Encoding Sensorimotor Redundancy for Flexible Behavior

Oliver Herbort
Supervisors: Martin V. Butz & Joachim Hoffmann

Department of Cognitive Psychology
University of Würzburg

11.01.2007

Contents: Computational models of...

highly flexible behavior...

and how it can be acquired (motor learning)

Focus on reaching movements

Computational Models of Motor Learning

actions

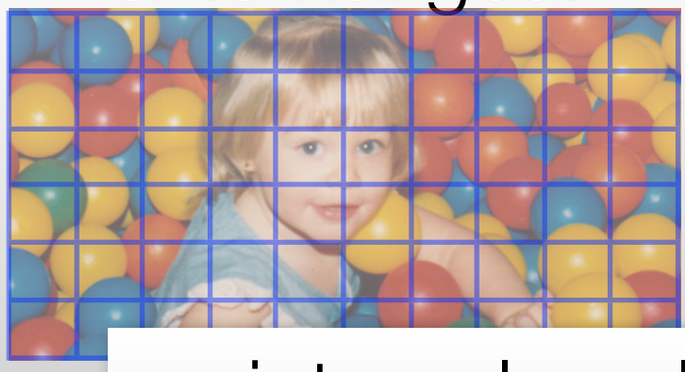
Learning

optimized inverse model

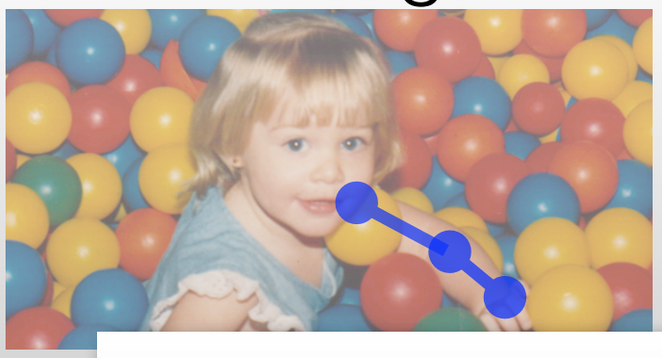
sensory state goal

- comfort
- smoothness
- reliability

