Universidade de São Paulo - São Carlos,SP
Instituto de Ciências Matemáticas e de Computação

USP - ICMC
Tutoriais de Computação

Robôs Móveis Autônomos e Inteligentes: UGVs e UAVs

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LRM – Laboratório de Robótica Móvel

Robôs Móveis Autônomos e Inteligentes

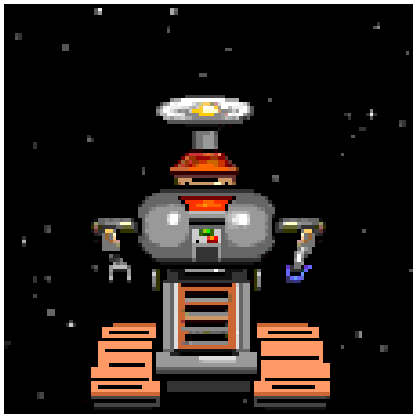
Agenda:

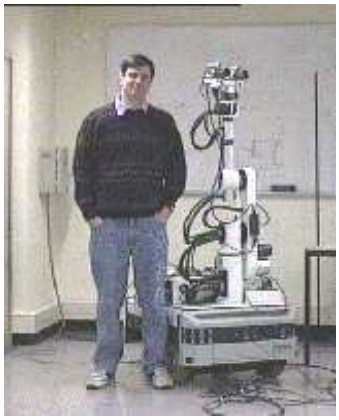
Robôs Móveis Autônomos:

1. **Histórico**
2. **Tipos de Robôs Móveis Autônomos**
3. **Conceitos sobre Robôs Móveis Autônomos**
4. **Exemplos de Aplicações: UAVs e UGVs**
5. **Desafios**
6. **Futuro?**

Robôs Móveis Autônomos

Da ficção científica à realidade...





Robôs Móveis Autônomos - HISTÓRICO

History Making Mobile-Robots - HM

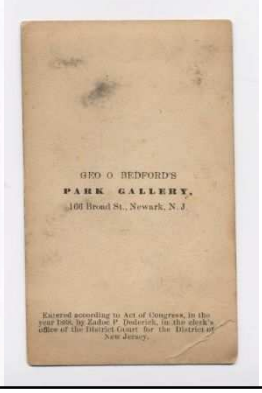
(Not yet included in list - Stanford Cart, Xee, Hebot1.....)

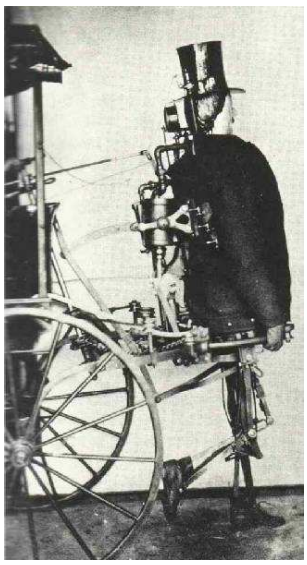
Significant Robots - *and time-line events*

http://davidbuckley.net/DB/HistoryMakers.htm

Robôs Móveis Autônomos

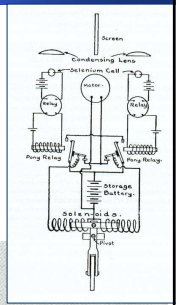
Histórico – 1868: A Steam Man
Mr. Zadock Deddrick1, a Newark machinist,
has invented a man; one that, moved by steam,
will perform some of the most important functions of
humanity; that will, standing upright, walk or run…

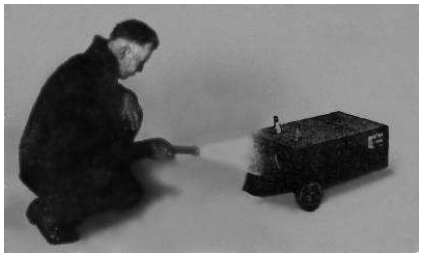


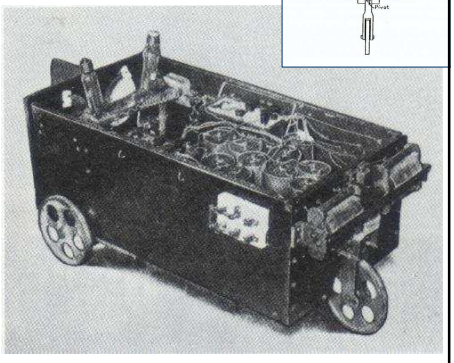


Robôs Móveis Autônomos

Histórico – Electric Dog - 1912
An electric dog, the ancestor of all phototropic self-directing robots,
was designed in 1912 and constructed in the USA by researchers
John Hammond, Jr. and Benjamin Miessner



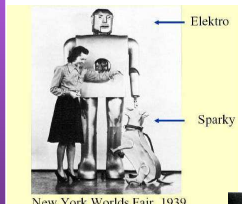




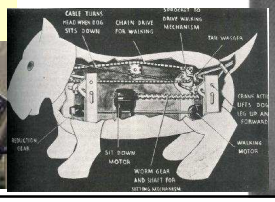
Robôs Móveis Autônomos

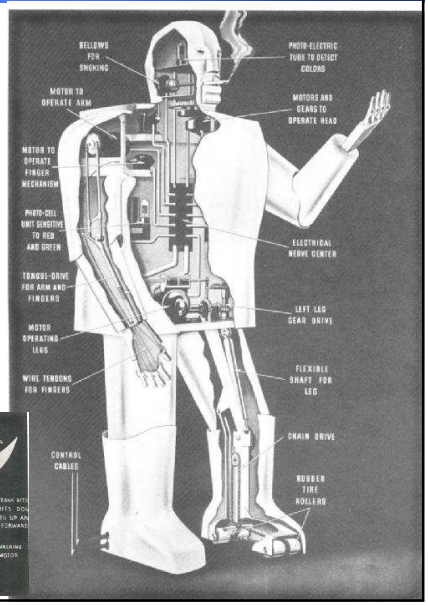
Robôs Móveis Autônomos

Histórico – Elektro
Westinghouse Elektro - 1937
Westinghouse Sparko – 1940
Elektro was built in 1937/38 by Westinghouse



New York Worlds Fair, 1939
(Westinghouse Historical Collection)



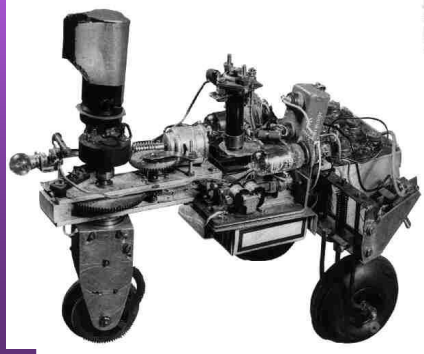


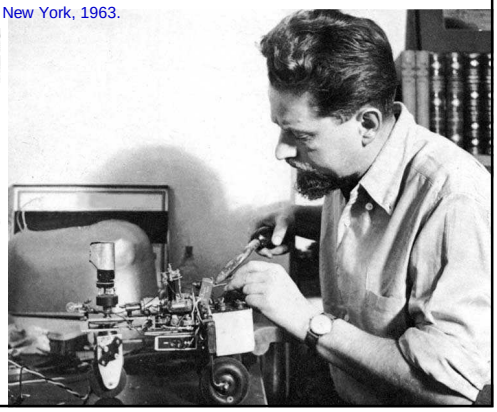
Robôs Móveis Autônomos

Robôs Móveis Autônomos

Histórico – 1948 - William Grey Walter, first tortoise Elmer
1949 - William Grey Walter. Elsie, Walter's second tortoise

* Walter, W. Grey - A machine that learns. Scientific American, 184(8): 60-63, August 1951.
* Walter, W. Grey - An imitation of life. Scientific American, 182(5): 42-45, May 1950.
* Walter, W. Grey - The Living Brain, W. W. Norton, New York, 1963.





