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

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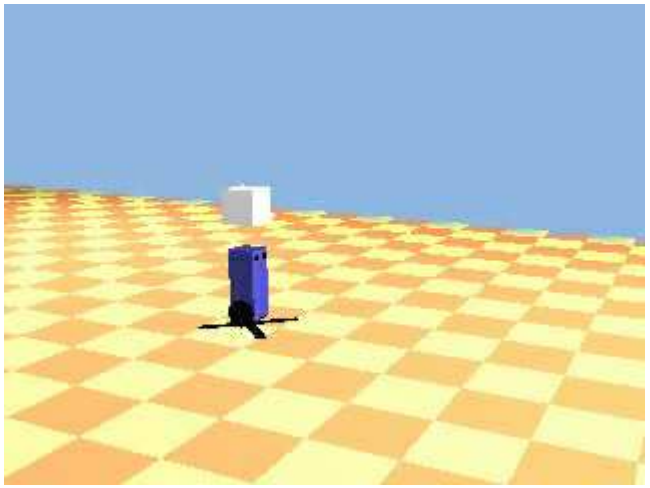
Motor control

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

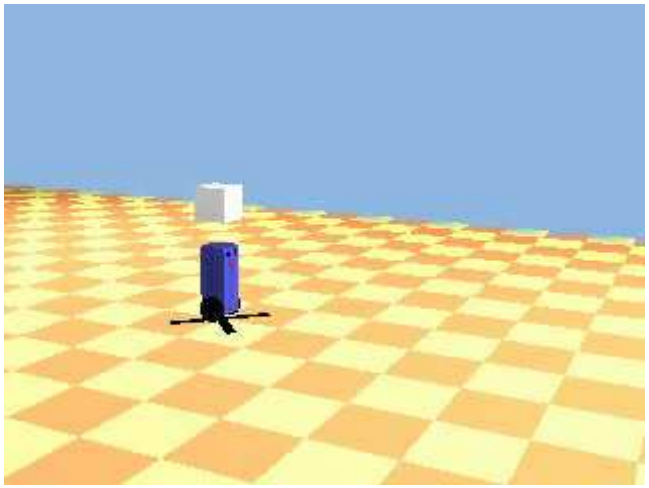
Cerebellar model

- 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

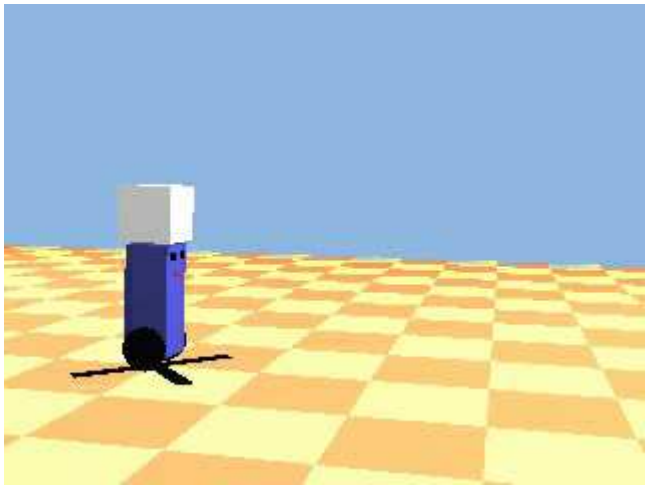


With delay

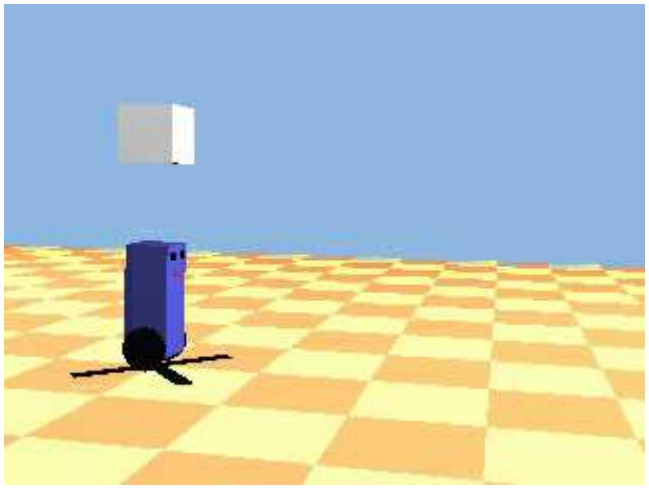
Changing context

- 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)

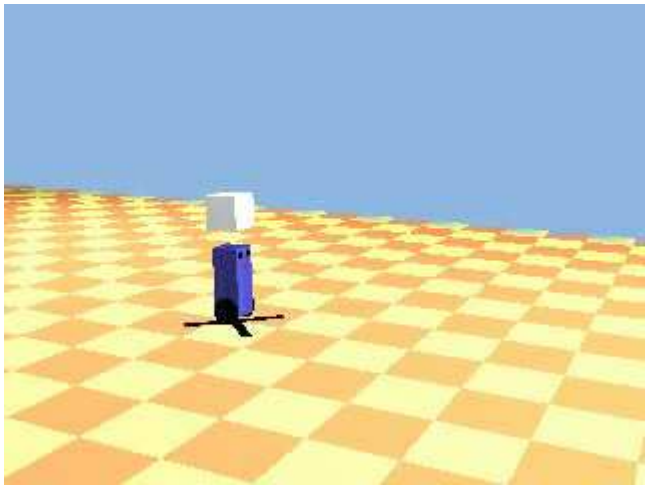


Load low

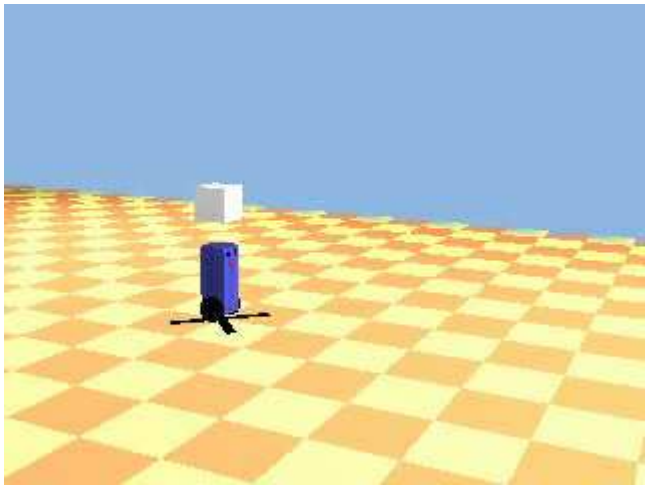


Load high

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