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LATEST MACHINE VISION SYSTEM

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1. FOREWORD

Japan is facing the age of full-scale introduction of machine vision systems. Fuji Electric has made many achievements centered about machine vision systems for industry. The present state of high-speed OCR for industry and mechanical engineering of machine vision system are described.

2. PRESENT STATE OF HIGH-SPEED OCR FOR INDUSTRY

Recent rapid FA and strengthening of Quality Control have increased the need for date of manufacture check and confirmation for sorting of produced by characters, marks, etc. Therefore, the demand for lot No. and reading, date confirmation, part No., and mark reading is increasing.

In the OA field, automatic readers are already being developed for printed character, handwriting, etc. and are being applied as document readers. The objects sensing method is different. This method is not suitable for FA from the standpoints of processing speed, etc. and high-speed reading and low-cost equipment is necessary.

Currently, there are many high-speed production lines of 300 to 600PMM and since the products are moved, their position also changes. The FA-OCR was developed as a device that can read printed characters, etc. even under these conditions.

Fuji Electric is commercializing the VR-1000Z reader of laser printed characters as an FA character reader. Its main applications are medium and lower speed processing with low contrast characters. This development is for high-speed lines. This completed our line-up of character readers.

2.1 Configuration and specifications

The FA-OCR high-speed optical character reader is shown in *Fig. 1*. This device consists of a television camera that inputs images, a control unit that performs character reading and inspection from the input images, and a monitor that displays the set data and images. The image to be inspected is fetched from the television camera and are image processed and character reading and character inspection are performed.

Fig. 1 FA-OCR

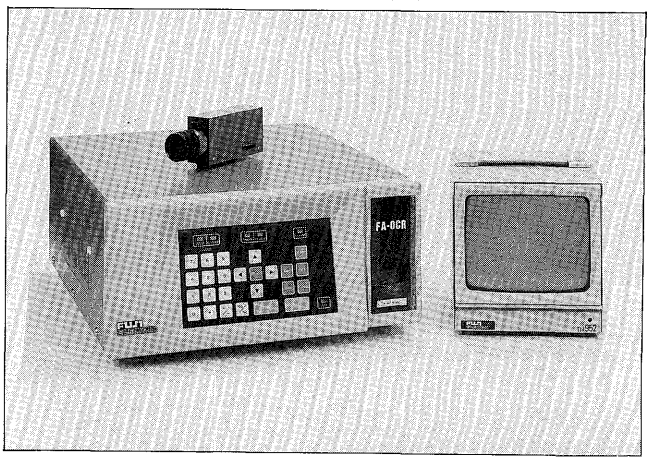


Table 1 FA-OCR basic specifications

Item	Specification
Division of field	H255 x V220 pixel
Registered characters	36 (max)/camera
Registration method	Shorting
Judgment parameter	Difference of area count
Threshold	4 channels
Position compensation function	X-Y compensation and rotation compensation (option)
Processing capacity	100~200ms/10 chars (registered characters 10 characters 0~9)
Objects	Numbers 0~9, letters
Character font	JIS-OCR-A, JIS-OCR-B Font, random font characters
Read characters	Max 16 chars/field
Connectable cameras	Max 2 (discrete judgment)

The control unit consists of a threshold circuit for obtaining a binary image, binary image memory, pattern dictionary memory that stores the judgment standard pattern, and pattern matching circuit that matches the binary image and the standard pattern. The control unit also contains a floppy disk drive for saving the various

setting data.

Up to two television cameras can be connected. The image input from each camera can be judged independently.

The basic specifications of the FA-OCR are shown in *Table 1.*

2.2 Basic functions

The FA-OCR processes the image signal obtained by televising the inspection object with a television camera and compares the image to the register character pattern images and performs character reading and inspection.

First, the standard object character pattern is televised with a television camera and the image signal is converted to binary at a set threshold level and the Y-X axis projection data is extracted. The X-Y axis position of the entire object character pattern is detected with this data as the base. A rectangular region (object region) matched to the thickness of the character is set for each character to segregate each character of the object character pattern corresponding to this standard position. The object regions can overlap. An object region setting example is shown in *Fig. 2.*

Next, the standard character patterns are registered to the pattern dictionary memory by showing. Patterns for similar character judgment are generated automatically at this time. The dictionary patterns created by showing can also be partially corrected. Here, upper and lower limit values are set for each registered dictionary pattern. The upper and lower limit values can be set freely to match changes in the character size and character shape.

