Smooth pursuit using coupled chaotic fields

B. Duran[1], G. Sandini[2], and G. Metta[3]
Italian Institute of Technology - University of Genova, Italy

[1] Boris Duran, boris@unige.it
[2] Giulio Sandini giulio.sandini@iit.it
[3] Giorgio Metta giorgio.metta@iit.it

Poster abstract

The purpose of this research is to demonstrate the feasibility of using coupled map lattices (CML) and globally coupled maps (GCM) [1] within the area of cognitive developmental robotics. Based on the model of behavior emergence introduced by Kuniyoshi et al. [2], we study the coordination of multiple degrees of freedom in humanoid robots. The task of tracking an object has been fully studied and many solutions presented before, therefore it would not be necessary to develop new solutions; however, this problem represented the simplest test bed for the study of coupled chaotic systems, both in a simulated environment and for its implementation in a real platform. Another equally important goal of this research is the possibility of having new insights about how the coordination of multiple degrees of freedom emerges in human infants.

A virtual eye was created using two rotational joints, one perpendicular to the other, in order to simulate the 'pan' and 'tilt' motions of a real eye. Each joint is modeled by a spring and a damper, trying to replicate also the physical characteristics of real muscles. A virtual camera mounted in front of the eye gives the visual input needed for modulating the chaotic field. It is assumed that the values of saliency are obtained from other visual components. This was simulated by a black circular shape moving on a white screen. Even though the trajectory followed by the object is circular all the time, it accelerates and slows down several times; this was used as a basic test for the robustness of the system. Once the object appears in front of the camera, we demonstrate that the visual input is enough for the self-organization of the controller that generates the torques applied to each of the joints controlling the motion of our device. No learning or specific coding of the task is needed, which results in a very fast reactive behavior.

The results from the simulation gave us enough confidence to implement this algorithm in a real platform. A copy of the iCub's head from the RobotCub project [3] is being used to test these experiments in a real environment. The main differences between the virtual and the iCub's eyes were the gains and offsets to be applied in each joint; all the other parameters were kept in the same magnitudes. The coordinates of the object to be tracked was given by one of the scripts found in the YARP repository [4]; the output of this script are the x and y coordinates of a moving object in front of the camera. The algorithm was tested by changing both the chaoticity of the system and the coupling among its elements. In both cases, simulation and implementation, the smooth pursuit behavior emerges when the system is highly chaotic and there is a weak coupling among its elements.

The iCub'head has also an inertial sensor which will be included in the future as another element influencing the chaotic field. Future work involves the emergence of a coordinated motion between th two eyes and finally among the motors represeting the three degrees of freedom of neck (yaw, picth and roll) and the three degrees of freedom of the eyes (left eye yaw, right eye yaw, and both eyes pitch). Several questions should be addressed regarding the correspondences between this research and the biological counterpart; for example, if a smooth pursuit behavior emerged from the interaction of chaotic units, could it be possible to obtain other visual behaviors like vestibulo-ocular reflex (VOR), vergence or saccades in the same way?

References

1. K. Kaneko, I. Tsuda: *Complex Systems: Chaos and Beyond* (Springer-Verlag 2001)
2. Y. Kuniyoshi, S. Suzuki: Dynamic Emergence and Adaptation of Behavior through Embodiment as a Coupled Chaotic Field (2004)
3. RobotCub Project: http://www.robotcub.org
4. Yet Another Robot Platform: http://eris.liralab.it/yarp/