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Digital Cameras Overview
You've come a Long Way, Baby!

When digital cameras started becoming available in 1991, buyers were faced with few choices and very high cost! By the end of 1997, more than 50 companies offered digital cameras and digital cameras were available for less than $250 US. The new easy availability and low prices make digital capture appear to be an attractive choice for image creators, but deciding which camera to buy is far from easy.

A Short History of Applied Electronic Imaging

1920's Bartlane cable picture transmission system
3 hours
5 gray levels
1929 15 gray levels

1936 NBC
First regular telecast in U.S.

1953 U.S. color telecasts

A Short History of Applied Electronic Imaging

1964 Jet Propulsion Lab
Computer enhancement of Ranger 7 images from the moon
1979 Scitex
Digital CEPS
1981 Sony
Announcement of Still Video
1984 First production Still Video camera

A Short History of Applied Electronic Imaging

1984 Apple Computer
The Macintosh
1988 Canon
RC-760 (600k pixels) and Xapshot cameras
1988 Sony Mavica

A Short History of Applied Electronic Imaging

1989 Sony
ProMavica MVC-5000
2 chip Hi-band

A Short History of Applied Electronic Imaging

1990 Adobe Systems
Photoshop 1.0
1990 Dycam
Dycam digital camera (90k pixels, B&W)

A Short History of Applied Electronic Imaging

1990 Eastman Kodak
Prototype digital camera (1.3 megapixels)

1991 Adobe Systems
Photoshop 2.0

A Short History of Applied Electronic Imaging

1991 Eastman Kodak
DCS digital camera
1992 Leaf Systems
Digital camera back (2k x 2k)

A Short History of Applied Electronic Imaging

1992 Eastman Kodak
DCS 200 digital camera
1993 KanImage
Up to 2320 x 3072 pixels with piezo crystal displacement, 12 bits per color
1993 Phase One
Tri-linear 5k element linear sensor, up to 5k x 7k, 12 bits per color

A Short History of Applied Electronic Imaging

1994 Apple Computer
QuickTime 100 digital camera
480 x 640 pixels

1994 Eastman Kodak NC-2000 digital camera
1024 x 1280 pixels 16µ square
PCMCIA image storage

A Short History of Applied Electronic Imaging

1994 Dicomed
4 x 5 scanning camera back
6000 element tri-color CCD sensor
6000 x 7520 maximum image size
1994 Eastman Kodak
DCS 420 digital camera
1012 x 1524 pixels 9µ square
1994 Nikon E2/E2s
Fuji DS-505/DS-515
1000 x 1280 pixels
Relay lens assembly

A Short History of Applied Electronic Imaging

1994 Connectix

QuickCam digital camera
>$100, 240 x 320 pixels, 4-bit (16 greys)

1994 Eastman Kodak

DCS 460/465 digital cameras
2036 x 3060 pixels 9µ square

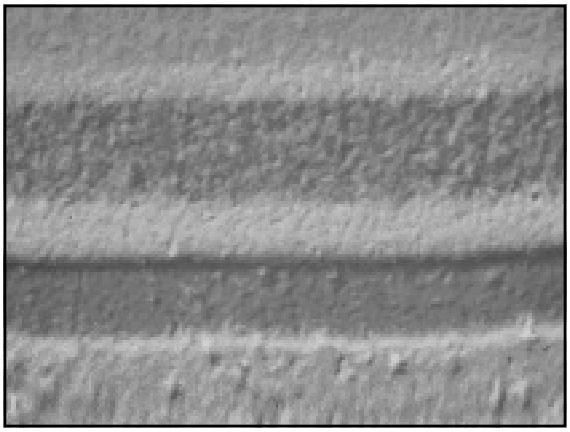
1994 Leaf Systems

CatchLight digital camera back
2048 x 2048 pixels 15µ square
Red, Green, Blue, and Teal
Pseudo-random pattern

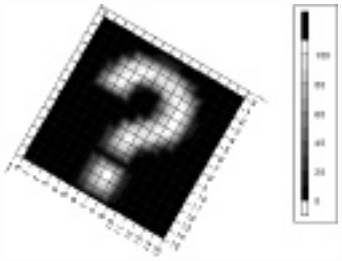
A Short History of Applied Electronic Imaging

1995 ScanView/ColorCrisp

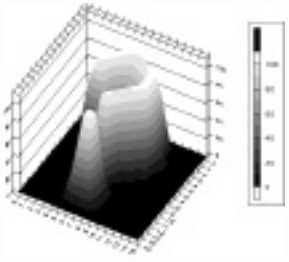
DigiCam 2000/Carnival digital cameras
2k x 2k sensor



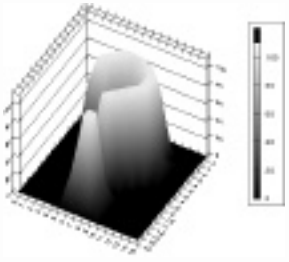
Digital Images Are Sampled In Space
- Spatial Resolution (Pixels/Inch)



