Printing Technology to Improve Efficiency and Support Module Expansion

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There are unique and advanced requirements in fields where printed matter becomes part of the product, such as labeling in print shops and on manufacturing lines. This article introduces printing technologies that improve the efficiency of such printing fields and support the module expansion of various printing systems.

Introduction

Similar to other industries, the problems of labor shortages and rising labor costs have become serious in the printing industry. Therefore, there are high expectations for improved quality and productivity through workflow automation and data utilization.

Taking advantage of its strength in providing tough, space-saving, and simple (ease of maintenance) printers, OKI is expanding its expertise from office printing to label printing on manufacturing lines, and it is working to solve problems in a wide range of printing fields.

Past Efforts at Automation and Efficiency

OKI's solutions that support the printing fields are introduced.

(1) Automated Printing Instruction

Printing errors and the burden of manual confirmation have been issues on the manufacturing line. The automated printing instruction solution reads the two-dimensional code printed on work instructions or ID tag and automatically sends instructions to a printer for correct printing of product labels, thereby reducing the burden on workers and improving work efficiency (**Figure 1**).

Figure 1. Automated Printing Instruction

(2) Visualization of Equipment Abnormalities and Warnings

When printing stops due to a printer abnormality or warning, workers separated from the printer may not immediately notice the stoppage. The visualization solution for equipment abnormalities and warnings links a patrol lamp with the printer to provide a visual notification when a printer abnormality occurs, enabling workers to take quicker action and reduce downtime (**Figure 2**).

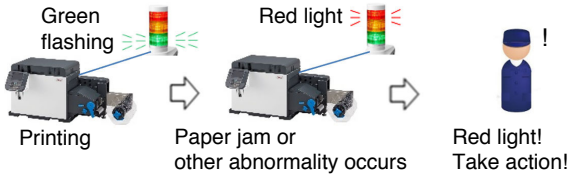

Figure 2. Visualization of Equipment Abnormalities and Warnings

(3) Efficient Label Printing

OKI has also focused on improving the efficiency of product label printing for beverage bottles and other products.

Printing a wide variety of labels in small quantities using conventional offset printing machines requires the creation of plates and advanced adjustments, which is costly, but OKI provides small label printers to meet the demand for digital printing machines from small to medium-sized printing factories and print shops.

Furthermore, there is high demand for digital printing using transfer paper to print images on T-shirts and cloth. Using an expandable built-in modular structure that can configure a variety of printing systems, OKI is working with printing equipment manufacturers to provide digital printing solutions that replace offset printing. The printing control of these systems is being required to contribute even more to the improvement of business efficiency.

The following section describes the technological details of the "AI automatic correction of printing position for small label printers" (**Figure 3**) and "built-in modularization of A3 color printers" (**Figure 4**) to improve business efficiency.

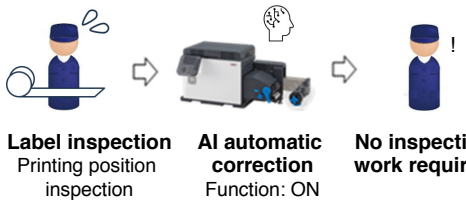

Figure 3. AI Automatic Correction of Printing Position for Small Label Printers

Figure 4. Built-In Modularization of A3 Color Printers

AI Automatic Printing Position Correction for Small Label Printers

OKI offers the PLAVI*1) Pro10 series (hereinafter referred to as the Pro10 series), a color LED label printer that supports high-mix low-volume label printing. The Pro10 series is a toner-based printer capable of printing on a wide variety of label materials including water-resistant media. However, there was an issue that the print position can become slowly misaligned during continuous printing (**Figure 5**).

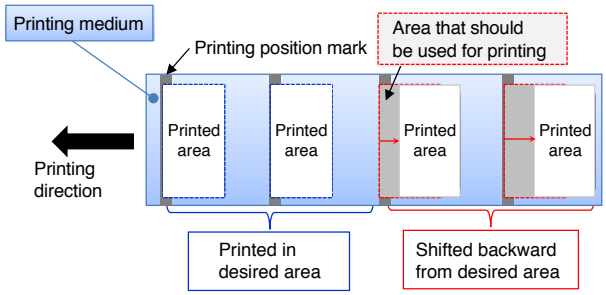

Figure 5. Misalignment of Printing Position

Stable printing position is especially vital for medical labels since the printed content must be accurately understood. OKI has incorporated AI into its printers to automate the correction of the printing position required for each individual device and each type of label media.

