Advanced Manufacturing Program and Laboratories For Engineering Majors

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Abstract

An advanced manufacturing program and laboratories can help the third world countries to standardize their products and use mass production for being able to compete in the highly competitive international market. It will be a great help to the industrial companies of these countries if the educational institutions educate and train their graduates for being employed by these companies. The state-of-the-art Computer Integrated Manufacturing (CIM), Computer Aided Design (CAD), Computer Aided Manufacturing (CAM), and Robotics laboratories should be considered for this educational goal. These labs will significantly improve the quality and capacity of educational programs[6] by providing excellent teaching aids and hands-on experience to educate students in the theory and application of computer integrated manufacturing technology. A new advanced manufacturing curriculum can be designed that includes robotics and advanced manufacturing related courses and labs to provide meaningful hands-on activities. All students in this program will receive enhanced training and experience utilizing multimedia software and workbooks specifically tailored for this program. Also local industry expertise can use these labs to demonstrate the potential industrial use of CIM and related labs to increase productivity, accuracy and safety. As a result, the Industrial Robotics & Advanced Manufacturing program graduates can satisfy the growing need for robotics and real-time programming expertise in industries and government agencies and will significantly improve the future of undergraduate education [1, 2, 3]. In this paper, we describe a new state-of-the-art Computer Integrated Manufacturing (CIM) lab which plays the key role and has been established in our school to support our future Industrial Robotics & Advanced Manufacturing program. This lab can be used

as a model by other schools intending to offer a similar program.

Introduction

An advanced manufacturing program and laboratories can help the third world countries to be able to compete in the international market. This market is highly competitive especially for the countries without advanced technology. It may be very difficult for these countries to sell their product in the international market because they may not have mass production and as a result their prices are not competitive. Even if their prices can be lower because of cheaper labor, their product may not be able to compete with other products in the market because they may not follow the international standards. To solve this problem, these countries need to use advanced manufacturing technology and move toward mass production. To do so, the companies need to hire highly educated and well experienced personnel in the related fields.

It will be a great help to the industrial companies if the educational institutes educate and train their graduates in the necessary technologies. The state-of-the-art Computer Integrated Manufacturing (CIM), Computer Aided Design (CAD), Computer Aided Manufacturing (CAM), and Robotics laboratories should be considered for this educational goal.

A state-of-the-art CIM lab, a CAD/CAM lab and a Robotics lab can be established in a school to support an Industrial Robotics & Advanced Manufacturing program. These labs will significantly enhance this program by providing excellent teaching aids and hands-on experience to educate students in the theory and application of advanced manufacturing technology. A new related curriculum can be designed that includes robotics, advanced manufacturing, and CAD/CAM related courses and labs to provide meaningful hands-on activities. The students in this field will receive enhanced training utilizing multimedia software and workbooks specifically tailored for this field of study. Also local industry expertise can use these labs to demonstrate the potential industrial use of advanced manufacturing for increasing productivity, quality and safety. As a result, the Industrial Robotics & Advanced Manufacturing program graduates will be more marketable and can satisfy the growing need of robotics and real-time programming expertise in industries. The industries hiring these well educated and experienced students will be able to produce high quality products for this highly competitive international market. In this paper we describe the implementation of a CIM lab that has been established in Louisiana State University in Shreveport (LSUS) to support a Robotics and Advanced Manufacturing program and hope this can be used as a model by other schools that intend to offer a similar program. We also intend to implement a similar lab in Utah Valley State College in the near future.

The Rational For This Project

As labor becomes more and more expensive, the production and the manufacturing cost increase and it becomes more difficult for industries to compete in this highly competitive international market. For this reason industries and jobs will move to other countries where labor is less expensive. In order to prevent this, the industries need to use robotics and advanced automated manufacturing to have standard and mass production. To support this kind of manufacturing, the industries need highly trained labors and expertise. It will be very cost effective and helpful to these industries if the local educational institutions can provide such training for the industries employees and their own graduates.

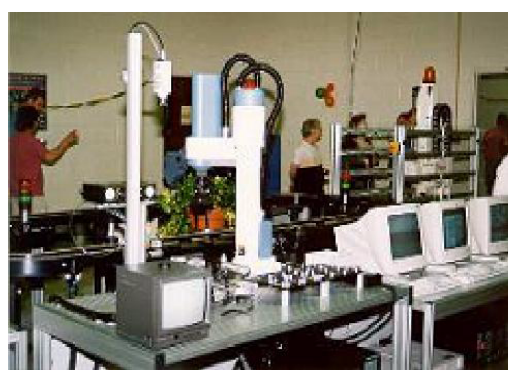
LSUS is the only senior public university located in this area and currently serves 4,400 regular students and 11,000 non-credit students per year. There are several industries in our area which use robotics in their production lines. General Motors Truck Assembly, General Electric, AT&T, International Paper Company, Frymaster and Neighbor Trailer are only a few examples. Therefore, we decided to develop a robotics and advanced manufacturing program to satisfy the need of these industries and to teach robotics and advanced manufacturing to our students to be prepared for the future job market.

Since LSUS does not have engineering programs yet, we initiated the robotics and advanced manufacturing program in our computer science department which offers only two degrees: a bachelor's degree in computer science and a master's degree in systems technology. Currently we have three labs for this new program: a robotics lab, a CAD/CAM lab and a CIM lab, and we have developed a major curriculum initiative in the area of industrial robotics and advanced manufacturing. This program has a great impact on the local economy because previously there was no institution in the nearby area offering industrial robotics and advanced manufacturing training. As a result, the students did not have the opportunity to learn about such technology. The above industries needed to send their employees to other cities and even other states to receive such training. Now the new labs are up and running and we are capable of providing such training for our students and the industries at a substantial savings in time and travel-related expenses. In the following sections we explain the implementation of our CIM lab which is the core of this new program.

CIM Lab Implementation

To implement the lab, a grant proposal was submitted to the Board Of Regents Support Fund for the amount of $277,895 in the fall of 1998. The grant proposal was funded 100 percent, and the CIM lab was subsequently established within the Computer Science department.

Much research was conducted to determine the best equipment supplier for the new CIM lab. Past experience in CIM projects, especially academic projects, was of prime concern in the selection process. Eshed Robotec was selected as the equipment/technology vendor for the project. The company offered an impressive background in the development and production of educational systems for the study of manufacturing technologies.



Since the time of the contract award, Eshed Robotec has merged with Light Machines, a designer and supplier of bench top CNC machines for the educational marketplace. The new, combined company is called Intelitek, Inc. The company offers training systems including Computer Numerical Control (CNC) machines, Computer-Aided-Design (CAD) and Computer-Aided-Manufacturing (CAM), hydraulics and pneumatics, Programmable Logic Control (PLC), process control, data acquisition, sensors, robotics and machine vision.

After working with the vendor to determine the CIM lab layout, the equipment was ordered and arrived, on schedule, in late 1999. Early in the spring of 2000, the setup process was begun and, by mid March, this process was completed. A team of technicians from Eshed Robotec worked on-site to assemble the conveyor system and specific robotic assembly, milling and vision workstations. The first training session for the instructor and his lab assistant began on March 17, 2000, and lasted for three weeks. By early April 2000, the lab was ready for demonstration to the public and an open house was scheduled. The open house was held by the Computer Science Department and was very successful. Hundreds of people from different industries and organizations attended the open house to observe these exciting activities. This open house event was reported on local television and in the local newspapers and resulted in great publicity for the department and the university and many students were attracted to this program.

CIM Lab Benefits

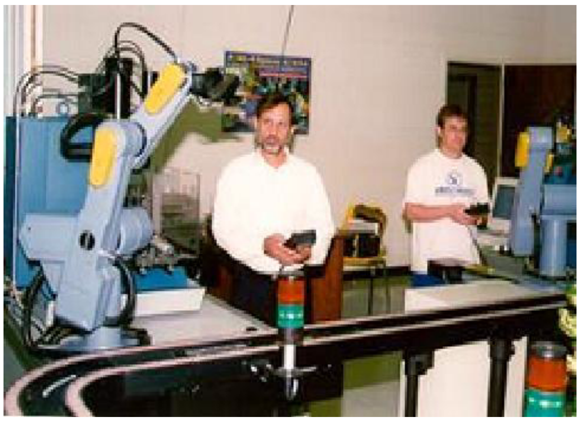
"Computer Control and networks are at the heart of CIM cells. The interdisciplinary nature of CIM cells brings Computer Science students together with Engineering Technology and other students face-to-face with real world problems"[4]. Interdisciplinary courses can be developed in which students from different majors benefit using CIM and related labs. The Computer Science students will benefit from these labs by concentrating on networking and software development aspects of these labs. The engineering and engineering technology students can benefit by focusing on part design, hardware and mechanical components of the labs such as robots, sensors, gripper, hydraulic and pneumatic drive systems, etc.

