Human-like Motion For Anthropomorphic Robots

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Motivation

Robots interacting with humans can benefit from communicating in a manner that is socially relevant and familiar to their human partners. Believable behavior establishes appropriate social expectations. Our work addresses the overall problem of how to generate believable or human-like motion for an anthropomorphic robot.

Research Problem

Anthropomorphic robot bodies are different from human bodies. The challenge is to create human-like motion for robots autonomously from minimal input information, despite the differences between robots and humans. Our work focuses on a series of algorithms that work toward improving motion quality for social robots.

Approach

We divide the problem of human-like robot motion for anthropomorphic robots into a series of discrete components, each of which present unique challenges.

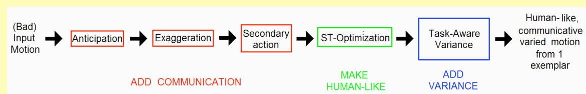
(1) Social robots must use motion as a communication channel to communicate with human partners

(2) Motion must exhibit variety, as opposed to redundancy, so that gestures are never performed the same way twice.

(3) Motion should appear intuitive, recognizable, and familiar to human partners.

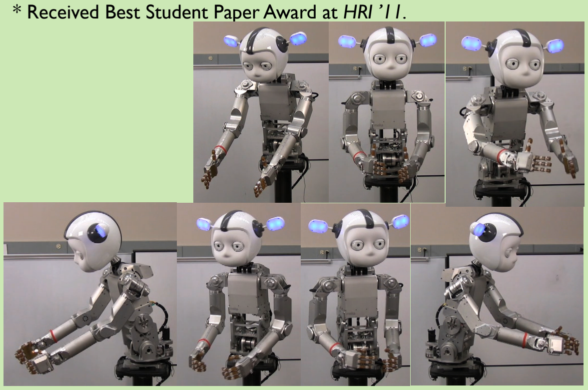
(4) Social robots must maintain world constraints in unison with all social constraints.

The Components of Human-like Motion



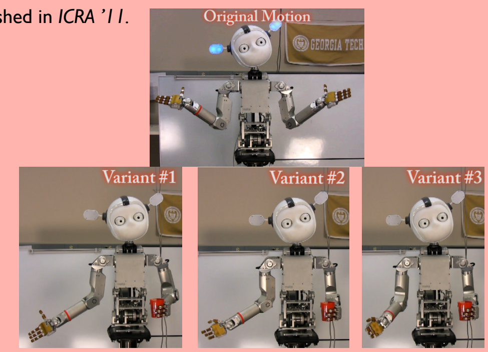
Optimized To Be Spatially & Temporally Coordinated

* Humans can more accurately label, recognize, and imitate STC-optimized motion than uncoordinated motion.
* Coordinating robot motion with respect to the STC metric makes the motion more human-like.
* Coordinating motion increases recognition accuracy and the ability to imitate.
* Received Best Student Paper Award at *HRI '11*.



Variance in the Presence of Constraints

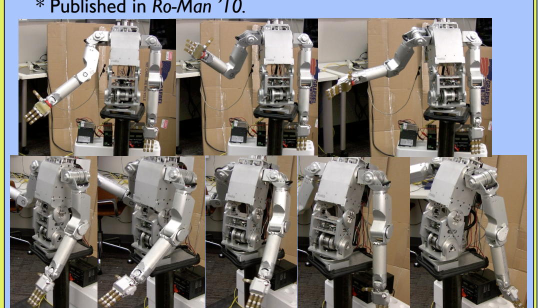
* Optimal control can be used to find a local solution for state-space directions to inject torque-space noise.
* The injection of this noise produces visible differences to motion, thereby creating motion variants similar to the original motion.
* When coupled to operational space control, the resultant motions respect task-based world constraints.
* Published in *ICRA '11*.



Adding Communication

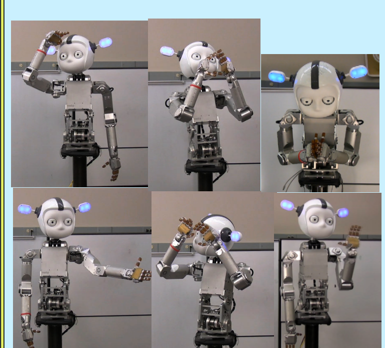
Secondary Action

* Secondary action communicates internal (robot) and external (world) state information such as motor temperature (fatigue), friction, mass, and passivity.
* Eigenanalysis on motion torques allows decomposition of coordinates into highly-actuated and nearly-unactuated.
* Our algorithm projects the highly-actuated torque response onto the nearly-unactuated coordinates so that internal and external force responses are consistent with respect to motion across the entire robot body.
* Published in *Ro-Man '10*.



Anticipation

* Motion used for communication contains what we term as the 'symbol,' which is one frame that yields highest motion recognition accuracy.
* By extracting and moving a symbol earlier in motion, humans can consistently label motion intent sooner, which has social interaction benefits such as decreased frustration and increased cooperative task response time from the human partner.



Exaggeration

* Exaggeration is used to draw attention, when something will be communicated via motion.
* Exaggeration moves parts of the body through larger regions of travel in Cartesian space, while minimizing the parts of the body to which attention should not be drawn.
* By "extremizing" coordinates based on actuation spectrum a single parameter can be used to control the amount of exaggeration to induce into a particular motion.