Part 9

Planning and Modeling
Session Summary

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This session includes one paper on path planning and three on modeling and control. In the planning paper, Sanchez and Latombe describe an efficient probabilistic roadmap planner for handling complex multi-robot maneuvers. The control papers include an interactive system for drawing and modifying 3-D animations developed at the University of Tokyo by Yamane and Nakamura, plus two theoretical papers describing aspects of contact and compliance. Huang and Kao derive the Conservative Congruence Transformation, which models robot stiffness under external loads, and Featherstone describes a theory for controlling a robot operating in an environment with unknown dynamics.

Sanchez and Latombe present a new route planner that is designed to minimize collision testing, because they made two observations. First, probabilistic roadmap (PRM) planners spend 90% of their time checking for possible collisions. And second, the most expensive path segments to test are the ones that don’t have a collision. The new planner is 4 to 40 times as fast as previous PRM planners, depending on the complexity of the environment and the number of degrees of freedom of the “robot.” The planner is a Single-query, Bi-directional, Lazy collision checking (SBL) planner. It is single-query in the sense that it explores each path problem from scratch as opposed to generating a persistent representation of free space that is used to answer several queries. It is bi-directional because it explores two trees in parallel, one rooted at the starting configuration and one at the ending configuration. It is lazy in the sense that it postpones collision detection until after a path has been found, and then it checks the segments that are most likely to have occlusions first.

Yamane and Nakamura present a pin-and-drag method for generating and editing animation sequences of three-dimensional figures, such as people. The technique runs in real time on a PC with models that contain 50 degrees of freedom, making it possible for an animator to interactively design motions by pinning some joints, constraining others, and then dragging one joint into a desired position. To achieve this fast and natural interaction, Yamane and Nakamura prioritize the joints in the model and introduce a feedback controller into the differential kinematics. They use a singularity-robust (SR) inverse procedure instead of a pseudoinverse routine in order to avoid problems near singularities. They also incorporate methods to handle spherical joints, such as shoulders, that have limited ranges of motion. And finally, they extend the basic pin-and-drag system so that an animator can edit dynamic sequences.

Huang and Kao present a derivation of the Conservative Congruence Transformation, and then explain how it correctly models compliant robot behavior under external loads. They use Screw Theory to highlight key insights in the derivation. In addition, they briefly discuss three common errors that arise in mathematical models.

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of stiffness that are caused by incorrect assumptions about finite versus infinitesimal quantities and static versus dynamic quantities.

In the fourth paper, Featherstone presents a new theoretical approach for designing a hybrid motion/force controller for a six degree of freedom robot to operate in an environment having unknown dynamics. The approach produces motion and force subsystems that are instantaneously decoupled. The idea is to handle non-instantaneous effects as slowly-varying disturbances. Experimental validation of this theory is being planned.