

# A Motion Planner for the Human Hand

Project by:  
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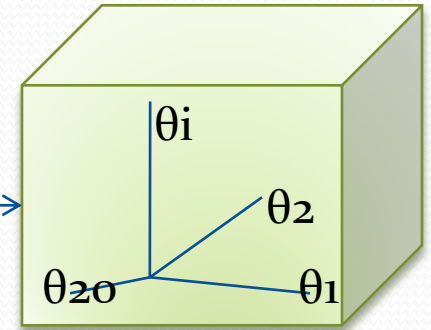
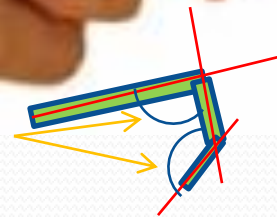
# Motion Planning for the Human Hand



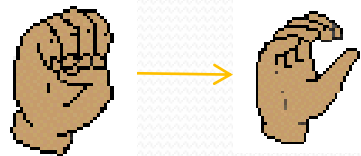
Generate Hand Skeleton



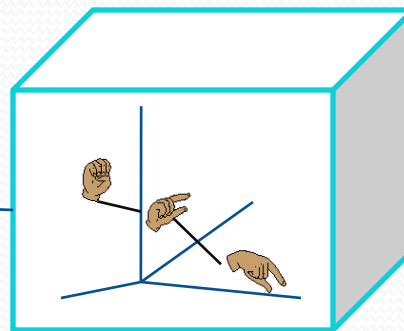
Find Parametrization Vector,  $\Theta\{\theta_1, \theta_2..\}$



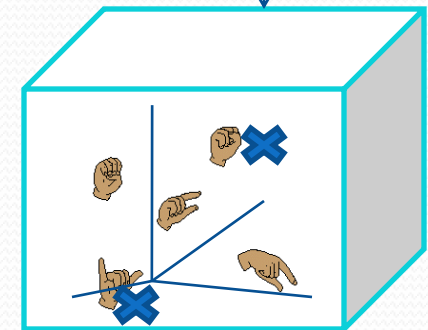
Define Configuration Space



User defines two poses – Find Path & Smoothen to get Realistic Motion



Connect Adjacent Configurations



Sample Configuration Space for Milestones & Collisions

# The Human Hand

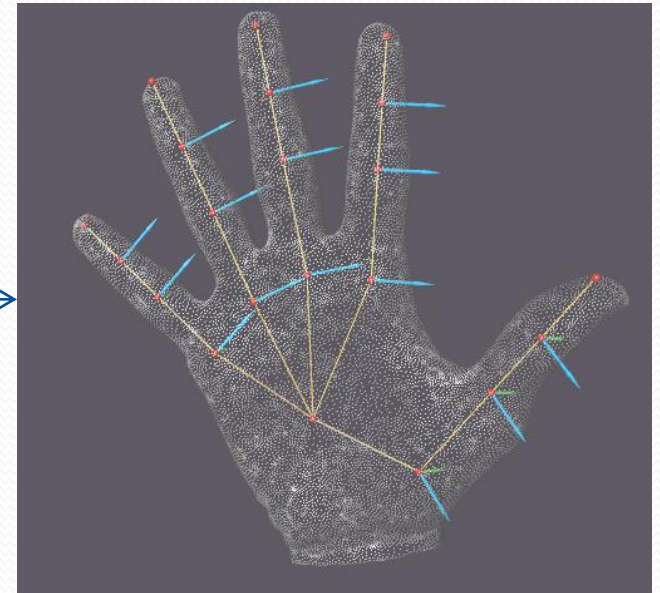
- Motion is induced by the application of musculo-skeletal control
- We demonstrate planned motion of a human hand
- Simulated hand has a 20 degree of freedom skeleton
- Control is applied to the joint angles of the skeleton
- Planning takes place in 20-dimensional joint configuration space
- The planned path is executed in a simulated model of the human hand

# The Hand Skeleton

- The human hand may be modeled using a 20 DoF skeleton parameterization
- Configuration of the human hand is represented by a 20 dimensional joint angle vector



