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Development of an Automatic Marking System for Fabric Inspection Machine

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ABSTRACT

In this study, an automatic marking system for fabric inspection machines was developed. The main objectives of the study were to promote intelligence and automation for the inspection process, as well as to increase textile industrial productivity. Generally, when a worker manually inspects and marks a fabric, human error and reduced efficiency are unavoidable. To overcome these problems, we developed an automatic marking system that uses robots. This system incorporates a vision camera to automatically recognize defects, and an optical fiber sensor to detect the side of the fabric. To verify the performance, the control system sends a command directly to the robot to mark the fabric. Finally, the actual production confirmed that the proposed system could perform the desired motion.

Keywords : Inspection Machine(검사 기계), Automatic Marking(자동 마킹), Robot System(로봇 시스템), Motor Control(모터 제어), Vision System(비전 시스템)

1. Introduction

Generally, the production process of the dyed fabric proceeds in the order of fabric receipt, dyeing, drying, inspection, and dispatch. In the entire processes, inspection is the most important process that determines the quality of the fabric. In the current inspection of textile factories, experienced workers inspect defects with the naked eye and manually mark the locations using a pen. However, there are many deficiencies in inspection because the discrimination criteria differs depending on the workers, and the types of defects (holes, stains, color difference, etc.) are diverse.

Recently, employment in the textile industry has decreased, and the workforce is aging; consequently, repeated physical exhaustion can lead to human error.

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Therefore, it is necessary to develop an automatic inspection and marking system that can be applied in the textile industry.

2. Development of Auto Marking System

2.1 System configuration

This study aimed to develop an automatic marking system for textile fabric defects. Automatic marking systems cannot operate independently. Figure 1 shows the configuration of the evaluation system for automatic marking.

The evaluation system for automatic marking consists of a machine vision system for detecting fabric, a marking system using a scara robot, a conveyor belt system for fabric transfer, an orthogonal robot-type motor control system for automatic marking, and an upper control system for the overall system control.

The overall control was achieved using the upper control system, which is designed to interface with external PLC systems and various manufacturing-site devices.

To develop an automatic marking system in the evaluation system, the flow of the inspection process is defined. Based on this, a new system was developed. A flowchart of the fabrication inspection device is shown in Fig. 2.

Fig. 1 Evaluation system structure for auto marking

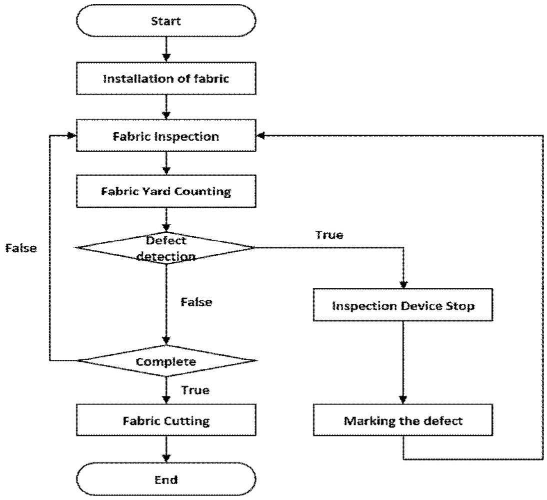

Fig. 2 Fabric inspection device flowchart

Step 1. Place the fabric for inspection on the device.
Step 2. Driving the device & fabric yard counting.
Step 3. If a defect is found, the device is stopped.
Step 4. Mark the defect location.
Step 5. Restart the fabric inspection device.
Step 6. Repeat Step2 to Step5.
Step 7. If there is no defect, cut the fabric.

2.2 Development of upper control system

In the evaluation system for automatic marking, upper control system is required for overall control. Therefore, an embedded-based PLC system was developed. A diagram of the embedded-based PLC system is shown in Fig. 3[1].

