WHAT IS CCD

University Of Lübeck
ISNM

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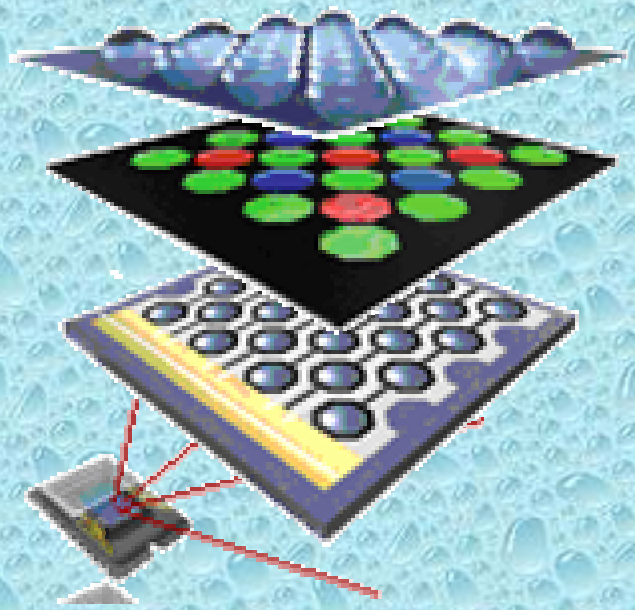


Presented by: Omar A. Hanoun

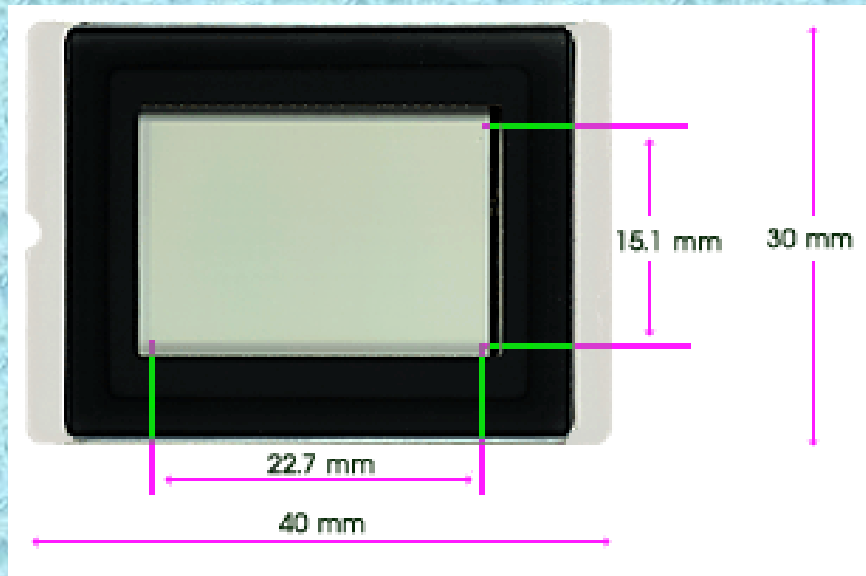
WHAT IS CCD

What Is CCD?

Image Sensor: solid-state device used in digital cameras to capture and store an image.

Photosites: photosensitive diodes containing in the fingernail-sized silicon image sensor.

Pixels: picture elements.



WHAT IS CCD

The Development of the CCD:

- **On October 17, 1969,** George Smith and Willard Boyle sketched out the CCD's basic structure.
- **By 1970,** the Bell Labs researchers had built the CCD into the world's first solid-state video camera.
- **In 1975,** they demonstrated the first CCD camera with image quality sharp enough for broadcast television.
- **Since 1983,** astronomers used to study objects thousands of times fainter than what the most sensitive photographic plates could capture, and to image in seconds what would have taken hours before.

Willard Boyle (left) and George Smith (right).

WHAT IS DIGITAL

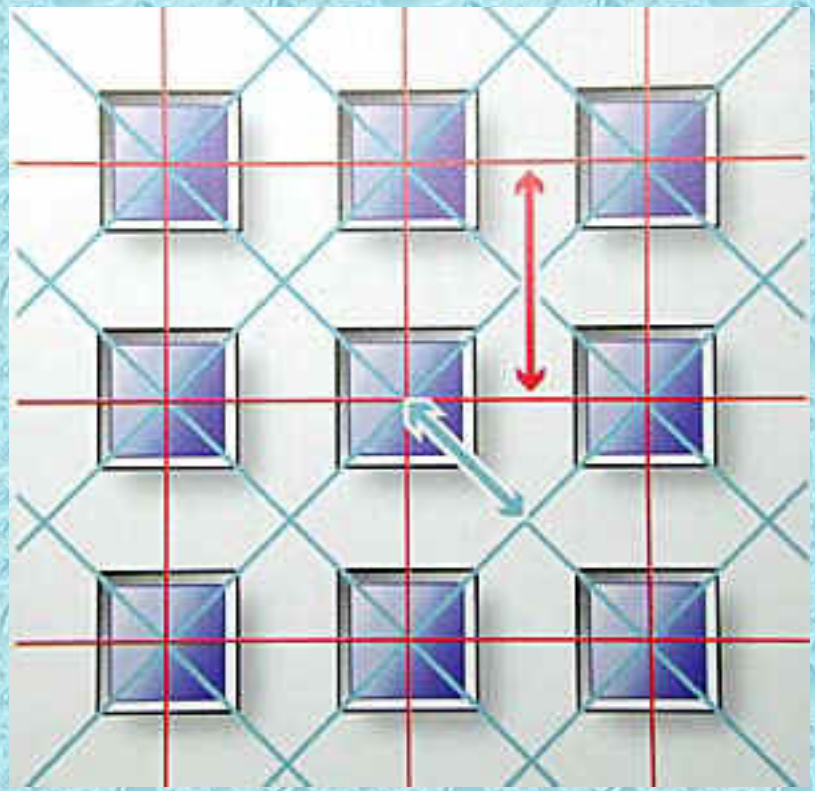
Image Sensors and Pixels :

Here you see a reproduction of the famous painting "The Spirit of '76" done in jelly beans. Think of each jelly bean as a pixel and it's easy to see how dots can form images. Jelly Bean Spirit of '76 courtesy of Herman Goelitz Candy Company Inc. Makers of Jelly Belly.

