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

USP - ICMC - SSC
SSC 0714 (RMA) - 1o. Semestre 2010

Disciplina de Robôs Móveis Autônomos SSC-0714

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Wiki ICMC: http://wiki.icmc.usp.br/index.php/SSC-714

Aula 02

Aula 02 – Robôs Móveis Autônomos

Agenda:

Robôs Móveis Autônomos:

1. História
2. Tipos de RMAs
3. Exemplos de Aplicações
4. Desafios
5. Futuro?

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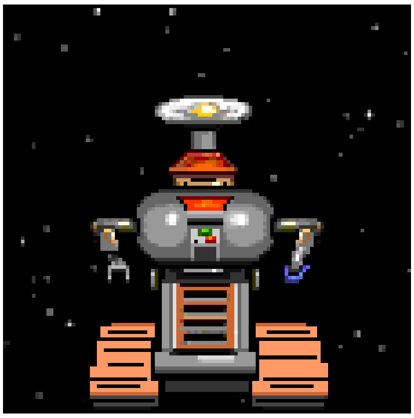
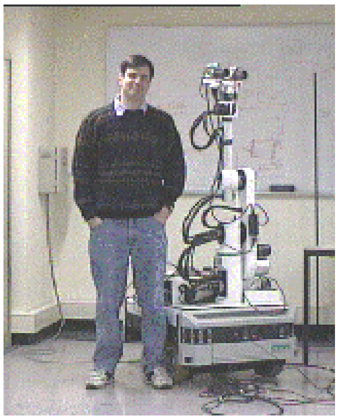
Da ficção científica à realidade...





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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

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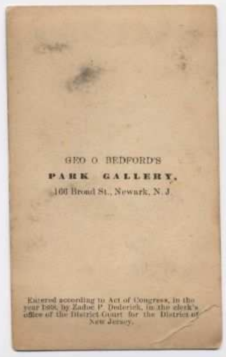
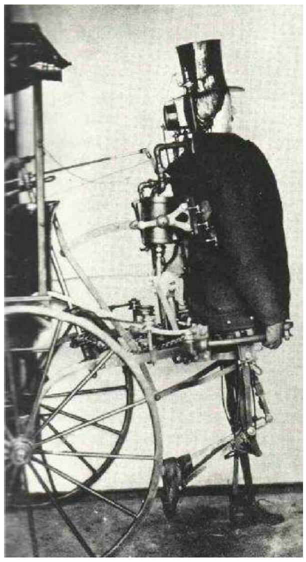
Robôs Móveis Autônomos

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…





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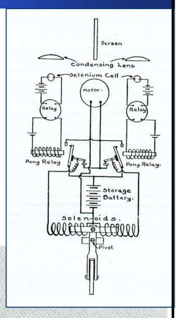
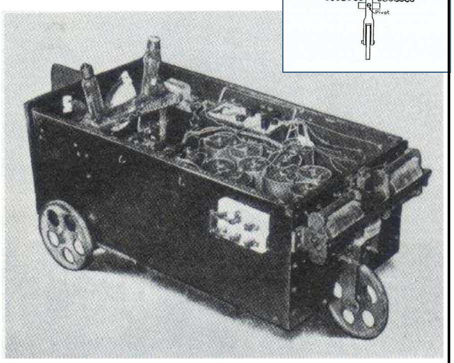
Robôs Móveis Autônomos