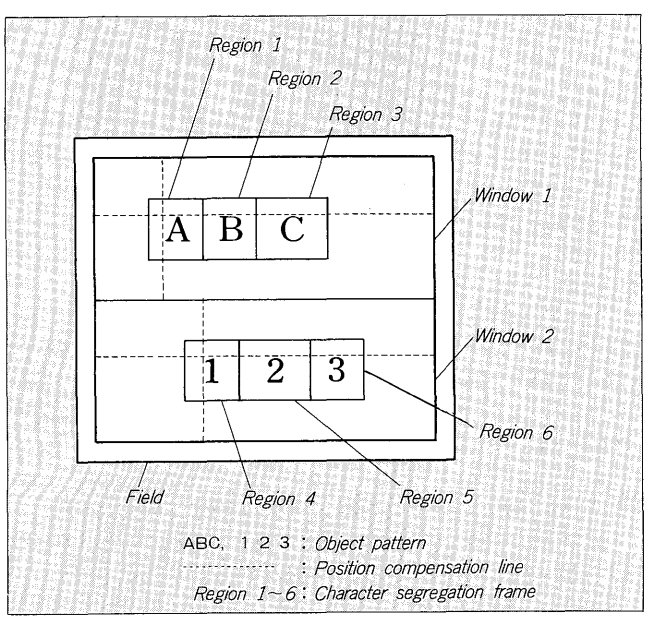
Judgment detects the position of the image by means of the image of the object character pattern input from the television camera and segregates the character outside shape for each object corresponding to the detected position. The character size and the character position in the object are detected by means of this.

The registered dictionary patterns are sequentially matched against the detected pattern position and the difference is measured. This measured value and the preset upper and lower limit values are compared and whether or not the characters are the same is judged.

When there are several dictionary patterns judged to be candidate characters, judgment is performed by using the similar character judgment pattern and the most similar pattern is used. When there is no character that is the same, the dictionary pattern judgment conditions for the inspection object character are changed and judgment is retried. The result obtained like this is made binary output or parallel output for each region.

The moment data can extracted from the binary image and the rotary axis detected by adding an option function. Therefore, the rotation angle can be corrected and the input image coordinates can be converted to standard position even if the inspection image rotation deviates at judgment.

Fig. 2 Region setting example



2.3 Functions and features

2.3.1 Simple and flexible setting

Since the threshold level, character position compensation region, character recognition condition, and other parameters needed at judgment can be set freely by the customer, printed characters, dot characters, and other object characters can be dealt with flexibly. Because these settings can be made by man-machine interface while watching a CRT monitor, operation is easy. Dictionary pattern setting can be performed by televising the standard character pattern with the television camera and registering the binary image as a dictionary pattern by showing setting. Therefore, dictionary patterns can be created easily even for complex patterns.

2.3.2 OCR and checking of character quality by matching

The standard character patterns needed at judgment are registers to the pattern dictionary memory by showing. These registered dictionary patterns and the object character pattern are matched and the missing image part and the projecting part are measured.

Character reading, short of character, soiling, and other quality checks can be performed by comparing this measured to the upper and lower limits of each dictionary pattern. An example of character reading shown in *Fig. 3.* An example of quality checking is shown in *Fig. 4.*

2.3.3 High speed processing

Matching processing and image processing that processes area measurement and other voluminous data are performed by hardware and have been speeded up by high-speed firmware. Therefore, judgment processing is performed up to 100ms/10 characters (registered dictionary pattern 10 characters).

2.3.4 High precision judgment

Regarding the threshold level, since one channel can be selected from among four channels for each region, that is, each object character, the object character can be converted to binary by means of the optimum threshold level.

