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Teaching Methods in Education for Industrial Robot Engineering and Their Results

- Particularly the Utilization of Hands-on Training on Air Robot with a System of Pattern Recognizing-

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Abstract

As the need for switchover to FA and for rationalization increases in the industrial world, educational courses in schools are more and more taking up the subjects of electronic machines, mechatronics and systems, etc., subjects which are a fusion of the previous subjects of electricity, electronics and machines.

At our junior college, a control engineering course was inaugurated in 1974 prior to any other schools that offered such courses. As automation progressed, the use of industrial robots spread rapidly. The year of 1980 is regarded as the first year that the use of industrial robots become widespread. Responding to the current requests, a one-year research course was added to the control engineering course in 1983. Moreover, a robot engineering course was newly established in 1984, in which mechatronics and industrial robotics were instructed intensively in high efficiency. As a teaching aid, an air robot system which was based particularly on the FMS model and possessed pattern recognition capabilities was completed in 1982. This system has been used since then as the nucleus for hands-on training with robots and systems.

As more and more intelligent machines and artificial intelligence become widespread in industry, these subjects are taking on greater importance and greater sophistication in the education offered by this department. Educational institutions are seeking to provide facilities and curricula which will meet the technological needs of this age. Our college is not an institution at the graduate school level, but rather a school which is at the more practical junior college level. An outline of the facilities introduced at our school is presented and the results of utilizing it in industrial robot engineering education is reported.

1.Positioning of Industrial Robot Technology Education

Education in areas of industrial robot technology is becoming an extremely important topic in the machining and manufacture of products, or their assembly, in order to release workers from dangerous or overly simple tasks, improve productivity and respond to demands for small lot production of many different types of product. FMS (Flexible Manufacturing System) is one type of production system developed with these requirements in mind.

Industrial robots also are expected to bear an important role in these production systems. They are being used to carry out loading and unloading in the metal stamping operations and the machining of metal materials, in plastics molding , in automotive painting and spot welding as well as in arc welding and other tasks.

On the other hand, robots with sensors are beginning to appear in the assembly of electrical and electronic devices and precision machinery, as well as the assembly of semiconductors, as well as in tasks which require high precision or which are highly complex.

When these production systems or robots are introduced in large numbers, then people who are proficient in the technologies for operating and maintaining them are needed.

When we think of just the body of a robot, a knowledge of mechanical, electrical, electronic, measuring instrumentation, control, materials and other technologies is required, not to mention systems,technologies. And when we consider production systems, an even higher, broader range of knowledge is vital for the systematic application of all these in order to achieve FA (Factory Automation) and FMS design and construction, etc.

In order to meet the need for such technologies, industrial high schools, colleges and other educational institutions are introducing industrial robots as experimental equipment and incorporating them into their classes. Education in the various technologies required for their use is also being introduced in the form of new courses of instruction for the purpose of technical education.

When incorporated into a production system, there are almost no instances where an industrial robot can be used all by itself, but it is used in unison with machining centers, NC machines, automatic warehouses and other peripheral equipment. For this reason, industrial robots should be one mechanical element of FA or FMS. In robot technology education, it is necessary that it be based on the fundamentales of how to achieve linking with peripheral equipment and introduction of robots as a part of the system.

Robots include mechanisms, sensors, actuators, microcomputers and systems related to these devices, and as such, they constitute an excellent teaching resource for inculcating the basic technologies of mechatronics.

In imparting a reasonable amount of technical strength to students within a short period of time (2-3 years), the broad based instructional content needs to somewhat restricted. For that reason, microcomputers, mechanical and servo technologies are given the greatest importance. On the other hand, when we consider production systems, achieving efficiency in FMS and is largely dependent on the correct arrangement of hardware and machines and methods of operation. Therefore, systems engineering for hardware and machines and production management for operation are included in course contents. Also the more energy saving and automation are required, the more close attention must be paid to human psychology, which is the back side of technology. For this reason, industrial psychology, courses are incorporated into the curriculum in an attempt to give support to these subjects.

The contents of this shool's courses of instruction for control engineering and robot engineering are shown in Fig.1 and Fig.2.

