NOTE Development of automatic inspection technology for label printing

Introduction

1.1 Status of Automatic Appearance Inspection at FUJITSU TEN

At manufacturing sites of FUJITSU TEN, to improve the external appearance of our products intended for the customers and to ensure the visual quality of our products, various inspections are performed. Conventionally, a visual inspection had been performed by inspectors. However, recently, to ensure the stability of the inspection quality and to reduce the man-hours consumed by the visual inspection, an automatic inspection using a camera and image processing has been introduced.

So far, FUJITSU TEN has developed the automatic judging technologies using image processing for missing / incorrect part inspection methods, for confirming contents of printed matters/display objects, and for automatically determining whether a processing state or an assembly state is acceptable or not, and these technologies are already widely used at respective production sites (**Fig. 1**). However, under the circumstances, sensory inspections relating to human sensitivity such as printing failures, scars and color shifts are not automated yet, and these are visually inspected by inspectors.



Fig.1 Automatic appearance inspection at FUJITSU TEN

1.2 Label Printing Quality Inspection and Problems

It is required for labels (name plates) attached to our products (**Fig. 2**) to satisfy customer demands, legal authentication, non-defective conditions of logos and trademark. If the printing quality is poor, not only the information described on the label is misread or illegible, but also the reliability of our products is impaired. Therefore, the label printing quality is an important inspection item.

However, since the automatic inspection erroneously determines variations within a non-defective range which occur in printed matters as failures, the automatic inspec-

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tion cannot effectively be operated. Therefore, in the present circumstances, these inspections cannot be automated, and visual inspections by inspectors are performed.



Fig.2 Sample of label attached to FUJITSU TEN product

Since the visual inspection of the printing quality largely depends on skill of inspectors in respect of the quality, there are the following problems.

- (1) Depending on types and degrees of printing failures, defective printing may be overlooked (Fig. 3 (1)).
- (2) Since foreign characters are difficult to be read by inspectors, it is required to compare them with normal printing and it takes a lot of inspection manhours (Fig. 3 (2)). This problem tends to expand due to globalization of businesses.



unless it is compared with the normal printing.

Fig.3 Example of object that inspectors have difficulty in inspecting

determined as non-failure.

In order to solve these problems, FUJITSU TEN has carried out the development of the automatic printing inspection technologies.

2 Automatic Inspection

2.1 Common Automatic Inspection Method

This section explains the common method of automatic printing inspection using a camera and image processing.

First, an actual image of a non-defective printing, an averaged image of a plurality of non-defective printings, or an image created based on the printing data is prepared as a proper image.

Next, an inspection object image and a proper image are compared to each other, and an image representing differences between them called a differential image is calculated. **Fig.4** shows examples of the inspection object image, proper image and differential image. The differential image of this example shows the part where the inspection object image is whiter than the proper image caused by printing missing, etc. as white, and contrarily, shows the part where the inspection object image is blacker than the proper image caused by strains, etc. as black. Then, the area and the shape of the differences are measured, and if there is any portion not conforming to inspection standards, it is determined that the part is not acceptable.



Fig.4 Example of judgment based on differential image

This is the common automatic printing inspection method using a camera and image processing.

In practice, since variations occur in printed matters due to feeding shift of the roller of the printing machine, differences occur between the printed matter and the proper image. Even if the variation is within a non-defective range and it can be determined as acceptable by visual inspection by inspectors, the automatic inspection determines it as unacceptable (over-detection) (**Fig. 5**).



Fig.5 Misjudgment due to variation in printing

Therefore, it is necessary to take measures to reduce over-detection by excluding the variation range from the inspection region or relaxing inspection standards.

2.2 Problems of Automatic Inspection

The required quality for our products is high, and the defect to be detected is smaller than the variation in printing. That is, if inspection standards are relaxed to prevent over-detection due to the variation in printing, small defects cannot be detected and are flown out (**Fig. 6**).



Fig.6 Variation in printing and defect to be detected

Therefore, we carried out the development of the image processing technology capable of preventing overdetection due to the variation in printing without relaxing inspection standards.

3 Development of Inspection Method

In order to perform inspections without being influenced by variation in printing, we considered that it is sufficient to modify the proper image by expanding or reducing it depending on the variation in printing, so as not to form differences due to the variation. Thus, the inspection method based on the following procedures was developed.