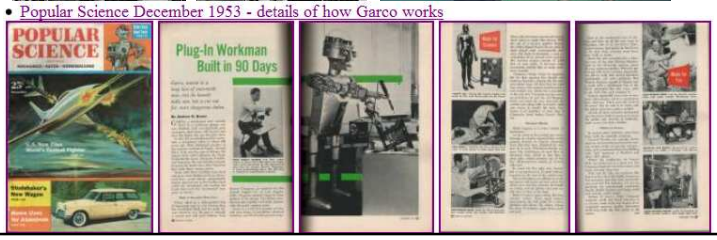
Robôs Móveis Autônomos

Histórico – 1944 – II World War – German Tank
Goliath (YouTube)
Human Controlled Vehicle
"Remote Control"

Robôs Móveis Autônomos

Histórico – 1944: The robot Garco was created by Harvey Chapman.
The robot, built from discarded aircraft parts, is operated by remote control.
Human Controlled Humanoid - "Remote Control"

- Popular Science December 1953 - details of how Garco works



Robôs Móveis Autônomos

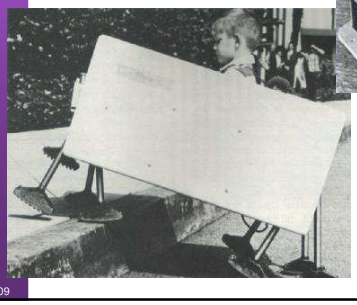
Histórico

1960: Zemanek build a series of robots to model combination of conditioned reflexes

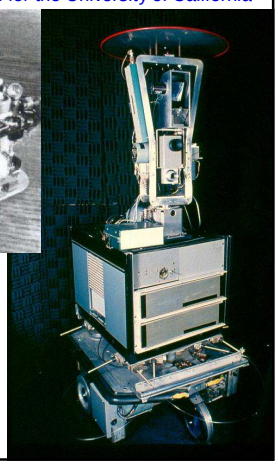
1965: Moonwalker - an 8-leg 'wheelchair' developed by Aerojet General for the University of California

1966: Shakey Shakey
Stanford Research Institute

Moonwalker



Zemanek



Shakey

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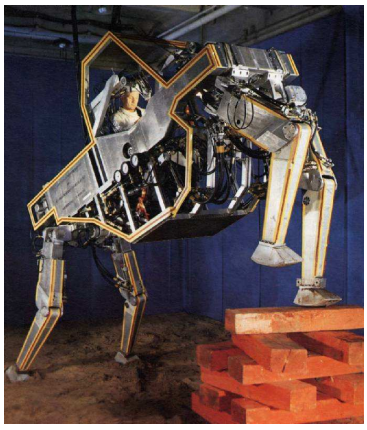
Robôs Móveis Autônomos

Robôs Móveis Autônomos

Histórico:

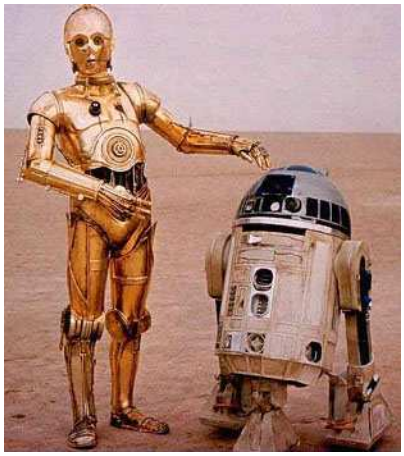
GE Walking Truck 1968

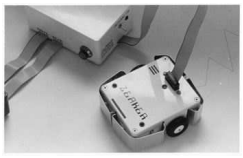
The Walking Truck was developed by Ralph S. Mosher for General Electric under a commission in 1966 from the US Army.



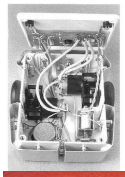
Robôs Móveis Autônomos

Histórico – Ficção Científica
1977 Droids – Film: Star Wars - R2-D2, C-3PO

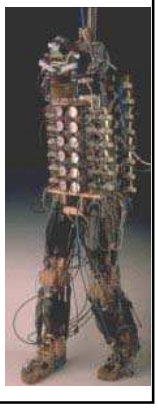


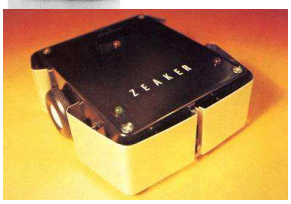


1983: Zeaker
by David Buckley



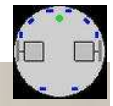
1988: Shadow
Biped Walker
by David Buckley





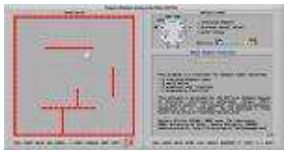
Robôs Móveis Autônomos

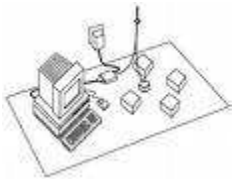
Histórico – 1996 Khepera (EPFL)
Khepera mobile robot [From Wikipedia]
The first generation Khepera robot released in 1996



The Khepera is a small (5.5 cm) differential wheeled mobile robot that was developed at the LAMI laboratory of Prof. Jean-Daniel Nicoud at EPFL (Lausanne, Switzerland) in the mid '90s. It was developed by Edo. Franzi, Francesco Mondada, André Guignard and others.

Small, fast, and architectured around a Motorola 68331, it served researchers for 10 years, widely used by over 500 universities worldwide. It is now outdated, even with its upgraded processor and flash in version 2.0.





Robôs Móveis Autônomos

Histórico – 1996: Honda P2

Honda's first public showing of a Biped Robot after a 10 year development program

P2

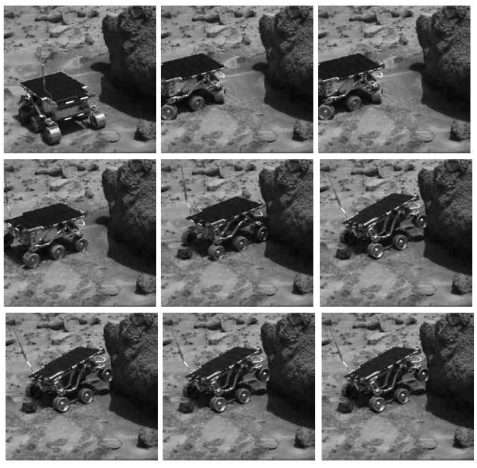
Prototype Model 2
1993-1997

First humanoid stunned the public with realistic movement.

The world's first self-regulating, two-legged humanoid walking robot debuted in December, 1996.
Height: 1,820mm, Weight: 210kg,Using wireless techniques, the torso contained a computer, motor drives, battery, wireless radio and other necessary devices, all of which were built in. Independent walking, walking up and down stairs, cart pushing and other operations were achieved without wires, allowing independent operation.

Robôs Móveis Autônomos

1997 Mars Rover: Soujourner / PathFinder



The rover goes a little too far and begins to climb Yogi (NASA)

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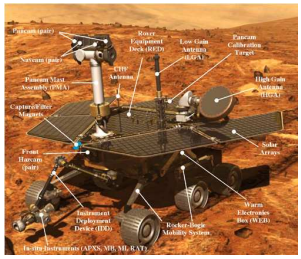
2004: Spirit and Opportunity



Robôs Móveis Autônomos

Histórico:

ActivRobots / MobileRobots1995 – Pioneer

iRobot 2002 – Roomba

The Roomba is a robotic vacuum cleaner made and sold by iRobot.
The Roomba was introduced in 2002; several updates and new models have since been released. As of January 2008, over 2.5 million units have been sold.

Boston Dynamics 2005 – BigDog

Sony 1999-2006 - Aibo

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Mobile Robots – Wikipedia : http://en.wikipedia.org/wiki/Mobile_robots

1995 The Pioneer programmable mobile robot becomes commercially available at an affordable price, enabling a widespread increase in robotics research and university study over the next decade as mobile robotics becomes a standard part of the university curriculum.

1996-1997 NASA sends the Mars Pathfinder with its rover Sojourner to Mars. The rover explores the surface, commanded from earth. Sojourner was equipped with a hazard avoidance system. This enabled Sojourner to autonomously find it s way through unknown martian terrain.

1999 Sony introduces Aibo, a robotic dog capable of seeing, walking and interacting with its environment. The PackBot remote-controlled military mobile robot is introduced.

2001 Start of the Swarm-bots project. Swarm bots resemble insect colonies. Typically they consist of a large number of individual simple robots, that can interact with each other and together perform complex tasks.

2002 Appears Roomba, a domestic autonomous mobile robot that cleans the floor.

2004 Robosapien, a biomorphic toy robot designed by Mark Tilden is commercially available. In 'The Centibots Project' 100 autonomous robots work together to make a map of an unknown environment and search for objects within the environment.

2004 In the first DARPA Grand Challenge competition, fully autonomous vehicles compete against each other on a desert course.

2005 Boston Dynamics creates a quadruped robot intended to carry heavy loads across terrain too rough for vehicles.

2006 Sony stops making Aibo and HelpMate halts production, but a lower-cost PatrolBot customizable autonomous service robot system becomes available as mobile robots continue the struggle to become commercially viable. The US Department of Defense drops the MDARS-I project, but funds MDARS-E, an autonomous field robot. TALON-Sword, the first commercially available robot with grenade launcher and other integrated weapons options, is released. Honda's Asimo learns to run and climb stairs.

