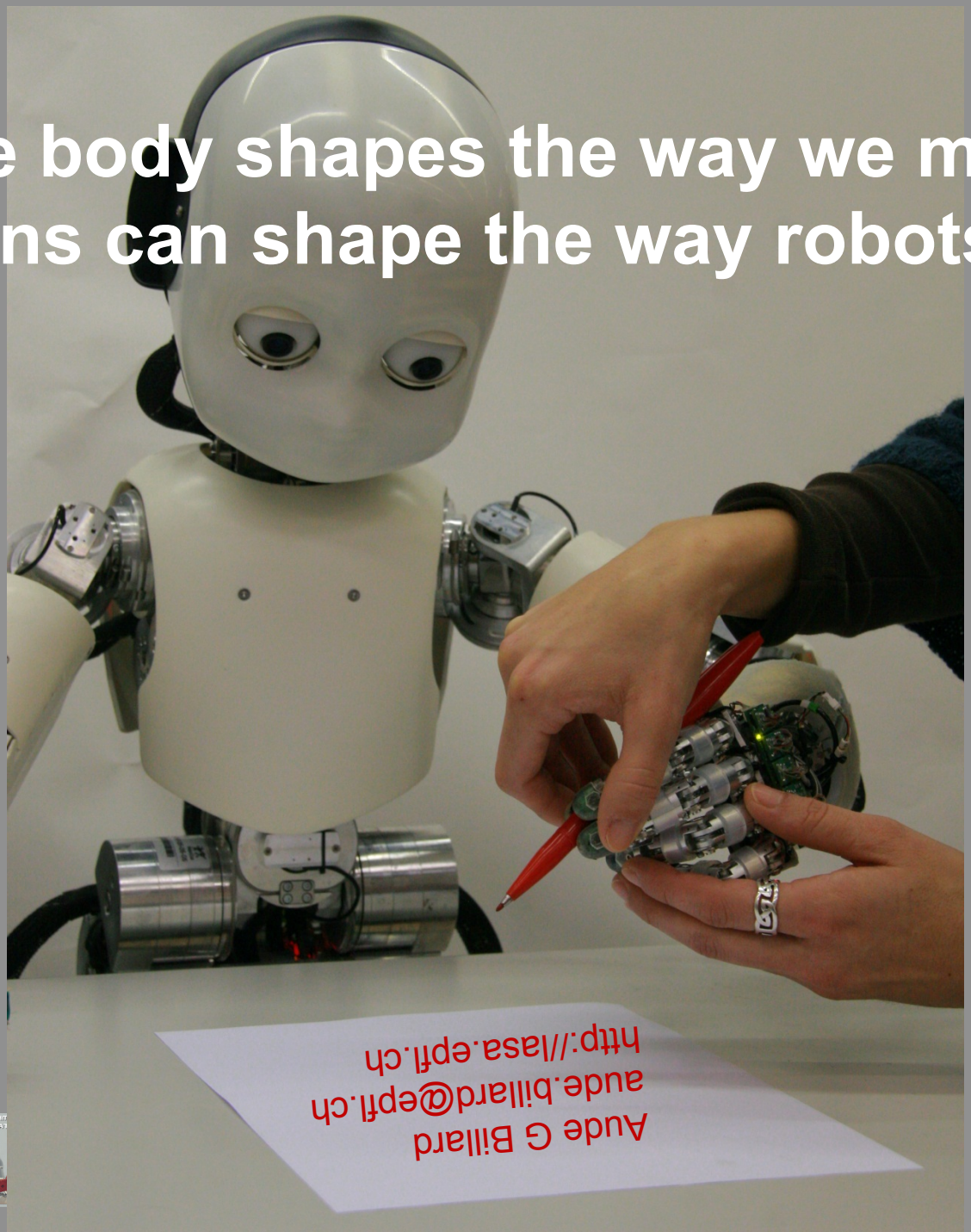
Tutorial on Learning from Demonstration

Part 6: Discussion and Overview of Open Issues

Why Learning from Human Demonstration?

