Title (tentative): A proposal of a disparity-vergence control circuit based on distributed representation of disparity and disparity flux

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Motivation and application domain

Stereopsis is usually thought as a static problem, since the depth map obtained by a fixed-geometry stereo camera is sufficient to reconstruct the 3D spatial layout of the observed scene, and eye movements are regarded as an unnecessary complication. Things are different for a binocular foveated system with a vergent stereo geometry. In such conditions, the perceptual process intrinsically gains a motor dimension as the 3D information is collected dynamically with respect to the fixation point.

General objectives and main activities

The goal is to investigate the role of the "disparity flux" (i.e. the temporal variations of the binocular disparity due to ocular convergence/divergence) in controlling binocular fixations and in perception itself. Starting from a vergence algorithm that relies on the explicit derivative (dt) of the estimated disparity map, the thesis will demonstrate how, through properly designed spatiotemporal binocular receptive fields (RFs), it is possible to directly gain disparity-vergence and dt-vergence curves without requiring an explicit estimate of the disparity. The resulting neuromorphic modules will be capable of driving the control and, at the same time, assisting stereopsis through a continuous interaction with the environment. As starting point: a library of cortical modules that mimic the functionality of the striate cortex and a model to hierarchically obtain RFs sensitive to the disparity flux. The performance of the network will be comparatively assessed against the algorithm.

Training Objectives (technical/analytical tools, experimental methodologies)

- Dynamic stereopsis: a different perspective on stereo vision (mainly based on the analysis of the variations of the binocular visual signal due to the eye movements around the fixation point).
- Binocular control of eye movements.
- Development of software modules (MATLAB) to validate the approach in simulation.
- Possible integration (in C++) on the iCub stereo head for final validation in real-world operating conditions.

Place(s) where the thesis work will be carried out: DIBRIS

Pre-requisite abilities/skills: Joint interest for theoretical work and applications.

Maximum number of students: 2