Autonomous and Mobile Robotics
Prof. Giuseppe Oriolo
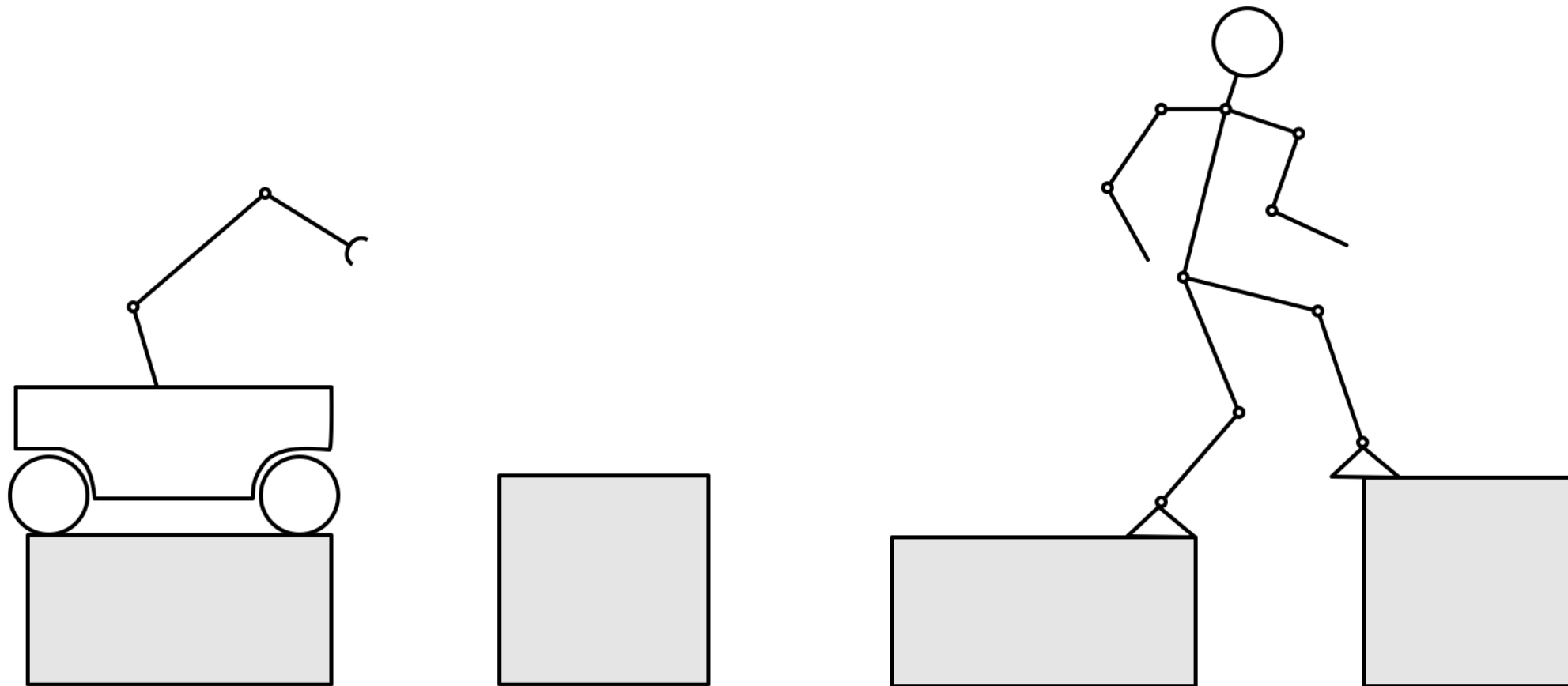
Humanoid Robots 1:
Introduction