Fig. 3 Character reading by matching

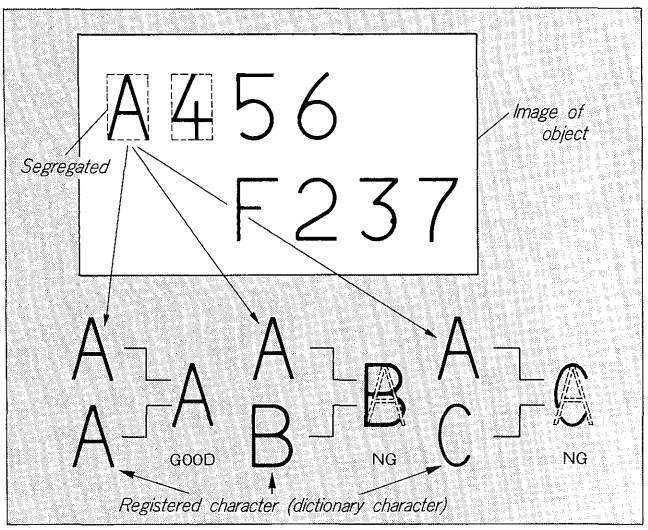
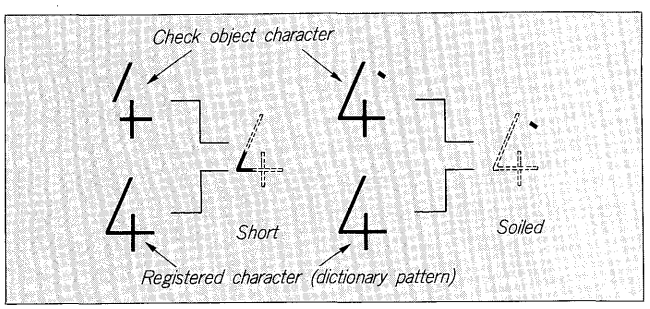


Fig. 4 Quality check by matching



Character that cannot be read at one judgment can be read by retry function by changing the judgment conditions. High precision character reading is possible by means of this function.

2.4 Application examples

Examples of reading of the date figures and alphabetic control symbols printed on a label are shown in *Fig. 5* and *Fig. 6*. *Fig. 5* is a field at which the Y coordinates are detected at the top of the numbers and the X coordinate are detected at the left end of the alphabetic characters to perform position compensation. Here, regions corresponding to the detected coordinates are generated as shown in *Fig. 6* and the character in each region is segregated and the character position is detected accurately. The characters are matched with the registered dictionary patterns are the detected character position and character reading is performed. In this case, the figures of the top row only have to be matched to the dictionary pattern figure 0 to 9 and the alphabetic characters of the bottom row only have to be matched to the dictionary pattern letters A to Z.

3. MACHINE VISION SYSTEMS MECHANICAL ENGINEERING

The enterprises that have introduced machine vision to

Fig. 5 Position compensated image of printed characters on label

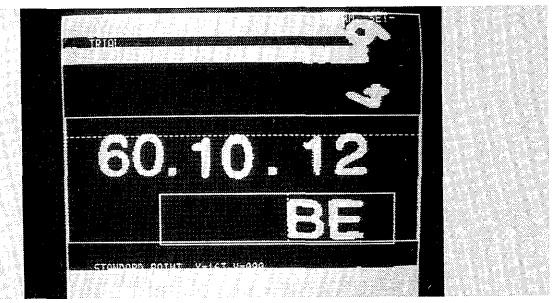
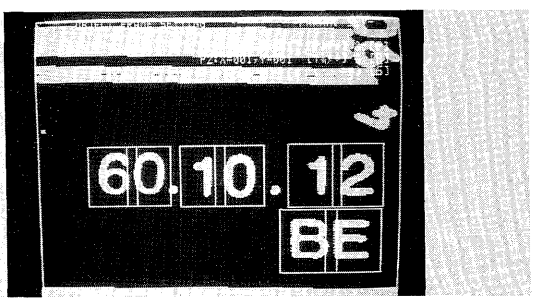


Fig. 6 Real image of printed characters on label



automation systems to visual operation has increased with the advance of quality control and FA. Many customers are operating machine vision systems on many actual lines in various field of industry. With this delivery record as background, machine vision systems can be grouped by usage objective into visual inspection, image recognition, visual measurement, visual analysis, etc. Machine vision system mechanical engineering centered about the automatic visual inspection machine is introduced.

3.1 Important of engineering

Roughly, the motives for introducing video sensors are improvement of quality and productivity, rationalization, etc. The automatic visual inspection introduction investigation procedure is shown in *Fig. 7*.

The resolution, precessing speed, processing volume, number of cameras, lighting condition, and other machine vision system inspection performances are determined by optoelectronics engineering. However, since the environmental conditions and machine processing capacity, including object position, background, and other handling machine technology, make a large contribution to inspection performance, these engineerings are necessary when considering a total machine vision system.

When building a machine vision system using general-purpose type or popular type video sensors, the introduction of new ideas based on experience in IE (Industrial Engineering) supported by optronics, mechatronics, and electronics becomes the key point.

