Reaching and Grasping

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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

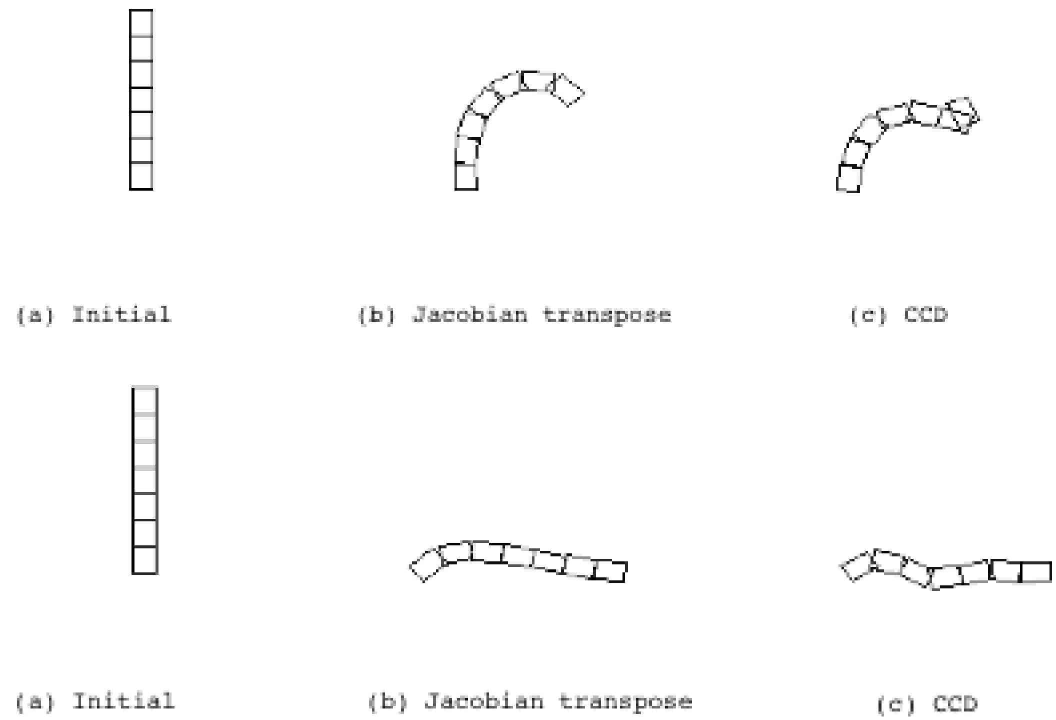
Basic Inverse Kinematics Approach

- 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



Welman, C. Inverse Kinematics and Geometric Constraints for Articulated Figure Manipulation. Thesis. Simon Fraser Univ. 1993. http://fas.sfu.ca/pub/cs/theses/1993/ChrisWelmanMSc.ps.gz

Early Robotics

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

http://infolab.stanford.edu/pub/voy/museum/pictures/display/1-Robot.htm

Robotics

- Barraquand and Latombe (1991) develop a potential field-based method for obstacle avoidance using Monte Carlo method (RPP)

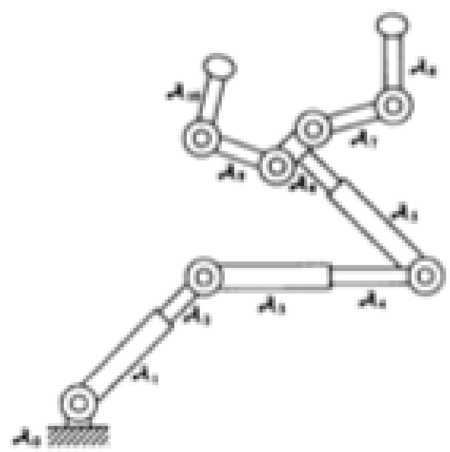


Fig. 11. Structure of the 10-DOF manipulator.