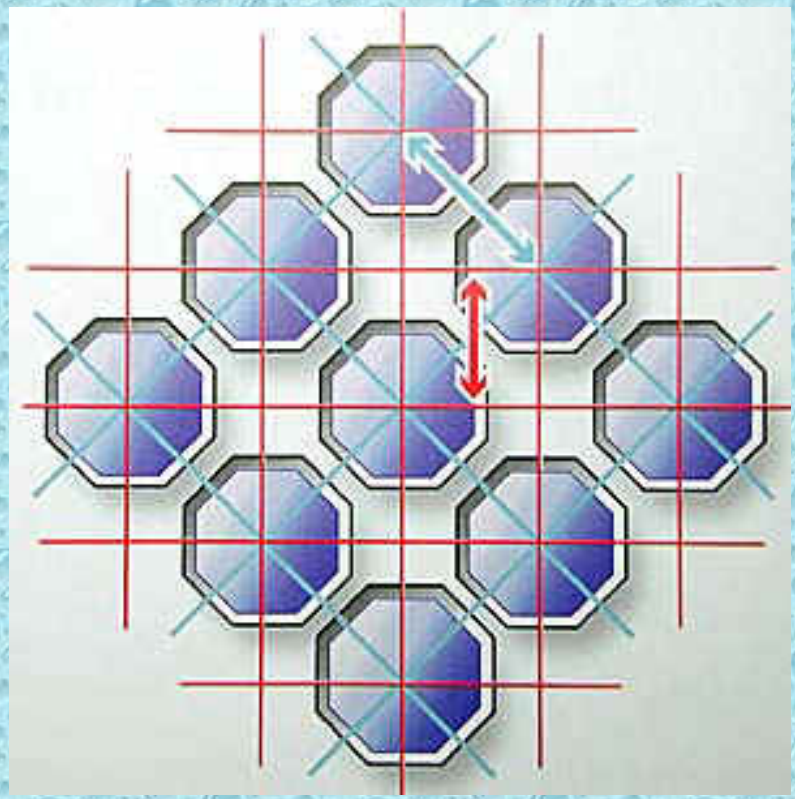
BMP: Bit-maps

WHAT IS CCD

Arrangments Of Image Sensors:



A typical image sensor has square photosites arranged in rows and columns.



The Super CCD from Fuji uses octagonal pixels arranged in a honeycomb pattern.

WHAT IS DIGITAL

- **Resolution:** The quality of a digital image, whether printed or displayed on a screen, depends in part on the number of pixels used to create the image.
- **The Optical Resolution:** of a camera or scanner is an absolute number refers to the image sensor's photosites.
- **Interpolated Resolution:** The process to improve resolution in limited respects, using software, by adding pixels to the image.

The photo of the face (right) looks normal, but when the eye is enlarged too much (left) the pixels begin to show. Each pixel is a small square made up of a single color.

WHAT IS CCD

The resolution and total pixels for some devices:

Element	Resolution	Total Pixels
Color TV (NTSC)	320 x 525	168,000
Human eye	11,000 x 11,000	120 million
35-mm slide		The "Economist" magazine says it has 20 million or more. CMOS Imaging News says 5 to 10 million depending on the film. Another source says about 80 million pixels. Robert Caspe at SoundVision states that color negative film has 1000 pixels per inch while color positive film has 2000 pixels per inch.
1982 Kodak Disc camera film		3 million pixels—each about 0.0003 inch in diameter

WHAT IS GOOD

Image Size:

The size of a photograph is specified in one of two ways-by its dimensions in pixels or by the total number of pixels it contains (2.88 million).

This digital image of a Monarch butterfly chrysalis is 1800 pixels wide and 1600 pixels tall. It's said to be 1800x1600.

WHAT IS CCD

Resolution of Digital Devices:

1- Camera Resolutions

Megapixel Cameras: The cameras, those with 1 million or more pixels.
Multi-Megapixel cameras: The cameras, those with over 2-million.

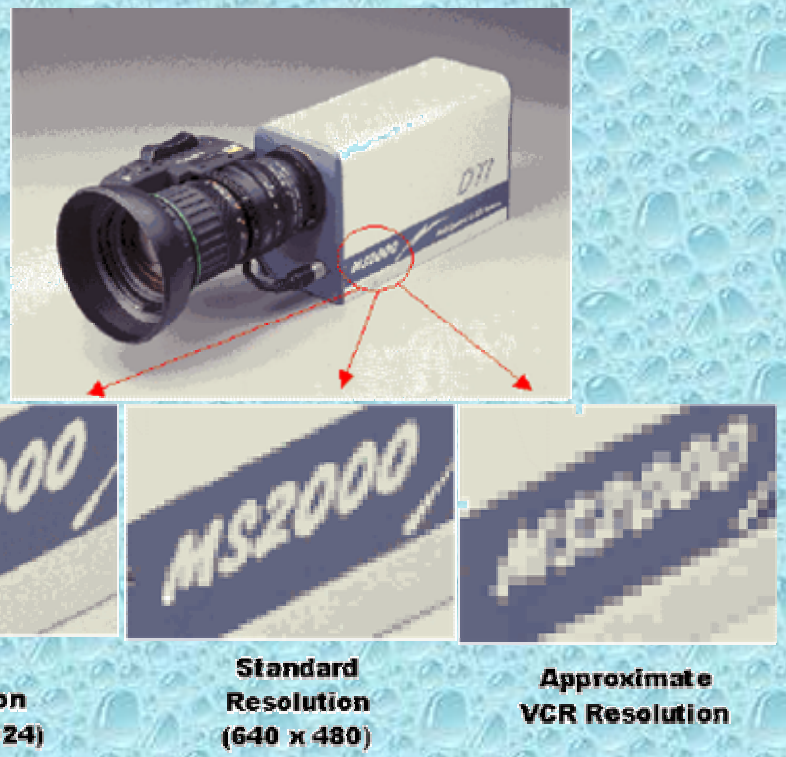


Image Resolution is Critical for Medical, Machine Vision, and Aerial.

