Programming a Robotic Arm to Play Air Hockey

Chris Atwood Jessica Heasley Fabien Heitz
Richard Juchniewicz Stephanie Rosenthal Steven Shamlian Andy Shen
Jacob Thomas Ram Yalamanchili Paul Zagieboylo

Abstract
Last semester, using funding from the Undergraduate Research Initiative with a Student Undergraduate Research Grant, our group developed and built a robotic arm that has the speed and agility to play air hockey against a human player. The arm consists of two tracks mounted at right angles. One track moves vertically along the length of the table and the other track moves horizontally across the table's width. An overhead camera will tell the arm where the puck is at any given time. The arm then responds by making a decision whether to protect the goal or to hit the puck. In the course of this project, we will be applying several existing technologies such as robotic manipulation, image recognition algorithms, and basic artificial intelligence to create a robotic air hockey table. This final phase of the project deals with the architecture and programming of the robotic arm to play air hockey.

Introduction
In the mid-1980s, the CMU Robotics Club built a robotic air hockey table. It was quite limited in design. The arm had but one degree of freedom – left and right, and its logic was not very good. A picture of the air hockey table is available at CMU Robotics Club website at http://www.roboticsclub.org/pics/hockey-robot.gif. Our plan is to produce an artificial intelligence to play air hockey. In this we will be developing new feedback-control algorithms for use with motion-planning systems, useful for many applications. These include mobile robotics, coordination tasks, and other similar problems.

Proposal
Last semester, our goal was to build a robotic arm with three degrees of freedom that can play air hockey. In this first phase of the project, we focused on developing the robotic arm and its control board. The arm consists of two tracks mounted at right angles, one track that can move vertically and the other that can move horizontally. This design allows the arm to reach any location on its half of the table. A vertical pole holding the paddle is attached to the crossed tracks. The pole moves up and down through the use of a solenoid (the third degree of freedom) so that the arm can catch the puck and also not worry about friction while moving. We can test the motion of the arm using a joystick.

This semester, we plan to develop a vision system for the air hockey table. The vision system will send input to the control board which in turn directs the arm to move to a particular location. The vision system will consist of a camera hooked up to a computer running our custom software through a video capture card. The software we write will process the input, predict the motion of the puck in real time, and then direct the motion of the robotic arm through a serial link to the motor controllers. By the end of this second phase of the project, we will have a working robotic arm that can play a decent game of air hockey against a human player.

Since this project is sponsored by the CMU Robotics Club, we will have the opportunity to discuss our project with several senior officers with vast experience in robotics. We also have access to all the resources that the Robotics Club can provide. After the project is finished, if further improvements can be made to the project, the air hockey table will remain with the Robotics Club. Otherwise, an air hockey table with an intelligent robotic arm will be donated to Carnegie Mellon University.

Applicants

Chris Atwood is a junior in Mechanical Engineering. He is the President of the Robotics Club and has worked on several robotic projects including Urban Search and Rescue and a vertical take off and landing vehicle. **Jessica Heasley** is a sophomore in Mechanical Engineering. She has worked on the Snake Robot Research Team designing and constructing modular serpentine robots. **Fabien Heitz** is a sophomore in Mechanical Engineering. He has taken Physics I, II, and Statics. He enjoys building, working on, and fixing his model cars, boats, and airplanes. He is proficient in Solidworks, Bryce, and 3D Studio MAX. **Richard Juchniewicz** is a sophomore Mechanical Engineer. He is the Robotics Club Treasurer. His accomplishments include entering the first legged Mobot in Mobot history, thanks to a grant from URI. That being said, he is quite adept in mechanical design and construction. **Stephanie Rosenthal** is a freshman in Computer Science. She has worked on mobile Ad Hoc networking for robots, and was a member of the GRACE team (a robot that attended the AAAI conference and gave a talk), contributing to the synchronization of emotions and speech. **Steven Shamlian** is a sophomore in Electrical and Computer Engineering and the Vice President of the Robotics Club. He has worked for Illah Nourbakhsh on Urban Search and Rescue robots for the last three semesters and at iRobot Corp. on the Roomba autonomous vacuum cleaner for the last two summers. His QA embedded test beds are currently in use in China on the Roomba production line. **Andy Shen** is a sophmore in Electrical and Computer Engineering. He has worked on the Trinity Firebot project and on Simultaneous Localization and Mapping. Currently he is working on a voice recognition system for the Pocket PC. **Jacob Thomas** is a sophomore electrical engineering major. He has worked on independent projects ranging from basic robotics to a small scale Automated distillation facility. **Ram Yalamanchili** is a sophomore in Electrical and Computer Engineering. He has worked at the Autonomous Helicopter Lab and developed embedded control systems with integration into VxWorks RTOS for servo and camera control. **Paul Zagieboylo** is a freshman in Computer Science. Currently he is a member of the robotics club working on a Mobot project.

For this project, the mechanical engineers Chris Atwood, Jessica Healey, Fabien Heitz, and Richard Juchniewicz have been responsible for building the robotic arm. Electrical engineers Steven Shamlian, Andy Shen, Jacob Thomas, and Ram Yalamanchili implemented the circuitry, control board, and joystick controller for the robotic arm. Computer Scientists Stephanie Rosenthal and Paul Zagieboylo will be responsible for programming motion algorithms for the robotic arm. All members of the team will contribute to the design of these algorithms.

Dissemination of Knowledge

We will be submitting our findings to Momentum and any industries that would find our work interesting. After completion the robotic air hockey table will also be open to the public.

Presentation and Evaluation

We will present our final results at the Undergraduate Research Symposium. In addition, we will exchange weekly emails with our advisor Tsuhan Chen to ensure that we stay on track. Once it is finished, the table will be on display on campus, perhaps at the Robotics Club.

Proposed Budget

Components		Cost
Camera		$200
Video Capture Board		$200
Computer		$600
	Total	$1,000