Autonomous and Mobile Robotics

Prof. Giuseppe Oriolo

Humanoid Robots 1:

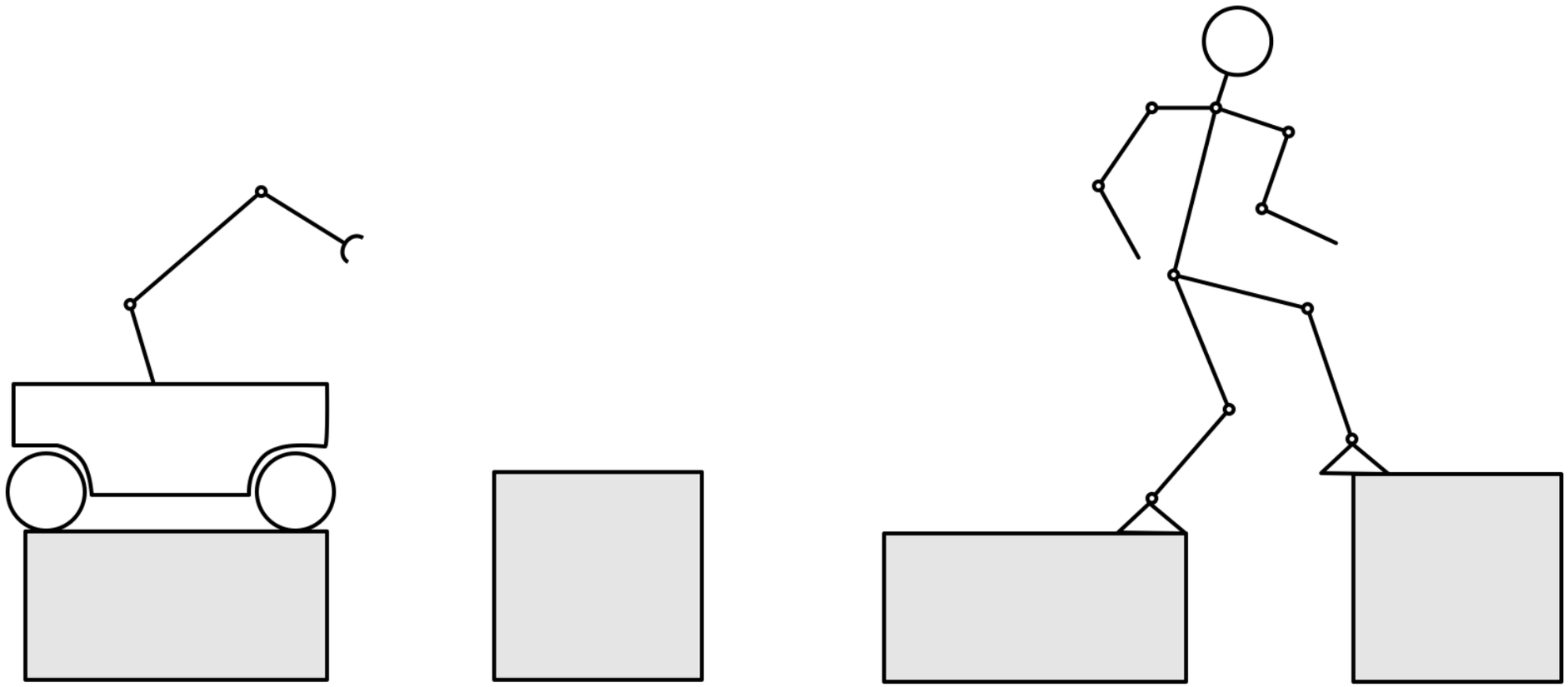
Introduction

DIPARTIMENTO DI INGEGNERIA INFORMATICA
AUTOMATICA E GESTIONALE ANTONIO RUBERTI

SAPIENZA
UNIVERSITÀ DI ROMA

why humanoids

- practical reasons:
  in many cases humanoids are the most sensible choice

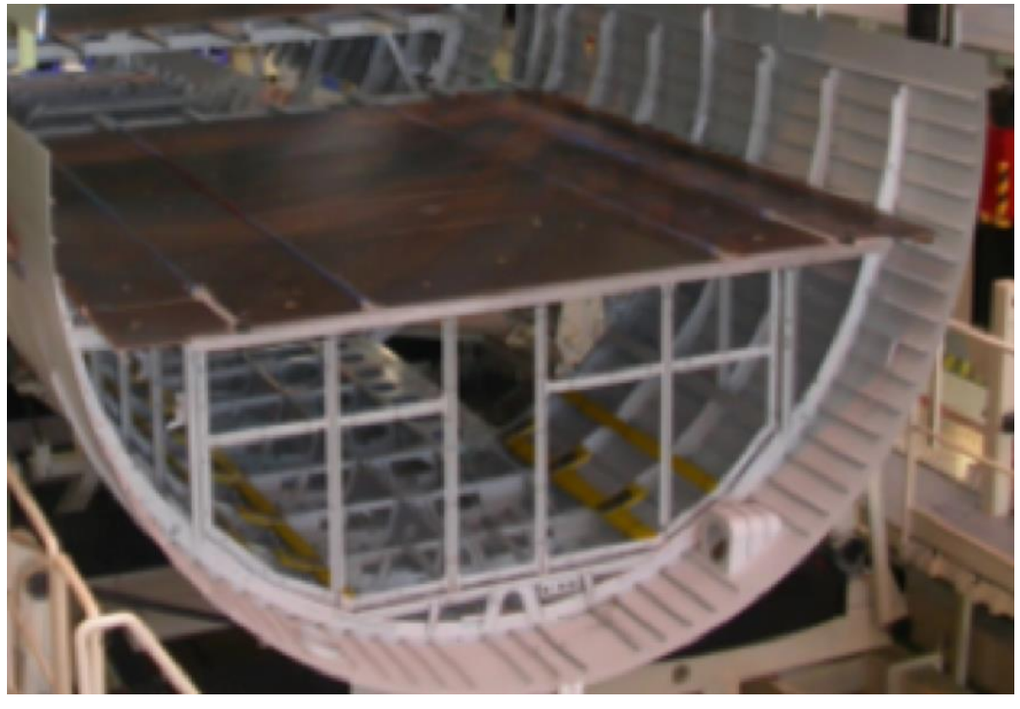


- psychological and commercial reasons:
  humanoids have a major appeal

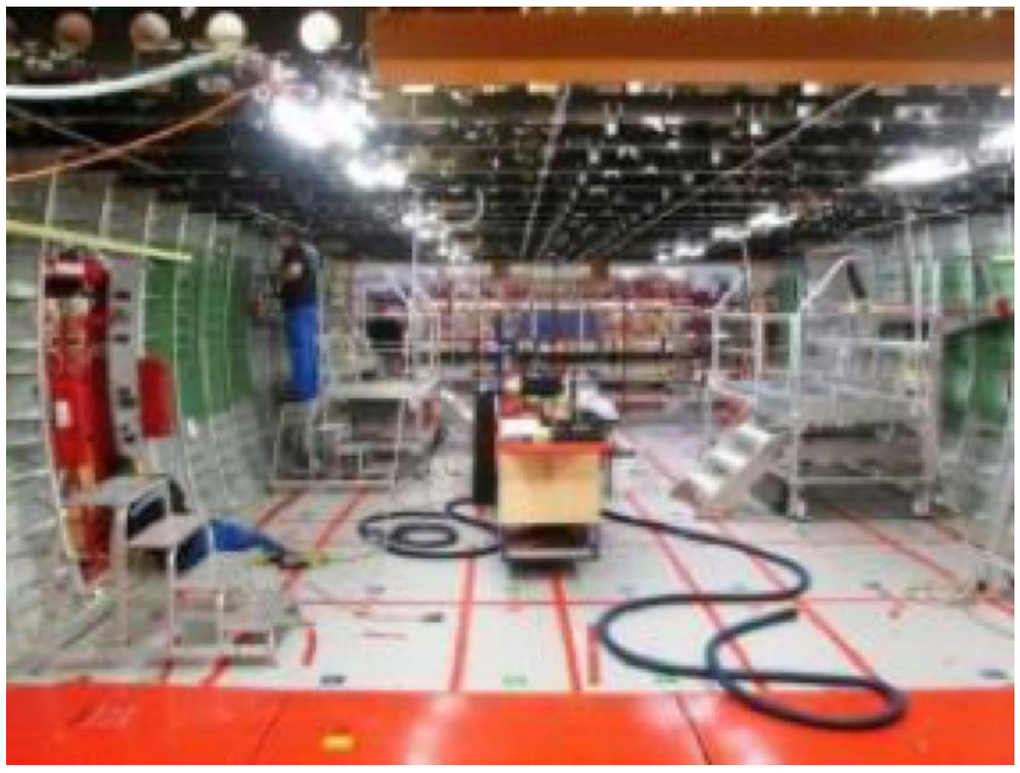
why humanoids

- multipurpose: sensing, manipulation, locomotion etc…
- adaptability: humanoids can work in environments suitable for humans and expand their capabilities by using machines designed for humans
