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ABSTRACT

Robots are becoming increasingly common in American industry. By 1990, they will revolutionize the way industry functions, replacing hundreds of workers and doing hot, dirty jobs better and more quickly than the workers could have done them. Robotics should be taught in high school industrial arts programs as a major curriculum component. The benefits to students are great. Robots are interesting and highly motivating, and the cost is reasonable when compared to other major acquisitions. Students can be made aware of a variety of career opportunities through the study of robotics. Finally, the study of robotics can bring schools and industry closer together in cooperative programming activities. In junior high school industrial arts, students can be offered hands-on experiences with simple robots and microprocessors as control devices. By using the modular toy, Capsela, in combination with sensing devices and a computer interface, the fundamentals of robotics are within reach of both junior high school students' abilities and school budgets. The teaching of robotics can be an exciting and rewarding component of the industrial arts curriculum at both the high school and the junior high school levels. (KC)

ROBOTICS AND INDUSTRIAL ARTS

A Presentation to
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PART I -- TECHNICAL DEVELOPMENTS IN ROBOTICS -- Dr. Glenn A. Edmison

Computers are everywhere--we all see them daily--on our wrist, controlling appliances, entertaining and teaching our children and ourselves both at home and at school, and, of course, in the workplace. We are told that by 1975 fully 75% of all jobs will involve computers. We are all very much aware of the computer revolution and readily accept the coming of the Cybernetic Age.

We are not generally aware of the quiet revolution occuring in industry (the replacement of many human workers in routine repetitious, monotonous, demanding tasks by the industrial robots). Many of us are familiar with NC, CNC and DNC machines which can do fixed sequential tasks at a fixed workplace routinely and tirelessly--as precisely as they are programmed--and which are usually tended by an observor-operator.

We are not so familiar with machines that can follow along with a workpiece moving along an assembly line--or adjust to unpredictable variations caused by movement of the workpiece, in the nature of the work itself, or the environment.

The idea of "pick-and-place" robots used to transfer identical items from one place to another (see fig. 1) or even a fixed sequence of items to a fixed

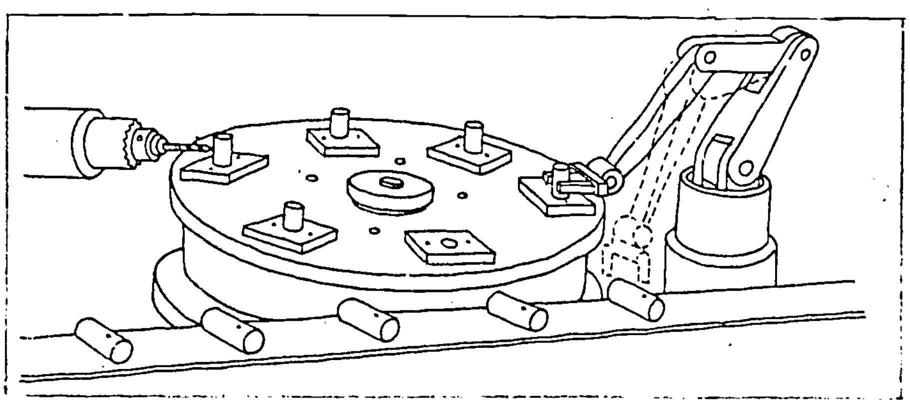


FIGURE 1

sequence of locations is not really mind-boggling . Automatic warehousing is a reality. Consider if you will, a robot with a "shopping list" of parts or materials housed in a totally dark or semi-dark warehouse. The robot enters, travels to prescribed locations, collects the necessary number of items on its "list" and takes them to a delivery point. A well-known photographic company already has such a system in operation for storage of light sensitive chemicals.

On a simpler scale, consider stock storage, retrieval and lodging of raw stock to be sawn into lengths to satisfy production demands (see fig. 2). Or