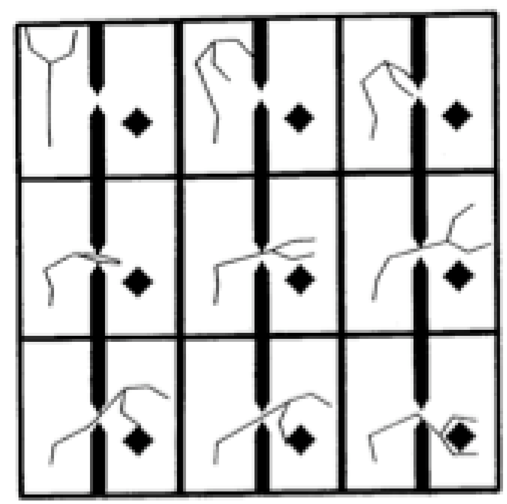
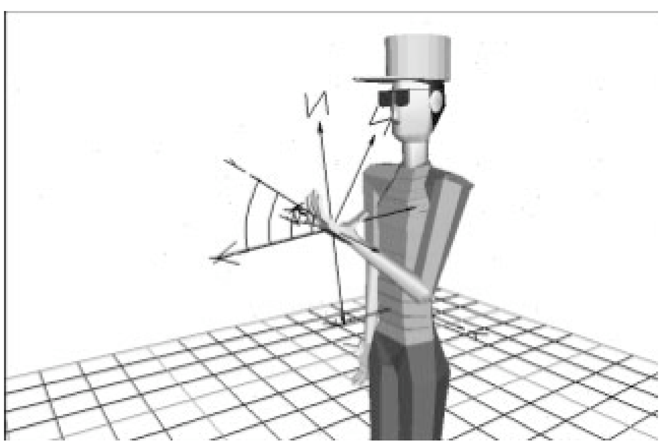


Fig. 12. Path generated for the 10-DOF manipulator.

Jack

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

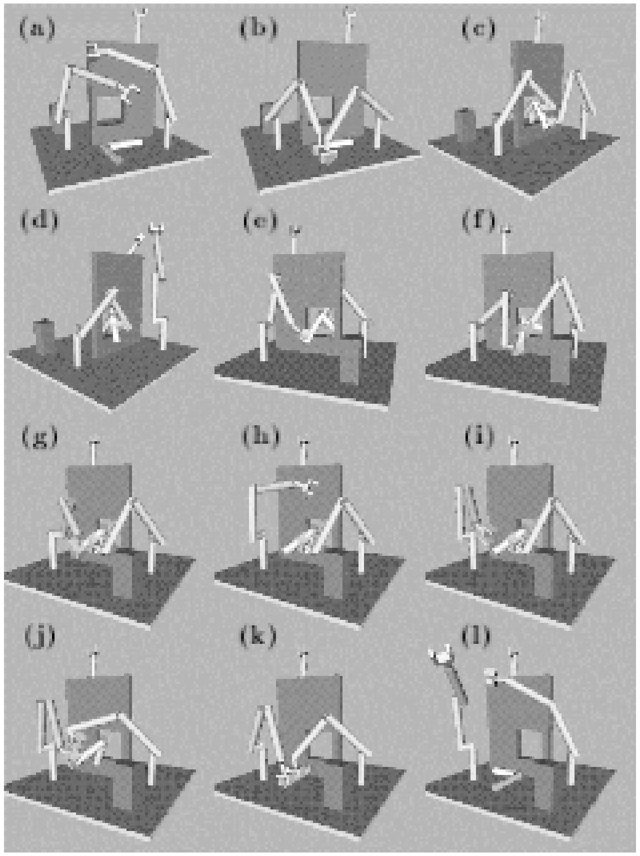


Norman Badler, Cary Phillips, Bonnie Webber. Simulating Humans. Oxford University Press. 1999.

http://cg.cis.upenn.edu/hms/technology.html

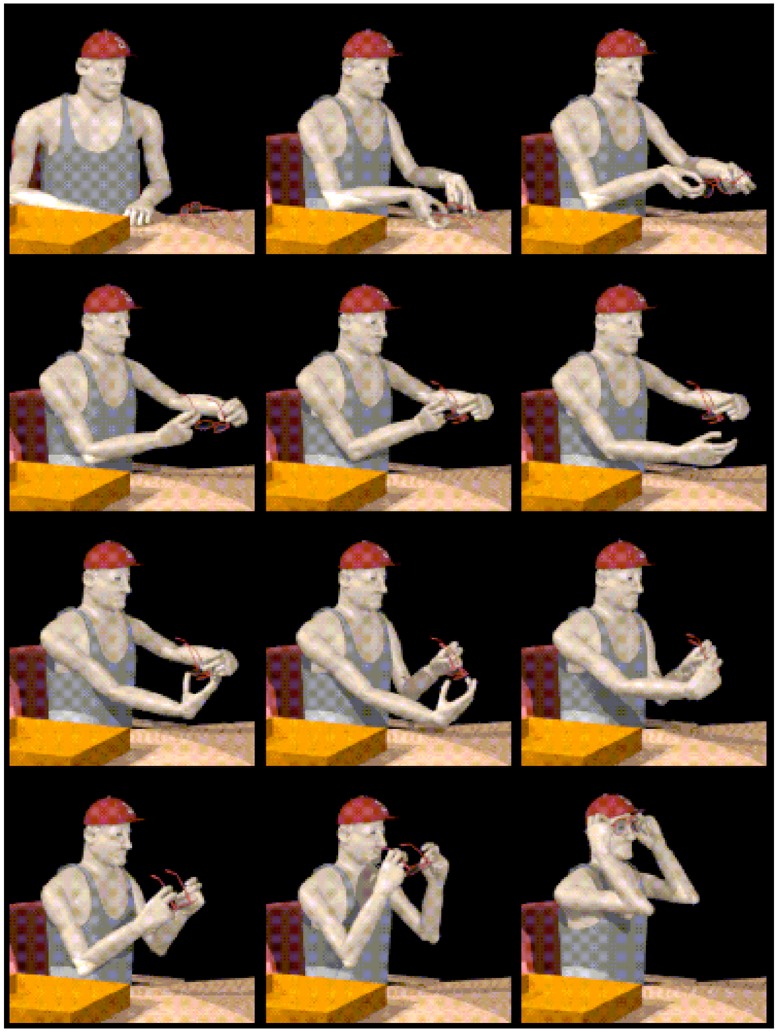
Multi-arm Planning

- Koga and Latombe (1994) extend RPP to handle two cooperating manipulators
- Plans transfer subtasks that are guaranteed to have connecting transit paths



Human-like Motion

- 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

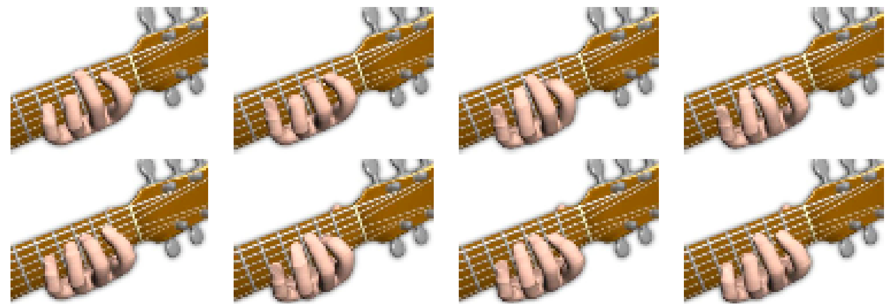
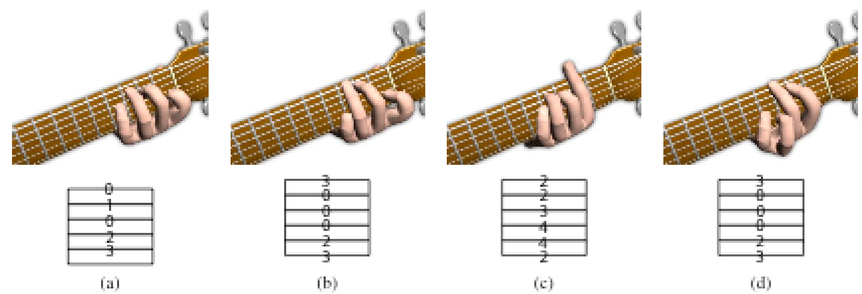