3.2 Classification of machine vision system machines

For video sensor visual inspection systems, a system study that develops image processing performance to the maximum is necessary. However, balancing with total

Fig. 7 Automatic visual inspection introduction investigation procedure

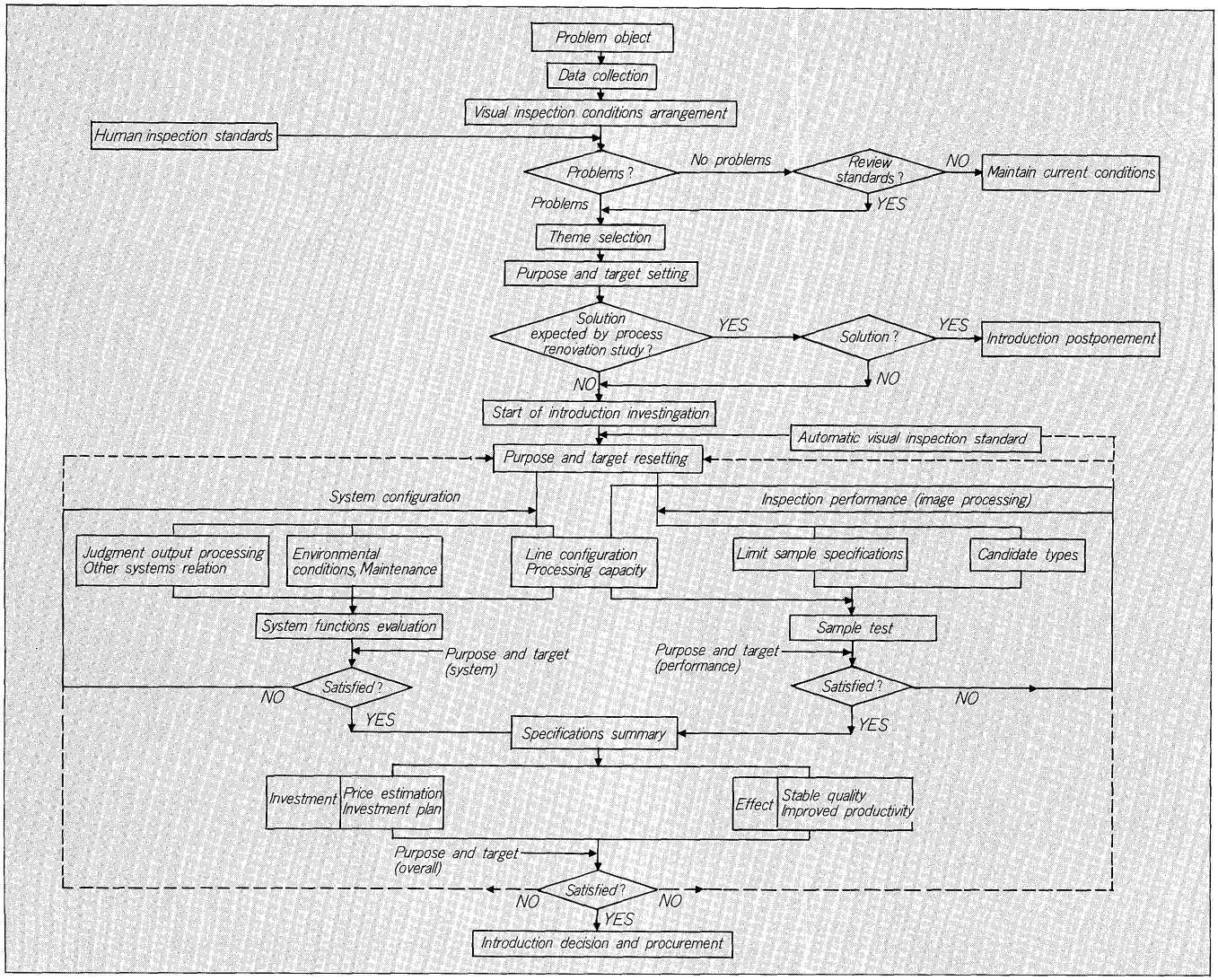


Fig. 8 Machinery and equipment range

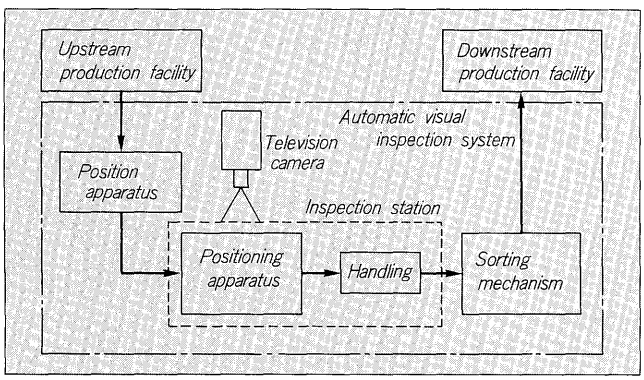


Table 2 Main uses versus feeder

Feeder		Main use
Automatic feed	Handling	Conveyer, star wheel
	Machinery	Robot, material handling
	Vibration	Boll feeder, linear feeder
	Air	Air suction, air blow
	Magnetism	Magnetic feeder
	Dropping	Bucket feed
Manual feed	Tray	Manual setting on tray
	Magazine	Manual setting at magazine
	Manual placement	Manual placement at inspection site, handling site, etc.

cost is also an important topic.

The simple purposes and an outline of the position control apparatus, inspection station, automatic rejection, and automatic sorting mechanisms of the machinery and equipment range shown in *Fig. 8* are introduced and they are classified as machines below.

3.2.1 Position control apparatus

The purpose of the position control apparatus is to disassemble and separate the objects and simplify position at the next stage to display the functions of the image processing system adequately.

Main uses versus feeder are shown in *Table 2.*

Table 3 Machine positioning methods