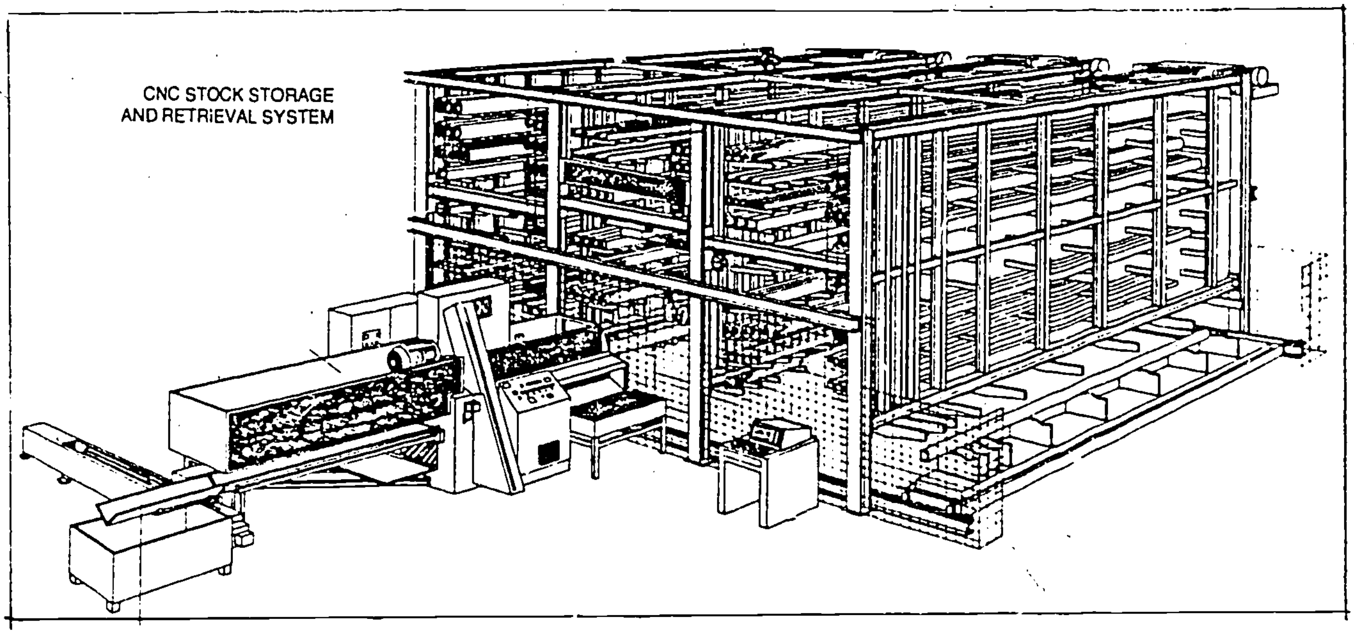
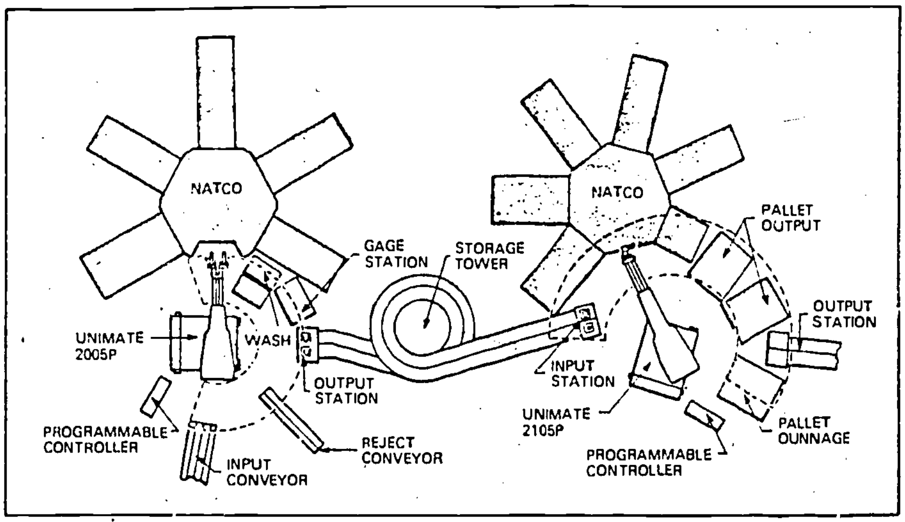


FIGURE 2

how about the concept of a group of machines tended by a single robot, performing a whole series of placement and inspection activities relating to workpieces moving between machines which are themselves capable of a number of machining and inspection operations incorporating automatic in-process tool-wear compensation. The degree of flexibility, accuracy and productivity are indeed mind-boggling (see fig. 3).



two-cell system with storage tower between cells.

FIGURE 3

> "The objectives of any automation," says Ralph Maiette, Group Manager of Systems Division, Automation, Inc., "whether it be hard automation or flexible automation using industrial robots, have always been to reduce in-process inventory, cut lead times, minimize direct and indirect labor costs, make maximum use of capital equipment and increased the number and quality of parts per shift."[1]

These objectives are currently being realized for welding and spray coating operations, the most common current industrial user. Tim Bublick[2] of DeVilbiss, speaking to the Chemical Coatings Association annual meeting in Milwaukee, listed the following eleven advantages for robot spray coating.

