Imagerie numérique

F. Baret

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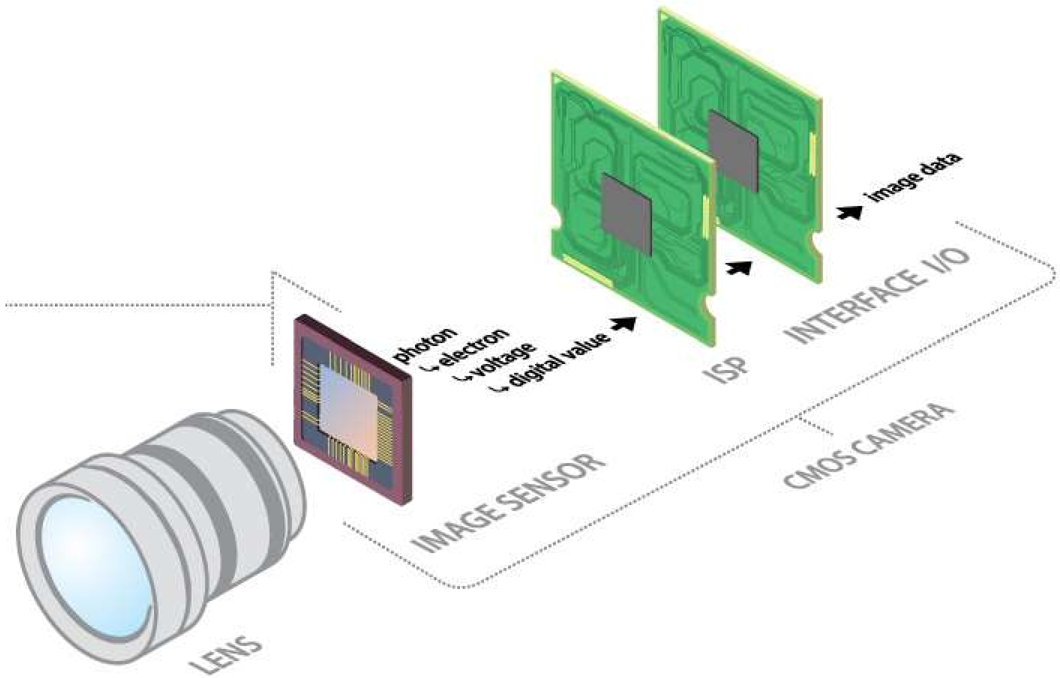
The camera and sensors



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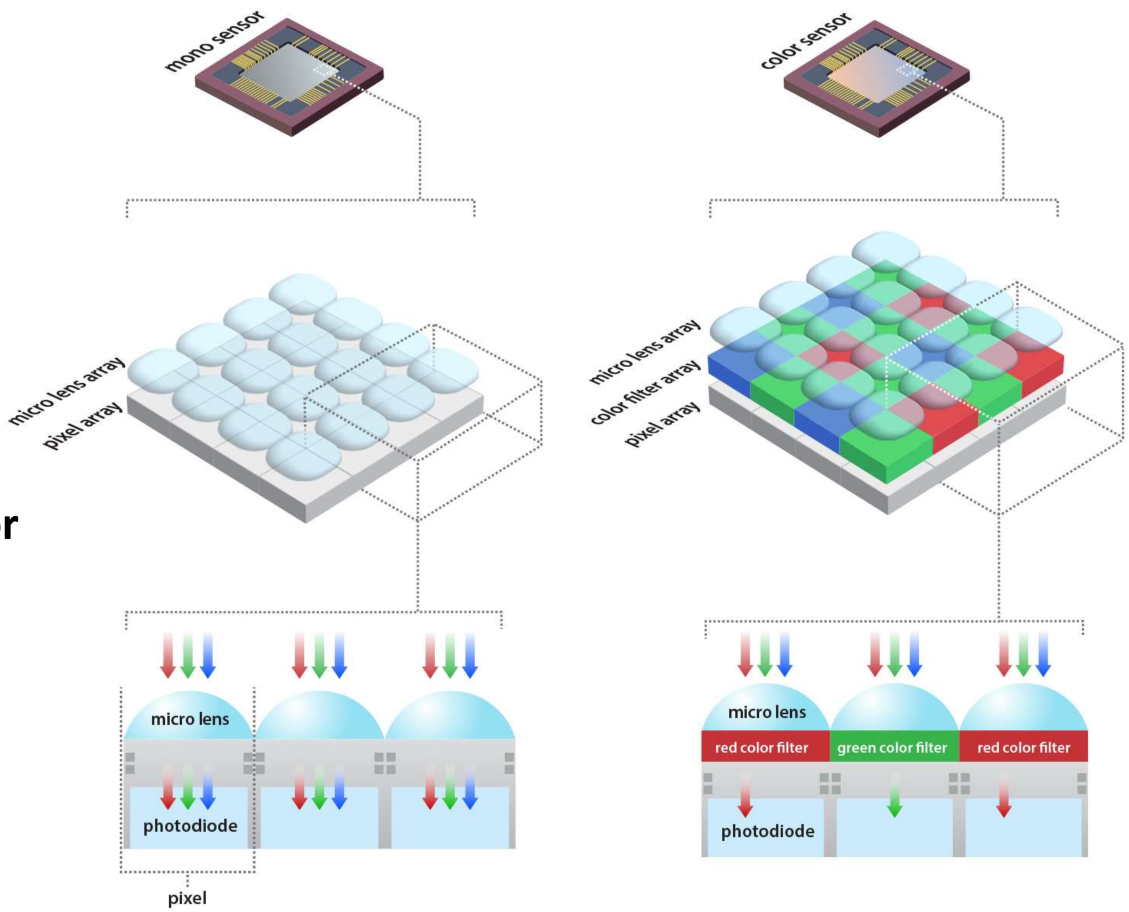
Mono-color & RGB sensors

