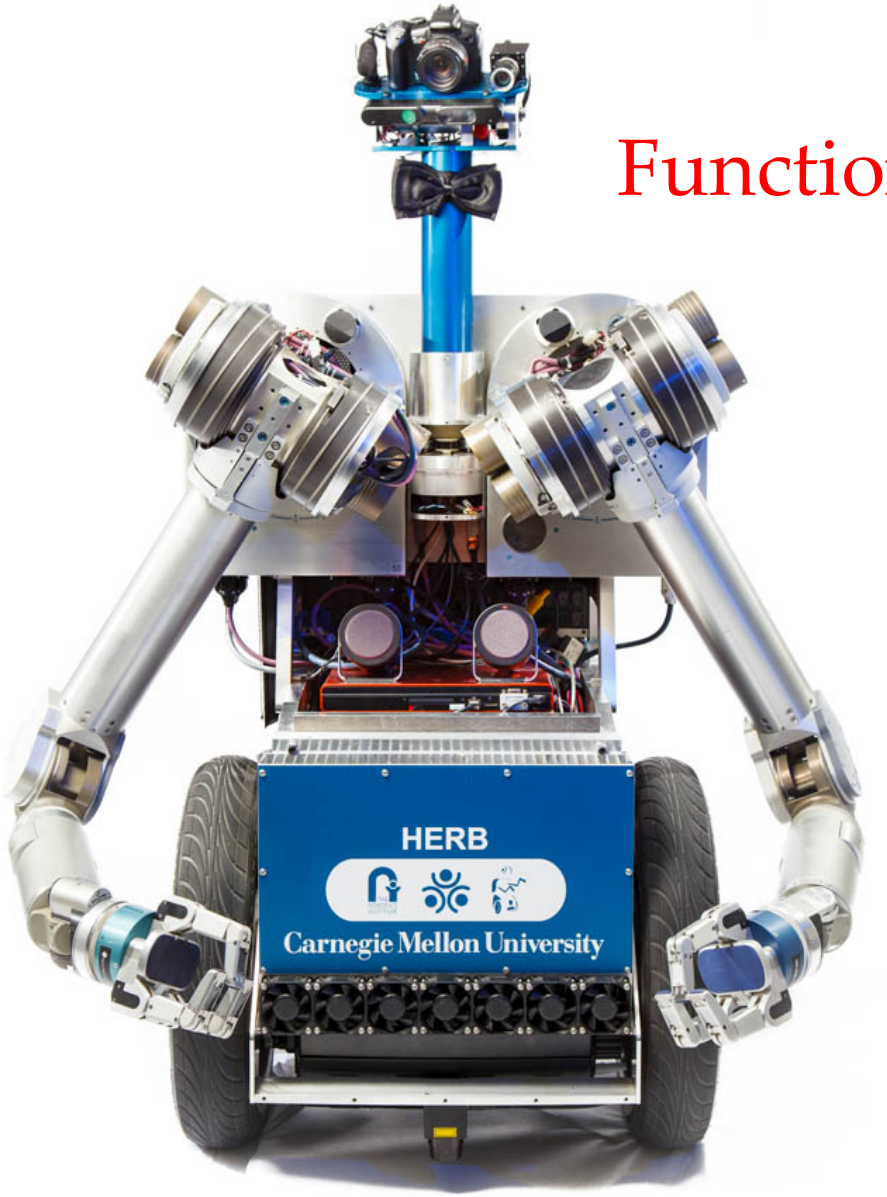
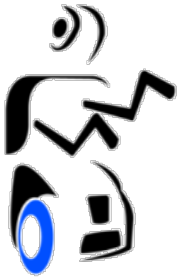


