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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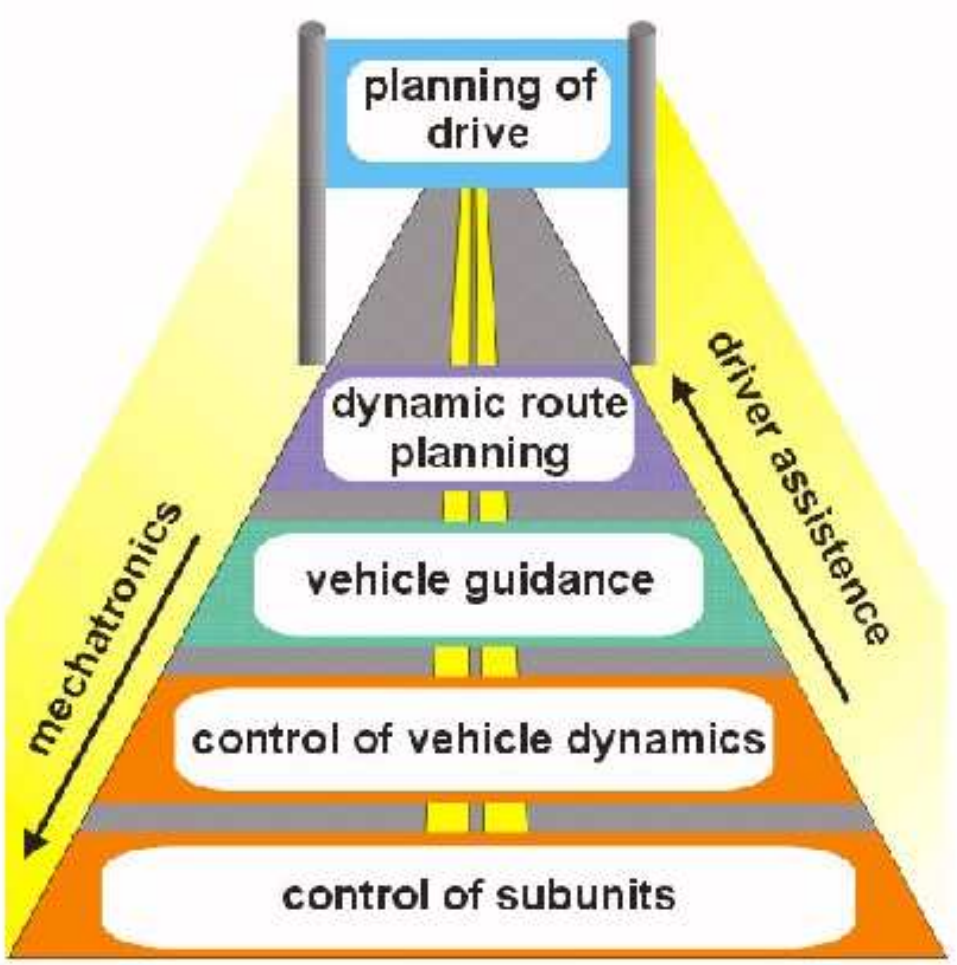
Intelligent Autonomous Vehicles

- Introduction
- Robotic: Automatons, 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]

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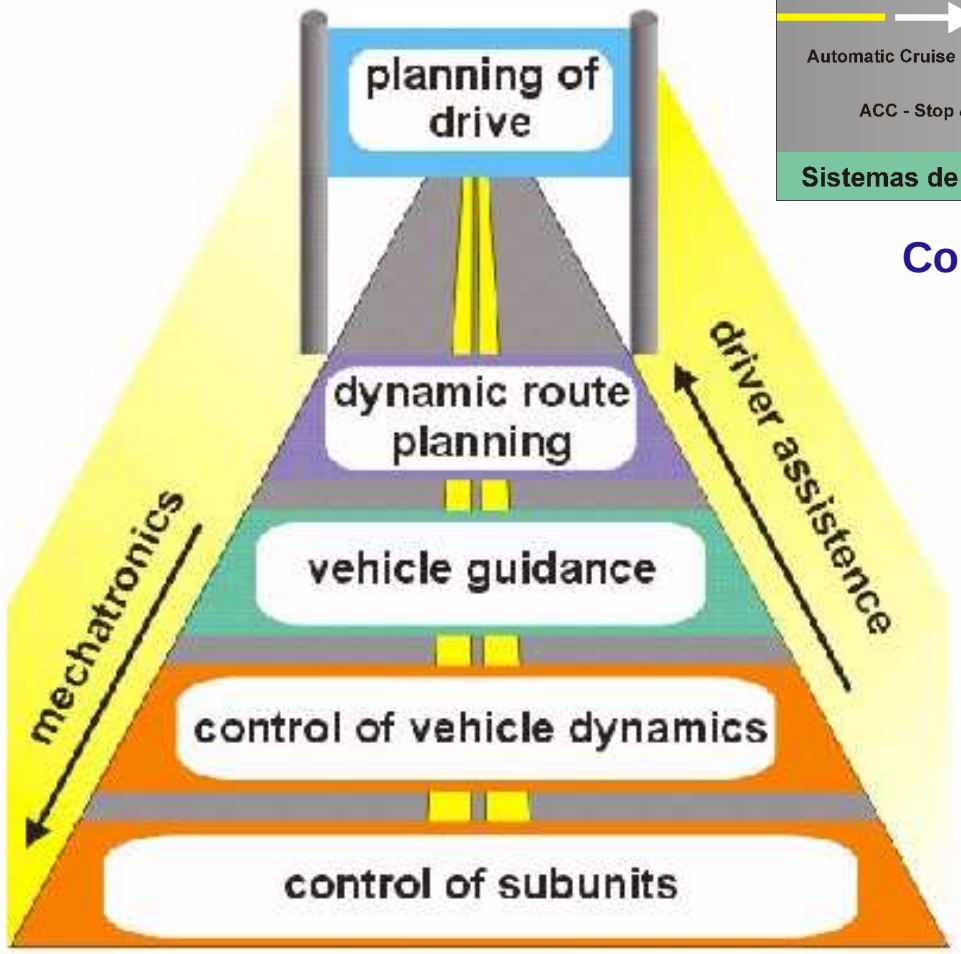
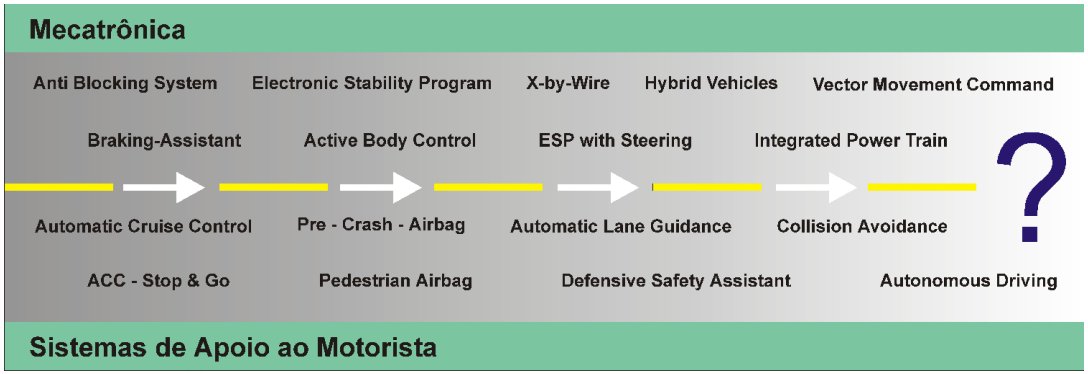
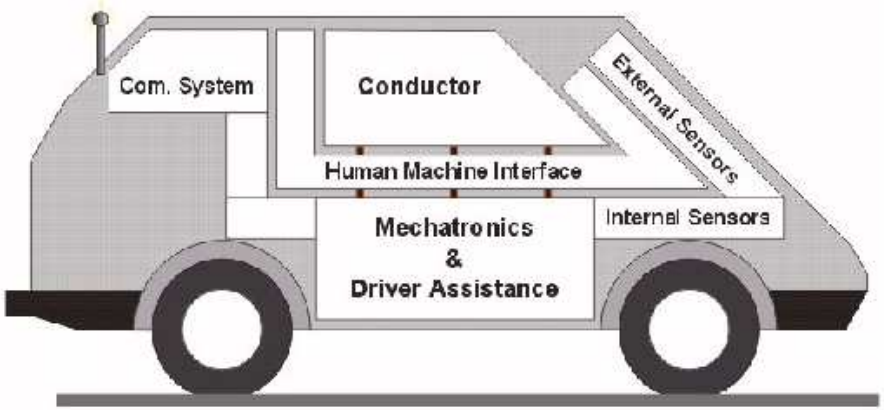