- collaboration: humanoid motion is easy for humans to understand and predict
- human-like appearance: empathy

why humanoids



e.g., in aeronautic industry shop floors are not easily accessible for wheeled mobile robots



(H2020 project COMANOID)

some history

- pre-research period: humans always fascinated by the idea of building anthropomorphic machines

- pioneering period (1970s-1990s): initial research on biped prototypes

- new millennium: industrial companies showed that building actual humanoids was possible

- today: research focusing on humanoid robustness, efficiency and versatility

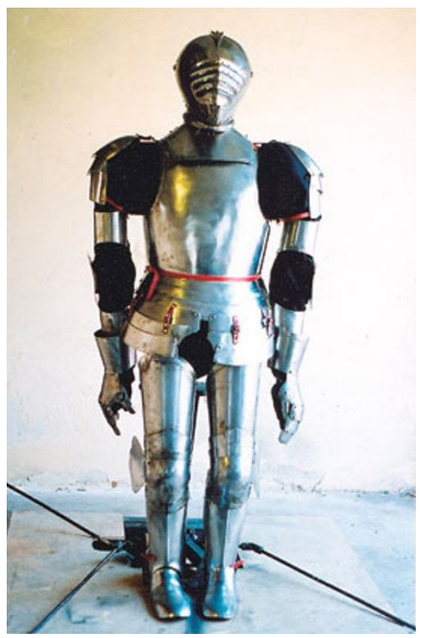
pre-research period

Hero's Automata
(1st century)