	System	Position detection element	Detection system	Positioning precision (mm)
(a) Position detection system	Mechanical	Various jigs Cam, link, gear	Digital	1~0.005
	Electrical	Microswitch Proximity switch	Digital	0.02~ 1~0.05
		Electric micrometer Electrical linear scale	Analog Digital	0.02~0.001
		Pulse motor	Digital	0.02~0.005
	Pneumatic	Air micrometer	Analog	0.02~0.001
	Optical	Photoelectric switch	Digital	1~0.5
		Photoelectric linear scale	Digital	0.02~0.001
		Light wave interference meter	Digital	0.005~0.0001
(b) Drive system	Conveyer belt drive, hydraulic drive, compressed air drive, ballscrew drive, machine link drive, linear motor drive	(c) Guide system	Slideway (dry, lubrication, nonmetallic), rolling guide (linearway), static pressure dri drive (oil, air), magnetic guide, semi-floating guide	

Table 4 Handling methods

Item	Continuous handling carrier	Intermittent carrier
Linear motion	◦ Belt conveyer ◦ Chain conveyer ◦ Roller conveyer ◦ X-Y table	◦ Chain conveyer Gear, Cam drive ◦ Slot conveyer sensor motion ◦ X-Y table step motion ◦ Transfer carrier
Rotary motion	◦ Curved conveyer ◦ Turntable ◦ Drum carrier	◦ Index table ◦ Drum carrier, Gear ◦ Vehicle, Cam drive
Composite motion	◦ Various system by combination	◦ Various system by combination

3.2.2 Positioning apparatus

In an automatic visual inspection system, the positioning apparatus is the most important part for keeping the inspection object and television camera relationship optimum and safe.

