INTEL FACULTY FELLOWSHIP GRANT: CURRICULUM DEVELOPMENT: INTRODUCTION OF TEST AND MACHINE LEARNING IDEAS TO UNDERGRADUATE LABORATORIES THROUGH ROBOTICS

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GOALS OF ROBOTICS PROJECTS

To augment the traditional integrated undergraduate electronics/instrumentation laboratory of ECE Department at PSU with materials, software and equipment required for conducting:

- **robot building**,
- **robot application** and
- **machine learning/evolution** experiments.

These experiments will illustrate material from the following courses: Introductory Logic Circuits, Analog Circuits, Finite State Machine design, Digital Systems, Microprocessors, Artificial Intelligence (AI), Neural Nets, and Testing and Design for Test.

ROBOTICS PROJECTS

- Three interrelated projects, all connected to robotics.
- The projects will illustrate the following topics:

1. robotics in integrated test and manufacturing,
2. sensor integration,
3. image processing for robotics,
4. voice control of robots,
5. reactive robots based on learning state machines.

DYDACTIC GOALS

- Robotics illustrates ideas across the computer engineering undergraduate curriculum.
- Students' enthusiasm and creativity.
- Practical Hardware Design.
- A variety of different projects using the same equipment.
- Integration of software and hardware.
- **Hardware integration on system level** and **software/hardware co-design.**

INEXPENSIVE ROBOTIC KITS, CAMERAS AND SOFTWARE

• **Robotic Arm Trainer** from OWI. $ 45 (on sale). A student has assembled this arm from the kit in 3.5 hours.

• **LEGO MINDSTORMS**. $ 200, can be upgraded in modules $ 80. Has been designed by the top world authorities in robotics, computer education and curricula development from MIT. Papert, Brooks.

• Allows to build robotic manipulators, hands, legs, and various kinds of animals and space creatures. CD-ROM and software exist as well as books with hundreds of projects.

• Robix, $ 500, allows to build many different animals and models of industrial manipulators.

• Rhino robot donated by Mechanical Engineering as a step to built an integrated intelligent robotics lab at PSU.

- New generation of toys. Mr. Arnold, Furby, Barney and other.
- Cameras with software under $ 100.
- Public Domain Image Processing and Voice Recognition Software.

WHAT WE LEARNED IN THE PAST

Based on our limited but personal robotics experiences mentioned above, we can formulate some ideas that will be the base of the new projects.

What was good with our previous robotics projects.

1. Students learned integration of analog, digital, and mechanical design, sensors/motors integration.
2. Students learned integration of software and hardware and assembly/C programming in real-time environment.
3. Students became less afraid of building hardware with their hands. Their build PCBs, learned how to wirewrap, assemble, test, etc.
4. Students had a sense of accomplishment and were proud during Open Houses, national exhibitions, Science Fairs, etc.
5. Robotics entusiasts created Cybernetics(WSU) and Student Robotic (PSU) Societies and participated in competitions.

WHAT WAS WRONG IN THE PAST

1. Toys difficult to convert.
2. Projects too time consuming.
3. After completion, the project was dead and practically not usable.
4. Equipment was not reliable.
5. It was not possible to have this kind of projects for many students in a regular lab environment. The lab students in the first years will also assemble the OWI robots from kits. This will take them much less time than converting toys and will be fun. With many kits, there will be a unification and (partial) repeatibility of projects.
6. Pre-canned intelligent programming exercises should be created. Interesting, teach important concepts. More time will be spend on integration based on "Building Block" philosophy of LEGO and experimentation/machine-learning. Projects sufficiently different.

THE MAIN DYDACTIC OBJECTIVES

1. Understand the basic robotic components and concepts.
2. Reinforce the concepts of a Combinational Function, Finite State Machine, in application to robotics.
3. Gain practical experience with EPLDs for various practical applications.
4. Understand principles of automatic test.
5. Learn about rule-based programming for robotics.
6. Learn about Machine Learning and Pattern recognition software and hardware in simple robotic applications.
7. Understand basic principles of the most important current advanced robotic programming methods.

8. Create and practically develop a complete interesting robotic system from existing software and hardware modules.
9. Learn how to document work and present results using WWW Pages.

EQUIPMENT AND SOFTWARE FOR THE ROBOTICS PROJECTS

- The PC computer with graphics.
- The interface to robot (parallel or serial port).
- The robot itself. It can be: (1) completely assembled (from the kit, by student-staff); (2) assembled by the laboratory students from the kit in a standard way; (3) assembled by the laboratory students from the kit in a non-standard way, according to their idea (new animal? a face? new space creature?, new kind of tool or crane?).
- Sensors to be mounted on the robot (touch, bump, photoresistors, microphone, camera, etc.)

EQUIPMENT AND SOFTWARE FOR THE ROBOTICS PROJECTS (cont)

- Other additional robot building materials: LEGO Technic resource sets, children's motorized building kits from Meccano, K'Nex, Fischer Technik, Capsela, etc., containers, ON/OFF switches, photoresistors, and a standard television remote (for infra red signals), boxes, etc, provided by the lab or by students.
- Basic control softwares (come with kits). Written in C.
- Visual software DUAL by Alan Mishchenko, adopted to learn Reactive State Machines (RSM). Written in C++.

PROPOSED EXPERIMENTS

- **Experiment 1: Robot Programming for Test of Electronic Boards in Industrial Environment.**
- **Experiment 2: Reactive State Machines.**
- **Experiment 3: Evolvable Robot that learns from its mistakes in environment**