Hand Space

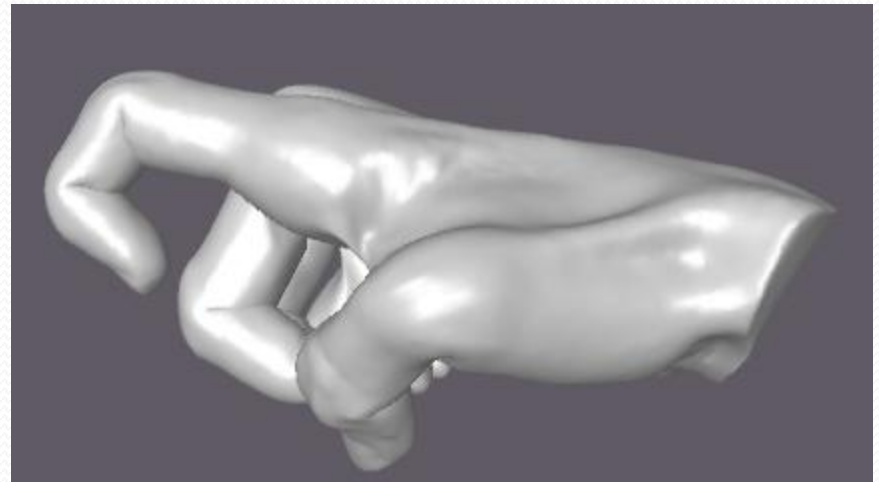


# Modeling the Hand

- ‘Hand-space’ models an actual human hand
- The hand is represented by a mesh representation of a laser scanned hand
- The parameterization allows the emulation of a real hand

