Achieving Uniform Coatings and Flat Solid Colours on Conventional Substrates and Complex Objects

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12th November 2019 – Technical Conference
GIS – Company Overview

• Leading provider of technology solutions to industrial inkjet systems builders
• Supported printhead manufacturers
  – Fujifilm Dimatix, Konica Minolta, Kyocera, Ricoh, Toshiba Tec, Xaar
• Founded November 2006
  – Privately owned
• Based in Cambridge, UK
  – Technical support in UK, China and Japan
• Employees 70+
• Patent protected technology
• Supplier & partner to over 130 customers worldwide
The GIS EcoSystem

Complete image management from pixel to drop

Software

Datapath Electronics

Ink Delivery Systems
How Hard Can It Be?
Nothing is perfect and digital printing is no exception. However, software can compensate for machine imperfections.

PRINT QUALITY ISSUES
What are the real world issues experienced in the field?

SOFTWARE CORRECTION METHODS
What methods are available to correct these issues?
Factors Affecting Print Quality

Print Quality

- Source Image
- Resolution
- Compression
- Gamut
- Ink
- Ink Temp
- Dissolved Gas
- Meniscus Pressure
- Flow Rate
- Media Control
- Static Build-up
- Mechanical
- Printhead
- Alignment & Rotation
- Jet Straightness
- Waveform
- Height
- Jitter
- Position
- Resolution
- Stitching
- Pre & Post Treatment
- Multipass
- Resolution
- Encoder
- Process
- Software
- Screening
- Grey Level Mappings
- Colour Management
- Linearisation
- Ink Limiting
- Resolution
- Surface Energy
- Rigidity
- White point
- Substrate
Printhead Alignment and Stitching

Why is a good stitch important?

- The human eye is very good at spotting discontinuities especially in areas of flat colour

What needs to be controlled?

- Printhead alignment: Typically positioned to within <20% of the diameter of a drop
- Printhead calibration: Printheads ideally need to be tuned for jet straightness and drop size conformity
- Ink substrate interaction: Ink moves over time creating visible artefacts – ink migration control

Stitched printheads do not all jet in the same place at the same time

Some will be printing *wet on dry* while others will print *wet on / near wet*
Printhead Stitching

Scanning / Multi-pass (x1, x2, x3, x4, …)
- Safe and reliable
- Errors recoverable
- Lower productivity

Single pass
- No room for error
- Defects highly visible
  - Missing nozzles
  - Jet straightness
  - Consistent jet velocity
- High productivity
- Reliability critical
Hard Stitching – Binary Printing

- Masking (Hard Stitching)
  - Nozzle on/nozzle off
  - Wide variety of options
- Stitches can massively improve output quality & different applications benefit from different strategies

<table>
<thead>
<tr>
<th>Print Direction</th>
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<tbody>
<tr>
<td>Head 1</td>
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<td>Head 2</td>
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2-D Density
X & Y Dither

Flat/No Stitch
50% Stitch
1-D Gradient
X & Y Dither
Stitching Examples

“Flat” or “No” Stitch across flat colour

‘Moving Stitch’ across flat colour
Exploring Stitching Strategies

The choice of stitching relates to the printing method

- Multi-pass
- Single-pass
  - substrate

And the errors that you are expecting or wish to hide

- Printhead-to-printhead non-uniformity
- Colour-to-colour density variation
- Alignment errors (printhead-to-printhead, colour-to-colour)
- Jetting errors (nozzle jet deviation)
Stitching Strategies – Understanding Errors
Soft Stitching – Grey Scale Stitching

- Greyscale stitching makes full use of the greyscale capabilities of the head
  - Slowly reduces the density of the image printed by one printhead while increasing the density printed by the next printhead
- Only adds value over masking in areas where the density of the image is greater than the smallest drop size

Printhead 1

Printhead 2

Greyscale stitching makes full use of the greyscale capabilities of the head – Slowly reduces the density of the image printed by one printhead while increasing the density printed by the next printhead

Masking

Greyscale

Printhead 1

Printhead 2
Linear Printhead Density

Inkjet systems need to:

• Stitch printheads without visible joins
• Print large areas of solids/flat colours

Drop volumes not always consistent across printhead

• More apparent the more heads you have in an array
• “Non-linearity” in drop volume
• Even small difference can affect final print – particularly areas of solid colour
• We want uniformity - flat colours

Lots of reasons this can happen:-

• Printhead manufacturing issue - drop ejection may not be consistent
• Temperature variation in ink system - affects ink viscosity
• Piezo activity - heavy use of some sections of printhead creates warm areas
• Electronics - uncalibrated/low quality electronics may affect drop volume
Incorrect colour channel density linearization means the input colour value for a single colour does not match the output colour value comparatively to other colours.

