

Predictive Simulation of Biological Motion using SCONe

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2 parts, what why how / example

Inverse Simulation

- derive unobservable metrics
- lacks validation
- can't produce new movement

Predictive Simulation

- Neural Model for excitation
- joint limit model to limit issues

Neural Model (Controller)

- Open loop
 - + excitation \rightarrow MSK Sim \rightarrow Simple but limited
 - Closed loop
 - + \rightarrow excitation \rightarrow MSK Sim \rightarrow feedback enabled
- stable, but need feedback model

Parameter Optimization

- Set of control params $P = \{p_1 \dots p_n\}$
- + trajectory control points
- + feedback gains
- + neural network params.
- + etc.
- find best P according to obj. function

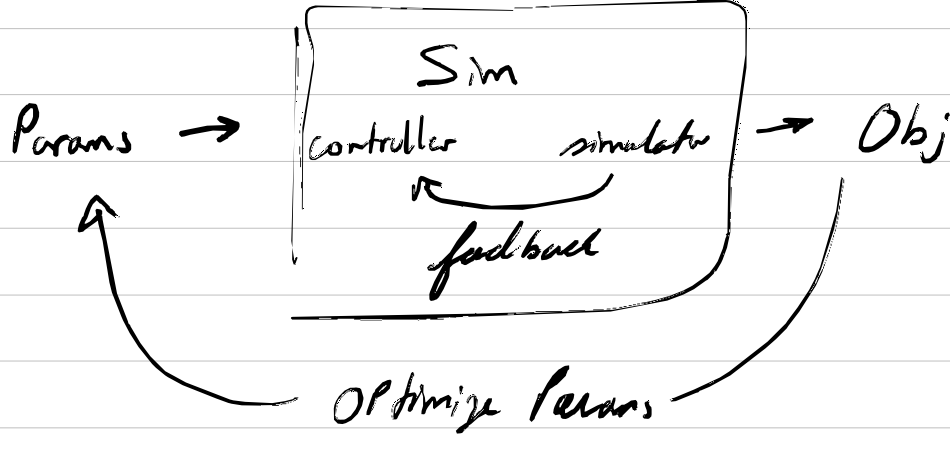
Objective Function

$O(P)$ = optimize for metabolic cost
COM velocity
distance to target pose
avoid joint load / muscle length

non-trivial, weighted combination

Optimization Strategies

- Shooting / Evolutionary Strategy (SCONe uses)
- + flexible, black box, optimizes everything
- + slow, not usable $\dim(P) > 100$
- Direct Collocation
- + approximate dynamic state using splines
- * fast works well for trajectory optimization
- * less flexible, lots of derivatives
- * upcoming project MOLO
- Reinforcement Learning
- + upcoming approach



Covariance Matrix Adaptation (CMA)

- maintain population / distribution
- + Sample, evaluate, adapt

Demos

- High Jump
- + maximize COM height
- + open loop controller, easy
- Walking
- + minimize cost of transport
- + closed loop

Future Direction of SCONe

- 3D Gait model
- faster simulation
- user feedback

Questions / Answers (5 year old video ...)

- Q: Shooting vs collocation vs RL. When does shooting shine?
- A: If you have any type of feedback controller; optimize model parameters (e.g. attachment point of the muscles)
- Q: 3D gait model, where is that?
- A: optimization
- Q: Free moments using SCONe?
- A: Yes, Perturbation Controller
- Q: Validation?
- A: Best is to produce motion that matches experimental data
- Q: Link between SCONe & MATLAB?
- A: Scripting interface (lua file)
- Q: SCONe vs MOLO
- A: Relatively young. Main strength of MOLO \rightarrow optimize fast forward really quickly