Control of Electrical and Mechanical Systems:

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



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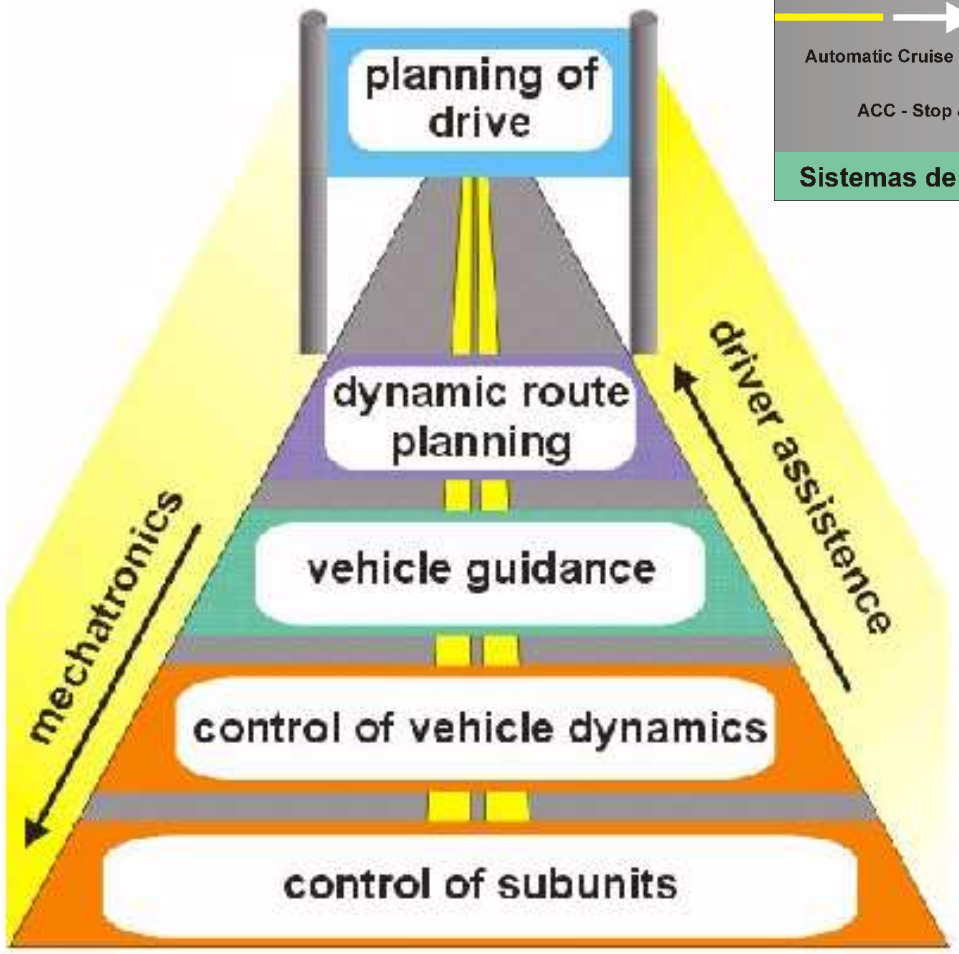
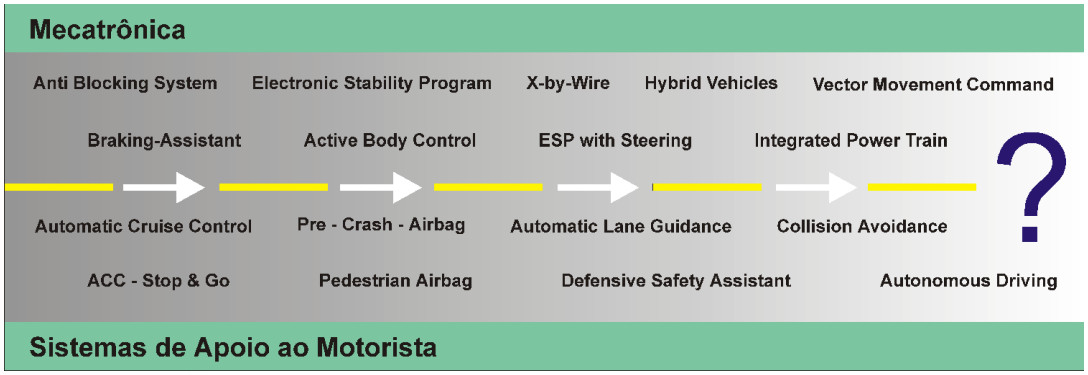
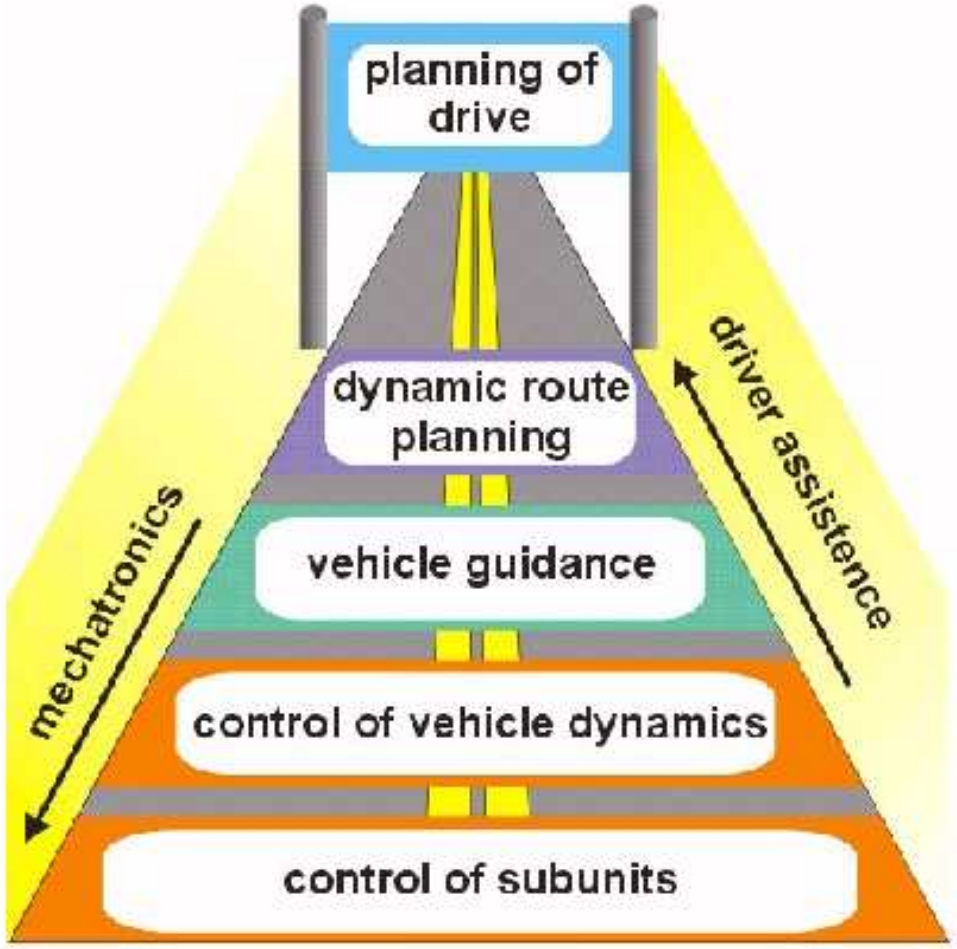
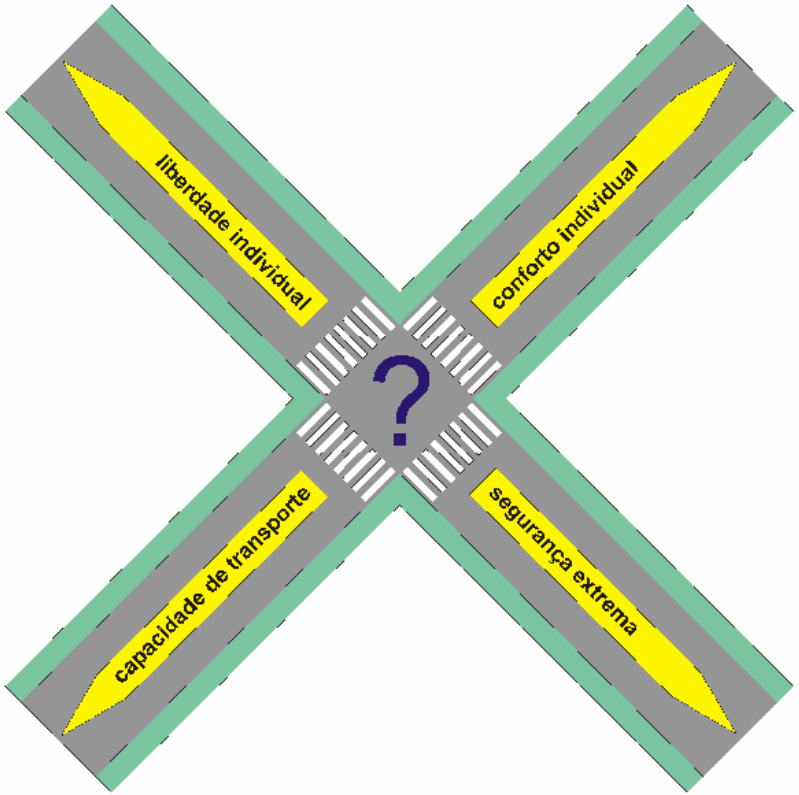




