Robotics, Automation, and Dance (RAD) Lab

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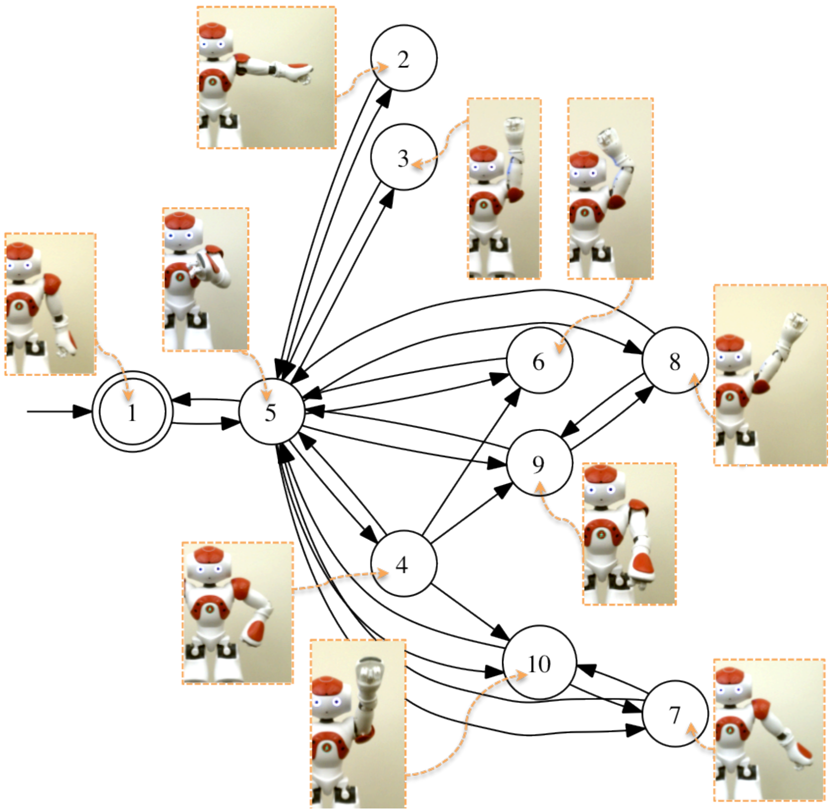

"Studying human behavior using tools from engineering in order to make robots move in a sensible way."

The Robotics, Automation, and Dance (RAD) Lab is interested in finding algorithmic definitions of what defines organized human movement. Without definitions to classify various types of desirable, high level behaviors, robots are just expensive piles of plastic, motors, and circuits. For example, the stylized movement exhibited by individuals in different cannons of movement like ballet, tai chi, and flamenco dancing is an extraordinary phenomenon that is not readily reproducible in an algorithmic way. We strive to change that by developing metrics for human behavior and methods for reproducing similar behavior on robots through close collaboration with the performing arts.

Movement Classification and Segmentation

Extracting features of interest from human motion data (i.e., from mocap systems) can be a useful tool for endowing robots with interesting, even useful, behaviors. In this work, we formulate and solve an inverse optimal control optimal control problem in order to extract some such features. For example, we have developed a framework which can determine such the values of weights in order to recreate the original human motion and measure of our notion of *quality*.

Stylistic Movement Generation

Typically, robotic algorithms focus on tasks which have concrete, functional objectives. Our framework aims to allow for more general specification based on stylistic considerations. Namely, we may think of the movement styles as exhibited by different dance styles as differentiated by distinct *stylistic tasks*. Combined frameworks produced movement sequences with pose sequences that are consistent with each style and with transitions or movements between those poses which are consistent with a desired movement quality – thus answering the questions, "which movements are allowed," and "how should they be executed," respectively. Allowable transitions are described by an automata while the trajectories corresponding to each transition are found as the solution to an optimal control problem with style sensitive weights.

Movement Modulation

Dancers have long studied how to modify movements to produce motion sequences that have desired stylistic properties. In this work we pair dance theoretician, Rudolf Laban's notion of motion factors to weights in an optimal control problem; hence, we are able to produce *motion trajectories* which are bound or free, sudden or sustained, strong or light, and direct or flexible.

Movement Sequencing

This work employs a model of a dancer's working leg during the barre – a set of canonical exercises used by ballet dancers to train their muscles. The states of this discrete event system are body poses critical to the experience of ballet, and the transitions represent movements between theses poses. The availability of transitions from each state encodes movement rules employed by a ballet dancer. The behavior of two legs can be described by a composition of two such systems; however, this composition allows for pose sequences which may be physically and/or aesthetically disallowed. In collaboration with the Hybrid and Networked Systems (HyNeSs) Lab at Boston University we extend the power of this model by utilizing a set of propositions about the system, i.e., "the right leg is off the ground" and temporal logic statements, i.e., "don't life the right leg off the ground if the left leg is also in the air," we create a system which describes the motion of two legs performing balletic motions. To demonstrate, we provide movement sequences which obey the specific physics of bipedal geometry and the aesthetic of basic classical ballet. Our framework not only controls a novel system but also crystallizes rules which govern a novel case of human behavior.

Dynamic Spectral Clustering

We are also developing a dynamic clustering algorithm whose main features are a time-aggregated weight and sliding time window (which is tuned to the dynamic qualities of the dataset) that broaden the abilities of an existing spectral clustering method. Our simple extension allows the algorithm to use time evolving information about the data as it selects classifications (or clusters) for each data point. We have also presented methods for extracting such time scales from data automatically.

RECENT RESEARCH DEVELOPMENTS

- Moving into new space in the Observatory Mountain Engineering Research Facility (OMERF).
- Research featured in Georgia Tech's alumni magazine: http://issuu.com/gtalumni/docs/8903_proof/17

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