Why Humanoid Robots?*

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Outline

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- Bipedalism and Cognition
- Bipedal Locomotion
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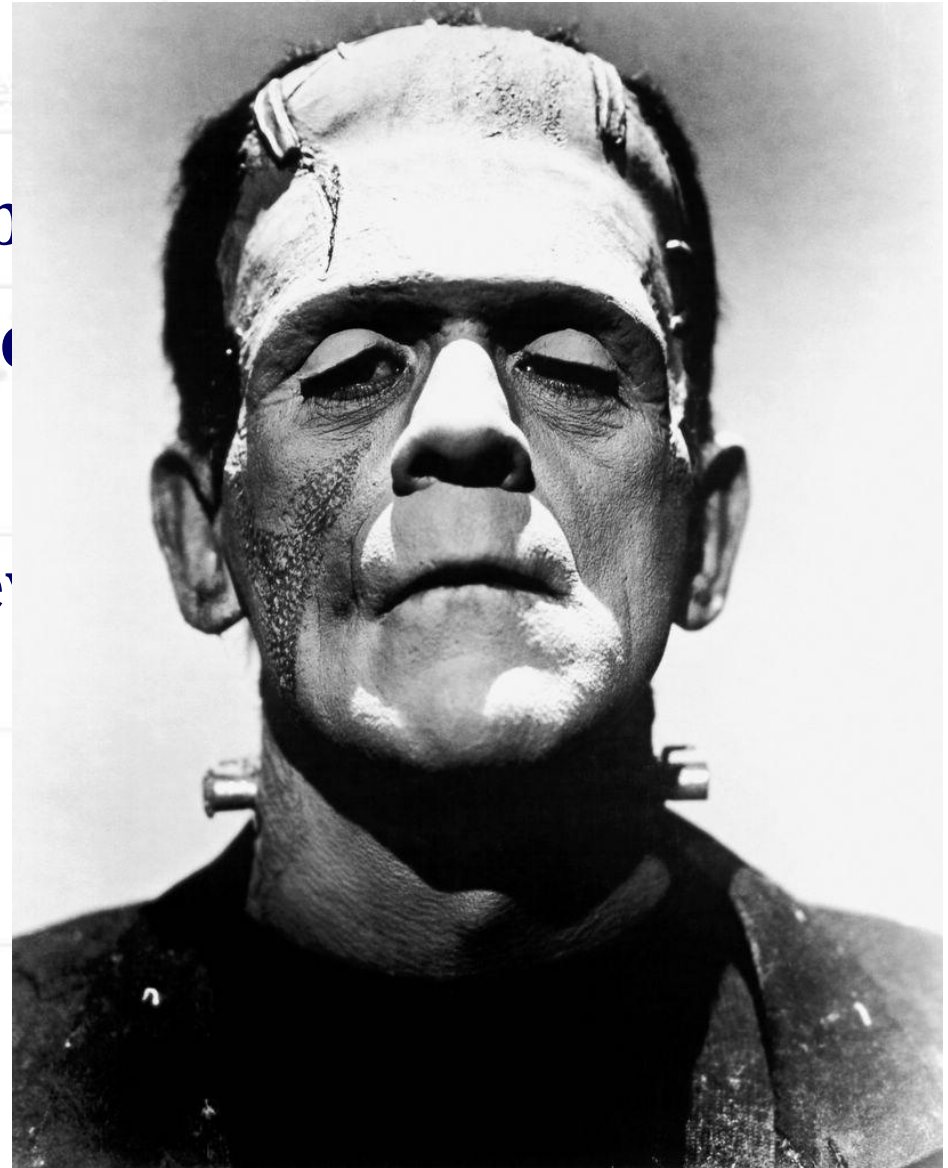- Humanoid Robot Applications
- Social Aspects

Motivation

... of the ...

Motivation (cont'd)

What is a Humanoid Anyway?

Humanoid refers to any being whose body structure resembles that of a human: head, torso, legs, arms, hands.

But it is also a robot made to resemble a human both in **appearance** and **behavior**.

The difference between a **robot** and **android** is only skin-deep, looks exactly like humans on the outside, but with internal mechanics of humanoid robot.

Why Develop Humanoids?

More rational reasons

They can work in human environment without a need to adapt themselves or adjust the environment

Our environment and our tools are adapted for us

Why adapt all to robots?!