Videos-Robotica\atuador.mpg

Control Layers





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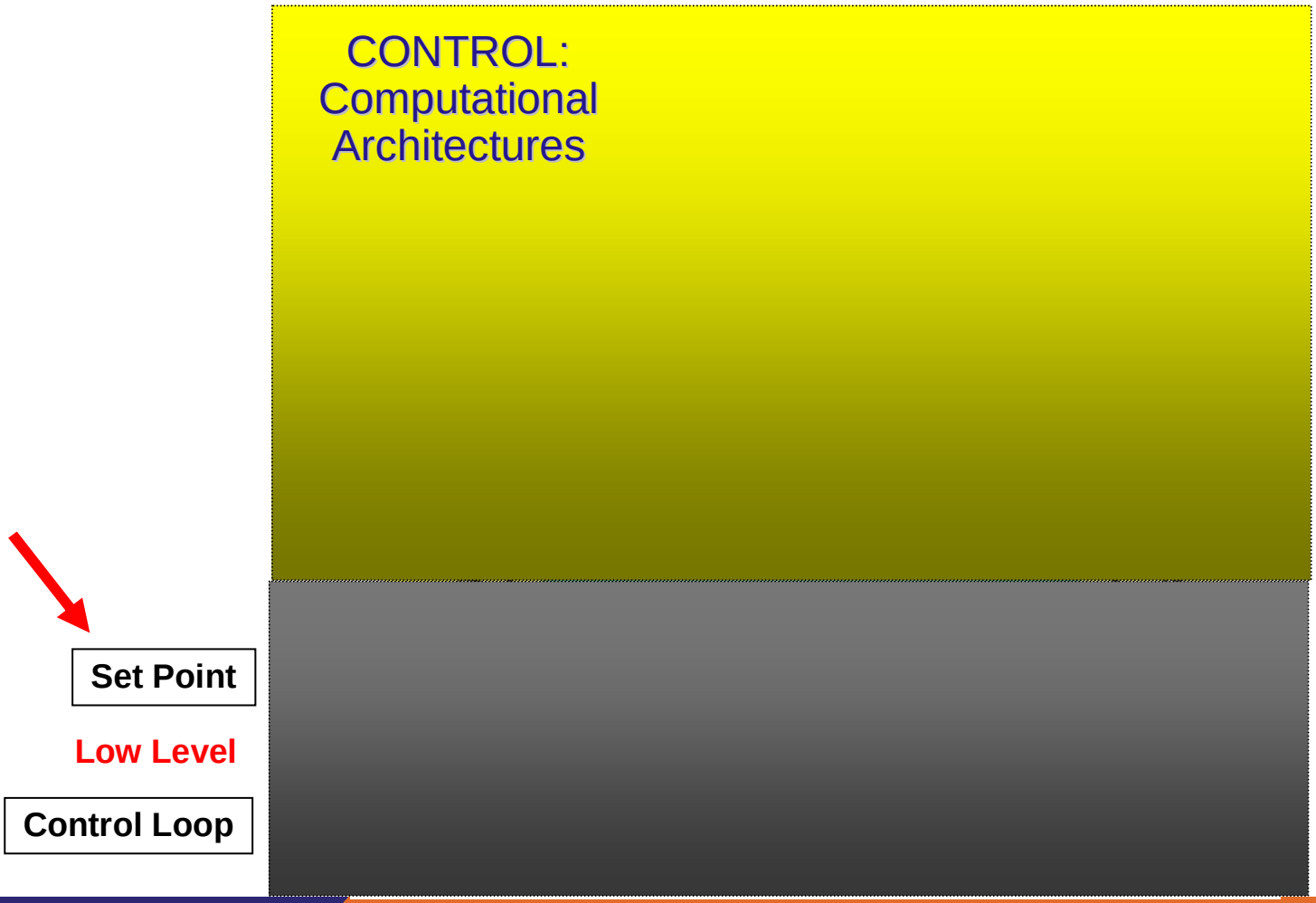
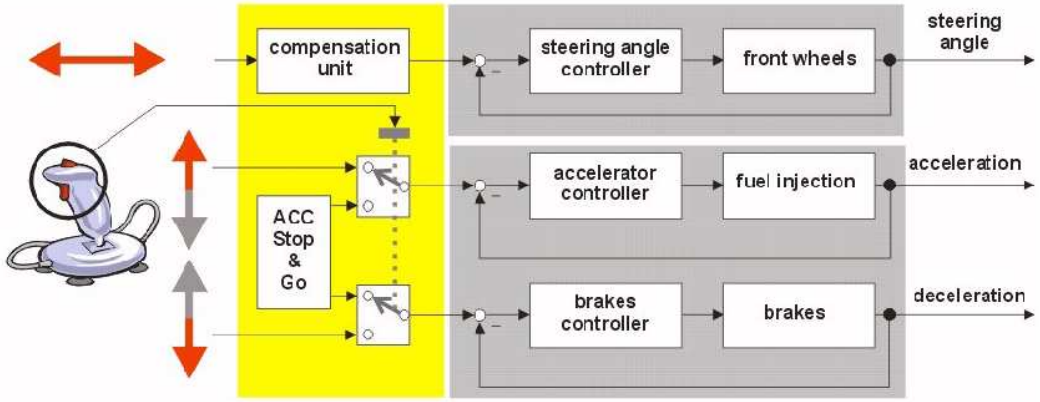
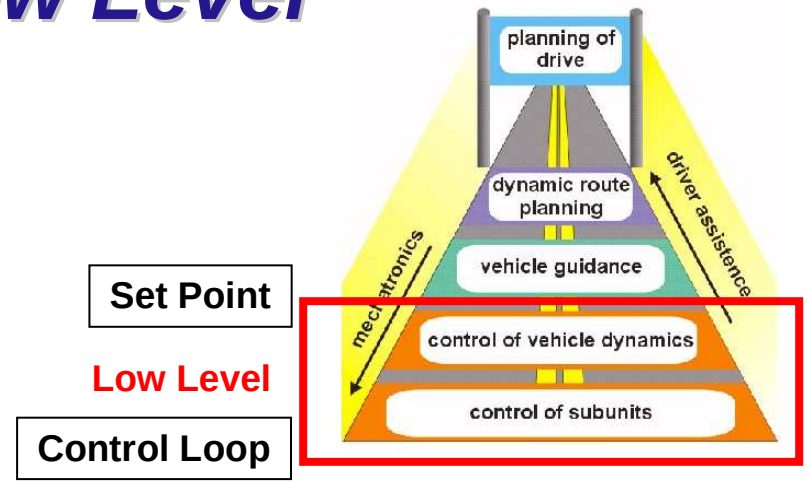


Control Layers - Low Level

[Kelber et al., IEEE ISIE 2005]