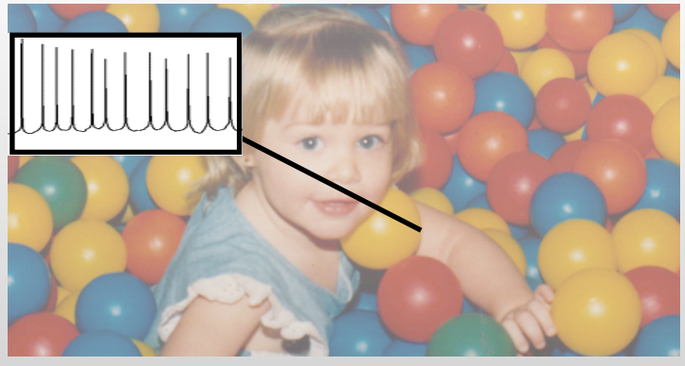
external goal



internal goal



motor commands



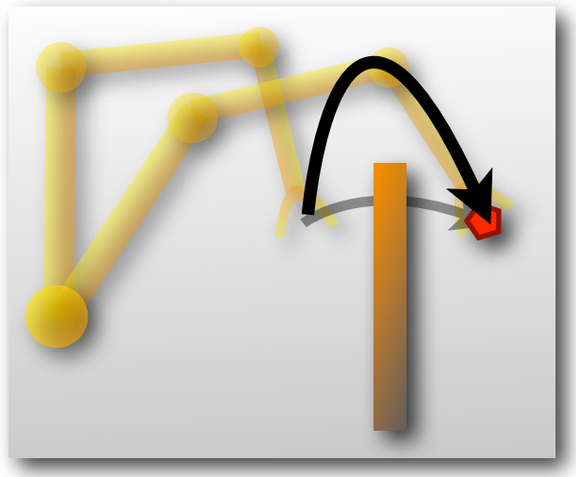
Kinematic inflexibility

optimized inverse model

goal

provides THE perfect action

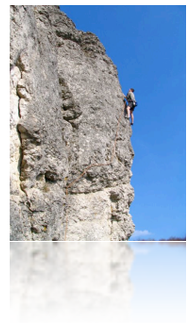
new kinematic constraints



obstacles

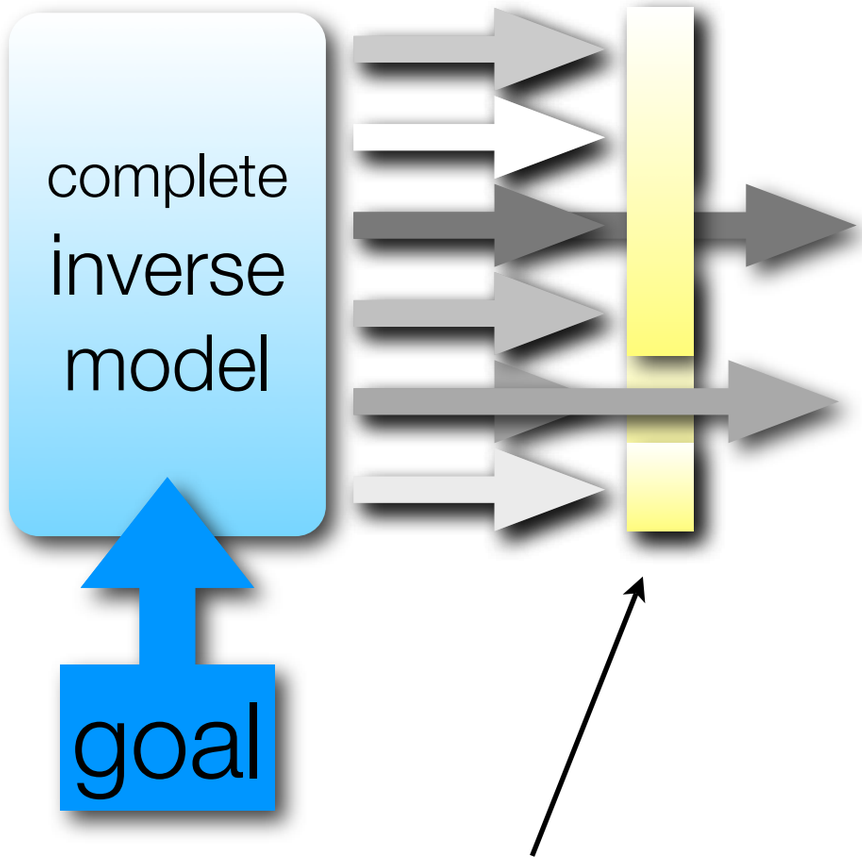
No flexible behavior

Computational Models of Flexible Behavior



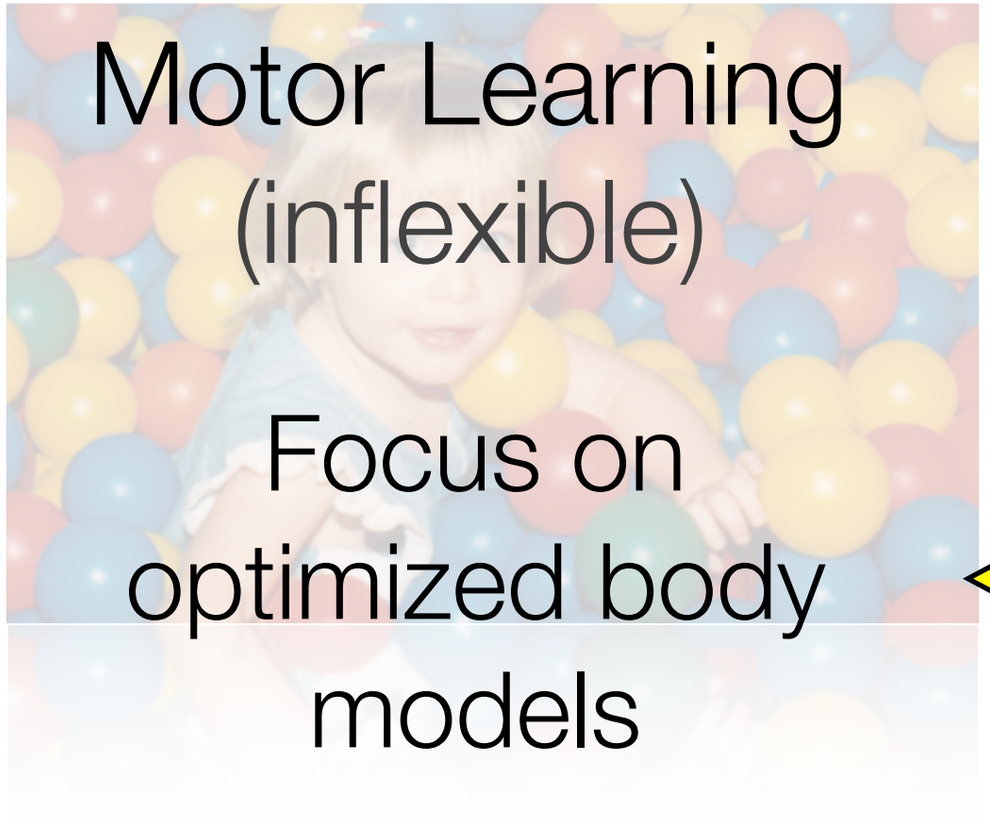
Learning

Control



select best action
task dependently

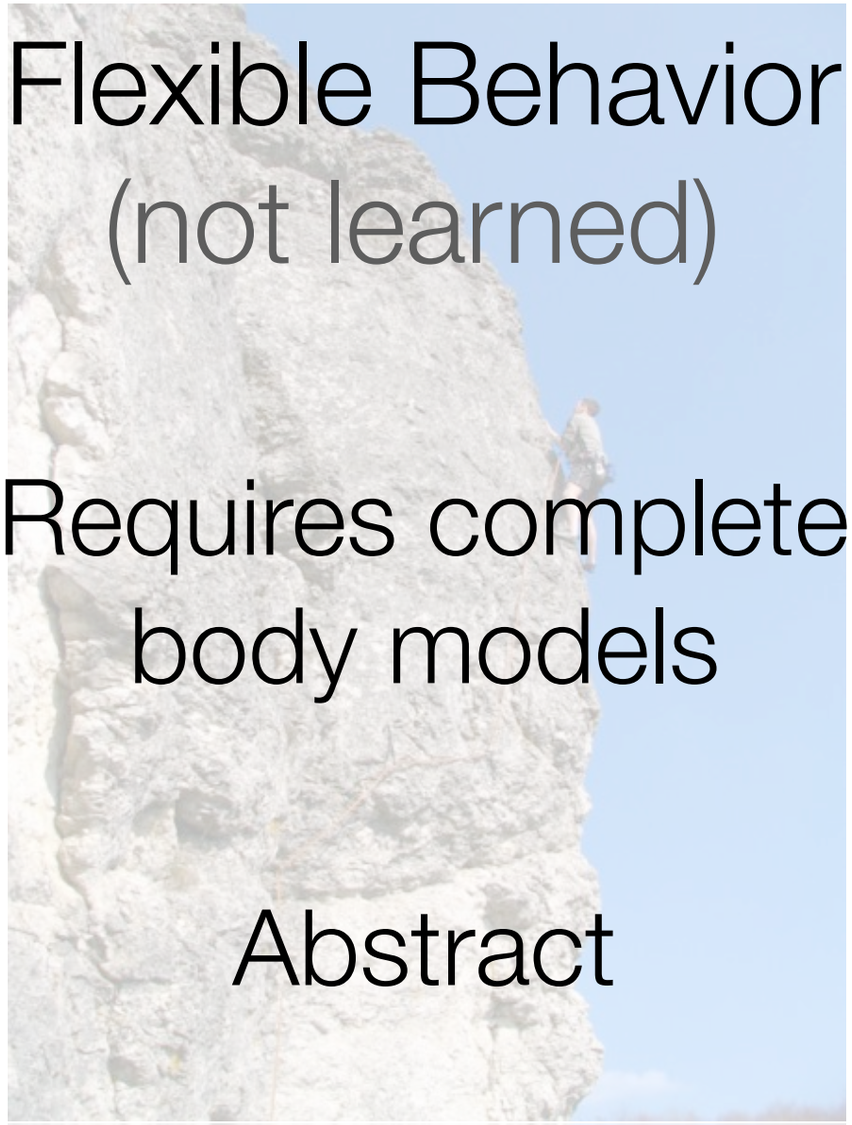
Why don‘t they go together?