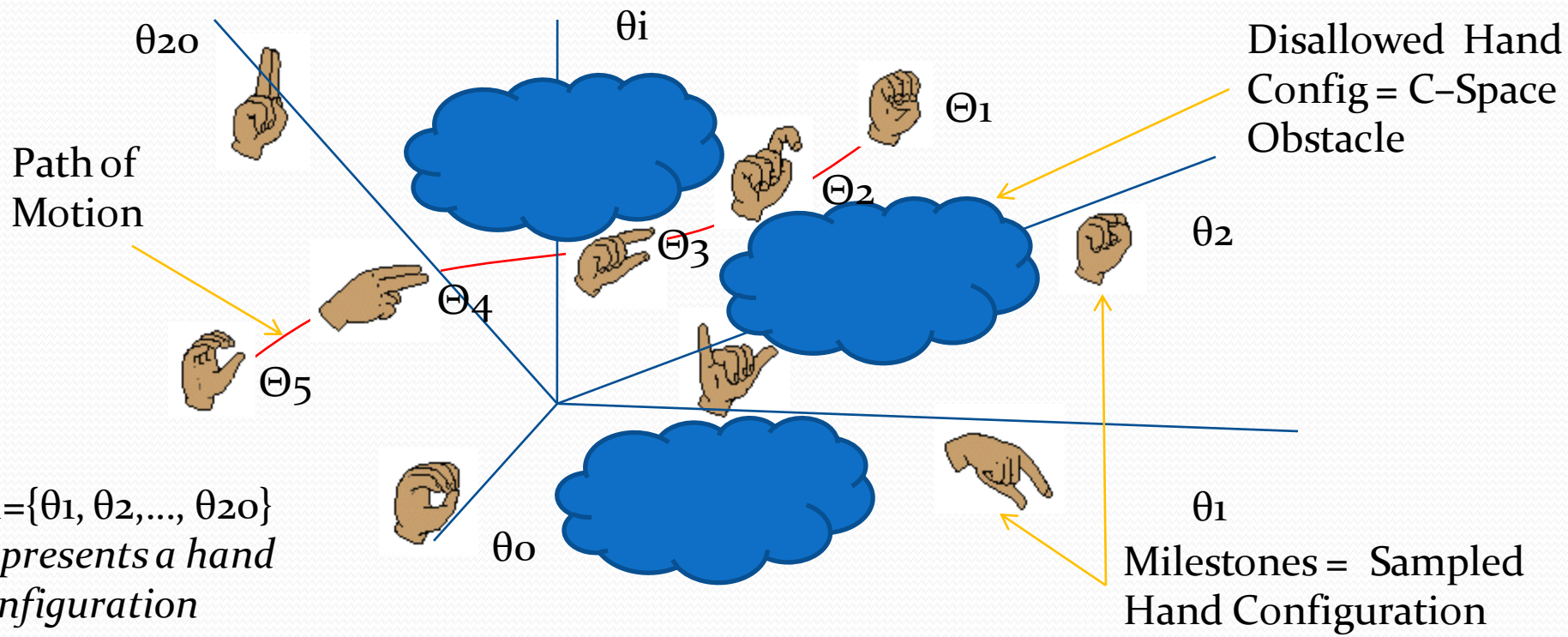


Hand Space  
Configuration →



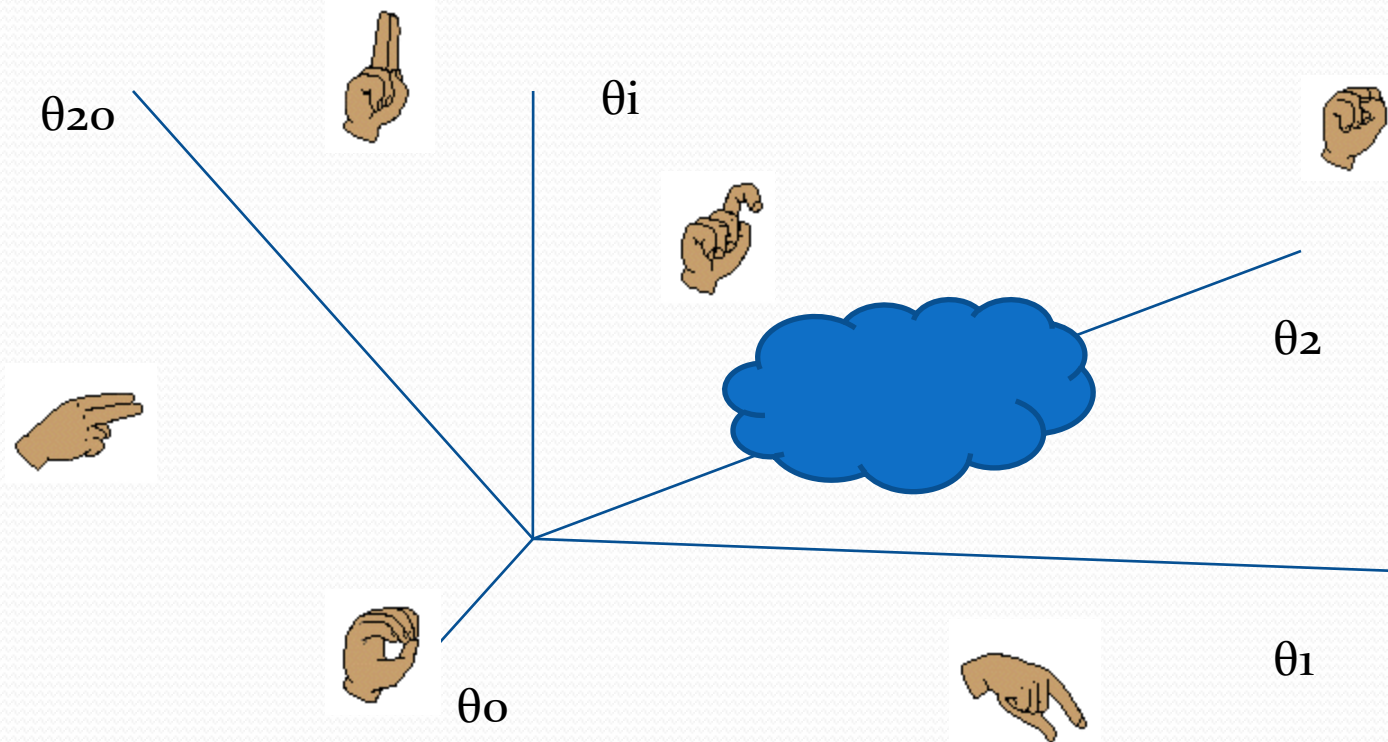
# Configuration Space

- Hand motion is in 20 dimensional configuration space along the planned path