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



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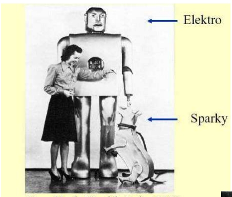
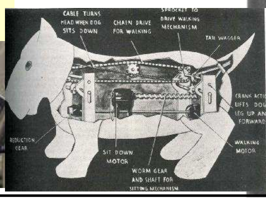
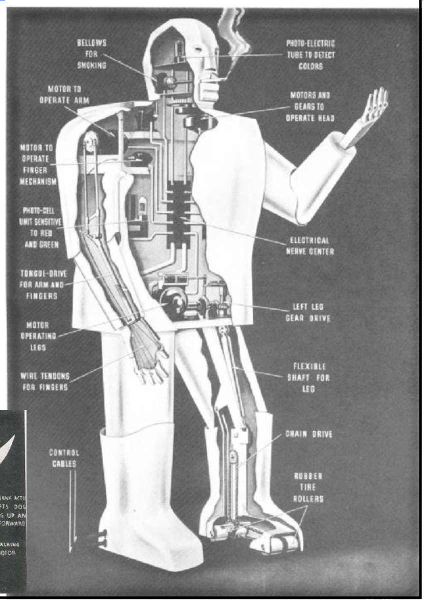
Histórico – Elektro
Westinghouse Elektro - 1937
Westinghouse Sparko – 1940
Elektro was built in 1937/38 by Westinghouse



New York Worlds Fair, 1939
(Westinghouse Historical Collection)





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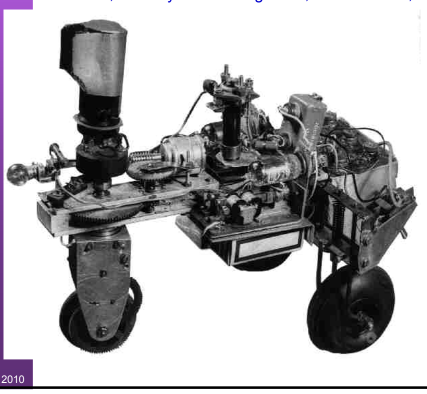
Histórico – 1948 - William Grey Walter, first tortoise Elmer
1949 - William Grey Walter. Elsie, Walter's second tortoise

* 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.



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

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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

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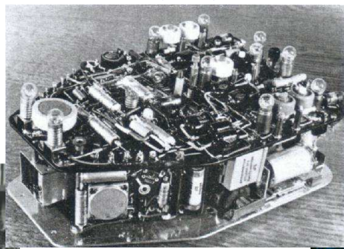
Histórico

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

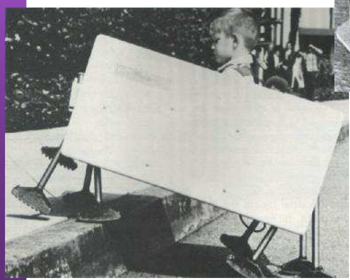
1965: Moonwalker - an 8-leg 'wheelchair' developed by Aerojet General for the University of California

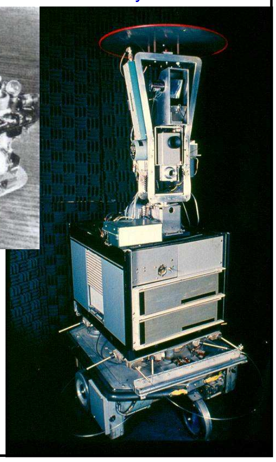
1966: Shakey Shakey
Stanford Research Institute



Zemanek

Moonwalker





Shakey

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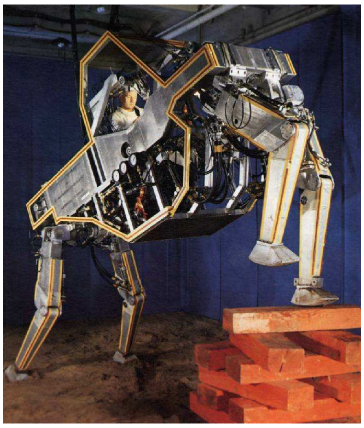
Histórico:

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.



