Bio-plausible robot control via the Mirror Neuron System

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Introduction

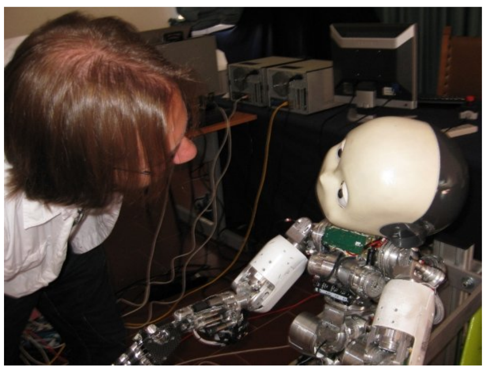
We are developing a neuro-inspired robot controller based on the mirror neuron system (MNS - thought to underlie amongst others much of human action recognition and imitation) which will endowe the robot with the capabilities and advantages of such a system. At the same time we intend to use this research to further the understanding of the MNS itself.

Here, we summarise the basic approach, model improvements and motor control paradigm. In a nutshell, we intend to develop a controller that is:

1) Biologically plausible to the extent where it clearly reproduces the functions of the MNS and allows us to further our understanding thereof.

2) Adaptive to the extent where actions the robot can execute are not hard-coded but can be learned over time.

3) Capable of habituation at the motor level in line with psychological findings.



The fundamental model

It is believed that pools of mirror neurons encoding specific action primitives combine to form a chain of activation representing a complete motion (Fogassi, 2005). A computational model based on this obeservation, called the **Chain Model** (Fig. 1), has been developed by Chersi (2006) and has been shown to be an adequate basis for a robot controller.

One of the most important questions that the model currently does not address, however, is how the action primitives are both formed initially and learned later on.

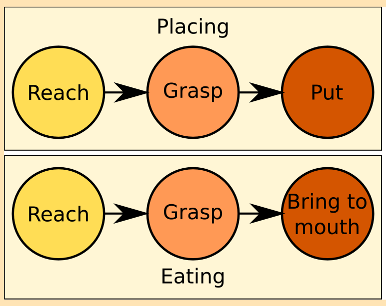


Figure 1.
The basic chain model: Every overall movement is encoded by a chain of action primitives.The same action is encoded by different neurons if the goal of the overall movement is different.

The formation of primitives

The action primitives in the chain model are presently hard-coded and arbitrary. This is inadequate if an embodied, adaptive robot controller is desired. We are therefore using the ShapeHand system (Fig. 2) to record a variety of motions. Data thus captured is used to investigate how it would be separated into primitives by humans, leading to insights on both the nature and origins of cognitively plausible primitives.

Figure 2.
The ShapeHand worn by one of the authors.

Motor control

Dynamic fields (Fig. 3) are a relatively novel way of representing behavioral and physical dimensions. They can be seen as a succint summary of neural activation.

At the same time they are one of the only approaches to motor control that implicitly allow for habituation effects (see Thelen and Smith, 1994).

They thus provide a good basis for controlling the robot motors based on behavioural goals defined by the chain model (but see also Erlhagen and Bicho, 2006).

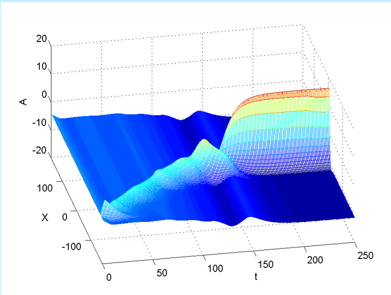


Figure 3.
A dynamic field: The visualisation shows a field controlling a rotating motor (e.g. in a robot elbow). x represents the chosen target position. The activation (summarising neural activity) A moves the motor over time t until the target position has been reached.

Conclusion

This poster summarises the development and architecture of a neuro-inspired robot controller. The basic model, firmly grounded in neuroscience, ensures **biological plausibility**. Human-subject investigations into the formation of primtives that make up the basic model ensure **adaptability**. The neurologically inspired form of motor control further ensures plausibility by enabling the reproduction of **habituation** effects .

References

Chersi et al (2006) A model of intention understanding based on learned chains of motor acts in the parietal lobe. P*roceedings of the 15th Ann. Comp. Neurosci. Meeting*

Erlhagen and Bicho (2006) The dynamic neural field approach to cognitive robotics. *J Neural Eng 3*, pp R36-R54

Fogassi et al (2005) Parietal lobe: from action organization to intention understanding. *Science 308*, pp662-667

Thelen and Smith (1994) *A Dynamic Systems Approach to the Development of Cognition and Action*. Cambridge, MA: MIT Press

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