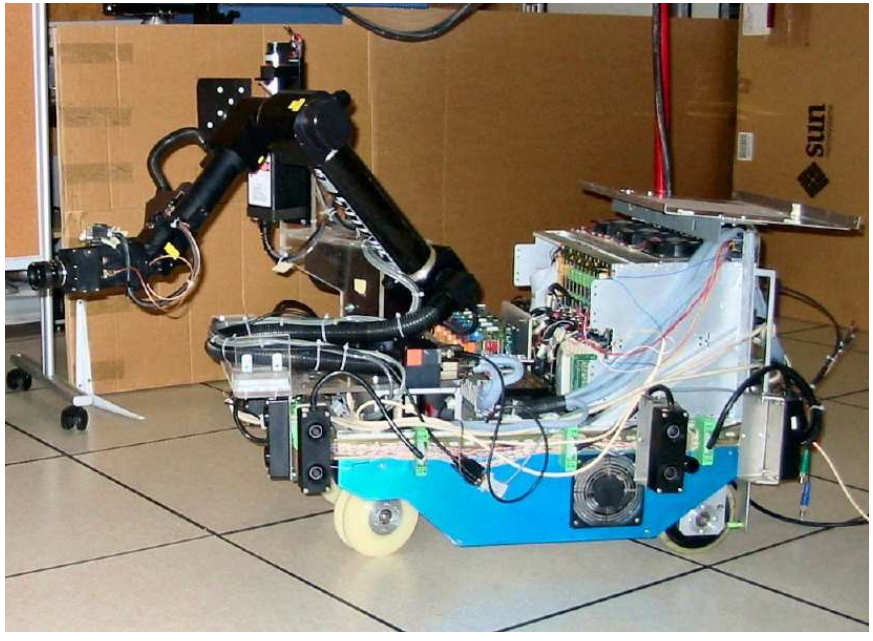
Unicycle : ϵ petit



Tricycle avec erreur initiale

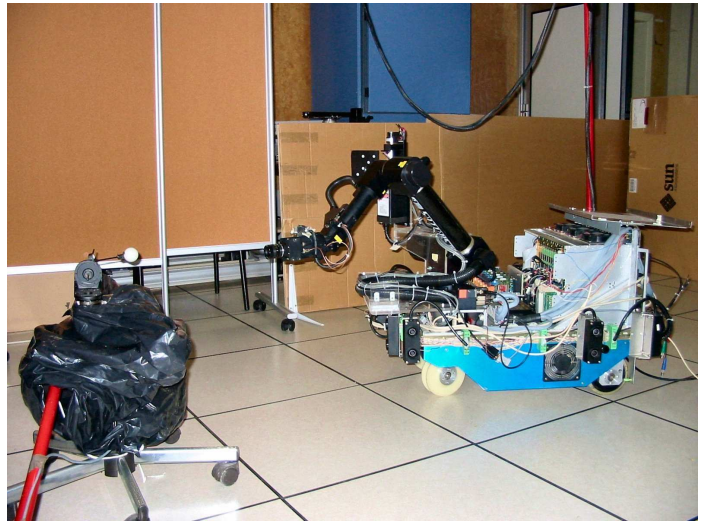
Ph.D's current works

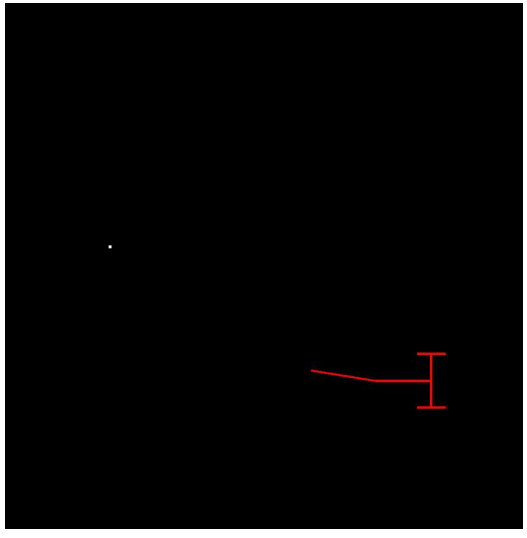
G. Artus: Automatic tracking of a maneuvering vehicle with a non-holonomic robot

