Printing Technology

Lecture 13
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Imaging in the Electronic Age
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Subtractive Color
Additive & Subtractive Color Spaces
Subtractive Reflection Processes
Subtractive Ink Technology

\[ K = \min (C, M, Y) \]
\[ C' = C - K \]
\[ M' = M - K \]
\[ Y' = Y - K \]
Subtractive Ink Technology

50%  70%

25%

25%  45%

0%  25%
CMY vs. CMYK

- CMY
- CMYK

Wikipedia, CMYK separation
Halftoning

Analog halftone dots

Printer spots

[Diagram showing the transformation from analog halftone dots to printer spots]
Halftoning Image
Halftoning Dither Matrix

Number of intensity levels = $n^2 + 1$
Continuous-Tone Dithered Image
Dither Matrix

\[
\begin{bmatrix}
6 & 8 & 4 \\
1 & 0 & 3 \\
5 & 2 & 7 \\
\end{bmatrix}
\]

B = value of white (Imax) – Intensity (I)
For a 3 x 3 matrix, Imax = 9
B = 9 - I
Ink is dropped at all pixels whose dither matrix value is less than B
Dither Matrix – Ten intensity levels

Values of $B = 9 - I$
Color Laser Printing

Color Laser:  Electrophotographic printing using a laser beam and colored toners
Laser Printer

1. Controller
2. Photoconducting drum
3. Charging Roller
4. Laser Beam
5. Rotating Mirror
6. Developer Roller
7. Toner Hopper
8. Belt Assembly
9. Paper Tray
10. Charging Wire
11. Cleaning Blade
12. Fuser
Laser Printing

1. Charge - A photoconductive surface is given a uniform electrostatic charge on its surface

2. Expose - a laser “writes” the image on the photoconductor

3. Develop - fine toner particles are transported by electrostatic forces to the photoconductor
4. Transfer - the developed image is transferred from the photoconductor to the paper by contact

5. Fuse - the transferred image is permanently fixed to the paper by pressure or heat

6. Clean - the photoconductor drum is cleaned
Canon Copier
Continuous Ink Jet
Thermal Bubble Ink Jet

- Initial state with fluid at rest.
- Resistor is heated and bubble nucleates.
- Bubble grows to maximum size and ejects fluid out of nozzle.
- Bubble collapses; drop breaks off.
- System returns to initial conditions.
How Thermal Bubbles Work

http://mimech.com/printers/inkjet-printer-technology.asp
Inkjet Color Systems

• 4 ink systems: Black, Cyan, Magenta, Yellow

• 6 ink systems: Black, Cyan, Magenta, Yellow, Photo Cyan (light Cyan), Photo Magenta (light Magenta)

• 8 ink systems: Black, Cyan, Magenta, Yellow, Photo Cyan (light Cyan), Photo Magenta (light Magenta), Medium Gray, Light Gray
Resolution Limits

- resolution is a function of contrast sensitivity
Resolution

**Specific Resolution** - measured in dots per inch (horizontally) or lines per inch

Current ink jet resolution → 2400 dpi
1200 or 2400 lines per inch

Laser printing is higher

**Total Resolution** - defined as the total number of dots horizontally or lines vertically

The larger the picture size, the higher the total resolution
The triangle subtended by a 30 second angle

Sine of 30 sec = sine of 1/120 deg

= \sin (0.0083333333)

= 0.000145444

Thus 18"\sin(30 \text{ sec})

= 0.002617994"
What is the total picture resolution in dots?

- Current printer resolution
  2400 x 1200 dpi
How many dots (inkjet drops) per pixel?

iPhone5 with 8MP camera

- Assume 3200 x 2400 pixels
Conceptual comparison of pixels per inch and dots per inch.
Magnified Inkjet Printer Head

http://www.instructables.com/id/DIY-BioPrinter/?ALLSTEPS
Ink Droplets on Paper

Water based drying

Roller pressure drying

http://www.imaging.org/ist/resources/tutorials/inkjet.cfm
Dye vs pigment

cross-section near the paper surface
Inkjet speed (drops per second)

http://www.tappi.org/content/events/09papercon/papers/Lane.pdf
## Inkjet Drop Size

<table>
<thead>
<tr>
<th>year</th>
<th>relative drop size</th>
<th>picoliters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>70µm</td>
<td>86</td>
</tr>
<tr>
<td>1995</td>
<td>45µm</td>
<td>50</td>
</tr>
<tr>
<td>1996</td>
<td>40µm</td>
<td>32</td>
</tr>
<tr>
<td>1997</td>
<td>26µm</td>
<td>10</td>
</tr>
<tr>
<td>1999</td>
<td>19µm</td>
<td>4</td>
</tr>
<tr>
<td>2002</td>
<td>3µm</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Relative drop sizes in picoliters (trillionths of liters): (3 micron, 10 fl)

[http://www.tappi.org/content/events/09papercon/papers/Lane.pdf](http://www.tappi.org/content/events/09papercon/papers/Lane.pdf)
Thermal Wax Printing

Thermal-wax Transfer: Heated wax is melted onto special paper or transparency film
Typical heater element heating and cooling profile, for a 1 millisecond electrical energy pulse.
Figure 12.7. Thermal transfer printing. The printhead applies heat to the ribbon causing the ink layer to melt and to transfer to the paper.
Dye Sublimation Printing

Dye Sublimation: Vaporized dyes transfer to special paper
Dye Sublimation Output

Dye primary colors
The human eye blends four individual color dots into a single color.
The image area of the plate picks up ink from the ink rollers. The water rollers keep the ink off of the non-image areas. Each plate then transfers its image to a rubber blanket which transfers the image to the paper. The plate does not touch the paper, thus the term "offset" lithography. All of this occurs at an extremely high speed.
Offset Printing

Close-up of rollers. The top series of rollers transfers the yellow ink to the rubber "blanket" cylinder (bottom roller), and then to the paper that is passing horizontally under the "blanket."
Offset Printing

Web-press paper-feed system showing the double roll of paper just before the splice from the smaller roll (on the bottom) to the larger roll. Each roll of paper weighs nearly 1 ton and is sufficient for 9,000 impressions (72,000 printed pages).
End. . .