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APPLICATION OF IMAGE PROCESSING TO AUTOMATED SEWING SYSTEM

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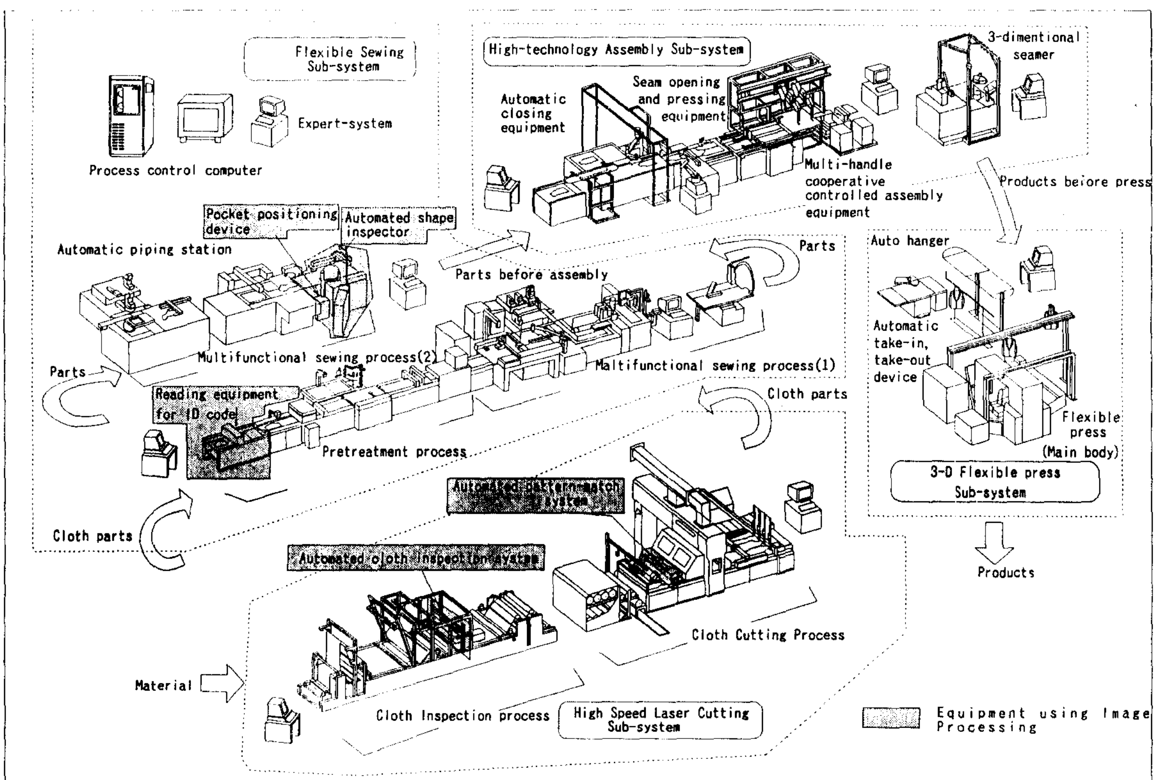
ABSTRACT

Since inspection, ID-code recognition, and pattern match processes requiring vision depend upon the high-grade human recognition capability, these processes have conventionally caused a bottle-neck in automatizing sewing system. However, the authors have recently developed the technology of inspecting the surface defects of textiles and recognizing ID-code by fully utilizing the image processing technology. In the ID-code recognition technology, the most difficult data given on patterns can be read as a result of developing the image processing technology and eliminating noises by using a special (fluorescent) ink. The inspection and pattern match technology was verified to be able to put into practical use through evaluation experiments in an experimental plant.

1. INTRODUCTION

The Agency of Industrial Science and Technology of MITI, Japan, built an experimental plant in Tsukuba Center for the purpose of validating 9 years' research results of a large-scale project 'Research and development of automated sewing system'. An overall operation experiment was completed in November, 1990, and a demonstration operation was carried out from January to february, 1991 to have finished the research and development with good reputation, while creating a sensation in related industries in Japan and aboard. This paper deals with the applied image processing technology, while emphasizing the ID code recognition technology developed in the automatic sewing system.