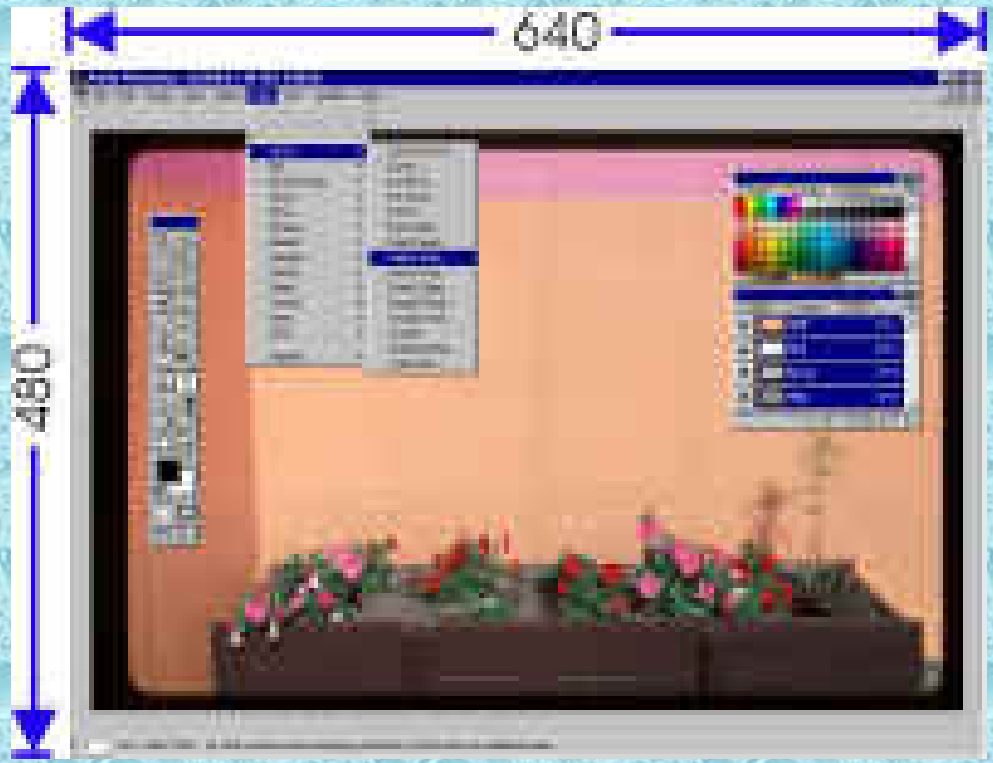
WHAT IS GIGO

Resolution of Digital Devices:

2- Monitor Resolutions

PPI: Pixels per inch.

Generally, images that are to be displayed on the screen are converted to 72 pixels per inch (ppi), a resolution held over from an early era in Apple's history.



This is a 640 x 480 display. That means there are 640 pixels on each row and there are 480 rows.

WHAT IS GOOD

Resolution of Digital Devices:

2- Monitor Resolutions

Resolution	Monitor Size (inch)				
	14	15	17	19	21
640 x 480	60	57	51	44	41
800 x 600	74	71	64	56	51
1024 x 768	95	91	82	71	65

this isn't an exact number for any resolution on any screen, but it tends to be a good compromise.

WHAT IS GOOD

Resolution of Digital Devices:

3- Printer and Scanner Resolutions

DPI: Dots per inch**.**

PPI $\stackrel{?}{=}$ DPI

WHAT IS CCD

Resolution of Digital Devices:

Note: Size isn't everything!!!

- **More photosites often means better images, adding more isn't easy and creates other problems.**
- **It adds significantly more photosites to the chip so the chip must be larger and each photosite smaller.**
- **Larger chips with more photosites increase difficulties (and costs) of manufacturing.**
- **Smaller photosites must be more sensitive to capture the same amount of light.**
- **More photosites create larger image files, creating storage problems.**

Why?

WHAT IS CCD

Resolution of Digital Devices:

Effective Pixels:

Total number of pixels	2140 x 1560 (3.34M)
Number of read pixels	2088 x 1550 (3.24M)
Number of active pixels	2080 x 1542 (3.21M)
Recommended recorded pixels	2048 x 1536 (3.14M)

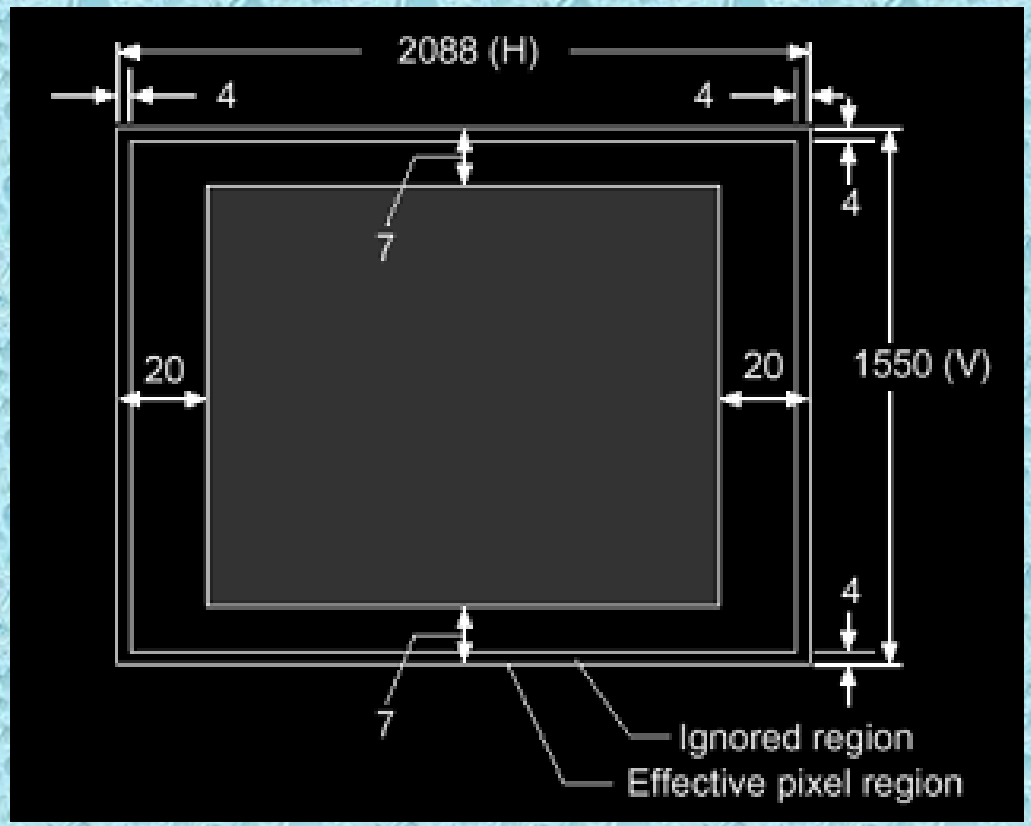
For Sony's DSC-F505V Camera.