Using CIM lab, our students have realized numerous applications and advantages of robotics and automated manufacturing such as material handling, increased productivity, safety, efficiency, quality control, standardization and consistency of products[5]. The CIM lab has also given students experience in real-time software system development[7], database, scheduling and expanded interaction with local industries. The following subsections elaborate some of the benefits of CIM lab implemented in our school.

a. Students Hands-on Experience

Students enrolled in the Industrial Robotics course will use ScantraCam software, a CAD software package provided by Eshed Robotec, to design objects to be manufactured using the CIM lab production processes. All students taking robotics or manufacturing classes use the CIM equipment. The lab has satisfied the needed access for hands-on experience in the area of automation and advanced manufacturing. It has also provided the faculty with an opportunity to increase their own professional CIM expertise. The lab has been extremely well received by those who have visited or used it.

The existing and planned changes have attracted, and will continue to attract students to this new area. As a side benefit, the CIM lab has made it possible to offer courses to provide general robotics education for any organization along with specialized instruction for those students who wish to become professionals in industrial automation. The Industrial Robotics class (CSC410) already has produced students with adequate training to be able to setup robotics and vision system equipment and write programs to control the robots. They also have learned how to design and produce products (such as chess pieces and a personalized desktop pen holder) using this automated system. Individuals with these skills will be more valuable in the job market.



The benefits resulting from the state grant to construct the CIM lab are many-fold. Student instruction in advanced manufacturing concepts will spur local and regional economic development. Many organizations are interested in sending their employees to these classes for training and are interested in hiring students with these skills. They no longer need to send their employees to other states for training. There will a greater demand for traditional student who receive hands on training. Faculty exposure to the CIM lab has made them interested in teaching new, CIM-related courses. One of the students has designed a hardware component which controls several robotics stations using a single PC. Thus, the future promises even more benefits as more manufacturing-related courses are added to the curriculum.

b. Improved Interaction with Local Industry

Demonstrations will be offered to local industries on how CIM can be used to increase productivity, accuracy, quality and safety. Many students in the program work in the manufacturing industries or serve as interns with such industries while they are students in our school. These students bring realistic and important projects from their work to the lab and use the new equipment to implement the projects. The college also partner with area industries to schedule classes and workshops for specific groups of employees wishing to upgrade or learn new skills. As the industries realize the benefits these labs, they will offer research project and financial support to our department which grantees our future grow.

c. Impact on Curriculum and Instruction

The study of CIM and related advanced manufacturing requires modern equipment that the student can utilize in a lab setting. The long run plan is to offer students CIM-related options in computer science and other pertinent fields. Such advanced offerings can be tailored to the student's individual career goals. Our developing interdisciplinary effort combines engineering and computer science with a series of specially designed new courses. An additional benefit of the project is to enhance the existing lower level courses through CIM discussion and demonstration.

More than 250 students per year are introduced to this exciting technology via demonstrations that focus on some of the basic theory underlying the technology applications. Through such introductions, more students will be attracted to this program to study industrial robotics, computer-integrated manufacturing, and related fields.