Fig・1 Test Plant Layout for Automated Sewing System

2. OUTLINE OF AUTOMATED SEWING SYSTEM

The experimental plant of the automated sewing system consists of four subsystems as shown in Fig.1. The image applied units reported herein are contained in both high-speed laser cutting subsystem and flexible sewing subsystem.

Fig.2 Reading equipment for ID-codes on parts

3. PROTOTYPE EQUIPMENT

3.1 READING EQUIPMENT FOR ID-CODES ON PARTS

This paragraph describes the reading equipment for control data (ID-codes) given on sewing parts. These ID codes are required for tracking in the automated operation. This equipment is mounted at the forefront of the cloth stabilizing pretreatment process as shown in Fig.1. It reads the ID codes of each part being loaded into this subsystem, and transmits readout results to a process control computer. These data are transferred to each subsequent automatic machine,and used for automatic selection of jigs, decision of processing procedures, and other operations. ID codes are drawn by special medium invisible under the normal light so as not to degrade products by these data. After recognizing the ID codes, the equipment reverses parts for facilitating the process in the next stage. Fig.2 shows an external view of the equipment.

3.2 AUTOMATED CLOTH INSPECTION SYSTEM

3.2.1 TWO-DIMENSIONAL VISUAL DEFECT DETECTOR

The newly developed two-dimensional visual defect detector is designed to automatically detect defects of textiles by analyzing an image from ITV (industrial TV) cameras . This equipment consists of a defect detector, detection control unit, ITV cameras, interrupt signal generator,and other components. The defect detector detects defects by means of image analysis.

The specifications of this system are outlined below.

Image processing device……Hitachi IP/5 5 units
ITV camera……Shutter camera(KP-181) 10 units
Lighting……DC power supply,reflected light, incandescent lamp
Inspectable cloth width……1,000mm

3.2.2 PATTERN PITCH MEASURING AND INSPECTION SYSTEM

This system is designed to measure the pitch width along the total length of textiles. The newly developed pattern pitch measuring and inspection system consists mainly of the inspection unit, ITV camera, interrupt signal generator, and encoder. Fig.3 shows an external view of this system. An interval between pitches is measured by using two input images entered from one camera unit at separate timing. The entry timing of two images is obtained by counting a signal from the encoder which is directly connected to a carrier roller.

The specifications of this system are outlined below.

Image processing unit……Hitachi IP/200 1 unit
ITV camera……Shutter camera(KP-181) 1 unit
Lighting……High-frequency fluorescent lamp

Fig.3 Pattern pitch measuring and inspection equipment

3.3 AUTOMATED PATTERN-MATCH SYSTEM FOR CUTTING

Cutting positions must be determined by taking patterns into account when cutting parts requiring pattern matching. The pattern recognition unit measures the pattern positions on textiles just before cutting , and inform the cutter of the measured pattern positions. This system is combined with a laser cutter to automatically execute pattern matching and cutting. It consists of an image processor and a robot for positioning a camera.

3.4 POCKET POSITIONING DEVICE

The pocket positioning device positions the pocket on the body, and feeds them to the pocketing station. Since sewing parts are made of cloth and shrinkable depending on the environmental conditions,such as humidity, temperature, etc. and handling methods, they must be visually recognized and positioned just before feeding them to the automated machine. The newly developed pocket positioning device executes positioning based on the image recognition technology.This device consists mainly of a multi-arm robot for positioning pockets, a gripper, a moving camera, and a transport table and pocket base. A plain pocket is positioned on the body by reading positioning marks given on both pocket and body through an ITV camera. These positioning marks are drawn by an invisible medium under the natural light. An image is entered under the lighting having a special wavelength, and marks are recognized to position the pocket.

A patterned cloth is positioned by pattern matching of the pocket body by means of a histogram method.

3.5 AUTOMATED SHAPE INSPECTOR

An automated shape inspector is mounted before and behind the automated sewing equipment to inspect whether input materials and processing results are normal or not. The newly developed inspector is mounted just behind the pocketing process as shown in Fig.1.

Its specifications are outlined below.

