Instrumentation Commande Architecture des Robots Evolusés

Program 4a: Automatic Control, Robotics, Signal Processing
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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- Perception, navigation and autonomy of mobile robots
- Simulation and experimentation (with VISA)
Testbeds for experimentation

Unicycle base

Anis: + 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
\[ \dot{x} = f(x, u), \quad f(0, 0) = 0, \quad f \text{ smooth} \]

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

2 Possibilities:
Stabilization of nonlinear systems

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2 Possibilities:

1. the linearized system

\[ \dot{x} = Ax + Bu, \quad A = \frac{\partial f}{\partial x}(0, 0), \quad B = \frac{\partial f}{\partial u}(0, 0) \]

is stabilizable (e.g. controllable: \(\text{Rang}\ (B, AB, \cdots, A^{n-1}B) = n\))
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2. the linearized system is not stabilizable: critical system
Non-holonomic systems (unicycle)

State: \((x, y, \theta)\), Control \(v, \omega\)
Example (continued)

- Under-actuated mechanical systems (slider)

State: \((x, y, \theta, v_1, v_2, \omega)\), Control \(f_1, f_2\)
Main control objectives

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- Tools: linear and nonlinear control techniques, differential geometry
Simulation results

Unicycle : $\epsilon$ grand

Unicycle : $\epsilon$ petit

Tricycle : $\epsilon$ grand

Tricycle avec erreur initiale
Ph.D’s current works

G. Artus: Automatic tracking of a maneuvering vehicle with a non-holonomic robot
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 Voronoi’s diagram
Safe Navigation in Urban Environment

Robust vehicle localization  Vision-based Platooning
Sensor-based control of a blimp

GPS-based control:
Sensor-based control of a blimp

GPS-based control:

Vision-based control: