

## Autonomous Vehicles:

### Research, Design and Implementation of Intelligent Autonomous Vehicles

**Autonomous Vehicles Research Group - GPVA**  
<http://www.eletrica.unisinos.br/~autonom>

Tutorial page: <http://inf.unisinos.br/~osorio/palestras/cerma07.html>

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Grupo de Pesquisas em Veículos Autônomos

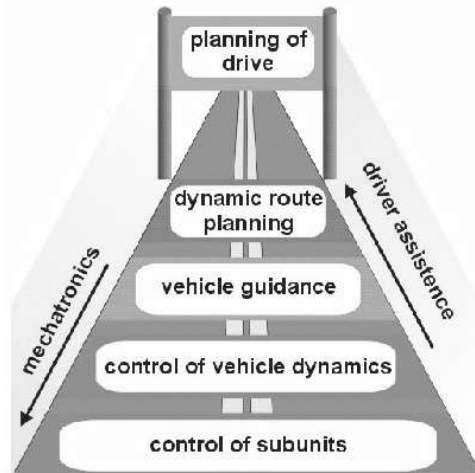
Autonomous Vehicles Research Group - Unisinos

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## Intelligent Autonomous Vehicles

- Introduction
- Robotic: Automats, Mobile Robots and Autonomous Robots
  - ⇒ Perception, Action, Locomotion e Communication
  - ⇒ Control and Intelligence
- Intelligent Vehicles
  - ⇒ Technologies for Vehicle Automation
  - ⇒ Control pyramid
- Intelligent Control of Autonomous Vehicles
  - ⇒ Control: Computational Architectures
  - ⇒ Simulation of Autonomous Vehicles
- Computer Vision
- Practical Applications

## Control Layers



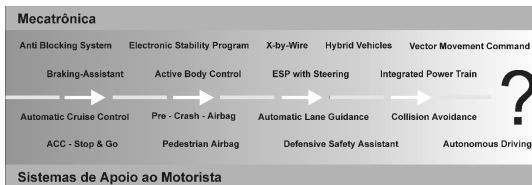
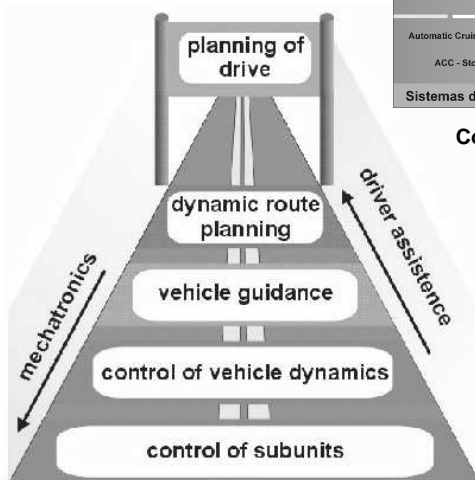
[Kelber et al., IEEE ISIE 2005]

Control Pyramid

Intelligent Autonomous Vehicles

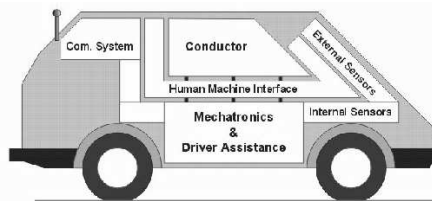
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## Control Layers



### Control of Electrical and Mechanical Systems:

- ABS Braking System
- Traction Control
- Active Suspension
- Stability Control
- Steering Systems
- Drive-by-Wire Technology

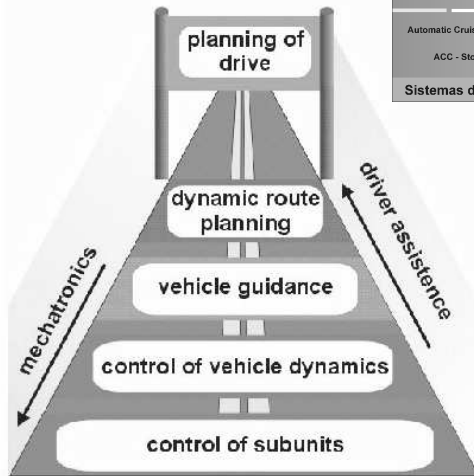


Control Pyramid

Intelligent Autonomous Vehicles

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### Control Layers



Mecatrônica				
Anti Blocking System	Electronic Stability Program	X-by-Wire	Hybrid Vehicles	Vector Movement Command
Braking-Assistant	Active Body Control	ESP with Steering	Integrated Power Train	?
Automatic Cruise Control	Pre - Crash - Airbag	Automatic Lane Guidance	Collision Avoidance	
ACC - Stop & Go	Pedestrian Airbag	Defensive Safety Assistant	Autonomous Driving	
Sistemas de Apoio ao Motorista				

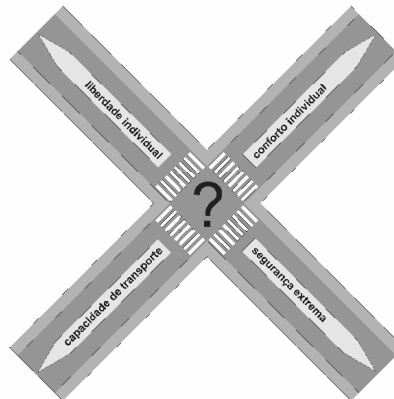
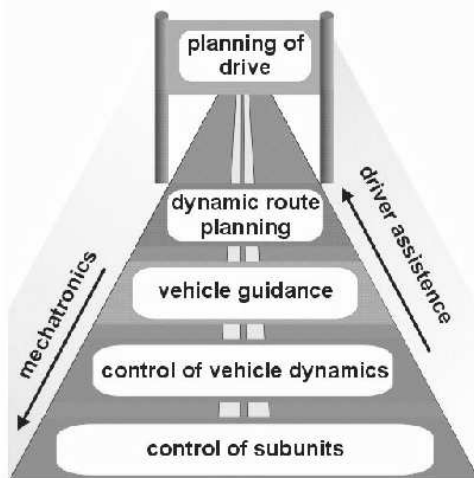


Videos-Robotica\atuador.mpg

Control Pyramid

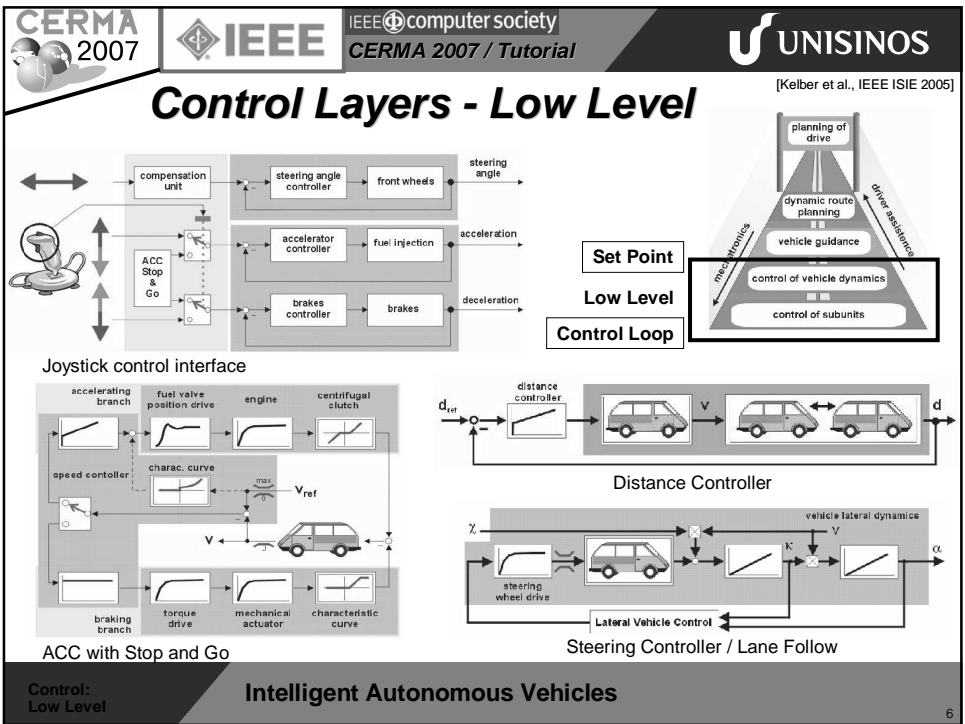
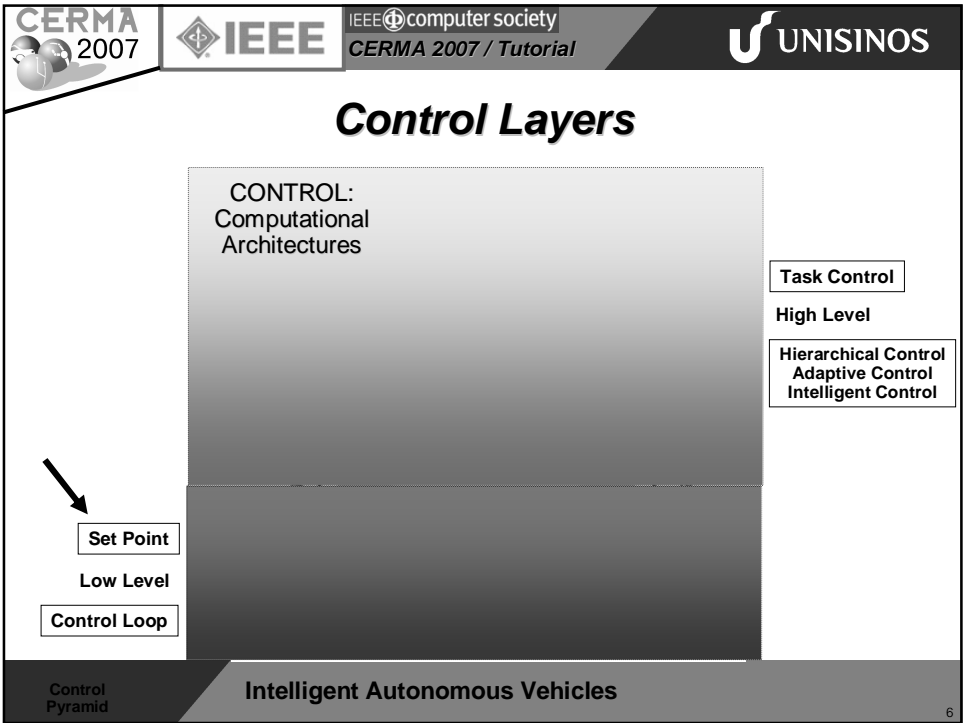
Intelligent Autonomous Vehicles