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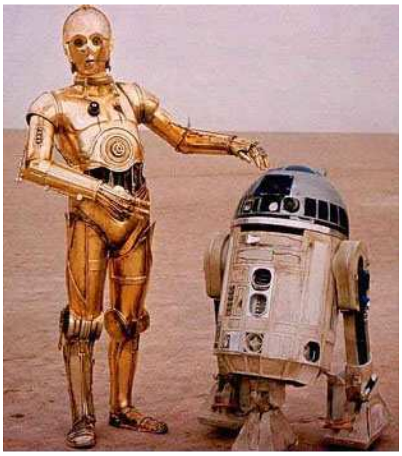
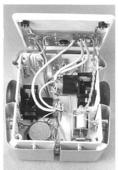
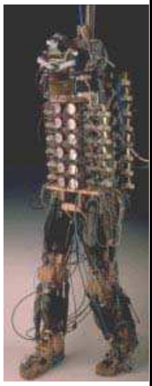
Histórico – Ficção Científica
1977 Droids – Film: Star Wars - R2-D2, C-3PO

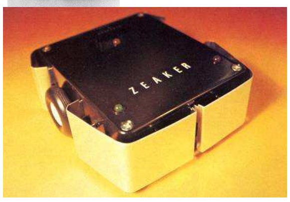


1983: Zeaker
by David Buckley



1988: Shadow
Biped Walker
by David Buckley





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Histórico

1989: Genghis - a 1Kg six legged robot which walks under **subsumption control** and has an extremely distributed control system.
Brooks, Rodney – MIT AI Lab

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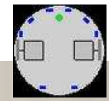
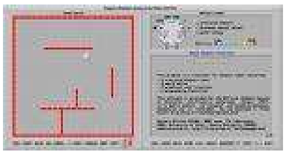
Histórico – 1996 Khepera (EPFL)

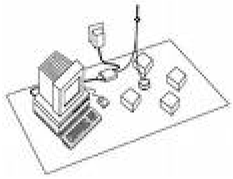
Khepera mobile robot [From Wikipedia]
The first generation Khepera robot released in 1996



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.





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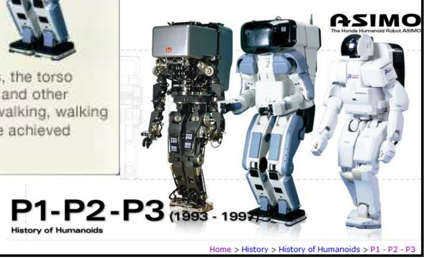
Histórico – 1996: Honda P2

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



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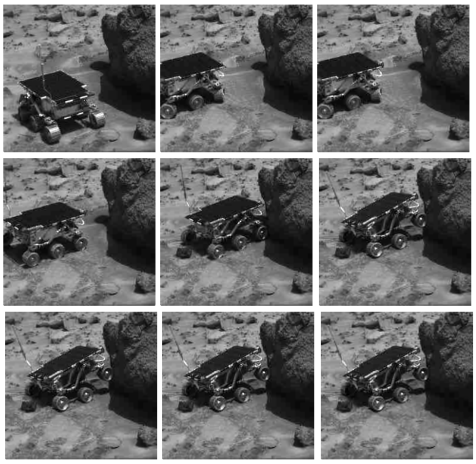
1997 Mars Rover: Soujourner / PathFinder



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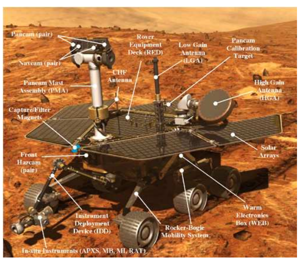
2004: Spirit and Opportunity



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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.

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DARPA Challenge

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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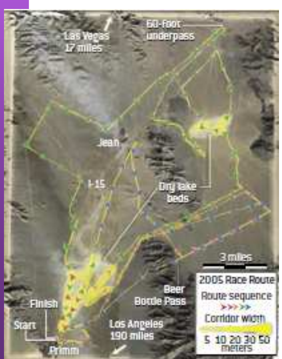
DARPA
Grand Challenge