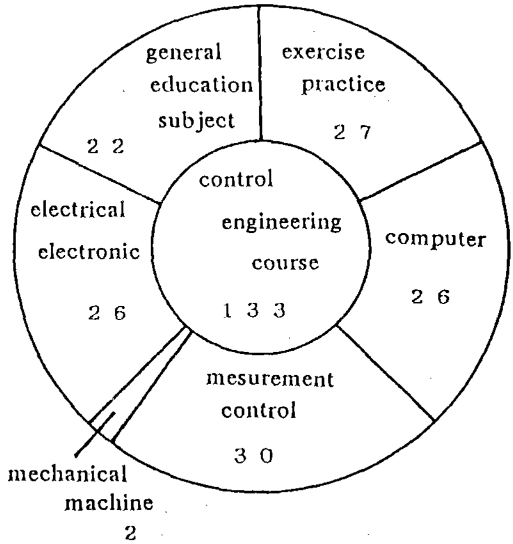

Fig.1. The contents of control engineering course

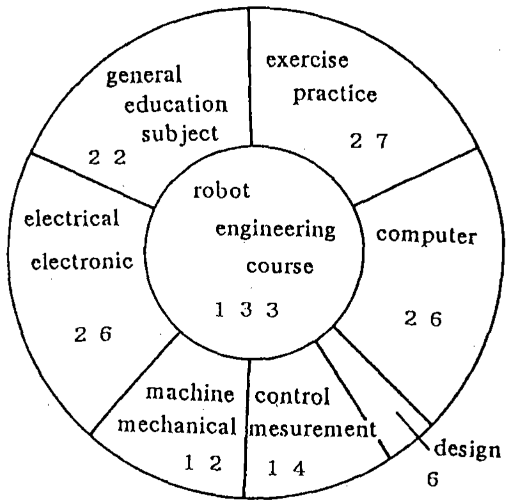

Fig.2. The contents of robot engineering course

2.Air Robot System with a Vision System for Education

At this school, an air robot system with a vision system consist of a CCD TV camera and a personal computer as a FMS model was completed.

Photo.1 shows the robot used in this experiment, equipped with the pattern recognition device made up of a CCD camera and imaged processor, and the color discriminator using a color sensor. The robot is comparatively small and is pneumatically operated.

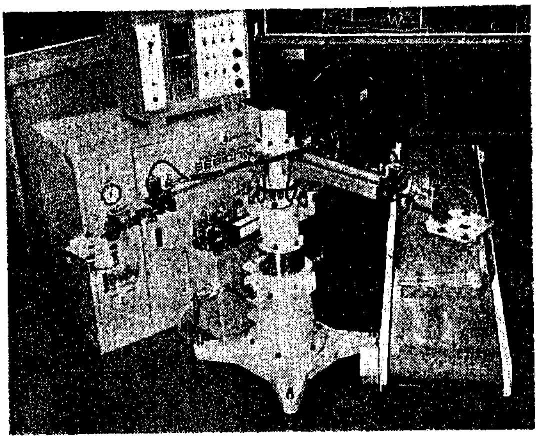

Photo. 1. Robot used in this experiment

When equipment capable of a wide range of uses and immediate response is considered, there is the possibility that fairly large-scale computers will be needed for control. Regarding this, this system was completed in order to investigate how the most flexibility can be achieved with the greatest simplicity in design.

3.Pattern recognition systems

3-1.System configuration

The configuration of a recognition device is shown in Fig.3. The system is composed of a CCD TV camera, video processor, television monitor, personal computer with floppy drive, character display, and printer.

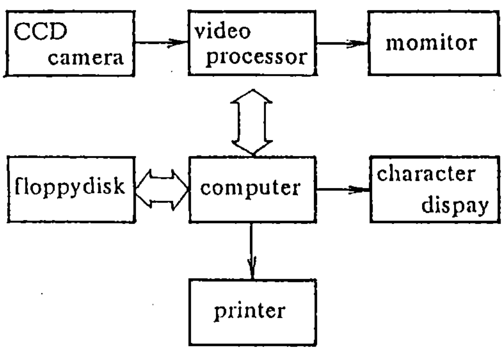

Fig.3. Configuration of recognition device

An image from the camera is stored in the computer. The computer then performs preprocessing, extracts to outline of the figure in the image, and finds its peaks. The number of peaks, peak angles, side lengths, and peak positions are stored as discrete values corresponding to the figure. Based on this stored information, it is determined whether the next figure examined is the same, if it is, how the positioning is different.

For the input method corresponding to the eye, a CCD camera was used, of the type recently widely used in the field of measurement control. The use of specialized equipment for handling the image signals was avoided when possible, and the form of the video signal that was input and output was the same as is used in ordinary commercially available televisions.

3-2.Recognition

A flowchart of the recognition process is shown in Fig.4. The screen of the figure read in is a 256×256 mesh in four gradations of tint from white to black. However, a considerable amount of noise is also contained in addition to the figure, which if unprocessed may lead to mistaken recognition.

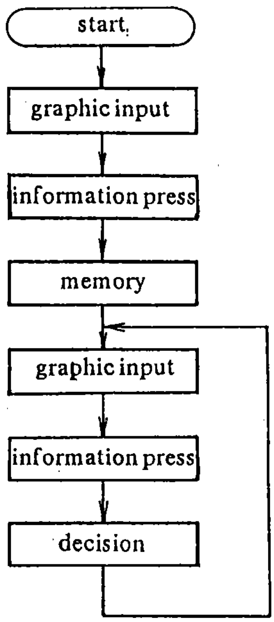

Fig.4. Flowchart of recognition process

4.Color discrimination

4-1.Discriminator

A monochromatic CCD camera was used in this investigation. For this reason equipment for color discrimination in the tasks became necessary, and a prototype discriminator was constructed. An outline of this device is shown in Fig.5.

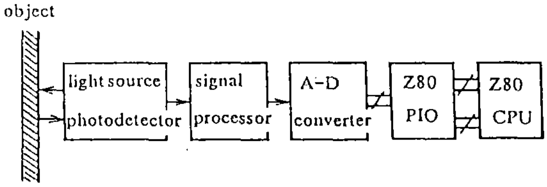

Fig.5. Outline of discriminator

A tungsten lamp was used for illumination, reflected light from the measured object was taken in by photodetector. The signal, after amplification and analog to digital conversion, was fed into the microcomputer.

An outline of this illumination and light reception section is given in Fig.6 and Fig.7 shows the circuit of the photodetector section using the color sensor.

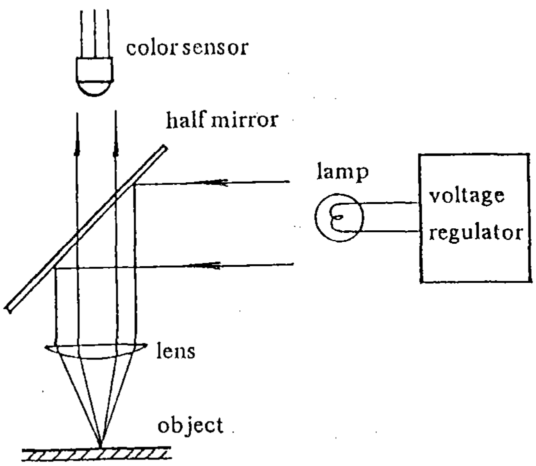

Fig.6. Outline of illumination and light reception section

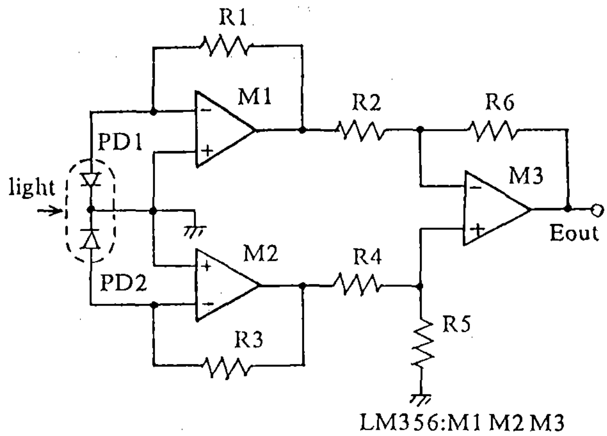

Fig.7. Circuit of photodetector

By using operational amplifier M_1, and M_2 according to differential, logarithmic conversion of the output of two photodiodes is performed, and after logarithmic conversion subtraction is performed simultaneously. When the output electric current from the photodiodes is I_{sc1} and I_{sc2}, output E_{out} expressed as:

$$E_{out} = -\log_a I_{sc2}/I_{sc1}$$

Where a is a constant.

4-2.Recognition device and results

The analog signals obtained by the photodetector were converted to digital signals and led into the PIO.

The sensor output voltages and their relation to color had been previously input into the computer in tabular form, and color was determined through comparison with the output form the A-D converter.

Fig.8 is a flowchart for this comparison routine. A singl-board microcomputer with a z-80 CPU was used for this purpose, permitting discrimination of ten colors. A robot hand equipped with this detector head is shown in Fig.9. The hand is pneumatically operated.