Image processor……Hitachi IP/200 1 unit

2-unit camera system……Two camera units are used to inspect large parts accurately.

Semi-transparent conveyor……BY lighting this semi-transparent conveyor from the bottom,part profiles can be extracted securely irrespective of the cloth and color phases of parts.

Lighting……The pocket positioning on the body can be recognized by unilizing the shadow of the pocket by means of lighting in multiple directions and controlling.

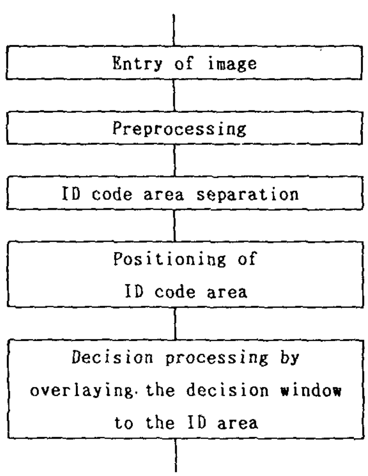


Fig.4 Data recognition procedure by a decision window

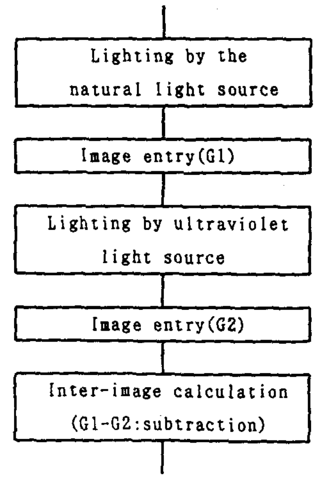


Fig. 5 Pattern removing method by inter-image calculation

4. DEVELOPED IMAGE PROCESSING TECHNOLOGY FOR AUTOMATED SEWING SYSTEM

Various image processing technology has been developed for cloth in this research and development. This section describes the technology, emphasizing the ID code recognition technology.

4.1 ID CODE RECOGNITION TECHNOLOGY

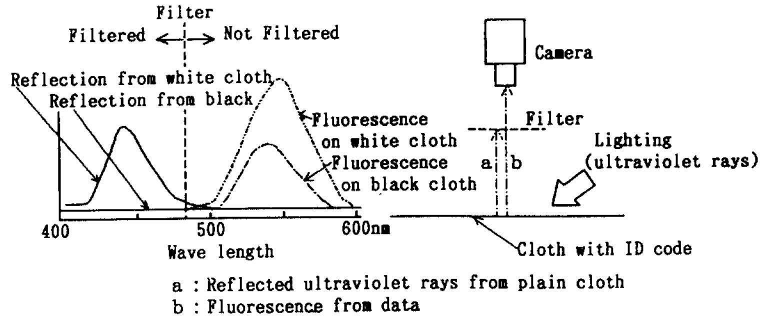
In the automated sewing system, the data required for tracking in the sewing process is given to sewing parts. Since these ID codes are not necessary after production products, they are drawn by using a medium(ink) which is not visible under the normal light but visible under a special wavelength band(ultraviolet)light source. An image of the data drawn on the cloth surface is entered by an ITV camara under the special light source, and recognized by analyzing it.

(1)OUTLINE OF PROCESSING

Fig.4 shows the developed ID code recognition procedure. After loading an image, preprocessing is done to eliminate noises by the spatial sum of product operation function and then the given portion is separated. An image of the given portion is analyzed to determine the directions and positions of given characters by analyzing the image of the given portion,and the characters are judged by overlaying the decision window onto the given character position.

(2)IMAGE CAPTURE

Patterns in an processing image disturb the recognition of the ID code. Fig.5 shows an example of the image processing to eliminate patterns from the image to be processed. This system loads both an image under the ultraviolet rays containing the natural light and an image under the natural light , and executes the inter-image operation(subtraction) of two images. By this image processing, an image is normally obtained with the ID code emphasized. In this case, since the fluorescence of the given medium on the dark background of cloth is



(i)Separation of reflected light from plain cloth and data fluorescence

(ii)Concept of the separation of data light

Fig.6 Method of eliminating pattern in an image

brighter than the reflected light from the brightest portion of patterns, the data of given characters can easily be separated from patterns. However, if the fluorescent of the medium given on a dark background is weaker than the reflected light at a bright pattern portion in certain cloth, patterns cannot be separated from the image, so that this system is not applicable.
Fig.6 shows an improved method of eliminating patterns from an input image by means of a special medium and a filter. Since this system can remove the useless reflection(reflection from a white cloth surface without given medium) from the input image, patterns' harmfull influence can be largely decreased on the image processing.

