ROBOTICS AND MECHATRONICS EDUCATION AT NEW MEXICO TECH

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ABSTRACT--*In recent years, there has been several innovative products that have had requirements for engineers with interdisciplinary skills for designing and integrating interdependent electrical, electronics and mechanical components. This new field of engineering has broadened the scope of the traditional field of electro-mechanics. Mechatronics, which is the synergetic combination of precision mechanical engineering, electronic control and systems thinking in the design of products and processes represents the multidisciplinary technological backbone of the "smart products' and the 'agile manufacturing systems.'*

In this paper, a "Mechatronics Model," an educational one, being implemented at NEW MEXICO TECH, is presented. Student group projects depict the integration of the topics covered within this new Mechatronics focus area.

Index Terms: Synergism, Integrated Electro- Mechanical System Intelligent System, Soft Computing. Multi-Disciplinary Technology, Design.

INTRODUCTION

The introduction of the microprocessor in the mid 1970's has produced an explosive development in new products which incorporate the technologies associated with mechanical engineering, electronics and information processing. It has also opened up an enormous business potential, which the Japanese industry has been the first to exploit. The design of mechatronic systems requires not only an integrated approach but also the co-ordination of the design tools and practice from the three fields of mechanical, electronic and software engineering.

Manufacturing and engineering industries are at the forefront of economic and trade battles. Therefore, mechatronics plays a key role within these technological measures, because it is a new and promising engineering discipline.

Engineers have indicated not only a growing awareness of the competitive potential of combining electronics and mechanics but have expressed concern about Japan's strong leading position in Mechatronics. The philosophy of mechatronics is a design attitude to solving problems which involves a system-thinking approach to satisfying overall objectives that require knowledge transfer across traditional boundaries.

The developments in microprocessor technology have enhanced the flexibility of automation within products and manufacturing systems for such products. In order to be competitive on today's world markets, industry requires skilled multi-disciplinary engineers with a broad-based knowledge and the ability to apply new technologies.

The ultimate aim of mechatronics is, therefore, to extend and to supplement mechanical systems with sensors and microcomputers to build intelligent and capable products. Components for such systems emerge from mechanics, electronics and computer technology. Methods to combine these components emerge from systems theory, control, and information technology. The fact that such a system detects changes in its environment with sensors, and reacts to these changes after processing the information, distinguishes it from the more conventional machines. Examples of mechatronic systems include robots, controlled combustion engines, anti-blocking breaking systems for vehicles and airplanes, contact free magnetic bearings, active vibration isolation, machine tools with self adapting tools, automatic suspension technology for transportation, micromechanical grippers among others. Typical for such a system is the high degree of system knowledge and software, which is necessary for its development, construction and deployment.

There has been a significant increase in the rate of growth of Machine Intelligence Quotient (MIQ) within consumer products and industrial systems.

There are many factors which account for this increase but the most prominent among them is the rapidly growing use of Soft Computing and especially fuzzy logic in the conception and design of intelligent systems.

The principal aim of Soft Computing is to exploit the tolerance for imprecision and uncertainty to achieve tractability, robustness and low cost solutions. The principal constituents of soft computing are fuzzy logic, neural computing and probabilistic reasoning, with the latter subsuming genetic algorithms, belief networks, chaotic systems and parts of learning theory.

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EDUCATION IN MECHATRONICS

The objectives of education in mechatronics are the promotion of interdisciplinary understanding, and the impact of specific knowledge in the various disciplines.

The Japanese industry, commerce and university invested in the creation of the Laboratory for Intelligent and Fuzzy Systems Engineering, LIFE, in Yokohama in 1989 with the ultimate aim of fostering the application of mechatronics. This exercise gave birth to new consumer products like the auto focus camera, sewing machines, photocopy machines, and washing machines using fuzzy controls. These serve just as few examples of the "smart products" (products that employ the use of microcomputers) that have changed the face of technology.

