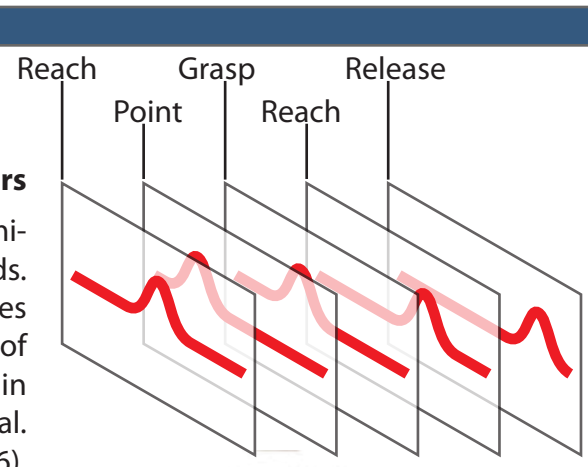
Modelling the mirror neuron system with dynamic fields

Boris Durán, Serge Thill, Tom Ziemke
Cognition and Interaction Lab, University of Skövde
{boris.duran}, {serge.thill}, {tom.ziemke} @his.se

Introduction

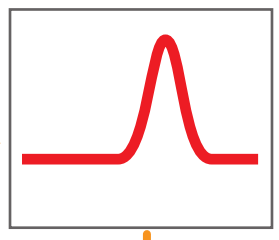
In this project we attempt to build a model of the mirror neuron system based completely on the dynamical systems approach. We expect that the use of dynamic fields (Schöner, 1995) in this model will provide us with biologically plausible tools capable of performing adaptive motor behaviors. Previous work on dynamic fields has created applications for mobile robots and fixed anthropomorphic arms. We would like to put together these different stages in a common architecture and platform in order to understand how they interact with each other in a more human-like environment.

We assume a vision module external to our model is providing the cartesian coordinates of the target object; with those coordinates the system dynamically reaches the desired position.
Our approach will follow the guidelines of the neuroscientific findings on mirror neurons in monkeys (Fogassi, 2005 & Chersi, 2006). The basic concepts from their "chain" model will be implemented using a sequential activation of dynamic fields (Sandamirskaya, 2009). The illustration below shows in general terms the main blocks of our approach.



Sequence of behaviors

Motor behaviors or primitives are encoded as fields. The different sequences represent the chains of motor behaviors specified in the model of Chersi et al. (2006).

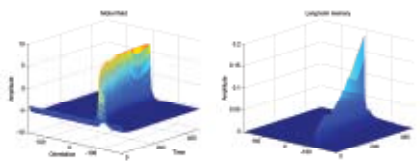


Behavior Output

This field is the output from the sequence generation module. A peak is detected in the corresponding behavior to be performed.

Motor Output

A peak in the behavior field activates the different motor outputs. The position of the target in the cartesian frame of reference is used to compute the forwards kinematics.



Motor Habituation

Each joint is activated by a dynamic field function of the target's position and the current activated behavior. These fields include a long term memory field simulation the muscular habituation of the human counterpart.

Objects as peaks

A 2D dynamic field is built at the level of the working environment. Peaks on this field represent the position of those objects selected for reaching and grasping.

Current and Future work

Forward kinematics for a five degrees-of-freedom (DOF) arm has been implemented using both attractor dynamics and dynamical fields. We have also implemented and tested the learning and execution of a sequence of positions to be reached. Our next goal aims at designing a connection between abstract behaviors representing a collecion of motor actions and the motor actions themselves.

This work is supported by the ROSSI project (FP7, 216125)
www.rossiproject.eu

References

Chersi et al, (2006). A model of intention understanding based on learned chains of motor acts in the parietal lobe. Proceedings of the 15th Ann. Comp. Neurosci. Meeting
Schöner et al, (1995). Dynamics of behavior: theory and applications for autonomous robot architectures. Robotics and Autonomous Systems, 16. pp. 213 - 245.
Fogassi et al, (2005). Parietal lobe: from action organization to intention understanding. Science 308, pp. 662-667.
Sandamirskaya & Schöner (2008). Dynamic field theory of sequential action: A model and its implementation on an embodied agent. Development and Learning, 7th IEEE International Conference on, 16. pp. 213 - 245.