Some aspects of sensori-motor control in human locomotion

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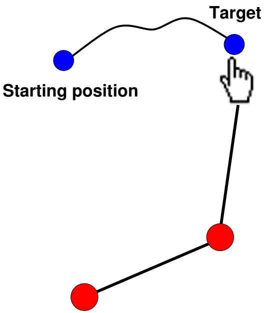
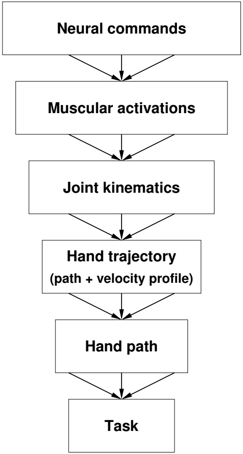
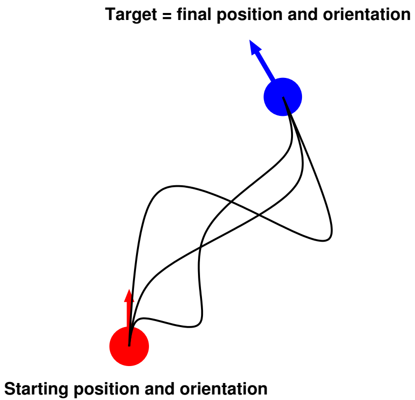
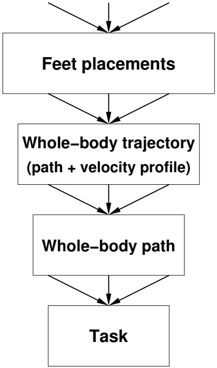
The "problem" of "redundancy" in human motor control



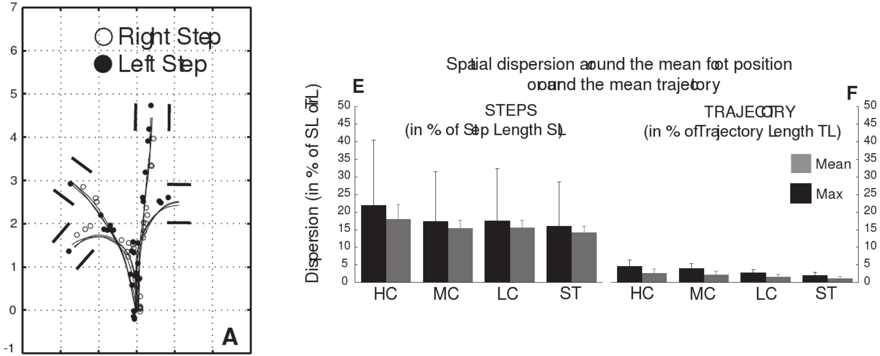


Adapted from Jordan & Wolpert, 1999


Target = final position and orientation
Starting position and orientation


Feet placements
Whole–body trajectory
(path + velocity profile)
Whole–body path
Task

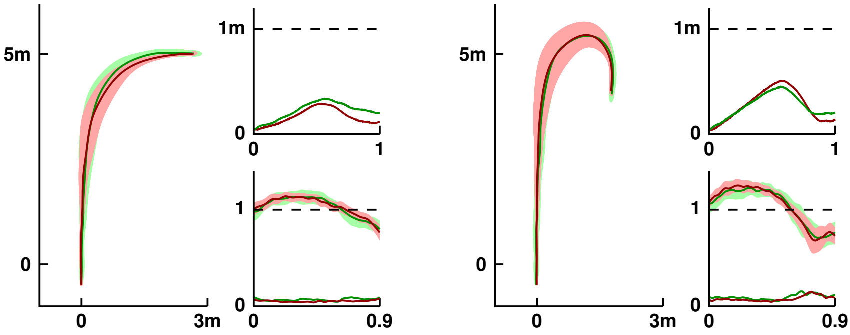
Variabilities of feet positions and of trajectories



Hicheur et al., *Eur. J. Neurosci. 2007*

Forward vs backward walking

Red: Forward walking / **Green: Backward walking**



Pham et al, in preparation (work supported by the Locanthrope project)

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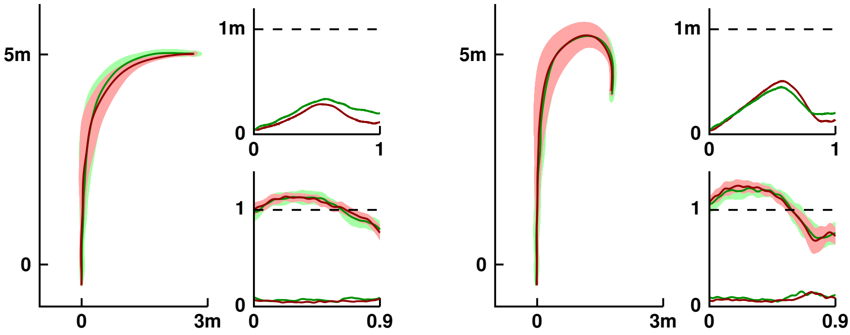
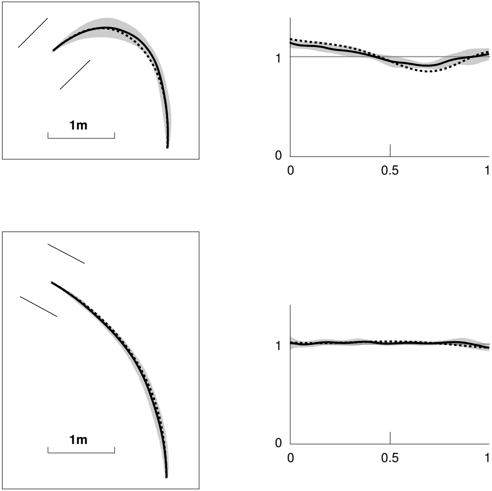