The intelligent washing machines eliminate sorting, the microwave comes with programs that facilitate auto-defrosting food items for instance, auto focus in cameras, and anti-blocking braking systems in automobiles count among the wide variety of smart products which utilize new technologies to accomplish that which was earlier considered either impossible to do with old technologies or was not cost effective.

These enumerated examples form part of the many interdependent components designed by diversed engineering disciplines. They may be complex systems, composed of integrated mechanical, electrical, and software components. Design, fabrication and operation of such systems and smart products require intimate knowledge in mechanical, electrical, electronic, computer, industrial, and manufacturing engineering.

In the USA, the National Science Foundations (NSF) funded the Center for Robotics in Microelectronics at the University of California in Santa Barbara. A similar exercise was repeated at San Jose State University. Today, many universities in the USA offer programs in mechatronics. At the Sandia National Laboratories, activities within the Micro Electro-Mechanical Systems (MEMS) division depict the significance of mechatronics.

The UNESCO has initiated and sponsored a program in mechatronics for the promotion of international intellectual cooperation involving the establishment of International Chairs. The first of such was established in 1993 at the Mechatronics Center at Bogazici University in Turkey. The main objectives of this center was to:

- Promote an integrated system of research, training, information and documentation activities in the field of mechatronics,
- Evolve as a center of excellence in the field of mechatronics for training and development of high-level human resources at regional levels.

The European Center for Mechatronics in Aachen (Germany), is active in the areas of robotics, sensors, mobile platforms, communication technology and welding technology.

The main objective of the Institute of Robotics and Mechatronics of the Deutsches Zentrum fuer Luft- und Raumfahrt e.V. (German Aerospace Center) is the design of mechatronic systems. Some of the examples at the institute include new lightweight robots and advanced vehicle systems with active components. The projects at the institute integrate the core skills in dynamic system modeling and simulation, design of robust control algorithms and multibody formalisms, development of highly integrated robot sensors and actuators and remote control of semi-autonomous systems.

Some leading mechatronics centers include but not limited to the following:

- Ford Research Laboratory, USA
- U.S. Army Aviation and Missile Command
- Mechatronics Program at Clemson University
- Center for Mechatronics at the ETHZ in Switzerland.
- INRIA in Toulouse,France
- Biomedical Mechatronics & Automation Laboratory at the University of Bristol, UK.
- University of Linz, Austria.

MECHATRONICS EDUCATION AT NEW MEXICO TECH

Robotics and Mechatronics have been incorporated into educational endeavors at New Mexico Tech to expose students to an exciting amalgam of technologies.

The education is offered by the Department of Mechanical Engineering in collaboration with the Electrical, Computer Science and Materials departments in the form of lectures, seminars, laboratory work, and projects.

At New Mexico Tech, we believe that the pervasive spread of mechatronics to engineered products and systems of all kinds calls for engineering students to be exposed to its principles and practices. In fact, regardless of discipline, engineers will continue to encounter mechatronic systems in their professional practice. In order to participate fully in all stages of engineering design, from conceptualization to final product design, a working understanding of the capabilities and limitations of mechatronics is of utmost significance. For the teaching of Mechatronics as an undergraduate course at New Mexico Tech, there is the active involvement of an interdisciplinary faculty team.

It is intended that the course will produce broad-based and creative multi-disciplinary engineers who can apply their knowledge and skills to the optimal design of products and engineering systems.

In particular the course is designed to:

- provide the student with professional skills commensurate with his/her future role in manufacturing industry;
- extend and enhance the student's understanding of the role of hardware and software in the control of a system;

- develop in the student a professional competence in evaluating and developing various technological aspects of the multi-disciplinary activities associated with mechatronics;
- extend the student's understanding of the management of new technology;
- develop in the student an ability to work as a member of a team engaged on a multi-disciplinary problem solving exercise;
- provide the student with the opportunity to demonstrate his/her ability to design and conduct a program of work aimed at providing a mechatronics solution to an appropriate industrial problem.