Karakuri Dolls
(17th–19th century)

1500 1700 1900

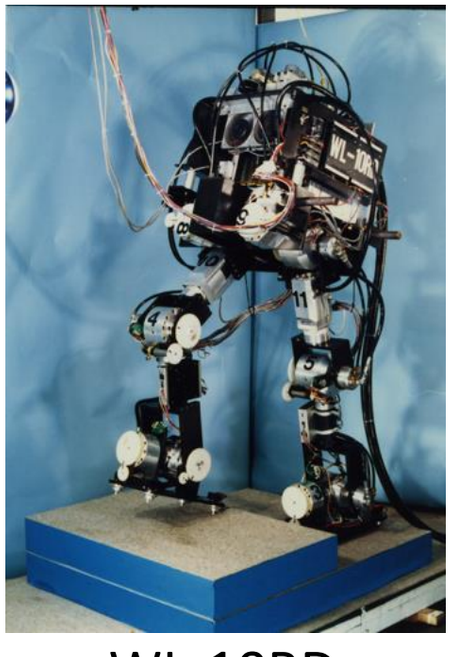
Leonardo's Robot
(1495)



Asimov's Laws of Robotics
(1942)

pioneering period

WABOT-1
(Kato, 1973)



WL-10RD
(Kato, 1984)

P2
(Honda, 1996)

1970 1980 1990 2000

ZMP concept
(Vukobratović, 1972)

First computer-controlled robot
(Raibert, 70s-80s)

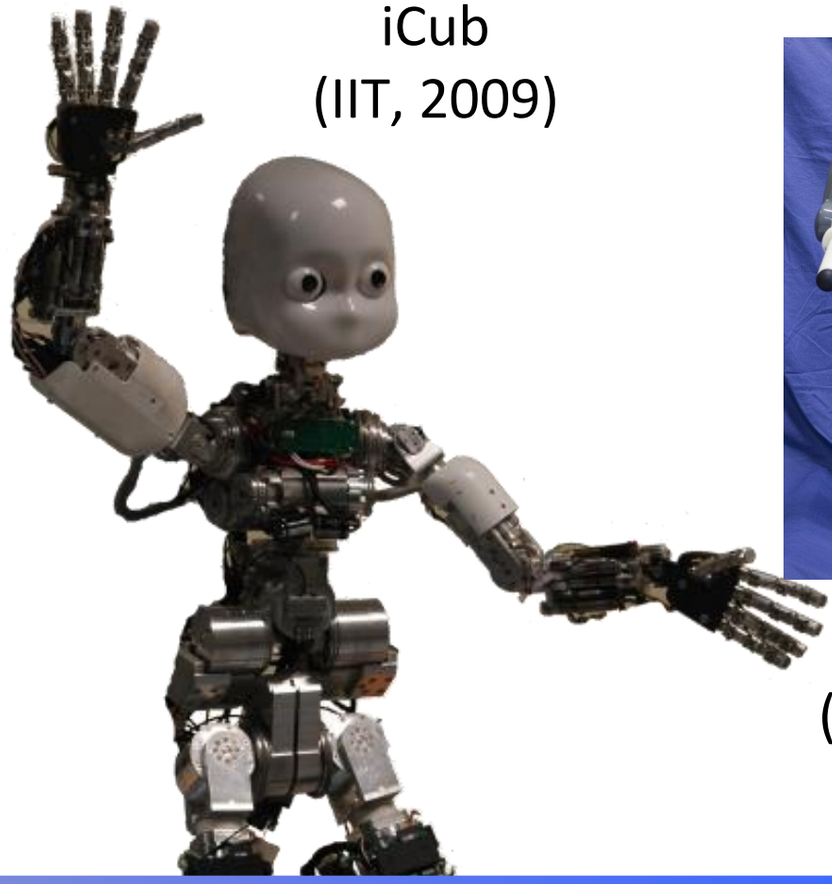
Purely passive dynamics
(McGeer, 1990)

new millennium

ASIMO
(Honda, 2000)

QRIO
(Sony, 2003)

NAO
(Aldebaran, 2005)



iCub
(IIT, 2009)

CoMan
(IIT, 2012)

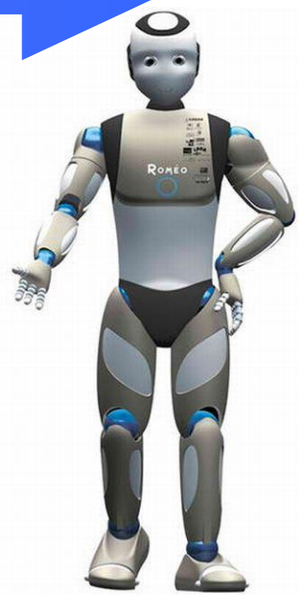
2000 2002 2004 2006 2008 2010 2012

HRP-2
(Kawada, 2002)

DARwIn-OP
(Robotis)

REEM-B
(Pal Robotics, 2008)

HRP-4
(AIST, 2013)