Digital Images Are Sampled In Brightness
- Brightness Resolution (Bits/Pixel)



Digital Images Are Sampled In Brightness
- Brightness Resolution (Bits/Pixel)



Digital Images Are Sampled In Brightness
- Brightness Resolution (Bits/Pixel)

Bits	Number of Grays	Number of Colors
1	2	8
2	4	64
3	8	512
4	16	4096
5	32	32768
6	64	262144
7	128	2097152
8	256	16777216
9	512	134217728
10	1024	1073741824

FILM PIXELS:

There is no generally accepted way to convert an AgX image into its 'PIXEL' equivalent, but we can approximate the pixel equivalent in the following way:

FILM PIXELS:

Resolving power of typical 100 speed color negative film at medium contrast is around 65 line pairs/mm.

A line pair represents a BLACK and a WHITE line so a line pair represents two pixels.

This means this film has around 130 pixels/mm.

For a 24 X 36 mm 35mm frame this gives 3120X4680=14.6 million pixels.

How is digital capture different from film?

DCS 200mi Data

Stops	log E	Shutter speed	f stop	Green CV
8	-2.4	8000		6
7	-2.1	4000		5
6	-1.8	2000		11
5	-1.5	1000		14
4	-1.2	500		25
3	-0.9	250		39
2	-0.6	125		61
1	-0.3	60		96
0	0	30	22	153
1	0.3	15		234
2	0.6	8		255
3	0.9	4		255
4	1.2	2		255
5	1.5	1"		
6	1.8	2"		
ISO	100			
Balance		None		
Color Correction		Off		
64 x 64 pixels				
Histogram				

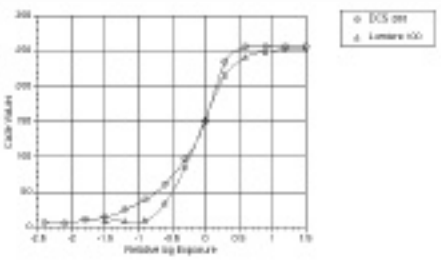
How is digital capture different from film?

Lumiere 100 Data

Stops	log E	Shutter speed	f stop	Green CV
8	-2.4	2000		
7	-2.1	1000		
6	-1.8	500		
5	-1.5	250		9
4	-1.2	125		9
3	-0.9	60		10
2	-0.6	30		34
1	-0.3	15		85
0	0	8	11	153
1	0.3	4		215
2	0.6	2		241
3	0.9	1"		249
4	1.2	2"		252
5	1.5	4"		253
6	1.8	8"		
ISO	100 Lumiere			
Balance		None		
Color Correction		Off		
64 x 64 pixels				
Histogram				

How is digital capture different from film?

DCS vs. Film tone reproduction



Sensor technology

CCD vs. CMOS

- **Both are built on silicon with similar sensitivity in visible and near-IR part of spectrum**
- **Both can use either photogates or photodiodes as light sensitive elements**
- **The sensors differ in the way the photo-induced charge from each pixel location is read-out**

Sensor technology

CCD sensors

- **Use shift-register arrays of overlapped gate devices to actually physically shift the charge collected at each pixel location across the surface of the sensor so it can be read out serial fashion, by an output amplifier**
- **This "bucket brigade" transfer requires a complicated series of clock pulses**
- **With CCD sensors, it is not possible to address any one specific pixel (or group) to directly read the data**

Sensor technology

CMOS sensors

- **Do not transfer individual charge packets, but detect the charge with sensing amplifiers made from CMOS transistors**
- **Passive pixel sensors have an amplifier at top of each column of pixels and one transistor at each pixel location to switch the charge from the pixel to the charge amplifier**
- **Active pixels sensors have the amplifier located at each pixel location and typically use three transistors per pixel**

Sensor technology

CMOS sensors continued

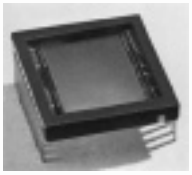
- **A disadvantage of CMOS sensors comes from mismatched gains of the many CMOS transistors that are used resulting in fixed pattern noise not present in CCD sensors**
- **The loss in sensitivity caused by the cell (pixel) area covered by non-light sensitive transistors can be compensated for by covering the sensor with a micro lens array**

Sensor technology

CMOS sensors continued

A major advantage of CMOS technology is the ease with which virtually all of the features needed for a digital camera can be integrated on the same chip

Sensor technology



Storage technology

Memory cards:

PCMCIA cards

- **Type I and II solid state, Type III hard disks**

CompactFlash

SSFDC (Smart Media)

Storage technology

File format:

- **Standard formats**
  - **JPEG (actually JFIF)**
  - **FlashPix**
  - **TIFF**
- **Proprietary**
  - **KDC**

Storage technology

File compression:

- **None**
- **High Quality (less than 1:8)**
- **Normal**
- **Economy**

Camera operating system (OS)

Flashpoint Technology

Digital camera categories

TETHERED TO A COMPUTER

- **Typical price: under $300 US**
- **Resolution: VGA or lower**
- **Typical use: video conferencing**

