Automatic Troubleshooting of Print Quality Defects in Inkjet Printers

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Abstract

When Print Quality is not reaching expected levels, current troubleshooting processes proposed to users follow two approaches. Either display a static list of recovery actions depending on the PQ problem (Line Quality, Banding, etc.) or request user to launch a diagnostic print, analyze it and then determine the corrective action which is required. In both cases, some user expertise is required.

This paper describes a new concept being implemented in the Large Forma Photo Printer HP Designjet Z6200 to automatically determine the status of a printing system in those areas affecting Print Quality and to actively propose to user a customized list of recommended actions to recover it.

By analyzing the results of calibrations and internal checks (such as Printhead Alignment, Nozzle health detection, Color Calibration and Media Advance data) printer build in algorithm identifies most probable cause of the problem and displays a precise list of corrective actions based on it.

The list of recovery actions is automatically displayed, so no need for interpretations/analysis by users. Actions are proposed in the optimal order. This is a dynamic list, so it's being updated every time an internal calibration or check is being performed.

As a result, even for the non expert users, recovery actions success is highly improved. In case a service call is required, process allows to remotely diagnose printing system status increasing on-site repair success rate.

Print Quality defects

When observing a print out, several kind of defects may be detected. We may classify them following the next criteria:

1. Line/Edge and Text Quality: line straightness & width consistency, edge sharpness, raggedness, line continuity, text readability, etc.

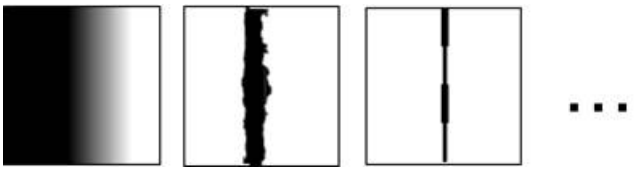

***Figure 1**. Line/Edge quality defects*

2. Area fill uniformity & transitions: banding, grain, mottle, contouring, etc.

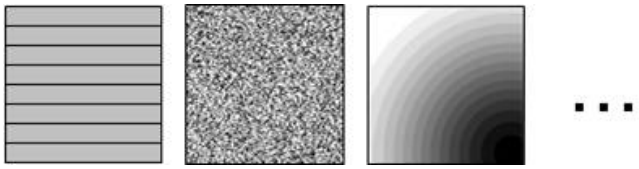

***Figure 2**. Area fill uniformity defects*

3. Color quality: color accuracy, saturation, black optical density, neutrality, shadow details, etc.

***Figure 3** Color related defects*

4. Media damage: curling, cockle.

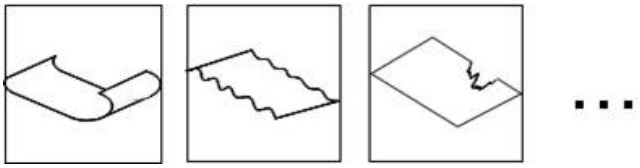

***Figure 4** Media damage defects*

5. Durability & permanence: smudge resistance, water fastness, scratches, light and air fade, etc.

In other words, if lines & text does not show defects, inked areas are uniform, transitions smooth, color is correct, media is not damaged, and printout lasts as expected, we may conclude the printout is meeting user expectations.

Some of these defects are inherent to the printing technology (Inkjet, LaserJet…) and the media on which we're printing (plain, coated, photo, vinyl…). That means a given combination of Ink, Media, Print Quality setting, etc. will consistently provide same results.

Some other defects are highly dependant on Printing System components performance (Printer, Supplies,…). That means

customer may face variation in output quality, from time to time and printer to printer.

Main contributors to PQ problems in Inkjet printers and user knobs to solve them

As Printed images are formed by combination of dots on top of the media, we can classify defects being caused mainly by:

Dots are missing
Dots are misplaced
Dots have wrong size, shape, color

Figure 5 *Missing, misplaced and defective dots.*

Main cause for missing dots is Printhead reliability (nozzles not firing). Printers use to check Printheads through Drop Detection systems and Printhead Servicing and Recovery routines to keep all nozzles firing correctly. Finally, nozzle substitution process is applied to maintain IQ level despite some nozzles are not recoverable.

Misplaced dots can be caused either by firing from the wrong place (printhead positioning), nozzle directionality, drop trajectory errors (aerodynamic effects…) or media not being positioned at the required position. In this case Printers have Calibration algorithms to measure Dot Placement Error (by means of printing/scanning) and correct for that.