How the body shapes the way we move
How humans can shape the way robots move



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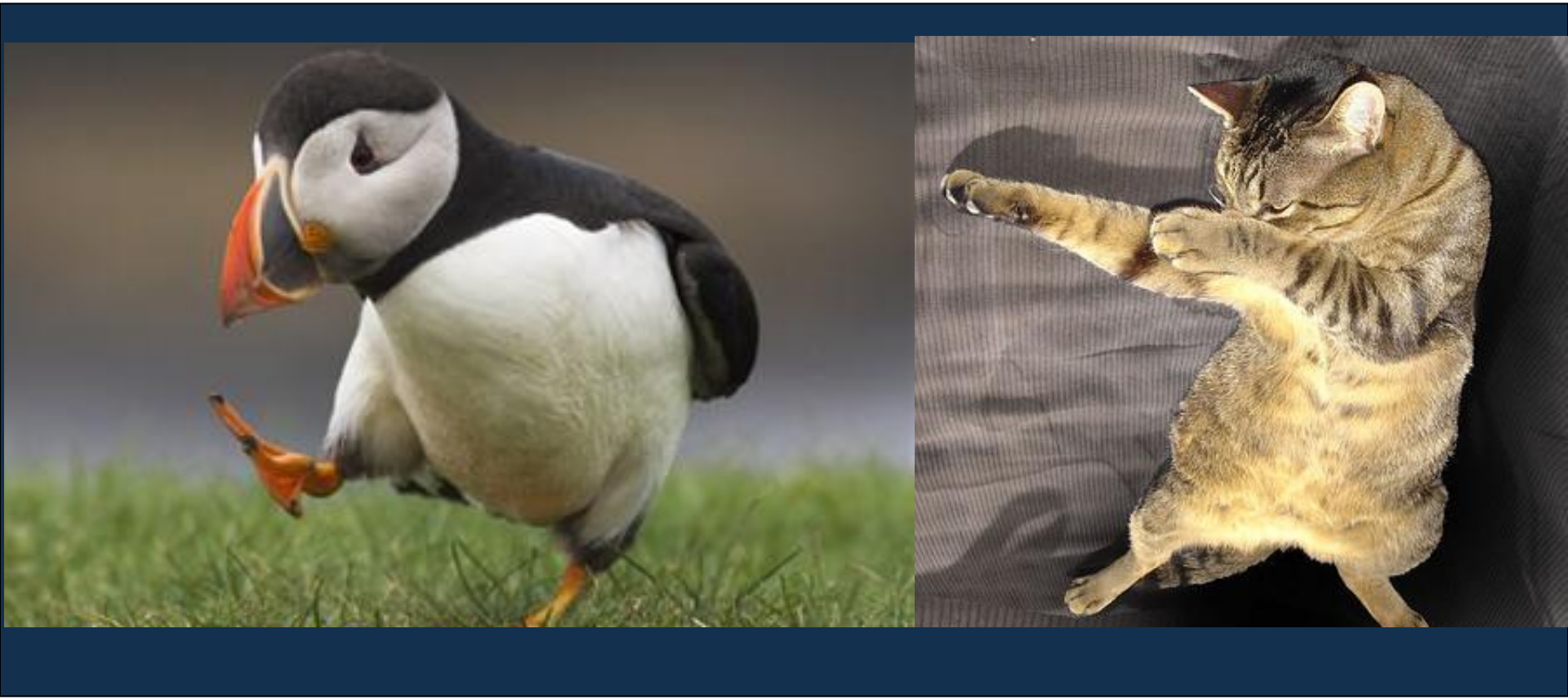
How the body shapes the way we move



Evolution has shaped the body and the control system simultaneously so as to optimize the animal's overall motor control system

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With enough training….

…we can get bodies to do things for which they were not designed for in the first place, but this requires tedious and long training periods.