AI Automatic Printing Position Correction

The three technologies that OKI has adopted to achieve the automatic printing position correction are introduced below.

*1) PLAVI is a registered trademark of Oki Electric Industry Co., Ltd.

(1) AI Model

The AI model determines the correction value to be applied to the printing position. The future printing position is predicted from the label spacing observed by the sensor during the past printing, making it possible to derive the correction value for the next page. This is performed in real-time for each page. This method is generally known as time series prediction, and uses the Long-Short Term Memory (LSTM)[1)] model.

(2) Data Pre-Processing

In data pre-processing, the values to be input into the AI model are processed in advance to improve the predictive performance of the AI model. Differences in the input values occur due to factors such as differences in the label medium used, individual differences in the printer, the environment, and settings. Values related to the correction value were derived using various observed data and their cumulative values.

(3) Data Post-Processing

Data post-processing is the process of converting the output of the AI model into a correction value. Due to the mechanical structure of the printer, the error in the printing position can only be observed when about 1m of printing has been completed after the start of the printing. Since there is a time lag between feeding back the error and actually performing the correction, the correction value is calculated taking into account the error accumulated during the time lag. The automatic printing position correction was achieved by incorporating the above three technologies (**Figure 6**).

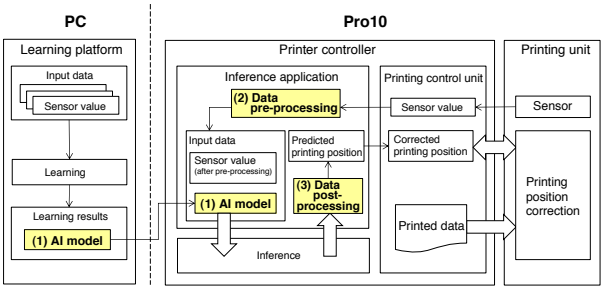

Figure 6. Block Diagram of AI Automatic Printing Position Correction

Dynamic Replacement of AI Model for Pro10 Series

The Pro10 series includes measures to ensure that the installation of an AI model for automatic printing position correction does not affect printing performance, as well as a mechanism to allow dynamic replacement of the AI model.

- **AI Operating Environment and Printing Performance**

Generally, AI has two processes: the learning process, in which the model learns data to achieve predictive ability, and inference process, in which the learned model is made to make predictions. Since learning requires high processing power, the process is performed on a PC in advance. The resulting learned model is transferred to the Pro10 series printer, so that only the inference process, which requires less calculation, is performed on the printer. This ensures that printing performance is not affected.

Furthermore, calculation processing for AI, such as matrix operation, has been implemented to speed up the inference process.

- **Dynamic Replacement of AI Model**

When using labels made of new materials, or when there are environmental changes, such as in temperature or humidity, the currently installed AI model may not be able to cope with the situation. In such a situation, the AI model can be replaced without updating the firmware (**Figure 7**).

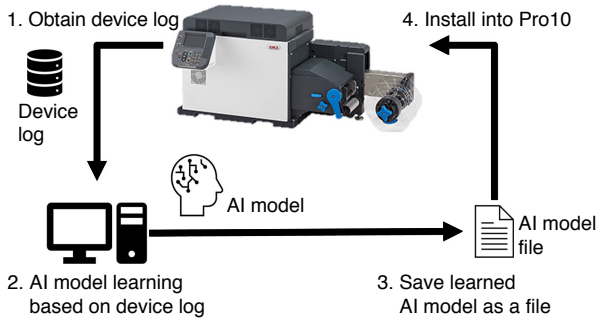

Figure 7. Dynamic Replacement of AI Model

The AI model is replaced using the following steps.

1) Print in the new environment and obtain a device log.
2) On the PC, have the AI model learn from the log data.
3) Save the learned AI model as a file.
4) Install the saved AI model into the Pro10.

This makes it possible to support various label materials and printing environments.

Future Studies for Printing Position Correction AI

As a result of applying printing position correction AI to the Pro10 series, the stability of the printing position has improved compared to before the application (**Figure 8**).

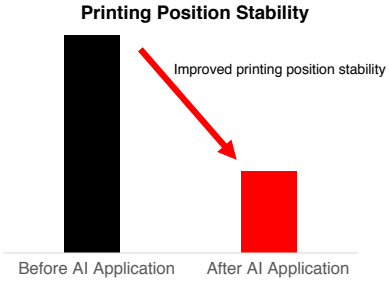

Figure 8. Result of Applying Printing Position Correction AI

For future developments, it will be necessary to efficiently collect and store the data used for AI learning. Studies will be conducted on methods to efficiently collect logs, incorporating them into AI models, and integrating them with cloud technologies suitable for use.