2007 History is made with the DARPA Urban Grand Challenge, with six vehicles autonomously completing a complex course involving manned vehicles and obstacles. Seekur, the first widely available, non-military outdoor service robot, pulls a 3-ton vehicle across a parking lot , drives autonomously indoors and begins learning how to navigate itself outside. Meanwhile, PatrolBot learns to follow.

Robôs Móveis Autônomos - PRESENTE

Lewis Hamilton and the RC Office Grand Prix
RCGPGuys

YouTube
http://www.youtube.com/watch?v=FiLoANg6nNY

http://www.youtube.com/results?search_type=&search_query=Hamilton+F1+RC&aq=f

Using a Data-Glove to Recognize Postures
ANN Gesture Recognition

Control RC Car
F. Osório, S. Musse, A. Tavares, M. Gomez, F. Garat
L. Poltosi, G. P. Breyer, F. Heinen

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Robôs Móveis Autônomos - PRESENTE

Lewis Hamilton and the RC Office Grand Prix
RCGPGuys

YouTube
http://www.youtube.com/watch?v=FiLoANg6nNY

http://www.youtube.com/results?search_type=&search_query=Hamilton+F1+RC&aq=f

ATUADORES
+
CONTROLE REMOTO
?!?!

Autonomos?

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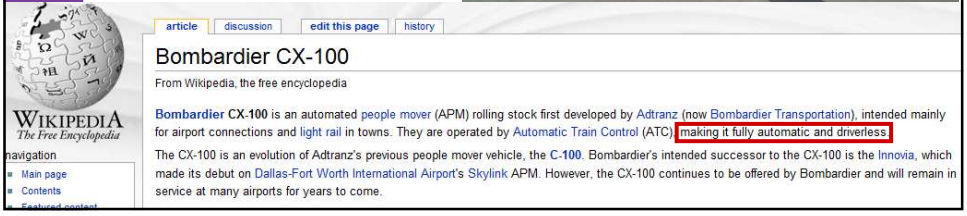
Robôs Móveis: Autônomos e Inteligentes

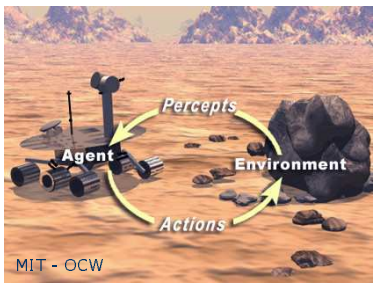
iPhone + Hamilton F1
x
Airport Shuttle



Robôs Móveis Autônomos

Robôs Móveis: Autônomos e Inteligentes - CONCEITOS

Robôs Móveis:
Agentes Autônomos dotados de **SENSORES** e **ATUADORES**



SENSORES
ATUADORES
CONTROLE INTELIGENTE

Sensores e Atuadores

Tipos de Sensores

Sensores mais comuns...

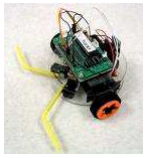
Detecção de Luz, Som, Ondas Eletromagnéticas, Contato

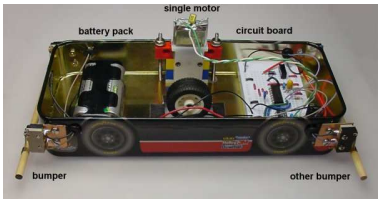
- **Bumbers**
- **Odômetros**
- **Sensores Infra-Vermelho (IR)**
- **Sensores do tipo Ultra-Som (Sonar)**
- **Sensores do tipo Laser (LIDAR - Light Detection and Ranging)**
- **Bússola (Compass)**
- **Sistema de GPS (Global Positioning System)**
- **Sistemas Inerciais (Acelerômetros, Giroscópios)**
- **Sistemas de Visão: Câmera de Vídeo**

Sensores e Atuadores

Tipos de Sensores

Sensor do Tipo *Bumper* (Sensor de Contato / "Pára-choque")





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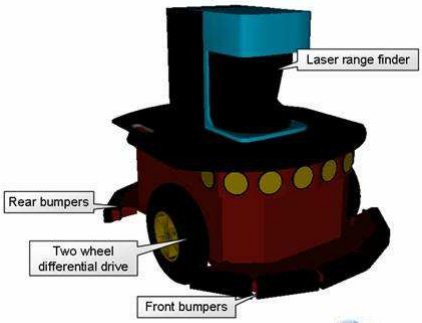
Sensores e Atuadores

Tipos de Sensores

Sensor do Tipo *Bumper* (Sensor de Contato / "Pára-choque")



Whiskers: "Bigodes de Gato"

Sensores e Atuadores

Tipos de Sensores

Sensores do tipo Odômetro

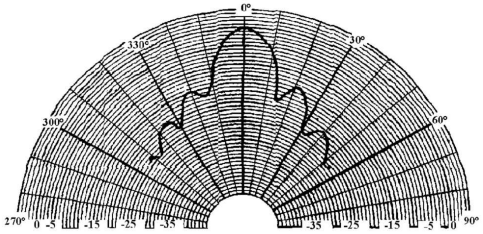
Odômetro

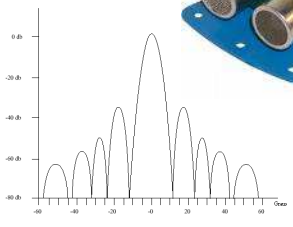
Encoder: Controle do giro da roda

Sensores e Atuadores

Tipos de Sensores

Sensores Ultra-Som (Sonar)

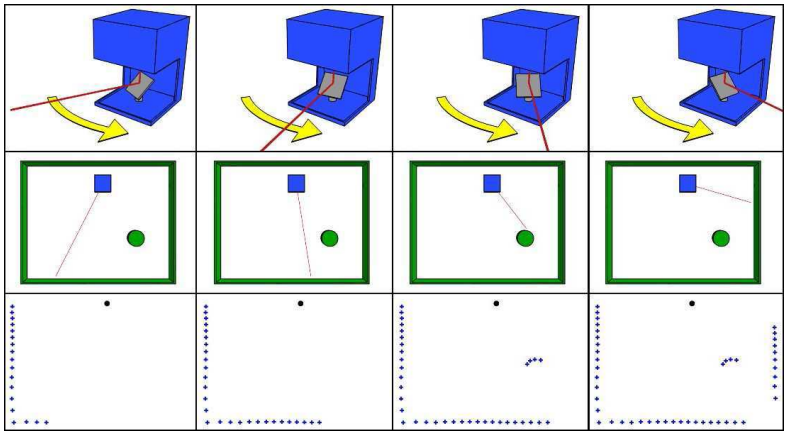




Sensores e Atuadores

Tipos de Sensores

Sensores LASER (Lidar - Light Detection and Ranging)



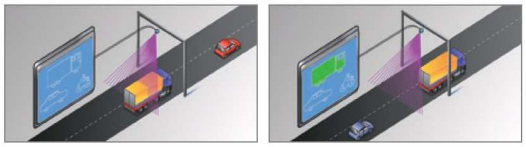
Fonte: Wikipedia LIDAR

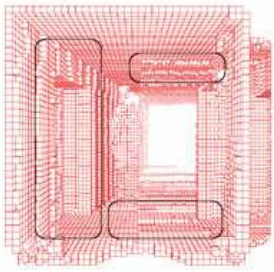
Sensores e Atuadores

Tipos de Sensores

Sensores LASER (Lidar)

SICK
IBEO
VELODYNE





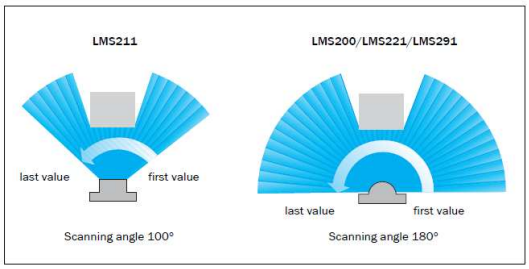


Fig. 5-1: Direction of transmission and maximum scanning angle (standard devices) on top view of the devices

Sensores e Atuadores

Tipos de Atuadores

Servomotor

Atuadores mais comuns...

