Cerebellar Model Tested in Control of a Load-Carrying Robot
or
On the Importance of Representing One’s Dynamics

Iina Aaltonen and Harri Valpola

Laboratory of Computational Engineering
Helsinki University of Technology TKK
Motor control

- Motor cortex
  - motor command execution
- Cerebellum
  - motor learning and regulation
  - timing and prediction
- Sensory systems
  - feedback
Cerebellar model

• Supervised learning using a reflex
• Prediction and timing
• Adaptive part is linear
• Inputs
  – motor efference copies
  – sensory systems
    • position, tilt angle and derivatives
    • sigmoidal nonlinearities included
Robot with stationary load

No sensory delay

With delay
Changing context

• Representation of body and dynamics
  – essential for motor control
• If the context, e.g. body dynamics, changes, can cerebellum still control?
  – theoretical analysis suggests: dynamics affect the optimal control in a multiplicative manner
  – multisensory processing required
Passive dynamics (no control)

Load low

Load high
Robot with moving load

Without delay

With delay
Results

• Without delay, cerebellum learned to keep the load-carrying robot upright
• With delay, changing the dynamics was critical
  – using a linear combination of the inputs the cerebellum cannot achieve stable control
Conclusion

• Contextual information is needed to account for changed dynamics
  – current inputs cannot provide context
  – multisensory brain regions modulating unisensory regions?

• Future work
  – how to provide the cerebellum with the context?
Thank you