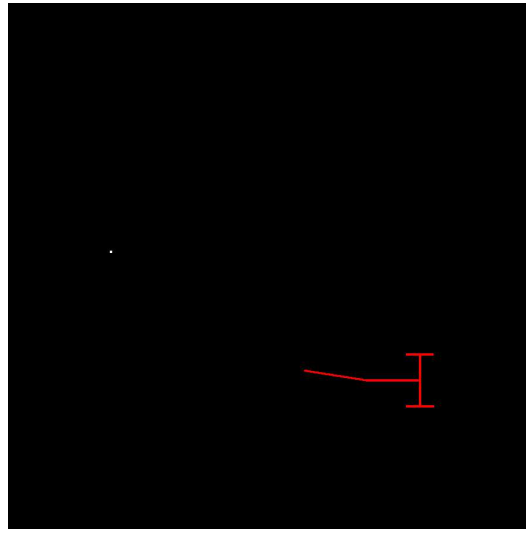


Ph.D students' work

M. Fruchard: Control of a manipulator arm on a nonholonomic robot



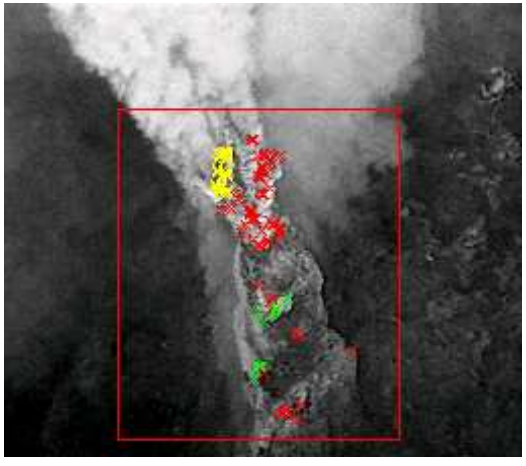


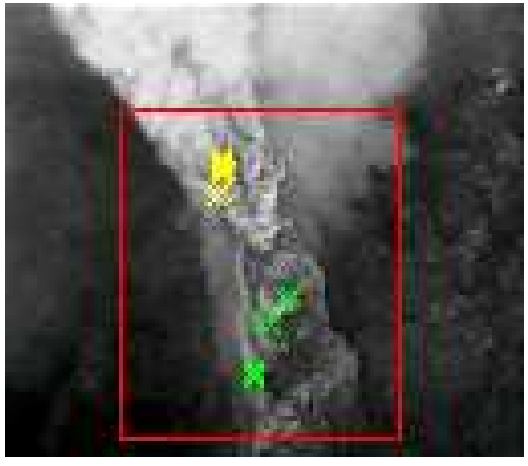


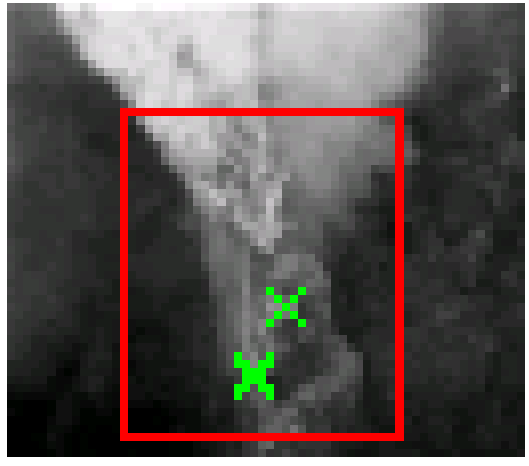
Perception, navigation and autonomy of mobile robots

- Sensor modeling
  - Vision, laser, ultrasound, GPS...
- Modeling of the environment
  - Reconstruction of natural 3D objects
  - Exploration and modeling of indoors scenes
- Localization of a mobile robot
  - using laser in an unknown indoors scenes
  - using vision in an urban-like environment
- Sensor based control
  - Visual servoing in natural scenes
  - Laser range-finder based control
  - Real time visual tracking
- Autonomy of mobile robots
  - Platooning for urban vehicles
  - Control of aerial and underwater vehicles