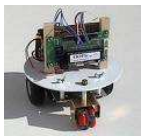
- **Motor DC**
- **Motor de Passo (Step-Motor)**

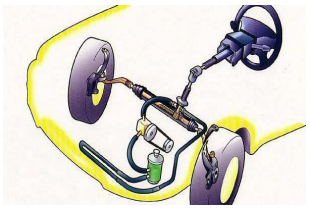
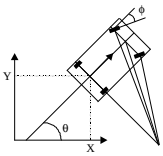
Atuador	Principal Tipo/Função	Exemplos
Base Fixa	Braço robótico com base fixa	Robôs industriais PUMA
Base Móvel: Rodas	2 Rodas independentes (diferencial)	Robôs Khepera e Pioneer P3-DX
	3 Rodas (triciclo, omni-directionais)	Robô BrainStem PPRK
	4 Rodas (veículos robóticos - ackermann)	Stanley - Stanford (Darpa Challenge)
Base Móvel: Esteira	Esteira (Slip/Skid locomotion - tracks)	Tanques e veículos militares
Base Móvel: Juntas e	Bípedes	Robôs Humanóides
Articulações	4 Patas (quadpods)	Robôs Sony Aibo, BigDog
	6 Patas (hexapods)	Robôs Inseto (Lynxmotion Hexapods)
Base Móvel: Propulsão	Veículos aéreos com hélices	Aviões, Helicópteros e Dirigíveis
Hélices ou Turbinas	Veículos aquáticos com hélices	Barcos autônomos
	Veículos sub-aquáticos	Submarinos autônomos
Outros tipos	Braços manipuladores com base móvel	Garras (Grippers) embarcadas
	Garras com ou sem feed-back sensorial	Mão robótica
	Mecanismos de disparo	Disparo do chute (futebol de robôs)

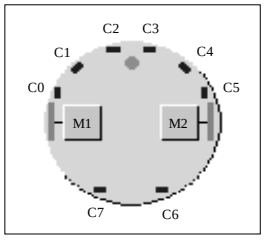
Sensores e Atuadores

Tipos de Atuadores

Atuadores: Robôs Móveis





Sensores e Atuadores

Modelos Sensoriais e Modelos de Atuadores

Como Agir?

Como Interpretar as Percepções?

Como Tomar Decisões?

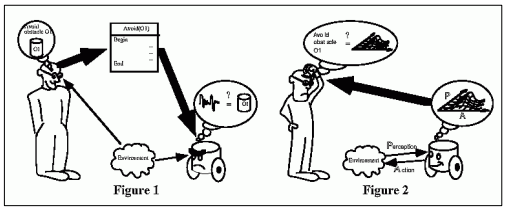


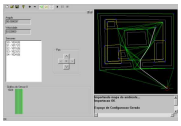
Figure 1 Figure 2

Sensores e Atuadores: Simulação

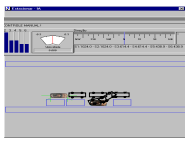
Modelos Sensoriais e Modelos de Atuadores

KHEPERA-SIM

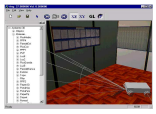
SIMROB2D



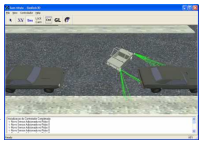
SEVA2D



SIMROB3D



SEVA3D



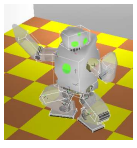
ODE-Robombeiros

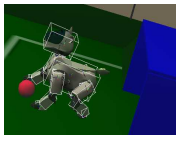
Player-Stage

Webots

Juice

MSF Robotics Studio

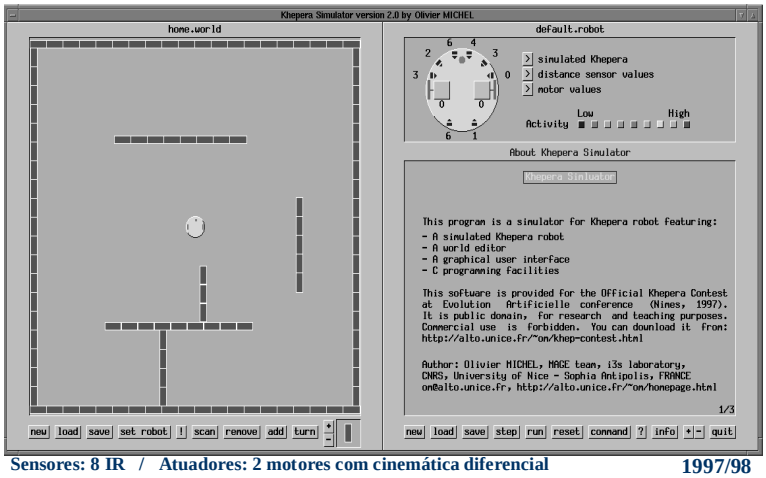




Sensores e Atuadores: Simulação

Robótica Autônoma
Controle Reativo

Simulador do *Khepera* / SIM 2.0 Unix / Olivier Mitchell / INRIA Sophia Antipolis



Sensores: 8 IR / Atuadores: 2 motores com cinemática diferencial **1997/98**

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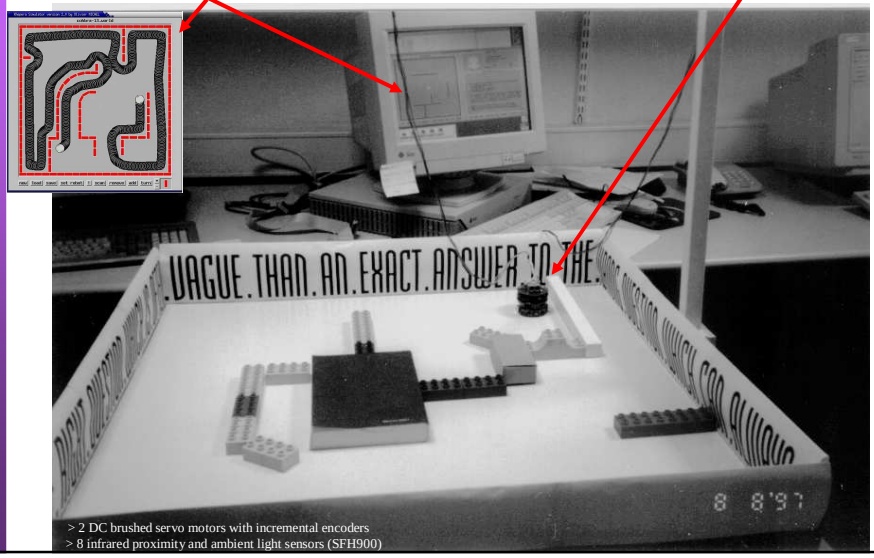
Prof. Fernando Osório - Grupo SEER / LRM

Sensores e Atuadores: Simulação

Robótica Autônoma - Controle Reativo

Simulador do *Khepera*

Robô *Khepera*



> 2 DC brushed servo motors with incremental encoders
> 8 infrared proximity and ambient light sensors (SFH900)

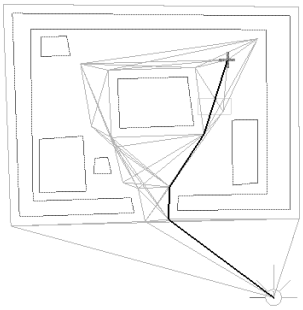
Sensores e Atuadores: Simulação

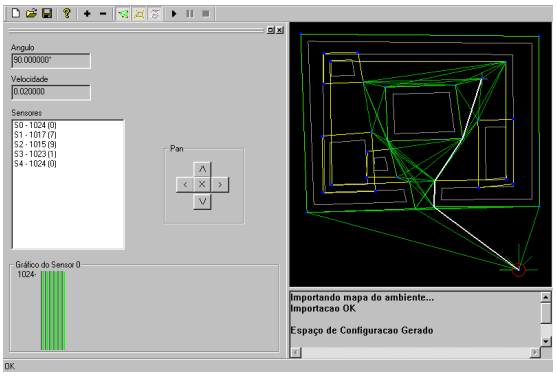
SIMROB2D

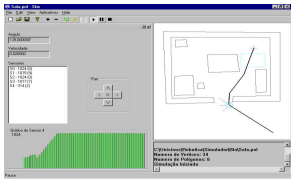
Robótica Autônoma
Controle Deliberativo

***Referência*:**
Farlei Heinen (Orientador: Fernando Osório)
Robótica Autônoma. 2000.

Sensores: 5 IR / Atuadores: 2 motores (diferencial)







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Sensores e Atuadores: Simulação