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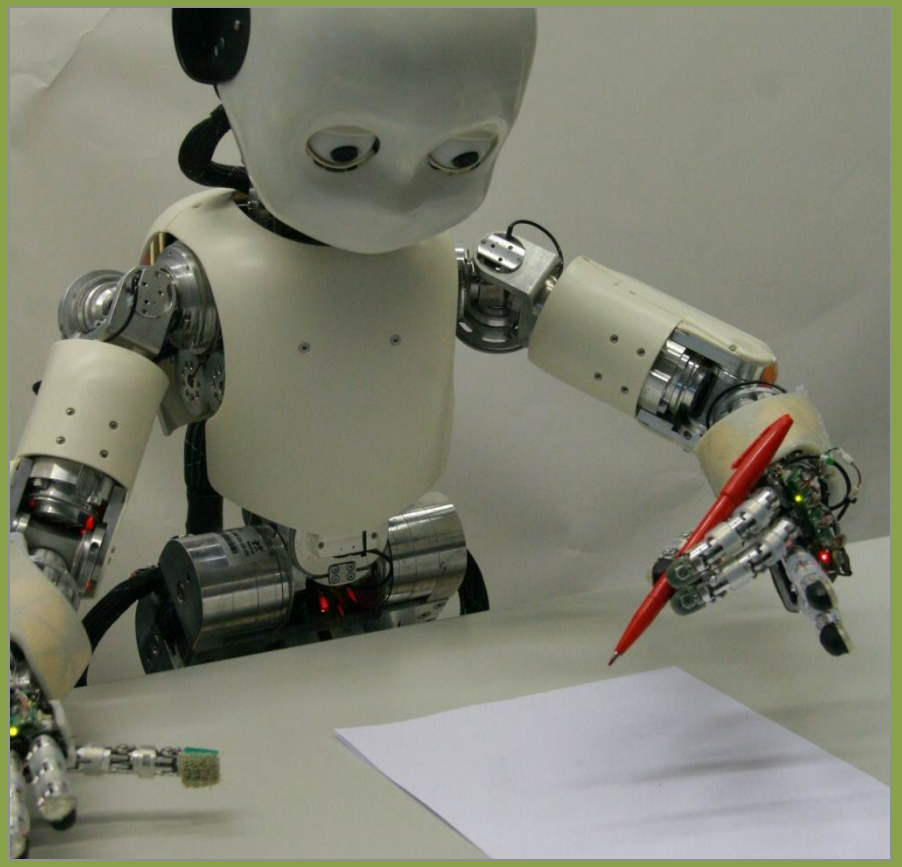
How the body shapes the way we move



Robots should have arms and hands that are similar to human hands and arms

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How the body shapes the design of tools

Robots should help us in our daily tasks

- manipulate the same objects
- objects are designed for the human hand

Bent to our needs!

Robots should move and act in a way that is similar to the way humans move and act

Why?

- *Makes robot's motions more predictable*
  - → *Increase safety during human-robot interaction*
  - → *Easier for robots and humans to collaborate*

- *Human motions have all these nice properties (robustness to perturbation, smoothness, energy efficiency), which we seek robots to have.*

What is easy and what is difficult to imitate

What is easy and what is difficult to imitate

Move 10cm on your right!

Move 10cm per secund on your right!

Move 10cm/s^2 on your right!