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DARPA Grand Challenge

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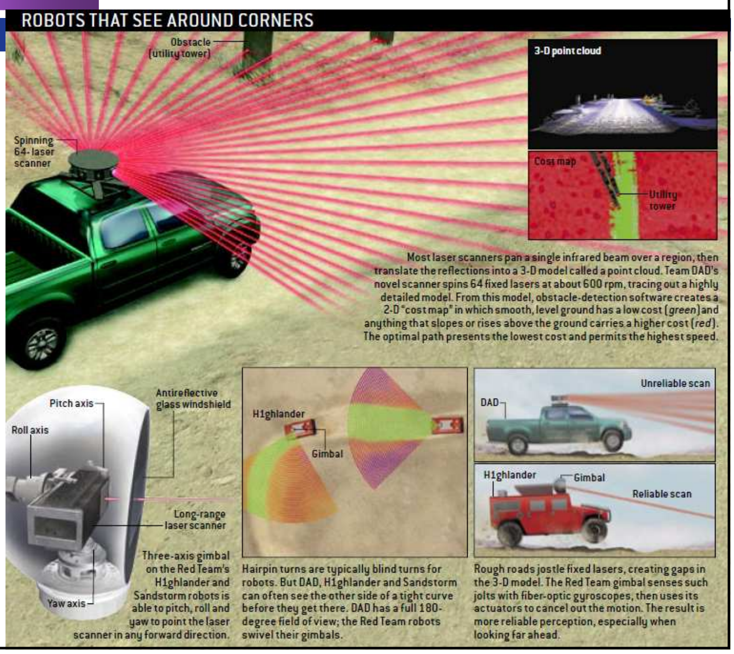
DARPA
Grand
Challenge



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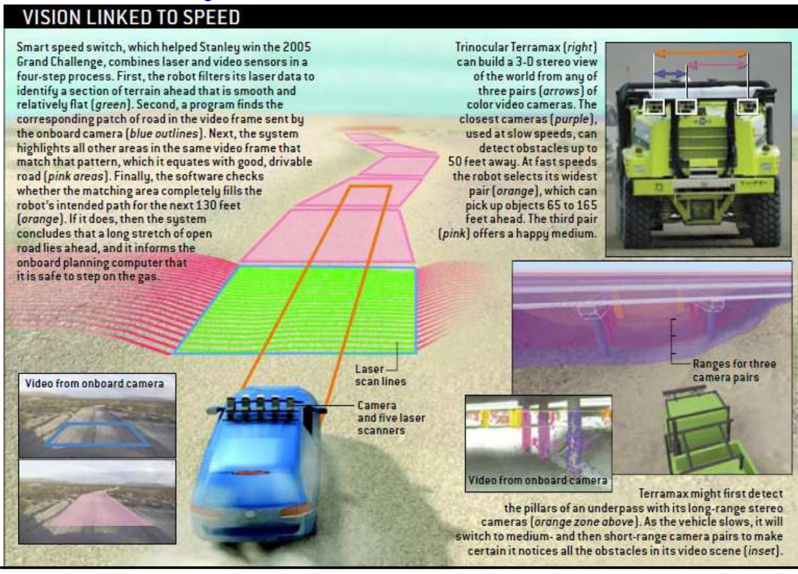
DARPA Grand Challenge



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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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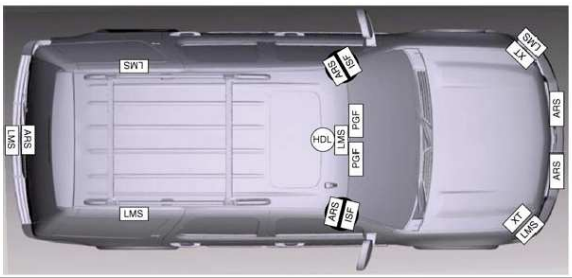
DARPA Urban Challenge

