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# Storia della Robotica in Intelligenza Artificiale

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## Robot – il termine

- La parola *robot* fu resa popolare da Karel Capek, scrittore degli anni '20

Origine attribuita a Joseph Capek

- robota = lavoro forzato
- robotnik = servo

Il termine *Robotics* fu usato da Asimov 1950



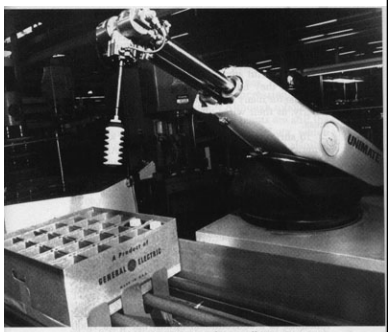
## Robot – le origini

- Nella mitologia greca Efesto costruì un uomo meccanico: Talo
- Molti automi meccanici furono costruiti a partire dal XVIII secolo
- La prima macchina programmabile è considerata il telaio di Jacquard (1805)
- Il primo robot commerciale Unimate per la costruzione di tubi catodici (1961)



## Unimate

- **In 1961 the first industrial robot, Unimate, joined the assembly line at a General Motors plant to work with heated die-casting machines.** Unimate took die castings from machines and performed welding on auto bodies; tasks that are unpleasant for people. Obeying step-by-step commands stored on a magnetic drum, the 4,000-pound arm is versatile enough to perform a variety of tasks.
- An industry was spawned and a variety of other tasks were also performed by robots, such as loading and unloading machine tools. Unimate industrial robots are among the most widely used industrial robots in the world. With over 20 years of continued improvement they are highly reliable, easy-to-use robots.
- The UNIMATE robots feature up to six fully programmable axes of motion and are designed for high-speed handling of parts weighing up to 500 lbs. The dedicated electronic control is regarded as one of the simplest controllers available in the industry today for teaching and operating industrial robots.
- Unimate was conceived in 1956 at a meeting between inventors George Devol and Joseph Engelberger, where they discussed the writings of science fiction. Together they made a serious commitment to develop a real, working robot.

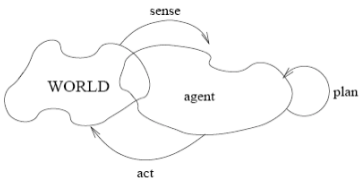


*Armed for duty. A Unimate robot—really, just an arm—picks up and puts down parts in a General Electric factory.*

## Per l'Intelligenza Artificiale



- Robot = Agente dotato di fisicità
- L'ambiente è molto complesso
- Le azioni del robot hanno effetti incerti






## Robot mobili



1950 W. Grey Walter's **light seeking tortoises**, with a light source and a light sensor. They appear to "dance" around each other.

1960-64 The **Hopkins beast**, which used sonar to guide it in the halls. Its goal was to find power outlets.

1970 **Shakey** (SRI) was driven by a remote-controlled computer, which formulated plans for moving and acting. It took about half an hour to move Shakey one meter.

1971-9 **Stanford cart**. Remote controlled by person or computer.

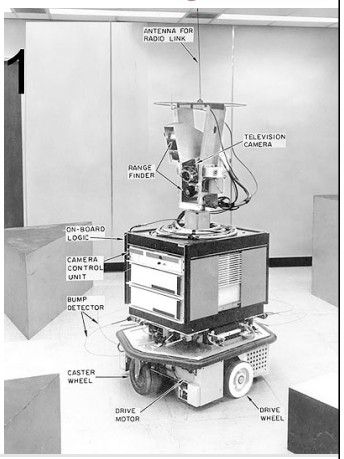
- 1971 follow the white line
- 1975 drive in a straight line by tracking skyline
- 1979 get through obstacle courses. Cross 30 meters in five hours, getting lost one time out of four