CHOMP

Functional Gradient Optimization for Manipulation



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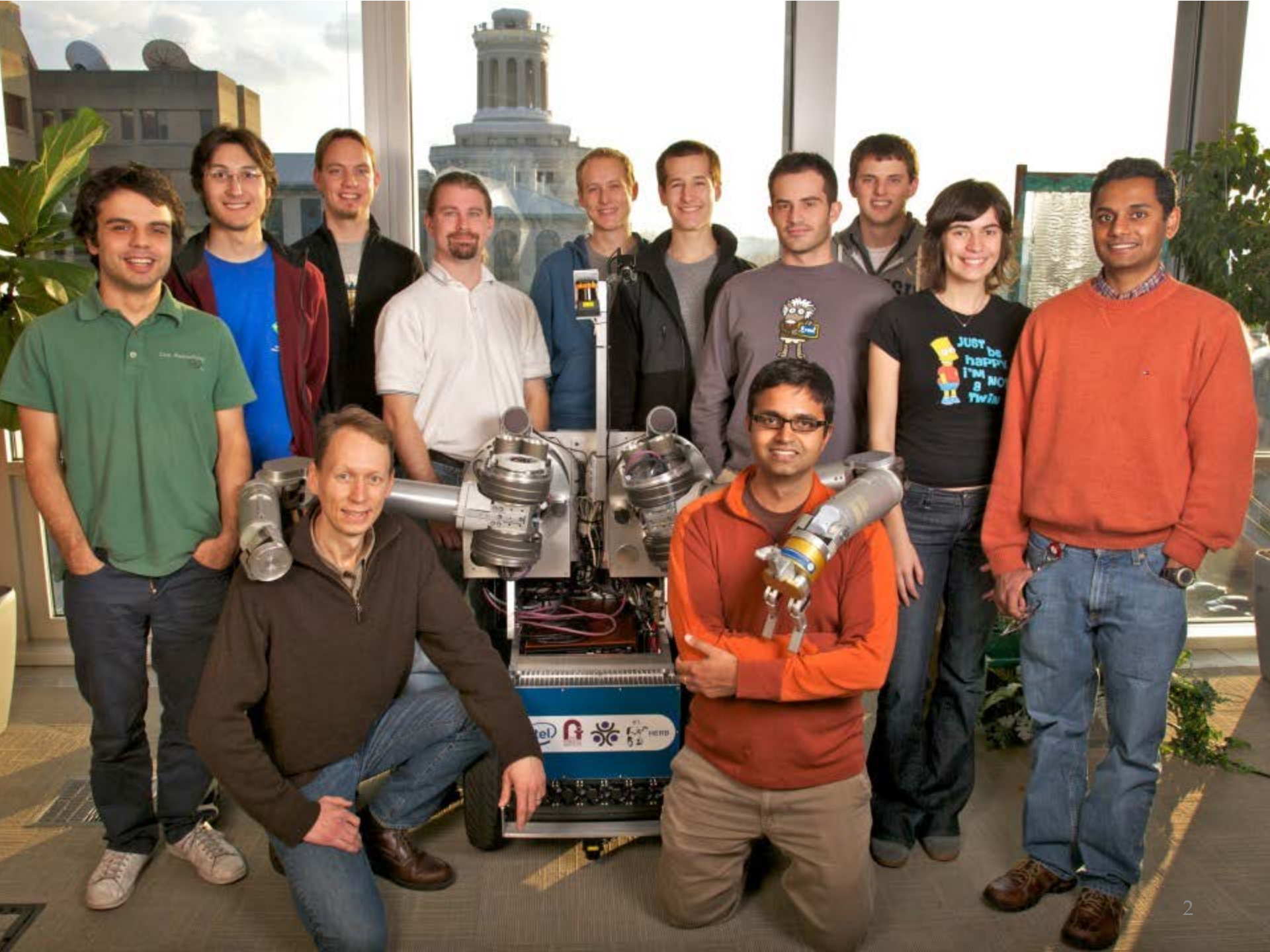
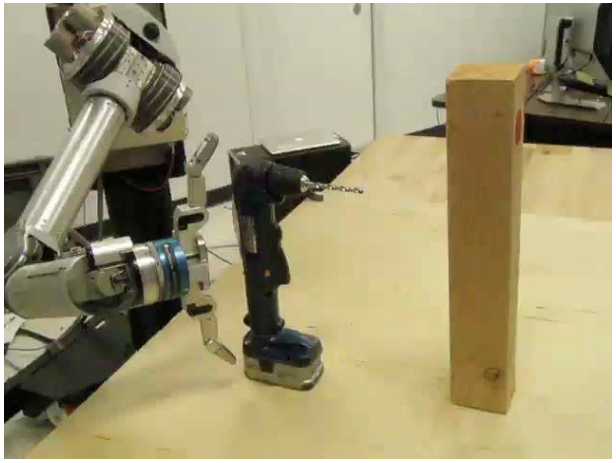
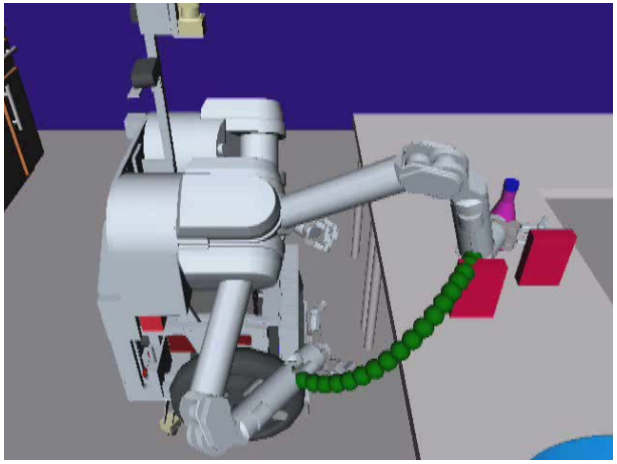
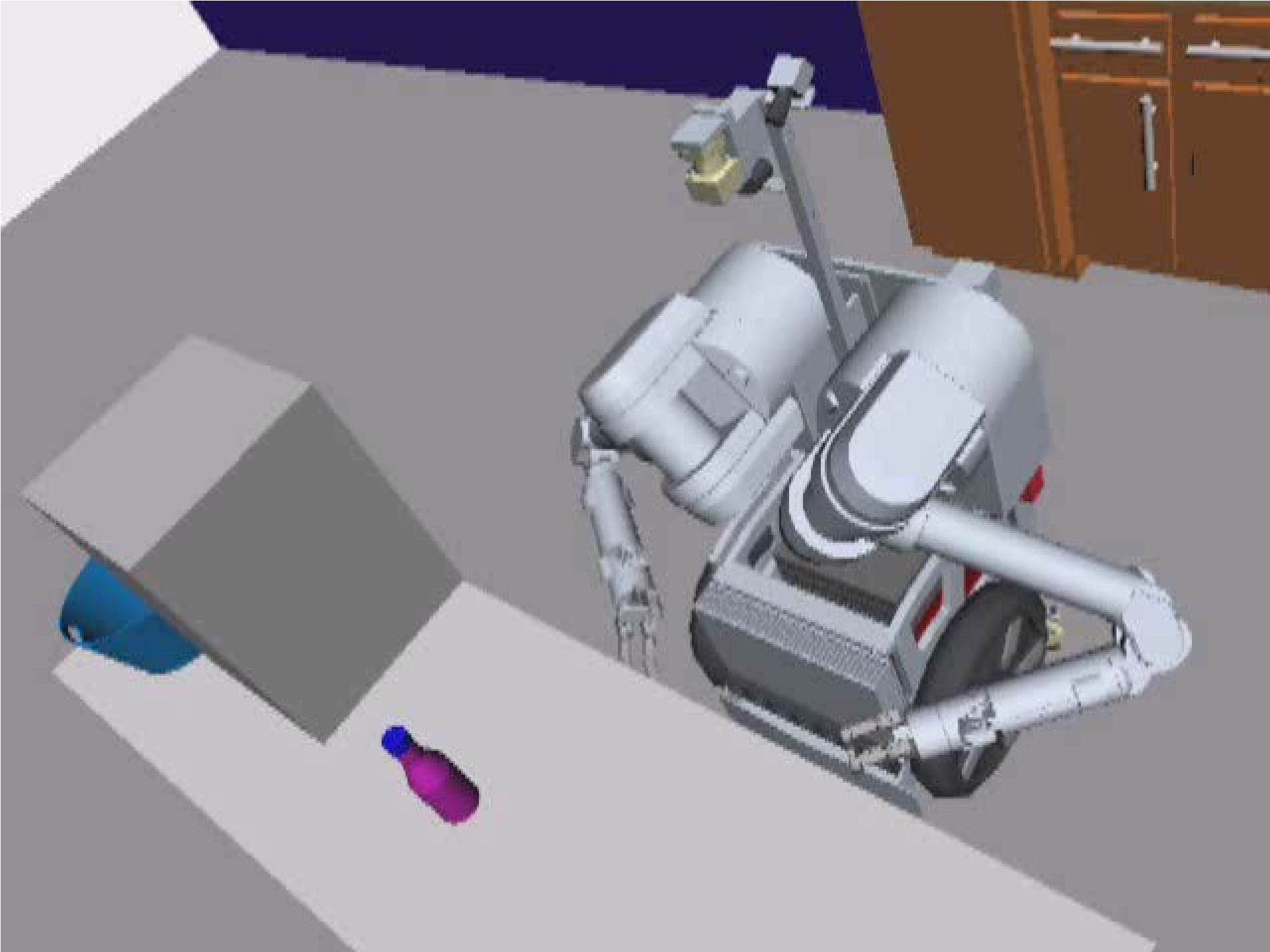