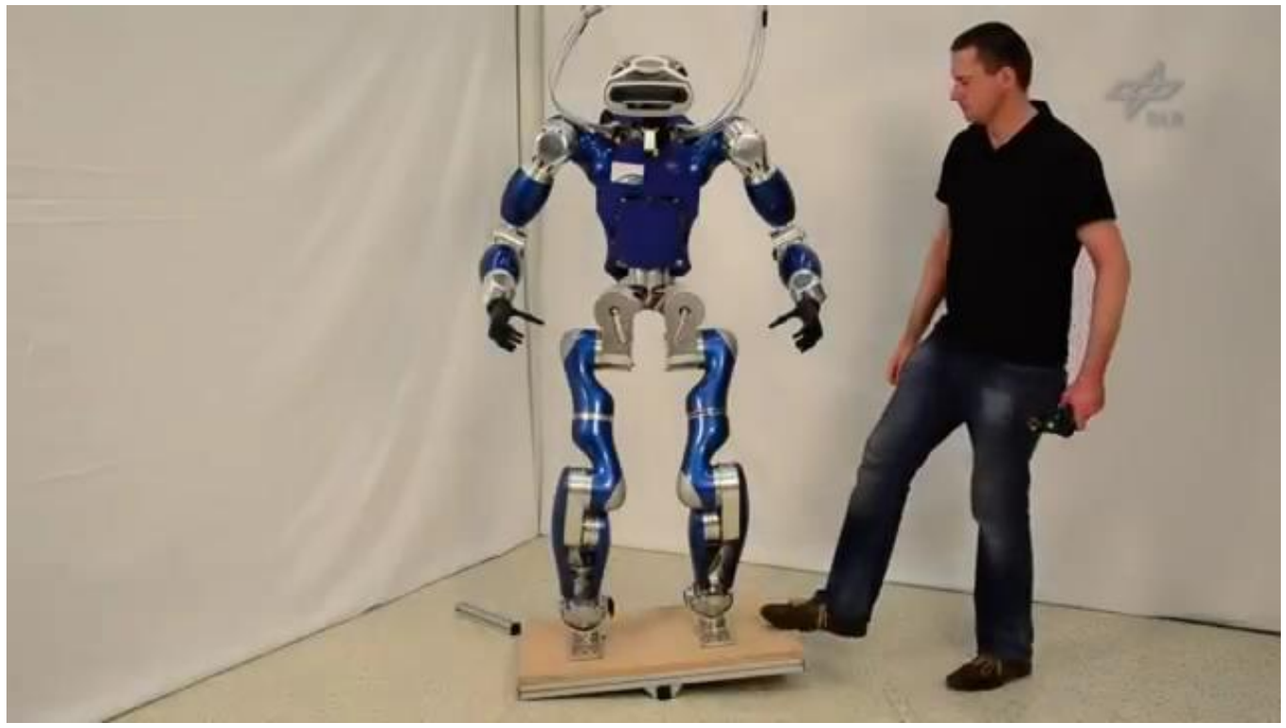


Romeo
(Aldebaran, 2013)

today

ATLAS
(Boston Dynamics)

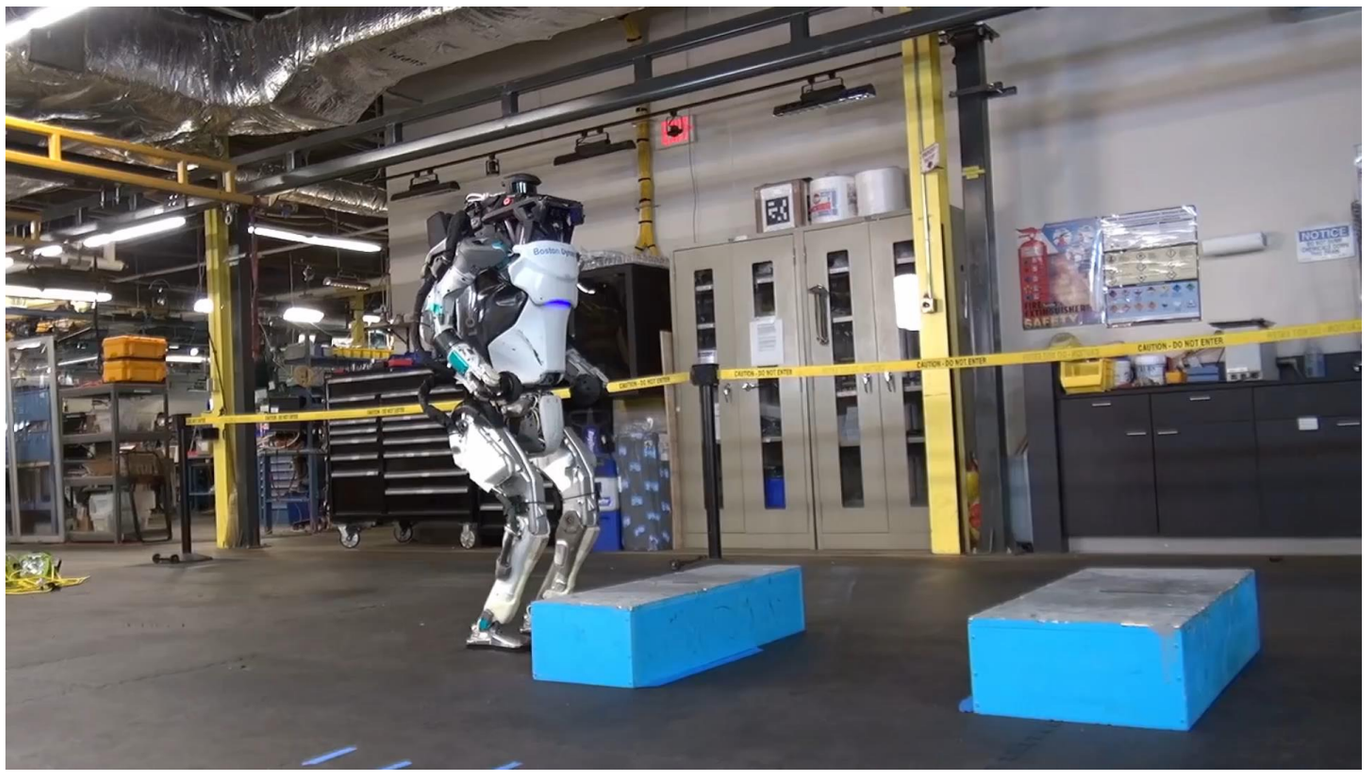
TORO
(DLR)