## Shakey



- **Shakey began in 1966 at the Stanford Research Institute (now SRI International).** Over years of research, this ungainly "bot" developed into a milestone application of artificial intelligence and robotics.
- Shakey... so-called because of its jerky motion... was the first mobile robot that could claim to reason about its actions. The design was practical, not elegant... a box of electronics on wheels, with bump detectors at the base and a TV camera and triangulating range finder for a head.
- As exhibited in the 1972 "Shakey" film produced by researchers Peter Hart and Nils Nilsson, Shakey was an intelligent robot. At first, it talked to large computers through a cable, and then through a wireless radio link.
- Shakey had programs for seeing, reasoning, and acting. It even had limited language capability; commands could be typed into Shakey's computer in English, and it would type back a response.
- Shakey's great accomplishment was that it could take general instructions that were not "step-by-step" and still figure out how to accomplish the objective.
- In a typical demonstration, Shakey would receive instructions from a team member asking it to move blocks around a room. Shakey would make and execute plans to achieve the goal. Shakey was even able to adjust to surprises like an object in its path.
- Shakey was a true pioneer in demonstrating the entire range of robot capabilities.






## Stanford Cart (and CMU Rover)

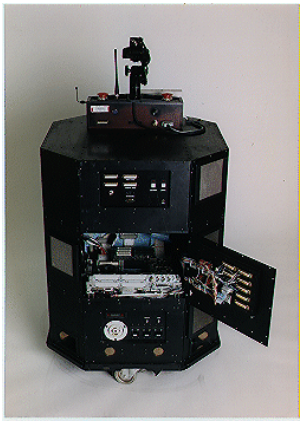


- SAIL, Moravec

## Flakey

Più di 10 anni dopo Shakey:

- Migliora l'HW (soprattutto il potere di calcolo
- Cambia l'architettura (Behaviour based)





## IA e Robotica si separano

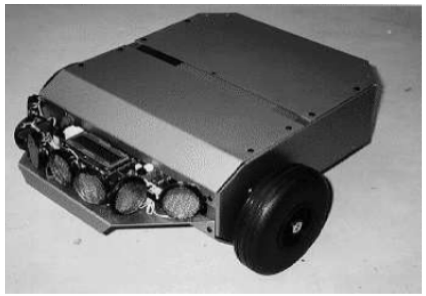
- Robotica industriale (Factory automation)
- Intelligenza Artificiale *without body*

All'inizio degli anni '90 le due discipline si riavvicinano



## Erratic

- Versione compatta di Flakey
- Economico, comandabile tramite radio modem





## Genghis

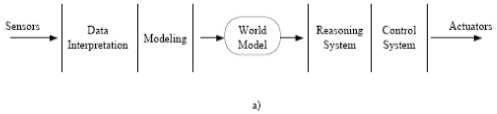
- Genghis is a 1 Kg six logged robot.
- It can walk and climb over rough terrain It has four onboard processors, twelve actuators with force feedback, six pyroelectric sensors, two whiskers, and pitch and tall inclinometers

Learning behaviours

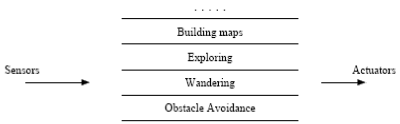
Adapting to rough terrains

## Architetture

- Orizzontali (Shakey '70)



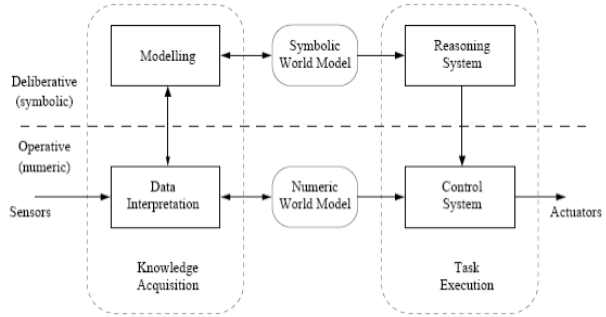

- Verticali (Subsumption/Behaviour '80)