"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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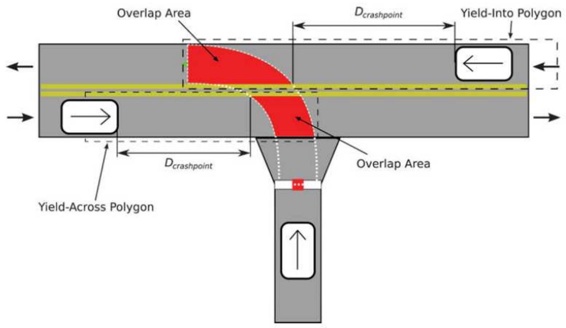
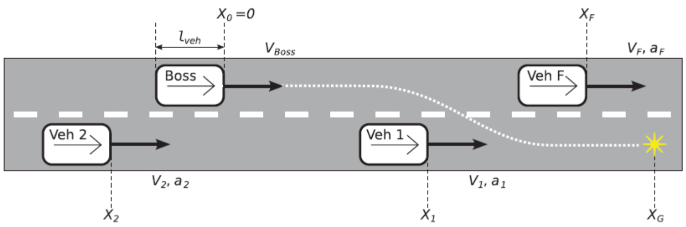
DARPA
Urban
Challenge

"Boss"
CMU





Robótica Autônoma
Tipos de Robôs

Tipos de Robôs

Robótica Autônoma
Tipos de Robôs

Tipos de Robôs

Percepção
Decisão
Ação

Tipo de Mobilidade
- **Base Fixa (manipuladores, braço robótico)**
- **Base Móvel: Com Restrição (grua) / Sem Restrição (veículo)**

Tipo de Mecanismo de Locomoção
- **Pernas, Rodas, Esteiras, Propulsão**

Tipo de Local de Atuação
- **Indoor (locais fechados, internos)**
- **Outdoor: Estruturados (estradas), Não Estruturados (off-road)**

Tipo de Autonomia
- **Controle e Ações Pré-Definidas**
- **Tele-Operados (tele-comandado)**
- **Semi-Autônomo (tele-operado + ações independentes)**
- **Autônomo** : sem intervenção humana durante a operação

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Robótica Autônoma
Tipos de Robôs

* **Robôs Manipuladores:**

- **Braços Robóticos de Base Fixa**
  Manipuladores Industriais
- **Braços Manipuladores Embarcados**
- **Gruas Robotizadas**

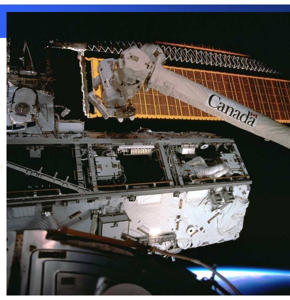
* **Robôs Móveis:**

- **AGV Industriais (Automated Guided Vehicles)**
- **Robôs Indoor: Veículos, Holonômicos, Humanoides, ...**
- **Robôs Outdoor: Terrestres (estradas, todos-terrenos),**
  Sub-Marinos, Aéreos, Inter-Planetários, ...

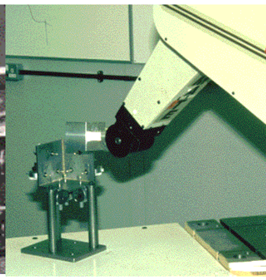
Robótica Autônoma
Tipos de Robôs

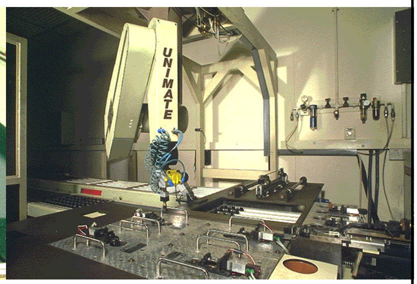
* **Robôs Manipuladores**:

- **Braços Robóticos de Base Fixa**
  Manipuladores Industriais



- **Braços Manipuladores Embarcados**
- **Gruas Robotizadas**





Robótica Autônoma
Tipos de Robôs

* **Robôs Manipuladores**:

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- **Braços Manipuladores Embarcados**
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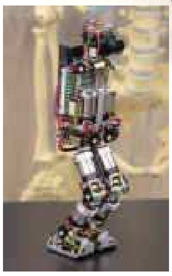
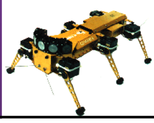