- (1) Finely measure the position shift between the proper image and the inspection object image
- (2) Modify the proper image based on the position shift thus measured
- (3) Compare the inspection object image with the modified proper image, and determine whether it is acceptable or unacceptable by referencing to inspection standards with regard to the differences
- (1) Measurement of position shift between the proper image and the inspection object image is performed on characteristic parts (**Fig. 7**) of the proper image. The positions of the characteristic parts of the proper image on the inspection object image are obtained through image processing. There are a large number of characteristic parts, and it takes a lot of time to calculate such parts. Therefore, by using a unique calculation method, the calculation speed is improved approximately 20 times compared to pattern search functions of commercial image processing libraries.



Fig.7 Example of characteristic parts

(2) Based on the measured position shift, the proper image is deformed (Fig. 8). At this time, positions of respective pixels of the image are discrete integral values, whereas the deformation amount is data including a decimal fraction. Therefore, an appropriate interpolation such as nearest neighbor interpolation, bilinear interpolation or bicubic interpolation is applied.



Fig.8 Modification of proper image

(3) The inspection object image is compared with the modified proper image. This is the same as the common method described in Chapter 2. The differential image when this method is applied to the inspection object image shown in Fig. 6 is shown in Fig. 9. It can be understood that there is no difference due to variation in printing and there is no necessity to relax inspection standards. Due to this, only defects can be extracted, and the over-detection due to variation in printing can be reduced.



Fig.9 Comparison with modified proper image



4.1 Trial Results with respect to Small Defects and Foreign Characters

Fig. 10 shows an example in which a label having small defects is prepared in order to confirm the capability of the developed method and the method is performed

FUJITSU TEN TECH. J. NO.40(2014)

on a trial basis. In the common method, the variation in printing is larger than the small defect and it cannot be determined whether there is any printing defect. However, in the developed method, small defects can be detected without being influenced by variation in printing.



In addition, **Fig. 11** shows an example in which a label having a defect regarding foreign characters which cannot be well-detected by inspectors is prepared and the method is performed on a trial basis. It can be understood that even failures which may be overlooked by visual inspection by humans can be reliably detected.



Fig.11 Result of trial to foreign character

4.2 Creation and Operation of Inspection Equipment

Equipment into which the developed image processing software is introduced has been created and introduced into the production line. A schematic diagram is shown in **Fig. 12**. This equipment is the small equipment only added to the existing printer in the production line. Therefore, when it is introduced, the layout change of the

FUJITSU TEN TECHNICAL JOURNAL

production line is not required. A table for flattening a label surface is mounted to a label exit of the printer, and a camera is mounted perpendicular to the table. Moreover, in order to prevent disturbance light, a light shielding cover is provided and lighting is mounted inside of the cover. Right after the printing, the automatic inspection is performed, and if the inspection result is good, a shutter opens and the label can be taken out. It takes about five seconds to inspect, but since the inspection is completed during the operator is performing another work, the operator does not have to wait for the inspection result.



Fig.12 Created inspection equipment

Fig. 13 shows an example of defect detected using this equipment. In the location where the defect is, defects may cause the wrong recognition as another letter (since a mustache portion of "Q" is cut, the letter looks like "O"), so inspectors evaluate the defects more strictly. Following this, in the automatic inspection, inspection standards for the mustache portion of "Q" are set strictly. According to this, the judgment equivalent to the one by inspectors is realized.



Fig.13 Defect detected by created equipment

From these results, it can be understood that the created equipment can detect defects more reliably than inspectors. In addition, by introducing the automatic inspection, visual inspection man-hours are also reduced.

5

Conclusion

Through this project, we could develop the method capable of preventing over-detection due to variation in printing without relaxing inspection standards.

However, the inspection time which takes five seconds per one label (about 300 letters) may become a problem depending on the production volume. We think that it will be necessary to increase the inspection speed in the future.

In order to effectively utilize the point in which the automatic inspection is particularly superior compared to the visual inspection by humans, that is, the fact that illegible letters such as foreign characters can be detected without decreasing the speed, we will equip this inspection system for domestic production of the export-bound products, and overseas production.

In addition, if the technology developed this time is applied, it is expected that the detection of wrinkles and breakage after attaching labels becomes possible. We will promote automation of inspections currently performed by visual inspection by humans, and would like to contribute to the establishment of the manufacturing process not depending on the visual ability of humans.

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FUJITSU TEN TECH. J. NO.40(2014)