Applying a biological model of the vestibulo-ocular reflex to control gaze stabilitzation in a humanoid robot

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March 25, 2015

Vestibulo-ocular reflex

Nucleo-olivary inhibition

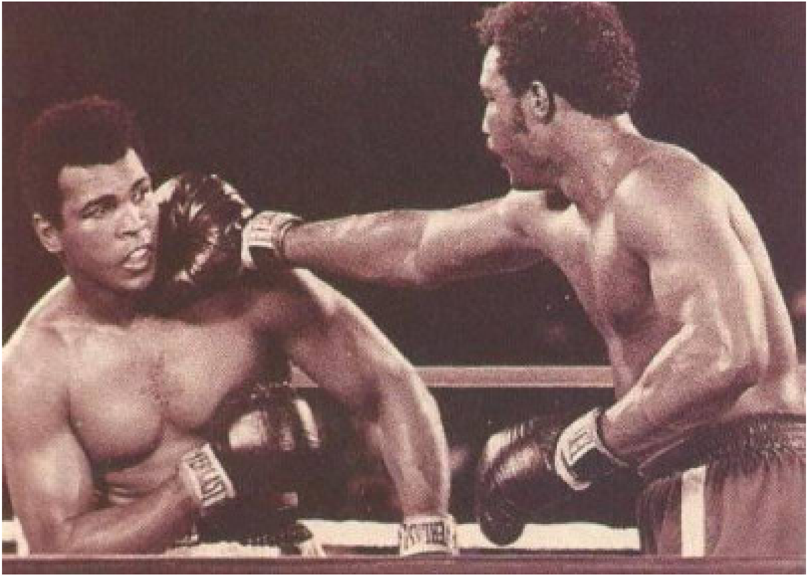
On the neuroanatomical circuitries and sites of cellular plasticity underlying adaptation of the vestibulo-ocular reflex there's a pathway that provides feedback for adjustment of the learning instruction.

It is formed by GABAergic neurons that innervate the neurons in the inferior olive from which the climbing fibres originate (De Zeeuw, Chris I, and Christopher H Yeo. 2005)

Problem statement

Computational models of the vestibulo-ocular reflex don't take into account the role of the nucleo-olivar inhibition although the

Trade-offs in avoidance actions



Extinction and NOI

Extinction in the dark of the vestibulo-ocular reflex adaptation task has been modeled as in-phase with vestibular information, but this predicts a linear decay of the adaptation when an exponential decay has shown experimentally.

Nucleo-olivary inhibition does this job in the eye-blink reflex.

State of the art

- From Marr-Albus-Ito to Clopath's model
- Nucleo-olivary inhibition in the eye-blink reflex

Research question

Is there nucleo-olivary inhibition (NOI) in the vestibulo-cerebellum?

Hints

- Existence of NOI in the eye-blink reflex
- There is extinction of the adaptive response in the absence of peripheral error
- VOR has a non-perfect performance, with a residual error proportional to the amount of cerebellar action required

Hypothesis

Adding nucleo-olivary inhibition in the vestibulo-cerebellum explains extinction in the state of the art vestibulo-ocular reflex computational models.

Methods

- Implementation of the detailed model (Clopath, 2014) of the VOR
- Reproduction of the results of the paper
- Add the NOI to the detailed model
- Simulation of adaptation, extinction and readaptation of the VOR

Project planning

Where we are now

- Detailed model (Clopath, 2014) implemented in Matlab
- Results reproduced as on the article
- NOI added to the model

Future work

- Analyze detailed model assumptions
  - What are the effects of clipping weights on the PF-PC synapses?
  - Identify other assumptions of the detailed model
- Comparing detailed and NOI models
  - Do they show linear or exponential decay after one week light deprivation?
  - What does maintaining the training to the cortex-nuclei memory balance?
  - Use PCA to describe granule cells learning

References

Clopath, Claudia, Aleksandra Badura, Chris I De Zeeuw, and Nicolas Brunel. 2014. "A Cerebellar Learning Model of Vestibulo-Ocular Reflex Adaptation in Wild-Type and Mutant Mice." The Journal of Neuroscience : The Official Journal of the Society for Neuroscience 34 (21): 7203–15. `doi:10.1523/JNEUROSCI.2791-13.2014`.

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