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

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
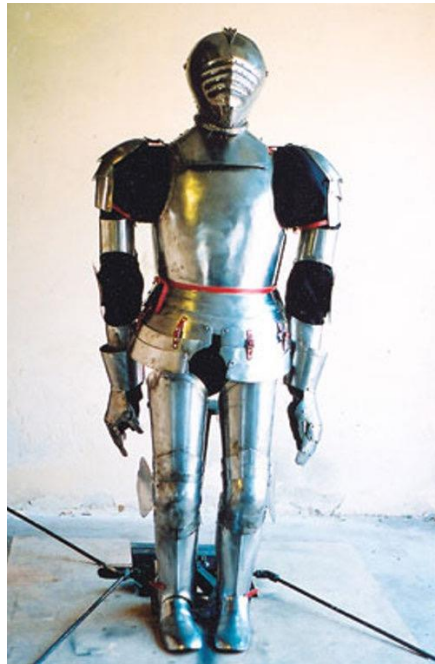
pre-research period

Hero's Automata
(1st century)

Karakuri Dolls
(17th–19th century)
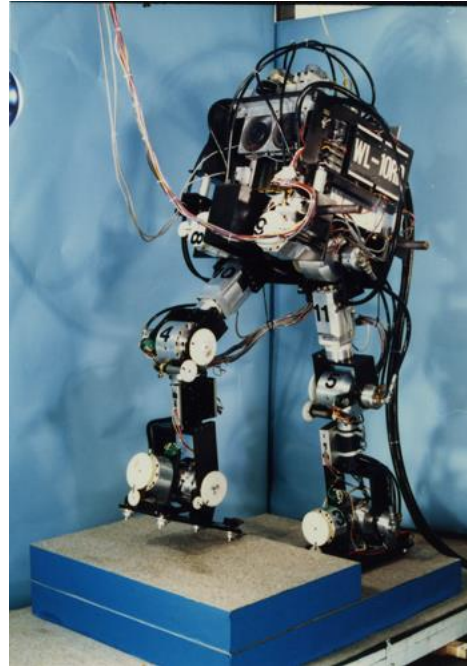
1500   1700   1900

Leonardo's Robot
(1495)

Asimov's Laws of Robotics
(1942)

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pioneering period

WABOT-1
(Kato, 1973)

WL-10RD
(Kato, 1984)

P2
(Honda, 1996)

1970   1980   1990   2000

ZMP concept
(Vukobratović, 1972)

Purely passive dynamics
(McGeer, 1990)

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

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new millennium

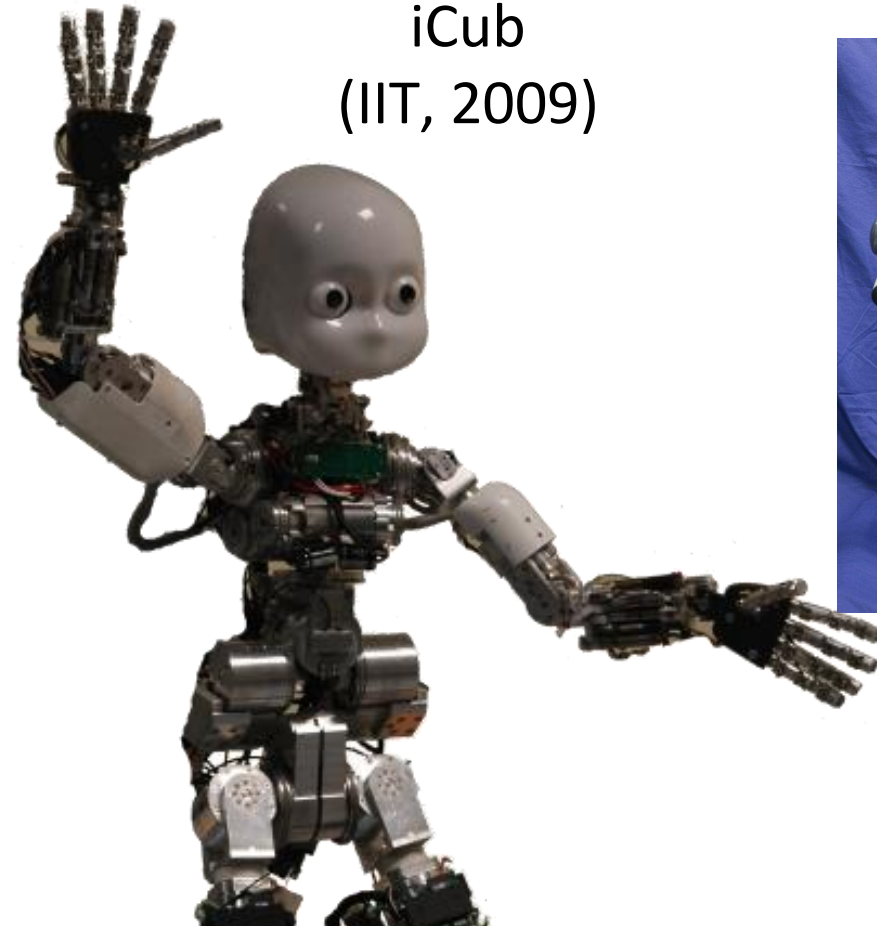iCub
(IIT, 2009)