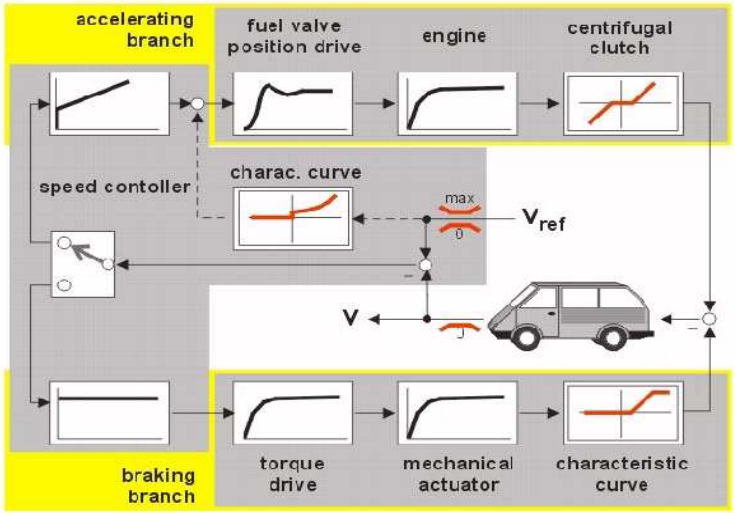
Joystick control interface



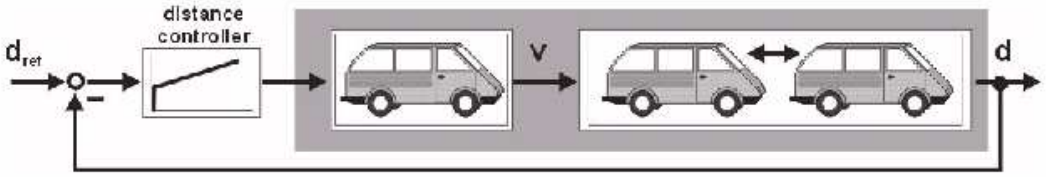
Set Point

Low Level

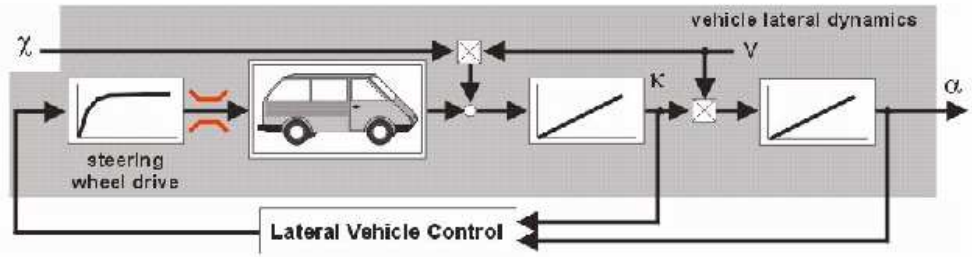
Control Loop



ACC with Stop and Go



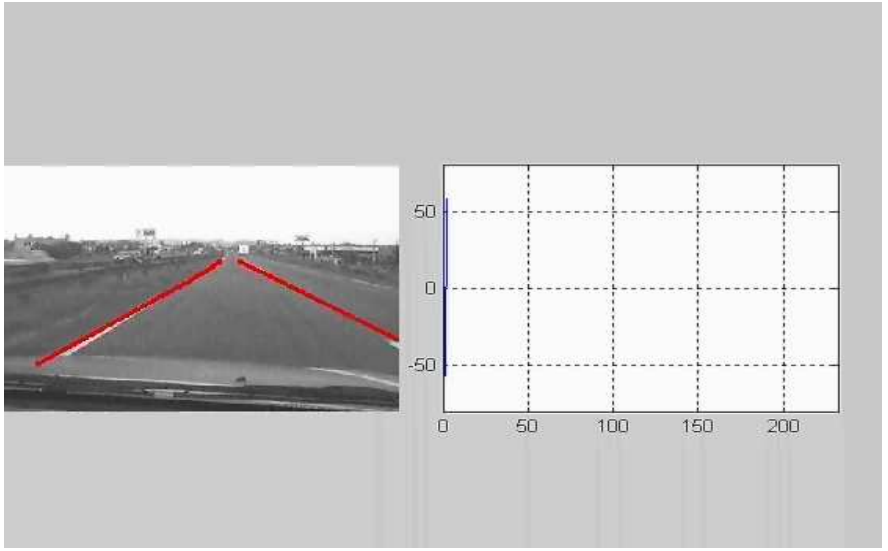
Distance Controller



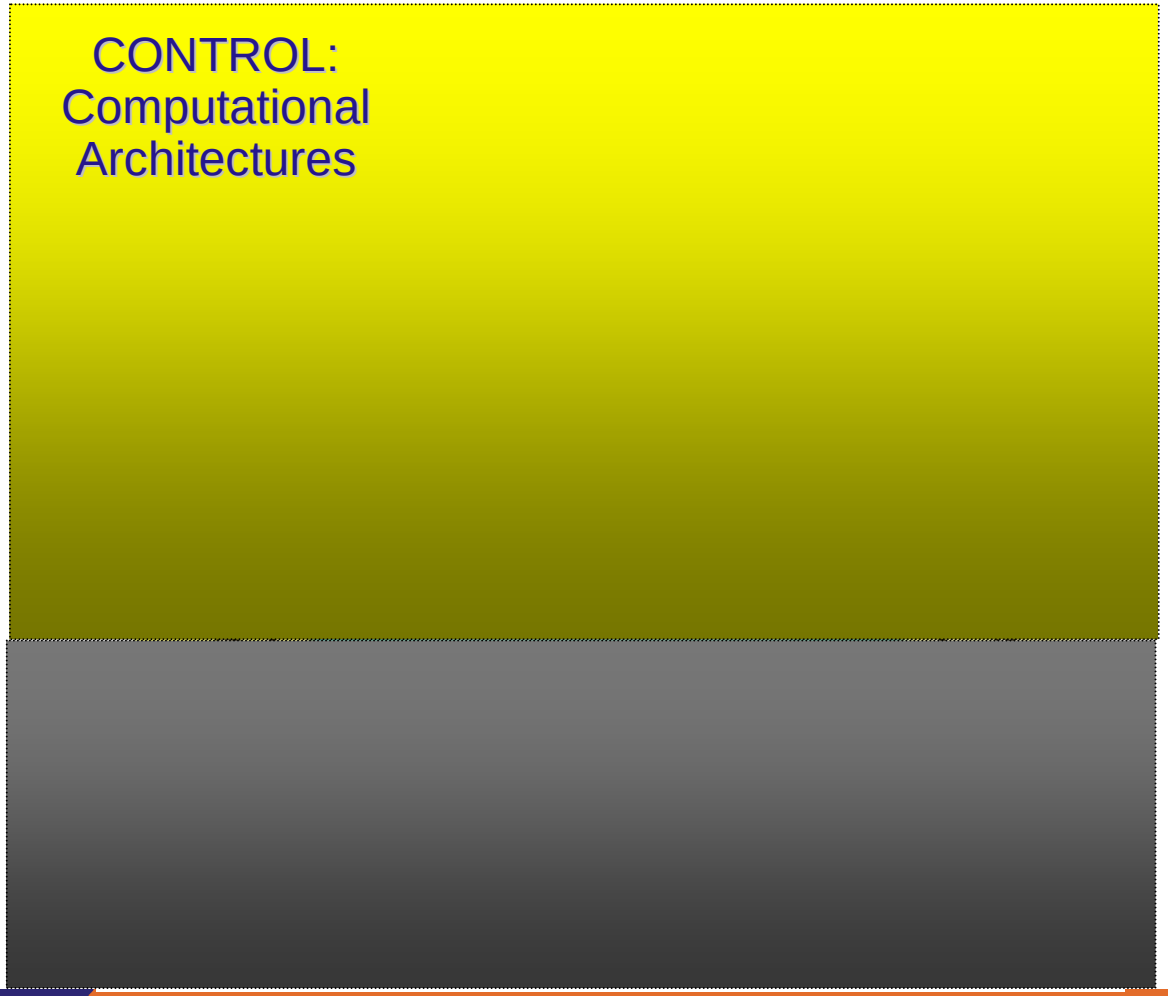
Steering Controller / Lane Follow

Joystick control interface

Steering Controller / Lane Follow



Control Layers



Task Control

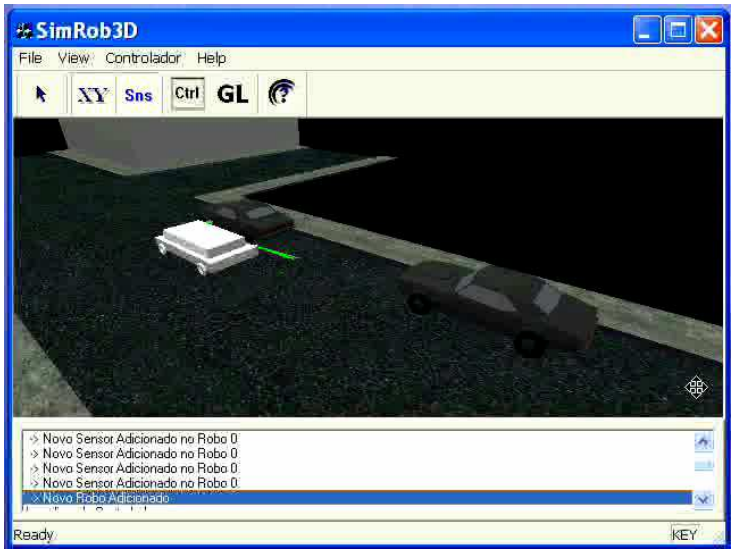
High Level

Hierarchical Control
Adaptive Control
Intelligent Control

Set Point

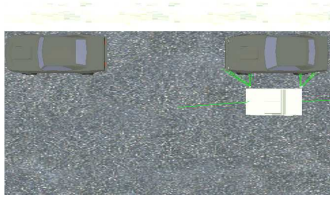
Low Level

Control Loop

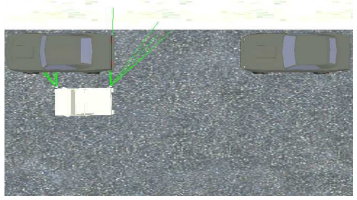


Autonomous Parking