JUST be happy I'M NOT A TWIN
HERB


x3





Motion




Sprite

Optimal Motion

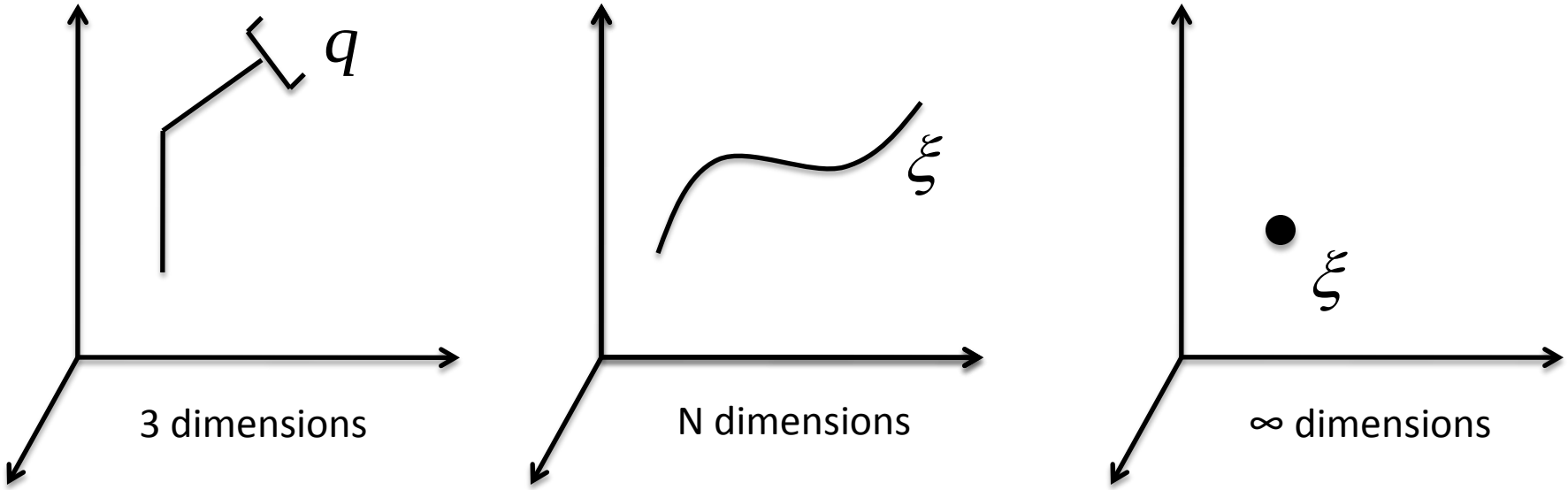
Optimal Motion with Functional Gradient Optimization

CHOMP: Covariant Hamiltonian Optimization for Motion Planning.

Zucker, Ratliff, Dragan, Pivtoraiko,
Klingensmith, Dellin, Bagnell, Srinivasa

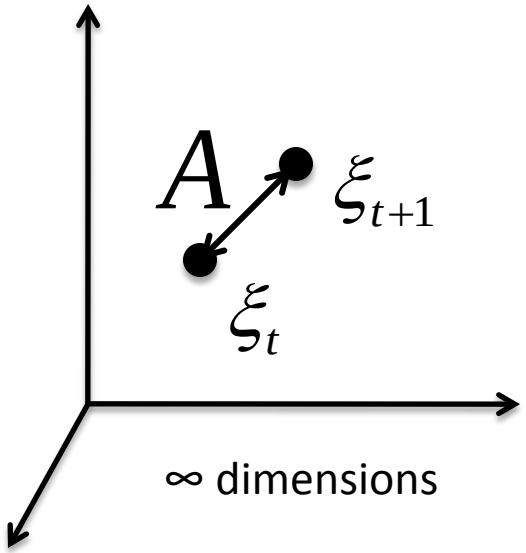
International Journal of Robotics Research (IJRR) 2013.

Three spaces of manipulation planning



W Q Ξ

$$\Xi$$



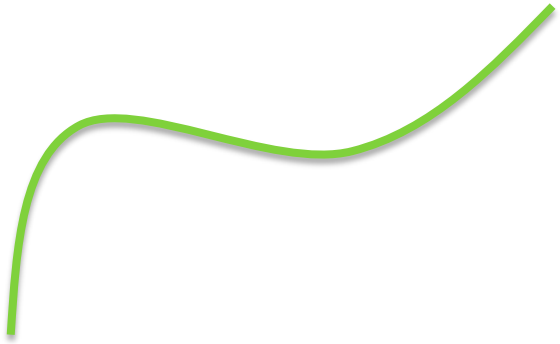
Infinite Dimensional Hilbert Space

Cost Functional

$$U[\xi] = \lambda f_{smooth}[\xi] + f_{obs}[\xi]$$

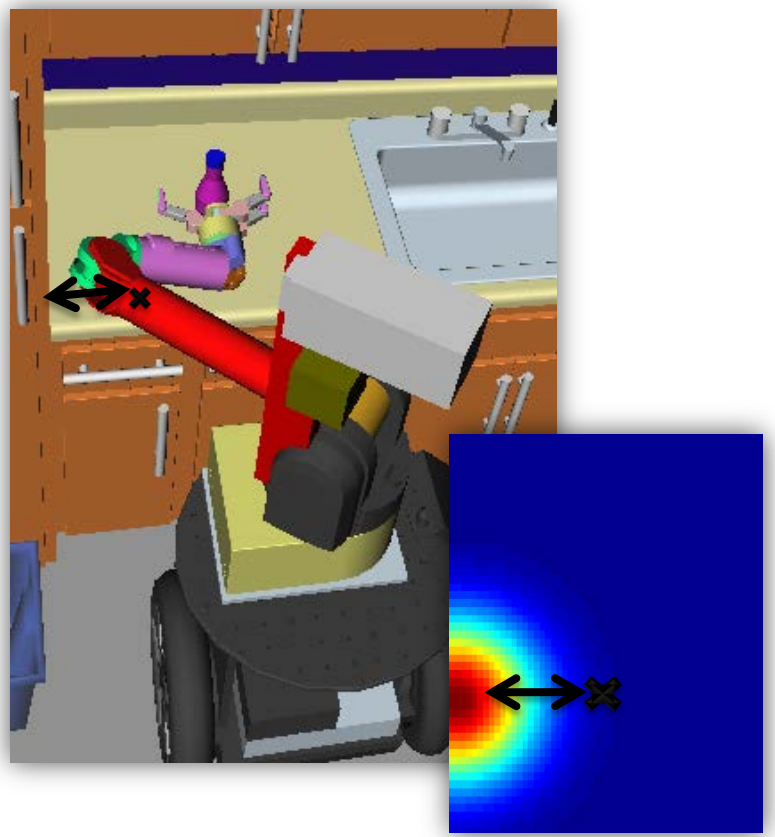
The Smoothness Cost

The Obstacle Cost



A

W



ICRA'09: Ratliff et. al
CHOMP: Gradient Optimization Techniques for Efficient Motion Planning

Optimizing the functional

gradient of *U*

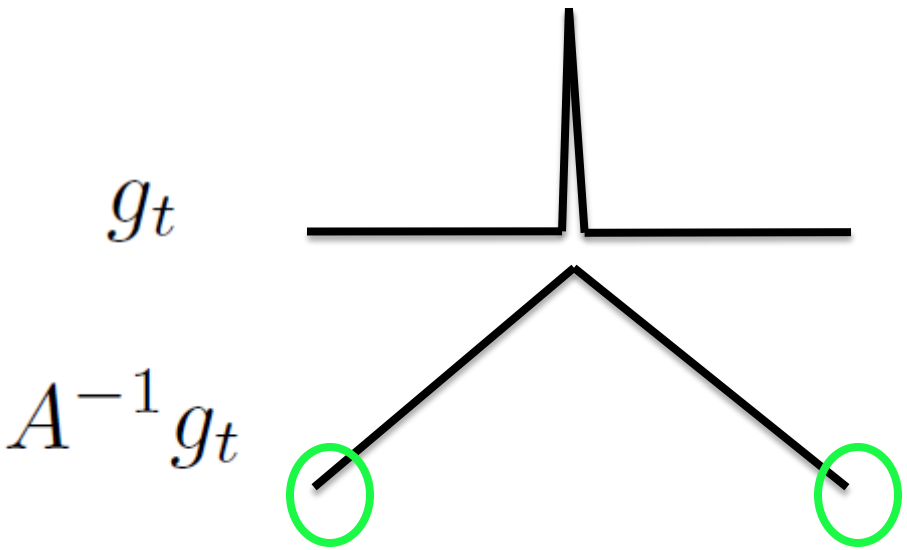
smoothness metric

$$\xi_{t+1} = \min_{\xi \in \Xi} \mathcal{U}(\xi_t) + g_t^T(\xi - \xi_t) + \frac{\eta_t}{2}\|\xi - \xi_t\|_A^2$$