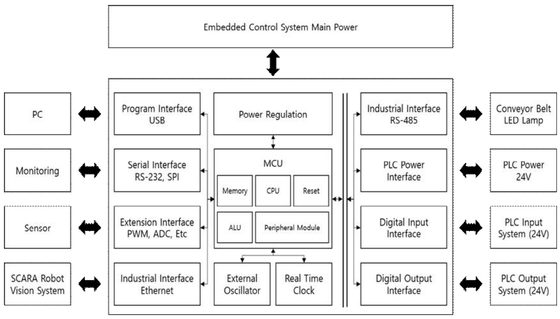

Fig. 3 Embedded-based PLC system diagram

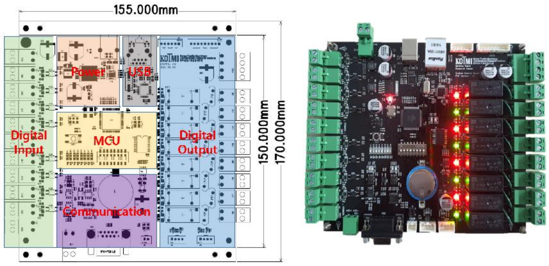

Fig. 4 PCB layout & upper control board sample

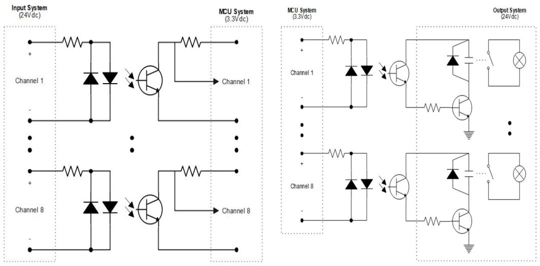

Fig. 5 Circuit of digital Input/Output

This system can be controlled by connecting various devices such as the Scara robot system, conveyor belt system, machine vision system, and motor control system[2].

The main MCU of the control board for the upper control system was ATmel's AVR. Additionally, it was designed to interface memory using the Arduino Mega 2560 Bootloader. The developed upper control board sample is shown in Fig. 4.

In industrial and manufacturing sites, MCUs often malfunction because of external surge noise. To prevent an MCU malfunction, it is designed to be isolated as shown in Fig. 5. Additionally, a surge protector and noise filter circuit were designed to protect the circuit from electric shocks.

2.3 Development of inspection system

Machine vision systems are required for automatic marking of defects in textile fabrics[3-4].

In this study, a vision system was constructed using Cognex's Insight 8505P. The detailed specifications of IS8505P are listed in Table 1.

Table 1 Specification of In-Sight 8505P

Parameter	Spec
Sensor Type	CMOS, Global Shutter
Resolution	5M Pixel Mono (2448x2048)
Communication	Giga Ethernet
Speed	32FPS
Program Memory	14.8GB

A fabric defect inspection system must generate trigger signals or coordinate data in the vision system for automatic marking. Therefore, the S/W was designed to detect defective fabrics using In-Sight 8505P and transmit the center coordinates of the defective fabrics to the client.

In a fabric defect inspection system, both the vision camera and lighting system are important. This is because the detection results vary depending on the lighting. To maintain the same brightness as the LED, it was configured using a buck-converter-type drive system and a high-luminance LED bar.

Additionally, RS-485 communication circuits and control systems were designed to enable LED lighting on/off control and brightness control in the upper control systems.

2.4 Marking system using scara robot

The machine vision system and Scara robot system were linked to automatically mark the fabric defects[5-6].

The detailed specifications of the Scara Robot are listed in Table 2.

Table 2 Specification of Epson T6-602S

Parameter	Spec
Payload	2kg(Typical), 6kg(Max)
Operation region	600mm
Weight	22kg
Standard Cycle Time	2kg : 0.49sec
Communication	Ethernet

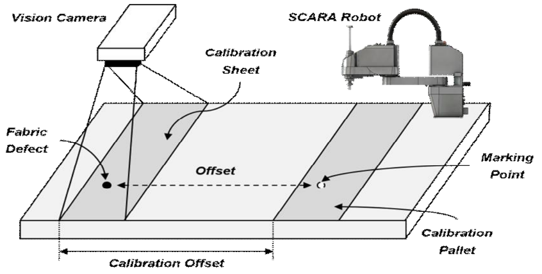

Fig. 6 Vision system and robot system calibration

For the automatic marking test, Epson's Scara robot T6-602S and Cognex's Insight 8505P were configured as shown in Fig. 6.

