A Hands-Off Assistive Robotic Educational Intervention Strategy for Children with Attention-Deficit/Hyperactivity Disorder

Jenny Chang Ho
Interaction Laboratory
University of Southern California
941 West 37th Place, Los Angeles, CA 90089-0781
changjen@robotics.usc.edu

Jen Yu
School of Film & Video
California Institute of the Arts
24700 McBean Parkway, Valencia, CA 91355-2397
jenyu@calarts.edu

I. Project Motivation

Many children diagnosed with Attention-Deficit/Hyperactivity Disorder (AD/HD) today. Early intervention will provide long-term effects that will improve their lives. Some of the negative consequences of Children and Adults with Attention-Deficit/Hyperactivity Disorder (CHADD) that could be prevented through early intervention are "low self esteem, social and academic failure, substance abuse, and a possible increase in the risk of antisocial and criminal behavior" [2]. Moreover, the fact sheet indicates that "Treating AD/HD in children requires medical, educational, behavioral and psychological interventions" [2]. Teaching AD/HD children also requires special training and individualized attention from the teachers. However, due to the shortage of special education teachers and AD/HD students being placed in the same classrooms with average students, regular teachers' attentions make up for less than what an AD/HD student needs. The goal of this project is to use an assistive mobile robot to provide an educational intervention strategy for an elementary school student. The human-robot interaction is not only going to provide one-on-one attention needed by a student with AD/HD, but also supervise the student's progress and eventually improve the student's self-esteem.

II. Project Goals and Approach

The main goals of this project are to implement a robot to do the following:

(1) Provide an educational intervention strategy through human-robot interaction.
(2) Provide one-on-one attention needed by a student with AD/HD.
(3) Supervise the student's progress in the absence of a teacher.
(4) Determine the effectiveness of the proposed educational intervention strategy in terms of improving the student's scores.

The target student of this project is a 5th grade student who is diagnosed with AD/HD. He or she can be doing some exercises from a book, a computer, or other alternative forms of learning. For the purpose of this project, an educational software that is specially developed to supplement a 5th grade Math curriculum will be used because of its automated scoring process, as well as its ability to keep track of the length of time consumed by the student. The AD/HD student doing his or her work may sometimes have difficulty following instructions or paying attention. He or she may not feel comfortable with seeking assistance from the teacher. It is suggested that using an educational toy robot to interact with the student on a one-on-one basis can indirectly help the student build his or her self-esteem. This is accomplished by engaging the student to do some physical exercises or answer relevant questions such as elementary Math problems like addition, subtraction, multiplication, and division [1]. In this case, the robot is serving as a socially competent peer and a supervisor for the AD/HD student. The supervising robot will monitor the student's progress by making sure he or she is on task. At random intervals, the robot will initiate contact with the student by asking to play a game. The student will also have the opportunity to initiate contact with the robot by using fluorescent colored flash cards to get the robot's attention; this element of physical interaction will provide a subtle way for the AD/HD student to develop social skills. In general, the series of exchanges taking place in all parties culminate as solutions in improving the student's educational and social well-being.

III. Evaluation Test Bed

This project involves two types of interactions: student-computer and student-robot. The educational software installed in the student's computer is an off-the-shelf product. The software has a feature that keeps track of the length of time taken and number of problems the student solves correctly. Whenever the student interacts with the robot, the robot also keeps track of the problems solved correctly and the time taken during each interaction. The results are useful for quantitative comparisons.

The process starts with a student working on the computer. He or she is encouraged to initiate contact with the robot as a subtle way to help develop social skills. The student is expected to initiate the contact when he or she wants to take a break from the computer by using a fluorescent colored flash card to signal the robot to approach. The fluorescent colored flash cards indicate the types of interaction the student wants with the robot. A fluorescent yellow colored flash card tells the robot the student wants to play a game. A blue colored flash card tells the robot the student wants to exercise, so the robot selects one of five exercise videos for the student to perform. The first goal is satisfied in this process. The color detection of the flash cards is accomplished via vision sensing on the robot. Fluorescent colors are specifically used to distinguish the flash cards from other natural colored objects in the environment, thus making the color detection more accurate. They are also used to assist the student in organizing the ways in which he or she can interact with the robot. If the student does not initiate any contact with the robot, the robot will approach the student and ask him or her to play a game at random intervals. This process enables the robot to monitor the student's progress and check whether the student is on task or understanding the exercises.