first order approximation of *U*

regularization

Covariant Functional Gradient Update



$$\xi_{t+1} = \xi_t - \frac{1}{\eta_t} A^{-1} g_t$$

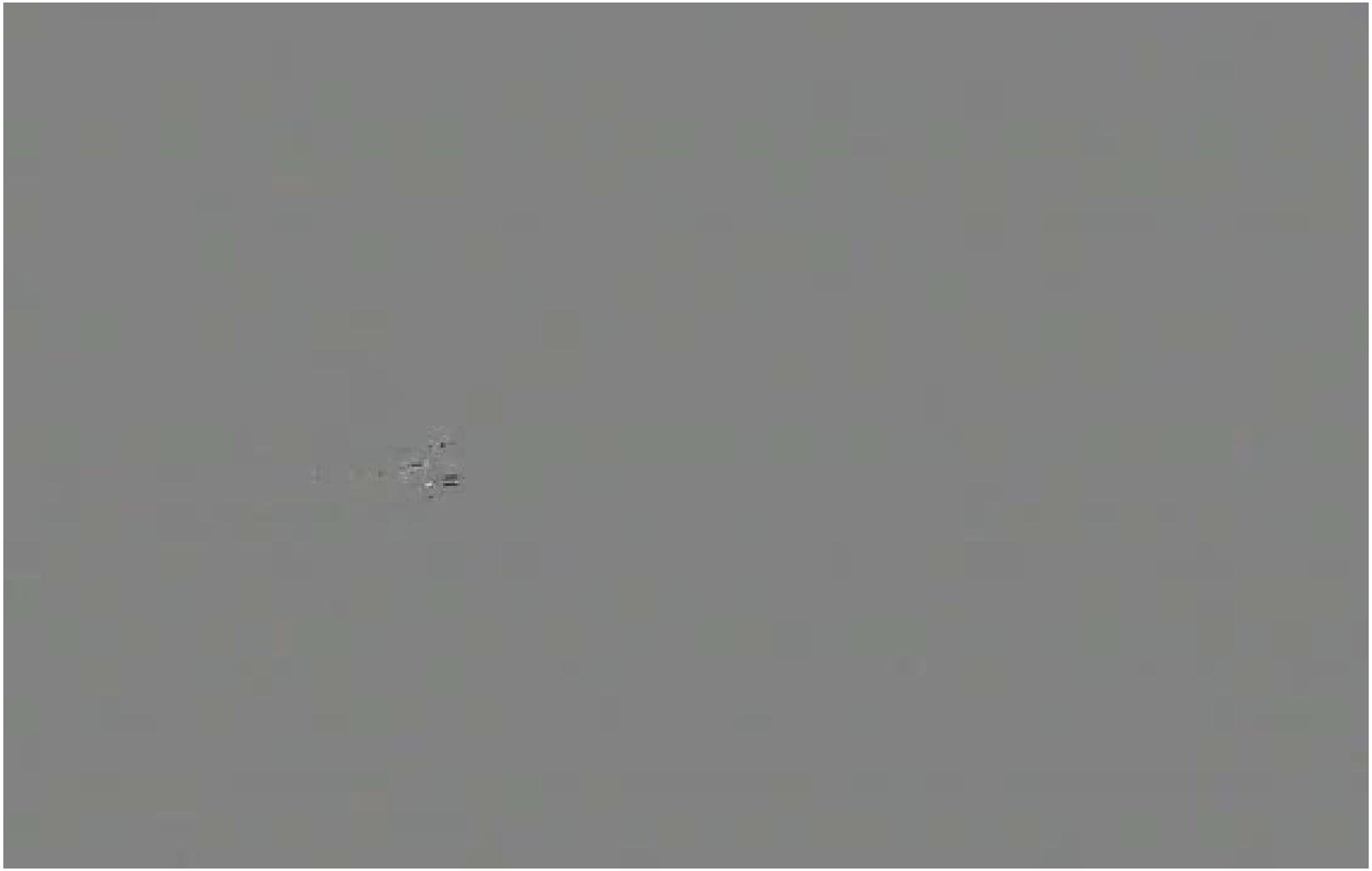
SING AND READ STORYBOOK™

THE ANTS GO MARCHING

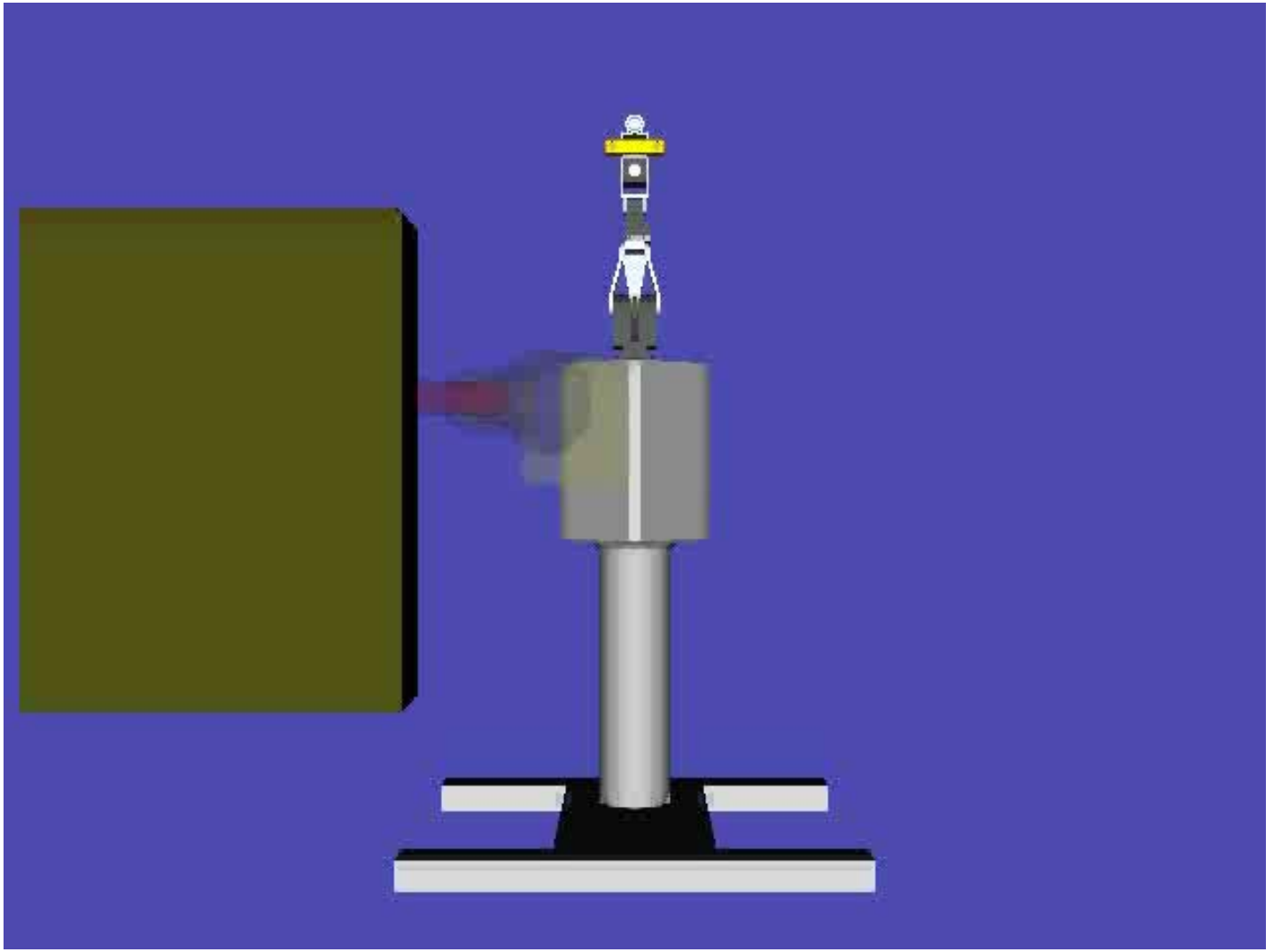
Illustrated by Jeffrey Scherer

