learning and quantitative evaluation

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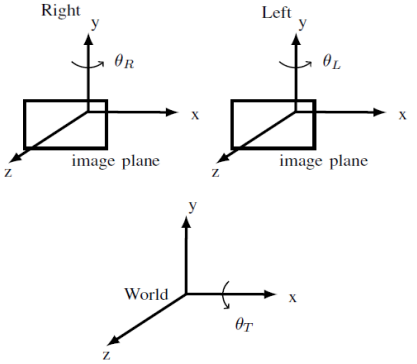
Motivation and Objective

The aim of this work is to investigate quantitatively the performance of a bioinspired active stereo vision system based on the Hering's law of equal innervation.

The system was briefly presented in [1]. We extended it, proposing a training method, and we sistematically evaluated its capabilities to foveate points in 3D space.

Vergence system



Control law:

$$\dot{\theta}_{version} = K_1(x_L + x_R) \qquad \dot{\theta}_r = \dot{\theta}_{version} - \dot{\theta}_{vergence}$$
$$\dot{\theta}_{vergence} = K_2\delta \qquad \dot{\theta}_l = \dot{\theta}_{version} + \dot{\theta}_{vergence}$$
$$\dot{\theta}_{tilt} = K_3(y_L + y_R) \qquad \dot{\theta}_t = -\dot{\theta}_{tilt}$$

where δ is the disparity that can be computed with a bioinspired model of the primary visual cortex [2].

Learning method

The optimal values of the parameters K were estimated by running the following minimization:

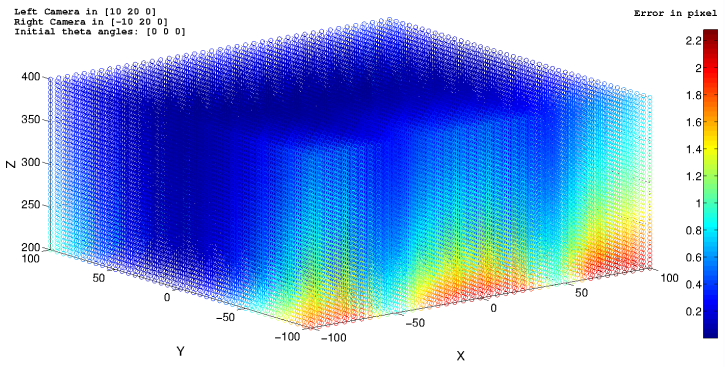
$$c(X,Y,Z) = e^2_{left} + e^2_{right} + \sum_j |\dot{\theta}_l|_j + \sum_j |\dot{\theta}_r|_j + \sum_j |\dot{\theta}_t|_j$$

$$K = argmin_{K_1,K_2,K_3} \sum_x \sum_y \sum_z c(x,y,z)$$

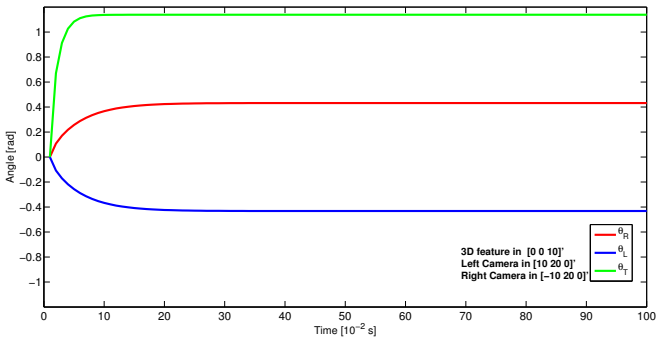
where e_{left} and e_{right} are the euclidean distances between the position of the point in the image plane after the motion and the center of the image, and the sum terms are the variation of movements of both eye and the tilt component.
We used the gradient descent technique to estimate the optimal values of the parameters.

Experimental results

Error map to foveate features in a 3D subspace:



Example of trajectory of the head joints:



The estimated parameters K are:

$$K1 = 0.0166$$
$$K2 = 0.0985$$
$$K3 = 0.3700$$

Conclusion and future works

We investigated the capabilities of the system to foveate a generic feature in the 3D space, starting from a generic intial configuration of the active stereo system.
The obtained results are very promising in terms of performance, showing human-like trajectories of the eyes.

Future directions of research include:
1- adding a new degree of freedom associated to the neck, to have a redundant stereo system.
2- investigating the biological plausibility of the control system with the added degree of freedom

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References:
(1) J. G. Samarawickrama and S. P. Sabatini. Version and vergence control of a stereo camera head by fitting the movement into the Hering's law. In Proc. 4th Canadian Conf. CRV '07, 2007
(2) F. Mutti and G. Gini. Bio-inspired disparity estimation system from energy neurons. 1st International Conference on Applied Bionics and Biomechanics, 2010.