Reconstruction of natural 3D objects

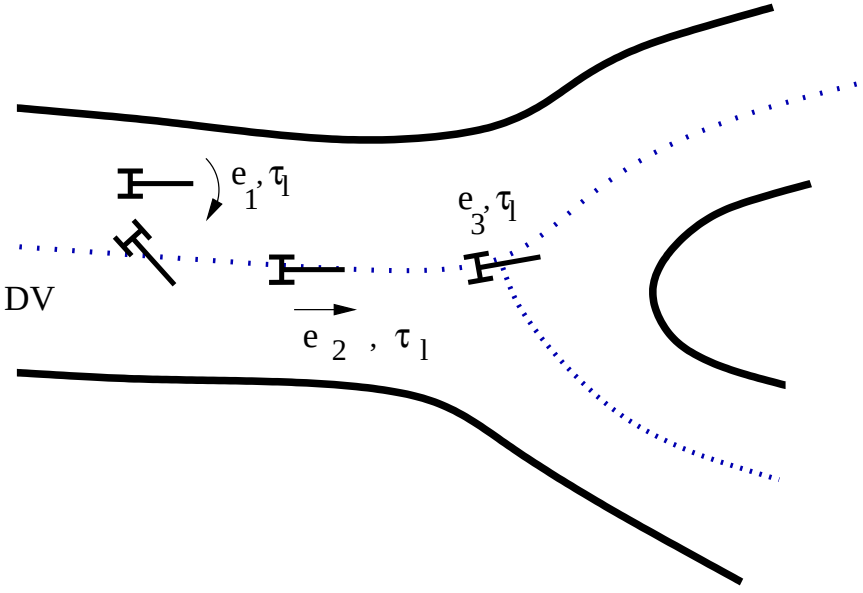


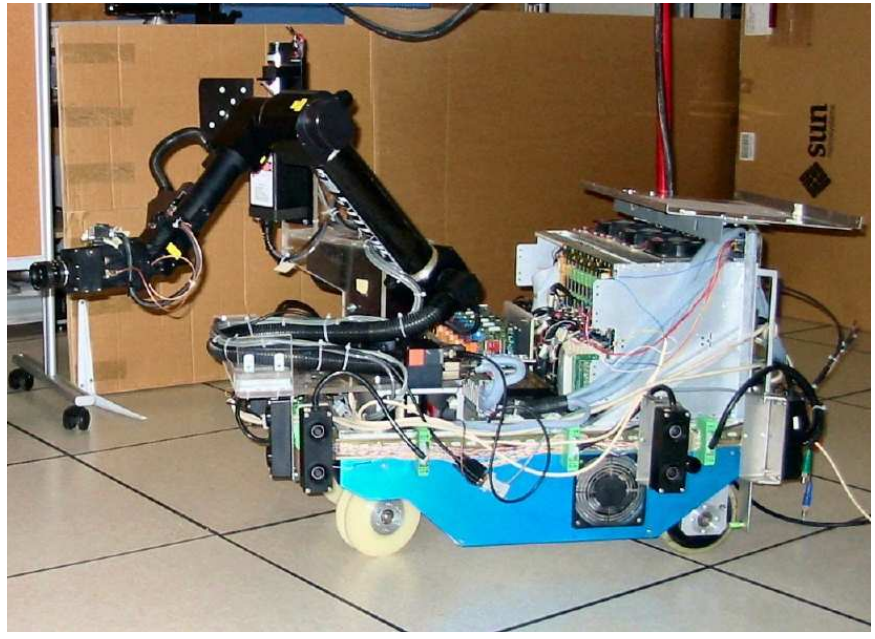




Localization of a mobile robot in an unknown environment

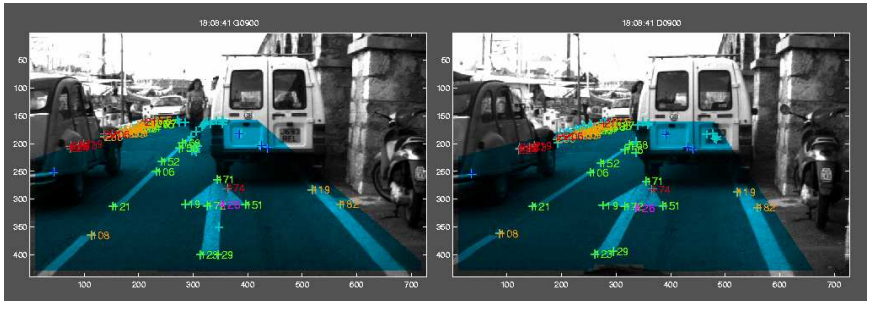
Laser-based exploration using Voronoï's diagram





Safe Navigation in Urban Environment

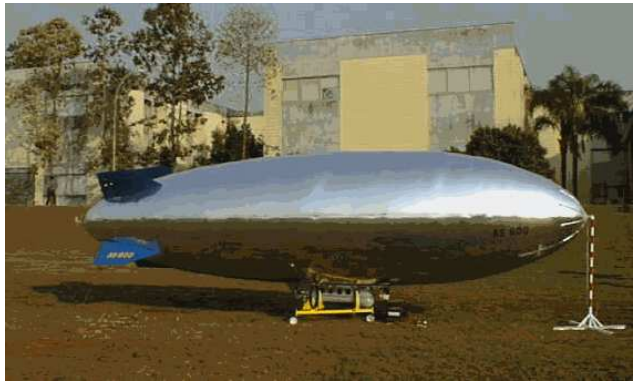
Robust vehicle localization



Vision-based Platooning

Sensor-based control of a blimp

GPS-based control:



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GPS-based control:

Vision-based control: