Robotic Coaching of Complex Physical Tasks

Alexandru Litoiu and Brian Scassellati
Department of Computer Science, Yale University

Introduction

- How do we deliver advice to effectively induce a transformation from incorrect human movements into correct human movements?
- This is difficult as the inputs and outputs of the student's control algorithm are different from those of the coach.
- This question has broad implications for helping children become more physically active and assisting rehabilitation patients.

Research Questions

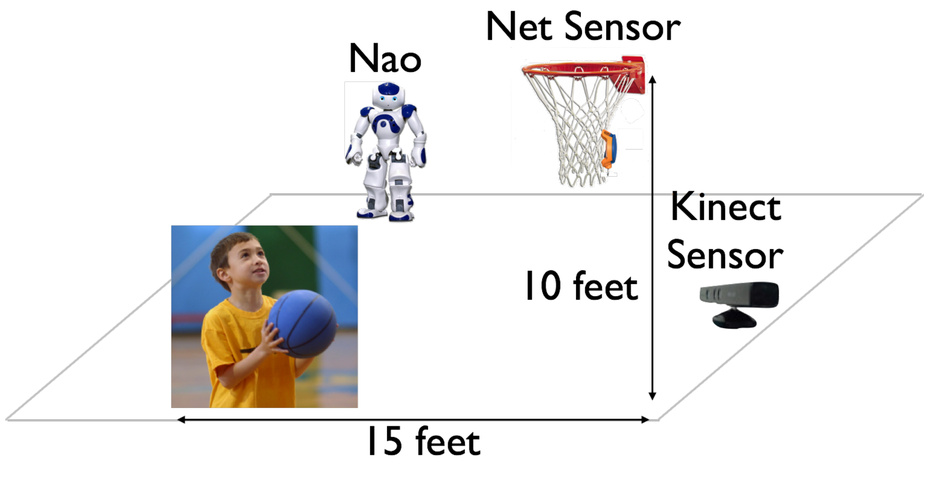
Q1	Perception	*What is the most minimal perception suite that sufficiently captures human movement?*
Q2	Problem Quantification	*What algorithm best quantifies problems in a motion and mines inter-dependencies between these problems?*
Q3	Prioritization	*What algorithm best prioritizes which problems the student should address for most rapid improvement?*
Q4	Communication	*What techniques enable a robot to most effectively deliver advice on a physical skill through verbal and physical demonstration?*

Present Work – Q1

Is the Kinect camera sufficiently accurate to effectively inform physical skill coaching?

Experimental Setup

- Participants shot the basketball from a fixed position
- Skeleton tracked with Kinect 3D camera
- Supervisory success signal recorded



Procedure

- Smoothed, bucketed, and dynamic time warped data
- Split corpus into training, validation, and testing thirds
- Classified whether shooting motion led to success using Support Vector Machine with Radial Basis Kernel

Data

- 521 shot motions recorded from 11 participants
- 40 dimensional time series per shot
- Supervisory success flag for each shot

Results

- Prediction rate of 82.6% versus 71.8% rate of guessing most common label
- Kinect is a promising data capture device
- Room for improvement by augmenting key joints

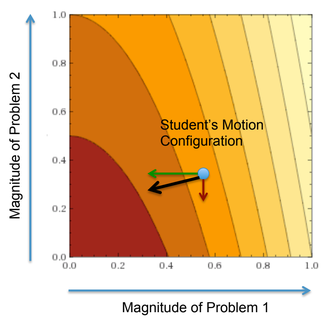
Future Work

Problem Quantification – Q2

- Developed operational problem quantification algorithm
- Aligns 40-dimensional motion time series with gold standard reference motion using dynamic time warping
- Subtracts input signal from gold standard signal
- Buckets each resulting dimension into time partitions

- Will attempt additional features such as joint velocity, max, and min
- Will model inter-relationships between features

Prioritization Module – Q3

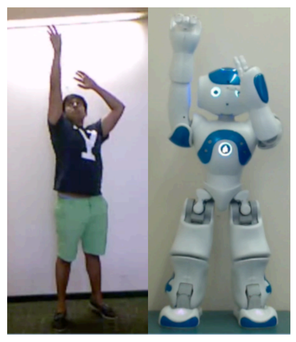


- Important to prioritize most detrimental problems to increase student rate of improvement
- Existing literature prioritizes problems based on expert-chosen heuristics

- Will develop a machine learning approach to prioritize problems in order of importance
- Will investigate modified gradient descent regression and Bayes Networks

Demonstration System– Q4

- Developed demonstration system that allows Nao to imitate student movements while maintaining static stability



- Will develop an exaggeration system to emphasize problems with student movements
- Will investigate effectiveness of exaggerated demonstrations versus verbal advice

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