The grades for this course are based on a numerical average calculated with some weighting in relation to Quizzes and Homeworks, Midterm and Final examinations, and design projects.

Even though the mechatronics program was commenced just a year ago, the student resonance at the course has been very impressive. There were a number of excellent projects that ranged from the design of an electric jar opener, automated medicine capsule dispenser, ankle rehabilitation device prototype, child-proof cap opener, to automated hospital assistant, which were all designed by the students.

COURSE STRUCTURE AND FACULTY

Mechatronics is a core course within the mechanical engineering program and is offered every semester, spring and fall. One primary way the New Mexico Tech Mechatronics Program differs from other programs developed in the country is that it also integrates Materials Science, an important subject that provides the designer an edge over other competitors. Rapid developments in materials science, such as the development of new shape memory alloys and piezo-electric materials, requires that the designer be familiar with the mechanisms and mechanics that provide a specific material characteristic. Without that insight it is increasingly more difficult for designers to integrate new concepts into practice. We believe that this additional aspect of the curriculum will make the program more successful, leading to possible emulation by other universities in this country and abroad.

Another primary factor in which way the New Mexico Tech Mechatronics Program differs from other programs developed in the country is in the integration of Soft Computing in the curriculum.

The structure of the Mechatronics Course at New Mexico Tech is illustrated in figure 1.

The critical elements of the mechatronics course are (Figure 1):

- The modeling, analysis, and simulation of dynamic systems,
- Measurements and instrumentation (selection and interfacing of sensors, actuators, and microprocessor/microcomputers),
- Special topics involving magnetic bearings/levitation, biomechanics, fuzzy control,
- Intelligent materials, to mention a few.

FACULTY:

Affiliated with the program are the following faculty members who are involved in complementary teaching and research activities.

Department of Mechanical Engineering

Thompson Sarkodie-Gyan, P.E.

- *Research Interests:* measurement science, instrumentation, dynamic systems and control, robotics, machine vision and pattern recognition, soft computing, biomedical engineering, mechatronics systems
- *Qualifications:* B.S.M.S., Technical University Magdeburg, Germany; M.S., Ph.D., Technical University of Berlin, Germany

Department of Materials:

Dr. Bhaskar S. Majumdar

- *Research Interests:* mechanics of materials and interfaces, composites, fracture
- *Qualifications:* B.Tech., Kanpur, India; M.S., Indian Institute of Science, Bangalore, India; Ph.D., University of Rochester

Department of Computer Science

Andrew H. Sung, chair of department

- *Research Interests:* computational intelligence and its applications, high-performance computing, algorithms
- *Qualifications:* B.S., National Taiwan University; M.S., University of Texas at Dallas; Ph.D., State University of New York at Stony Brook

Department of Computer Science

WILLIE Chang

- *Research Interests:* Multimedia and Internet technologies, data mining, digital image and speech processing.
- *Qualifications:* B.S., Chinese Culture University; M.S., California State University at Sacramento; Ph.D., New Mexico Institute of Mining and Technology.

Department of electrical Engineering

Steven Bruder

- *Research Interests:* robotics and control, multi-sensor integration and data fusion

- *Qualifications:* B.Sc., University of the West Indies; M.Sc., Ph.D., Queen's University, Ontario, Canada .

Department of Electrical Engineering.
Kevin J. Wedeward

- *Research Interests:* adaptive control of robotic systems
- *Qualifications:* B.S., Ph.D., New Mexico State University.

CONCLUSION

The institutionalization of mechatronics curriculum has taken many advantages of existing courses . The beneficial aspects of the course to the students involve the exposure into a curriculum which is crucial to effective development of modern engineering curricula. Moreover, mechatronics engineering at New Mexico Tech seeks to address several critical needs for engineering education, namely, synthesis interdisciplinary content, industrial practice, hands-on activity, and teamwork.

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Figure 1. Structure of Mechatronics Course at New Mexico Tech