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# Humanoid Robots

CSCE 774: Robotic Systems

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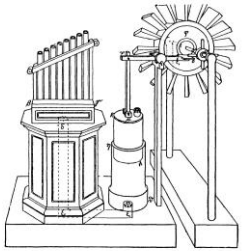
Behnke, Sven. 2008. *Humanoid Robots – From Fiction to Reality?* KI-Zeitschrift, 4/08, pp. 5-9.

# Definition

Humanoid robot: A robot with an anthropomorphic body plan and human-like senses

# History and evolution

50 AD
Hero of Alexandria
Water, air and steam pressure statues



1900s
Mechanical Dolls

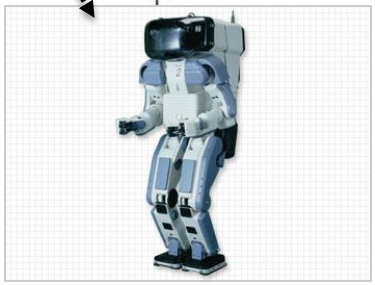
1986
Honda

Goal: a robot "should coexist and cooperate with human beings, by doing what a person cannot do and by cultivating a new dimension in mobility to ultimately benefit society."

2000
Sony Dream Robot

1495
Leonardo da Vinci's
Armored Knight

1973
Construction of a human-like robot was started at the Waseda University in Tokyo



1996
Honda P2

2002
Asimo

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# Issues

*Robots that work in close cooperation with humans in the same environment designed to suit user needs*

- Bipedal locomotion
- Dexterous manipulation
- Audio-visual perception
- Human-robot interaction
- Learning and adaptive behavior

# Bipedal locomotion


- Bipedal locomotion – moving on two legs in an upright position
- Walking and running may seem simple for humans but humanoid robots have difficulties
- Zero-moment-point (ZMP) theory

# Bipedal locomotion

Zero-moment-point (ZMP) theory

- Introduced by  Miomir Vukobratovic and his team
- One of the most used and famous terms for biped locomotion
- The point on the ground where the sum of the moments of all attractive forces equals 0
- Issues:
  - Ability to walk on difficult terrain
  - Handling pushes or other disturbances


Honda Asimo

Sony Qrio

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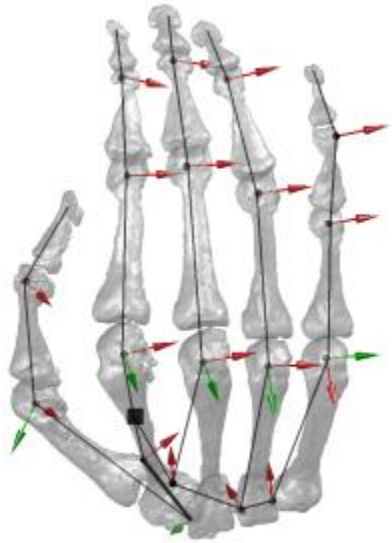
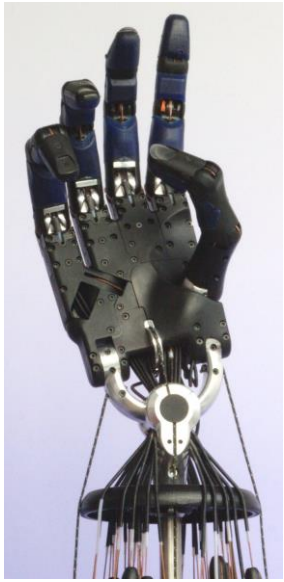
# Dexterous manipulation

Using manipulators (i.e. fingers) for grasping and manipulation



Shadow Hand

- 20 actuated degrees of freedom
- 4 under-actuated movements
- 24 joints
- Each joint has a movement similar to that of a human hand
  - including the thumb
  - flex of the palm for the little finger.
- Force sensing for each actuator
- Tactile sensing on fingertips
- Temperature and motor current and voltage sensing



Shadow Hand

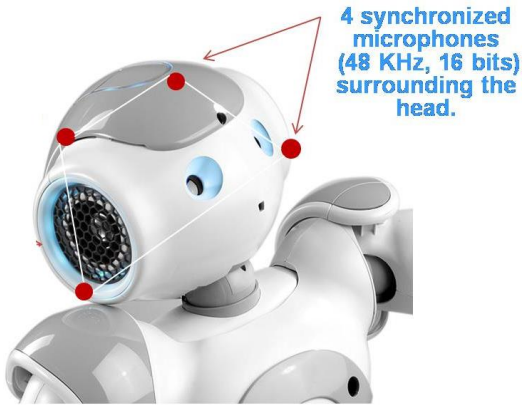
# Dexterous manipulation

- 29 degrees of freedom
- 4 fingers
- Thumb has 1 extra degree of freedom
- Each finger is made up of four joints
- Each joint has force and positioning data from sensors

DLR-HIT Hand

# Audio-visual perception

- Vision:
  - Cameras and image interpretation
  - Issue: Interpreting real-world image sequences
    - Simplified environment
    - Color code key objects to make their perception easier
- Audio:
  - Onboard microphones audio interpretation
  - Issue: Separation of the sound source of interest (e.g. a human communication partner) from other sound sources and noise