### Control Layers



Control Pyramid

Intelligent Autonomous Vehicles

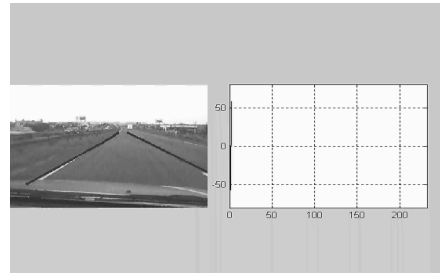




Joystick control interface



Steering Controller / Lane Follow



Control:  
Low Level

### Intelligent Autonomous Vehicles

## Control Layers

CONTROL:  
Computational  
Architectures

Task Control

High Level

Hierarchical Control  
Adaptive Control  
Intelligent Control

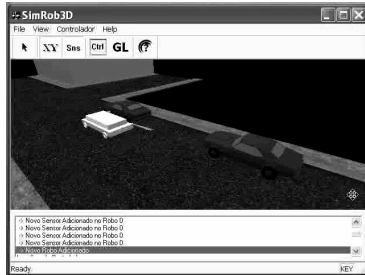
Set Point

Low Level

Control Loop

Control  
Pyramid

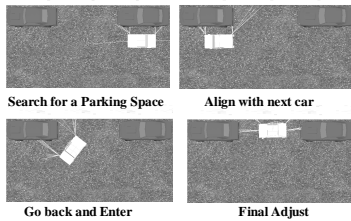
### Intelligent Autonomous Vehicles



Autonomous Parking



Darpa Challenge 2005 - Desert



Search for a Parking Space

Align with next car

Go back and Enter

Final Adjust



Darpa Challenge 2007 - Urban

Control:  
Low Level

Intelligent Autonomous Vehicles

CONTROL: Computational Architectures

- Sensorial Models
- Kinematics Models
- Robotic Control:
  - \* Reactive
  - \* Deliberative
  - \* Hierarchical
  - \* Hybrid
- Environment Maps
  - \* Building Maps
  - \* Path Planning
  - \* SMPA - *Sense Model Plan Act*
- Problems:
  - \* Complex tasks
  - \* Avoid Obstacles: Static / Mobile - **Unexpected obstacles**
  - \* Robot actual position estimation - **Where am I ?**

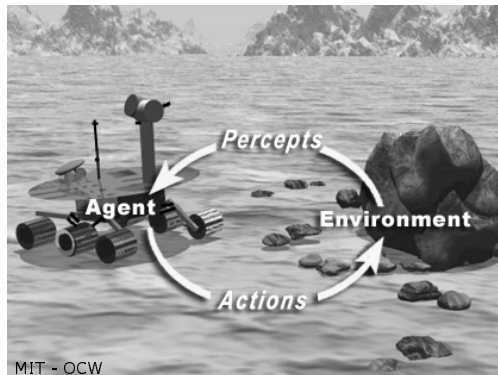
Control  
Architectures

Intelligent Autonomous Vehicles

### Autonomous Robots Sensors e Actuators

\* Sensors: Environment Perception

\* Actuators: Motors - Control actions and robot displacement



### Autonomous Robots Sensors e Actuators

\* Sensors:

Distance: Light, Sound, Touch \_\_\_\_\_

- Infrared
- Sonar (ultrasound) e Radar
- Laser
- Video Cameras - Linear / Matrix (CCD), Mono or Binocular
- Contact Sensor (bumpers, "cat whiskers")

Other Components

- > Battery charge meter
- > Temperature, Pressure
- > Humidity
- > Smoke.
- > Smells, etc

Positioning and Orientation

- GPS
- Compass
- Gyroscope
- Odometer
- Beacons (ex. radio beacons) or Video Cameras

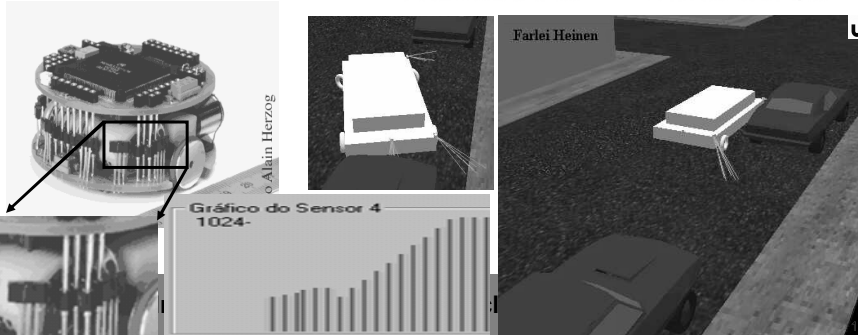
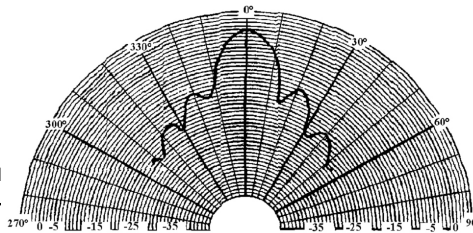
\* Actuators...

