Good Enough

Optimal Control

Internal Models

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Spinal Circuitry as Optimal Regulator

Feedback gains for correcting small perturbations to standing posture
IEEE Trans on Automatic Control, 36:322-332
Spinal Circuitry as Optimizable Regulator

Internal Models for Computing Optimal Control
State & Efference Copy allows negative latency adjustment, giving the appearance of a forward model.

Task Recognition and read-out of previously stored program, giving the appearance of an inverse model.
Small Subset of Spinal Interneuronal Circuitry
Is this really modeled in the brain?

Modeled Pathways
1. Propriospinal
2. Monosynaptic Ia
3. Reciprocal Ia
4. Renshaw
5. Ib inhibitory
...or does the brain learn by trial-and-error to send commands that result in useful behaviors?

Task:

SET the gains of the SLR to resist an impulsive perturbation at the endpoint.

Cost = \[ \int (\text{Endpoint deviation from initial position})^2 \, dt \]
Learning curves

- Cost with no muscular action
- Good-enough performance

Jared Goodner, George Tsianos, Yao Li
Learning curves

Cost with no muscular action

Good-enough performance

Convergence rate

Jared Goodner, George Tsianos, Yao Li
BioSearch™ Corticospinal Learning Algorithm

Hypothesis: Landscape has so many “good enough” local minima that a Random Walk is a viable learning process

Steps vs. Learning Curves

Optimal step size

Delta gain distributions

Simulation

Cost

ΔC

ΔC*

Gain

Delta gain

Delta gain1

Delta gain2

Delta gain3

Delta gain4

Delta gain400
BioSearch Learning Curves
perturbing impulse at randomized times
Motor Learning ≠ Task Recognition

Take your pick…

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Engineers build models to understand complex systems, e.g. posters at this meeting by Li, Loeb & Levine; Tsianos, Goodner & Loeb. The brain doesn’t build models and it doesn’t understand itself.
A Brief History of Theoretical Motor Neuroscience

Sensory

Motor Invariance

R.I.P.

Stiffness

Tensors

Reserved for Equilibrium Point

Partitioning

Over Complete

Felix

Tombstone Memorial Jerry G.

Task Groups

Sympathy Frances

Graveyard of the Biomechanically Damned