not only walking

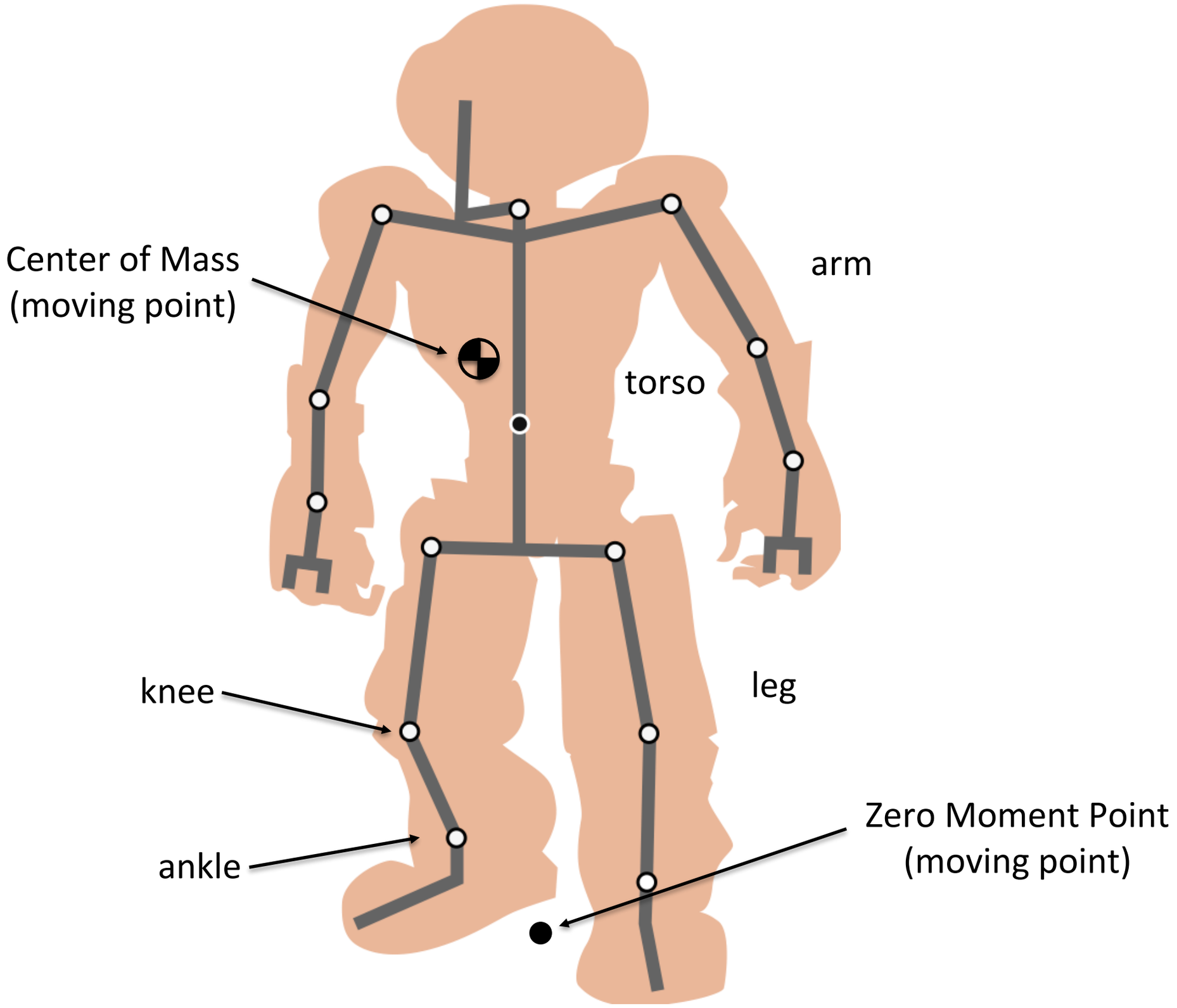
running

jumping

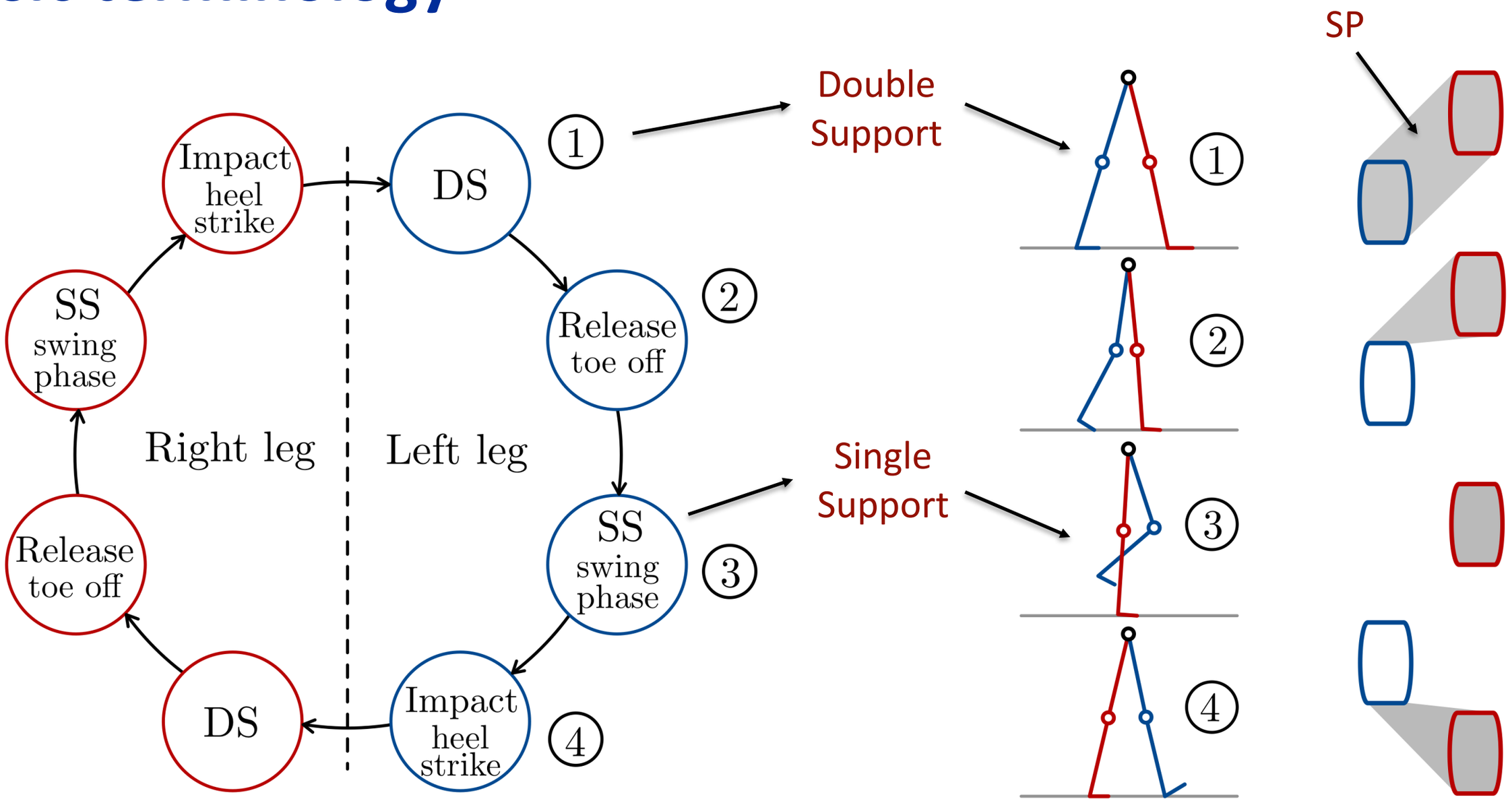


whole-body control

basic terminology



basic terminology



- walking: cyclic alternation of 4 phases