Robótica Autônoma
Tipos de Robôs

* **<u>Robôs Manipuladores</u>:**

- **Braços Robóticos de Base Fixa**
  Manipuladores Industriais
- **Braços Manipuladores Embarcados**
- **Gruas Robotizadas**

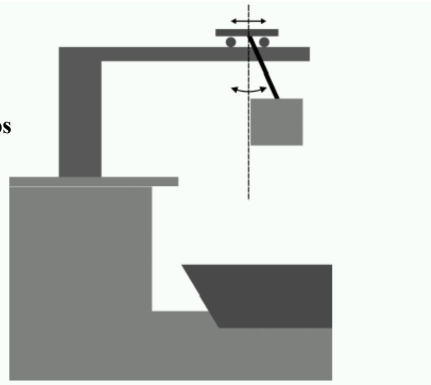


Figura 1: Ponte Rolante para Carga e Descarga de Containers

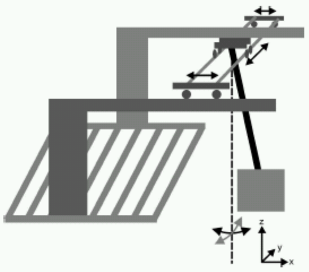
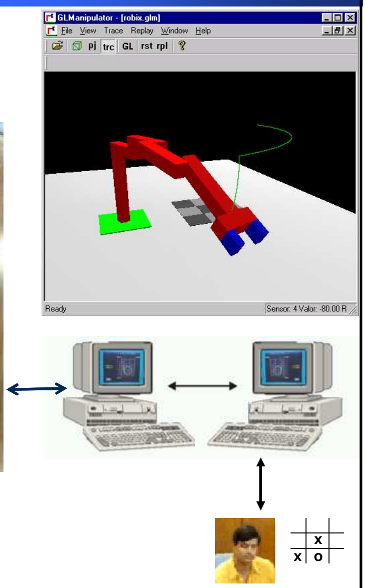


Figura 2: Ponte Rolante

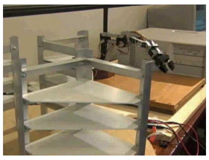
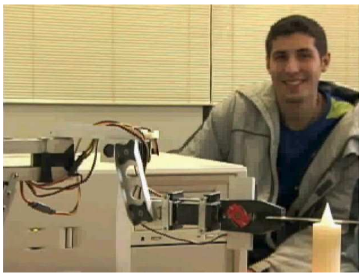
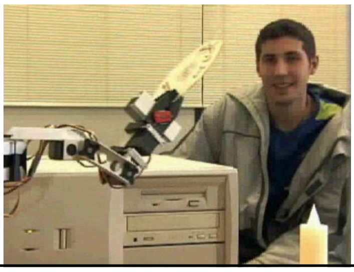
Robótica Autônoma
Tipos de Robôs

*** Robôs Manipuladores:**
Braços Robóticos de Base Fixa



Robótica Autônoma
Tipos de Robôs

* **Robôs Manipuladores:**
Braços Robóticos de Base Fixa

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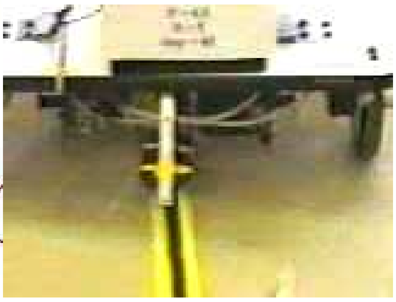
Robôs Móveis Autônomos
Prof. Fernando Osório / Maurício Dias

Robótica Autônoma
Tipos de Robôs

* **Robôs Móveis:**


B. Robôs Móveis Semi-Autônomos => AGV

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Robótica Autônoma
Tele-Operado x Autônomo