WHAT IS CCD

Resolution of Digital Devices:

Effective Pixels:

Thats because: Because they fitted this new CCD into last years body and as the CCD was slightly larger the lens wasn't able to cover the whole CCD frame.



WHAT IS CCD

Image Sensors:

Lens is controlled by a shutter.

Types of electronic shutters that control the exposure of the digital cameras :

1. **Electronically shuttered sensors** use the image sensor itself to set the exposure time. A timing circuit tells it when to start and stop the exposure
2. **Electromechanical shutters** are mechanical devices that are controlled electronically.
3. **Electro-optical shutters** are electronically driven devices in front of the image sensor which change the optical path transmittance.

WHAT IS CCD

From Light Beams to Images:

- The shutter opens,
- The image sensor contains a grid of tiny photosites.
- As the lens focuses the scene on the sensor,
- Some photosites record highlights,
- Some shadows,
- Others record all of the levels of brightness in between.
- Each site converts the light falling on it into an electrical charge.
- The brighter the light the higher the charge will be.
- When the shutter closes and the exposure is complete,
- The sensor "remembers" the pattern it recorded.
- The various levels of charge are then converted to digital numbers that can be used to recreate the image.

WHAT IS CCD

From Light Beams to Images:

When an image is focused through the camera (or scanner) lens, it falls on the image sensor. Varying amounts of light hit each photosite and knock loose electrons that are then captured and stored. The number of electrons knocked loose from any photosite is directly proportional to the amount of light hitting it.

1	1	1	1	1	1	1	1	1
1	1	5	5	5	5	5	1	1
1	1	5	10	10	10	5	1	1
1	1	5	10	10	10	5	1	1
1	1	5	10	10	10	5	1	1
1	1	5	10	10	10	5	1	1
1	1	5	10	10	10	5	1	1
1	1	5	5	5	5	5	1	1
1	1	1	1	1	1	1	1	1

WHAT IS CCD

Interlaced vs. Progressive Scan:

The charges stored on the sensor are read row at a time.

There are two ways read the rows:

1- Interlaced scans;

2- Progressive scans.

WHAT IS CCD

Interlaced vs. Progressive Scan:

interlaced scan sensor

The image is first processed by the odd lines, and then by the even lines. These kinds of sensors are frequently used in video cameras because television broadcasts are interlaced.

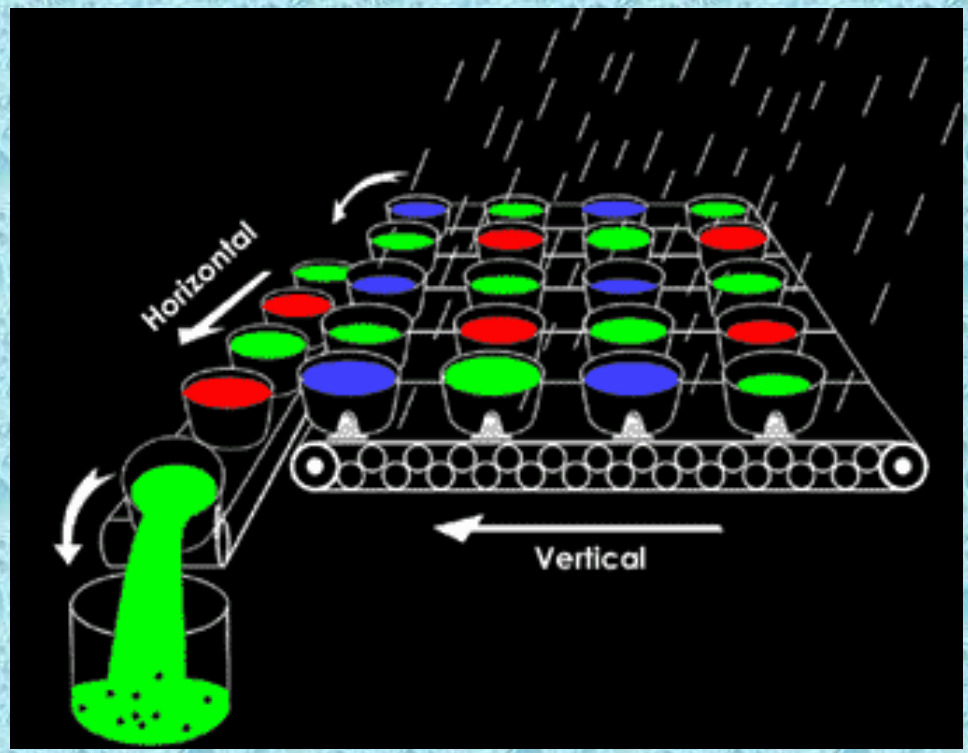
WHAT IS CCD

Interlaced vs. Progressive Scan:

progressive scan sensor

The rows are processed one after another in sequence.

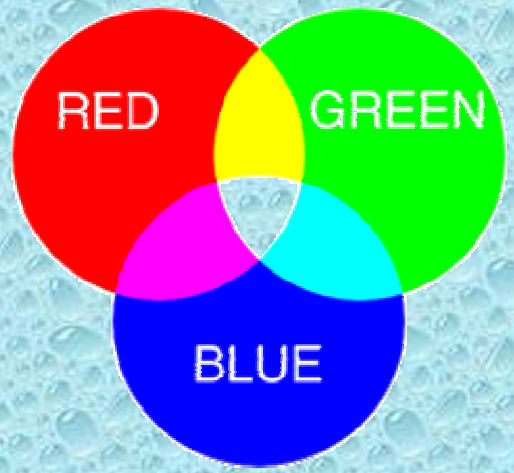
An array of buckets on conveyor belts, the raindrops represent the photons of light falling on to the CCD surface and being captured in 'bit buckets' (photosites; pixels). The conveyor belts which empty them are known as the shift registers, in progressive CCD's the CCD is read one horizontal line, shift the vertical down one pixel, one horizontal line, and repeat...



WHAT IS CCD

Image Sensors and Colors:

1860 James Clerk Maxwell's discovery that color photographs could be formed using red, blue, and green filters.



1- Additive Color system…….. RGB

In 1903 first commercially successful use to capture color images by the Lumerie brothers and became know as the Autochrome process.