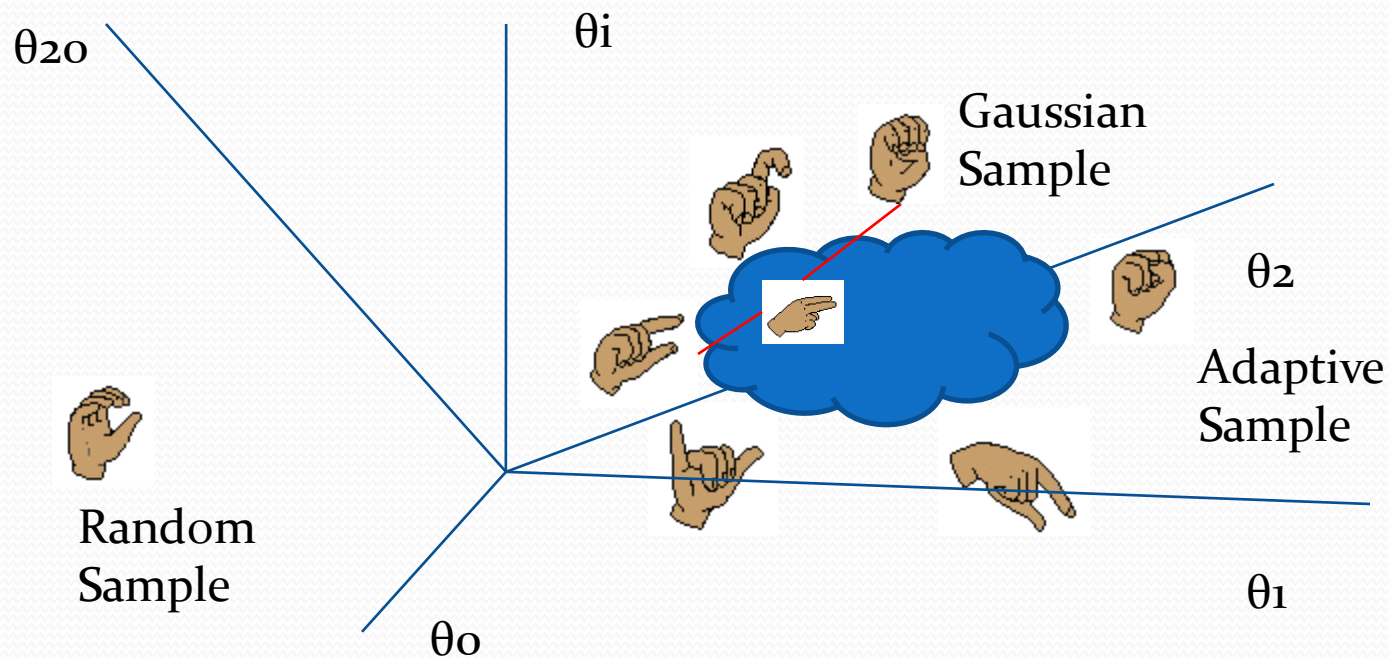
# Uniform Sampling

- A uniformly random sampler



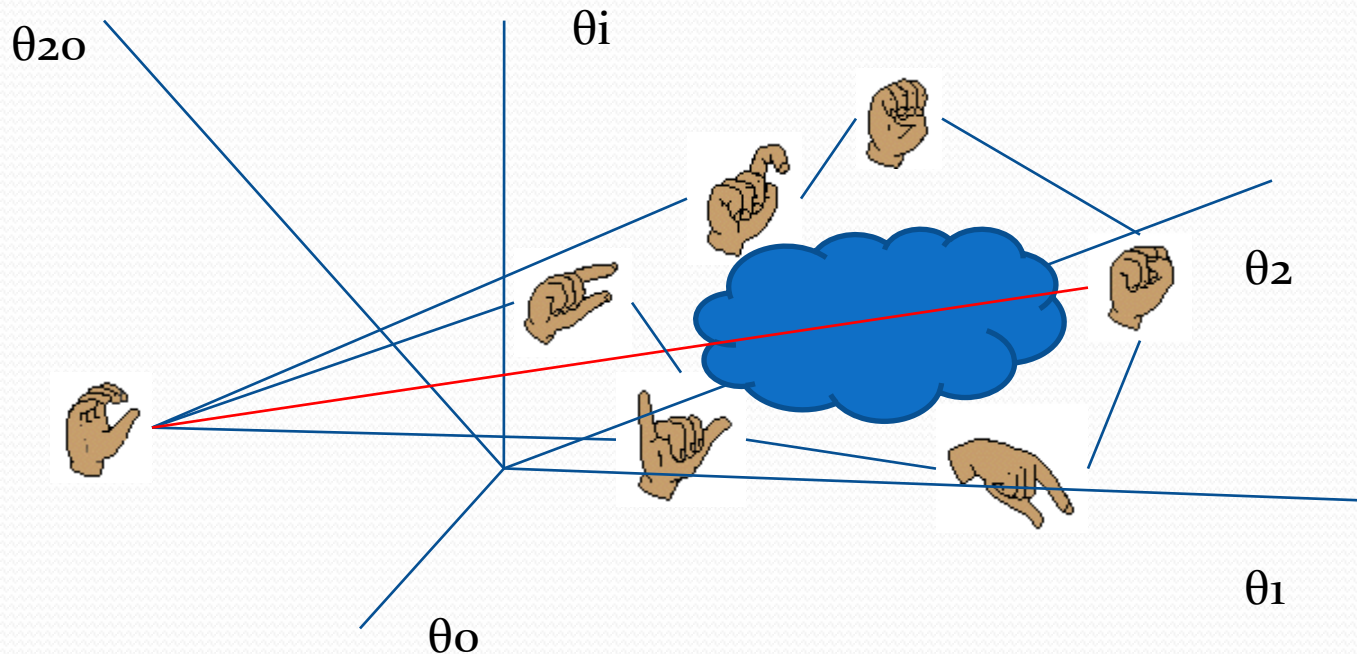
# Adaptive-Gaussian-Random Sampling

- An adaptive gaussian sampler