Mono-color sensor



Bayer matrix

RGB sensor

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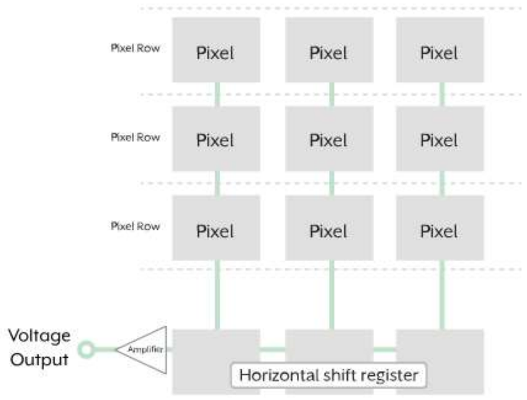
Camera sensor types

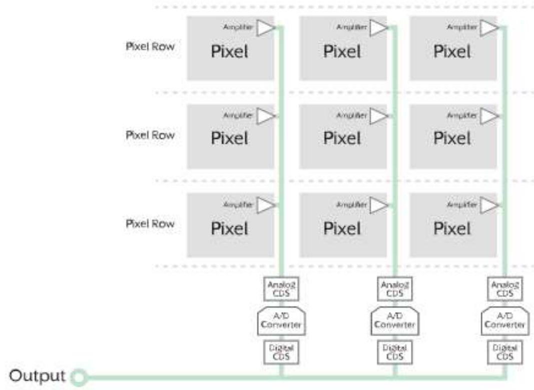
CCD

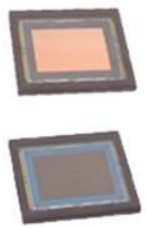


CCD characteristics:

- Global shutter
- Low noise
- High dynamic range
- Medium range frame rates
- Subject to smearing

CMOS





Modern CMOS characteristics:

- Global shutter and rolling shutter models
- Low to very low noise
- High to very high dynamic range
- Very high frame rates
- No smearing

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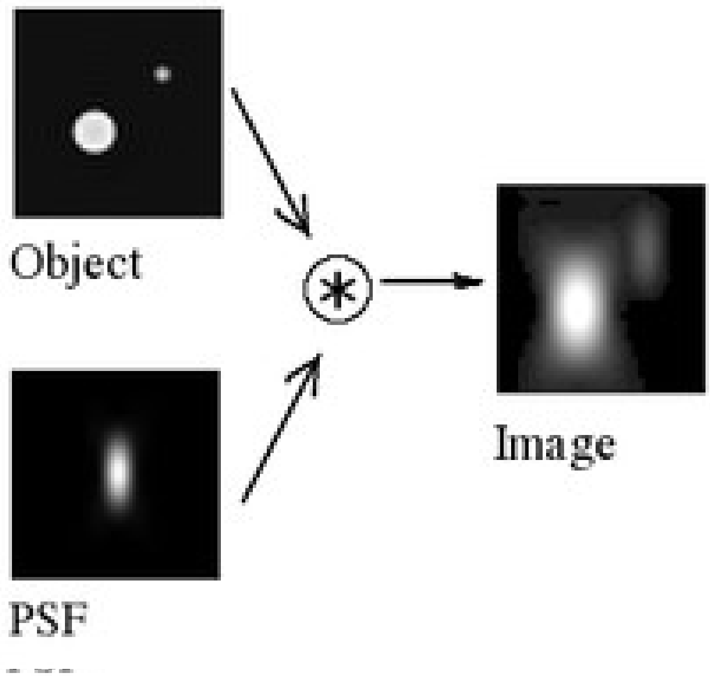
Résolution optique