1. The robot lacks human needs, such as paycheck, coffee and lunch breaks, complaining and fringe benefits.
2. An average of 1.17 year payback quickly produces real savings.
3. Workers can be freed from hazardous environments.
4. Painting quality is increased.
5. A 15% spray savings is usually realized due to spray consistancy.
6. Energy can be saved because heat can be turned down, and less booth ventilation is required.
7. Spray booth emissions and maintenance are reduced because less paint is being sprayed.
8. Painting savings can allow reducing the product price.
9. Savings are made on overalls and respirators required for workers.

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1 "How to plan a Robotic Machining Cell," Tooling and Production, July 1983, p. 85.
2 "Robot Interest, Technology Soar," Industrial Finishing, August 1983, p. 16.

10. Electrical savings: The robot can work in the dark.
11. The robot can finish a task quicker than a person.

Other finishing applications where robots are being utilized include: grinding, polishing, buffing, sanding, flame spraying and cleaning. Among other uses, an Australian has been experimenting with the use of robots to shear sheep. Possible uses seem only to require the identification of a need and the willingness to work through the application of presently available technology. For example, robots described or exhibited at recent robot shows included:

"Gilberto," a robot equipped with touch, voice, hearing, vision, and a mechanical hand for grasping.

A robot with two hands.

A robot with a three-fingered hand.

A robot that can visually identify objects and speaks with a synthesized voice.

The Odex-1, a prototype walking, multifunctional robot equipped with 6 legs which can walk in any direction at a minimum height of 21 inches or a maximum height of 78 inches and can lift up to 2078 pounds.[3]

Current accuracy of good U.S. robots in within 0.001 inches (a Japanese robot is said to be able to locate to within 0.00016 inches) at a speed of 200 inches per second, reaching more than 12 feet and lifting several hundred pounds. Products in development include computer integrated vision, allowing robots to learn to recognize shapes and select from among mixed items in random positions. Robots may be taught to respond to voice commands or to a sense of "touch." The current race between Japan and the United States where heavily funded "think tanks" of experts are seeking to develop "fifth generation" computer capable artificial intelligence promises an almost unlimited prospect when incorporated into robotics.

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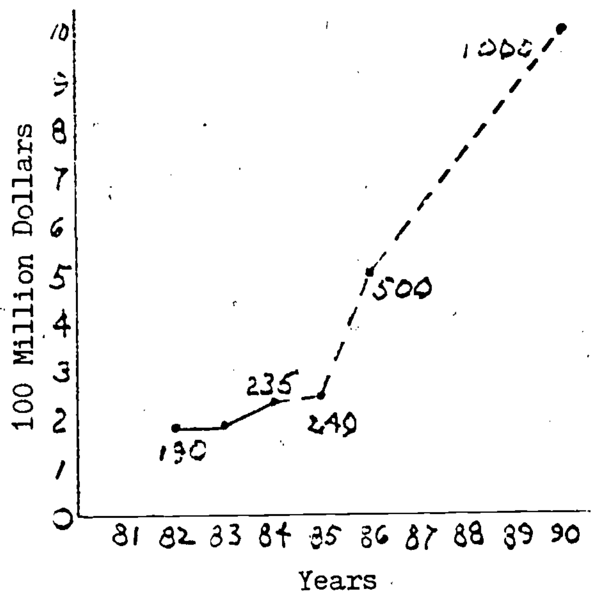
3 "Robot Interest, Technology Soar," Industrial Finishing, August 1983, p. 15.

These are not just fads--they are the moving wave of industrial change. The projected growth of the number and dollar investment for industrial robots is staggering (see fig. 4).

PROJECTED VALUE OF ROBOT SALES[4]



1982--8,000 robots in use
Current cost $2,500 table-top
$10,000-$100,000
sophisticated industrial model

1990--Estimated 100,000 robots in use
Estimated average cost $20,000-$25,000

FIGURE 4

The effect on what we teach about how industry works and potential careers in industry is important--and perhaps as important as anything is consideration of the effect on workers.

Robots can be hazardous as they blindly go about their tasks. One company is equipping its robots with proximity sensors accurate to .001 inch. Another provides a separate safety computer to control safety features.

4 Walter K. Weisel, Past-President, RI/SME; "Robot 7 reprint," Iron Age; June 6, 1983, p. 41.

What about workers displaced by robots? Employers report that robots are creating thousands of new jobs in sales, service, design, engineering and training. It is estimated that one robot displaces two workers. Thus by 1990, the 100,000 robots expected to be in use in the U.S. will displace 200,000 workers. Of this number, 90% are expected to be transferred in-house; less than 5% will be terminated. None of these changes will be without pain--upgrading to new levels of knowledge and skill--even requiring moving to where companies have available jobs.