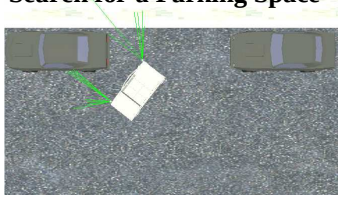
Darpa Challenge 2005 - Desert



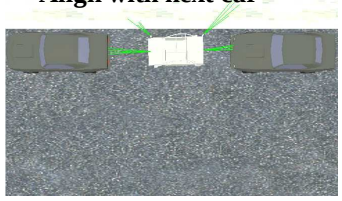
Search for a Parking Space



Align with next car



Go back and Enter



Final Adjust

Darpa Challenge 2007 - Urban

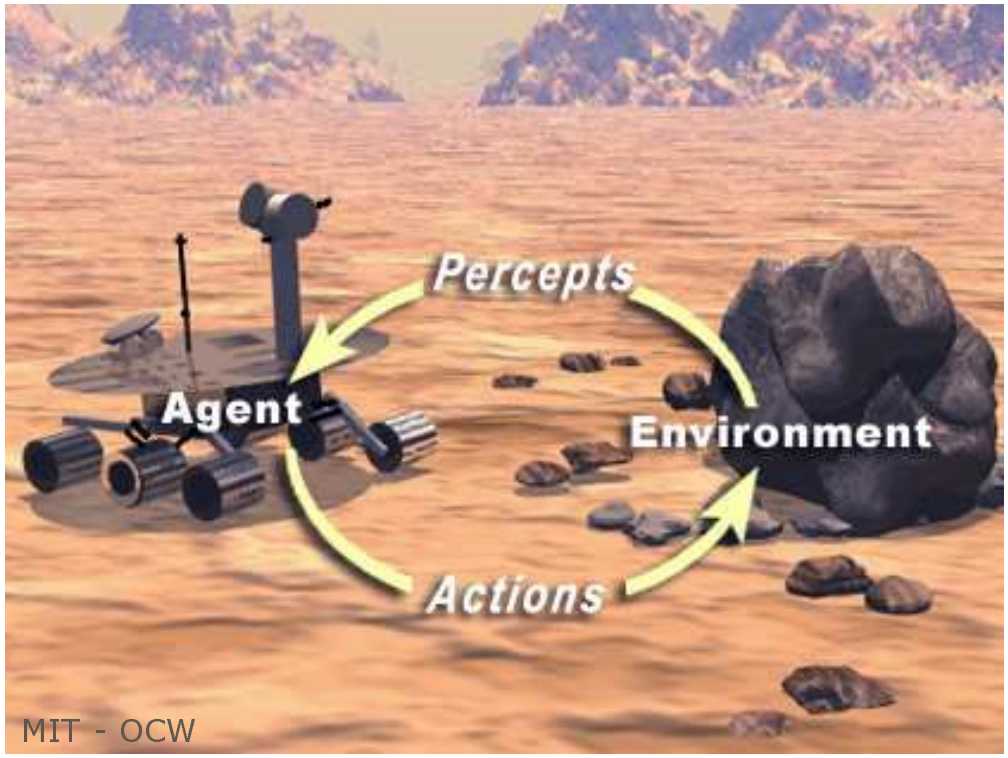
CONTROL: Computational Architectures

- 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 ?**

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")**

Positioning and Orientation

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

Other Components

> Battery charge meter

> Temperature, Pressure

> Humidity

> Smoke.

> Smells, etc

* Actuators...

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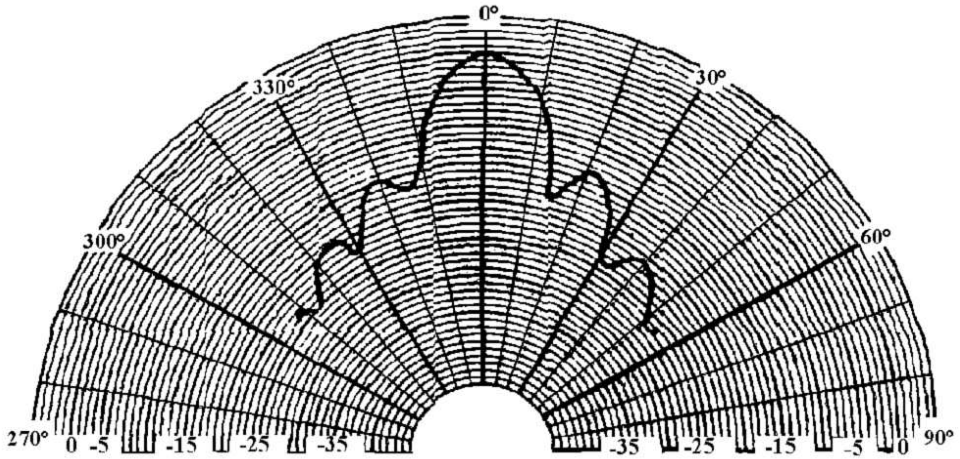