Autonomia

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Robôs Móveis: Autônomia

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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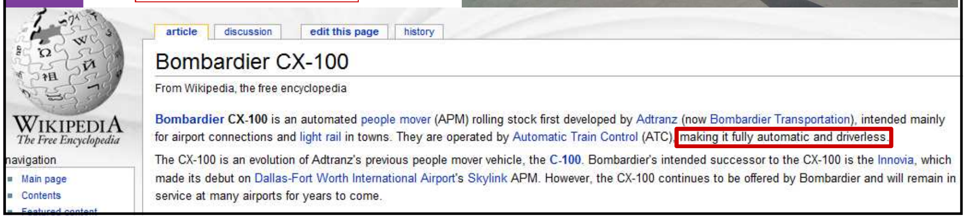
Abril 2009

Robôs Móveis: Autônomia

Robôs Móveis: Autônomos e Inteligentes

iPhone + Hamilton F1
x
Airport Shuttle


WIKIPEDIA
The Free Encyclopedia
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Main page
Contents
Featured content

article | discussion | edit this page | history

Bombardier CX-100

From Wikipedia, the free encyclopedia

Bombardier CX-100 is an automated people mover (APM) rolling stock first developed by Adtranz (now Bombardier Transportation), intended mainly for airport connections and light rail in towns. They are operated by Automatic Train Control (ATC) making it fully automatic and driverless.

The CX-100 is an evolution of Adtranz's previous people mover vehicle, the C-100. Bombardier's intended successor to the CX-100 is the Innovia, which made its debut on Dallas-Fort Worth International Airport's Skylink APM. However, the CX-100 continues to be offered by Bombardier and will remain in service at many airports for years to come.

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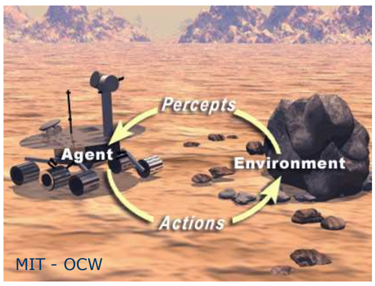
Robôs Móveis: Autônomia

Robôs Móveis: Autônomos e Inteligentes

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



SENSORES
ATUADORES
CONTROLE INTELIGENTE

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Robótica Autônoma
Aplicações

Aplicações

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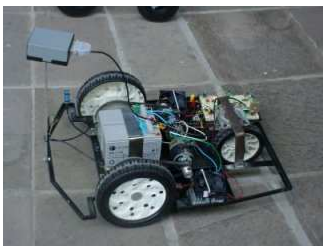
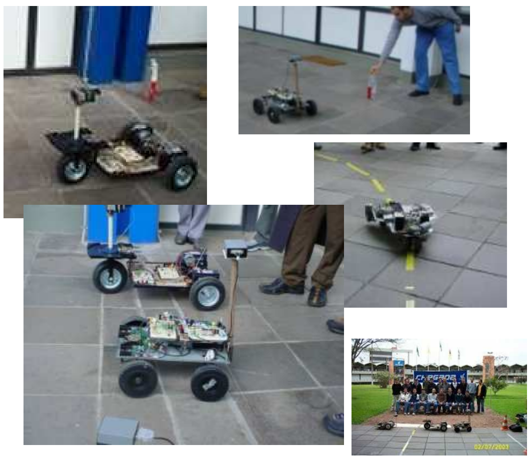
Robôs Móveis Autônomos

Exemplos de Aplicações...

O que aprendemos de
todas estas aplicações?





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Março 2010

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Exemplos de Aplicações...





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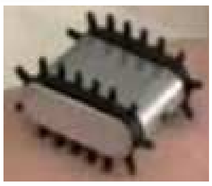
Robôs Móveis Autônomos

Exemplos de Aplicações...





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Março 2010

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Robôs Móveis Autônomos Aplicações

UAVs

UAVs – UnManed Aerial Vehicles

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

AGPlane
AGX Tecnologia

Projeto ARARA Onofre Trindade Jr.

