1. Background and Motivation

The advantages of one-on-one tutoring when compared to standard classroom instruction in student academic performance has been well documented in education research—in general, students perform one to two standard deviations better when receiving one-on-one tutoring. However, schools often lack the funding and resources to provide this kind of personal instruction on a consistent basis for all or even some of their students. Initial investigative research has been conducted on ways to provide an education experience that produces similarly impressive student achievement results while being more easily scalable. The ultimate goal in this field of research is to be able to provide a personalized, individual tutoring experience for students without the need for extensive human capital in the form of skilled tutors and teachers.

While there are a variety of approaches to building an intelligent tutoring system, research has indicated that (1) the physical presence of a robot tutor can be effective in increasing learning gains and (2) a robot tutor utilizing simple personalization strategies can have a significant positive impact on student achievement. From these principles, Ramachandran, Litoiu, & Scassellati recently investigated the effect of simple strategies aimed at shaping productive help-seeking behaviors and found that students who received adaptive strategies targeting suboptimal help requests (i.e. asking for too much help or not asking for enough help) not only reduced their suboptimal behavior over time but also significantly improved their test performance when compared to a control group.
2. General Project Overview

The goal of this research project is to build an intelligent robot tutoring system that can utilize (1) data collected from previous research studies and (2) real time data from student-robot interactions to autonomously provide effective help for students. The system will attempt first to construct a help-providing strategy based on an initial evaluation of the student and then fine-tune this strategy with real-time information gathered from the subsequent tutoring interaction. This type of help-providing behavior is meant to simulate the traditional human tutor and student interaction where a tutor autonomously guides the student with hints when the student is stuck, oftentimes without the student explicitly asking for help. Furthermore, this approach will allow for a more personalized tutoring interaction with students, which should help promote academic gains.

For this intelligent robot tutoring system, the NAO humanoid robot will be used to interact verbally and visually with students. In addition, an Android tablet application will be used as a method to display and check answers to problems given in the tutoring sessions. The system, while meant to be generalizable, will first be used to tutor fifth and sixth graders in math fraction problems as part of a study.

3. Project Scope

There are two main sources of information that can be analyzed in real-time from the robot-tutor interaction. One source is the video feed of the interaction that can be used in conjunction with image processing software to detect student affect information (i.e. is the student confused, focused, or bored?). A second source is the data collected from student interaction with the Android tablet application. In particular, data about the types of problems that a particular student has successfully and unsuccessfully tackled in the past, the amount of time a student has taken on each kind of problem, the kinds of help given to a student and its
effectiveness in the past etc. could be leveraged in real-time to fine-tune the baseline help-providing strategy of the tutoring system.

My project will focus on the utilization of this second source of data to refine the help-providing strategy of the robot tutor. This process will begin with a literature review of previous attempts that intelligent tutoring systems have made in leveraging this kind of real-time data to refine personal tutoring strategies. A simultaneous literature review will be conducted in the field of educational psychology particularly as it pertains to one-on-one tutoring. Subsequently, work will be done determining the relevant metrics to be used and building a scalable model to record and access this data for each individual student user—this step will involve working with the Android tablet application. Afterwards, in collaboration with researchers working on the baseline adaptive model and the affect detection modifications to the model, real-time learning software will be developed that allows for the input of these relevant student-tablet interaction metrics to alter the behavior of the robot—this process will involve interfacing with the NAO robot through Python. Finally, a report will be written and submitted concerning the research conducted this semester as well as documentation for the software developed and its efficacy (or projected efficacy) in real-world systems.

4. Final Notes and Other Areas of Interest

This project will be a collaborative research endeavor with Prof. Brian Scassellati, Aditi Ramachandran, and Eric Ho. Above, I presented a preliminary aspect of this problem that my research will focus on. However, due to the nature of this investigative project, there may be some changes to the scope of my contributions that will become clearer as the project advances.

Since this project involves a large amount of exploratory research, there are several other areas that may be pursued to further the goal of creating an adaptive, personalized robot tutoring experience. In particular, reinforcing a “growth mindset” (i.e. problem solving ability can be improved through effort) as opposed to a “fixed mindset” (i.e. problem solving ability is innate) in students through specific
robot interactions may be of interest in creating a more effective adaptive tutoring model. Additionally, affect detection could be further enhanced by the use of vital sign data (especially pulse rate and body temperature) through the use of heart rate monitors or IR cameras.