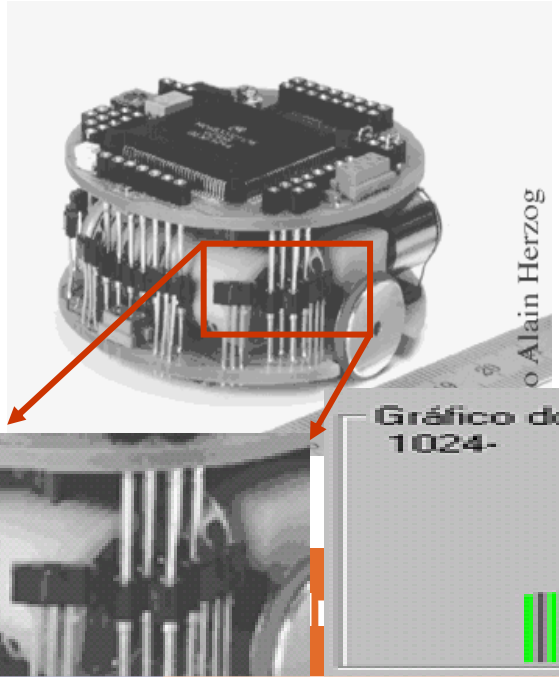

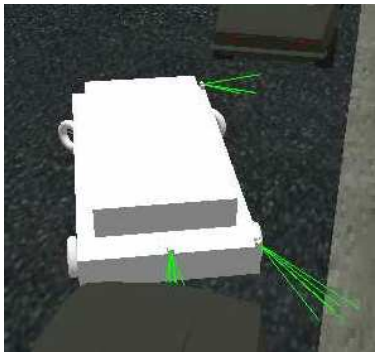

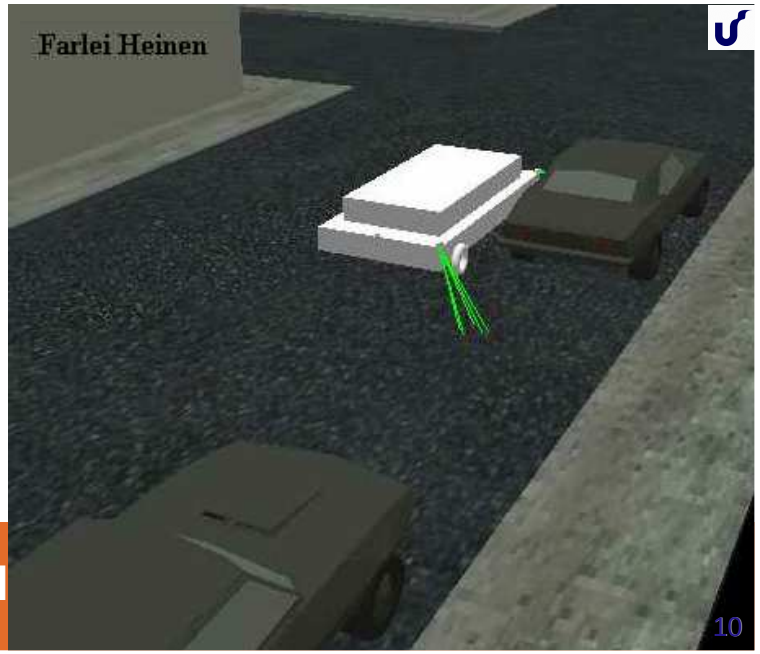

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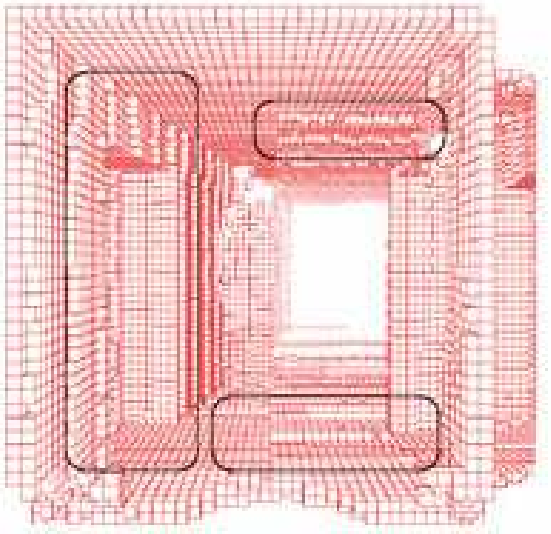

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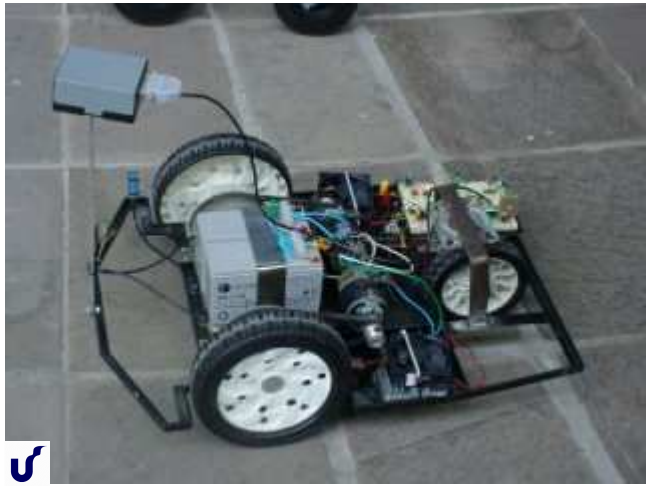

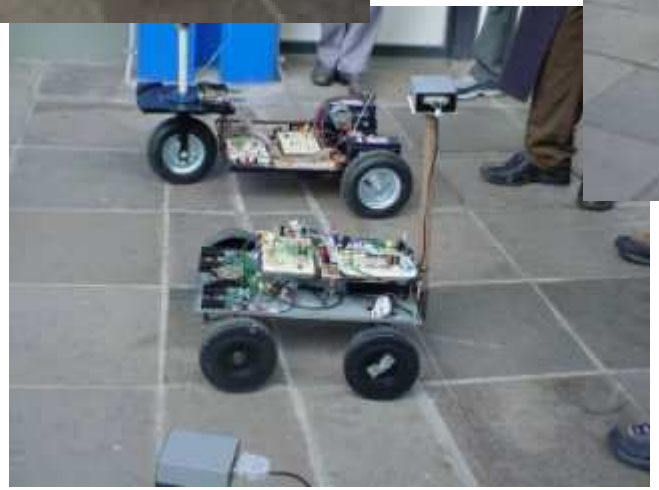

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Autonomous Robots
Sensors e Actuators

* 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, ...**

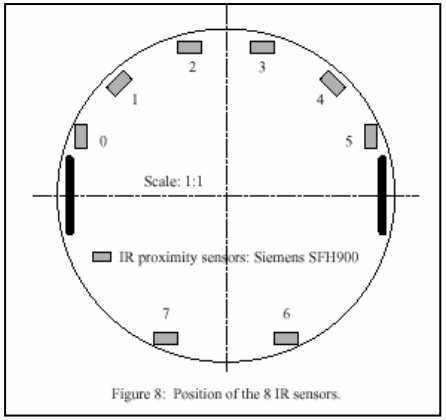

Figure 8: Position of the 8 IR sensors.

3.1 The Khepera miniature robot

3.1.1 Overview