QRIO
(Sony, 2003)

NAO
(Aldebaran, 2005)

CoMan
(IIT, 2012)

ASIMO
(Honda, 2000)

2000 2002 2004 2006 2008 2010 2012
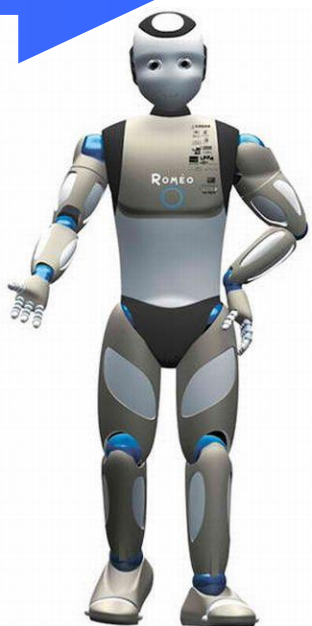
HRP-2
(Kawada, 2002)

DARwIn-OP
(Robotis)

REEM-B
(Pal Robotics, 2008)

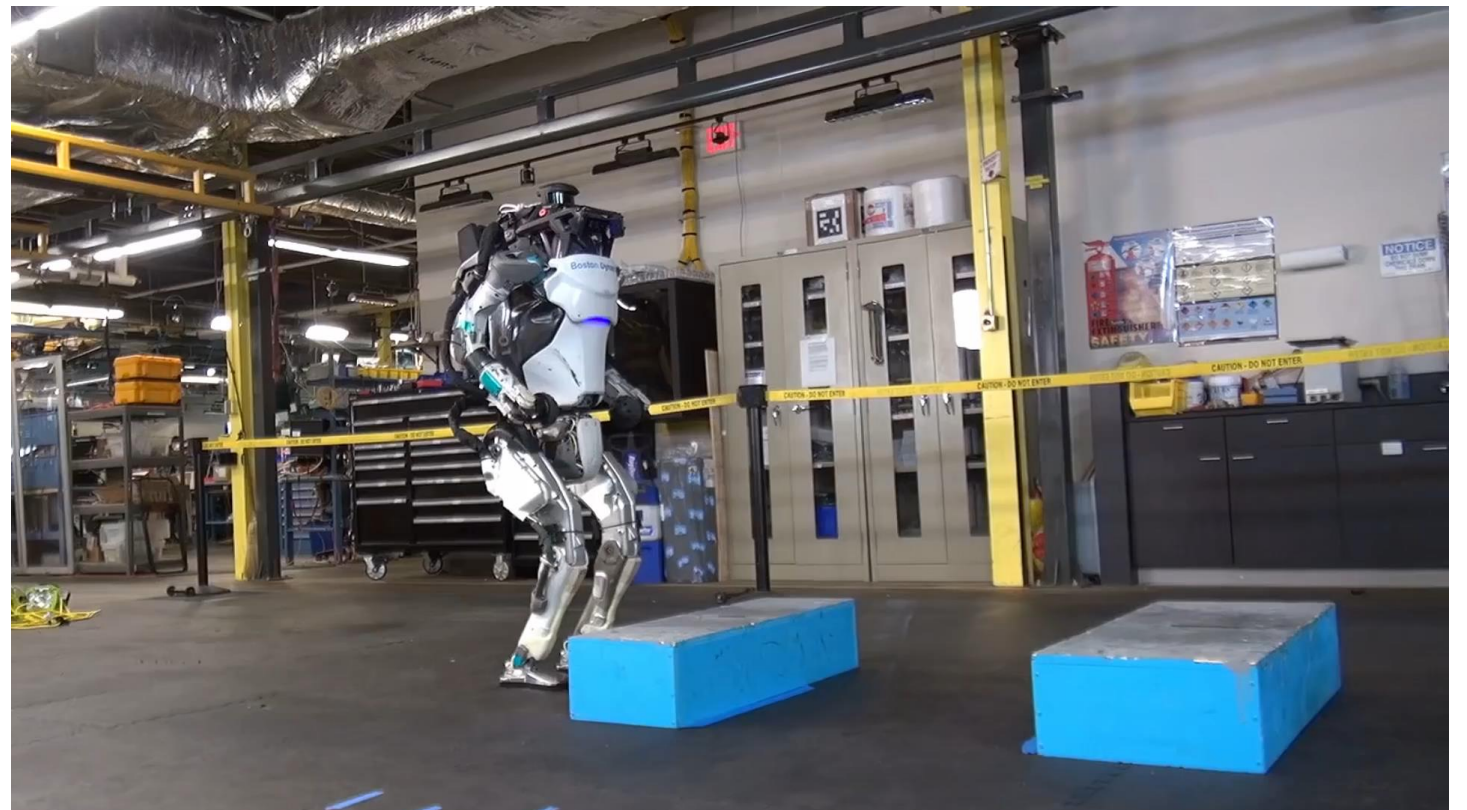HRP-4
(AIST, 2013)