PART II -- ROBOTICS IS INDUSTRIAL ARTS -- Dr. Merrill M. Oaks

Introduction

One of the most significant changes currently sweeping the manufacturing industry is the increasing use of robots. It was 1961 when the first industrial robot was produced. Since that time their use has increased dramatically; "By 1979, yearly production had grown to 1,300 units. It is estimated that in 1990 (only seven years from now) 31,000 robots will be built in the United States alone."[5] Currently more than 5,000 machines are being used in all facets of manufacturing.

With robots becoming an important component of industry and technology, it is clear that the study of robotics has much to offer as an integral component of the industrial arts curriculum. Why? At least four factors make the topic particularly suited to industrial arts:

1. Robotics attracts student interest and encourages motivation.
2. The cost is reasonable.
3. Robotics create new career opportunities.
4. The study of robotics provides a means of cooperating within the schools and with industry.

Student Interest and Motivation

There are few areas that generate more genuine student interest and excitement than watching a robot in action. Questions regarding how and why the mechanical arm can closely duplicate human movement give new meaning to skills

5 Kaiser, Joe. "Robots and Industrial Education," Industrial Education, February, 1983, Vol. 72, no. 2.

typically learned by industrial arts students. The often seemingly unrelated concepts of electronic and mechanical principles are instantly brought together in a way which students can both understand and appreciate.

Reasonable Cost

All too frequently the study of "high technology" also means high cost. Fortunately robots can be produced inexpensively. A recent article in "The Technology Teacher"[6] describes a robot capable of being programmed for sixteen different moves being marketed for less than $50.00. Several teaching robots are currently available for approximately $3,000, while fully programmable, multiple axis machines can be purchased for $5-10,000. The overall cost of introducing robotics is not high when compared with the purchase of other equipment typically found in the industrial arts laboratory. Perhaps the best news is that the future projection costs for robotics indicates a gradual decrease in price which should ensure reasonable availability to industrial arts programs.

Career Education

Preparation for new technology careers frequently starts in the industrial arts laboratory. The virtual explosion of the robotics industry and subsequent use of robots in manufacturing ensures that industrial arts teachers can play a key role in introducing students to a variety of careers associated with the robotics industry. The need to inform students early about the reality of career choices was recently emphasized in a "Fortune" journal article. A factory that would require 2,500 men is currently being equipped with robots and will produce at a comparable rate with 215 men![7] Certainly the rapid adoption

6 Sheets, Everett. "An Inexpensive Robot for the Classroom," The Technology Teacher, September/October 1983, Vol. 43, no. 1, page 25.

7 Bylinski, Gene. "The Race to the Automatic Factory," Fortune Magazine, February 21, 1983, pp. 52-64.

of robots will eliminate many semi-skilled positions, however, new robotics careers are being developed in areas including: design, service, sales and manufacturing. It is these exciting new careers that can be introduced most effectively in the industrial arts curriculum.

Interdisciplinary and Industry Cooperation

Perhaps one of the most important benefits for including robotics is the development of cooperative linkages between disciplines within the school system and with the industrial community. The study of robotics can and should be a coordinated effort between such disciplines as science, mathematics and industrial arts. Similarly, personnel from the robotics industry can provide schools with valuable information and guidance when it comes to career information and technical assistance.

Summary

Industrial arts stands in the unique position of offering the study of robotics as one major curriculum component. The benefits to students are great. Robots are interesting and highly motivating, and the cost is reasonable when compared to other major acquisitions. There are a variety of career opportunities for which students can be made aware through the study of robotics. Finally, the study of robotics can bring schools and industry closer together in cooperative programming activities.

It is an exciting and rewarding challenge. Industrial arts is the logical program to accept the major responsibility for teaching one of advanced technology's most important areas.

PART III -- ROBOTICS IN JUNIOR HIGH INDUSTRIAL ARTS -- Harold E. Richards

Industrial Arts/Technology Education teachers have long claimed to educate the nations youth about American industry. Success has been determined by a willingness to update curriculum to reflect the evolution of industry. With the computer becoming important to the control of more industrial functions, ways must be found to help students gain an awareness of the potential of automatically controlled machines. Methods must be found to include hands-on activities within the industrial arts curriculum that demonstrate concepts involved in combining mechanical, electromechnical and electronic control devices to produce machines that do work without the aid of an operator. The study of robotics seems to fulfill this need.