In this system, the initial vision sensor and robot coordinate data are different for the marking. Therefore, the coordinates are calibrated for each system. Subsequently, an automatic marking system was constructed by adding a calibration offset.

The offset value is the distance at which the conveyor belt is stopped after fabric detection.

When a defect is recognized through the vision camera, the belt stops after a few seconds. This can be automatically marked by an offset value.

2.5 Marking system using orthogonal robot

Automatic marking systems and devices were designed for the automatic marking of defects in textile fabric using ball screw-type orthogonal robots, step motors, and limiter sensors. A step motor was used to drive the orthogonal robot, and a limiter sensor was used to check the coordinates of the motor. The designed automatic marking device is illustrated in Fig. 7.

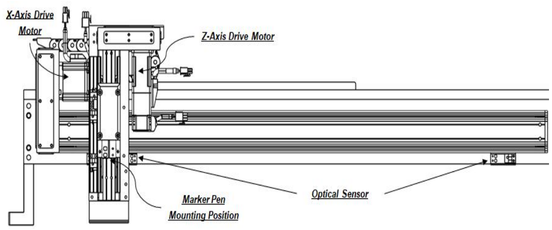

Fig. 7 Design of marking system using orthogonal robot

The automatic marking system was marked only when there was a defect in the textile fabric.

When the marking system is not operating, the marking pen should be moved to the initial position to prevent drying. Therefore, a marker pen holder and bracket are designed to fix the marker pen. Additionally, the end-effector of the spring structure was designed as shown in Fig. 8.

The automatic marking system of this system operates through step motor control. Step motors are widely used in automation systems because they are easy to control and are inexpensive. A step motor is available in systems that require precision because it rotates by a specific angle according to the pulse signal. The basic internal configuration of a step motor consists of a stator and a rotor. When a pulse voltage is supplied to the stator coil, current flows through the coil to generate a magnetic force, and the motor rotates. The rotational concept of the motor is illustrated in Fig. 9[7].

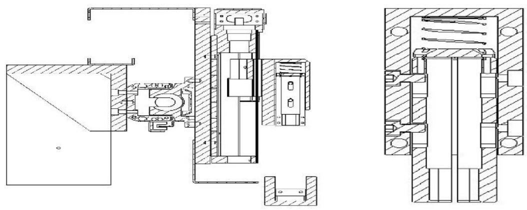

Fig. 8 Design of end-effector

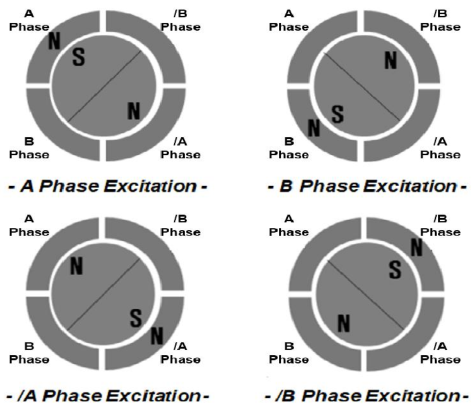

Fig. 9 Rotation principle of the step motor

When the A-phase coil is excited, the S-pole of the rotor is pulled because it is magnetized to the N-pole. When the B-phase coil is excited, S is pulled because the B-phase coil is magnetized to the N pole.

If repeated pulses are applied in the order A, B, /A, /B, the step motor is driven counterclockwise.

Fig. 10 shows the pulse control cycle of the microcontroller used to rotate the step motor. When one cycle is applied continuously, the step motor rotates continuously. Additionally, when the pulse was applied in reverse, the rotation direction was reversed.

The pulse period was related to the rotational speed of the motor. The area of the pulse is equal to the torque of the step motor. When a pulse is applied at a high speed, the step motor is driven at high speed.

Moreover, if the pulse voltage applied to the step motor is maintained for a long time, a large torque load can be generated[8].

In this study, the embedded board shown in Fig. 4 was used to control the position of the motor. A pulse signal was generated using the GPIO output of the designed PCB board and was applied to the A, B, /A, and /B phases of the step motor.