SCHOLASTIC

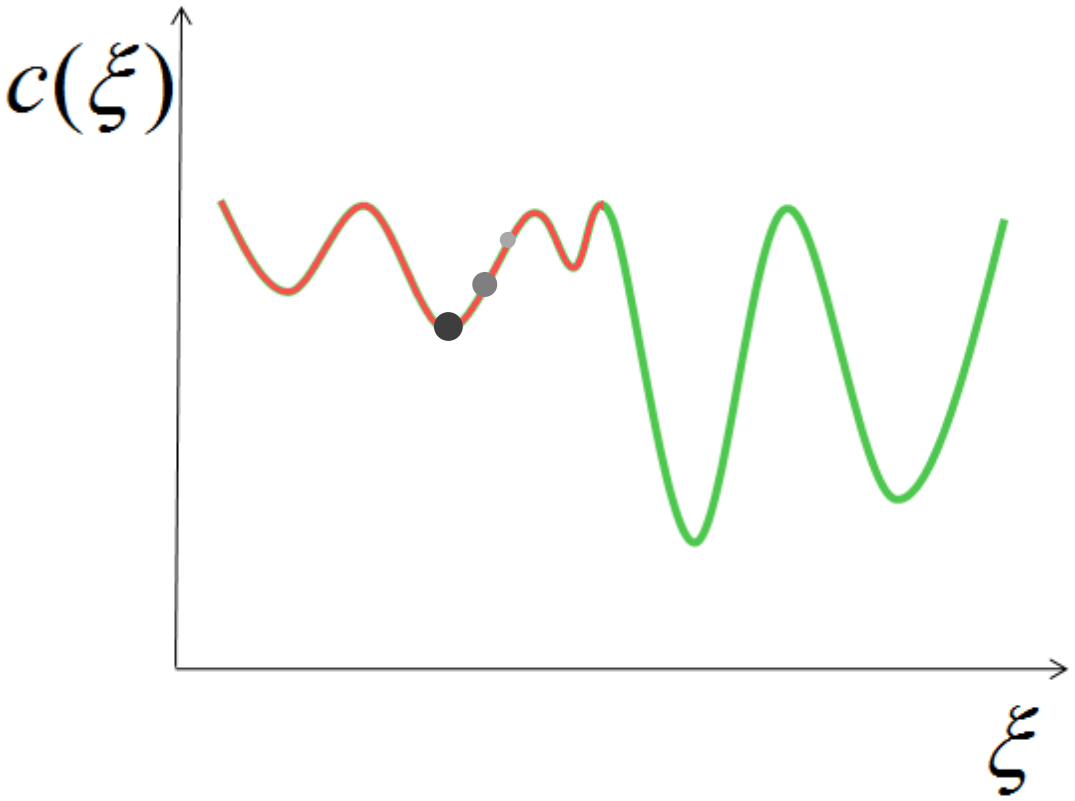
CHOMP:Realtime



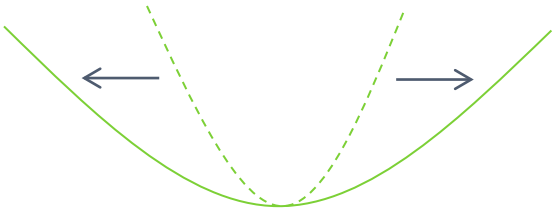
CHOMP:Realtime



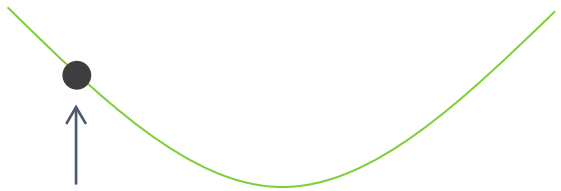
Local minima



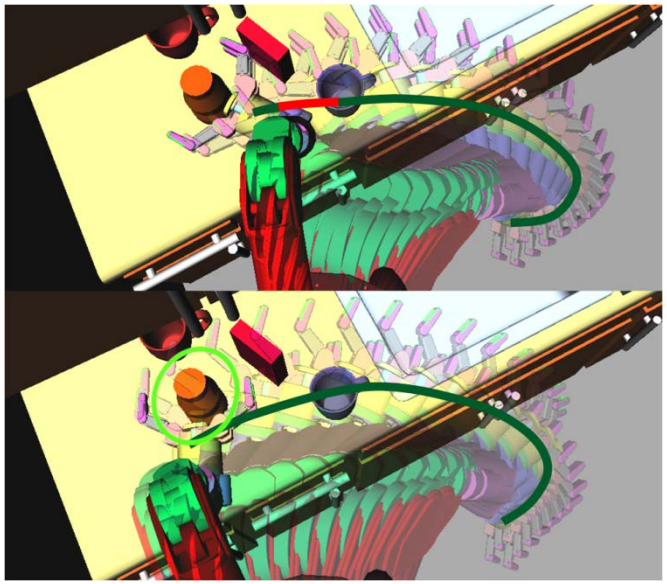
Alleviating the local minima problem