Curricular Need for the Project

Most students majoring in robotics and related programs are seeking education in not only the theoretical principles of science but also in practical industrial applications of those principles. The robotics faculty has teamed with faculty in other disciplines and with representatives of area industries to develop the current advanced manufacturing options plus several courses planned for the future. Due to the powerful capabilities of the microprocessor and its marriage to machines of all kinds, industries are able to manufacture products from design to production and packaging at significantly lower cost and higher quality. Students considering careers in advanced manufacturing need to understand the basic concepts of computer controlled machine tools (i.e.; CNC lathes and mills), materials transfer mechanisms (i.e.; robots and conveyors), and design systems (i.e.; CAD/CAM). Students also need the appropriate programming and interfacing skills to make these systems work together in the manufacturing process. The development of CIM is the result of the combination of these control technologies into the manufacturing process. The new CIM lab significantly increases the capacity for students' hands-on learning, scientific inquiry and critical thinking. Several industries and government agencies in this area are currently using advanced manufacturing in their operations. This program is designed with input from these industries to provide robotics related education and laboratory experiences for students. A nearby medical center has identified robotics as a definite need for microsurgery applications and is interested in using robotic positioning devices for positioning instruments during surgery. To support this kind of education, we have developed and plan to develop some new course described in the following two sections.

New Courses Already Implemented:

CSC410: Industrial Robotics and Automation - Three hours lecture and lab; 3 credits. Introducing basic concepts, the organization and operation of microcomputer-controlled manipulators. Experiments include kinematics, manipulation, dynamics, trajectory planning and a programming language for robots. Students apply computer-controlled robots in manufacturing and programmable automation.

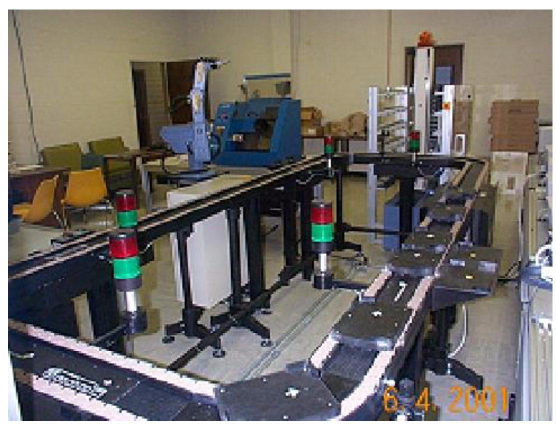
CSC455, CSC655: Computer-aided Design and Drafting - Three hours lecture and lab; 3 credits. Introducing the concepts, principles and applications of CAD. A CAD software system, Pro/Engineer, is used to support laboratory experiences and the projects. Graduate students prepare a research paper for presentation to the class.

CSC475: Computer Integrated Manufacturing - Three hours lecture and lab; 3 credits. Introducing the use of CIM systems to improve productivity, information flow and management of resources. Students design and operate a pilot-scale flexible manufacturing system. Emphasis is on hardware, software, part design and economical considerations. ScantraCam and Pro/Mechanica software packages is used to support the projects.

Planned Future Course Development:

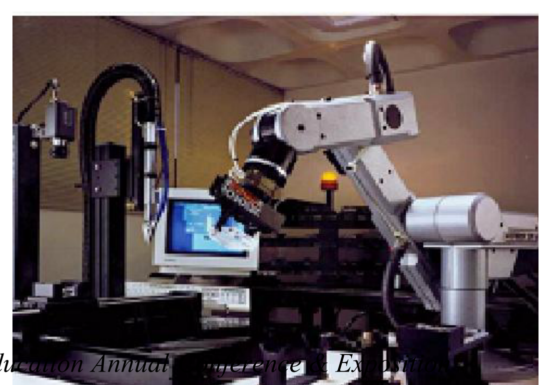
CSC491: Machine Vision - Three hours lecture and lab; 3 credits. Introduces machine vision systems as applied to manufacturing. Course content includes lighting, optics, vision hardware and software. Students will analyze various methods of utilizing vision systems in industrial applications, focusing on hardware, the frame grabber board, memory allocation, software development, system troubleshooting and repair in the following applications areas: part identification, part orientation, range finding and image analysis techniques.