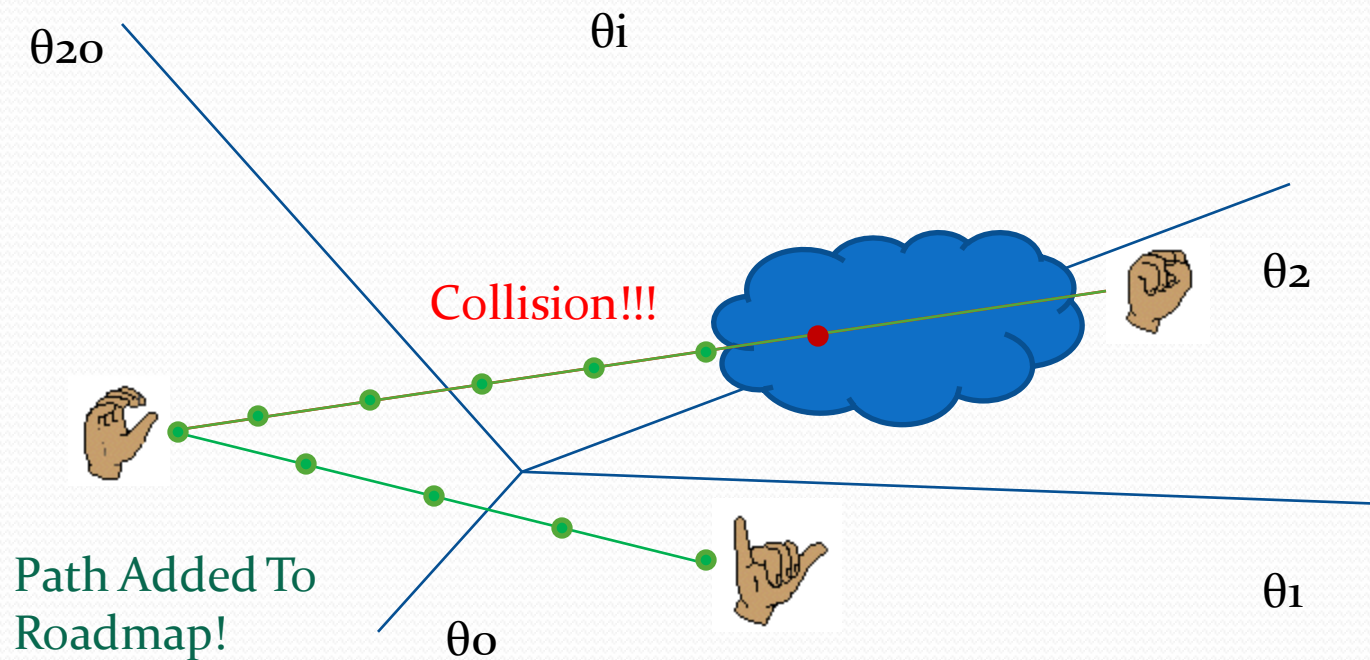


# Connecting Samples

- Obtain a roadmap in the form of a search graph
- Connect each sample to 10 closest samples and check for collision
- Reject connections with collisions

