Human motion: Back to Real

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Back to real: humanoid versus human

References:


E.J. Marey in Le Mouvement, 1894
Humanoid Robots: facing dynamics

- HRP-2: 58kg against gravity
- Accounting for second derivatives
- Coupling with force sensors
- ZMP approach

Humanoid Robots: ZMP Approach

- Dynamic stability: ZMP above the support polygon
- Dynamic pattern generator [Kajita 03]
  - Inverted pendulum
  - Preview control
Humanoid Robots: Motion Planning

- Combine kinematics and dynamics via iterative reshaping:
  - Compute a path
  - Apply dynamic pattern generator
  - Check collision and reshape

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Human Locomotion: a NeuroRobotics Perspective

- An old still open problem
- To find motion invariants

Etienne-Jules Marey in *Le mouvement*, 1894
Human Locomotion: a NeuroRobotics Perspective

- Problem statement:
  - Why that path?

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Human Locomotion: Approach

- Body position and direction are coupled
- Not integrable coupling: natural human locomotion is nonholonomic

\[ \tan \theta = \frac{\dot{y}}{\dot{x}} \]

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Human Locomotion: Protocol

- Build the \((x,y,\theta)\)-space

1430 trajectories (14km)
7 subjects
Human Locomotion: Methodology

• Stereotyped behaviors

• Nonholonomic behavior

• Geometry from optimal control

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Human Locomotion

• “Theorem”: Locomotor trajectories optimize the derivative of the curvature.

• “Demonstration”: 90% of 1430 trajectories with error less than 10cm

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Human Motion: Perspectives

- What are the invariant parameters of a given motion?
- What is an “action”? 