(3)ADOPTION OF A NOISE-TOLERANT SEGMENT PATTERN

Since part ID codes are drawn on cloth, noises and incomplete characters occur unavoidably on an input image due to the influences of woven and knitting structures typical to cloth.
This tendency is particularly noticeable in case of patterned cloth.
If an attempt is made to recognize an image containing noises and incomplete characters, the image cannot be recognized as characters because of the lack of a pattern having seven coincident segments. In order to reduce such nonrecognition, a segment correction was adopted to allow pattern fluctions of ±1 segment within a range where corresponding characters are not recognized as other characters. By this method, nonrecognition can be reduced without increasing erroneous recognition, even if the image quality of an input image is rather low, like in patterned cloth. Table 1 shows the segment patterns corresponding to characters.
These patterns are provided to maximize each inter-character distance by optimizing the component segment of each character within a readable range.

(4)CHARACTER DECISION WINDOW

Seven-segment characters are read by using two decision windows as shown in Fig.7.
The recognition is considered correct when decision results of both windows agree with each other. Thus, the reliability of recognition results has been improved.

(5)CHARACTER DECISION ALGORITHM

Fig.8 shows the character decision algorithm. On-off criteria of segment are set for determining characters based on the maximum effective picture element counted for every seven segment of each character.

·Counting of the maximum number of dots: The maximumnumber of dots (max dot) of each character is obtained by counting the number of effective picture elements

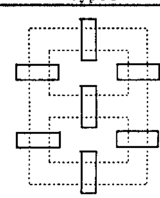
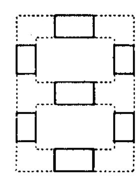
	Type1	Type2
Decision window shape		
Dislocation	strong	weak
Blur of characters	weak	strong
Noise	weak	strong

Fig.7 An example of decision window

Table 1. Segment patterns where fluctuations of ±1 segment are allowable

Recognized numeric	Normal segment pattern	Missing segment number SG1	SG2	SG3	SG4	SG5	SG6	SG7	noise-appearing segment number SG1	SG2	SG3	SG4	SG5	SG6	SG7	Allowable No. of patterns
1																3
2																2
3																1
4																7
5																2
6																1
7																5
8																1
9																3
0																5

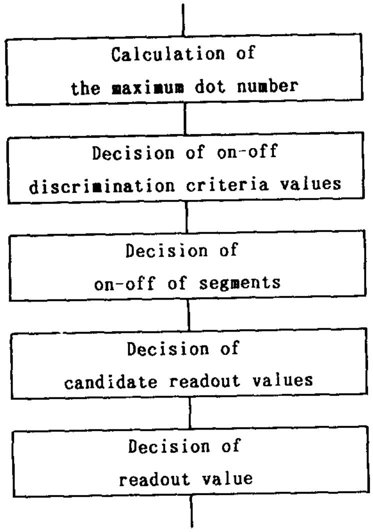


Fig.8 Character decision processing

(dots) of seven segments.

·Decision of on-off discrimination criteria: Three kinds of on-off criteria shown below are determined from max-dot.

Criteria 1: max.dot × 1/6
Effective for blurred characters and dislocation

Criteria 2: max.dot × 2/6
Effective for general cases

Criteria 3: max.dot × 3/6
Effective for frequent noises

·Three candidate readout values are determined from on-off patterns of segments using criteria 1-3.

·Each digit is then decided applying the majority rule to the three cancidate digits, and also using check digit.

4.2 CLOTH INSPECTION TECHNOLOGY

Table 2 shows outlines of developed technology for two-dimensional defect inspection and pattern pitch measurement.