Motor Learning
(inflexible)

Focus on optimized body models

Grounded



Flexible Behavior
(not learned)

Requires complete body models

Abstract

Merging Motor Learning and Flexible Behavior

Motor Learning (inflexible)

unsupervised learning of complete sensorimotor model

Grounded

Flexible Behavior (not learned)

Rely on complete body models

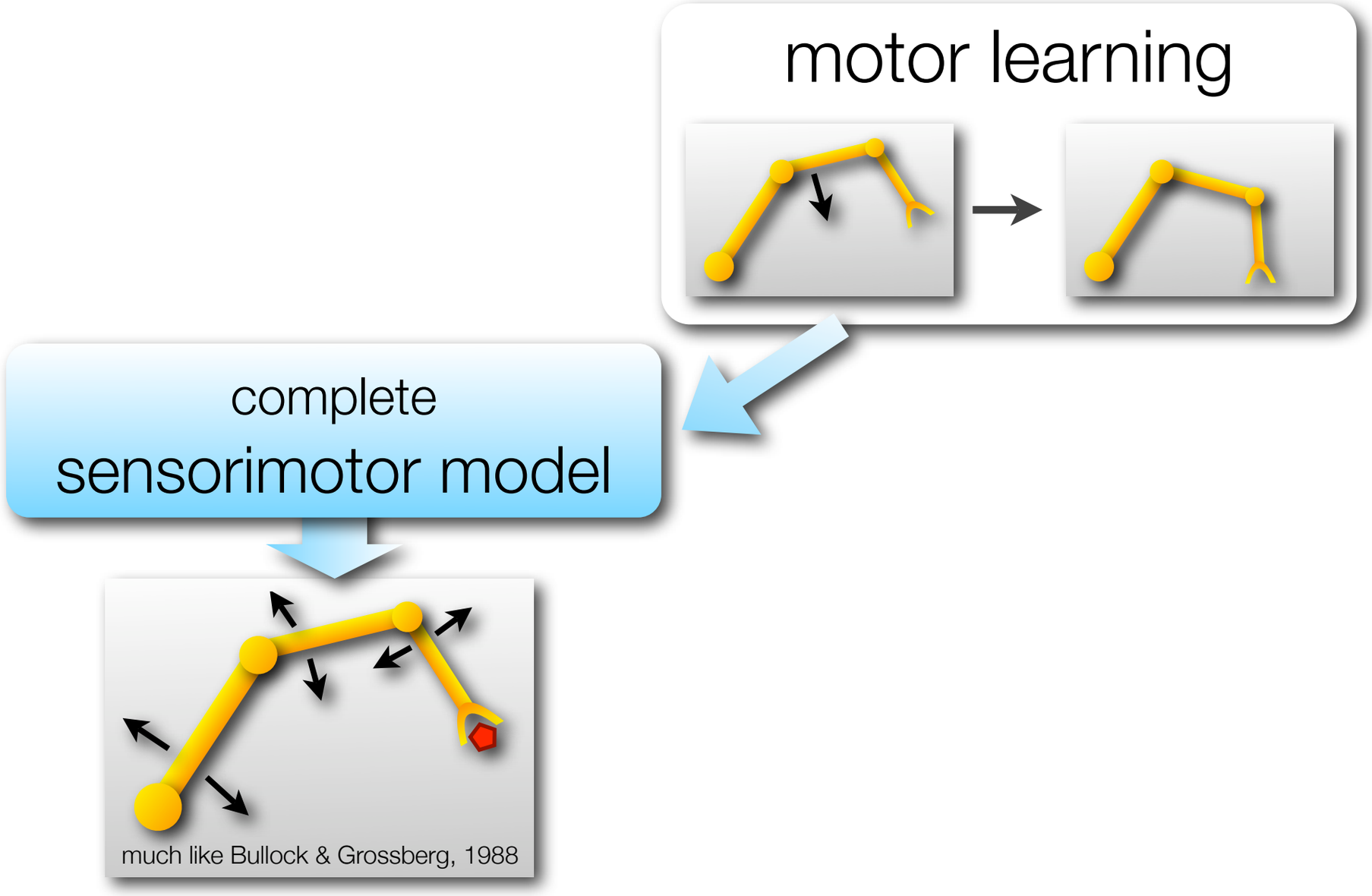
Abstract

SURE_REACH

Sensorimotor Unsupervised Redundancy Resolving Architecture

The SURE_REACH Approach

Acquiring a complete sensorimotor model