Robótica Autônoma - Controle Híbrido

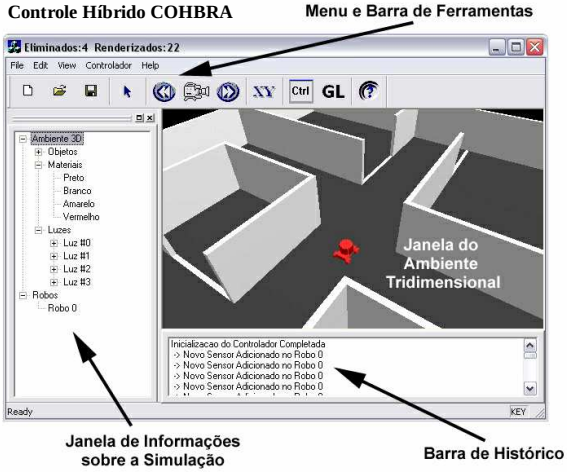
SIMROB3D – Simulador de Robôs 3D / Controle Híbrido COHBRA

Sensores: Bumper, IR ou Sonar (configurável pelo usuário)
Atuadores: Cinemática diferencial ou Ackerman (configurável pelo usuário)

Sensores e Atuadores: Simulação

Robótica Autônoma - Controle Híbrido

SIMROB3D – Simulador de Robôs 3D
Controle Híbrido COHBRA



Sensores: Bumper, IR ou Sonar (configurável pelo usuário)
Atuadores: Cinemática diferencial ou Ackerman (configurável pelo usuário)

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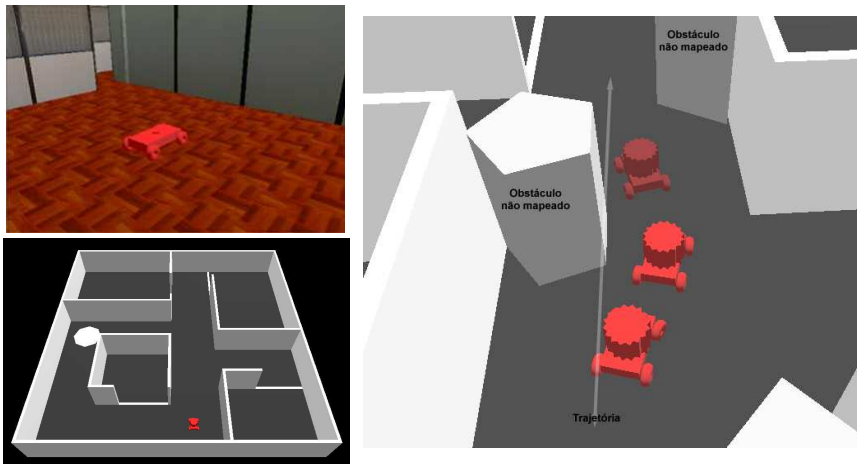
Prof. Fernando Osório - Grupo SEER / LRM

Sensores e Atuadores: Simulação

Robótica Autônoma - Controle Híbrido

SIMROB3D – Simulador de Robôs 3D / Controle Híbrido COHBRA

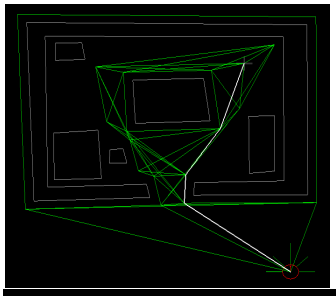


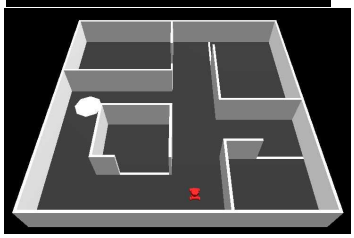
Sensores: Bumper, IR ou Sonar (configurável pelo usuário)
Atuadores: Cinemática Diferencial ou Ackerman (configurável pelo usuário)

Sensores e Atuadores: Simulação

Robótica Autônoma - Controle Híbrido

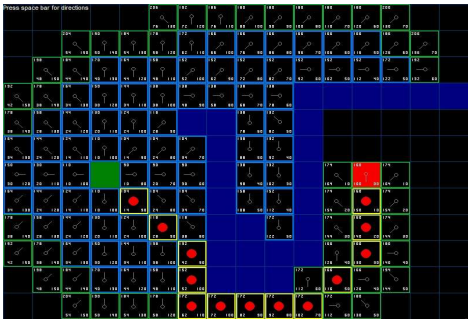
SIMROB3D – Simulador de Robôs 3D / Controle Híbrido COHBRA





ALGORITMOS DE PLANEJAMENTO DE TRAJETÓRIA BASEADOS EM MAPAS

Algoritmo A* - A Star [Lester 2004, 2007]

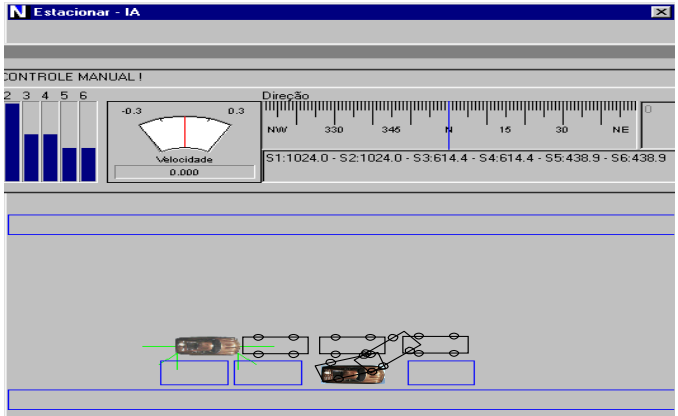


ESTIMATIVA DE POSIÇÃO: ALGORITMOS DE AUTO-LOCALIZAÇÃO

Sensores e Atuadores: Simulação

Robótica Autônoma - Controle Híbrido

SEVA2D – Simulador de Estacionamento de Veículos Autônomos 2D

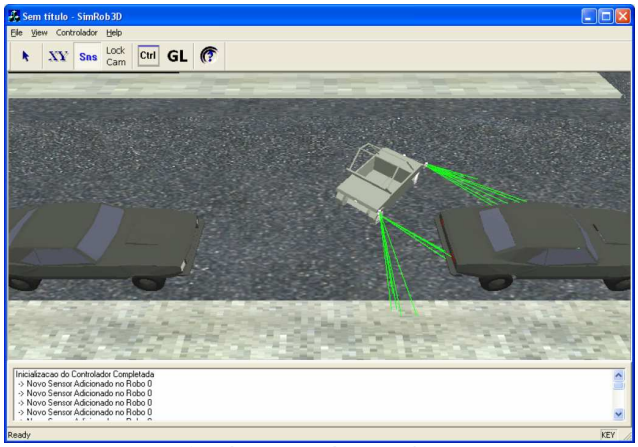


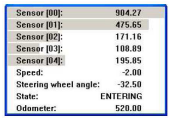
Sensores: 6 sensores de proximidade
Atuadores: atuador de direção (steering) e de aceleração (gas pedal) + frente/ré
Cinemática do tipo Ackerman (veículo) / Sem simulação da dinâmica do veículo

Sensores e Atuadores: Simulação

Robótica Autônoma - Controle Híbrido

SEVA3D – Simulador de Estacionamento de Veículos Autônomos 3D





Sensores: Sonar (configurável pelo usuário) e Odômetro
Atuadores: Cinemática Ackerman
Usual: 6 sonares com posições específicas, odômetro, controle de velocidade e de giro da direção

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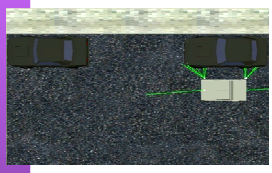
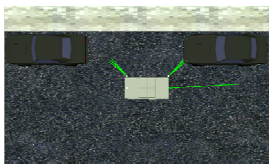
Sensores e Atuadores: Simulação

Robótica Autônoma - Controle Híbrido

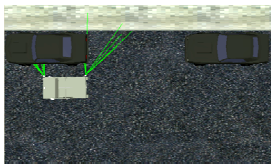
SEVA3D – Simulador de Estacionamento de Veículos Autônomos 3D



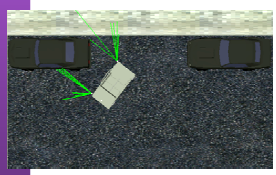
Searching Parking Space



Positioning Outside



Entering



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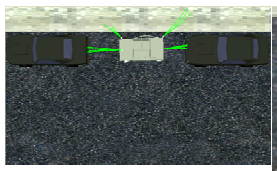
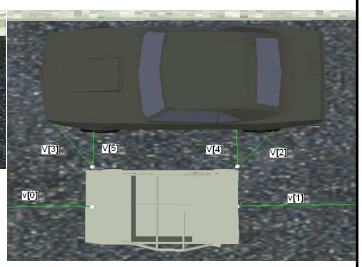