## Architetture multi-livello

- Ibride 2 strati/ 3 strati






## CMU Hall of Fame

- 2003 Unimate, Mars Pathfinder
- 2004 Asimo, Shakey
- 2006 Aibo, Scara (ind. Arm)
- 2008 Marc Raibert's Hopper, Nav Lab 5, Lego Mindstorm

http://www.robothalloffame.org/



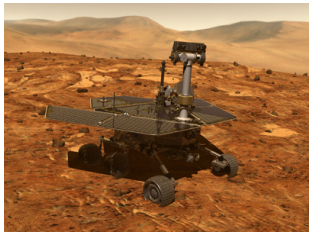
## MARS pathfinder Sojurner Rover

- **The Mars Pathfinder Sojourner Rover, a lightweight machine on wheels**, accomplished a revolutionary feat on the surface of Mars. For the first time, a thinking robot equipped with sophisticated laser eyes and automated programming reacted to unplanned events on the surface of another planet.
- After a few days on the Martian surface the NASA controllers turned on Sojourner's hazard avoidance system and asked it to start making some of its own decisions. This hazard avoidance system set the rover apart from all other machines that have explored space. Sojourner made trips between designated points without the benefit of detailed information to warn it of obstacles along the way
- Sojourner moved slowly at one and one half feet per minute and stopped a lot along the way to sense the terrain and process information, but there was no hurry on Mars which is not visited very often.
- Sojourner was carried to Mars by Pathfinder which launched on December 4, 1996 and reached Mars on July 4, 1997, directly entering the planet's atmosphere and bouncing on inflated airbags.
- Sojourner was designed by a large NASA team lead by Jacob Matijevic and Donna Shirley.
- Sojouner traveled a total of about 100 meters (328 feet) in 230 commanded maneuvers, performed more than 16 chemical analyses of rocks and soil, carried out soil mechanics and technology experiments, and explored about 250 square meters (2691 square feet) of the Martian surface. During the mission, the spacecraft relayed an unprecedented 2.3 gigabits of data, including 16,500 images from the lander's camera, 550 images from the rover camera, 16 chemical analyses of rocks and soil, and 8.5 million measurements of atmospheric pressure, temperature and wind.
- The flight team lost communication with the Sojouner September 27, after 83 days of daily commanding and data return. In all, the small 10.5 kilogram (23 lb) Sojouner operated 12 times its expected lifetime of seven days.
- http://marsrovers.jpl.nasa.gov/gallery/video/animation.html

## Mars Rovers: Spirit and Opportunity



- Landed in 2003/2004
- Still operational @ Gusev Crater http://marsrover.nasa.gov/home/index.html
- Travelled distance: 4.7 miles, 7.2 miles



Autonomy is needed: transmission delay > 20 min.



## Robot umanoidi



- **ASIMO was introduced to the world October 31st, 2000.** This engaging humanoid robot is the result of fifteen years of research and endeavor by Honda Motor Co., Ltd., a company dedicated to expanding and enhancing human mobility.
- ASIMO's very name is an acronym that highlights its revolutionary mobility... Advanced... Step... in... Innovative... MObility... A-S-I-M-O.
- ASIMO is the world's first humanoid robot to walk dynamically, as humans walk ... to walk forward AND backward, to turn while walking, and even to climb and descend stairs with grace and ease.
- In a world full of high curbs, uneven surfaces, obstacles and stairways, a robot must be able to navigate easily around these barriers so that it can assist human beings. That's the vision behind ASIMO...that similar robots will improve the quality of life for humans by assisting the physically challenged and the elderly as helpful companions.
- ASIMO has toured the country in an original stage production to introduce families and students to humanoid robots in a positive, fun, and friendly way. The highlight of the show is when ASIMO takes on the challenge of climbing and descending a set of stairs.
- And, Honda engineers continue to improve ASIMO's capabilities. ASIMO's latest intelligence technologies include voice and facial recognition, digital mapping of its environment, gesture and posture recognition and Internet connectivity. The application of these technologies will all be necessary for ASIMO to one day operate effectively in our world, allowing ASIMO to interact with humans in a helpful manner.




## Roomba




Roomba Classic, l'aspirapolvere robot, una volta premuto il pulsante di avvio pulisce il pavimento della casa senza bisogno di alcun aiuto. Grazie ad un sensore posto nel parte superiore, e' in grado di riconoscere ed evitare gli oggetti presenti nella stanza, le pareti e le scale evitando cosi' di cadere. Il suo profilo di 8,5 cm gli permette di pulire anche al di sotto dei mobili o dei letti. Il pacchetto comprende un muro virtuale, una batteria ricaricabile, il carica batteria (con presa elettrica italiana da 220 V), 2 filtri di ricambio, l'accessorio per la pulizia e il manuale d'uso in italiano.