- Support Polygon (SP): convex hull of the contact points
- robots with flat feet have only Single and Double Support phases

gaits

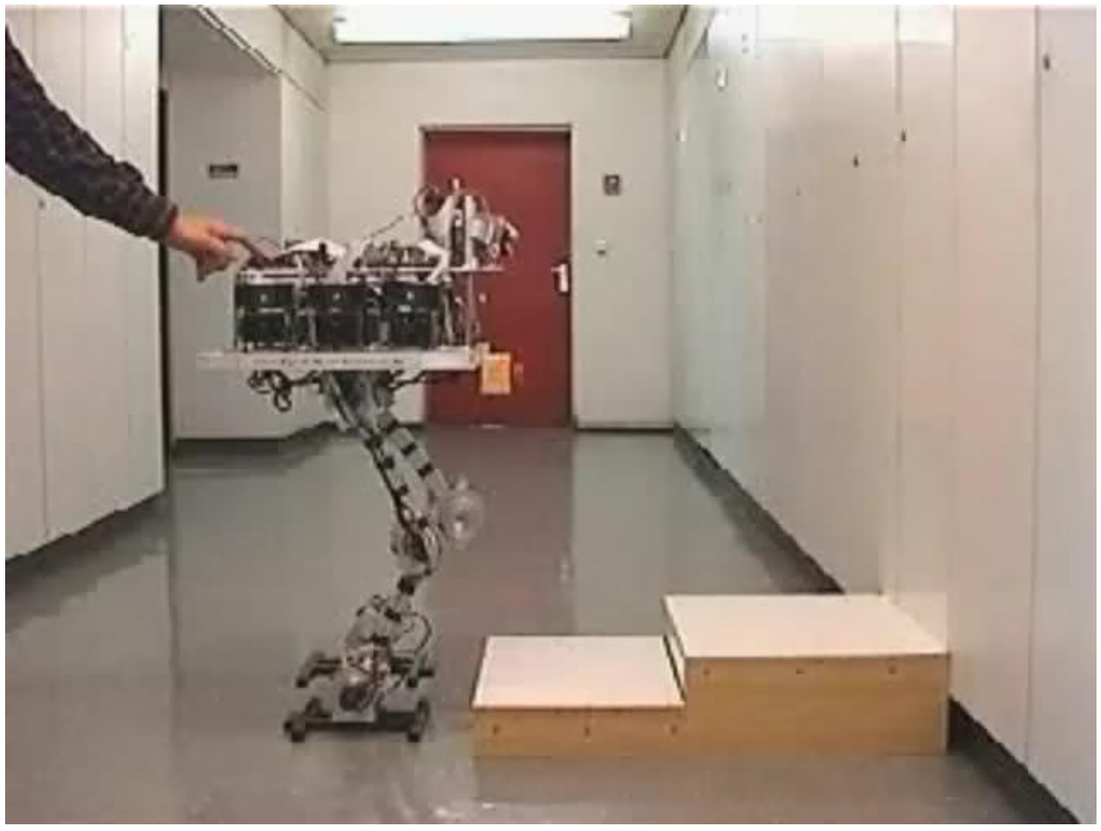
- static(ally stable) gait: the projection of the CoM on the ground is always inside the SP