Finally, this marking system consists of an X-axis and Z-axis, and an automatic marking system is implemented using the step motor control.

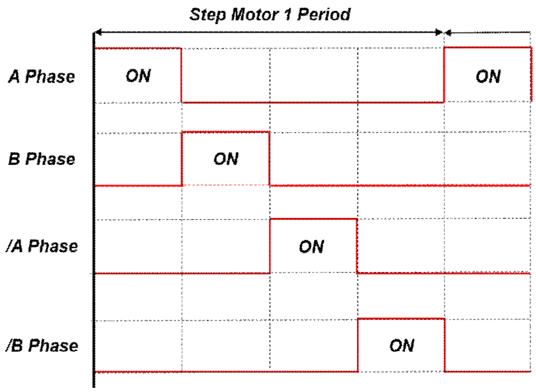

Fig. 10 Rotation principle of the step motor

2.5 Inspection fabric side detection

In the industrial field, when a defect in textile fabric is detected, an inspection device operator marks the side of the fabric using a marker pen.

Approximately 1 cm of fabric was not used to produce textile fabric products. Fig. 11 shows the fabric-marking method.

There are two methods of marking fabric: Horizontal and vertical marking.

In this study, a yarn-side detection method was proposed to mark the defect area of the fabric[9]. The side of the fabric can be detected based on the reflected signal using a reflective optical fiber sensor. The detection concept of the reflective optical fiber unit for side detection is illustrated in Fig. 12.

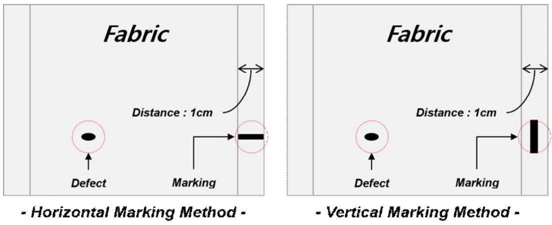

Fig. 11 Methods of marking fabric

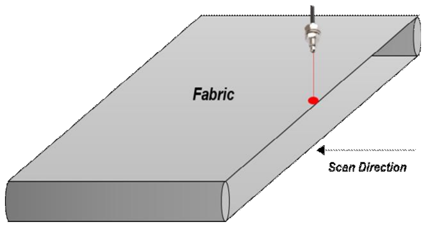

Fig. 12 Detection principle of textile fabric

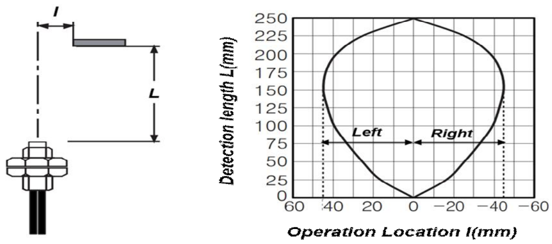

Fig. 13 Specification of FD-620-10

The fiber sensor unit (Autonics's FD-620-10) used for detection has a different detection distance (l) depending on the distance (L) between the sensor and object.

In this study, the distance (L) between the sensor and ground was designed to be approximately 30 mm. Therefore, as shown in Fig. 13, the fabric was detected within approximately 20 mm to the left and right of the fiber sensor. Using this sensor, the system was implemented to enable automatic marking within 1 cm of the side.

3. Experiment Results and Discussion

3.1 Defect detection & robot marking test

Fig. 14 shows the fabric defect detection and marking test environment using the robot. The vision system used was Cognex's In-Sight 8505P, and the Scara robot system used was Epson's T6-602S. These two systems exchange data through Ethernet communication. To test the automatic marking system, a system was implemented to detect the fabric defects and transmit coordinates using a vision system. Subsequently, a pattern detection algorithm for defects was designed, and a defect detection test was conducted. The defect detection test was conducted while continuously driving the conveyor belt. The motion defects were detected in real time. The detection results are shown in Fig. 15. Through this test, it was confirmed that the center coordinates of the defects were detected.