Equipment



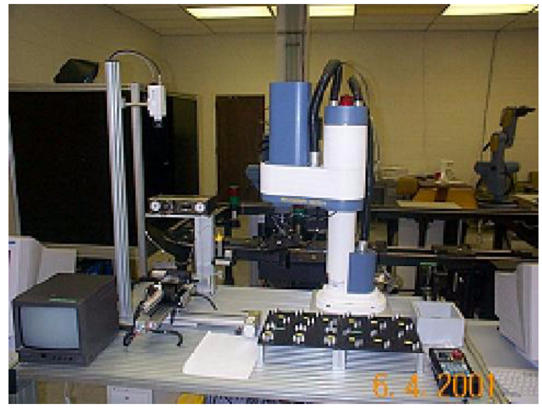
The CIM laboratory is designed to provide all the equipment (robots, CNC machines), computer software and curriculum materials, needed to teach students the skills and content relative to each respective technology. The CIM lab is divided into modules. The modules are installed around a closed conveyor. Each module incorporates the necessary hardware and curricular materials specific to its areas of technology. The curriculum contains all of the relevant content and skills for this control technology. In addition, the programming language used in all the robotic related control software provides a uniform programming environment for students and teacher -- from the basics through advanced cell control. This provides continuity for the learning process and minimizes the need to learn one language for teaching/learning and another for industrial control. The modular design allows for any of the modules to be attached to other modules, to expand capabilities, or to be used as an individual station to teach various subjects. The CIM lab has the following major modular components:

a. Robotic Training Stations



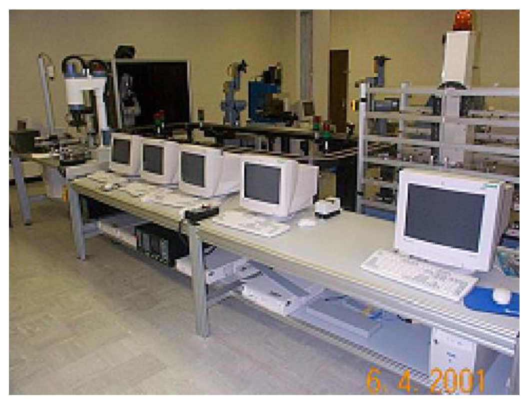
Robotic training stations provide specific training in the basics of robotics, material handling, sensing systems and basic system integration. Each robot is a point-to-point, vertically or horizontally articulated, dc-servo controlled, closed loop controlled robot. Students receive basic robotic programming instruction at the stations where simpler material transfer operations are conducted. Next, they progress to advanced programming instruction at the more complex stations. This transition from simple to advanced programming is aided by the fact that the same type robot controller is used for each material transfer device. The vertically articulated robot is a SCORBOT-ER IX, while the horizontally articulated robot is a SCARA-ER 14. These assembly stations cost $74,470.

b. Advanced Robotic/Machine Vision Training Stations



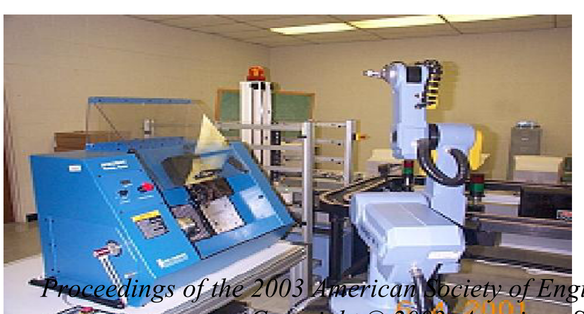
An advanced robotic/machine vision training station offers robotic control plus machine vision training. Machine vision technology can be leveraged for image processing and enhancement, gauging and measurement and pattern matching. Flaw detection and assembly inspection are practical applications for this technology. The machine vision system (a computer-controlled camera used for part recognition, inspection and robot guidance) prepares students for state-of-the-art training in current quality-control technology. Students may design and develop their own vision applications using the manufacturer's Visual Basic for Applications (VBA) compatible scripting environment. The machine vision station, including robot, cost $40,360.

c. Industrial CIM Control Station



The control station is the center for all of the technologies in the CIM processing center. Parts can be machined, loaded in and out of the CNC machines by the robots, and transferred between machines by a closed loop conveyor system. Students are able to produce parts as lab experiments. This centralized control station cost $14,830. The opposite picture shows the central control station along with the individual man-machine interfaces for the individual stations. The automatic storage and retrieval system is to the right while the vision station is to the left.