Aligning

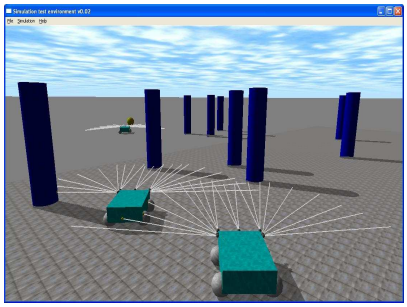


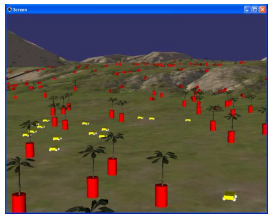
Sensores: Sonar (configurável pelo usuário) e Odômetro
Atuadores: Cinemática Ackerman (velocidade e giro da direção)

Sensores e Atuadores: Simulação

Robótica Autônoma - Controle Inteligente Multi-Robôs

RoBombeiros – Simulador Robôs para Combate à Incêndios



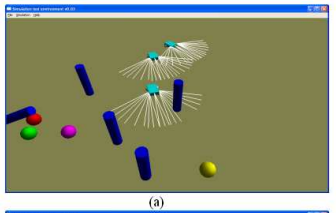


Simulação Física usando a ODE

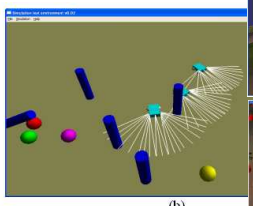
Sensores e Atuadores: Simulação

Robótica Autônoma:
Controle Inteligente Multi-Robôs

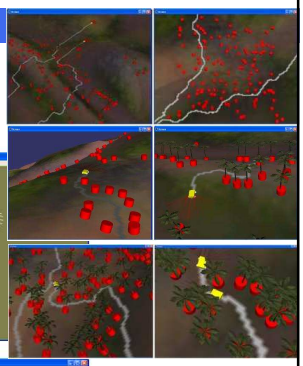
RoBombeiros – Simulador Robôs para Combate à Incêndios

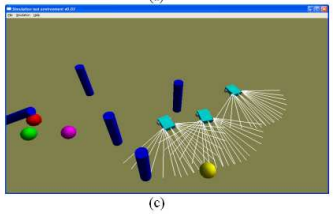


(a)

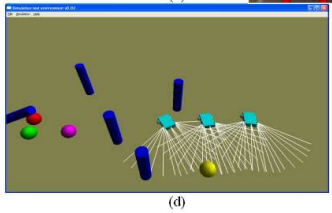


(b)





(c)



(d)

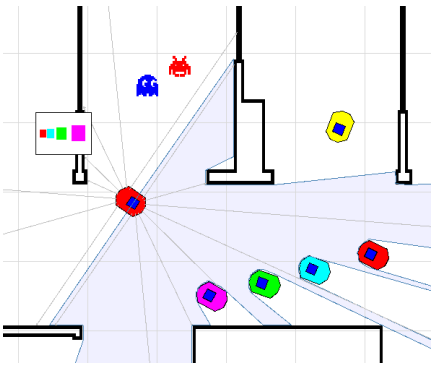
Seqüências de uma simulação com navegação e desvio satisfatórios

Simulação Física usando a ODE

Sensores e Atuadores: Simulação

Player – Stage - Gazebo

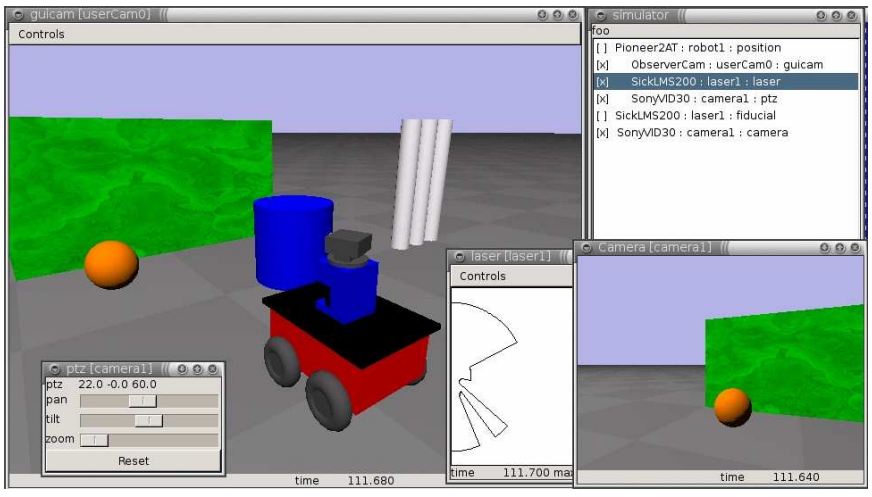
Robótica Autônoma Móvel:
Sistemas Inteligentes Multi-Robôs



Simulação Virtual
Sistemas de Controle de Robôs

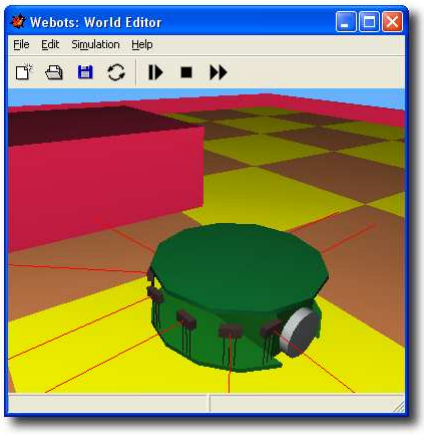
Sensores e Atuadores: Simulação

Player – Stage - Gazebo



Sensores e Atuadores: Simulação

Webots



The Sony Dream Robot in the real world

The Sony Dream Robot simulated into Webots

Robôs Móveis Autônomos

Robôs Móveis Autônomos – Aplicações UGVs

DARPA Challenge - UGVs [*Unmaned Ground Vehicles*]

2004 - Darpa Grand Challenge – Prêmio: US$ 1 Milhão - Sem Vencedores

First Grand Challenge, held on March 13, 2004, when only 13 teams were able to field machines for the ***142-mile course and none cleared the first mountain crossing*** (see "A New Race of Robots," by W. Wayt Gibbs; SCIENTIFIC AMERICAN, March 2004).

2005 - Darpa Grand Challenge – Prêmio: US$ 2 Milhões - Vencedor: Stanley / Stanford

Five out of 23 competing robots successfully navigated a 132-mile course through the Mojave Desert in October 2005 as part of the DARPA Grand Challenge race. **To qualify** for the $2-million prize, the driverless vehicles had to finish **in less than 10 hours**. ***Four turned in elapsed times under 7.5 hours***.

2007 – Darpa Urban Challenge – Prêmio: US$ 2 milhões – Vencedor: Boss / CMU

The Urban Challenge, announced in April 2006, called for autonomous vehicles to drive 97 km through an urban environment, interacting with other moving vehicles and obeying the California Driver Handbook. Interest in the event was immense, with 89 teams from around the world registering interest in competing. Competition took place on November 3, 2007.

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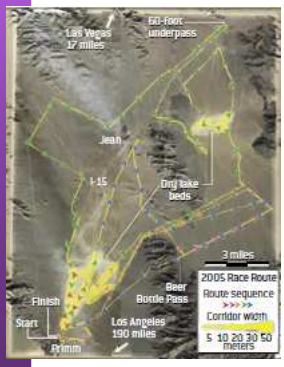
DARPA
Grand Challenge

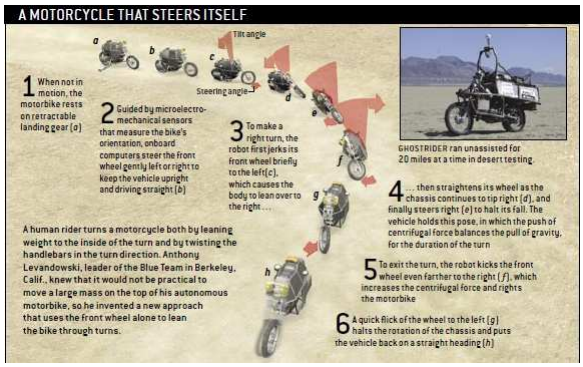


MACHINE ON A MISSION. Sandstorm swivels its laser-scanning "eye" (inside silver dome) to peer around a tight turn as it negotiates Beer Bottle Pass in the 2005 Grand Challenge race, followed by a DARPA chase vehicle. The autonomous Humvee drove the 132-mile course at an average speed of 18.6 miles an hour but was bested by a slightly faster robot.