# Human-robot interaction

- Employ the same techniques used in human-human communication
  - Speech
  - Gaze
  - Facial Expressions
  - Gestures
  - Body Language
- Issue: Insufficient perception performance

# Learning and adaptive behavior

*Humanoid robots must be able to adapt existing capabilities and need to cope with changes*

- Imitation learning (programming by demonstration):
  - Teach robots without programming
  - Show the robot how to perform a task
  - Provide more demonstrations when failures occur

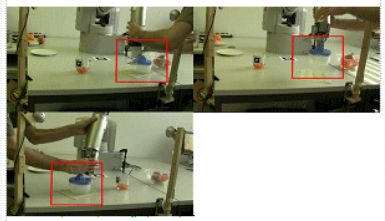


Figure 1: The teacher performs several demonstrations of the same task, changing the location of each item in between to allow the robot to generalize correctly. From observing these changes the robot can infer that the relative positions of the objects matter, but that their absolute positions do not.

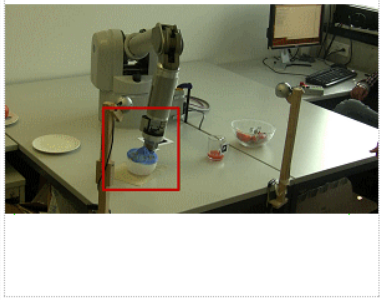
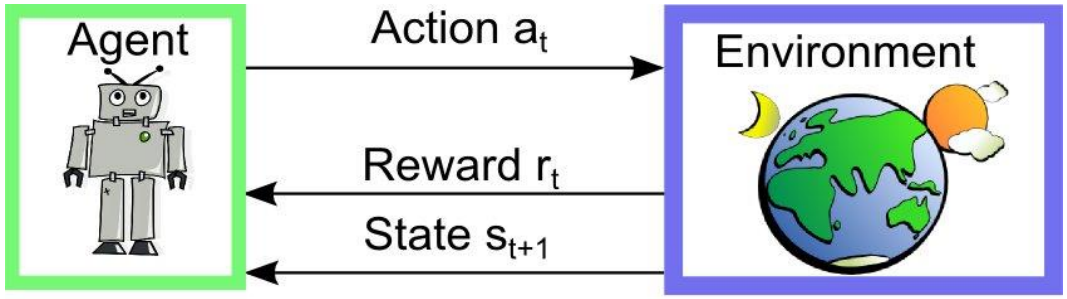


Figure 2: After learning, the robot successfully reproduces the task even when all objects are in novel positions.

- Reinforcement learning
  - Reward or punish the robot while its interacting with the environment
  - Robot tries to maximize the accumulated reward over time




Reinforcement Learning Setup

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# Application domains

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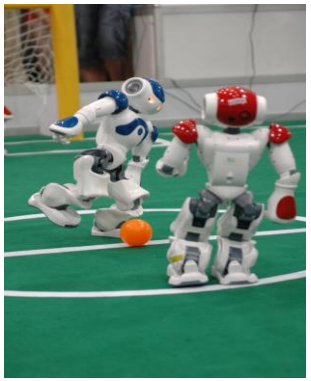
|  |  |  |  |  |
| Technology Demonstrations | Space Missions | Manufacturing | Household | Robot Competitions |

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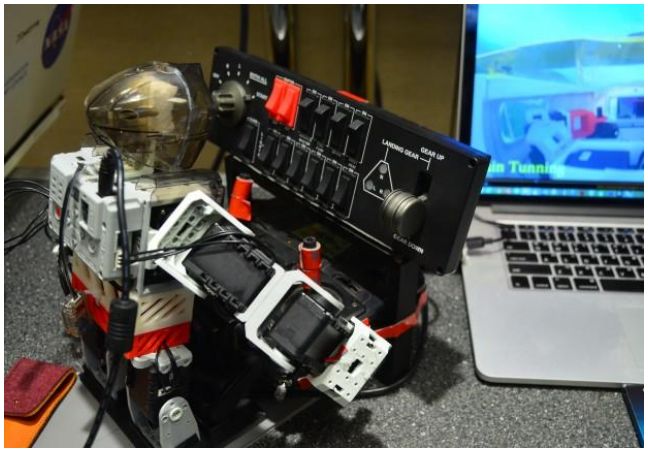
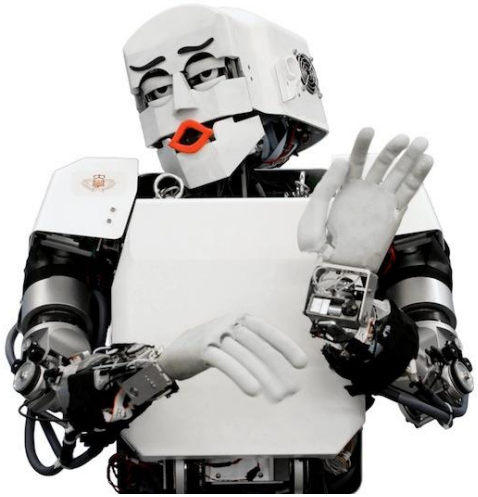
# Humanoid robot examples

Tiny Humanoid Robot Learning to Fly Real Airplanes



Humanoid Robot Nao Learns to Drive Its Own Car

Humanoid Robot KOBIAN Learning to Be a Comedian



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*http://spectrum.ieee.org/robotics/humanoids*

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