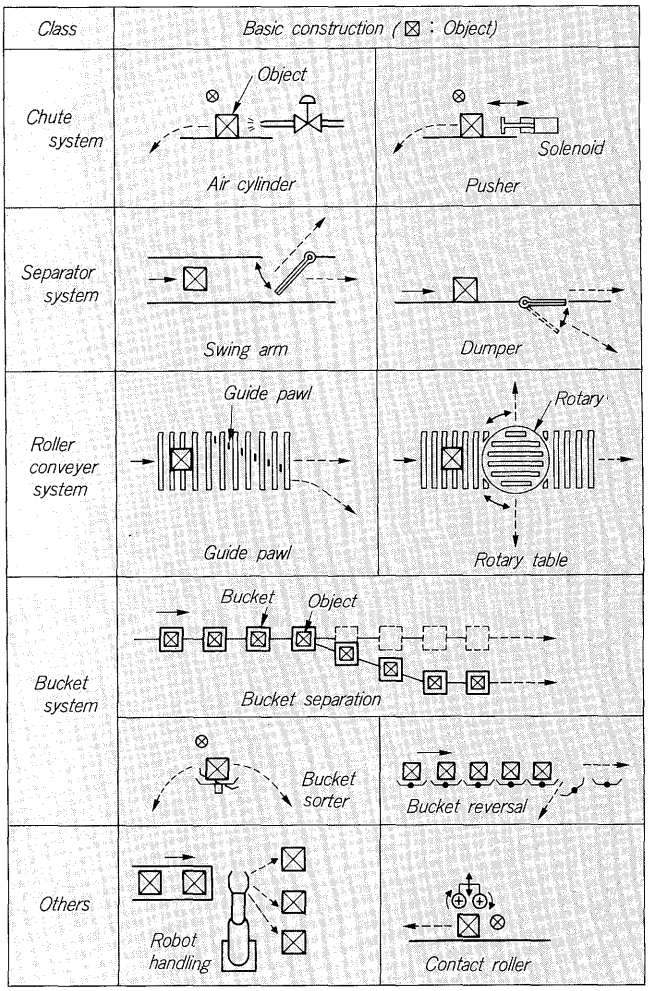
Positioning precision is related to the kind of compensation function of the image processor used and is determined by the inspection objective field of view and lighting method.

Machine positioning is selected from (a) position detection system, (b) drive system, and (c) guide system from the machine positioning methods shown in *Table 3* by taking into account the processing capacity of each system.

3.2.3 Handling system

Handling systems are classified by time into continuous handling carrier and intermittent carrier and are classified into linear carrier, rotary carrier, and composite carrier from the standpoint of the mode of motion of the inspection object.

Fig. 9 Sorting constructions



Typical systems are shown in *Table 4*.

3.2.4 Sorting mechanism

Sorting sorts the inspection object based on the result of inspection at the inspection station. It can be roughly classified as shown in *Fig. 9*. The sorting mechanism requires experience and know-how experience and so that the object is not damaged.

3.3 Achievement examples

3.3.1 Foreigner detection machine in Bayern glass bottle

This machine detects foreigners mixed in the medical power in Bayern glass bottle and automatically sorts the bottles into Bayern glass bottles with foreigners and normal Byern glass bottles. A photograph of the machine is shown in *Fig. 10*.

Position control apparatus: Star wheel segregation
Positioning apparatus: Photoelectric sensor detection
Handling method: Intermittent handling carrier by chain cam drive
Sorting and rejection: Defect rejection by separator system
Video sensor: Fuji multiwindow MW-2200

2.3.2 Automatic sorting machine

This machine inspects the visual pattern, hue, etc. of fruits, vegetables, etc. and sorts them by class. An

Fig. 10 Foreigner detection machine in Bayern glass bottle

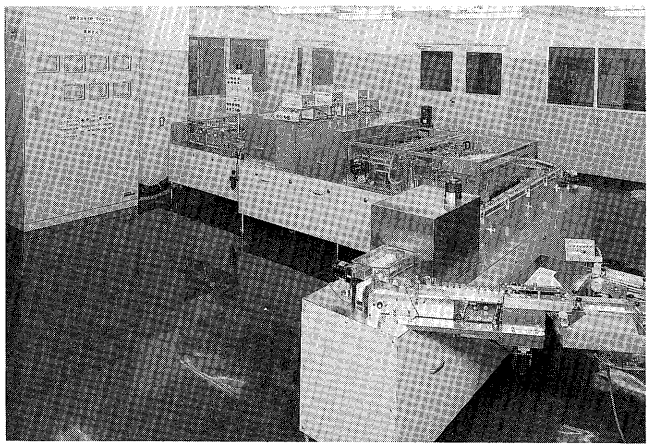
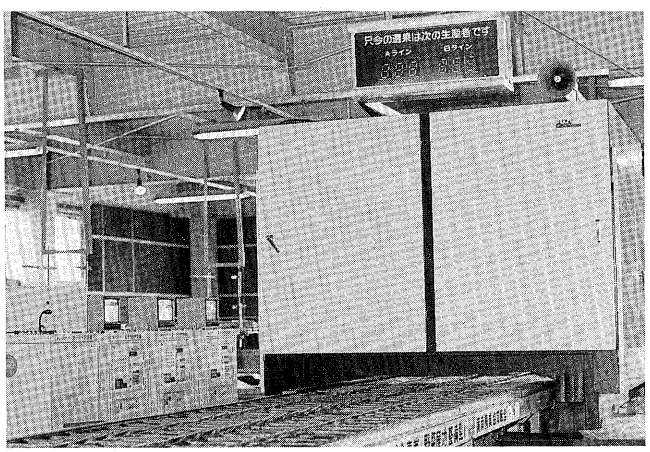


Fig. 11 Fruits sorting machine



automatic sorting machine is shown in *Fig. 11* as an example.