The SURE_REACH Approach

Motor control

goal

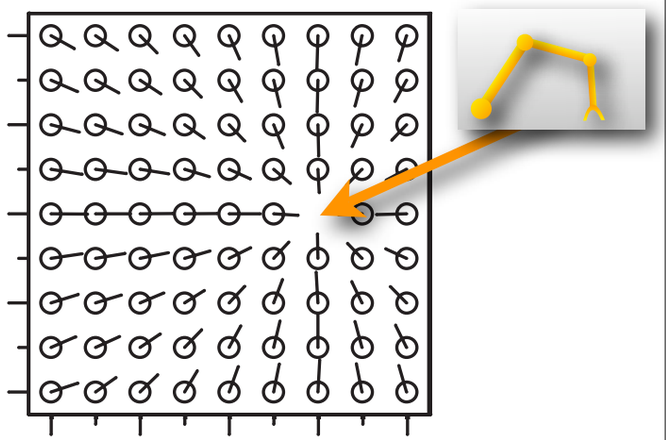
goal: posture space

complete
sensorimotor model

posture space

much like Bullock & Grossberg, 1988

Generates task dependent
sensory-to-motor mapping



The SURE_REACH Approach

Flexible goal representations

goal

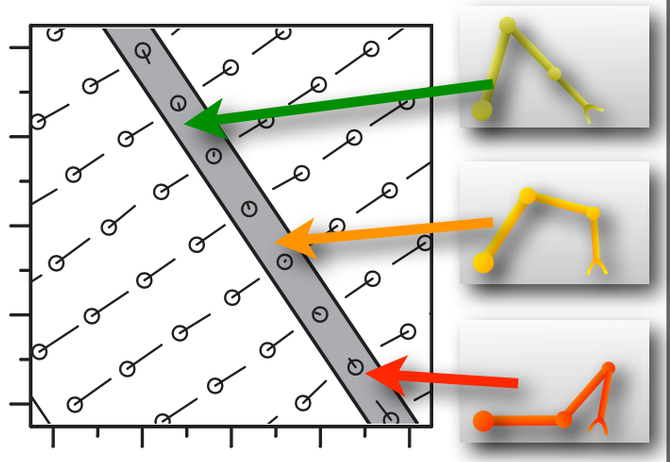
goal: posture space

complete
sensorimotor model

posture space

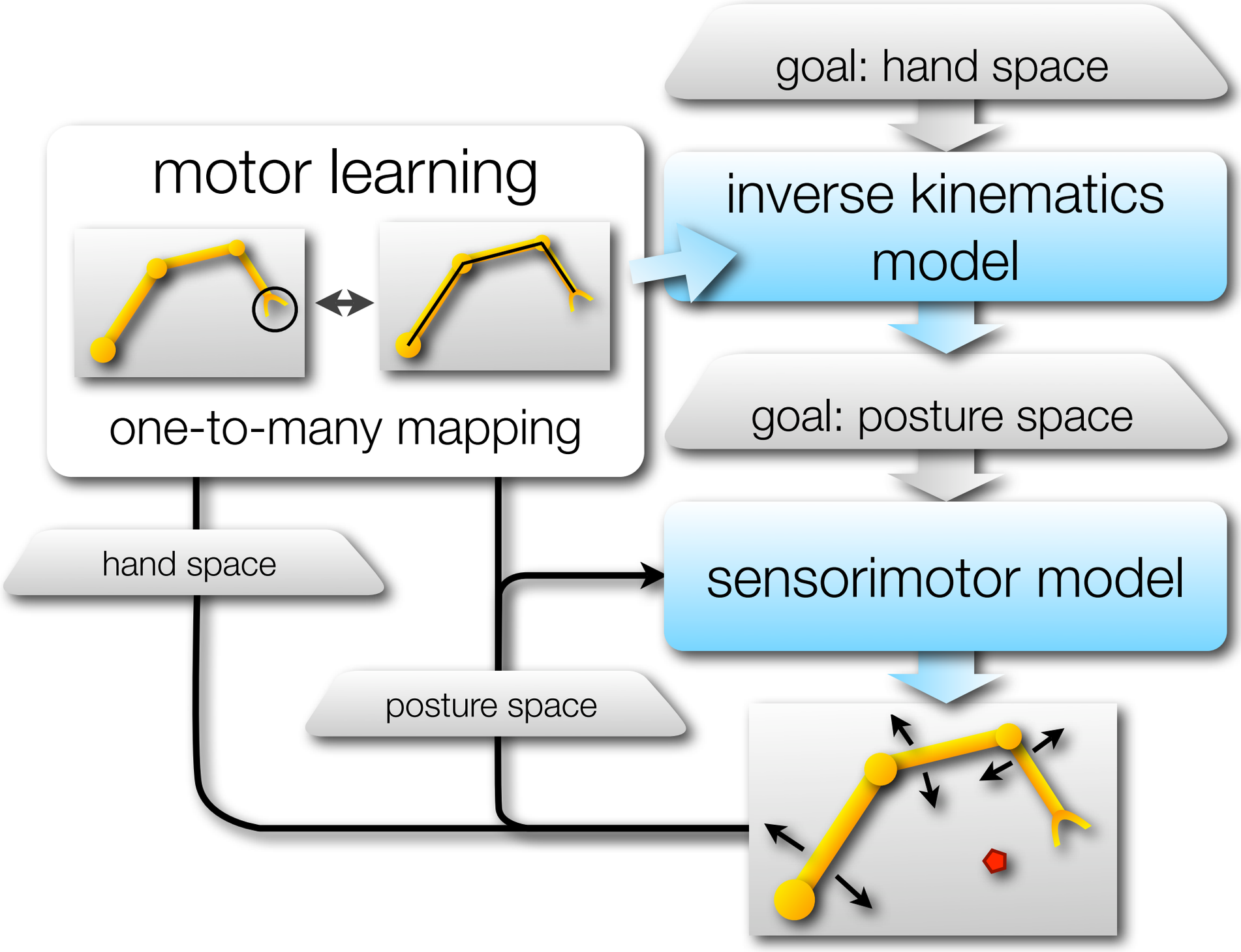
much like Bullock & Grossberg, 1988