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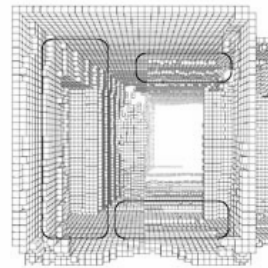
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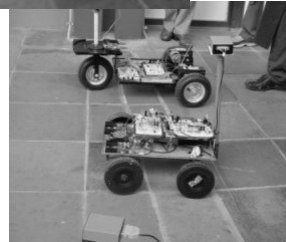
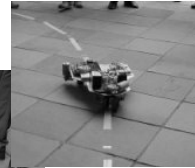
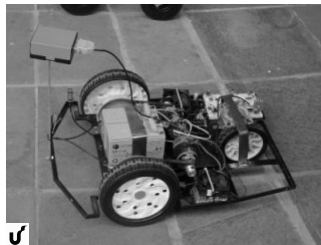


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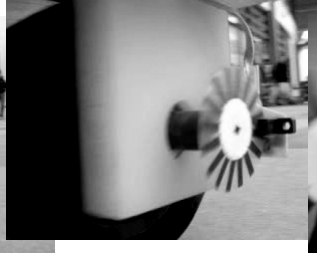
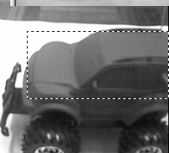
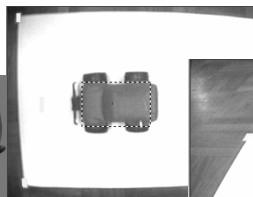


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### Autonomous Robots Sensors e Actuators

**\* Actuators:**

Locomotion:

- Step motor / DC Motors: Direction (Steering), Velocity (Speed)

Wheels, Tank Tracks, Propulsion, Legs

Tricycle steering, Differential drive, Skid steer,

Ackermann steering, Synchro drive, ...

- Walking: Equilibrium problem / Gait control

- Propulsion: Aquatic, Underwater, Aerial

Robotic Arms: Grippers, Lifters, Fingers, ...

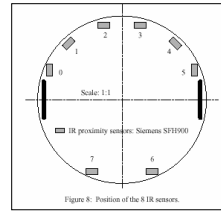


Figure 8: Position of the 8 IR sensors.

3.1 The Khepera miniature robot

3.1.1 Overview

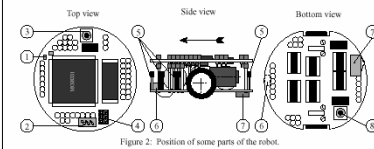


Figure 2: Position of some parts of the robot.

Make an external inspection of the robot. Note the location of the following parts:

1. LEDs
2. Serial line (S) connector.
3. Reset button.
4. Jumpers for the running mode selection.
5. Infra-Red proximity sensors.
6. Battery recharge connector.
7. ON - OFF battery switch.
8. Second reset button (same function as 3).

### Autonomous Robots Sensors e Actuators

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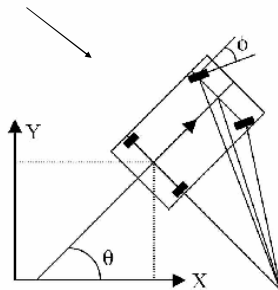
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$$\begin{cases} \dot{x} = v \cos \phi \cos \theta, \\ \dot{y} = v \cos \phi \sin \theta, \\ \dot{\theta} = \frac{v}{L} \sin \phi, \end{cases}$$

**Kinematics Model**

Velocity  $v$   
Steering wheel angle  $\phi$

Position  $(X, Y)$   
Orientation  $\theta$

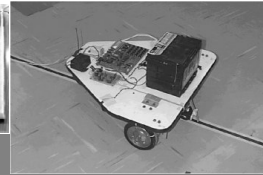
**Intelligent Autonomous Robots  
<< Intelligence >>**

- \* Action Planning
- \* Ability to Perceive the Environment
- \* Ability to Decide
- \* Ability to Act
- \* High Level Tasks Planning
- \* Reaction: Sensorial-Motor Integration
- \* Estimate Actual and Future States:  
Environment + Behavior = Interaction
- \* Adaptation and Learning
- \* Robustness: Unexpected Situations

=> From where do I start ???

**Robótica Autônoma Inteligente  
Inteligência e Robótica**

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