Defective dots (wrong size, shape, color) can be caused by printhead performance (drop weight variability, ink mixing, etc.), ink media interactions (dot gain, penetration, coalescence) and specific printing conditions (undesirable printing frequencies, etc.). Some of these defects can be calibrated too (Color Calibration to compensate for Dot Size/Gain effects).

User knobs to solve Print Quality defects

Whenever the automatic checks and corrective actions have not been successful and a Print Quality problem is present, user can trigger some specific actions in order to recover standard Print Quality levels. These actions are very similar across Printer models and brands:

Print settings: Inkjet printers, which are capable to print on a vast variety of media , have optimized print modes and color profiles adapted to the different substrates and print speed. First check, prior to any other corrective action is to verify settings are the right ones (media being correctly selected in the printer front panel/driver, right print quality/speed selection, etc.).

On top of this, other kind of misuse related to printing workflows may affect print quality too: original file, software application, color management, processing hardware, connectivity, etc).

Then, the specific corrective actions for the printer are:

Printhead recovery: in case problem is caused by printhead malfunction, user can manually launch some check and recovery routines to recover printhead. Ultimately, printhead may be replaced.

Printhead calibrations: in case the problem is caused by dot placement, shape or color error, running manual or automatic calibration routines available may help.

Media Advance adjustment or Calibration: the other source of dot placement error. Due to the high variety of printing substrates being supported (material, thickness, coating…), printing system may need some adjustment in order to optimize media advance to the specific conditions. Some printers support automatic calibrations, other allow customer to manually adjust media advance until IQ is being optimized.

Identifying the appropriate corrective action/s

Most of Printers follow the same approach in order to guide customer through the troubleshooting process and to determine this way which is the appropriate corrective action.

Once all internal/automatic processes are not enough and it is required a user intervention to address a problem, two options are commonly given:

Knowing the defect, User Manuals or on-line help provide a list of pre-defined recommended actions, based in most probable cause of the problem. If clear bands are being observed, most probably printheads are not firing correctly, so user should run recovery routines to solve the problem. If problem persists, an adjustment or calibration of media advance may be required.

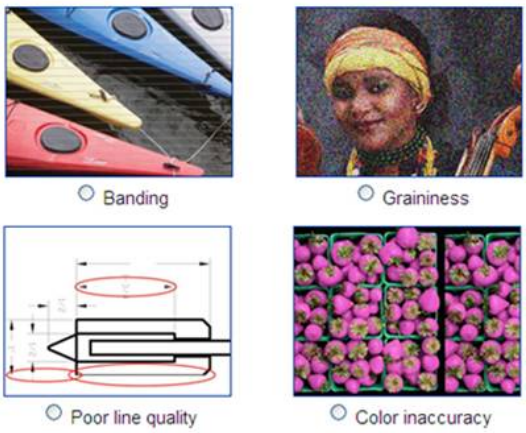

Figure 6 *4 IQ defect categories in HP Designjet T-series support center*

Another approach consist in launching an IQ diagnostic print. In this case, user must interpret the results of this printed image, as described in the User Manual, in order to determine what is failing and then execute the required corrective action for the specific

component failing. Although the concept is not very complex, the interpretation of these prints may be difficult (sometimes no defect is seen in the print, some others too many defects are seen).

Figure 7 *HP Designjet Z3100 diagnostic print*

Ultimately, user can decide to execute all corrective actions in order to optimize Print Quality.

Automatic troubleshooting process implementation

HP Designjet Z6200(Photo) and T7100(Technical) large format printers implement a new set of functionality in order to build and display a real-time list of prioritized corrective actions, as a result of internal checks results.

Customer will be able to access in the front panel and/or printer utility a list of OPTIMIZATION SUGGESTED ACTIONS to perform to optimize print quality.

The list proposes the required actions to be taken and the order in which they have to be performed.

Figure 8 *HP Designjet Z6200/T7100 print quality troubleshooting options*

Notice that an 'Optimize Print Quality" options is already provided. By clicking it, one-step image-quality and diagnostic correction is executed, that is printheads check and recovery + media advance calibration + printhead alignment + color calibration.

Based in the results of automatic calibrations/check, a quality grading is assigned for each of them, so printer can determine if results could be better and which are the actions required to bring the printing system to its optimal level.

In case Printing System status is optimal, message being displayed is: "Printing System optimized: No Action suggested"

This is a Dynamic list, so it's being updated every time one of the following actions is being performed:

1. Printhead nozzle check
2. Media Advance Calibration
3. Printhead Alignment
4. Closed Loop Color Calibration

For each one of these calibrations/checks, it is calculated a STATUS CODE which contains detailed info of calibration/check Quality Grade for each one of the printheads and colors in the printer.