Generates task dependent sensory-to-motor mapping



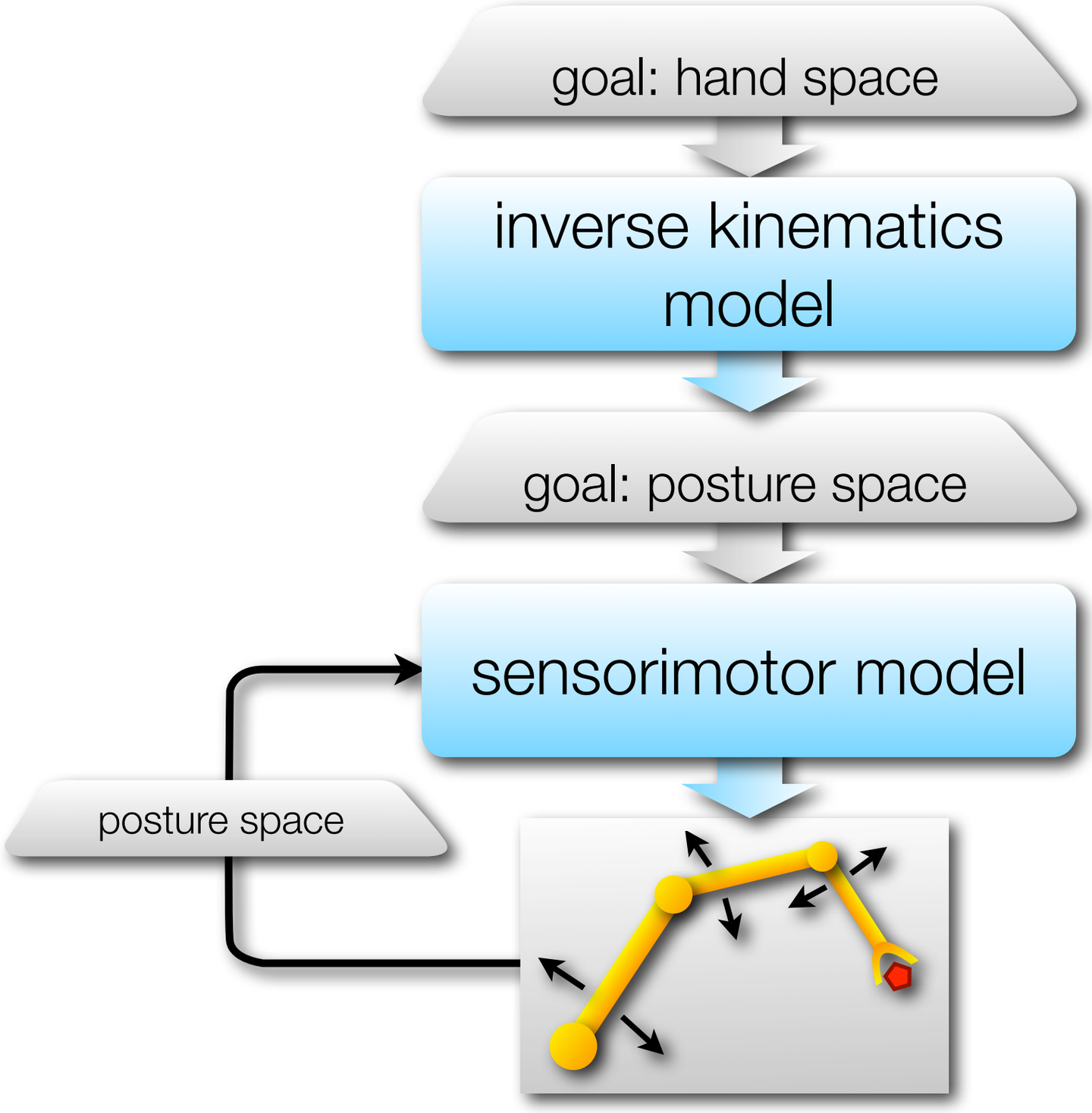
The SURE_REACH Approach

Acquiring a complete inverse kinematics model



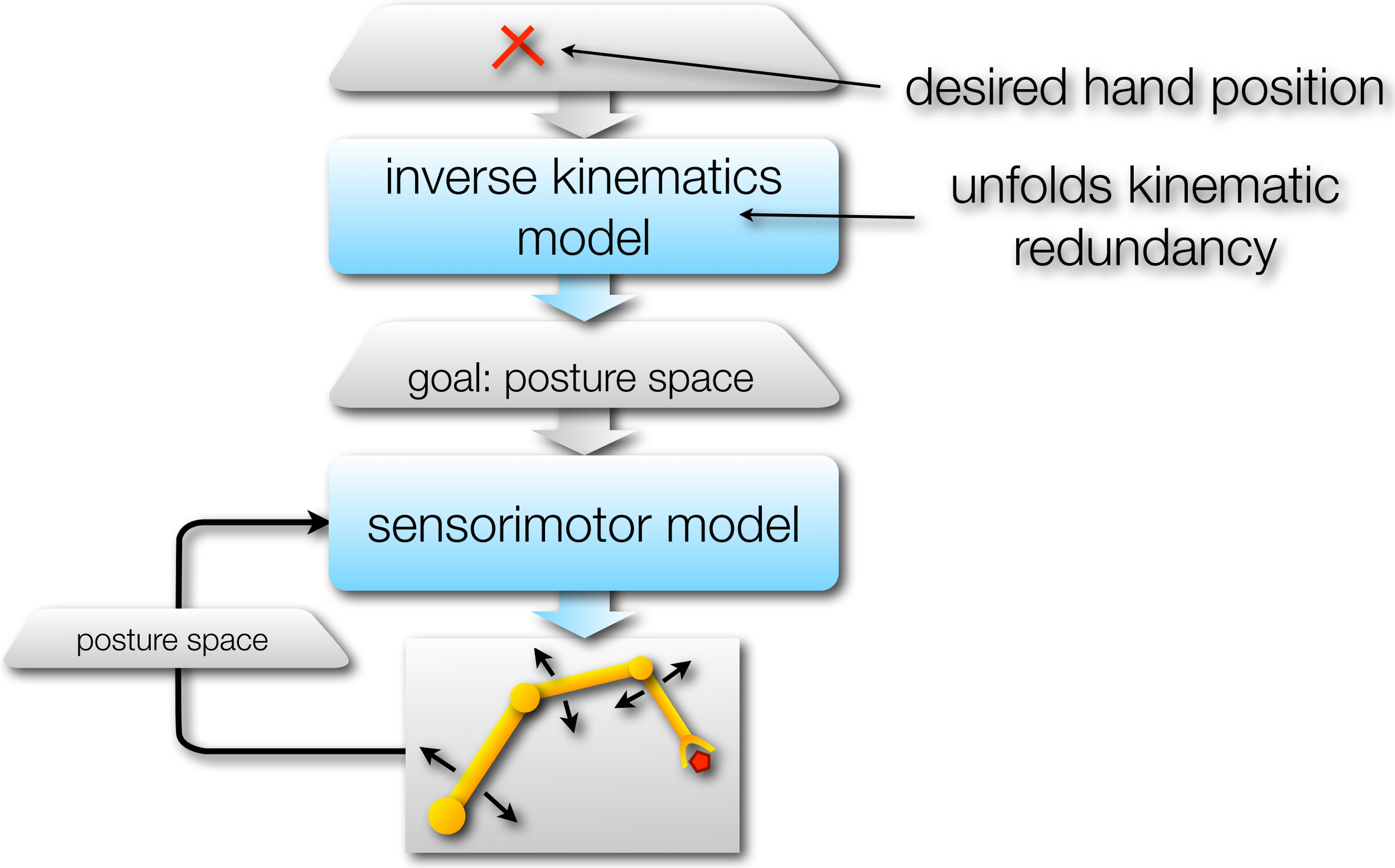
The SURE_REACH Approach

Motor control



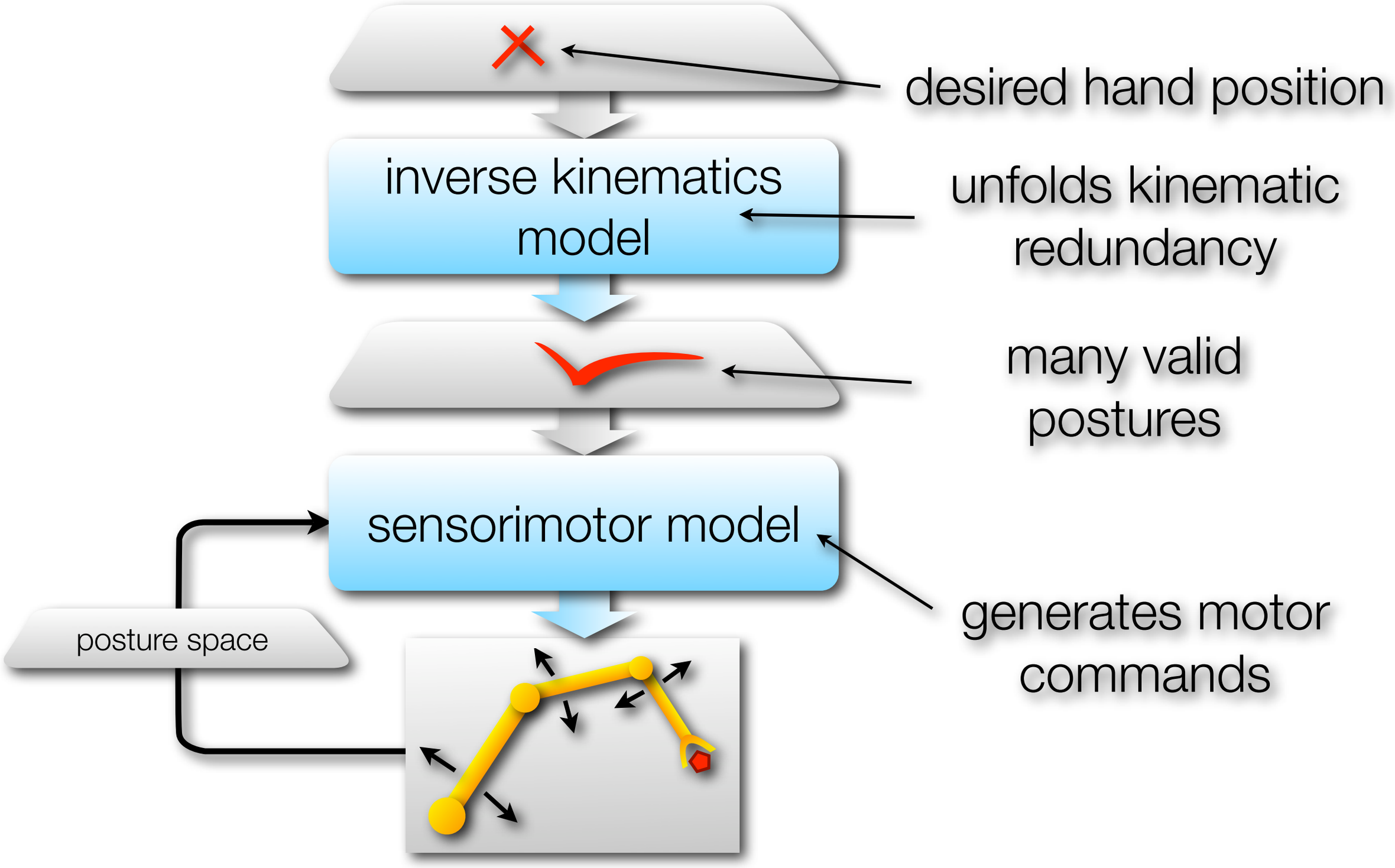
The SURE_REACH Approach

Motor control



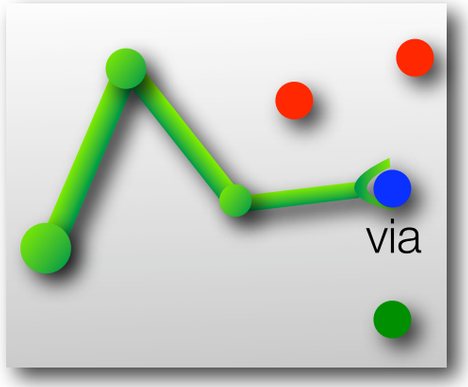
The SURE_REACH Approach

Motor control



Modularity enables Flexible Behavior

incorporating kinematic constraints



anticipation of future tasks