d. CIM Workstations- CNC Lathe /Robot and CNC Mill /Robot



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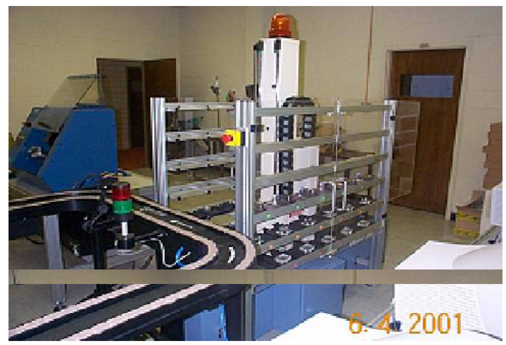
ns integrate CNC machines with industrial grade robots. Each station is multipurpose, capable of being used as a training station to teach basic and advanced robotics along with basic and advanced CNC programming. One station includes a lathe and a material-handling robot; the other includes a mill and another material-handling robot. Each station has the capability of conducting integrated parts manufacturing and integrating with a CAD package for bi-directional associativity between designer and the manufacturing floor. These cost $59,740 and $58,550 respectively.

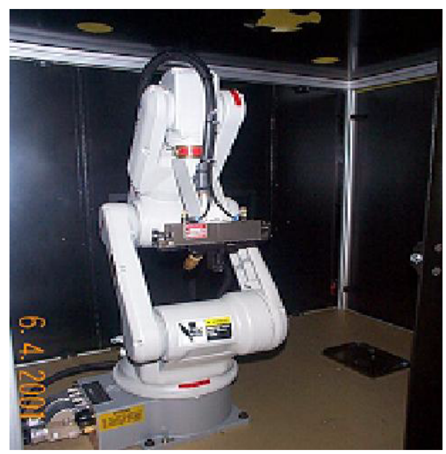
e. Automated Storage and Retrieval System (ASRS)

The ASRS is an integral component allowing storage of materials, manufactured components and assemblies in various states of completion. The system works in conjunction with the central CIM workstation to manage storage and parts retrieval for each individual station. The ASRS and automated conveyor system are key components in the CIM structure. Identification of individual part trays is by a laser barcode scanning system.



f. Robotic Welding Station

Recently added to the CIM lab is a robotic welding station. This station is fully automatic and is integrated into the processes controlled by the Industrial CIM Workstation. It includes a continuous path robot, a flux cored arc welder, a workbench welding torch holder, gripper adapters for the robot, welding fixtures, finished parts cooling pallet and a fully enclosed safety booth. Parts to be welded are fixed on a jig. The robot is equipped for quick tool changing, utilizing its gripper and a welding torch adapter.



Conclusion

Judging by the feedback from students, faculty, administrators and public, the labs are wonderful additions to our program. The stated goal of the project was to augment the curriculum by the addition of introductory and advanced courses in the area of Industrial Robotics and Advanced Manufacturing. The photographs throughout this paper show the new CIM lab up and running. The first course, CSC410, Industrial Robotics, has been well received by the students every time it has been taught. The CAD course, CSC455/655, will be offered once/year. Computer Aided Design goes hand-in-hand with the CIM lab. Our department also operates a Robotics lab in addition to the CIM lab. The plan is to use all these labs for an Artificial Intelligence class too. Also on the horizon are the Computer Integrated Manufacturing and Machine Vision classes.

Students have completed several programs and projects. One student developed a project to control several robot arms using a single workstation. Other students conducted robotics research and presented their findings to the class. With the cooperation of local manufacturers, several field trips were conducted to observe actual CIM operations. Using CAD/CAM software, students are now able to design an object, convert it to appropriate numerical code and produce the object using the CIM lab. It has been a great hands-on experience for students and faculty, alike.

Computer Integrated Manufacturing is an ever-expanding field with many applications for artificial intelligence. No doubt, as breakthroughs occur in AI, new capabilities will be realized in CIM operations, also. The new CIM lab, along the complement of instructional courses based on the lab, has brought theory and reality together[4] and will help insure that we have a ready pool of eager graduates ready to tackle the challenges and pursue the opportunities afforded by a technological career in Computer Integrated Manufacturing.

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Biography

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