Results in non-linear response and incorrect colour.

Process black (≡C+Y+M+K) shows colour shift.
Printhead Linearisation
(via image correction)
Printhead Linearisation Correction

Electronic/printhead solutions

- Depending on printhead technology
- Trim each nozzle/cluster of nozzles/nozzle bank
- Trimming can introduce drop alignment problems
  - (Tuning for volume will modify velocity)

Image correction – offers greatest capability

- RIP’ed data (contone or screened) can be manipulated to:
  - Reduce the number of drops in given area, or
  - Reduce the size or value of the greyscale drop in a given area
Printhead Linearisation
(via image correction)

- Aim is to ensure achieve even density across a full printhead array for each grey level.
- Achieved by printing grey scale test pattern for each colour channel and measuring the density across the printhead array at a range of grey levels.
- Then adjusting the grey level mapping at intervals across the printhead array.
Printhead Linearisation (via image correction)

1. Printed Test Data
2. Scanner

A. Customer Image Analysis
B. GIS Image Analysis

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Colour Channel Linearisation

What is it?
• Linearization ensures the printer maps contone values evenly throughout the scale, from 0-100%

Why do it?
• It makes multiple printers behave in a similar predictable way
• It makes colour management easier

Method of control?
• Generate a linearisation test chart
• Print it
• Measure the output data
• Import the measurement data into the RIP to apply
Colour Channel Linearisation

Scan Results

Ink Laydown / %

Scan Position / pixel
Colour Channel Linearisation
# Density & Colour Drift

Jetting performance results in density variation and colour drift due to:

- Temperature changes affecting ink viscosity and jetting characteristics
- Temperature variations across large print arrays
- Printhead temperature affects jetting performance
- Each colour may be affected differently

## Strategies

- Pre-job print calibration
  - Test pattern print at beginning of print job or production shift
  - Colour calibration and ICC profile corrections applied
- Real-time image analysis
  - May be sufficient to only measure the density of each colour and correct density of the colour channel
  - May require full colorimetric measurements and ICC profile update
Closed Loop Workflows

Closed loop nozzle, density and colour correction

Job Workflow

TIFF
- TIFF MIME Handler
- Colour Management
- Image Print
- Nozzle Out and Nozzle Density Screener
- Datapath Electronics

PDF
- PDF MIME Handler
- PDF RIP
- RIP Settings
- ICC / Device Link / Spectral
- Colour Correction Data
- Nozzle Out & Density Data
- Dither Tables
- Nozzle Out & Density Data
- Image Analysis
- Line Scanner Input

Hardware Aware Print Queue

Print Output Analysis
Direct-to-Shape

Direct-to-shape requires a combination of complex techniques

• Time of flight compensation
• Resolution correction
• Curved surface screening
• Density and drop size compensation
Tubes, Cones & Tubs

Tubes well established/well understood technology

Cones or conical/tapered shapes

Software correction required?
- Typically no, for small area coverage
- Yes, for significant or full wrapping
  - Corrects nozzle alignment
  - Provides density correction
  - Ensures no dot gain issues
  - Ensures no screening artefacts

Tubs
- Requires correction changes during the print
  - Often from pixel to pixel
  - Multi-dimensional nozzle, density and screener correction technology can be adjusted to each surface type and associated application process
Complex Objects

Creation Tools

Import Mesh & Texture

Swathe Decomposition

Swathe paths

Transport Control

Measure & Correct

Unwrap

Colour Separation

Density Correction & Screening

Print Control
Full Object Coating – GIS Print Path Designer
Summary

• Huge range of factors affect print quality
• Software compensation can significantly improve image performance for system inaccuracies and errors
• GIS offers complete eco-system
  – Complete image management from pixel to drop
    • Flat surfaces
    • Complex shapes
  – Many more tools than we’ve been able to cover in this presentation
• Please visit our booth #437 to learn more
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