Built-In Modularization of A3 Color Printers

An example of high-mix low-volume printing is transfer printing onto T-shirts. However, in recent years, the demand from the textile market has also been growing rapidly for transfer printing onto curtains and other fabrics due to a wide variety of designs. To accommodate these diverse printing needs, not only the printer itself but also the system must be diversely configurable, such as connecting with a roll-type media suppling device.

OKI is collaborating with printing equipment manufacturers to provide A3 color printers (MICROLINE VINCI*2)) as built-in modules for printing systems to allow configuration of various systems, and is promoting global expansion of the printers as an entry-level model for digital printing equipment targeted at small and medium-sized printing factories and print shops.

- **MICROLINE VINCI Features**

A major feature of the MICROLINE VINCI is its compatibility with a wide range of printing media. The straight path inside the printer transports the printing media in a straight line, and therefore paper jams are less likely to occur (**Figure 9**).

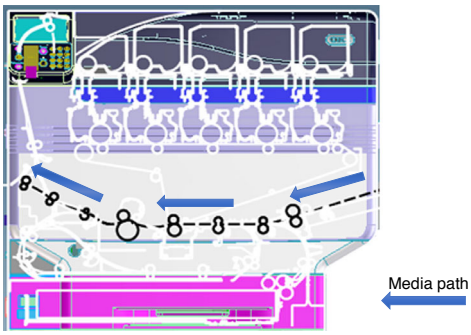

Figure 9. Printer Cross-Section

*2) MICROLINE and VINCI are registered trademarks of Oki Electric Industry Co., Ltd.

In addition, the use of a toner instead of ink enables the printer to consistently provide high quality printing on a wider range of media. The printer's simple device configuration also makes it easy to maintain.

- **System Configurability for Versatile Use**

Combining the MICROLINE VINCI as a built-in module with units from printing equipment manufacturers makes it possible to configure the following printing systems.

1) Roll-to-roll
2) Roll-to-cut
3) Marker recognition

Roll-to-roll is a system that turns prints from a rolled media into rolled products by connecting an unwinder (a device for supplying rolled media to the printer) to the feed side and a rewinder (a device for winding the printed media) to the discharge side (**Figure 10**).

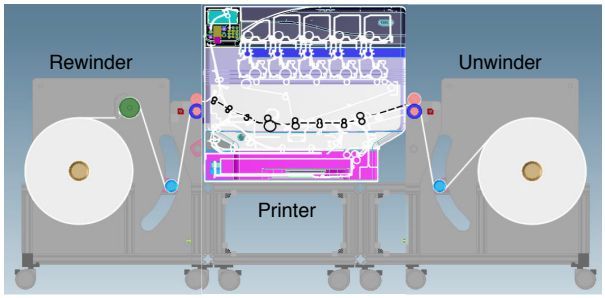

Figure 10. Configuration of Roll-to-Roll Printing System

In a roll-to-cut system, a cutter is installed on the feed side and the printer instructs when to cut the paper, making it possible to cut print media to any desired length.

With marker recognition, a marker sensor is added on the feed side and the timing of the media's printing position is sent to the printer, making it easier to print accurately at the marked position.

- **Other Technical Issues**

In addition to modularizing the printer, there were other issues that needed to be addressed in order to print on continuous media.

1) Transporting continuous media at a stable speed
2) Minimizing the waste media created before and after printing
3) Minimizing the page gaps

To solve these three issues, data collections and simulations were repeatedly performed to optimize the control algorithm and parameters. In particular, the page gaps were minimized by developing a new page management method, which enabled 0mm gap printing, allowing data to be printed seamlessly and accurately at the mark position.

Future Work and Prospects

The technologies above enable stable paper transport and high quality printing even with continuous roll paper of several hundred meters, and the system can be configured flexibly according to the application. For future deployment, improvements are required in the paper setting method and consumables replacement method. OKI will improve these points to provide a more user-friendly system. ◆◆

References

1) Sepp Hochreiter, Jürgen Schmidhuber, "Long Short-Term Memory", Neural Computation, Volume 9, Issue 8, 1735-1780, November 1997

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TIPS【Glossary】

Waste media
Unprinted part of the media that passed through the printer during the adjustment of print settings and discarded.

Page gap
Gap that occurs between pages, for example when continuously printing A3-sized print data. If the gap is 0, all pages are printed as one continuous image.