- however, static gaits are very slow and conservative

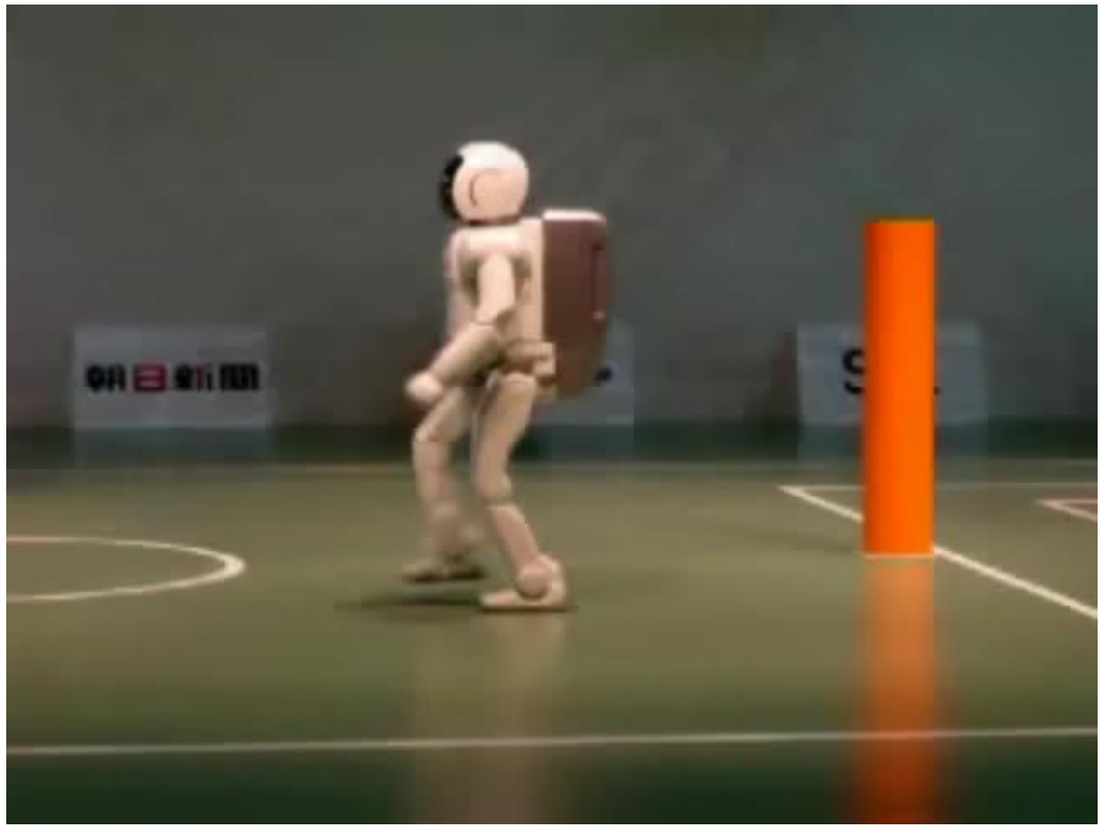
- Zero Moment Point (ZMP): point on the ground where the resultant of the reaction forces acts (more on this later)