It is easier for a human being to interact with a human-like being

Because it is a dream of generations

Challenges in Humanoids

- Bipedal human-like locomotion
  - Stable gait
    - Changing model during one/two feet support walking
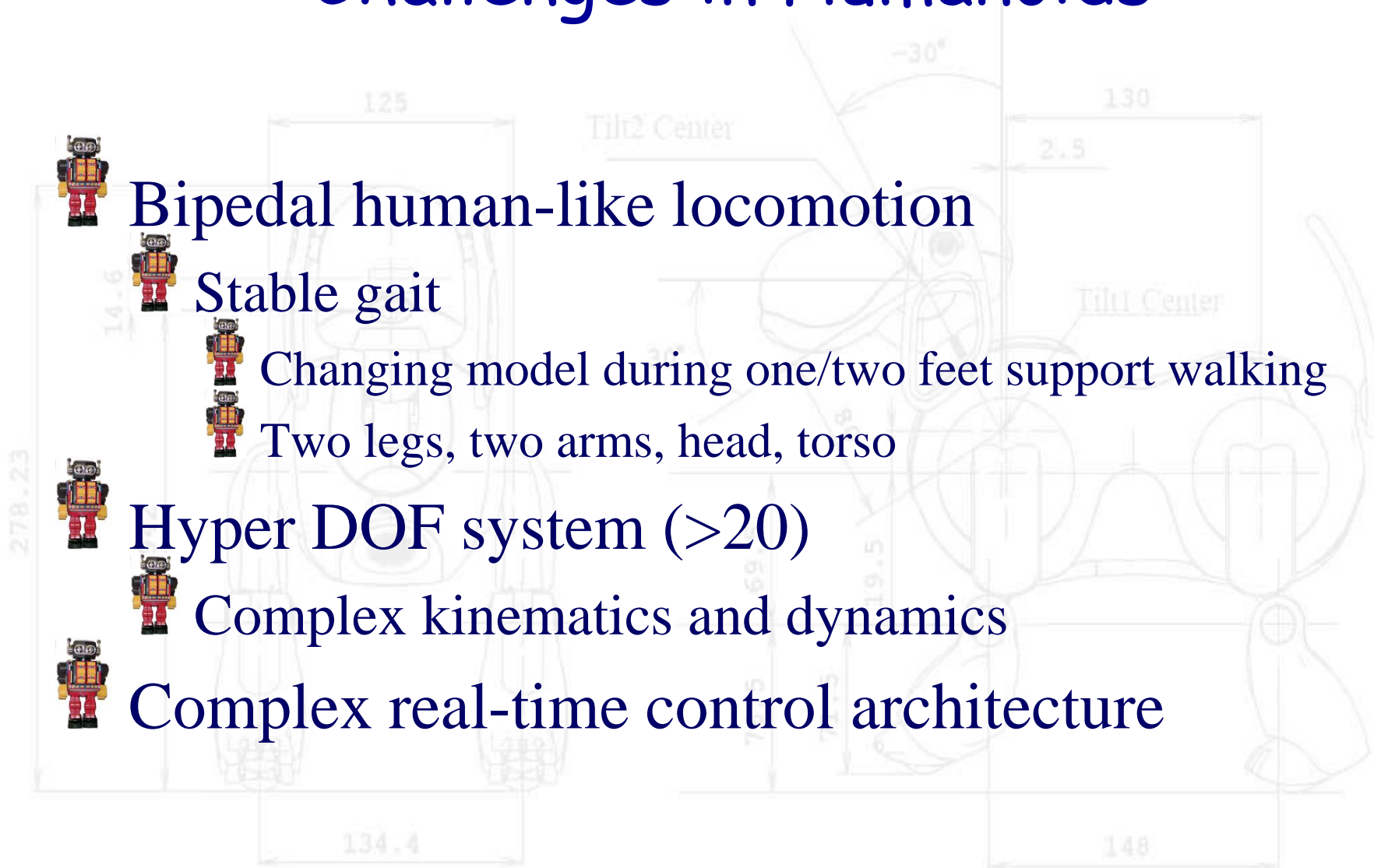   - Two legs, two arms, head, torso
- Hyper DOF system (>20)
  - Complex kinematics and dynamics
- Complex real-time control architecture

Bipedism and Cognition

Bipedism and cognition has a very close relationship

Is it possible to have cognition without locomotion?