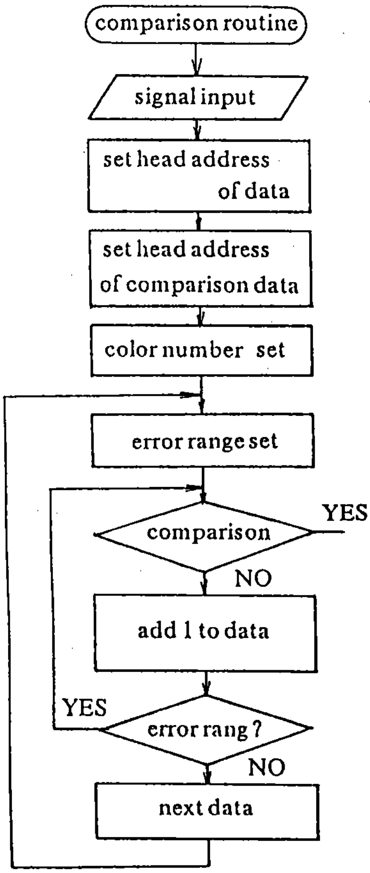

Fig.8. Flowchart for comparison routine

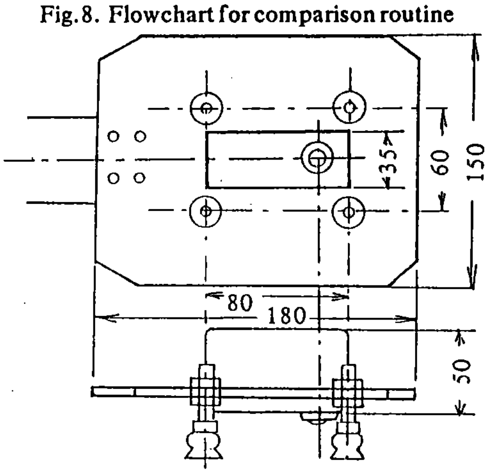

Fig.9 Robot hand equipped with detector head

5. Effects, etc.

Together with the utilization of this equipment in systems training practice courses, it is used for providing practice in programming of each station. It is also used separately in practicing assembly of a most popular one board microcomputer which uses a Z80 CPU.

By operating applications equipment, students are taught hardware and software technologies and receive a good fundamental mechatronics education.

The transition in graduates with job places, particularly in (1) robot related fields, (2) general electronics engineering related fields and (3) software fields, as well as the percentages of graduates of the control engineering course and robot engineering course out of the total of job places in the past 17 groups of graduates, is shown in Fig. 10.

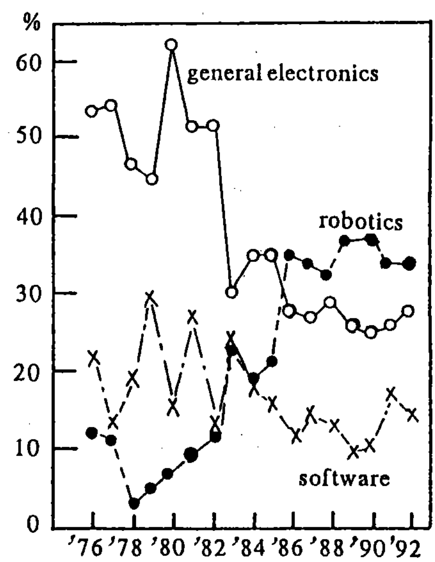

Fig. 10. The transition in graduates with job places

Also, transitions in the test results and passing rate for graduates who have placed as 1st Class, 2nd Class and 3rd Class microcomputer technicians in the proficiency tests held twice annually, confirming the level of their understanding in their mechatronics education, are shown in Fig. 11.

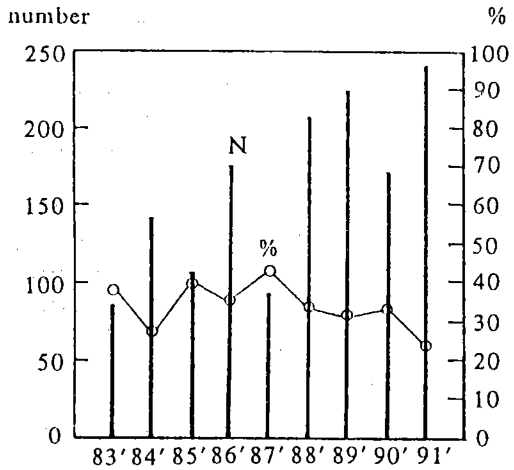

Fig.11. The test result of 2nd Class

6. Conclusions

Robot technical education encompasses a wide fields of knowledge. People entering this field of study can think of almost endless topics and specialties to master, or which they want to learn about. How much can they grasp within a limited period of time? Is it not necessary to perfect their own foundational strengths and limit to some extent the number of subjects covered? Also, robots are almost never used alone, but are grouped with several pieces of peripheral equipment. With these points in mind, we want to recommend that students be given a basic foundation of practical knowledge of macro systems. This method clarifies the position of robots within systems and gives them a thorough knowledge of that role.

In addition, students learn to operate applications equipment including microcomputers, and it is thought that the necessity of thinking about both hardware and software is what contributes to the attainment of good fundamental strength. When machines with intelligence and artificial intelligence become commonplace, the education gained in this department will becom more and more important, and it will be considered a high level department. In educational institutions, equipment and instructional content that will fulfill modern technological needs is being sought for. We want to do our best to carry on research in effective teaching materials.

7. Acknowledgments

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