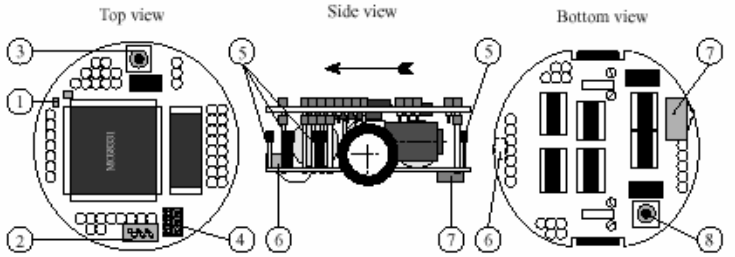

Figure 2: Position of some parts of the robot.

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).

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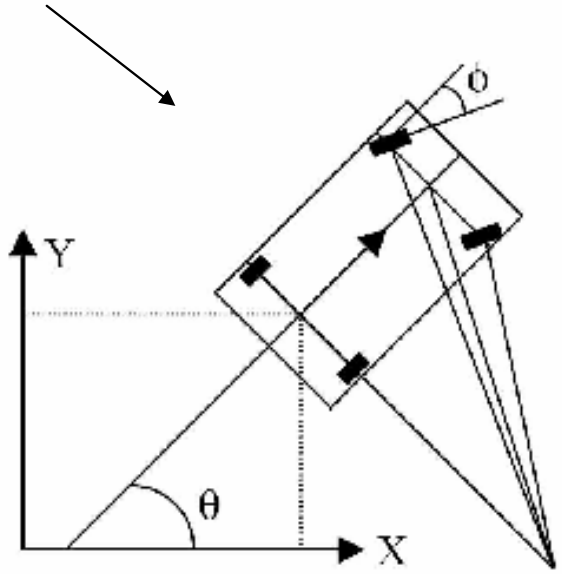

$$\begin{cases} \dot{x} = v\,\cos\phi\,\cos\theta, \\ \dot{y} = v\,\cos\phi\,\sin\theta, \\ \dot{\theta} = \frac{v}{L}\,\sin\phi, \end{cases}$$

Kinematics Model

Velocity v
Steering wheel angle Φ

Position (X,Y)
Orientation θ

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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UNIVERSIDADE DO VALE DO RIO DOS SINOS

Intelligent Autonomous Vehicles