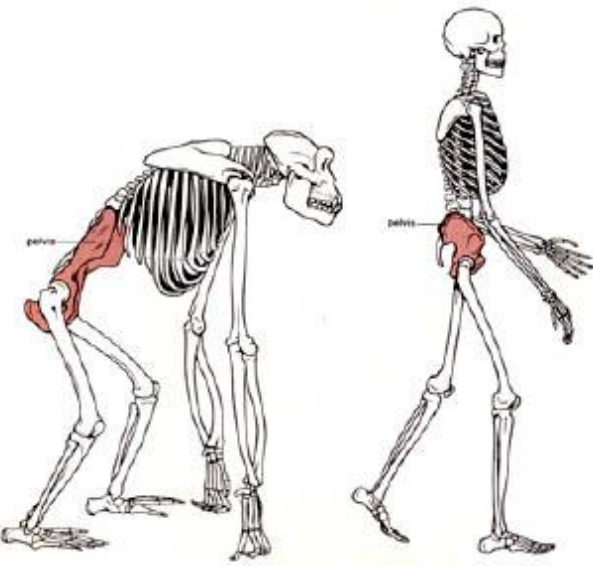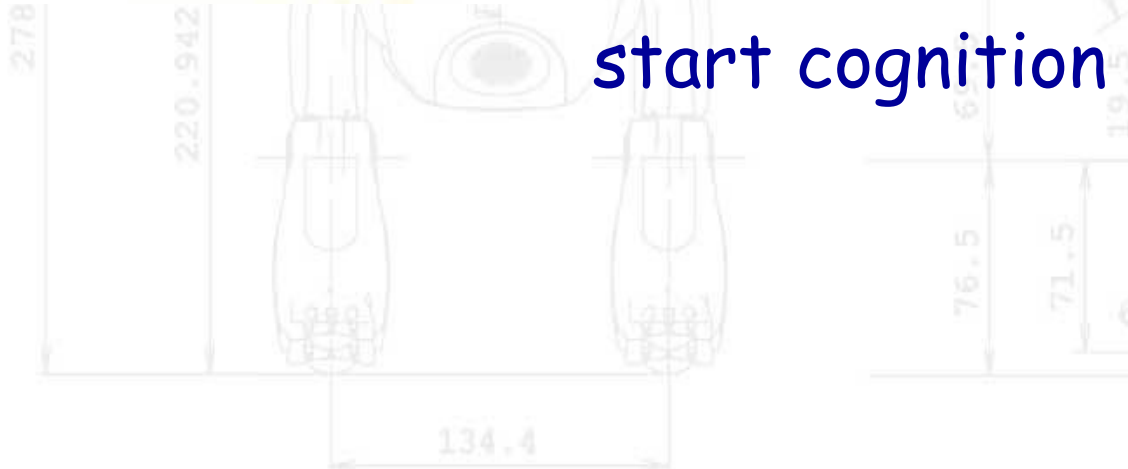Is it possible to have