Pham et al, in preparation (work supported by the Locanthrope project)

Similarity at the first-order (average trajectories) and the second-order (variability profile) !
⇒ The formation of the trajectory is independent of the detailed motor implementation.

A maximum-smoothness model for trajectory formation



Minimize

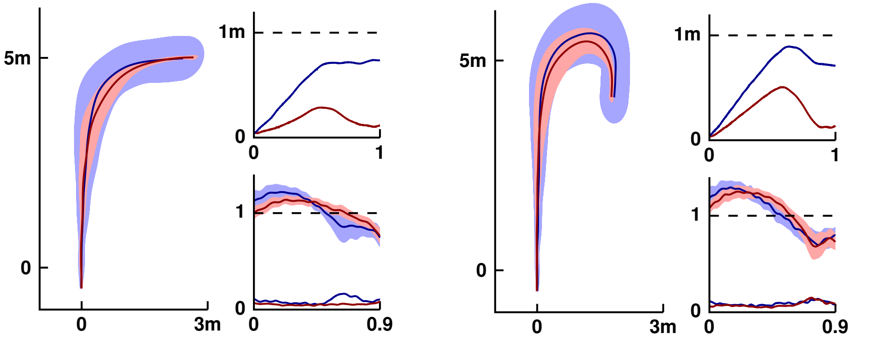
$$\int_0^1 \dddot{x}^2(t) + \dddot{y}^2(t) dt$$

Solid: actual
Dashed: model

Pham et al., *Eur. J. Neurosci. 2007*

The role of visual feedback: visual vs non-visual walking

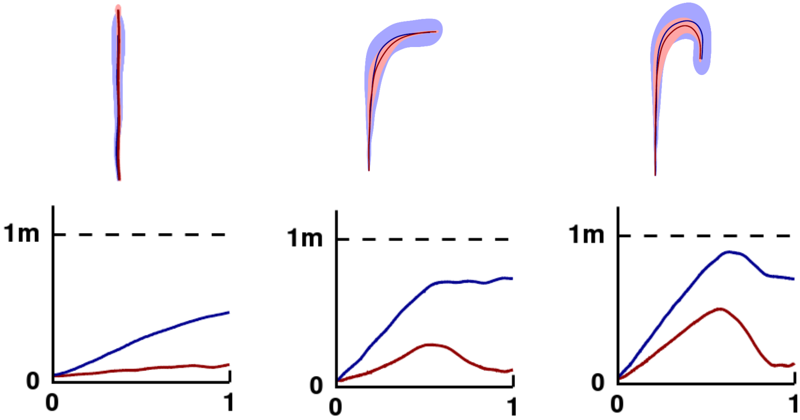
Red: Visual walking / **Blue: Non-visual walking**



Pham et al, in preparation (work supported by the Locanthrope project)

⇒ Very similar average trajectories, which suggests similar basic strategies

What about variability?



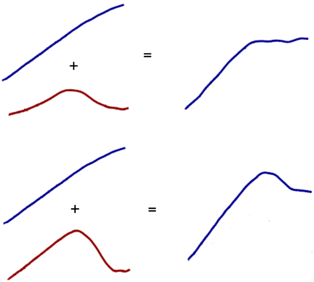
The variability profile in the non-visual condition is non-trivial. Indeed, we would expect the variability to increase all the time.

Possible interpretations

We suggest that

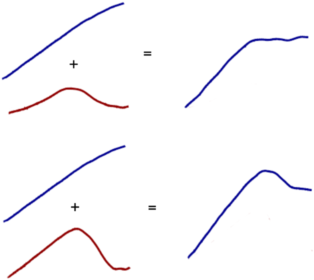
- In the visual condition, the bell-shaped variability profile is related to the fact that correction feedback is generated with respect to the task (as opposed to the "trajectory tracking" hypothesis, see Todorov and Jordan, 2002)
- In the non-visual condition, humans use the same strategy as in the visual condition, but correction feedback is generated towards a imagined target location (which generally differs from the actual target location, because of memory decay, sensory drift, etc.)

Modelling (ongoing work)



Sensory drift + Motor variability =
Variability in the non-visual condition

Modelling (ongoing work)



Sensory drift + Motor variability =
Variability in the non-visual condition

Following the above observations, we derive a simple online-feedback version of the previous maximum-smoothness model, which can now reproduce the average trajectories *and* the variability profiles in both visual and non-visual conditions.