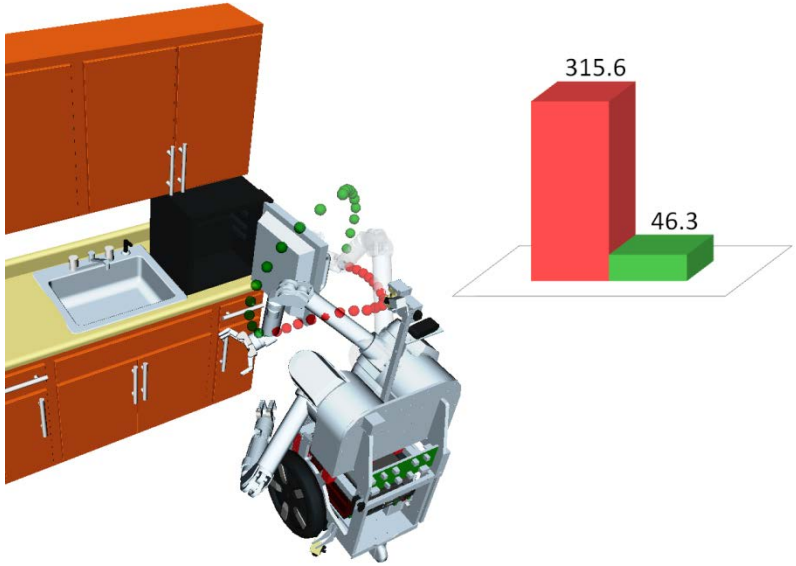


widening
good
basins

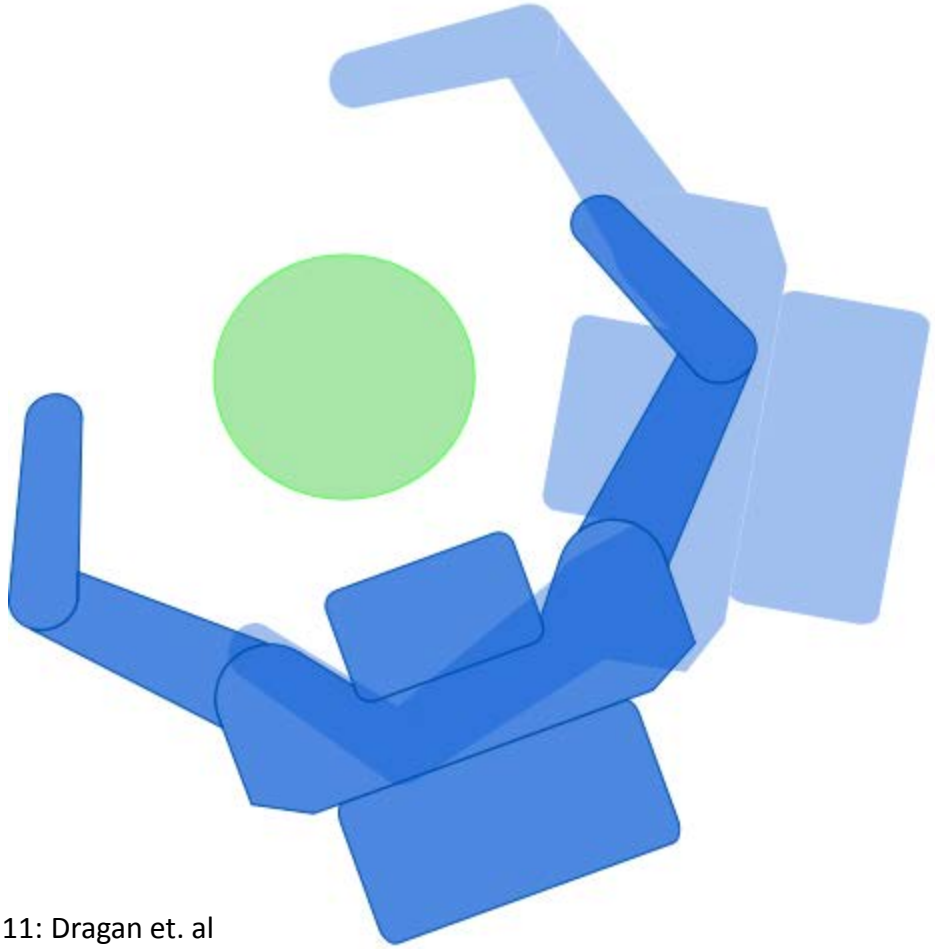


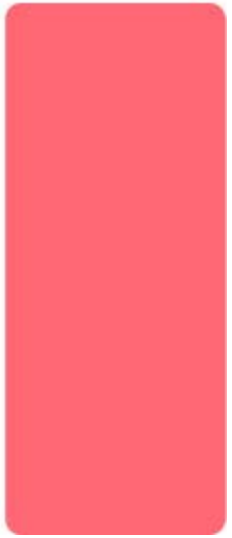
initializing in
good basins





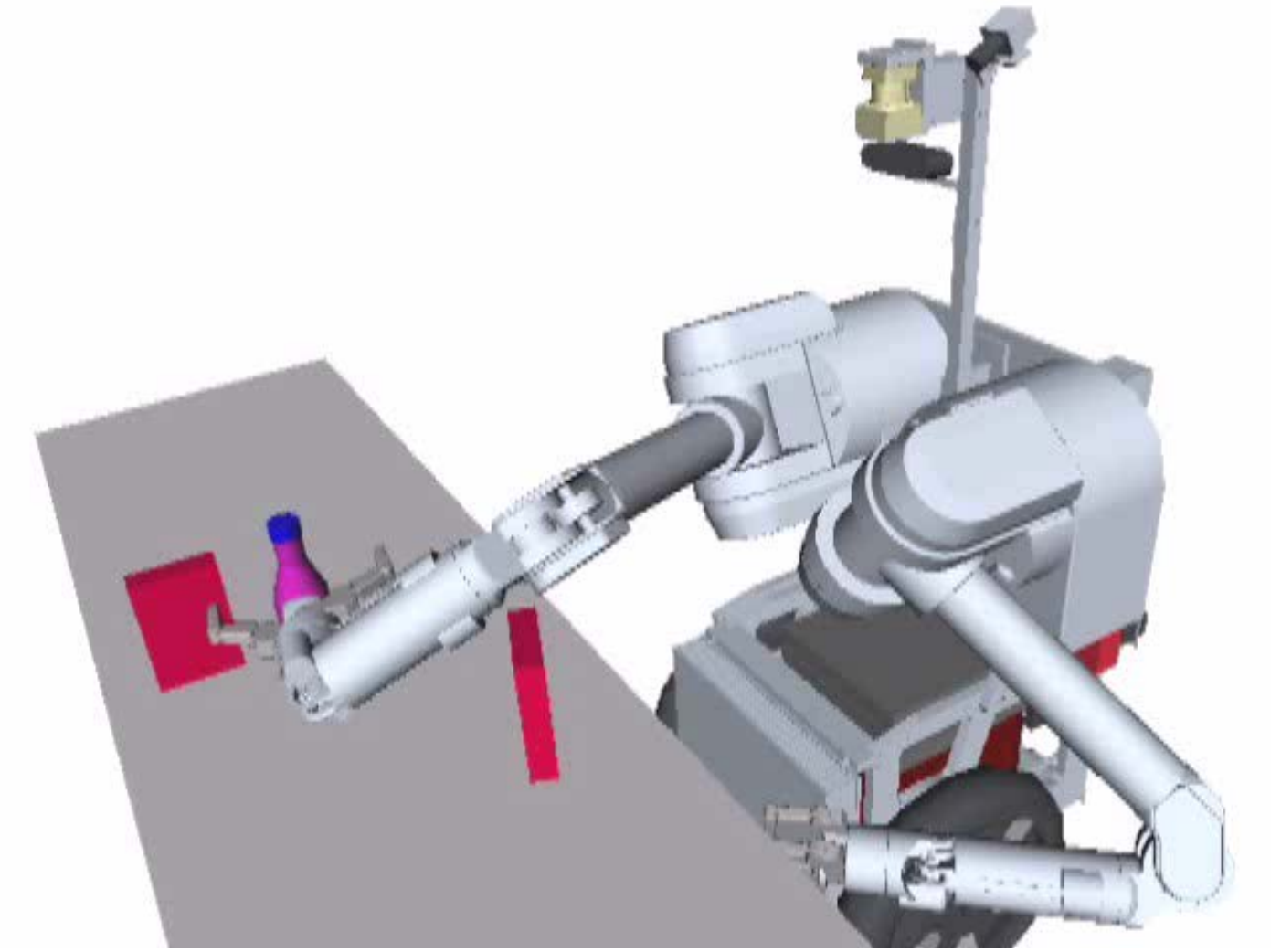
Make the problem easier by taking advantage of the natural flexibility in manipulation.