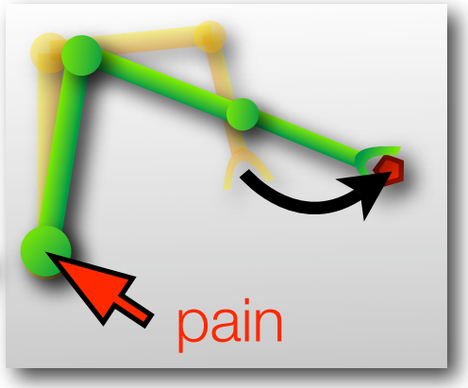
hand

inverse kinematics model

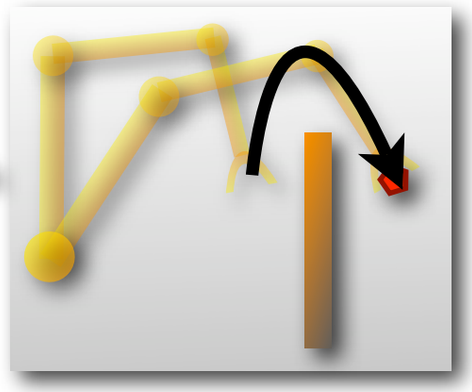
postures

sensorimotor model

posture space

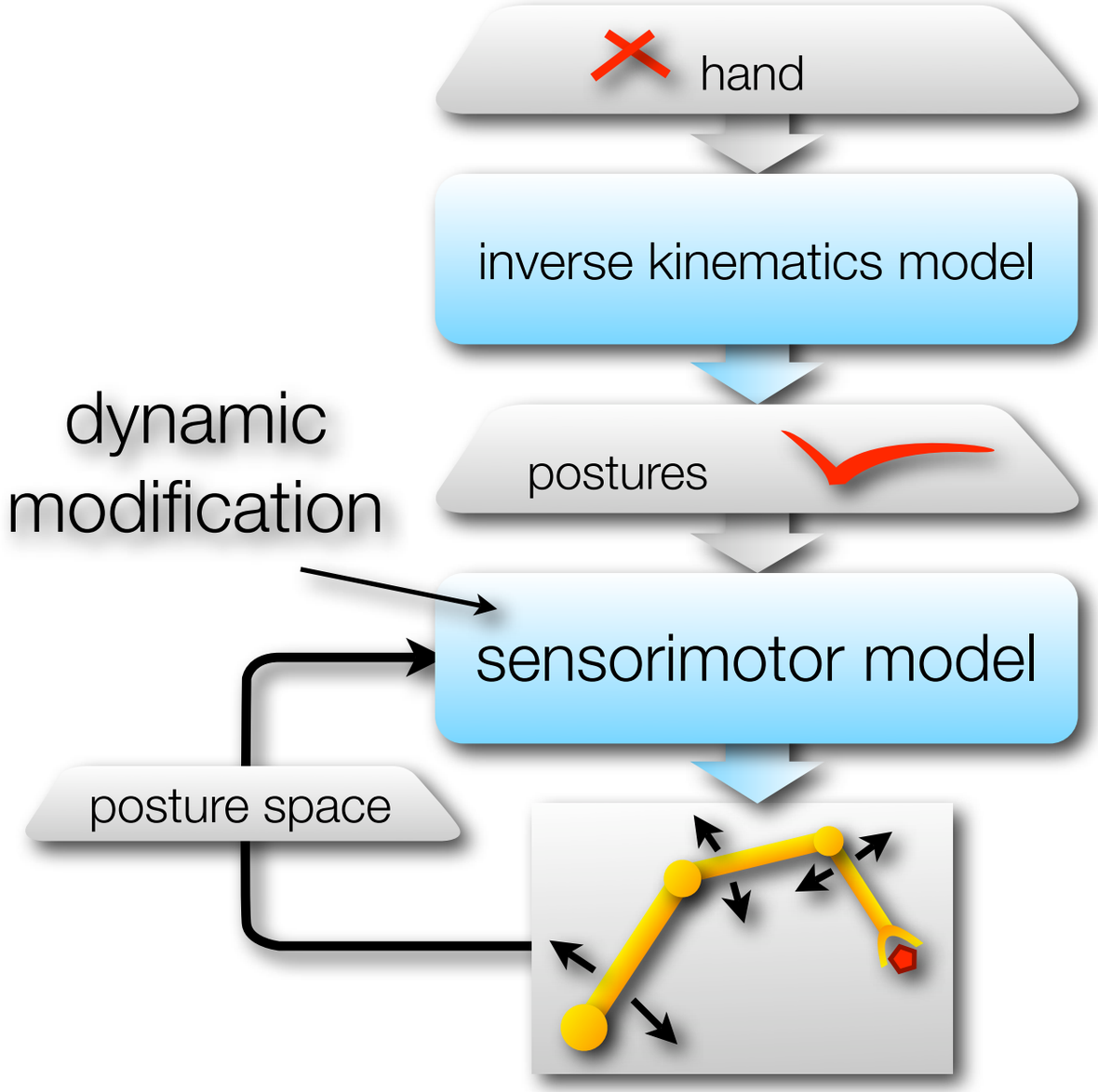


adjustment to novel costs



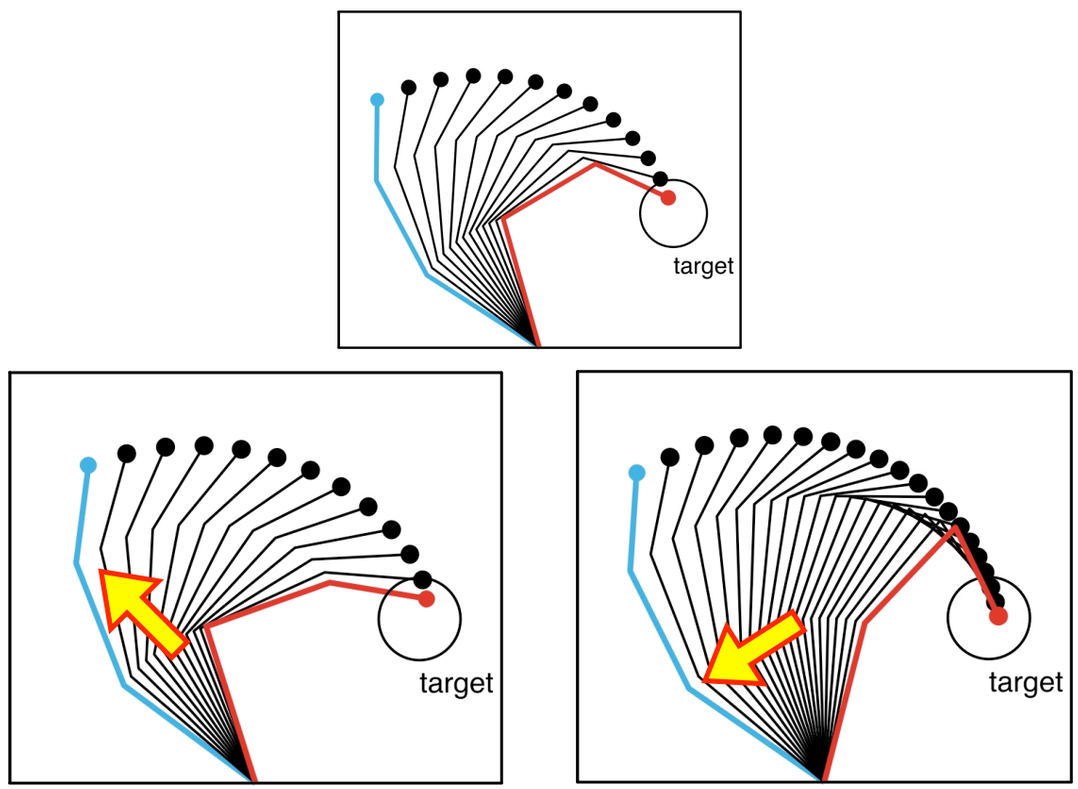
obstacle avoidance

Example: Novel Optimality Criteria



Task:
changed movement costs

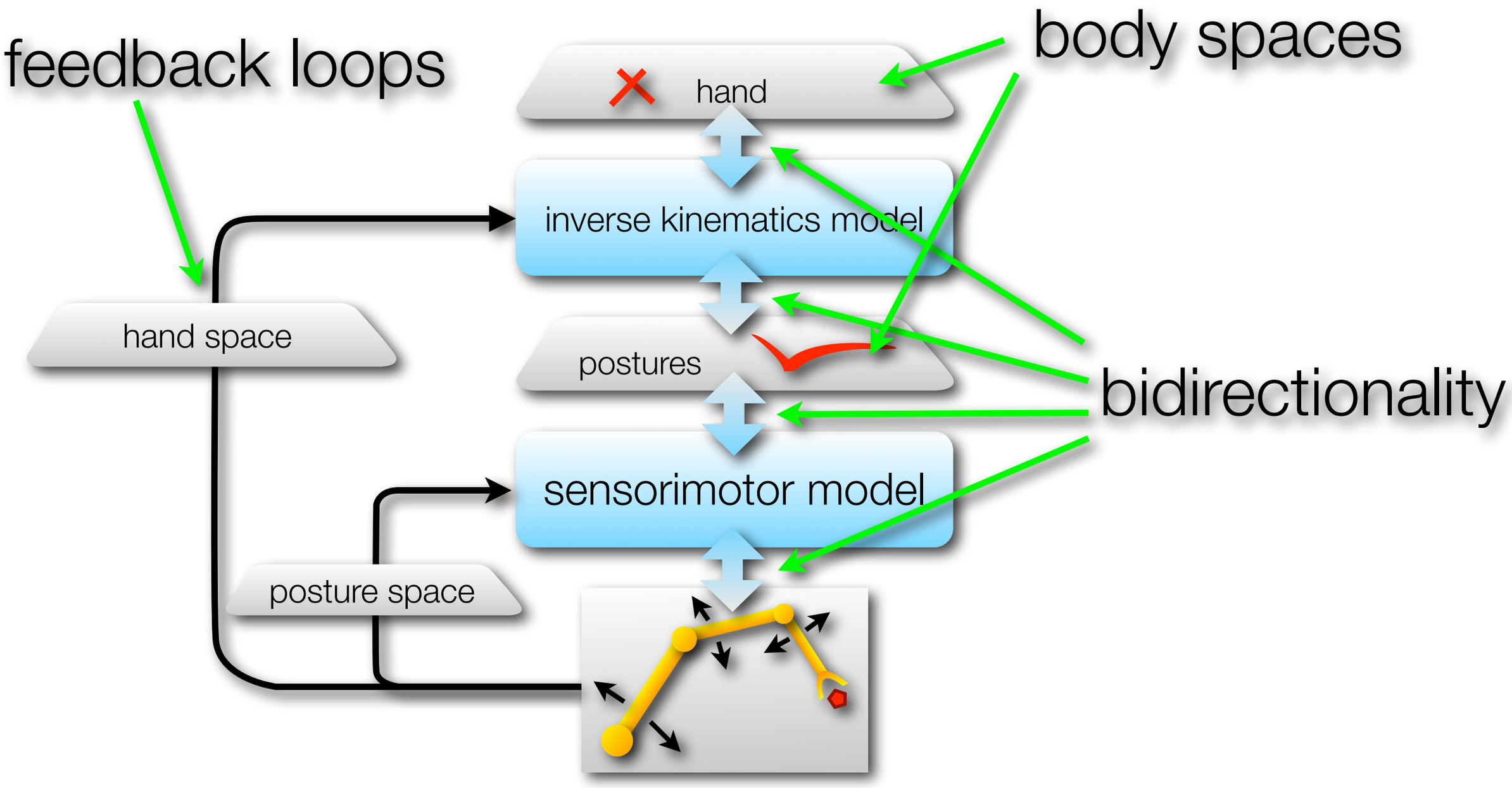
Results:



Psychological and Neurophysiological Relevance

- Psychology
  - Temporal aspects of motor control during learning
  - Priming effects
- Neurophysiology
  - Population encoding
  - Synaptic learning rules

Outlook


feedback loops
body spaces
hand
inverse kinematics model
hand space
postures
bidirectionality
sensorimotor model
posture space

Conclusion

flexible behavior

SURE_REACH

Exploiting Redundancy for Flexible Behavior: Unsupervised Learning in a Modular Sensorimotor Control Architecture (submitted).

Thank you for your attention

- email: oliver.herbort(at)psychologie.uni-wuerzburg.de
- url: http://www.psychologie.uni-wuerzburg.de/i3pages/

- Herbort, O., Butz, M. V., & Hoffmann, J., (2005). Towards an adaptive hierarchical anticipatory behavioral control system. In C. Castelfranchi, C. Balkenius, M. V. Butz, & A. Ortony (Eds.), From reactive to anticipatory cognitive embodied systems: Papers from the AAAI fall symposium (p. 83-90), Menlo Park, CA: AAAI Press.
- Butz, M.V., Herbort, O., & Hoffmann, J., (submitted). Exploiting Redundancy for Flexible Behavior: Unsupervised Learning in a Modular Sensorimotor Control Architecture.