As the potential of robotics is explored, the following questions must be answered:

*What is to be learned by studying robots?

*What is needed to build a simple robot?

*What method of construction is appropriate to seventh and eighth grade students?

Potential for Learning

Upon breaking down the robot into groups of devices, it is found that there are mechanical, electromechanical, sensing and control devices. Students will develop an elementary understanding of how these work and their interrelationship as they attempt to construct a robot. Mechanical devices such as gears, levers, pulleys and wheels provide the skeleton of the machine and must be put together in an appropriate manner to provide the desired mechanical advantage. Electromechanical devices such as motors and electromagnets provide power to the mechanical devices to cause work to be done. A switching mechanism must be used to provide the desired control over the electromechanical system and sensing devices are used to provide information for decision making by the control mechanism.

What is Needed to Build a Robot

To build a robot, mechanical and electromechanical devices are combined in such a way as to be capable of carrying out a desired function. The system must have the ability to turn on and off switches to operate the device. This takes the form of an electronic interface unit which uses the commands of a microprocessor (computer) to control various switches. Appropriate software and programing are utilized to accomplish needed commands. To allow the robot to detect things in the environment, sensing devices are used to supply information to the microprocessor.

The main stumbling block here is the interface between the microprocessor and the robot. This device has been developed by Dr. Al Haugerud, Department of Education, Seattle Pacific University, Seattle, WA 98119, and will be on the market in early 1984. This unit can be a simple circuit which permits the turning off and on of a low voltage circuit by a simple computer program, or it can consist of a multiple circuit which permits the turning on of any of 8-10 circuits with a simple computer program which keeps track of the circuit switches.

Method of Construction

There are several methods that might be used to provide hands-on activities with robots. There are numerous publications available that give detailed instructions on how to build a robot from scratch. There are kits available that can be constructed as well as teaching robots that can be used to teach the fundamentals of robotics. However, at this time it is believed that at an introductory level for junior high school students that these methods are time consuming, expensive and beyond the ability of most students.

An alternative to the above methods is a modular toy called Capsela[8]. The Capsela system is built around a series of clear plastic capsules, each having four distinct mechanical or electrical functions. Capsules contain motors and various arrangements of gears. The capsules are joined by octoganal couplings. The electrical connections are made by plugs and sockets. With the addition of axles, wheels, winding drums and bar connectors, all the parts for a robot are supplied.

Using the components of Capsela, various vehicles (robots) can be constructed and connected to a microprocessor (computer) through a multiple circuit interface. By adding sensing devices, to provide environmental information, all the elements of elementary robotics have been provided. By using the appropriate software and/or programing the robot can be controlled as desired.

Summary

Industrial Arts/Technology Education has the opportunity to offer hands-on experiences with simple robots and microprocessors as control devices. By using the modular toy, Capsela, in combination with sensing devices and a computer interface, the fundamentals of robotics is within reach of both junior high students' ability and the school budget. The possibilities are limited only by the imagination.

While the techniques discussed here are being used at the junior high (introductory) level to teach the basic concepts of robotics and computers, it is also hoped that the activities will stimulate interest and motivate further

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8 Capsela is a registered trademark of Play-Jour, Inc., 1271 Avenue of the Americas, Suite 2530, New York, NY 10020.

study at the high school level. Plans are underway to develop techniques for further exploration of robotics in high school industrial arts. Consideration is being give to a interdisciplinary approach combining electronics and metals in the construction of robots.

Resources:

Robotics Associations

Robotics Society of America
200 California Avenue, Suite 215
Palo Alto, CA 94306

Robot Institute of America
One SME Drive
P.O. Box 1366
Dearborn, MI 48121

Journals:

Byte
CNC West
Design News
High Technology
Industrial Finishing
Iron Age
Manufacturing Engineering
Radio-Electronics
Robotics Age
Science Digest
Technology Illustrated
The Futurist
Tooling and Production

Books:

Manager's Guide to Industrial Robots, Hitchcock Executive Book Service, Hitchcock Building, Wheaton, IL 60187

Engleberger, Joseph. Robotics in Practice, Anacom, New York, NY.

Robillard, Mark J. Microprocessor Based Robotics, Howard W. Sams and Co., Inc., New York, NY. (Includes a list of parts suppliers, robot supplies, books and magazines.)

Hoekstra, Robert. Introduction to Robotics Systems, Southwestern Publishing Co., Palo Alto, CA.

Heiserman, David L. Robot Intelligence--with Experiments, Tab Books, 1981.

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