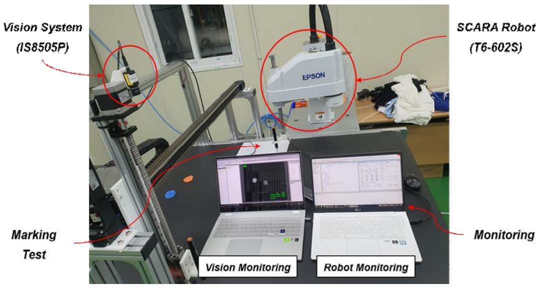

Fig. 14 In-Sight 8505P & T6-602S control test

Fig. 15 Fabric defect and position detection

In this system, In-Sight 8505P is a server and TS-602S is a client. Fig.15 shows the coordinate transmission from the server to the client.

Finally, it was confirmed that the scara robot marking was possible based on the coordinates of the vision system.

3.2 Developed auto marking system test

Fig. 16 shows the developed automatic marking system. This system consists of an x-axis y-axis ball-screw-type orthogonal robot, a limiter sensor, and a fiber sensor.

When a defect is detected in the fabric detection system, the marking system operates several seconds later. When the PLC signal was received, the marking device automatically detected the position of the side.

The position of the side was detected by the optical fiber sensor, while the orthogonal robot scanned to the right. The automatic marking system marked the side of the fabric when the fiber sensor detected the fabric. After marking, the marker pen was returned to its initial position after drying out.

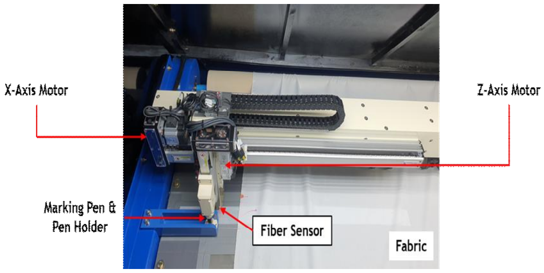

Fig. 16 Developed auto marking system structure

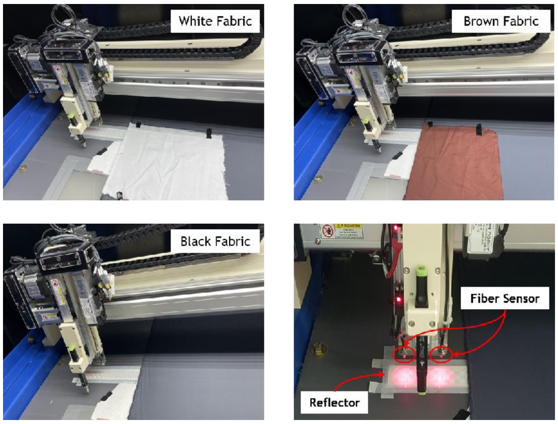

Fig. 17 Automatic marking test

The color of the textile fabric was tested for white, brown, and black fabrics. The test confirmed that the marking system was marked on the side of the fabric using the PLC control signal.

Textile fabric automatic marking systems should minimize the marking cycle time. This is because it is correlated with the workload at textile manufacturing and inspection sites.

However, to reduce the cycle time, the x-axis jog speed cannot be increased infinitely. This is because the response speed of the optical fiber sensor was limited.

Therefore, it is important to determine the x-axis jog speed by considering the sensor recognition time of the optical fiber unit.

Finally, it was confirmed that this system takes 3 s for side of fabric detection, automatic marking, and return to the initial position.

4. Conclusion

In this study, an automatic marking system based on a Scara robot and an orthogonal robot with a motor control system were presented. The performance of the proposed system was confirmed by experimental results. The conclusions of this study are summarized as follows.

1. The Scara robot can be used as an automatic marking system based on the coordinates of the vision system.
2. The marking system using orthogonal robot is confirmed by the PLC control system that sends the signal marking and returning.
3. An optical fiber sensor was used to detect the side of the fabric. Considering the response time of the sensor, the jog speed on the x-axis should be determined.
4. Through the automatic marking experiments, the performance was verified; moreover, the automatic marking system was confirmed through demonstration for the actual inspection machine.

Acknowledgment

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