Table 2. Outline of the development of cloth inspection technology

developed technology	Processing object	Purpose of image processing	Image processing method/algorithm	Employed Image processing command
Two dimensional defect inspection technology	Plain cloth	Defect detection (dirt, flaws, wrinkles)	Defects are detected by inter-image operation (subtraction) between a local maximum filter image and local minimum filter mage.	Smoothing, local filter image operation, binary coding, histogram and etc.
	Printed patterns : Simple patterns (polka-dotted patterns, striped patterns, checked patterns)	Defect detection (ink stain , fading)	Polka-dotted patterns: Detection of abnormal polka dots by the area and perimetrical length and detection of protrusion, holes, and notch flaws by the contraction and expansion method.	Smoothing, binary coding, expansion and contraction, labelling, inter-image operation, histgram, area, perimetrical length and etc.
Pattern pitch measurement technology	Checked-patterns(printed patterns, yarn-dyed patterns)	Measurement of pattern pitch width	Measuring of inter-pattern distance between two scenes by x-axis projection histogram and template matching method.	Histogram, template matching and etc.

Table 3. Outline of the development of other image applied technology

developed technology	Processing object	Purpose of image processing	Image processing method/algorithm	Employed Image processing command
Pattern recognition technology for cutting	Printed patterns : Yarn-dyed check striped patterns	Decision of the cutting start point by pattern recognition.	Measurement of pattern position by histogram method	Histogram, smoothing, local filter, differentiation
Automatic shape inspection technology	Sewing parts(body, pocket, and others)	Inspection of dimensions and shapes.	·Shape inspection by transmitted light and reflected light ·Use of a fixed camera and a moving camera	Smoothing, inter-image operation, histogram, local filter, template matching
Pocket positioning technology	Body and pocket	Positioning of pocket on the body.	·Patterned cloth: Positioning of pattern standard ·Plain cloth: Positioning of given symbol standard	Histogram, template matching

Table 4. Experimental results

Developed technology	Realized performance
ID code recognition technology	·Object cloth : Plain and figured cloth ·Processing time : 5sec/5-digits ·Recognition ratio : More than 95%
Two-dimensional visual defect inspection technology	·Inspection object : Plain cloth and print patterned cloth (single color and simple pattern: polka dot, stripe, check) ·Inspection speed : 20m/min(plain), 4m/min(printed pattern) ·Defect types Plain cloth : Stains, Flaws, holes(Third grade in gray scale, defect size 2mm□) Patterned cloth : Ink stains, fade(Second grade in gray scale, defect size 2mm□)
Pattern pitch measuring and inspection technology	·Object cloth : Checked patterned cloth ·Inspection Speed : 20m/min ·Accuracy : Better than ±2.5mm
Pattern match recognition technology for cutting	·Processing speed : 1sec/pattern matching point ·Accuracy : ±1mm(excluding an error of the cutter)
Automatic pocket positioning technology	·Pocket positioning time : 3sec (only image processing time) ·Pattern match accuracy : Better than ±1.5mm ·Inspection items : Pocket mounting position , curved length of stitching-up part of armhole, etc.
Automatic shape inspector	·Inspection time : Within 45 sec for inspecting the body (Including the camera moving time and cloth conveyance time) ·Accuracy : ±1mm

4.3 OTHER IMAGE APPLIED TECHNOLOGY

Table 3 shows an outline of the pattern recognition technology for cutting, automatic shape inspection technology and pocket positioning technology.

5. EXPERIMENTAL RESULT

Table 4 shows an outline of the results of this research and development.

6. CONCLUSION

The authors introduced the development and conditions of image applied units in the automatic sewing system. The image processing for cloth requires high-grade technology, and many problems remain unsolved because of weave texture, patterns, deformation, and other characteristics of cloth which cause troubles in image processing. The pattern recognition system for cutting is now ready for putting to practical use.

Inspections of defects on plain cloth surfaces and pattern pitch width are practically applicable. Recognition for yarn dyed patterns, complicated patterns, and assortment of defects has not been developed yet. These problems will not be solved easily without making great strides of the functions and performance of the image processing system (image memory capacity and processing speed, in particular).

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