Press with 1Newton on the table

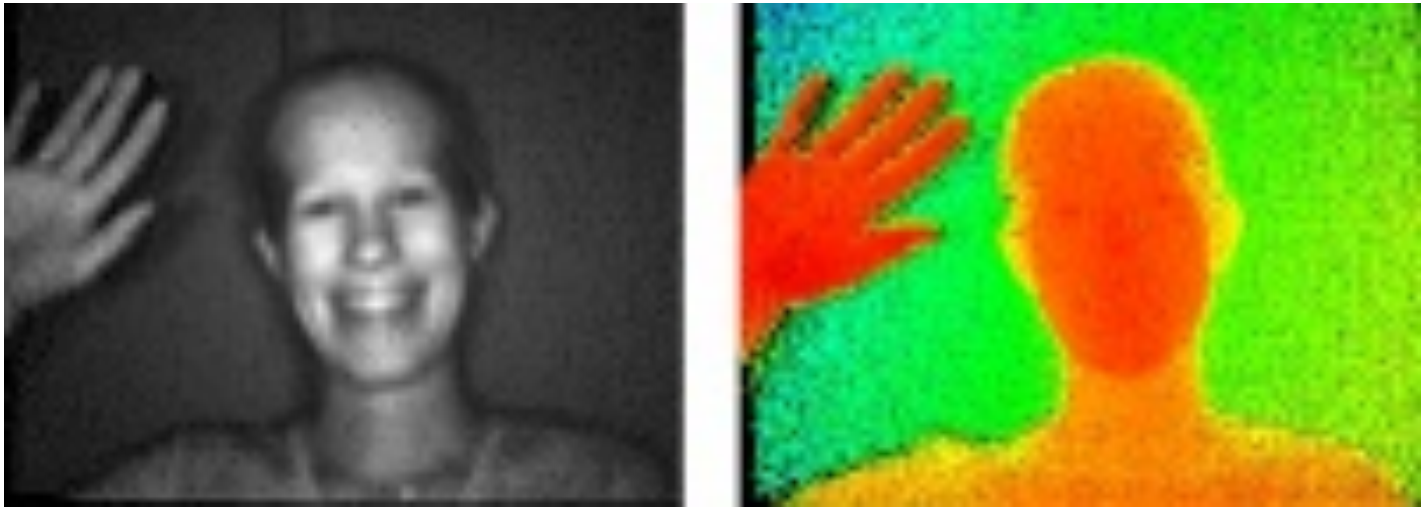
The correspondence problem

Humans and robots may differ tremendously in their body

The correspondence problem

Even when the robot looks more like the human, its body does not have the same range and dynamics of motion.

The correspondence problem



Robots do not perceive things like we do.
Sonars, infra-red sensors, lasers are common on robots and easier to process than information from cameras.

Partially Open Questions

Learning human skills by imitation includes learning:

- What to imitate?
- How to imitate?
- When to imitate?
- Who to imitate?

C. L. Nehaniv, K. Dautenhahn (2000): **Of Hummingbirds and Helicopters: An Algebraic Framework for Interdisciplinary Studies of Imitation and Its Applications**. *In: J. Demiris and A. Birk, eds., Interdisciplinary Approaches to Robot Learning, World Scientific Series in Robotics and Intelligent Systems* - Vol. 24.

Other Issues

Take humans as example

→ Hypothesis: Human is a good example!

→ Algorithms robust to imperfect demonstrations

→ Learn from few and very noisy data

→ Incremental learning

Human teaches the robot by showing how to perform the task

→ Hypothesis: There is an interface to teach the robot

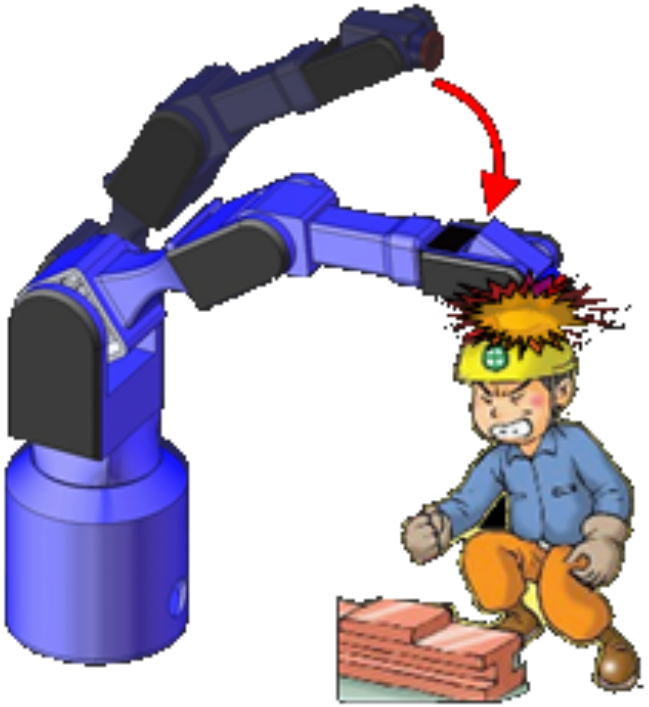
→ Need cheaper and more versatile interfaces for haptic control

→ Need easy ways to combine interfaces (speech, vision, haptic)

Safety in LfD

→Ok when robot is passive during demonstration.

What is actively compliant?



Source: Intelligent Robotics Lab, Korea Univ.

Other Issues

Start apply LfD in the real world and document users' reactions

Summary

Learning new tasks relies on various means of teaching the robots.

- Imitation learning is useful in so far that it gives hints as to the optimal solution
- The robot must however rely on generic skills of its own to adapt the demonstration to its own body and to the context
- Learning of complex skills is overall relatively slow and must proceed incrementally