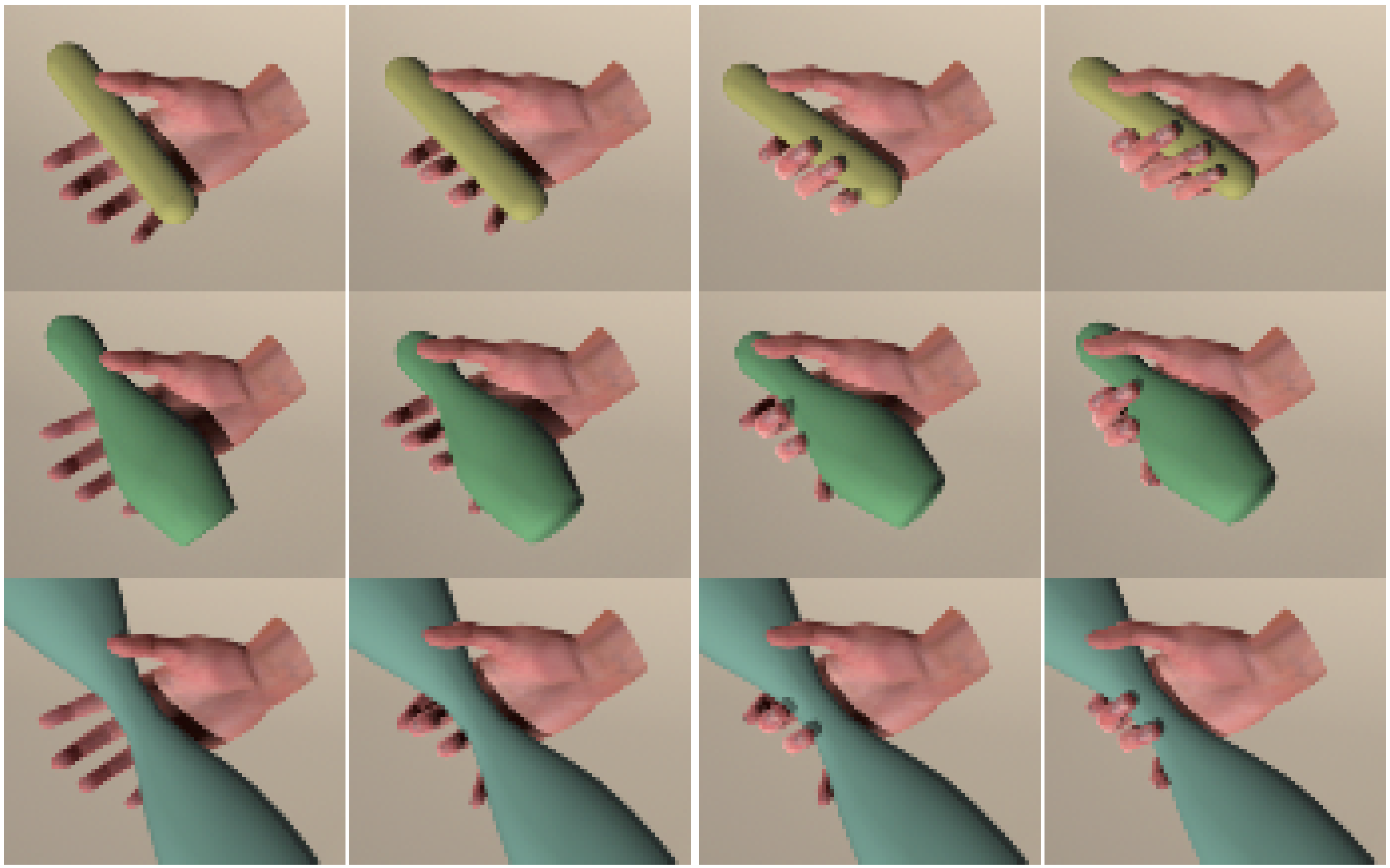
Figure 9: *Result of the algorithm running on a C-Major scale using the hand model.*



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?