bipedism without cognition?
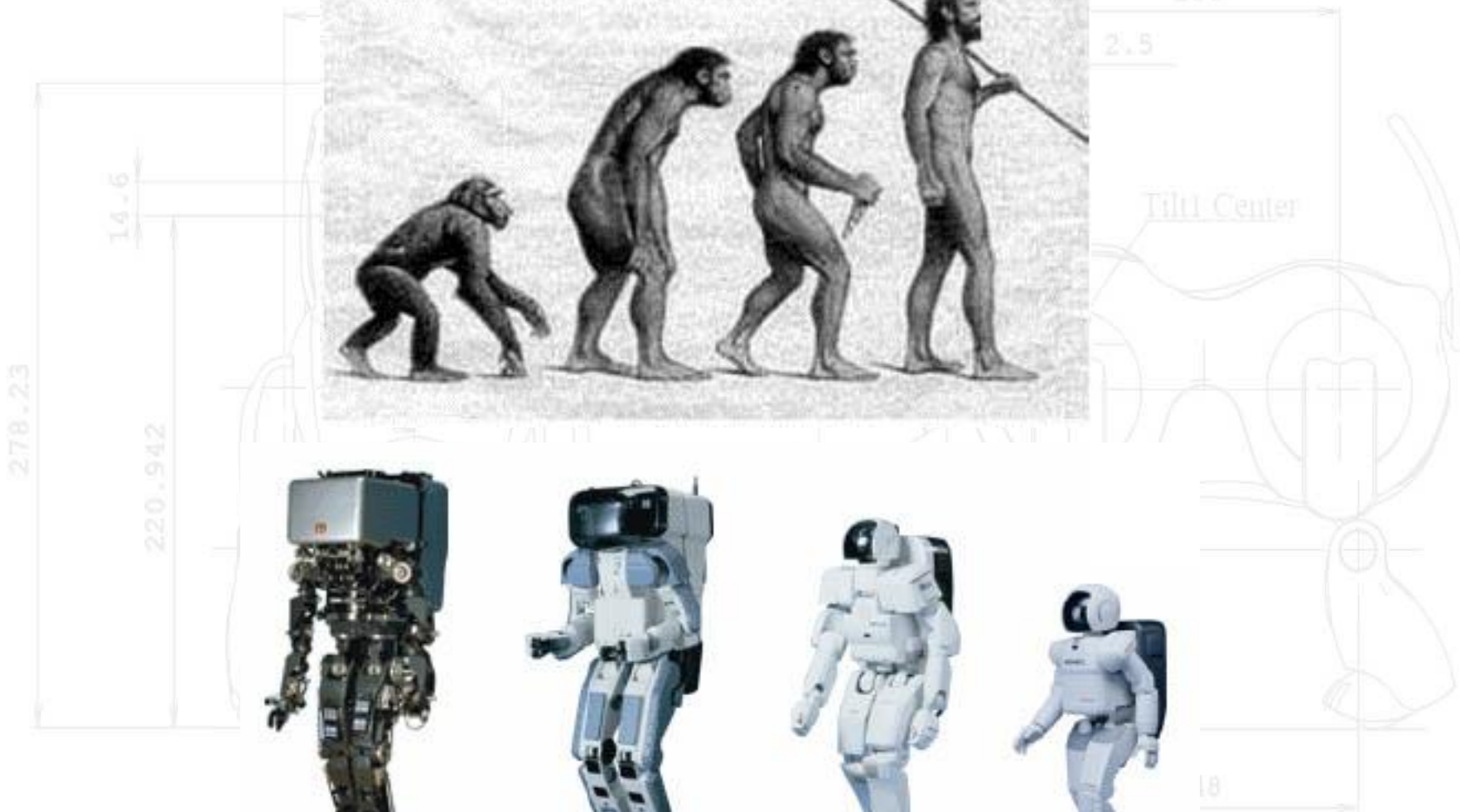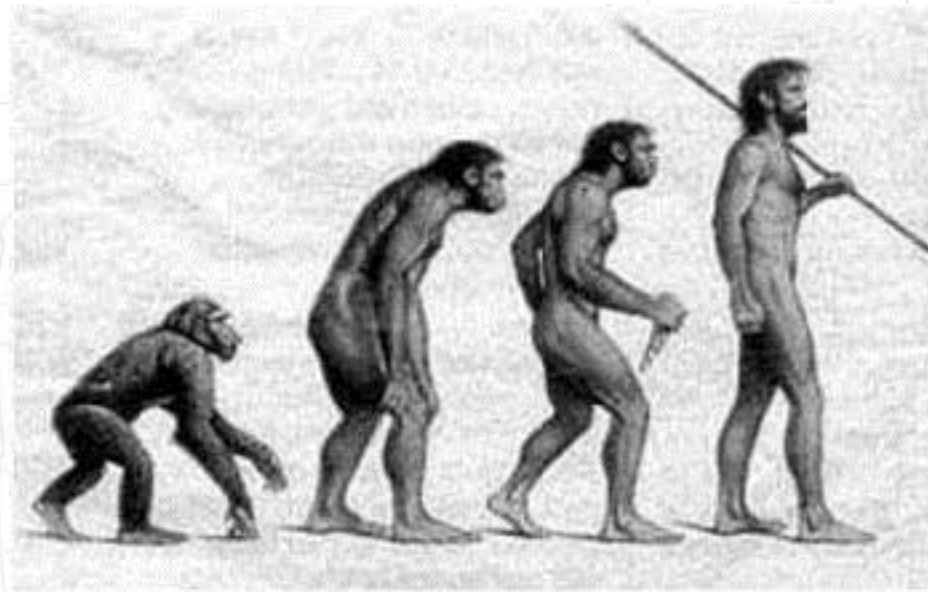