Position control apparatus:	Placement onto tray by hand
Positioning apparatus:	Photoelectric sensor detection
Handling method:	Intermittent handling carrier by chain conveyer
Sorting apparatus:	Classification by bucket system
Video sensor:	Fuji multiwindow MW-2200
Processing capacity:	Max 960PPM

3.3.3 Chip part automatic visual inspection machine

This machine visually inspects the top and bottom surfaces of capacitors, resistors and other chip parts for PC board surface mounting and automatically sorts them into defective parts and good parts.

The machine is shown in *Fig. 12.*

Position control apparatus:	Positioning by parts feeder
Positioning apparatus:	Pulse motor detection
Handling method:	Continuous carrier by turntable
Sorting apparatus:	Defects rejection by separator system
Video sensor:	Fuji multiwindow MWP3000
Processing capacity:	400PMM

3.3.4 Automatic inspection machine for electronic parts

This machine visually inspects the radial surface of

Fig. 12 Automatic visual inspection machine for electronic chip parts

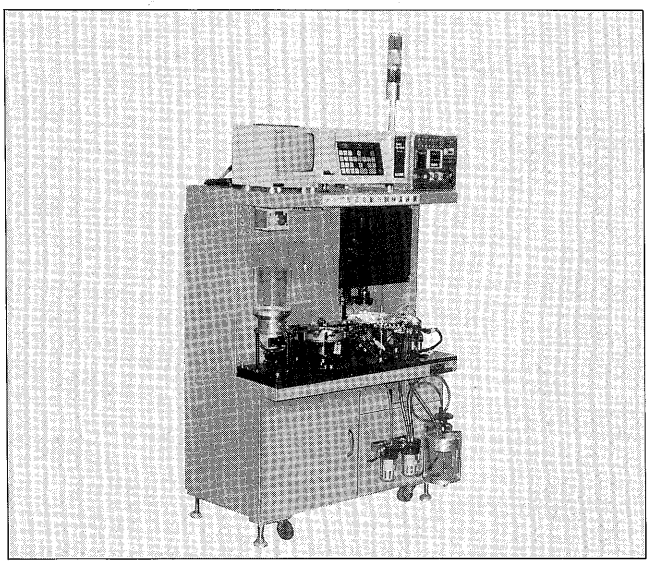


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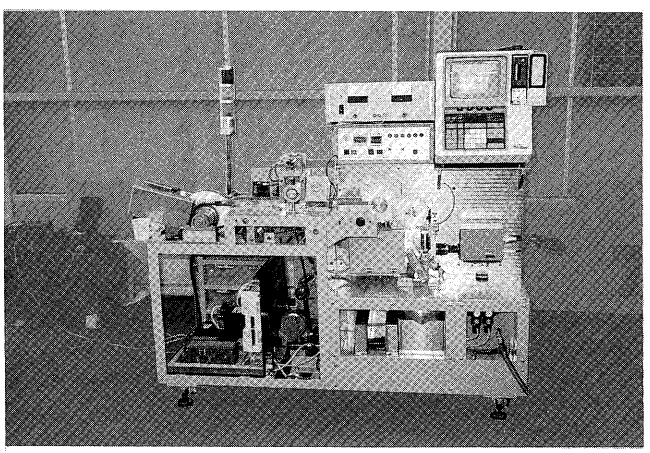
Fig. 13 Automatic inspection machine for electronic parts



capactiors, resistors, and other electronic parts with leads and automatically sorts them into no good parts and good parts.

Position control apparatus:	Positioning by magnet feeder
Positioning apparatus:	Photoelectric sensor detection
Handling method:	Material handling by air cylinder
Sorting apparatus:	Storing by chute system
Video sensor:	Fuji multiwindow MW-2000

4. CONCLUSION

The new-FA-OCR was introduced and engineering of the machine vision system peripheral devices was outlined. Fuji Electric video sensor technology is prized by numerous customers in various fields and is operating on many actual lines.

We will continue to take up the needs of customers positively and offer systems that are easy to use and have a wide range of applications.