If a colored flash card is detected by the robot, the robot detects where the student is located via a laser range-finder and positions itself around 5 feet away from the student. It finds the student using laser-based leg detection. If a fluorescent blue colored flash card is used, the robot shows an exercise video to help the student overcome his/her boredom. If a fluorescent yellow colored flash card is used, the robot plays a pre-recorded female speech asking the student to play a game. The game consists of solving an elementary Math problem. The robot will try to assess the student's learning in three levels: beginning, intermediate, and advanced. The level of the problem difficulty is chosen at random to test the student's understanding of the topic. After a problem is chosen, the robot visually displays an illustrated image on the 15" screen indicating the problem, and the possible solutions surrounded by squares with the corresponding fluorescent colored flash card color. Three more fluorescent colored flash cards with letters A, B, and C printed on them will be used by the student to signal a response to the robot. The student will have a fixed time of 5 minutes to think of a solution and use the fluorescent colored flash card corresponding to the possible solution. The robot praises the student for the correct solution; otherwise it encourages the student to do better next time and displays the solution both visually and verbally. Afterwards, the robot offers the option for the student to play again by asking the student to use the fluorescent yellow flash card. Any other fluorescent colored flash card is used to indicate the student wants to continue working on the computer. If a fluorescent yellow colored flash card is detected, the robot chooses a Math problem based on the performance of the last interaction for the student to work on. A similar problem will be chosen if the student solved the previous problem incorrectly, otherwise a random problem will be chosen. This process enables the student to practice solving similar problems and to improve. If the robot detects that student has walked back to his or her desk that is marked with a fiducial, it returns to idle state. It wakes up at random time intervals to interact with the student or when the student uses a fluorescent blue or yellow colored flash card again.

The robot that is described above uses a primary battery power and an ActivMedia Pioneer 2 DX mobile robot platform that enables mobility. A 2GHz Pentium M laptop running Ubuntu Linux is used to display a video using a movie player. The interface has to be very entertaining and capture the student's attention; therefore, it consists of 2D animated cartoon character with pre-recorded female speech. Pre-recorded human speech has been found to be very effective for motivating users through human-robot interaction [3]. The interface is designed with the assistance of Jen Yu, a California Institute of Arts student majoring in experimental animation. She will design and animate the face of the talking robot. Another sensor on the robot is a laser range-finder. A SICK LMS200 provides a 180 degree field of view for obstacle avoidance. The behavior-based system will provide the underlying architecture of the robot.

IV. Evaluation

The experiments will initially be conducted in a controlled environment at the University of Southern California's Interaction Laboratory. Each of the experiments will run for 30 minutes. The data collected for both the computer and robot interactions will be analyzed off-line to determine the effectiveness of the AD/HD educational intervention strategy. Comparison of the percentage of number of problems solved correctly between the human-computer interactions will be made. To determine how much the student's improvement is as a result of interacting with the robot, comparison of the percentage of number of problems solved correctly between the human-robot interactions will be used. These comparisons will serve as evidence whether the student is improving or not. The length of time in the logs will further indicate whether the student's attention span on the computer has increased after interacting with the robot. All this information will be plotted in charts. The number of human-robot interactions will indicate how often the student initiated the contact with the robot or vise versa. Finally, a survey will be conducted at the end of the experiment to show whether the student found this intervention strategy useful.

Ideally it is important to test the robot with real subjects, but due to project duration constraints in one semester, it is not long enough to do an extensive research. Future work will include testing with real subjects, determining the effectiveness of this intervention strategy by comparing it to other educational intervention strategies, whether the student's self-esteem has improved as a result of prolonged interactions with the robot, how often the student was on task with the presence of the robot, and making the robot more adaptable to support other elementary-level subjects. Finally, the results will be used to compare how another student with AD/HD performs without having any interaction with the robot.

V. Milestone

Task Name	Start	Finish	Duration
Interface design	9/26/2005	10/05/2005	1 week
Sound design	9/28/2005	10/05/2005	1 week
Code design/Algorithm	9/28/2005	10/05/2005	1 week
Code implementation	10/06/2005	11/02/2005	4 weeks
Testing	11/03/2005	11/10/2005	1 week
Demo	11/11/2005	11/11/2005	1 day
Testing on real robot	11/14/2005	11/18/2005	1 week
Project report	11/21/2005	11/30/2005	1.5 weeks
Project presentation preparation	12/1/2005	12/6/2005	1 week
Project presentation	12/7/2005	12/7/2005	1 day

VI. References

[1] California State Board of Education (2005). *Grade Five Mathematics Content Standards* [Electronic version]. Retrieved October 9, 2005, from http://www.cde.ca.gov/be/st/ss/mthgrade5.asp
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[3] J. Eriksson, M. J. Mataric´ and C. J. Winstein, "Hands-off Assistive Robotics for Post-Stroke Arm Rehabilitation," In *International Conference on Rehabilitation Robotics*, Chicago, Illinois, Jun 2005.
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