ICRA'11: Dragan et. al
Manipulation Planning with Goal Sets
Using Constrained Trajectory Optimization

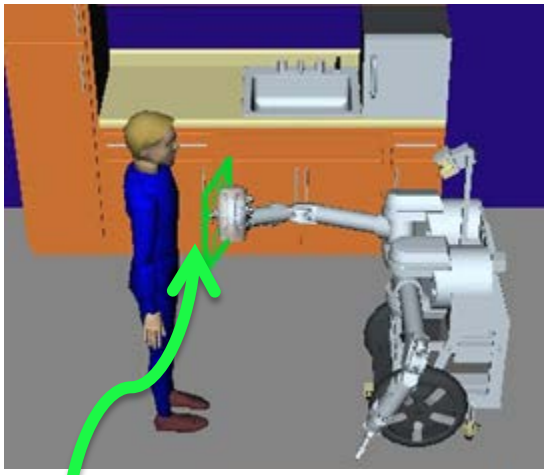
Goal sets



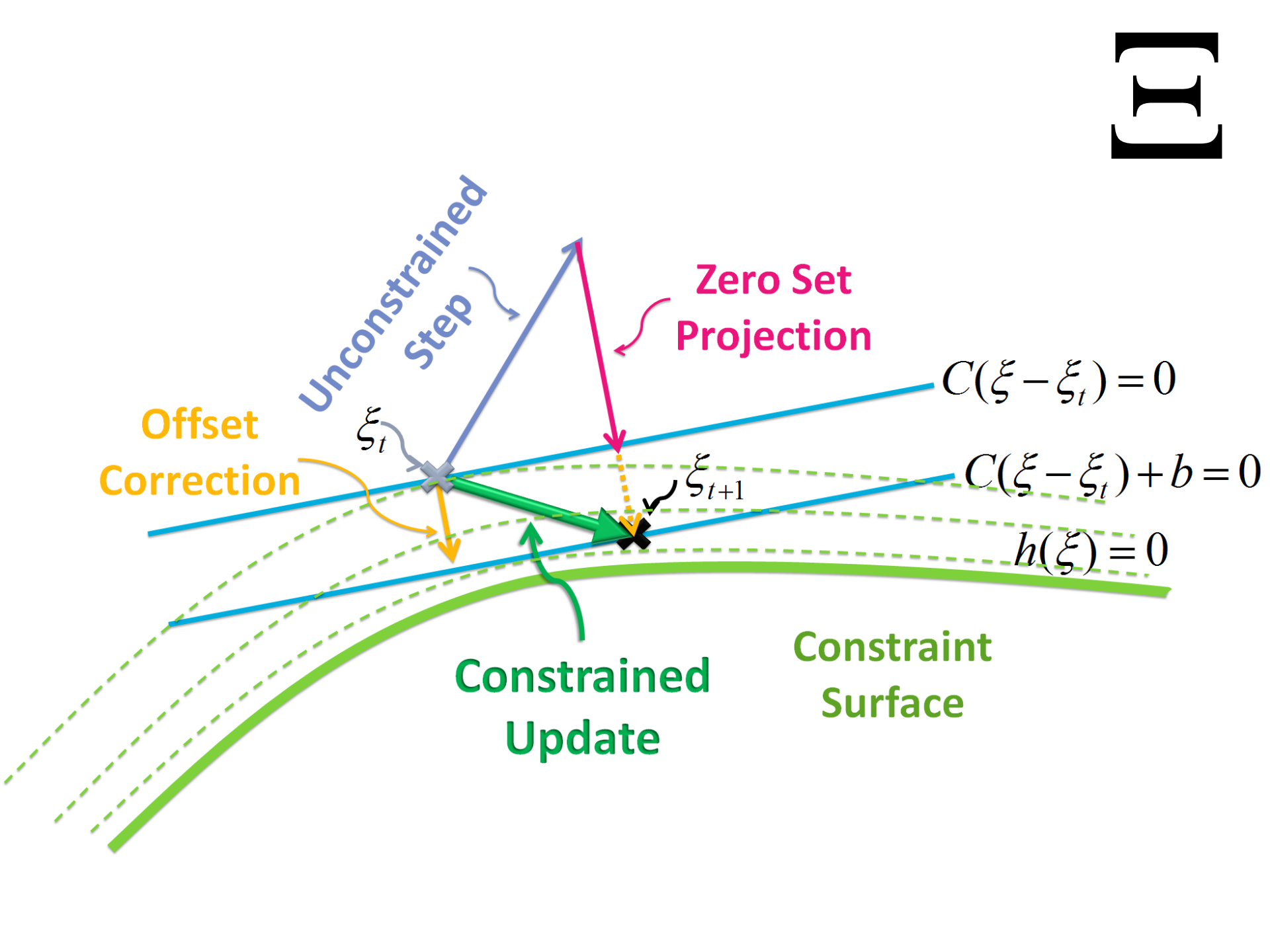
Goal sets

goal set for placing bowl on the dinner table

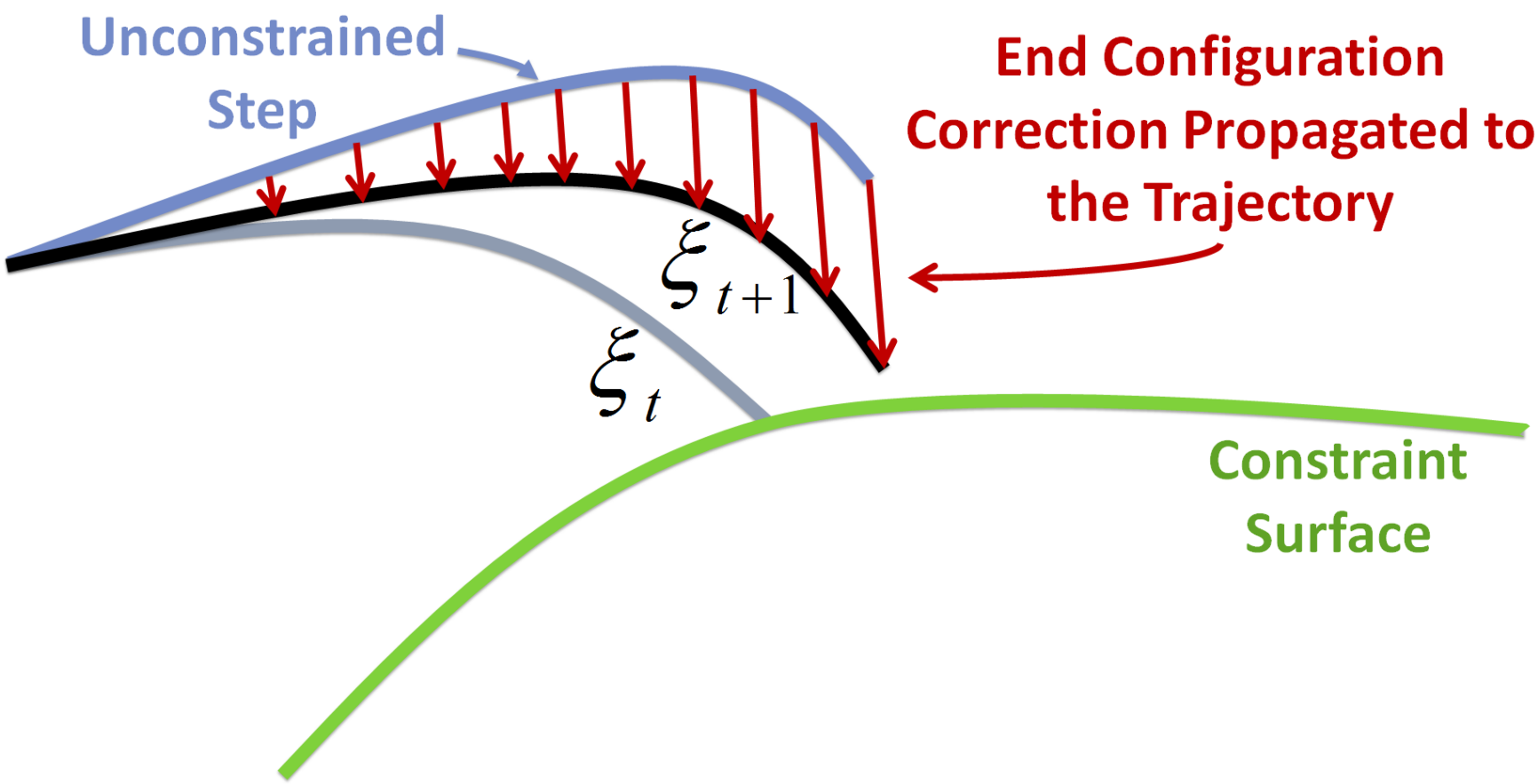
goal set for throwing objects into the recycle bin



goal set for hand-off


Unconstrained Step
Zero Set Projection
Offset Correction
ξ_t
ξ_{t+1}
$C(\xi - \xi_t) = 0$
$C(\xi - \xi_t) + b = 0$
