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Presentation Abstract

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Title:	Infinite horizon optimal control framework for goal directed movements
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Authors:	***D. HUH**[1,2], E. TODOROV[3], T. SEJNOWSKI[1,2]; [1]Salk Inst., La Jolla, CA; [2]UCSD, La Jolla, CA; [3]Univ. of Washington, Seattle, WA

Abstract: Most optimality-principle-based models of goal directed movements have been formulated within a fixed time-window. We propose an alternative formulation, based on the infinite-horizon framework, where movements do not have definite ending-time. It uses a mixed performance criterion of reward and energy-cost, which motivates and regularizes movements, respectively. For reaching movements, the relevant reward function has a saturating shape, consistent with a previous experimental result [1].

The iHOC (infinite-horizon-optimal-control) model has three (spatio-temporal) scaling parameters: one spatial parameter, δ, (target width, or accuracy requirement), and two temporal parameters, $1/\gamma$, which appears in the relative weight between energy-cost and reward, and σ^2, the muscle noise coefficient (multiplicative noise). γ determines the overall movement tempo, and therefore it is interpreted as the motivation level, while σ^2 determines the upper limit to the fastest tempo (Fitts' law relation). This formulation is consistent with recent findings, which mark motivation level as well as noise as determinant factors of movement tempo [2]. γ may be related to the tonic level of dopamine, as observed in PD patients and Tourette's syndrome patients.

iHOC generalizes the previous finite-horizon models: In deterministic limit ($\gamma \ll 1/\sigma^2$), iHOC predicts minimum-energy trajectories, while in the infinite motivation limit ($\gamma \gg 1/\sigma^2$), it reduces to the minimum-variance model. The fHOC (finite-horizon-optimal-control) is another special limit of the iHOC.

The optimal control law of iHOC formulation generates stable, time-independent dynamics. Moreover, it does not suffer from the critical problems of the fHOC formulation, such as movement initiation problem and non-zero bias from target location. These properties make iHOC an ideal framework for implementing real-time sensori-motor feedback controllers (with recurrent neural networks, for instance), which will be valuable computational models of the biological motor control system.

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[2] Mazzoni P, Hristova A, Krakauer JW. (2007) Why don't we move faster? Parkinson's disease, movement vigor, and implicit motivation (2007). *Journal of Neuroscience* (2007) July; 27(27):7105-16.

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