- Distance minimale qui doit exister entre 2 points contigus pour qu'ils soient correctement discernés au travers d'un système optique.

- Dépend de la longueur d'onde et de la lentille

Objet ponctuel donne une tâche floue

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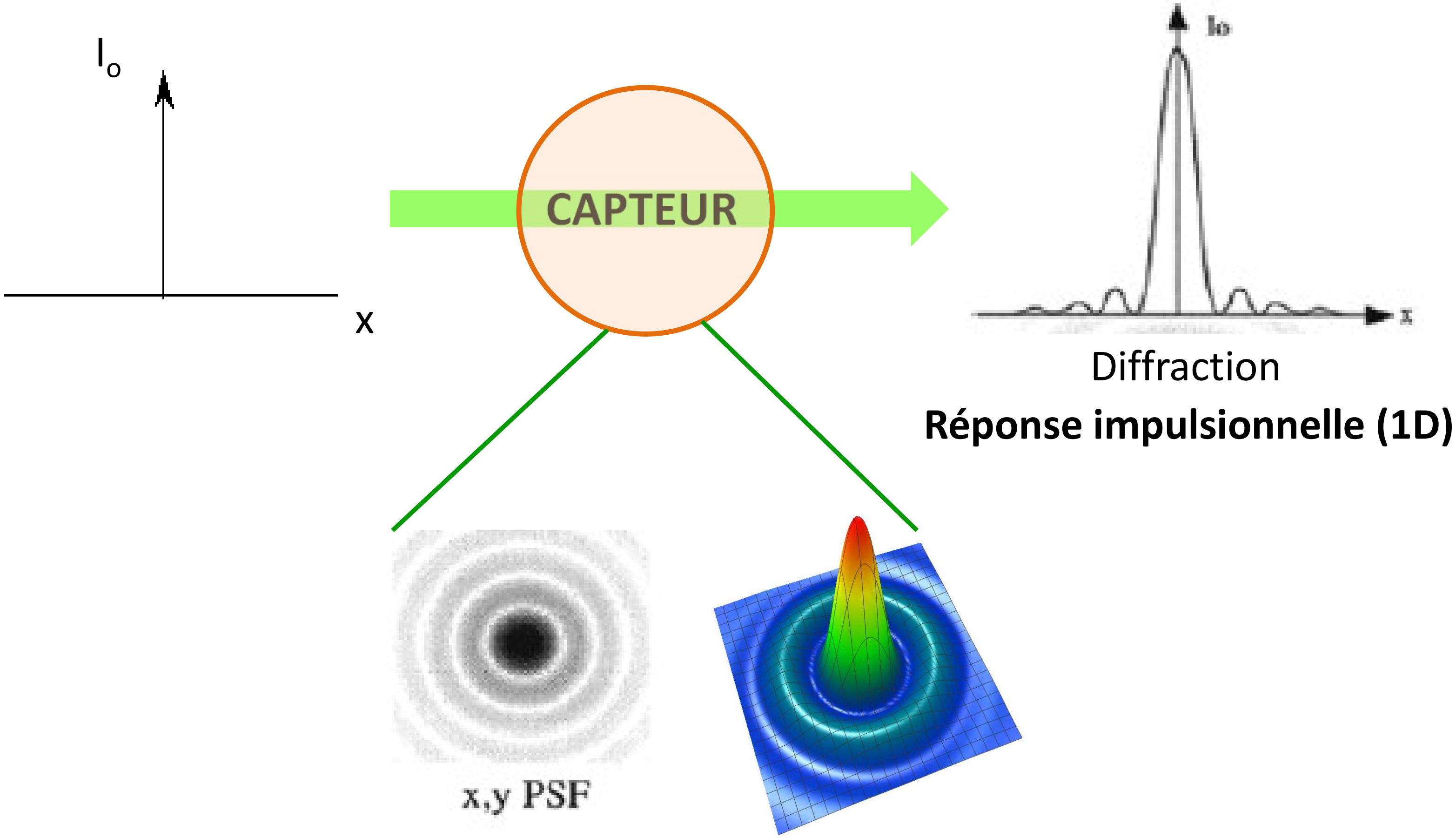
Fonction d'étalement (PSF)