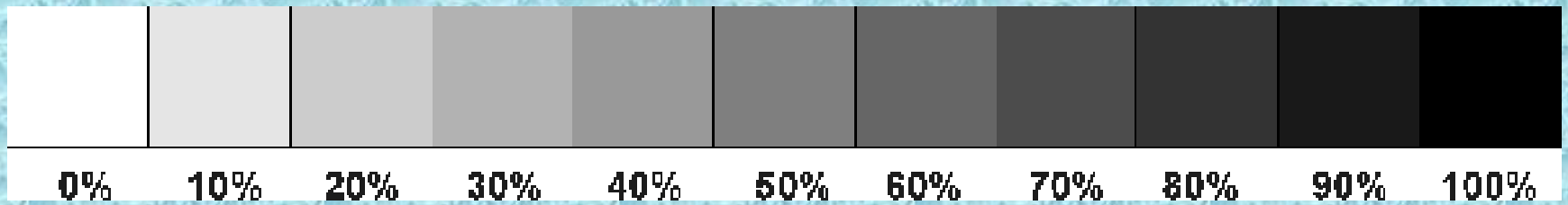
Subtractive Color system……CMYK

WHAT IS GOOD

***It's All Black and White After All*:**

Image sensors record only the **gray scale**, series of 256 tones ranging from pure white to pure black.

Basically, they only capture brightness.



WHAT IS CCD

How Then they Capture Color?

sensors record grays, But they use red, green, and blue filters (Likewise, the filters in a CMYK sensor will be cyan, magenta, or yellow.)

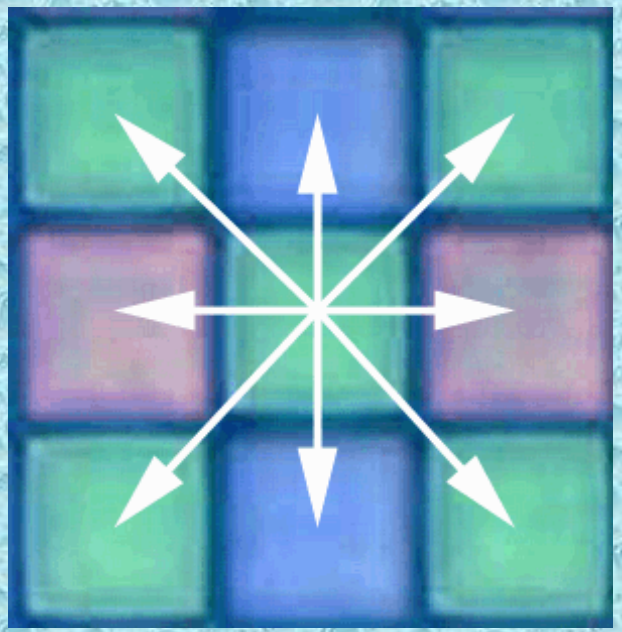
There are a number of ways to do this, including the following:

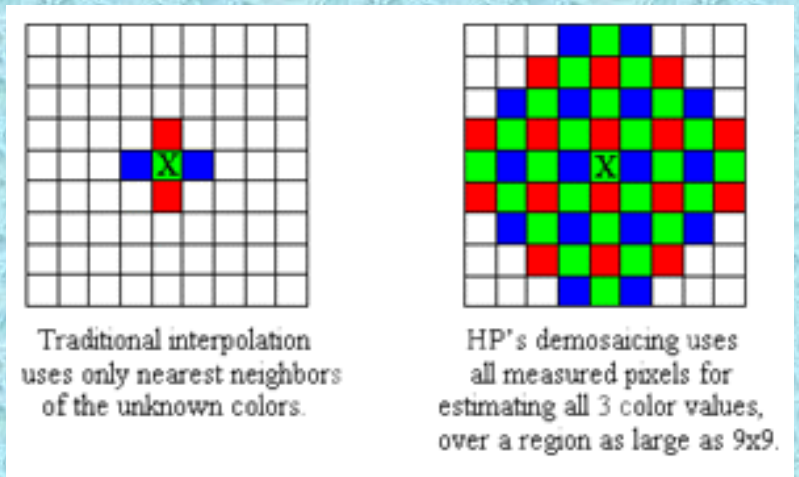
- Three separate image sensors can be used, each with its own filter.
- Three separate exposures can be made, changing the filter for each one.
- Filters can be placed over individual photosites so each can capture only one of the three colors (*the most popular is the Bayer mosaic pattern*).

WHAT IS CCD

From Black and White to Color

Here the full-color of the center green pixel is about to be interpolated from the colors of the eight surrounding pixels.



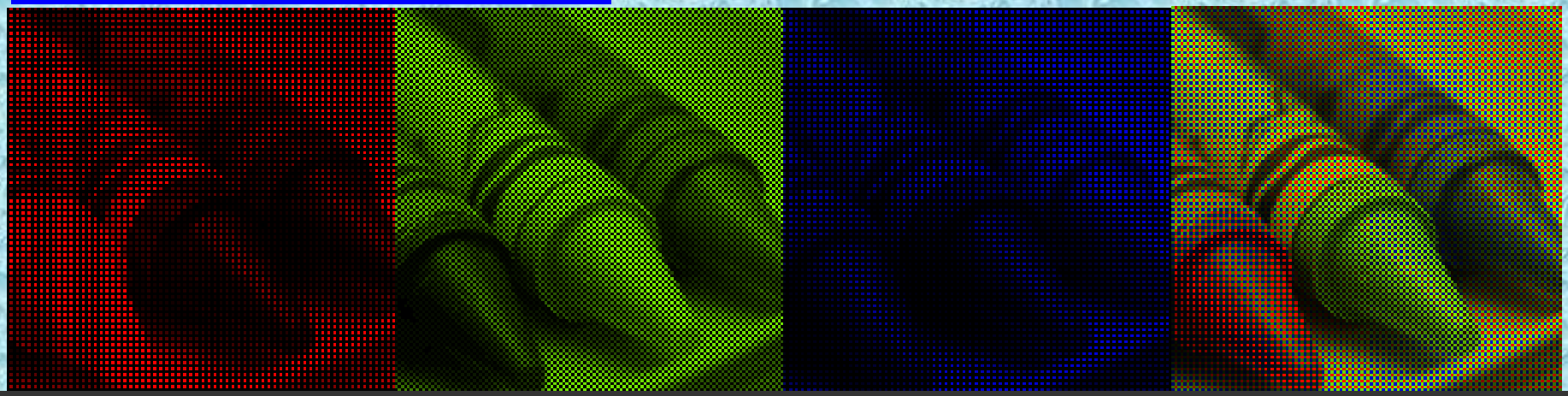


Traditional interpolation uses only nearest neighbors of the unknown colors.

HP's demosaicing uses all measured pixels for estimating all 3 color values, over a region as large as 9x9.