Robôs Móveis Autônomos - Aplicações

DARPA Grand Challenge

A MOTORCYCLE THAT STEERS ITSELF



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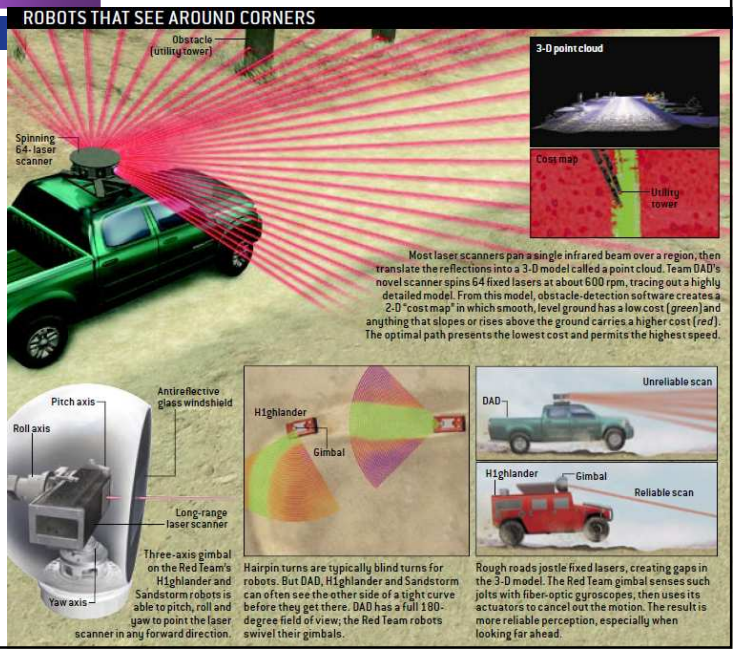
DARPA Grand Challenge



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Prof. Fernando Osório - Grupo SEER / LRM

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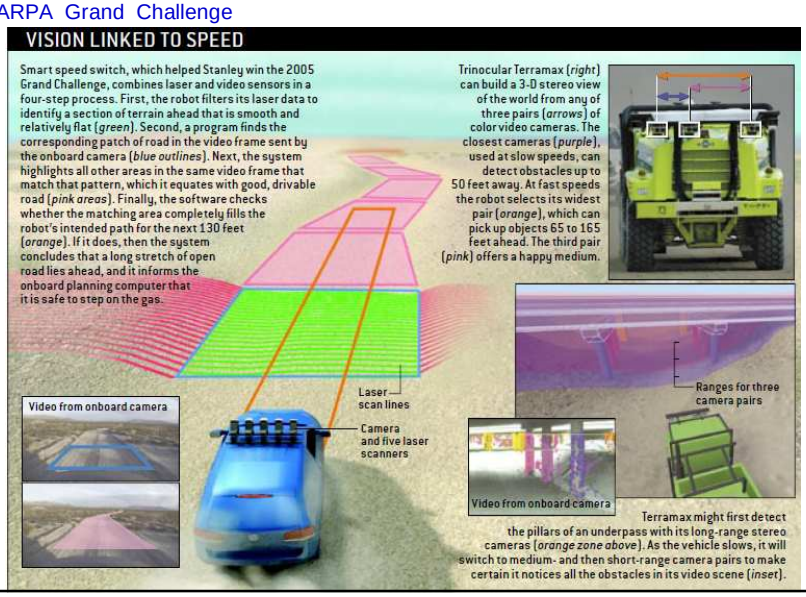
DARPA Grand Challenge



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DARPA Grand Challenge

Ganhadores – Stanley / Stanford University

Sebastian Thrun, Mike Montemerlo, Hendrik Dahlkamp, David Stavens, Andrei Aron, James Diebel, Philip Fong, John Gale, Morgan Halpenny, Gabriel Hoffmann, Kenny Lau, Celia Oakley, Mark Palatucci, Vaughan Pratt, and Pascal Stang
Stanford Artificial Intelligence Laboratory- Stanford University - Stanford, California 94305
Sven Strohband, Cedric Dupont, Lars-Erik Jendrossek, Christian Koelen, Charles Markey, Carlo Rummel, Joe van Niekerk, Eric Jensen, and Philippe Alessandrini
Volkswagen of America, Inc. - Electronics Research Laboratory - Palo Alto, California
Gary Bradski, Bob Davies, Scott Ettinger, Adrian Kaehler, and Ara Nefian
Intel Research - 2200 Mission College Boulevard
Santa Clara, California 95052
Pamela Mahoney
Mohr Davidow Ventures
Menlo Park, California 94025

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DARPA Urban Challenge
Boss, the autonomous Chevy Tahoe that won the 2007 DARPA Urban Challenge
Tartan Racing – CMU Carnegie Mellon University
Pittsburgh, Pennsylvania

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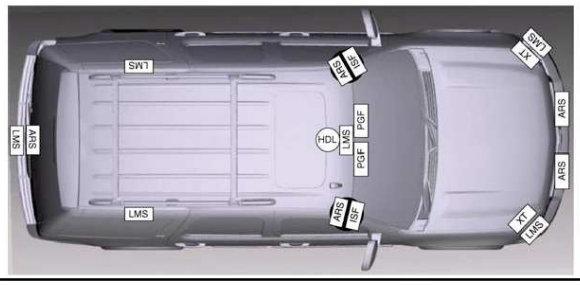
DARPA Urban Challenge

"Boss" CMU

Sensor	Characteristics
Applanix POS-LV 220/420 GPS/IMU (APLX)	• Submeter accuracy with Omnistar VBS corrections • Tightly coupled inertial/GPS bridges GPS outages
SICK LMS 291-S05/S14 LIDAR (LMS)	• 180/90 deg × 0.9 deg FOV with 1/0.5-deg angular resolution • 80-m maximum range
Velodyne HDL-64 LIDAR (HDL)	• 360 × 26-deg FOV with 0.1-deg angular resolution • 70-m maximum range
Continental ISF 172 LIDAR (ISF)	• 12 × 3.2 deg FOV • 150-m maximum range
IBEO Alasca XT LIDAR (XT)	• 240 × 3.2 deg FOV • 300-m maximum range
Continental ARS 300 Radar (ARS)	• 60/17 deg × 3.2 deg FOV • 60-m/200-m maximum range
Point Grey Firefly (PGF)	• High-dynamic-range camera • 45-deg FOV



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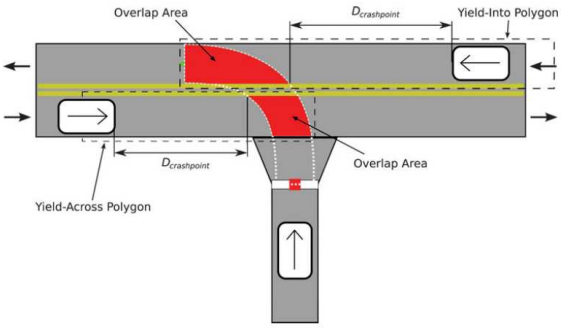
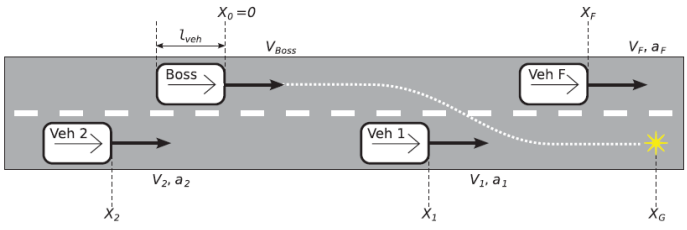
DARPA Urban Challenge

"Boss" CMU





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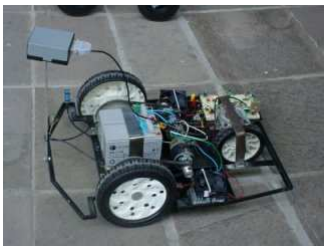
UGVs

Exemplos de Aplicações...
GPVA – Grupo de Pesquisa em Veículos Autônomos

O que aprendemos de todas estas aplicações?



