Reaching and Grasping

John Loy
CSE 888.14X
WI 08
Problem Outline

• Plan a path for a jointed arm
  – Obstacles
  – Human-like motion
• Find a joint configuration able to grasp an object
• High Degree of Freedom
  – 7 DoFs for human arm
  – ~27 DoFs for human hand
Kinematics

• Forward Kinematics
  – Explicitly specify joint parameters
• Inverse Kinematics
  – Specify end effector position
  – Solve for joint parameters
• Provide animator with precise control
Basic Inverse Kinematics Approach

• Construct the Jacobian to relate change in joint parameters to change in end effector position
• Solve using pseudo-inverse
• Sensitive to near-singularity
• Does not produce human-like motion
Null Space Solutions

• Used to
  – Avoid obstacles
  – Prevent singularities
  – Minimize joint torques
  – Soft constraints on joint angles
Cyclic Coordinate Descent

Early Robotics

- Stanford Arm
- Victor Scheinman, Stanford Artificial Intelligence Laboratory, 1969
- Closed-form solution for IK

Jack

• Virtual human modeling system
• Developed at Center for Human Modeling and Simulation at U. Penn. beginning in the 70’s.

Multi-arm Planning

- Koga and Latombe (1994) extend RPP to handle two cooperating manipulators
- Plans transfer subtasks that are guaranteed to have connecting transit paths
• Koga et. Al (Siggraph 1994) combine multi-arm RPP, and a null space IK solution based on a neurophysiological model by Soechting and Flanders to produce natural motion
Genetic Algorithms

• Miller (1993) uses RPP to generate an initial population of solutions and iteratively refines the solution

• Path fitness is a combination of factors including collisions, joint accelerations, torque, and jerk
Synthesized Motion

• Motion may be synthesized from motion capture data
• Pollard and Hodgins (2002) propose to generalize demonstrated manipulation
• New manipulation tasks can be synthesized based on similarity in contact points and applied forces
Handrix: Animating the Human Hand

- ElKoura and Singh (SCA 2003)
- Used motion capture data to generate a procedural model for guitar playing
Grasping from Example

• Pollard and Zordan (2005) develop a physically based motion controller for grasping than draws from example motion capture data
Grasping from Example
Dynamics

• Tsang et al give a muscle-tendon system for anatomically reasonable forward dynamics simulation and finding inverse dynamics solutions
Future Work

• Real-time solutions
• Natural grasping of arbitrary objects
• Animator control
Questions?