HAL 9000

Monkey

Human Evolution

Bipedism frees the hands to create tools and start cognition

Human Evolution vs. Humanoid Evolution

P1   P2   P3   Asimo

Humanoid Evolution (cont'd)

- Nowadays, humanoid robot researchers are focusing on bipedism more than they do in cognition
- Stable and robust bipedal locomotion is still a good lab example
- It is mandatory to solve it in order to be able to implement cognition
- We are in the pre-robotic era compared with the human evolution

Bipedal Locomotion

ZMP (Zero Moment Point) specifies the point with respect to which dynamic reaction force at the contact of the foot with the ground does not produce any moment, i.e. the point where total inertia force equals 0 (zero).

ZMP is the indicator of the stability of the robot:
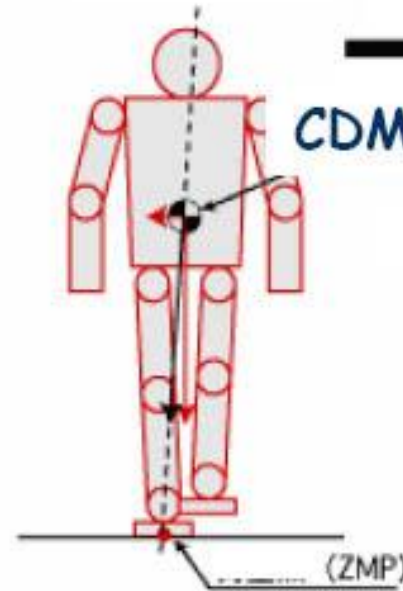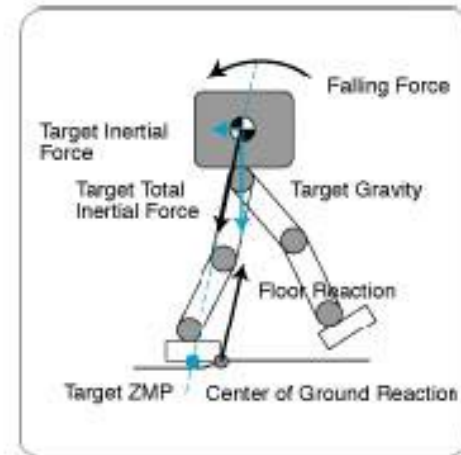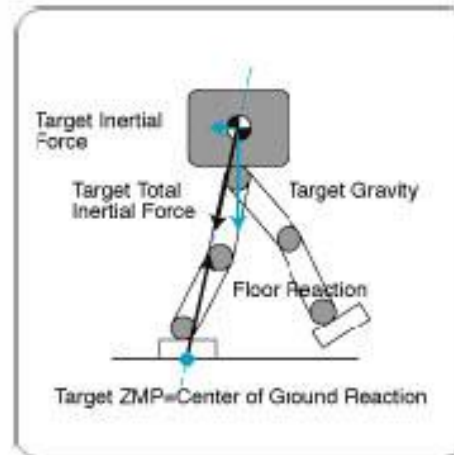- if it is in the foot shadow – stable,
- If not – unstable.

The shadow depends on single or double support phase.

Stable   Unstable

CDM   CDM

(ZMP)   (ZMP)

OUT   IN

Target Inertial Force

Target Total Inertial Force   Target Gravity

Floor Reaction

Target ZMP=Center of Ground Reaction

Falling Force

Target Inertial Force

Target Total Inertial Force   Target Gravity

Floor Reaction

Target ZMP / Center of Ground Reaction
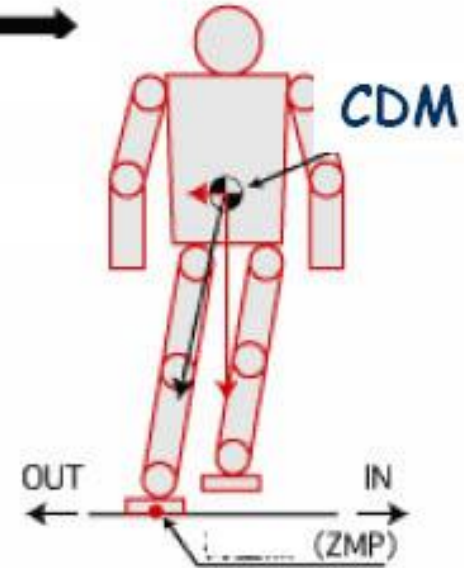
Active vs. Passive Locomotion

Common humanoid uses all their DOF to perform the movement:

- Continuous motor consumption (including arms)
- Continuous motor control and synchronization
- Extremely complex real-time control

How is possible to reduce complexity?