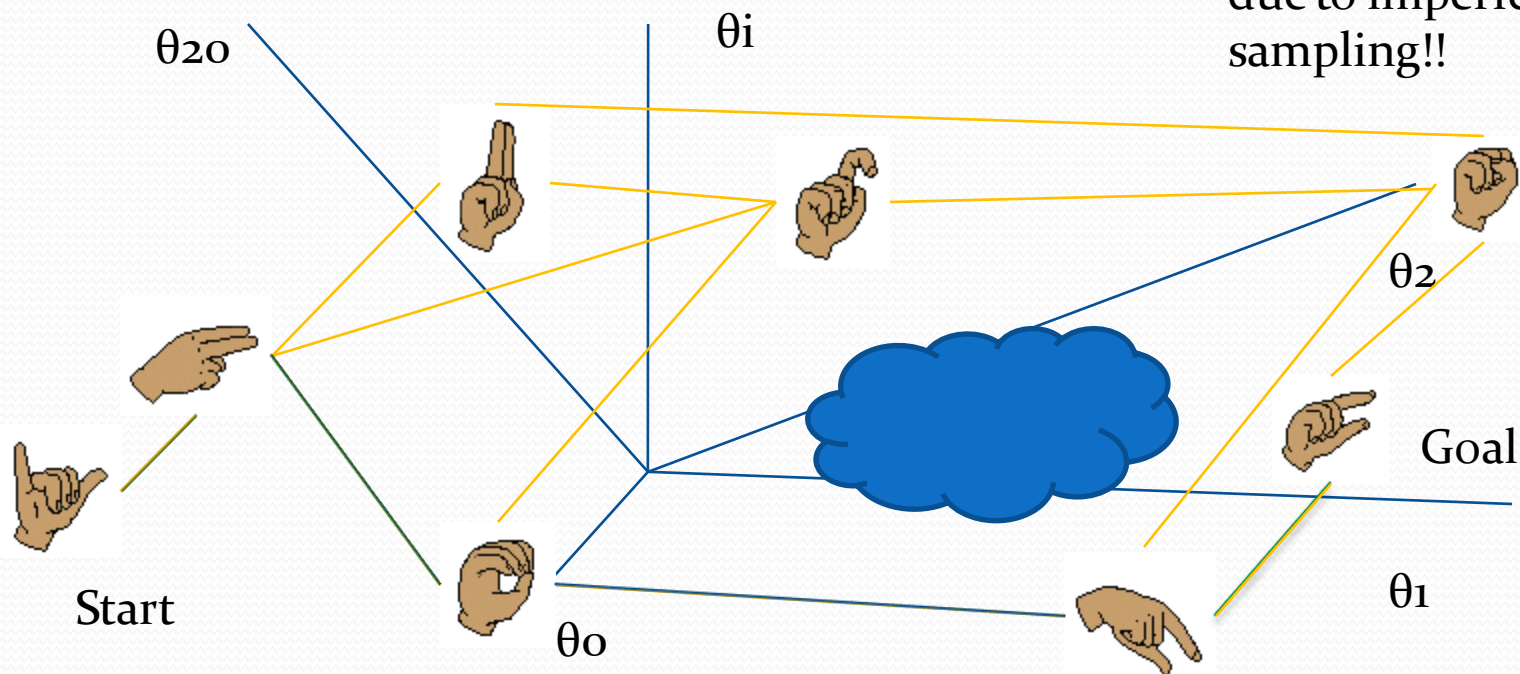


# Collision Detection Strategy



# Planning Hand Motion

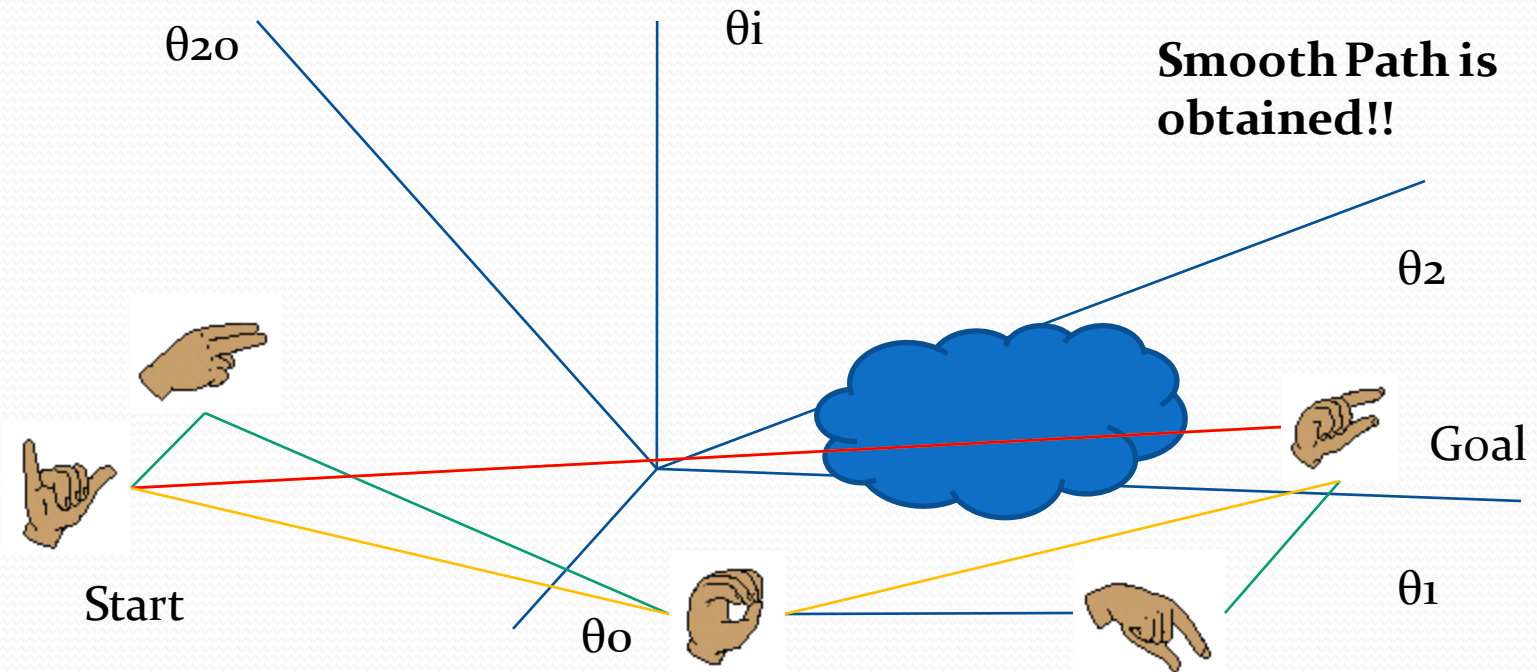
- Add start and goal configuration nodes to graph
- Search for a path in the graph