Romeo
(Aldebaran, 2013)

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8

today

ATLAS
(Boston Dynamics)

TORO
(DLR)

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not only walking

running

jumping

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whole-body control

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basic terminology

Center of Mass
(moving point)

arm

torso

knee

leg

ankle

Zero Moment Point
(moving point)

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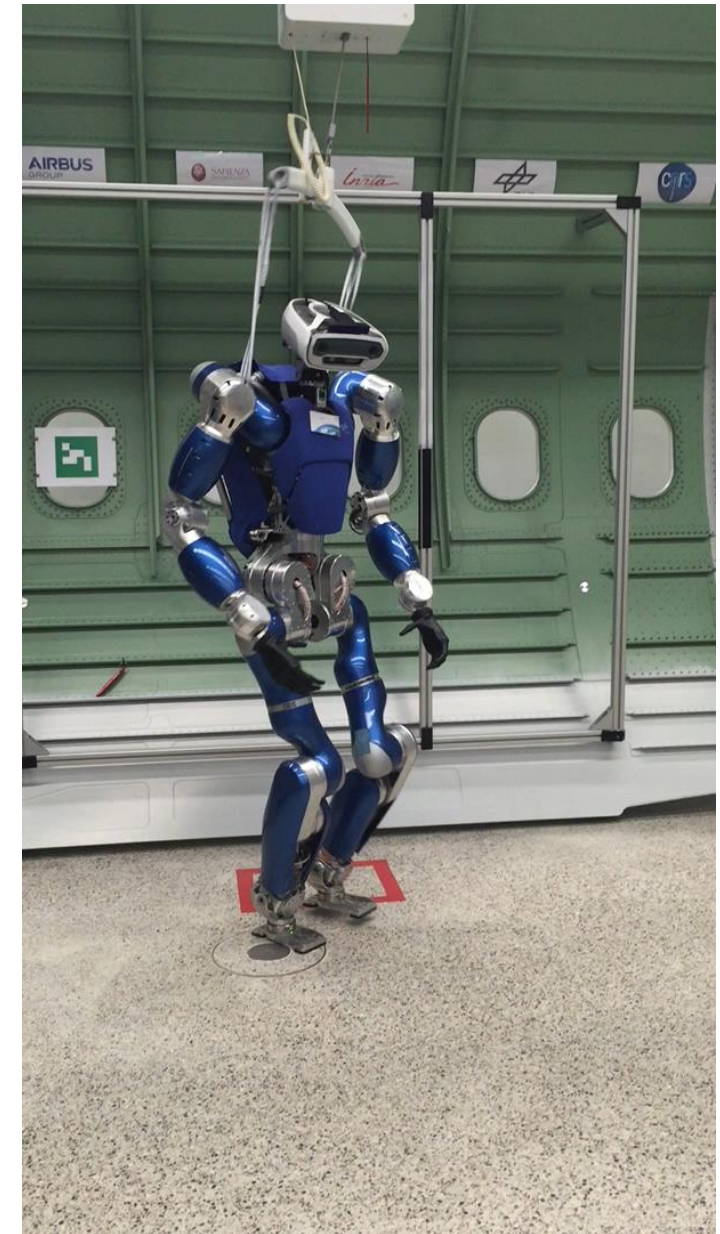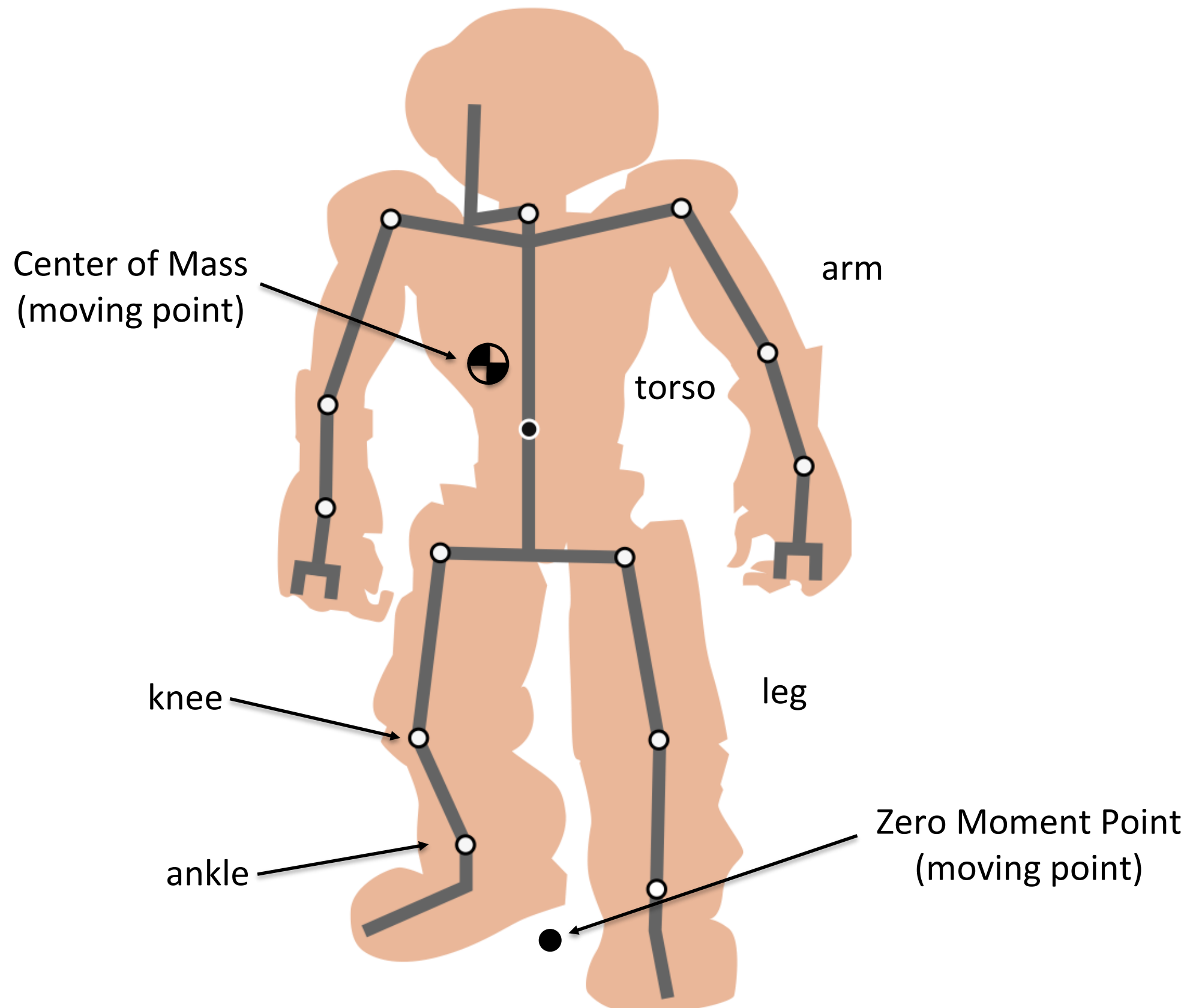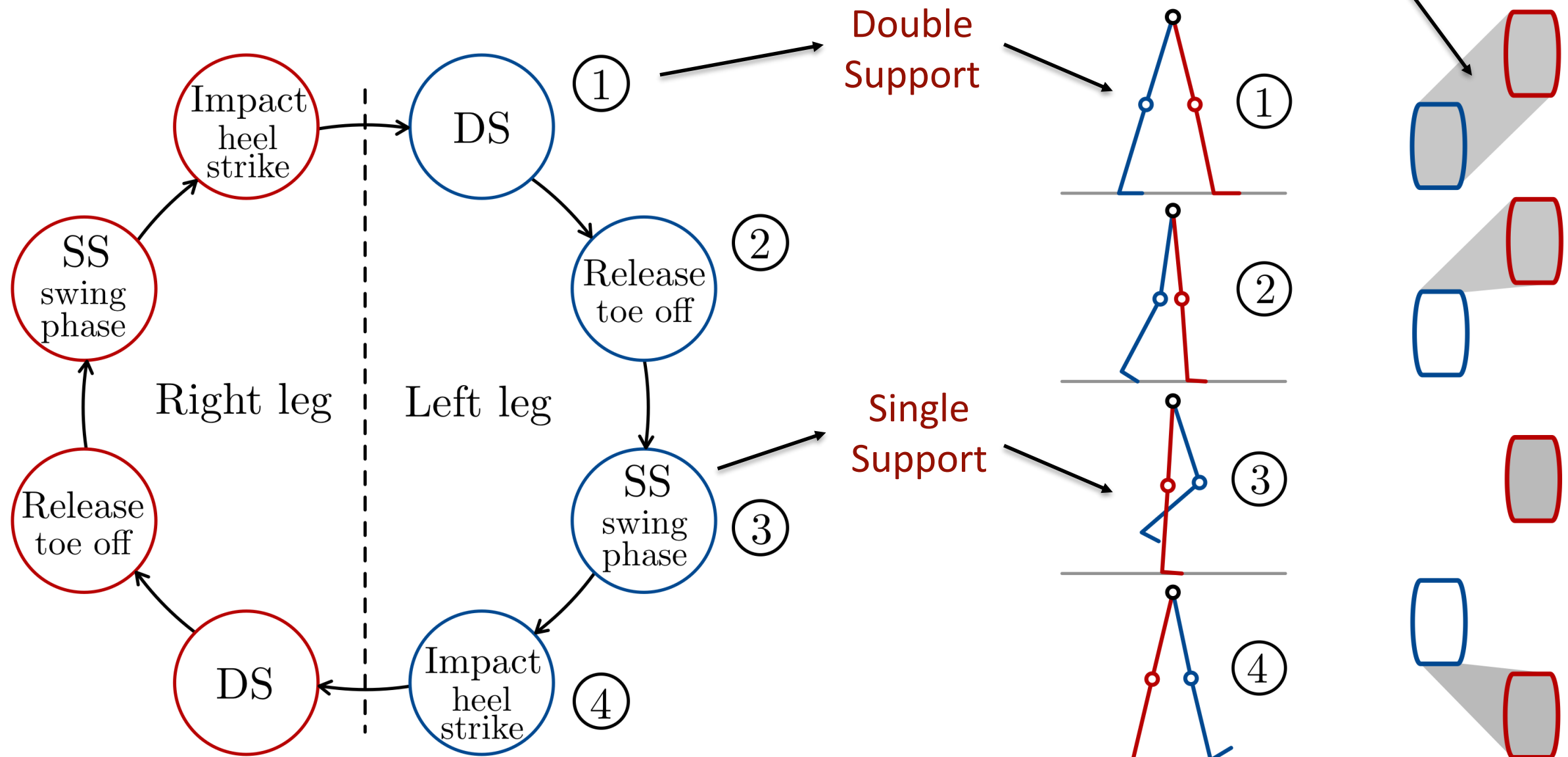
human walking: analysis