- Reducing number of active DOF
- Using DOF only when it is strictly necessary
- Using energy of previous step to generate the next
- These actions reduce also the consumption

Passive Dynamic Walking

Human walking strategy:

- Let their legs swing as they would on their own,
- Then add a little control and power, yielding a gait with inherently low energetic and control demands.

Advantages:

- In contrast to rigidly joint-controlled robots, walking robots based on passive-dynamic principles can have human-like efficiency and actuation requirements.
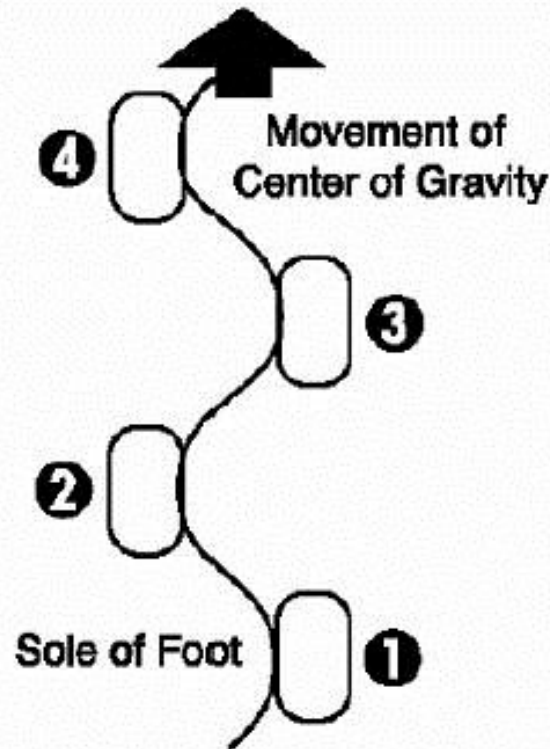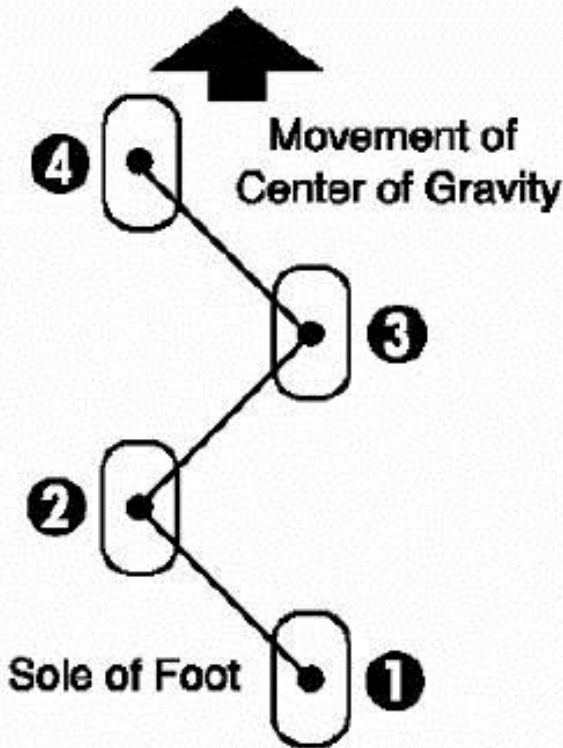
Disadvantages:

- Movements are mostly in sagital plane and in straight line, being extremely difficult to turn, go back, seat,etc. The motion is mostly symmetrical.