(PSF -2D)

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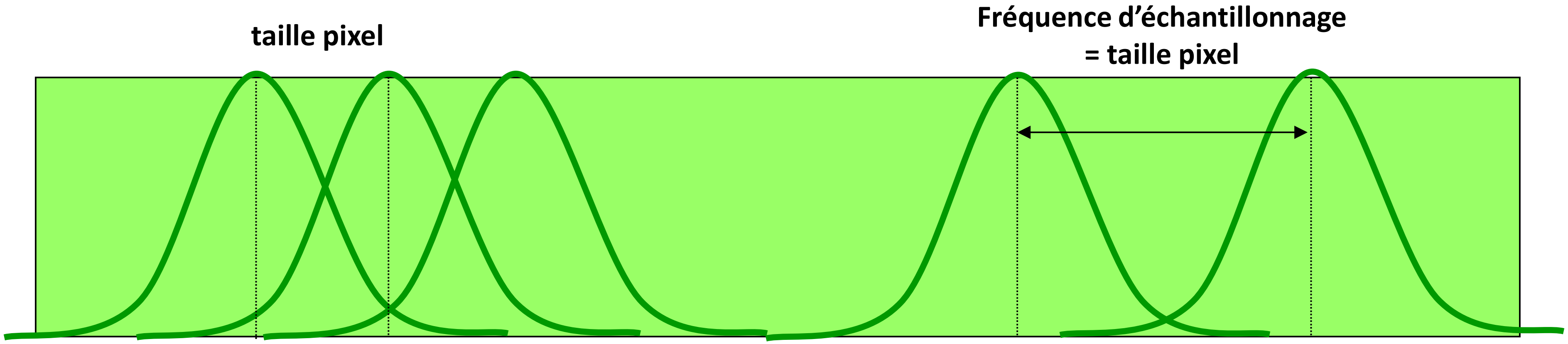
Théorème d'échantillonnage de Nyquist/Shanon



Sur-échantillonnage

Peu de bruit mais redondance de l'info

Sous-échantillonnage

Possibilité de perte d'information

- fréquence d'échantillonnage < 2* fréquence du signal
- En pratique
  - Taille pixel = 2.5,3 fois < résolution optique

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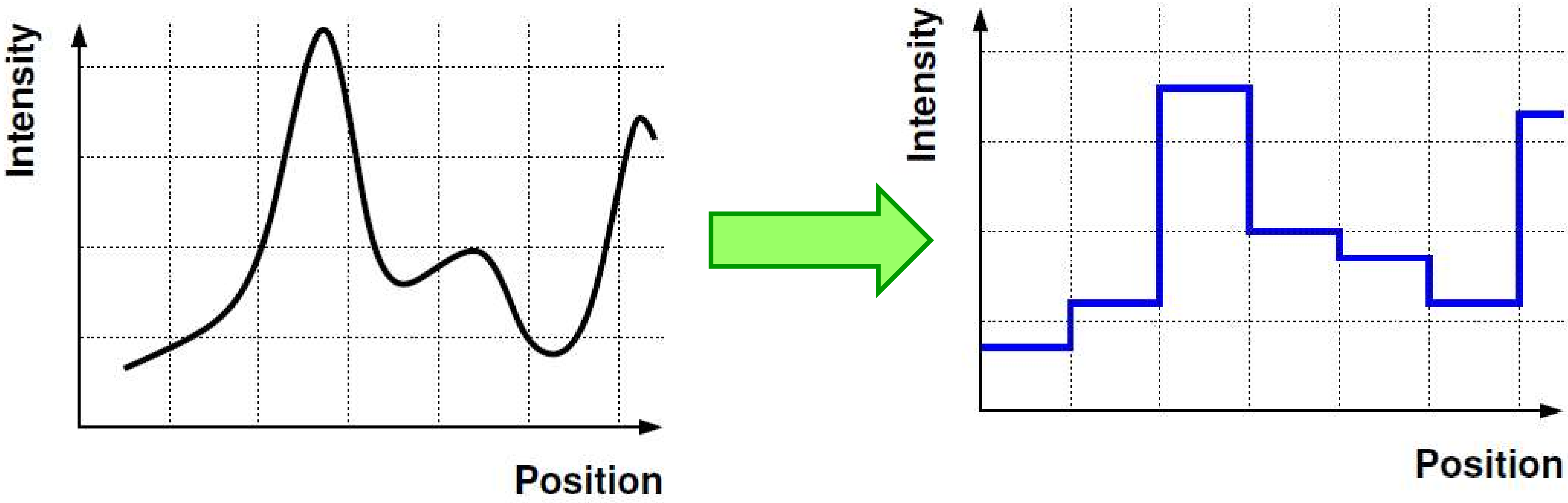
Quantification de l’intensité lumineuse (1)