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

Nagoya Inst. Tech. June 2005. About 4000 steps (about 35 minutes). Yoshito Ikemata, Akihito Sano & Hideo Fujimoto

- energy-efficient, natural gait (limit cycle)

- does not work on horizontal ground

- limited agility and responsiveness of motion

active (dynamic) walkers
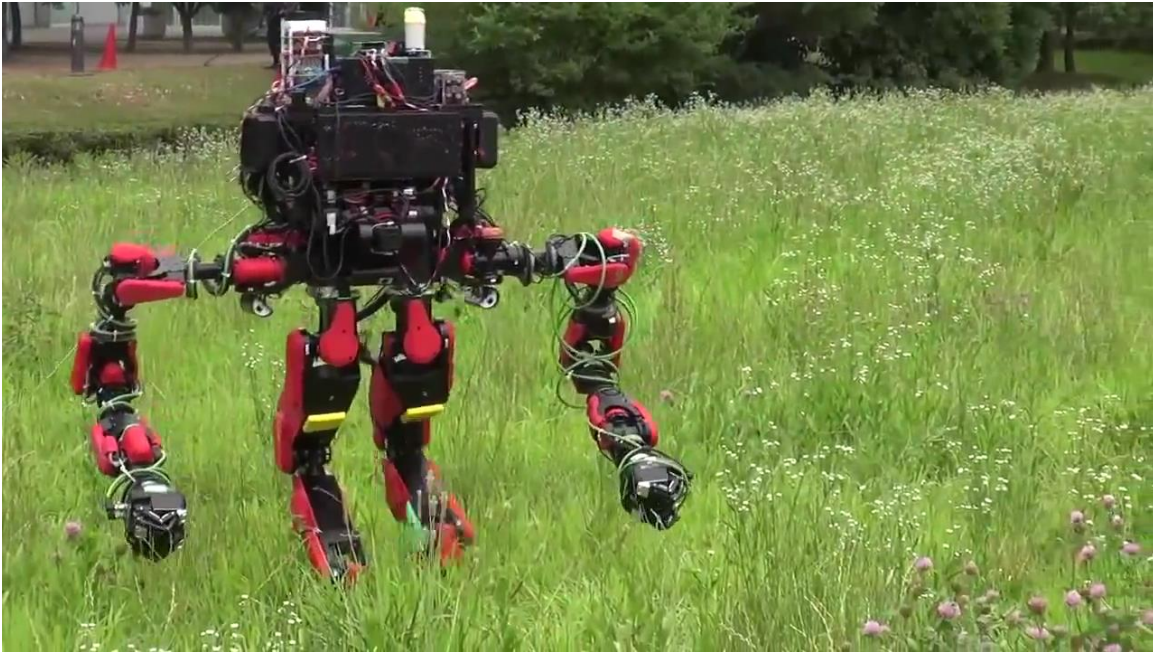
- actuated joints (energy consumption)

- feedback control needed

- robots with flat feet or non-trivial feet

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