- dynamic(ally stable) gait: the ZMP is always inside the SP

gaits

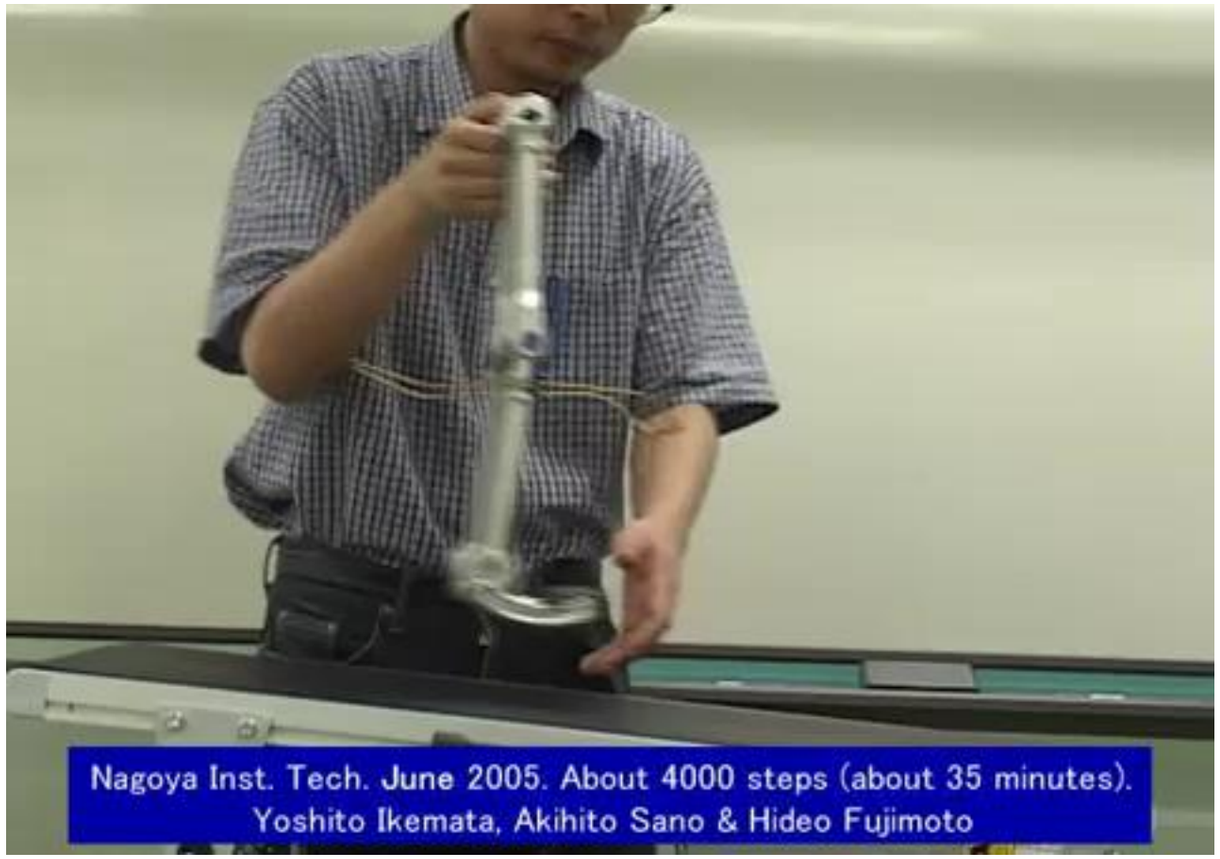


static walk



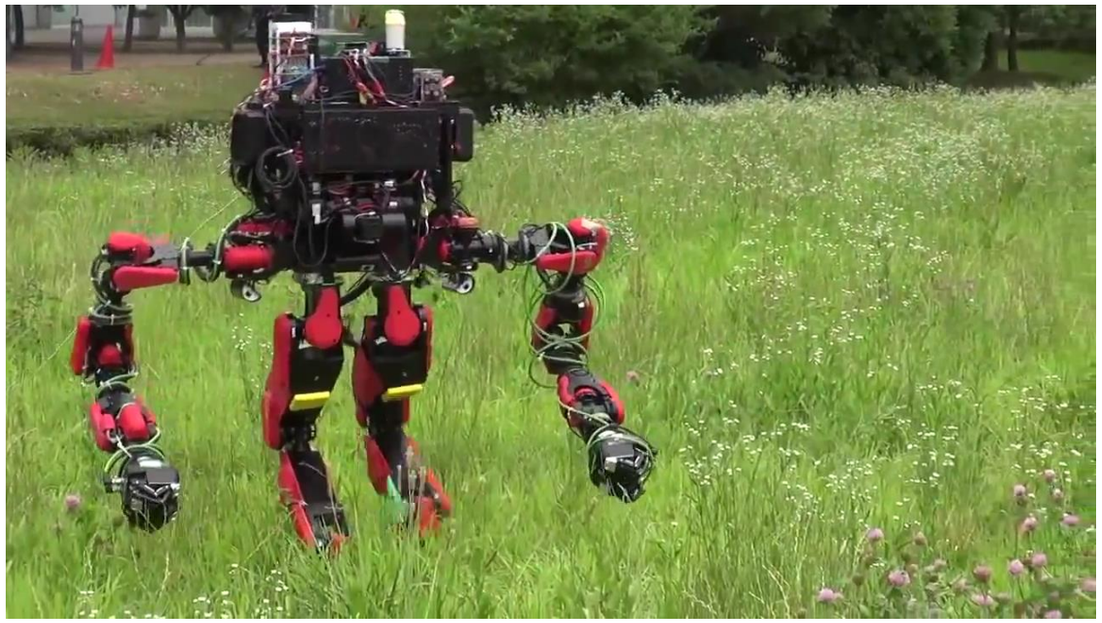
dynamic walk

passive (dynamic) walkers



- energy-efficient, natural gait (limit cycle)
- does not work on horizontal ground
- limited agility and responsiveness of motion

active (dynamic) walkers



- actuated joints (energy consumption)
- feedback control needed
- robots with flat feet or non-trivial feet