Optimizing Human Motion for the Control of a Humanoid Robot

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Humanoid robots are already common in theme parks where the investment for a new attraction is substantial. To make humanoid entertainment robots a viable alternative for smaller scale attractions such as location-based entertainment venues, museums, or restaurants, we need easier ways of programming these robots. Entertainment robots must have a natural and entertaining style of motion and often require substantial motion databases to ensure a large variety of behaviors.

For a humanoid robot, such as the Sarcos robot at ATR (DB) shown in Figure 1, one obvious approach is to drive the motion of the robot with motion capture data recorded from a professional actor. Such data would contain the timing and many of the other subtle elements of the actor's performance. However, the current mechanical limitations of humanoid robots prevent the recorded motion from being directly applied, unless the human actors use only a fraction of their natural joint range and move with slower velocities than those commonly seen in human motion.

To address these limitations, the location of the markers in the motion capture data is first mapped to the degrees of freedom of the robot by inverse kinematics on individual limbs. A constrained optimization technique is then used to impose joint angles and velocity limits on the motion while avoiding self-collisions. Optimization techniques allow us to transform the motion to the capabilities of the humanoid robot by specifying an objective function and a set of constraints that preserve the salient characteristics of the original motion. The robot tracks the trajectories of the transformed data using a position and velocity tracking system with feedforward trajectory learning.

We tested these techniques with fourteen motion sequences from seven professional actors. Each subject performed to the same audio track of the children's song, ''I'm a little teapot.'' We chose this selection because it was familiar enough that most actors would perform the motion in a similar but not identical way. It was our hope that an individual's style would be preserved through the transformations necessary to allow the robot to perform the motion. We assess the quality of the results by comparing the motion of the human actor to that of the robot, both visually and quantitatively.

Figure 1: The Sarcos humanoid robot at ATR (DB) tracking motion capture data of a human actor