

FY2008 Learning Technologies Grants Proposal
(COVER PAGE)

Project Information

A Synergistic Instructional Approach for Optomechatronics and Robotics
Project Title

C. N. Thai & W. D. Potter
Project Directors

Biological & Agricultural Engineering and Computer Science
Requesting Department

12,722
Amount Requested Year 1

6,672
Amount Requested Year 2

Project Director's Signature

Proposal Endorsement Signatures

Department Head

Dean

Proposal Abstract (100-word maximum)

This project seeks to enrich the curriculum of engineering and computer science by leveraging the natural synergy that exists among three related yet specialized courses: Applied Machine Vision, Introduction to Robotics, and Mechatronics Systems Engineering. Students will be taught how to design and develop a variety of devices (e.g., grippers, haulers, harvesters, data communications) under global and autonomous control leading to the design of a scaled-down version of a selective tree harvesting robotics system, using a series of phased-in hands-on challenges for students incorporated into the above three courses over a 2-year period.

A Synergistic Instructional Approach for Optomechatronics and Robotics

PROJECT DESCRIPTION

This project seeks to enrich the curriculum of engineering and computer science by leveraging the natural synergy that exists among three related yet specialized courses. The three courses are: (1) ENGR-4540/6540, Applied Machine Vision, which deals with automated vision systems for identification, measurement, and quality control, (2) ARTI/CSCI-4530/6530, Introduction to Robotics, which deals with cognitive behavior and motion of autonomous mobile robots, and (3) CSEE-xxxx, Mechatronics Systems Engineering, a course currently being developed for the newly formed Computer Systems Engineering degree program that will deal with integrated mechanical, electrical, and computing systems. The enrichment plan involves students from the various classes in the developmental phases of a major optomechatronics project that evolves over time. Students will be taught how to design and develop a variety of devices (e.g., grippers, haulers, harvesters) under global and autonomous control. Throughout the project the students will be exposed to real-world challenges of dealing with interdisciplinary goals, changing specifications, legacy designs, and various approaches to systems control.

The initial challenge that we plan to start with involves designing a selective tree harvester. A series of phased-in hands-on challenges for students will be incorporated into the above three courses and will lead to the design of a scaled-down version of a selective tree harvesting system by small-scale robots using autonomous and/or supervisory control. The "forest" will consist of "red" dowel rods that are to be harvested and "green" dowel rods that are to be left untouched. The positions of the red and green "trees" will be randomized so that students can develop solutions for autonomous intelligent robots as well as supervisory control solutions using robots with more limited local capabilities but receiving real-time tracking data of robot positions as well as the current "state" of the "forest" from a global tracking machine vision system.

Work Plan

Drs. Thai and Potter will be co-directors of this 2-year project. Dr. Thai will be in charge of the following courses: ENGR-4540/6540 (Applied Machine Vision - offered every other year - 10/15 students expected) and ENGR-4980 (Special Topics – to become the new Mechatronics course for the Computer Systems Engineering degree - 15-20 students expected per year). Dr. Potter will manage ARTI/CSCI-4530/6530 (Introduction to Robotics – offered each fall with currently 15 students/year, but expecting 25/30 students/year when the CSE degree gets on line).

SPRING 08 (work done via ENGR-4540/6540 - Applied Machine Vision):

The first goal is for engineering students to develop "Golden Eye", a global multi-object tracking system using custom machine vision hardware and software which will become the real-time source for tracking information used for controlling multiple robots. Depending on student progress, they can also tackle the wireless communication issues among "Golden Eye", laptop PCs acting as the supervisory controls for Intellibrain-2 robots and the robots themselves.

The second goal is for engineering students to get familiar with the workings of Intellibrain-2 robots equipped with CMUcam3 color cameras. Student teams will be asked to design a robot capable of navigating through a ski-slalom like course using colored dowels as

sign posts as fast as possible. Students can try different approaches such as using panoramic vision or forward vision only combined with sonar sensors for proximity determination. All progress will be documented to be used by Robotics students in Fall 2008.

FALL 08 (work done via CSCI-4530/6530 - Introduction to Robotics)

The goal for the Robotics class will be to integrate Intellibrain-2 robots equipped with CMUcam3 cameras and custom-designed Lego gripper arms so that they can then locate "marked" trees (red vertical dowels among a "forest" of red and green dowels), grab the red dowels, and either put them in a bin or take each to a gathering point. The students would follow an incremental development plan in order to work up to the harvesting challenge by first attacking smaller challenges with the Lego components and the Intellibrain-2 robot components. All progress will be documented to be used by engineering students in Spring 2009.

SPRING 09 (work done via ENGR-4980 Special Topics course - 2 credit hours - serving as a prototype and partial Mechatronics Course which will have 4 credit hours in Spring 2010)

Students will be taught specific technologies to design custom actuators to pick up trees and carry them to the gathering area. The goal will be for engineering students to gain experience in designing a new custom-built multi-controller platform using multiple Intellibrain-2 controllers. The multi-controller design will allow each controller to be dedicated to each main task of self-location, directed navigation, and harvesting control. The newly designed robotics platform will be the foundation used by future engineering and computer science students.