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Aplicações

Exemplos de Aplicações... **GPVA**

UGVs

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Robôs Móveis Autônomos Aplicações

UGVs

Exemplos de Aplicações... **LRM – ICMC - USP**

Denis Wolf

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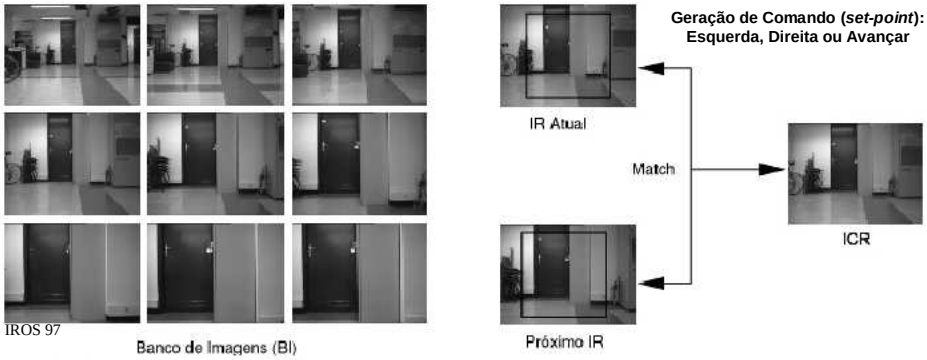
Robôs Móveis Autônomos Aplicações

UGVs

Exemplos de Aplicações... **LRM – ICMC - USP**

Navegação Visual

Correlação entre Imagens do Base de Imagens e Imagem do Robô



IROS 97

Seqüência de Imagens previamente Armazenadas
Rota de Navegação Visual: Banco de Imagens (BI)
IR = Imagem de Referência // ICR = Imagem Capturada pelo Robô

Fernando Osório

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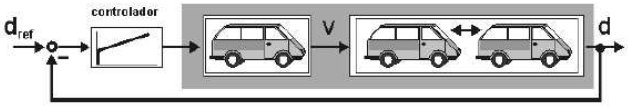
UGVs

Exemplos de Aplicações... **LRM – ICMC - USP**

Navegação Visual

Comboio de Veículos:
Follow-Me



F.Osório, F.Heinen, C.R.Jung, C.Kelber

Figura 4.15: Veículos em Comboio

Geração de Comando (*set-point*):
Esquerda, Direita ou Avançar

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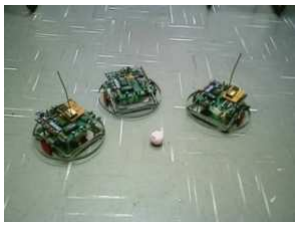
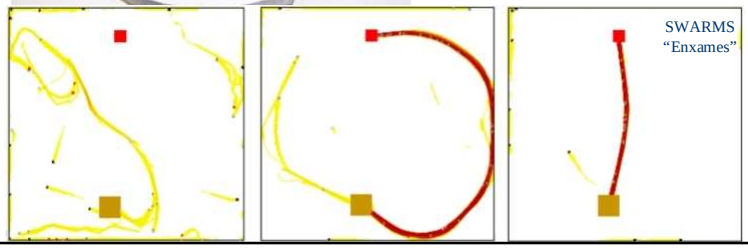
Robôs Móveis Autônomos Aplicações

UGVs

Exemplos de Aplicações... **LRM – ICMC - USP**



Eduardo Simões



SWARMS
"Enxames"

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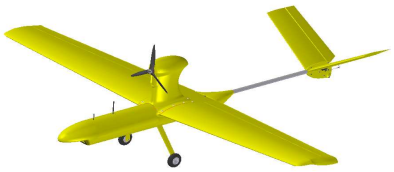
Robôs Móveis Autônomos Aplicações

UAVs

UAVs – UnManed Aerial Vehicles

Exemplos de Aplicações... **LRM – ICMC - USP**



AGPlane
AGX Tecnologia

YouTube: Seaech AGPLANE - MEMBECA 2008

Projeto
ARARA Onofre Trindade Jr.

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Robôs Móveis Autônomos Aplicações

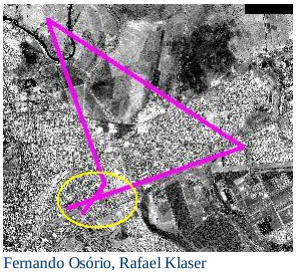
UAVs

Exemplos de Aplicações...

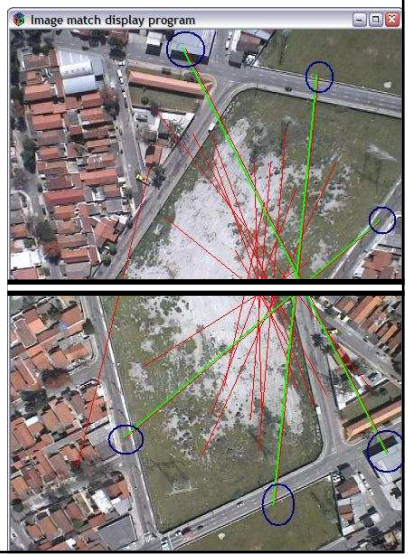
Navegação Visual

Sistema de Visão
para Veículos Aéreos
Não Tripulados

Correlação entre imagens de um helicóptero (cruzamento da rota)



Fernando Osório, Rafael Klaser



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Robôs Móveis Autônomos - Desafios

UGVs
UAVs

UGVs – UnManed Ground Vehicles

UAVs – UnManed Aerial Vehicles

Instituto Nacional de Ciência e Tecnologia

INCT Sistemas Embarcados Críticos

ICMC/USP

São Carlos, SP

VEÍCULOS INTELIGENTES:
Percepção, Planejamento, Decisão, Ação
Tolerância à Falhas em Sistemas Críticos

Sistema Embarcado de Navegação Autônoma (SENA) – EESC / ICMC / IFSC

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Robôs Móveis Autônomos – Futuro

Scientific American - January 2007

A Robot in Every Home
The leader of the PC revolution predicts that
the next hot field will be robotics
By Bill Gates

Imagine being present at the birth of a new industry.
It is an industry based on groundbreaking new technologies,
wherein a handful of well-established corporations sell
highly specialized devices for business use and
a fast-growing number of start-up companies produce
innovative toys, gadgets for hobbyists and other interesting
niche products. But it is also a highly fragmented industry
with few common standards or platforms.
Projects are complex, progress is slow, and practical applications
are relatively rare. In fact, for all the excitement and promise,
no one can say with any certainty when--or even if--this industry
will achieve critical mass. If it does, though,
it may well change the world.

Of course, the paragraph above could be a description of
the computer industry during the mid-1970s, around the time
that Paul Allen and I launched Microsoft.

Robôs Móveis Autônomos

Referências usadas nesta Aula:

Web Histórico

- http://davidbuckley.net/DB/HistoryMakers.htm
- http://en.wikipedia.org/wiki/Mobile_robots
- http://www.youtube.com/watch?v=I_dr0arBltU
  Search YouTube: WW2 – Goliath

Material Complementar – DARPA Challenge:

- Darpa Challenge Papers:
  http://osorio.wait4.org/RMA/Darpa-Papers/ [usp – guest]
  Ver também: Wikipedia

Robôs Móveis Autônomos

Material Complementar – Disciplinas ICMC

- RMA Graduação - http://coteia.icmc.usp.br/mostra.php?ident=575
- Introdução Robôs - http://www.icmc.usp.br/~fosorio/SSC5887/SSC5887.html
- Programação Robôs - http://www.icmc.usp.br/~denis/2009/0712/

Material Complementar – Simuladores:

- Player-Stage - http://playerstage.sourceforge.net/
- ODE (Física) - http://www.ode.org/
- SimRob3D - http://ncg.unisinos.br/robotica/simulador/default.htm
- SimRob2D – http://ncg.unisinos.br/robotica/robotica.html
- SEVA2D - http://ncg.unisinos.br/robotica/estac.htm
- SEVA3D - http://osorio.wait4.org/oldsite/seva3d/
- Robombeiros - http://pessin.googlepages.com/

Robôs Móveis Autônomos

Material Complementar – Grupos de Pesquisa

- GVPA – Grupo de Pesquisa em Veículos Autônomos
  http://www.exatec.unisinos.br/~autonom
- LRM – Laboratório de Robótica Móvel
  http://www.icmc.usp.br/~lrm/
- Projeto SENA – Sistema Embarcado de Navegação Autônoma
  http://www.eesc.usp.br/sena/

Material Complementar – Publicações:

- F.Osório - http://osorio.wait4.org/publications/Papers-Osorio.htm

Material Complementar – Video UAV:

- AGPlane - http://www.youtube.com/watch?v=rehhfWZ4nJ8

INFORMAÇÕES SOBRE A PALESTRA

USP - Universidade de São Paulo - São Carlos, SP
ICMC - Instituto de Ciências Matemáticas e de Computação
SSC - Departamento de Sistemas de Computação

Prof. Fernando Santos OSÓRIO
Web institucional: Http://www.icmc.usp.br/ssc/
Página pessoal: Http://www.icmc.usp.br/~fosorio/
E-mail: fosorio [at] icmc. usp. br ou fosorio [at] gmail. com

Robôs Móveis Autônomos – Disciplinas Graduação / Pós-Grad.
Web Disciplinas: Http://www.icmc.usp.br/~fosorio/
> Material de Aulas, Material de Apoio, Referências
> Palestras – PPTs, Artigos - PDFs
Material On-Line [usp – guest]