# Planning Hand Motion (contd.)

- Video of jerky motion

# Smoothing Motion

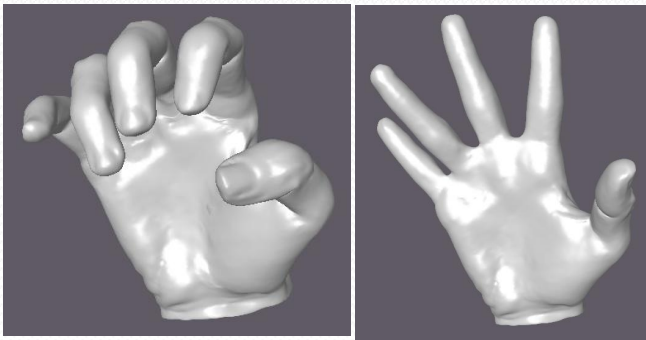


# Smoothing Motion (contd.)

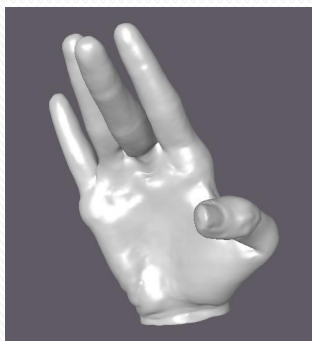
- Video of smooth motion

# Demo

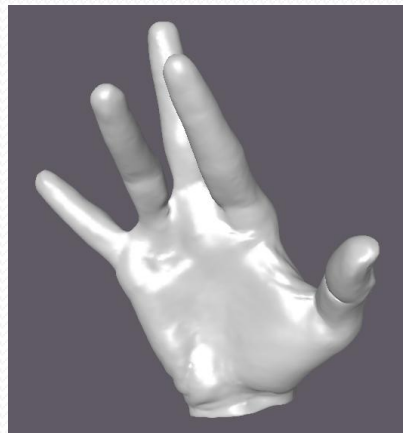
- System demo



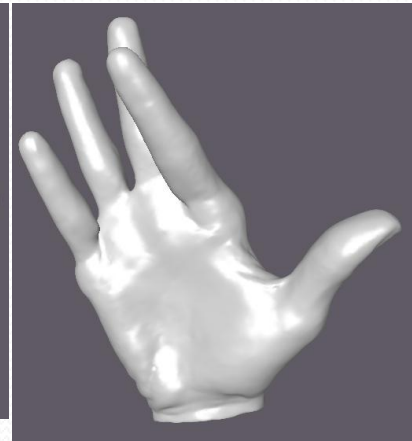
Eg.1



Eg.3

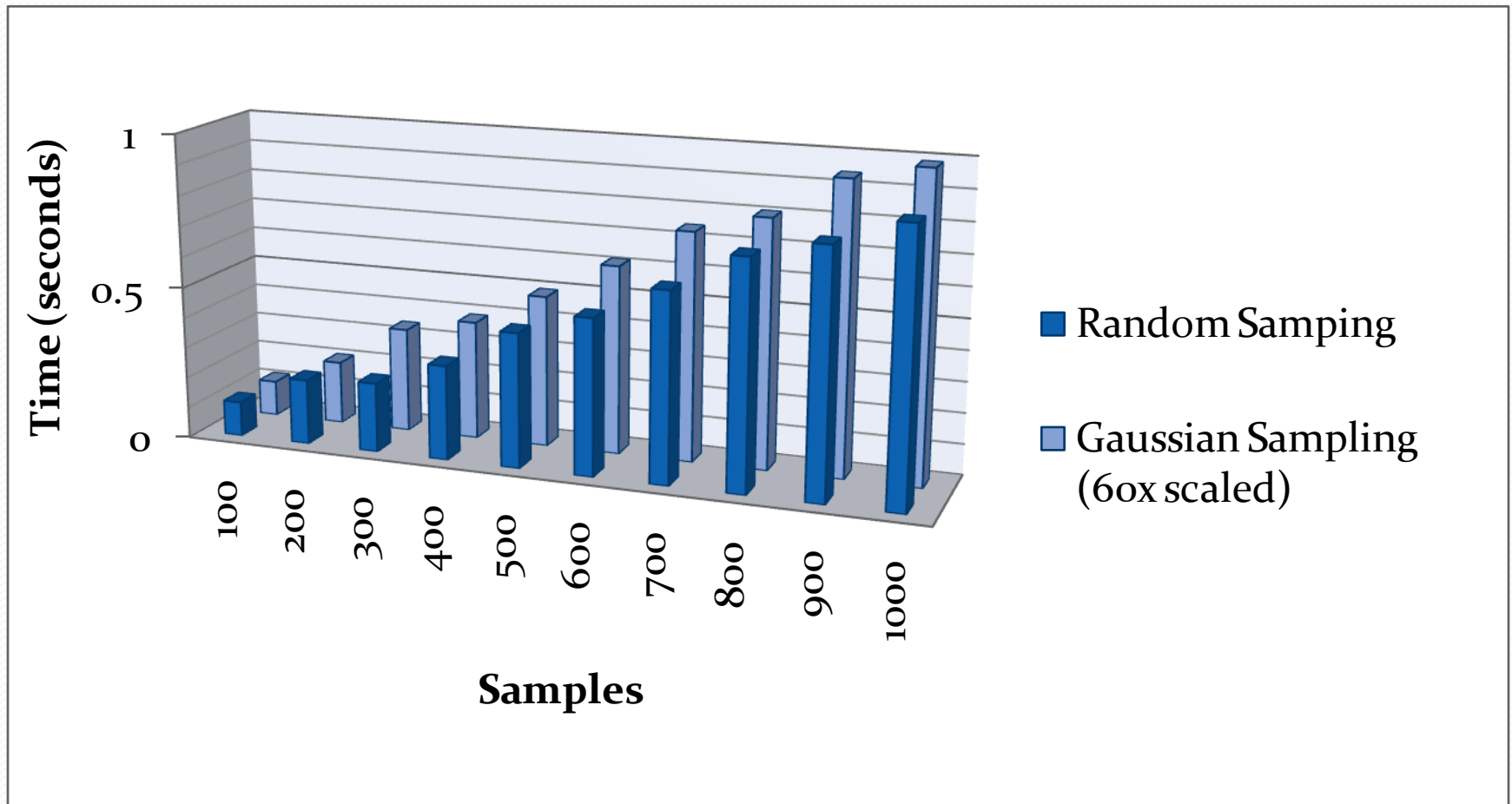


Eg.4



Eg.2

# Results: Sampling



# Results: Smoothing

	Smoothed Path Length	Smoothed Milestones	Time (sec)	Unsmoothed Path Length	Unsmoothed Milestones	Time (sec)
Eg.1	3.40	2	1.650	6.58	5	0.650
Eg.2	4.11	2	0.735	6.16	5	0.698
Eg.3	2.34	3	0.605	2.45	4	0.585
Eg.4	2.95	3	0.590	3.00	3	0.565

# Discussion

- Smoothing the path greatly improves motion quality
- Adaptive Gaussian Sampling can drastically reduce the required samples but it also requires more precomputation
- Straight line motion in higher dimensional space produces better quality than curved or spline motion.

# Future Work

- Areas for improvement:
- The project may be extended to involve:
  - Control applied to muscular configuration space
  - Improved skeleton that closely matches a real hand
  - System dynamics such as inertia and damping