Examples:

- **Connectix QuickCams**
- **Kodak DVC 3 xx cameras**

Digital camera categories

LOW-RESOLUTION

- **Typical price: under $400 US**
- **Resolution: VGA or lower**
- **Typical use: soft display**

Examples:

- **Kodak DC20 and DC 25**

Digital camera categories

VGA RESOLUTION

- **Typical price: under $600 US**
- **Resolution: VGA (640 x 480 pixels)**
- **Typical use: web pages**

Example:

- **Fuji DX-7**

Digital camera categories

MEGAPIXEL RESOLUTION

- **Typical price: under $1000 US**
- **Typical resolution: 1024 x 768 pixels**
- **Typical use: consumer photo quality**

Example:

- **Olympus D-320L**

This fast growing category is important to imaging professionals and designers

Digital camera categories

PROFESSIONAL FIELD MODELS

- **Typical price: under $30,000 US**
- **Resolution: 1.5k x 1k pixels to 3k x 3k pixels**
- **Typical use: near film quality applications**

Example:

- **Kodak DCS 520**

Digital camera categories

PROFESSIONAL STUDIO MODELS

- **Typical price: under $40,000 US**
- **Resolution: 2k x 2k pixels to 10.6k x 8k pixels**
- **Typical use: film quality applications**

Example:

- **Leaf/Scitex DCB II**

Digital camera categories

DIGITAL STILL VIDEO

Typical price: under $3,000 US

Typical resolution: 720 x 480 pixels

Typical use: QTVR objects

Example:

Canon Optura MV-1

Why digital cameras?

Immediacy

Raw materials cost reduction

Image verification

Rapid sharing

Gee-wiz factor

Why NOT digital cameras?

Equipment cost

Image quality

Image storage

What features do you need?

What features do you need?

Camera

Manufacturer

Model

Street price

Computer MAC ☐ PC ☐

What features do you need?

Resolution

Spatial (pixels W x pixels H)

Sub-VGA …… ☐

VGA (640 x 480) …… ☐

Megapixel …… ☐

Brightness (bits/pixel)

What features do you need?

Lens
- Fixed (35mm equivalent) ☐
- Zoom (35mm equivalent) ☐

Focus
- Fixed ☐
- Auto ☐
- Macro ☐

What features do you need?

Viewfinder
- Optical ☐
- Color LCD viewfinder ☐
- Color LCD playback ☐

What features do you need?

Image storage
- Format
  - Standard (jpeg, etc.) ☐
    - Compression levels
      - None ☐
      - High quality (<1:8) ☐
      - Normal ☐
      - Economy ☐
  - Proprietary (kdc, etc.) ☐
- Removable memory
  - None ☐
  - Standard solid state (SSFDC, CompactFlash) ☐ MB
  - Floppy disk ☐
  - Proprietary ☐

What features do you need?

Image transfer
- Camera to computer connection
  - Serial ☐
  - Printer ☐
  - SCSI ☐
  - USB ☐
  - IrDA ☐
  - Firewire ☐
- Software

What features do you need?

Power source
- Batteries
  - Standard alkaline ☐
  - NiCd ☐
  - Ni/Metal hydride ☐
  - Lithium ion ☐
  - Other ☐
- AC adapter ☐

What features do you need?

Exposure control
- Automatic ☐
- Manual ☐

White balance
- Automatic ☐
- Manual ☐

What features do you need?

Special features

- Audio recording ☐
- Live video out ☐
- Video playback ☐
- Scriptable ☐
- Other ☐

Where can you go for help?

Digital camera resources on the Internet

Kodak Digital Learning Center
http://www.kodak.com/daiHome/DLC

PC-Photo Forum
http://www.pcphotoforum.com

digital camera resource page
http://www.dcresource.com

Digital Cameras Set to Take Off, J. Berst, ZDNet
http:www.zdnet.com/anchordesk/story/story_2031.html

FlashPoint Technology
http://www.flashpnt.com

Where can you go for help?

Information on CMOS sensors

Photobit Corporation
http://www.photobit.com

Vision
http://www.vvl.co.uk

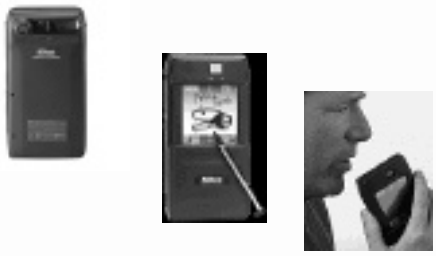
Unique Digital Cameras

Connectix QuickCam

Sony MVC-FD7

Sound Vision SVmini-209

Nikon Coolpix 300



Fuji MX-700

Olympus D-600L

Minolta Dimage V

Agfa ePhoto 1280

Nikon Coolpix 900

Nikon E2N/E2Ns

Minolta RD 175

Dicomed BigShot

Leaf/Scitex Catchlight

Better Light

Canon Optura MV-1