Human Cyber-Physical Systems

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Modeling of Musculoskeletal Dynamics and Human Control

This topic included efforts to model and predict human movement under directed tasks (for instance to go from one point to another or to track a reference trajectory). The formulation of hypothetical human control laws is included. Human control is poorly understood and researchers often adopt known paradigms (such as PID, backstepping or optimal control) and proceed to tune the corresponding parameters for resemblance to natural human motion, data fitment or to match known qualities of human control such as the ability to track, maintain stability or adapt to task changes or parameter variations.

We are no exception and have considered our own set of paradigms to model human control actions. Optimality, in the form of least physical effort, is a common link between all these approaches. Our specific efforts have been motivated by data fitment, simulation speed, analytical tractability and guaranteed properties (such as feasibility in certain constrained optimization problems).

1. Trajectory optimization and predictive simulation: Trajectory optimization for postural control identification: [7, 5] (stochastic), [6, 5] (deterministic); Rowing machine modeling, simulation and optimal control: [4, 3]

2. Backstepping control of MSD models: [8, 10, 11, 9]. Passivity of muscle dynamic models: [1].

3. Differential flatness and sum-of-squares optimization for MSD control: [2].

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