Depending on the case, the quality Grade can be based on:

1. Calculated correction values
2. Scanned data noise

A given calibration may be suboptimal because system performance (printhead DPE, Media Advance error, Drop Weight) is beyond correction capabilities or because the scanned data is very noisy so probably affecting accuracy of calculated corrections (wrong media loaded, problem in the sensors, erratic printhead behavior).

By analyzing the level of optimization of each one of the calibrations, the type of "error" (correction, noise) and doing a combined analysis of all the results of them, we're able to provide accurate messages to user in case it is required to run some corrective actions.

A key remark is required at this point: current inkjet printers have become really complex systems and incorporate lots of functionality in order to provide stable print quality despite different subsystems are not totally optimized. As an example, printhead may have a significant amount of nozzles not being fired and still Print Quality being totally acceptable (as drop detection and error hiding or nozzle substitution compensate for that).

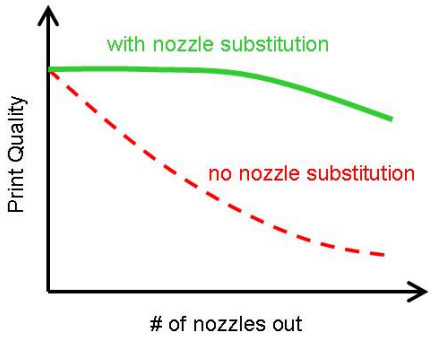

Figure 9 *IQ vs. Printhead Performance*

That means we can't directly assume that a subsystem not being at its optimal performance point is causing a Print Quality defect.

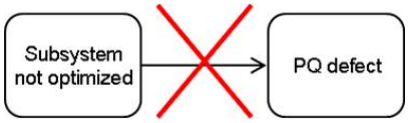

Figure 10 *PQ defects vs. Subsystem performance*

We need the interpret it in the other way around. In case we're facing a print quality problem, those subsystems not performing at their optimal level are the ones more suitable to be causing the problem.

Figure 11 *Suspect subsystem vs. PQ defects*

Benefits of automatic system

EFFECTIVENESS: The analysis of calibrations/checks let printer to identify a precise list of corrective actions. In case a printhead has nozzles out, system will actively point to this specific printhead in order to run the required recovery actions.

IDENTIFICATION OF EXTRA SOURCE OF PROBLEM: automatic system can determine extra corrective actions based in the combined analysis of data (e.g. if ONE pen FAILS at drop detection, corrective action is to RECOVER this printhead. If ALL printheads fail at drop detection, first corrective action is to clean the drop detect sensor). System is able to link data (coming from sensors) not accessible for user, so making a more accurate estimate of defects root cause.

USABILITY: detailed corrective actions required are automatically displayed through the standard channels (front panel, print utility...). No need for interpretations/analysis by user. Actions are proposed in the required order.

REAL TIME DATA: every time the is an update on the status of the printing system (a drop detection is performed, a pen alignment is launched, etc.) the list of corrective actions is being recalculated and actualized.

Specific messaging in HP Designjet Z6200

Describe below, some of the specific messages that can be displayed under the Suggested Actions list:

1. Clean the printhead drop detector and clean all printheads
2. Clean printheads [printhead id] and check Maintenance Cartridge if problem persists
3. Unload media, Clean the paper-advance sensor window and Calibrate Paper Advance
4. Adjust vacuum level and Calibrate paper advance
5. Ensure media type is properly selected and Calibrate paper advance
6. Reseat printheads [id] and Align Printheads
7. Load a Photographic or Coated media and Align Printheads
8. If you're experiencing Color related problems, ensure media type is properly selected and Calibrate Color.

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Author Biography

Jordi Sender received his ME degree in Mechanical Engineering from UPC, Barcelona (1991). He has worked in Hewlett Packard company, holding different engineering and management positions in Manufacturing and later on in R&D department for Large Format Printing Business.

Sergi Puigardeu holds an telecommunication degree from Polytechnic University of Catalonia (UPC, 2004). He has been working in the R&D lab in Large Format Printing in Hewlett Packard for the last 7 years in different positions such as Image Quality, Calibrations development, Printing Pipeline implementations and Asics design.

Joan Jorba holds a ME degree in Mechanical Engineering from UPC, Barcelona. He's been working in Hewlett Packard since 2001 in different positions in Manufacturing Engineering for small format printers and later on in Large Format R&D lab in Image Quality team, as new program development Chief Engineer and as Americas Advanced Technical Consultant.