YouTube: Seaech AGPLANE - MEMBECA 2008

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Abril 2009

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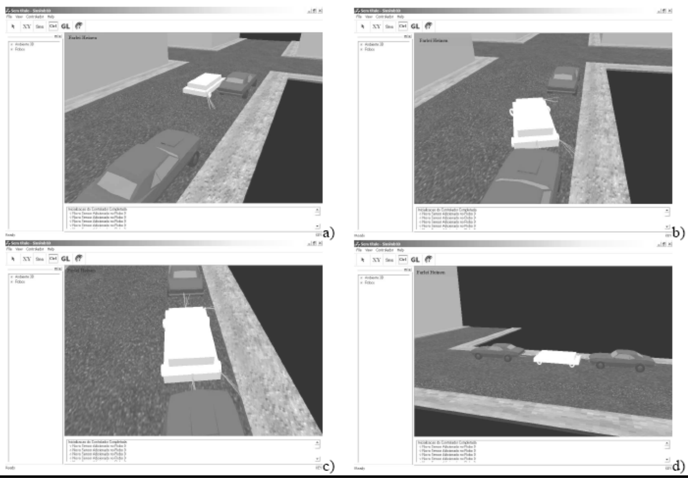
6. Robôs Móveis Autônomos

Robôs Móveis Autônomos

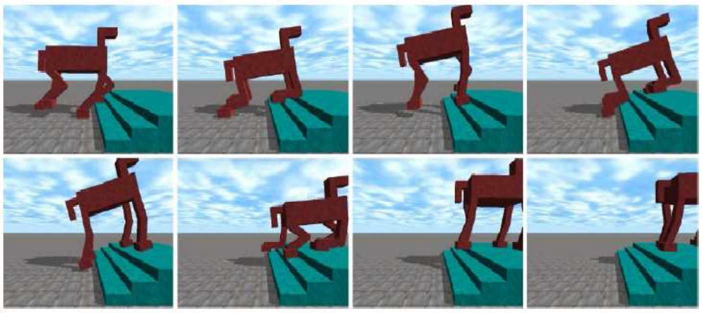
Exemplos de Aplicações...



Março 2010

Robôs Móveis Autônomos

Robôs Móveis Autônomos



Robôs Móveis Autônomos

Robôs Móveis Autônomos

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

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

Material Complementar:

- Darpa Challenge Papers:
  http://osorio.wait4.org/RMA/Darpa-Papers/
  Ver também: Wikipedia

6. Robôs Móveis Autônomos

Robôs Móveis Autônomos

Referências Complementares...

Exemplos de Aplicações desenvolvidas no LRM no ICMC

YouTube

- **Curso de Programação de Robôs**
  http://www.youtube.com/watch?v=pulqmRyBeO0
- **Robôs Móveis (Sist. de Visão)**
  http://www.youtube.com/fsosorio

SlideShare

- **Curso de Programação de Robôs à Distância (PUC-RS + ICMC)**
  http://www.slideshare.net/fosorio
  (Robôs localizados em São Carlos controlados de Porto Alegre)

6. Robôs Móveis Autônomos

Robôs Móveis Autônomos

Referências Complementares...

Exemplos de Aplicações desenvolvidas no LRM no ICMC

Fotos Picasa:

http://picasaweb.google.com/fosorio/USPICMCLRMLaboratorioDeRoboticaMovel#
http://picasaweb.google.com/fosorio/USPProjetoSENAGisa#

SemComp 2009

Veiculo com Sensores

Palestra Robot NAO

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

INFORMAÇÕES SOBRE A DISCIPLINA

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
PAE Maurício Acconcia Dias
Web institucional: Http://www.icmc.usp.br/ssc/
Página pessoal: Http://www.icmc.usp.br/~fosorio/
E-mail: fosorio[at]{ icmc.usp.br, gmail.com } # macccdias[at]gmail.com

Disciplina de Robôs Móveis Autônomos
Web Disciplinas: Http://www.icmc.usp.br/~fosorio/
Wiki ICMC: http://wiki.icmc.usp.br/index.php/SSC-714
> Programa, Material de Aulas, Critérios de Avaliação,
> Material de Apoio, Trabalhos Práticos