## HREX, BIG DOG



- http://www.youtube.com/watch?v=W1czBcnX1Ww

## Competizioni

- AAAI robotic competition

1992-2006

Office delivery

Life on Mars

Hors d'Oeuvres

Urban Search and Rescue

Human Robot Interaction

Scavenger Hunt

- RoboCup



## DARPA Challenge

The **2005 DARPA Grand Challenge**, a race between autonomous robots, was held on October 8 and 9th 2005 in the Mojave Desert along a route of 212.4 km (132.2 miles). The race was a follow-up to the DARPA Grand Challenge held in 2004. DARPA promised a $2 million prize for the builders of the robot that completed the course fastest (if under ten hours). This prize was double that of the 2004 Grand Challenge, which no vehicle completed.

- The route to be followed by the robots was supplied to the teams two hours before the start as a computer file with GPS coordinates, one every 72 m (237 feet) of the route. Some teams then went against the spirit of the competition by using topographic maps and aerial imagery to manually map out and program precise path and speed settings (CMU's Red Team employed 13 route editors.) Once the race had started, the robots were not allowed to contact humans in any way.
- Each robot started at a different time and was "paused" for different amounts of time during the race; DARPA compensated for the staggered start times and subtracted the pause time from each robot's total to derive its final official time. The $2 million prize was awarded on Sunday, October 9, 2005.
- The 2005 competitors were much more successful than those of 2004; only one failed to pass the 11.84 km (7.36 mile) mark set by the best-performing 2004 entry, Sandstorm. By the end, 18 robots had been disabled and five robots finished the course. On the first day, Stanley from Stanford University, and H1ghlander and Sandstorm from Carnegie Mellon University, finished within minutes of each other, with Stanley crossing the finish line first. Kat-5 from Gray Team started much later, but finished in a comparable time. The race paused overnight with one competitor, TerraMax, left on the course at mile 83; TerraMax had the stage to itself on Sunday as it belatedly rumbled home.



## Darpa Grand Challenge

The winner of the 2005 DARPA Grand Challenge was Stanley, with a course time of 6 hours 53 minutes and 8 seconds (6:53:08) with average speed of 30.7 km/h (19.1 mph). CMU's Sandstorm followed with 7:04:50 at 29.9 km/h (18.6 mph) and H1ghlander at 7:14:00 at 29.3 km/h (18.2 mph). Gray Team's Kat-5 came through at 7:30:16 with average speed of 28.2 km/h (17.5 mph). Oshkosh Truck's Terramax finished at 12:51 and would not have been eligible for the prize because it exceeded the ten-hour limit.



## Urban Darpa Challenge

- The DARPA Urban Challenge was held on November 3, 2007, at the former George AFB in Victorville, Calif. Building on the success of the 2004 and 2005 Grand Challenges, this event required teams to build an autonomous vehicle capable of driving in traffic, performing complex maneuvers such as merging, passing, parking and negotiating intersections. This event was truly groundbreaking as the first time autonomous vehicles have interacted with both manned and unmanned vehicle traffic in an urban environment.
- Thirty manned traffic vehicles were also released onto the course to increase traffic density. This fleet of Ford Tauruses were retrofitted with safety cages, race seats, fire systems, radios and tracking systems, and were driven by professional drivers. In all, over 50 vehicles, both manned and unmanned, were navigating the city streets simultaneously during the final event.
- Final Event in Victorville, CA. DARPA transformed the roads of the former George AFB into an autonomous vehicle testing ground, laying over four miles of protective k-rail barriers in creating multiple test courses.



## RoboCup

By 2050, build a team of fully autonomous humanoid which win against human world champion under the official regulation of FIFA

RoboCup goals

- Soccer
- Rescue + Home + Work
- Junior/Education



## Soccer challenge: overview