CYBER-Alaska: Training Tomorrow's Engineers in Cyber-Physical Systems (CPS)

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1 CYBER-Alaska Project Goals

Graduate students at UAF performing CPS related research will teach and mentor grade 7-12 students and teachers of urban and rural Alaska via course material and simple project models, to be developed related to their research. We will take the students through the whole development process of the project kits (i.e. modeling, simulation, mechanical design, control, and networking steps) in a level-appropriate manner, using an inquiry-based approach. The fellows will bring their research to classrooms primarily through the in-class development of simpler dynamic simulations or models—both physical and virtual—of the actual systems related to their research.

Such an interactive model of the actual system first acts like an "elevator speech" intro for the field, can help convey the fundamental principles of the field, and transforms mere discussion into concrete, tangible activity. The developed courses and project kits, both software and hardware, will be made accessible on the internet for use by other students, researchers, and general public. The following are examples of our projects.

2 Virtual/Real Coupled Simulation

As shown by the MATE ROV competition and MIT SeaPerch projects, even middle school students are capable of constructing underwater remotely operated vehicles (ROVs). UAF undergraduate students and Alaska middle and high school students have competed in the MATE ROV contest international finals in 2007, 2008, and 2010, mentored by Co-PI Lawlor. Typically, a control PC sends commands over a USB or serial link to an onboard microcontroller, which drives the thrusters and reads the vehicle's sensors. The pilot sits at the PC watching a video feed from the ROV, and commands the vehicle using a joystick or gamepad. As shown in Figure 1, we have found it useful to provide the pilot with a real-time simulation of the ROV, driven from the same control inputs, where a simple Newtonian physics model integrates the linear force and angular torques from the virtual thrusters. This linked real-time simulation provides the pilot with a "bird's eye view" of the ROV's position and orientation, and displays sensor data from the ROV. This interrelationship between physical and virtual robots helps naturally deliver CPS concepts to high school students.

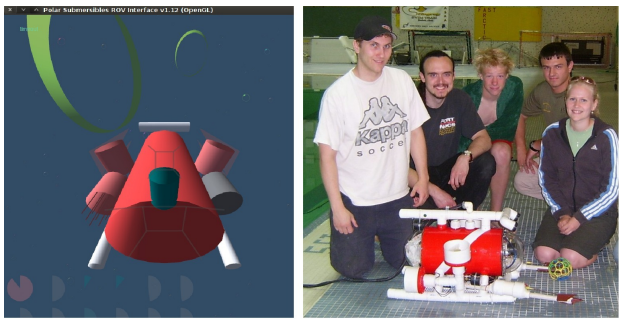

Figure 1: A simulated underwater robot, coupled in real-time to a real physical robot, as built by students.

3 Smart Buildings & Roads

The thermostat of a future energy-efficient house might combine sensor measurements of interior and exterior temperature with predicted weather, a detailed online simulation, and variety of passive and active actuators such as solar reflectors and heat pumps. As the coldest US state, and one with among the highest fuel prices, Alaskan children have a deep and intimate familiarity with the importance of energy-efficient heating systems, and the benefits of intelligently reducing energy consumption. We will build upon a house model which has been used at UAF for several years, where the house's central heater is emulated using an incandescent light bulb and a small fan.

We will add microprocessor controlled sensors and actuators linked to a PC, allowing us to plot temperatures, run experiments to measure transient and steady-state heating effects, run simple data fusion algorithms, and compare the physical kit measurements with various simulations. Because heat flow rates are a linear function of temperature difference, high school students should be able to construct useful models to predict energy use given interior and exterior temperatures. Based on these models, students can then construct heating control systems using CPS concepts, such as a smart thermostat that integrates sparse measurements with a linked simulation.

4 Further Examples

More details and downloadable simulation software examples are available at:

http://www.cs.uaf.edu/2011/research/cyberalaska/