WHAT IS RGB

From Black and White to Color



Red channel pixels | Green channel pixels | Blue channel pixels | Combined

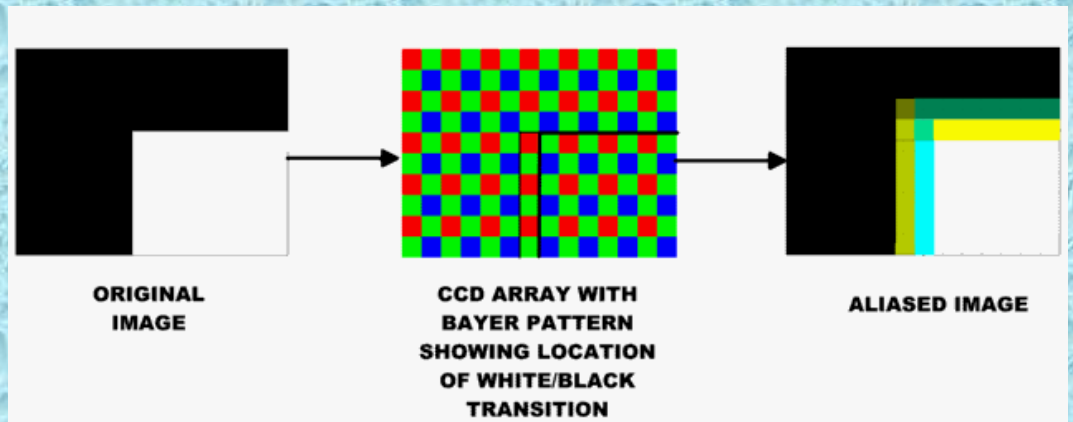
Through a **demosaicing algorithm** which combines the colour values of a pixel and it's eight neighbours to create a full 24-bit colour value for that pixel:

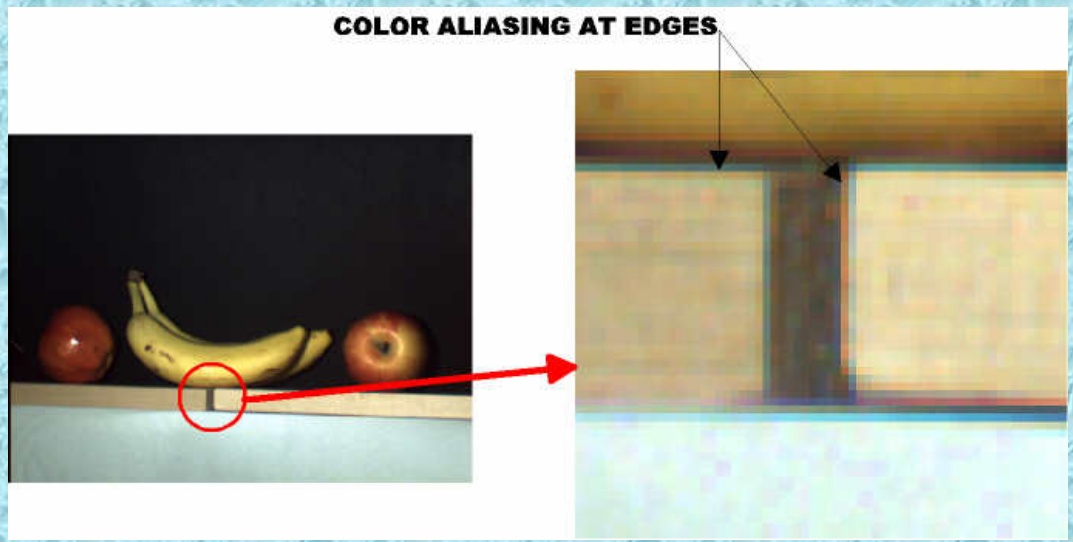
WHAT IS CCD

From Black and White to Color

Color Aliasing

Color Aliasing: that occurs when a spot of light in the original scene is only big enough to be read by one or two pixels (i.e. not three pixels or more) .



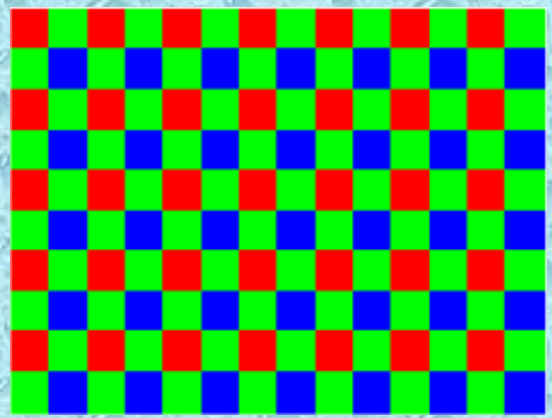


WHAT IS CCD

From Black and White to Color

Color Imaging with a Single CCD Array

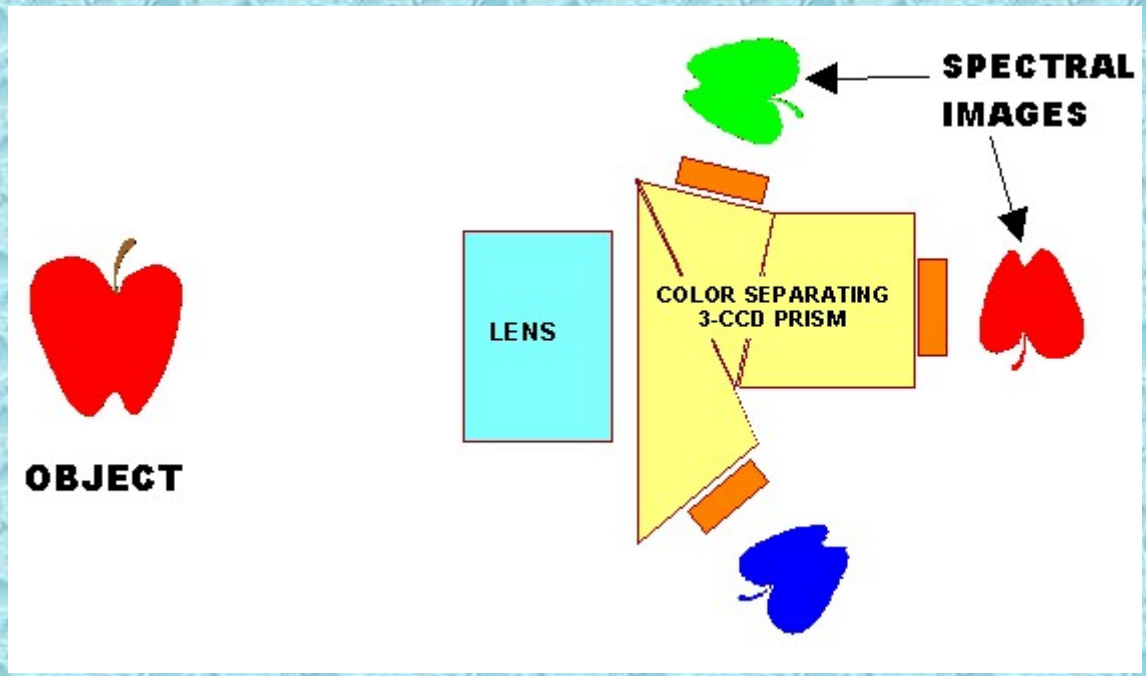
Bayer Pattern for Color CCD Imaging Arrays.