FALL 09 (work done via CSCI-4530/6530 - Introduction to Robotics and ENGR-4980 Special Topics)

Engineering and computer science students will be using the same multi-controller robotics platform developed in Spring 2009, however the goal for robotics students will be to enhance the autonomous behavior of the harvester robots using local vision, route planning, and optimization. The goal for engineering students will be to adapt the robots for remote supervisory control from the laptop PC using global location data from "Golden Eye". "Golden Eye" observations will be used to decide harvesting order and optimal routing for the robotics platform while on-board reasoning will determine local harvesting actions to be performed. Depending on student progress, issues of multi-robot cooperative harvesting may also be addressed.

BUDGET**Proposed Budget**

ITEM	Quantity	Total Cost	Requested from LTG	Provided by Other Sources
First Year budget (funds needed by Spring 2008)				
“Golden Eye” System:				
• Desktop PC (PCI Express Bus)	1	\$1,600	\$1,600	
• 1 Gigabit Color Camera	1	\$3,500	\$3,500	
• 1 Gigabit PC Interface Card for camera	1	\$450	\$450	
• 2 Laptop PCs for students	2	\$2,000	\$2,000	
• National Instruments Development Software	1	\$1,000		\$1,000
Intellibrain-2 Controller Kits	6	\$2,754	\$2,754	
CMUcam3 Color Cameras	6	\$1,434	\$1,434	
CMUcam Interface Cable & Mounting Kit	6	\$150	\$150	
AirCable Kits (Wireless Comm.)	6	\$834	\$834	
TOTAL for First Year		\$13,722	\$12,722	\$1,000
Second Year budget (funds needed by Fall 2008)				
Intellibrain-2 Controller Kits	6	\$2,754	\$2,754	
CMUcam3 Color Cameras	6	\$1,434	\$1,434	
CMUcam Interface Cable & Mounting Kit	6	\$150	\$150	
AirCable Kits (Wireless Comm.)	6	\$834	\$834	
Miscellaneous Mechatronics Hardware (Batteries & Charger, Servos, Gears, Actuators, Custom Sheet Metal Work, etc...)	1	\$1,500	\$1,500	
TOTAL for Second Year		\$6,672	\$6,672	
TOTAL REQUESTED FOR PROJECT		\$20,394	\$19,394	\$1,000

Budget Justification

The "Golden Eye" system and the first group of 6 Intellibrain-2 controller systems are needed for the Applied Machine Vision course already scheduled for Spring 2008. After Spring 2008, these controllers will be permanently released to the Robotics class scheduled for Fall 2008, and later in Spring 2009 they will be combined with the second group of Intellibrain-2 controllers for the design of the future multi-controller robotics platforms to be used by all engineering and computer science students. We hope to create 4 units of these multi-controller robotics platforms to take care of about 20 students, however if more are needed by that time, we may be able to use existing Intellibrain-1 controllers from the engineering department to create 2 or 3 more multi-controller robotics platforms. The miscellaneous Mechatronics Hardware items are needed to create the custom harvester arms and grippers to go on the multi-controller robotics platforms. Funding support provided by other sources will come from the Biological and Agricultural Engineering department and the Center for Artificial Intelligence.

Project Timeline

Date	Objective	Person(s) Responsible
Spring 08	<ul style="list-style-type: none"> • Design of "Golden Eye" system. • Ski Slalom project. • Design of Communication Systems among "Golden Eye", Laptop PCs and Bots. 	C. N. Thai
Summer 08	<ul style="list-style-type: none"> • Finishing steps for Communication Systems started in Spring 08. 	C. N. Thai & W. D. Potter
Fall 08	<ul style="list-style-type: none"> • Single-controller tree harvesting project (Intellibrain-2, CMUcam3 camera, Lego Gripper). 	W. D. Potter
Spring 09	<ul style="list-style-type: none"> • Design of Multi-controller Robotics Platforms (MRPs) with independent multi-task capabilities and new load-sensing grippers. 	C. N. Thai
Summer 09	<ul style="list-style-type: none"> • Initial Integration of MRPs to "Golden Eye" system. 	C. N. Thai
Fall 09	<ul style="list-style-type: none"> • Parallel development of Autonomous and Supervisory Control of Selective Tree Harvesting Systems using MRPs and "Golden Eye". 	W. D. Potter & C. N. Thai

LEARNING OUTCOMES

As can be seen from the example activities above, the synergy between the three courses will be used to continually and mutually enhance the instructional materials as well as the technical challenges for students taking these courses. This synergy can be exploited for many years to come by taking on other projects in the future such as robot teamwork challenges (cooperative and/or competitive), telemetry guided challenges, quadrupedal/bipedal "walking" robot challenges and so on.

The overall benefit will be to show students the relevancy of their acquired knowledge and training in solving real-world problems and highlight the signposts of their educational progress which should boost their self-confidence in dealing with new working environments after graduation.

SUPPORT PLAN

After the initial boost from the LTG grant for the first 2 years, we should be able to maintain the laptop PCs and robot systems using additional resources from the new engineering degrees which should be coming on-line by that time. New mechatronics projects will also be designed and implemented with these funds. Funds from local industry groups will also be sought as the mechatronics thrust of the engineering department should be of great interest to them in terms of investing in training of their future employees.