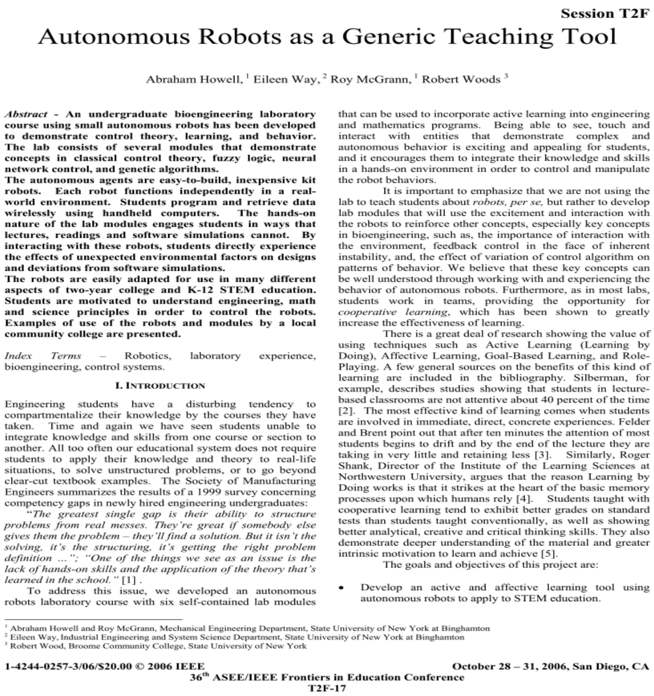
Virtual Learning: A Revolutionary Approach To Building A Highly Skilled Workforce



Session T2F

Autonomous Robots as a Generic Teaching Tool

Abraham Howell, [1] Eileen Way, [2] Roy McGrann, [1] Robert Woods [3]

***Abstract* - An undergraduate bioengineering laboratory course using small autonomous robots has been developed to demonstrate control theory, learning, and behavior. The lab consists of several modules that demonstrate concepts in classical control theory, fuzzy logic, neural network control, and genetic algorithms.**
The autonomous agents are easy-to-build, inexpensive kit robots. Each robot functions independently in a real-world environment. Students program and retrieve data wirelessly using handheld computers. The hands-on nature of the lab modules engages students in ways that lectures, readings and software simulations cannot. By interacting with these robots, students directly experience the effects of unexpected environmental factors on designs and deviations from software simulations.
The robots are easily adapted for use in many different aspects of two-year college and K-12 STEM education. Students are motivated to understand engineering, math and science principles in order to control the robots. Examples of use of the robots and modules by a local community college are presented.

Index Terms – Robotics, laboratory experience, bioengineering, control systems.

I. INTRODUCTION

Engineering students have a disturbing tendency to compartmentalize their knowledge by the courses they have taken. Time and again we have seen students unable to integrate knowledge and skills from one course or section to another. All too often our educational system does not require students to apply their knowledge and theory to real-life situations, to solve unstructured problems, or to go beyond clear-cut textbook examples. The Society of Manufacturing Engineers summarizes the results of a 1999 survey concerning competency gaps in newly hired engineering undergraduates:

"*The greatest single gap is their ability to structure problems from real messes. They're great if somebody else gives them the problem – they'll find a solution. But it isn't the solving, it's the structuring, it's getting the right problem definition …"; "One of the things we see as an issue is the lack of hands-on skills and the application of the theory that's learned in the school.*" [1] .

To address this issue, we developed an autonomous robots laboratory course with six self-contained lab modules that can be used to incorporate active learning into engineering and mathematics programs. Being able to see, touch and interact with entities that demonstrate complex and autonomous behavior is exciting and appealing for students, and it encourages them to integrate their knowledge and skills in a hands-on environment in order to control and manipulate the robot behaviors.

It is important to emphasize that we are not using the lab to teach students about *robots, per se,* but rather to develop lab modules that will use the excitement and interaction with the robots to reinforce other concepts, especially key concepts in bioengineering, such as, the importance of interaction with the environment, feedback control in the face of inherent instability, and, the effect of variation of control algorithm on patterns of behavior. We believe that these key concepts can be well understood through working with and experiencing the behavior of autonomous robots. Furthermore, as in most labs, students work in teams, providing the opportunity for *cooperative learning*, which has been shown to greatly increase the effectiveness of learning.

There is a great deal of research showing the value of using techniques such as Active Learning (Learning by Doing), Affective Learning, Goal-Based Learning, and Role-Playing. A few general sources on the benefits of this kind of learning are included in the bibliography. Silberman, for example, describes studies showing that students in lecture-based classrooms are not attentive about 40 percent of the time [2]. The most effective kind of learning comes when students are involved in immediate, direct, concrete experiences. Felder and Brent point out that after ten minutes the attention of most students begins to drift and by the end of the lecture they are taking in very little and retaining less [3]. Similarly, Roger Shank, Director of the Institute of the Learning Sciences at Northwestern University, argues that the reason Learning by Doing works is that it strikes at the heart of the basic memory processes upon which humans rely [4]. Students taught with cooperative learning tend to exhibit better grades on standard tests than students taught conventionally, as well as showing better analytical, creative and critical thinking skills. They also demonstrate deeper understanding of the material and greater intrinsic motivation to learn and achieve [5].

The goals and objectives of this project are:

- Develop an active and affective learning tool using autonomous robots to apply to STEM education.

[1] Abraham Howell and Roy McGrann, Mechanical Engineering Department, State University of New York at Binghamton
[2] Eileen Way, Industrial Engineering and System Science Department, State University of New York at Binghamton
[3] Robert Wood, Broome Community College, State University of New York

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