WHAT IS CCD

From Black and White to Color

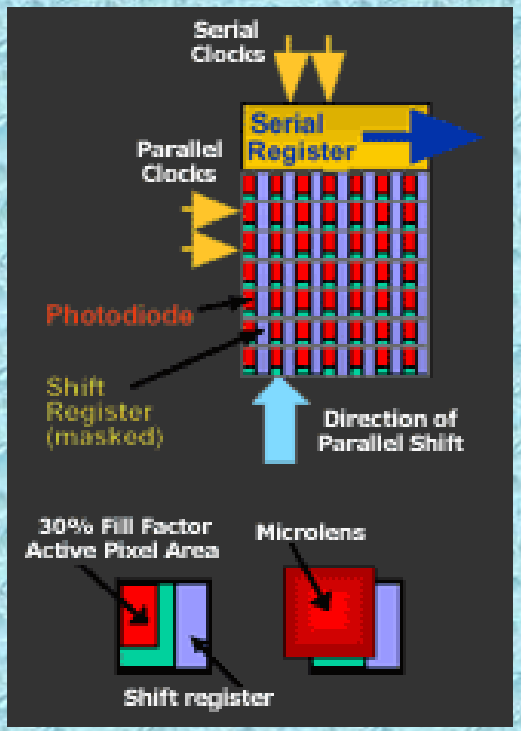
Color 3-CCD Camera Technology



WHAT IS CCD

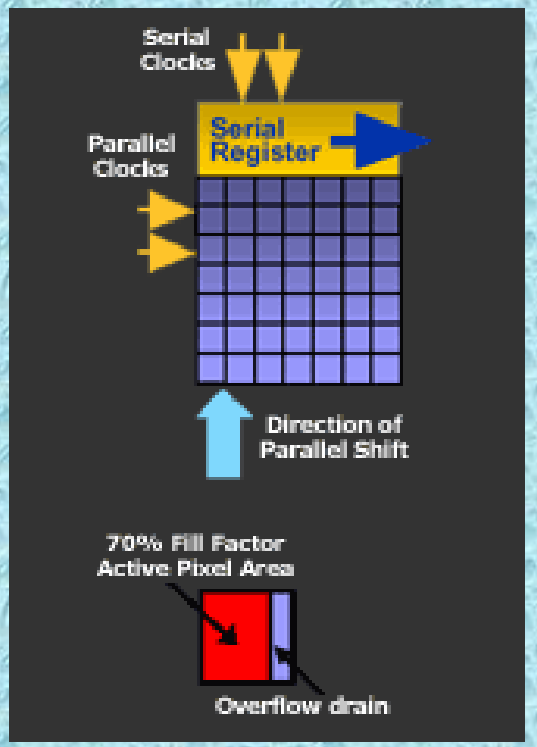
Interline Transfer sensor:

(Electronic shutters)



Full Frame sensor:

(Michanical Shutters)



WHAT IS CCD

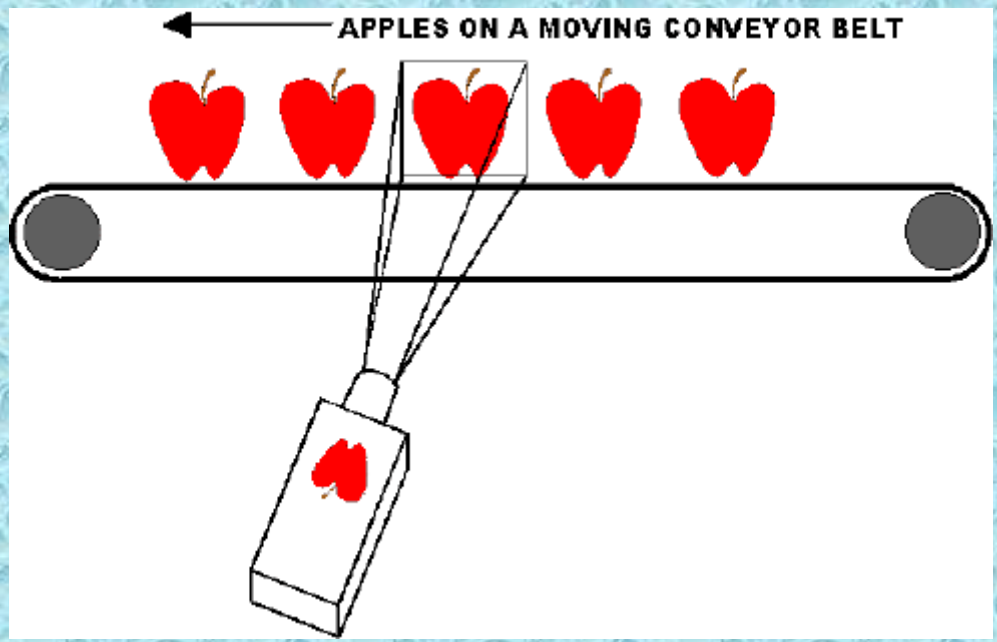
Pros & Con's associated with each CCD type:

Full Frame CCD		Interline Transfer CCD	
+	High image quality	+	Good image quality
+	High sensitivity	+	Good sensitivity when using microlenses
+	High dynamic range	+	Low noise
+	Larger sizes	+	High frame rates / electronic shutter
+	No microlenses	+	Video feed capable
-	Not capable of video feed	+	Don't need mechanical shutter
-	Top shutter speeds limited by mechanical shutter	-	Microlenses can cause aberrations
-	Require mechanical shutter		

WHAT IS CCD

Area Array and Linear Sensors:

Area-array Sensors



Can be incorporated into a camera in a variety of ways:

One-chip, one-shot cameras The most common form.