$h(\xi) = 0$
Constrained Update
Constraint Surface

Q


Unconstrained
Step
End Configuration
Correction Propagated to
the Trajectory
ξ_{t+1}
ξ_t
Constraint
Surface

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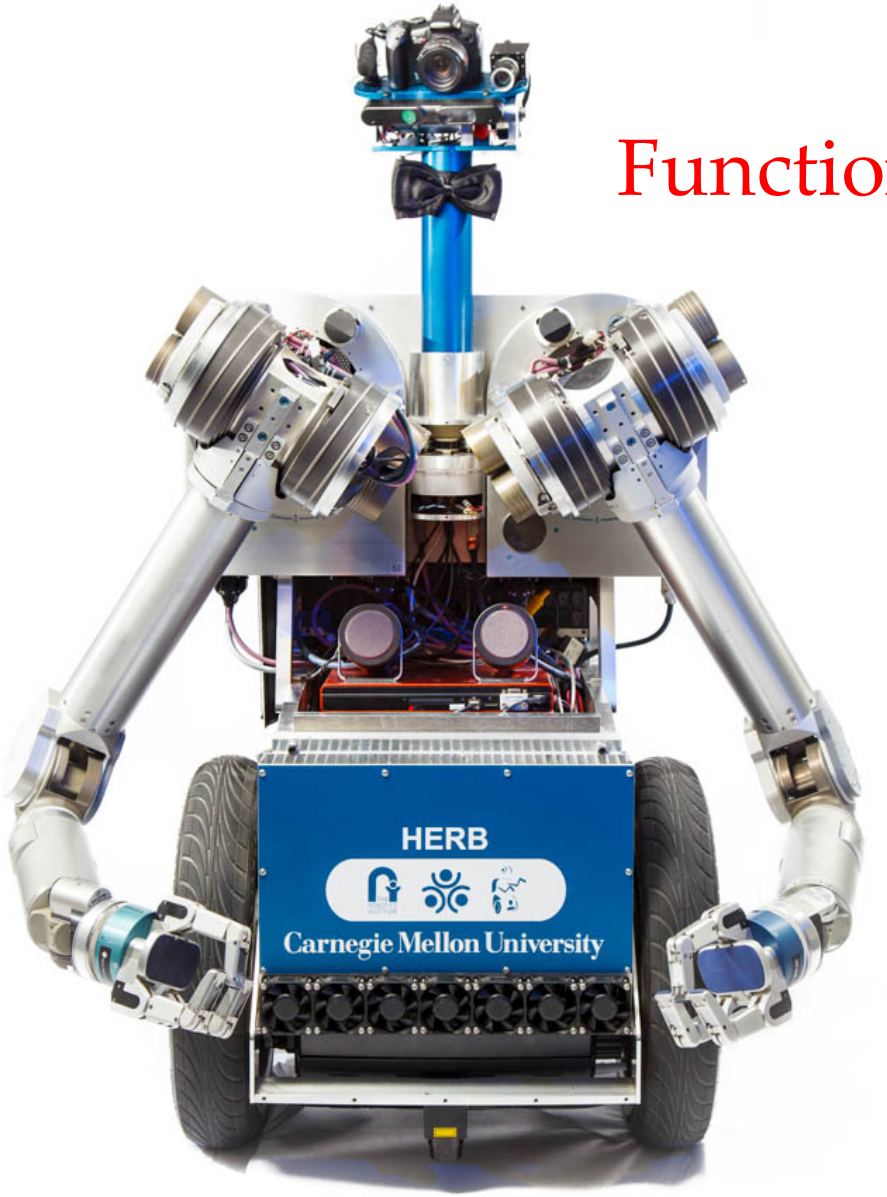
International Journal of Robotics Research (IJRR) 2013

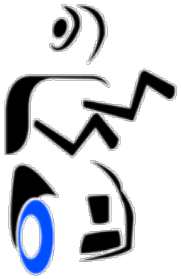
Optimal Motion


Sprite



CHOMP

Functional Gradient Optimization for Manipulation



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