Passive Dynamic Walking (cont'd)

Active Gait : Always stable
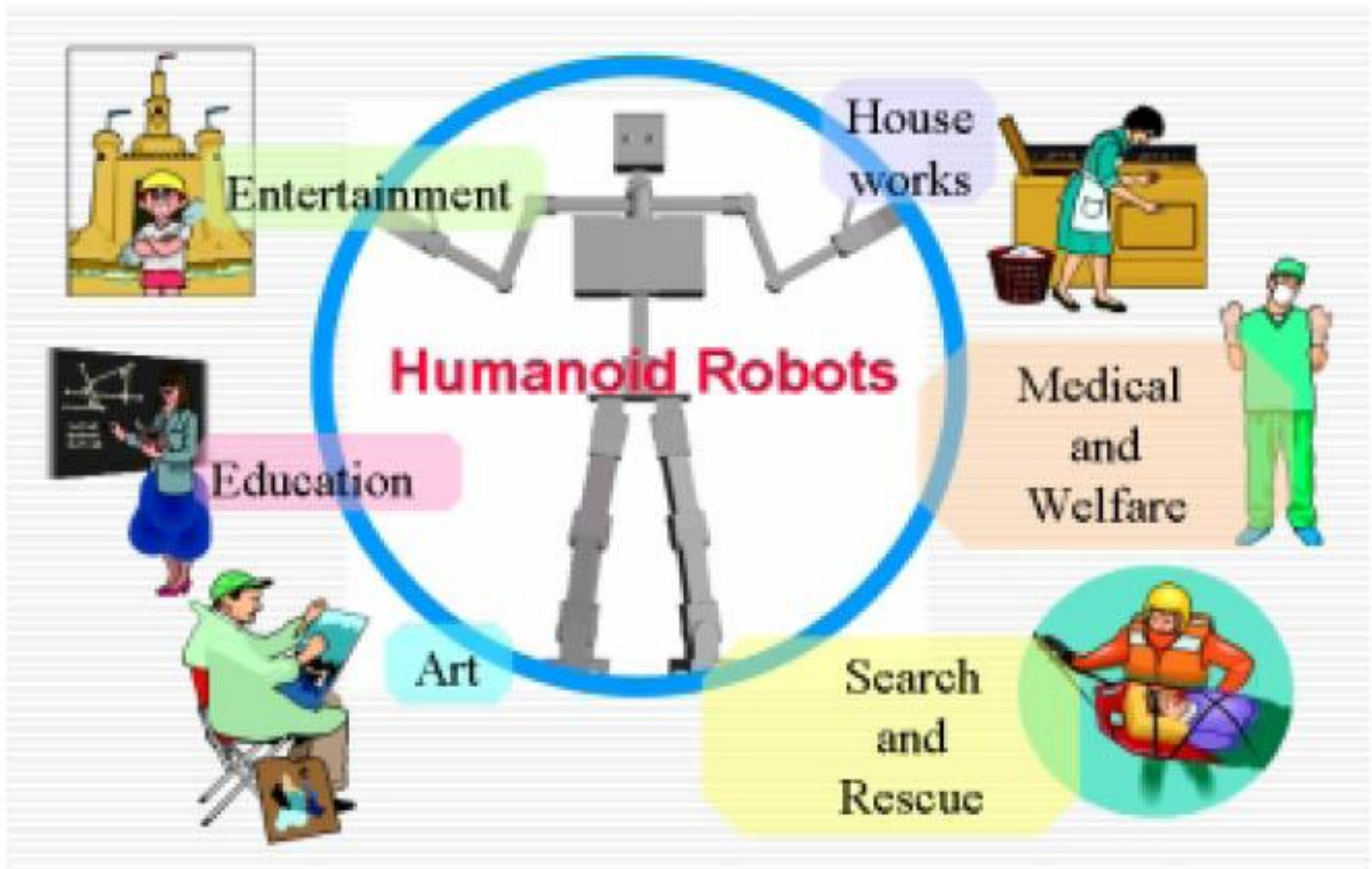
Passive Gait : Sometimes unstable

Movement of Center of Gravity

Sole of Foot

Humanoid Robot Applications

Social Aspects : What Are You Prefer

Humanoid as a **slave**

- **New electrical appliance?**
- **Will they be a new tamagotchi?**
- **Will they be adapted to the master?**
- **Back to slavery?**

Humanoid as a **companion**

- **Will they get socially accepted?**
- **Will they have social rights?**
- **Who will be responsible for them?**
- **Will they be able to acquire some conscience?**
- **Will they evolute?**