One chip, three shot cameras. These cameras cannot photograph moving objects in color and are usually used for studio photography.

Two-chip cameras used one sensor (usually equipped with filters for red light and blue light), and luminance with a second sensor (usually this one capturing green light). Require less interpolation to render true colors.

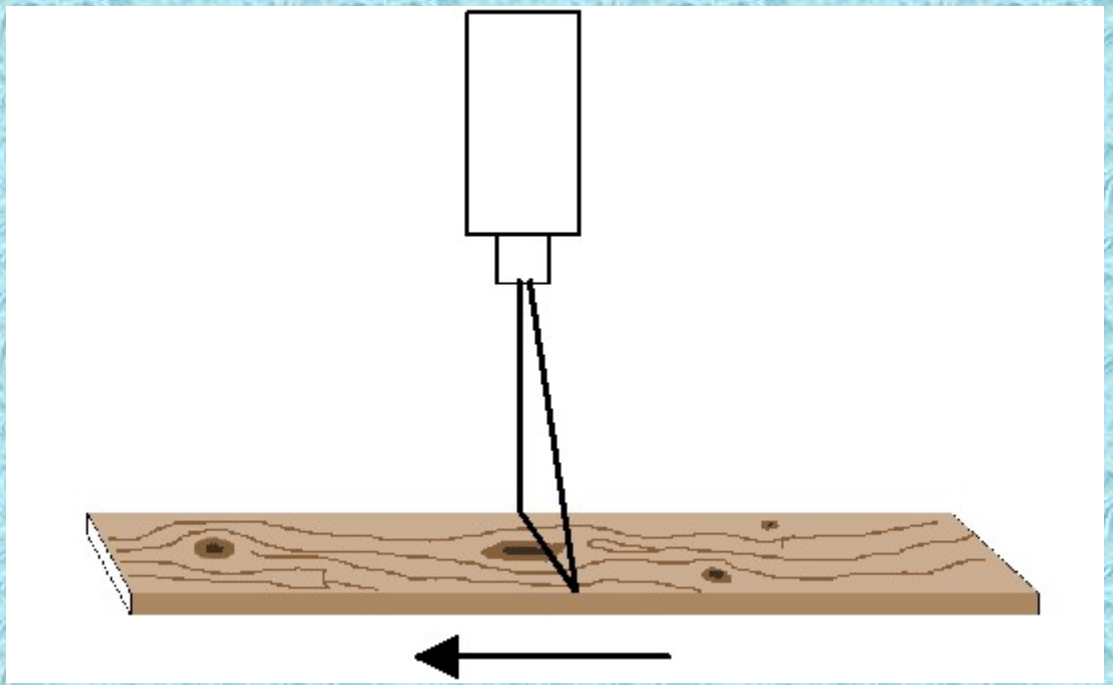
Three-chip cameras, (i. e. MegaVision), use three full frame image sensors. This design delivers high-resolution images with excellent color rendering. However, three-chip cameras tend to be both costly and bulky.

WHAT IS CCD

Linear Sensors

Scanners, and a few professional cameras, use image sensors with photosites arranged in either one row or three.

Useful only for motionless subjects and studio photography

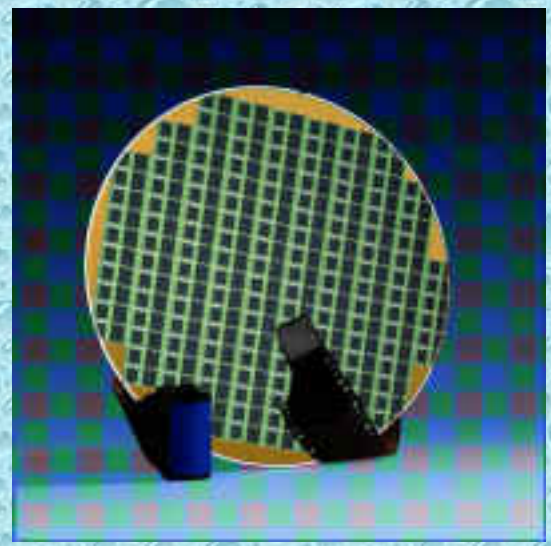


Linear image sensors put a different color filter over the device for three separate exposures, one each to capture red, blue or green.

Tri-linear sensors use three rows of photosites—each with a red, green, or blue filter. Since each pixel has it's own sensor, colors are captured very accurately in a single exposure.

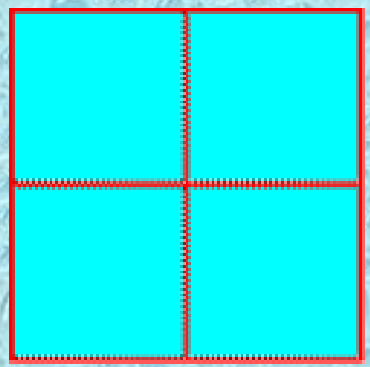
WHAT IS CCD

CCD And CMOS Image Sensors:

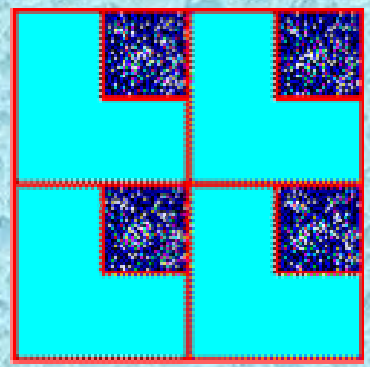


- CMOS image quality is now matching CCD quality in the
- low- and mid-range, leaving only the high-end image sensors still unchallenged.
- CMOS image sensors can incorporate other circuits on the same chip.
- CMOS image sensors can switch modes on the fly between still photography and video.
- CMOS sensors excel in the capture of outdoor pictures on sunny days, but suffer in low light conditions.
- CCDs have a 100% fill factor but CMOS cameras have much less.
- To compensate for lower fill-factors, micro-lenses can be added to each pixel to gather light from the insensitive portions of the pixel and "focus" it down to the photosite.

WHAT IS CCD



100% Fill factor



75% Fill factor

Fill factor refers to the percentage of a photosite that is sensitive to light. If circuits cover 25% of each photosite, the sensor is said to have a fill factor of 75%. The higher the fill factor, the more sensitive the sensor.

WHAT IS GOD

Thanks for All