- Discrétisation d’un signal continu ….



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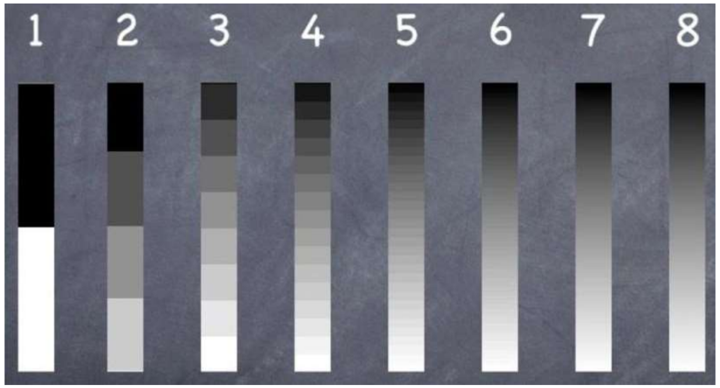
MW4

Profondeur d’une image

- Chaque pixel est codé sur un nombre limité de bits, n => 2^n niveaux de gris



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MW4 gamme de variation qui définit le codage
saturation du signal
decide du type de codage qu'on va utiliser
Marie Weiss; 20/11/2014

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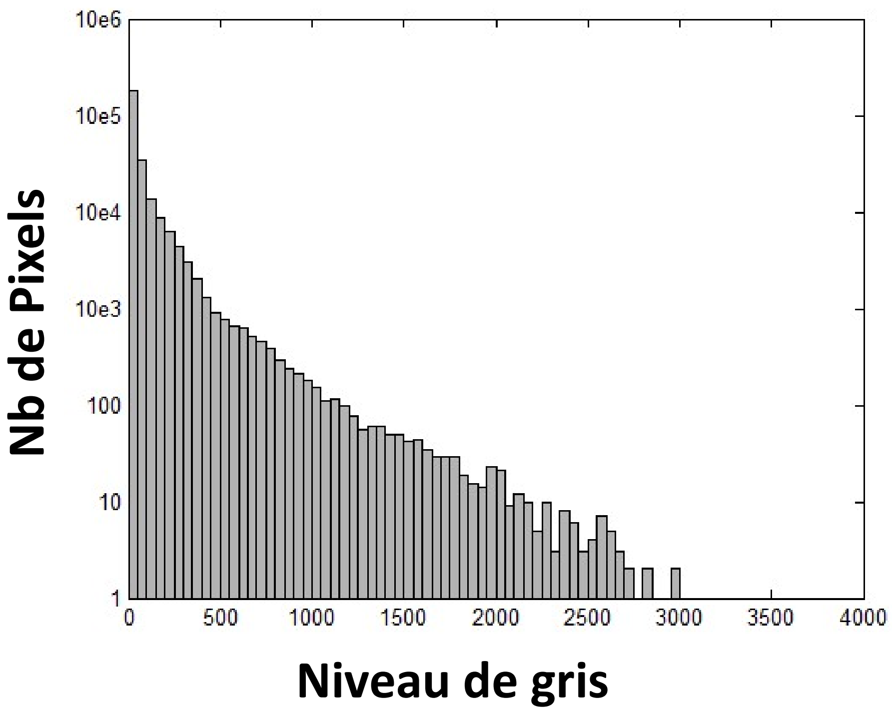
Quel choix de codage?

Codage	Nb de niveaux
10	1024
12	4096
16	65536
32	4 294 967 296



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Enregistrement des images

- Taille du fichier
  - Nombre de pixels * Nombre de niveaux de gris * Nombre de canaux* Nombre d’acquisitions (temps)

⇒

Compromis

- Taille fichier
- Dynamique des niveaux de gris dans l’image
- Niveau de précision requis pour l’accès à l’information

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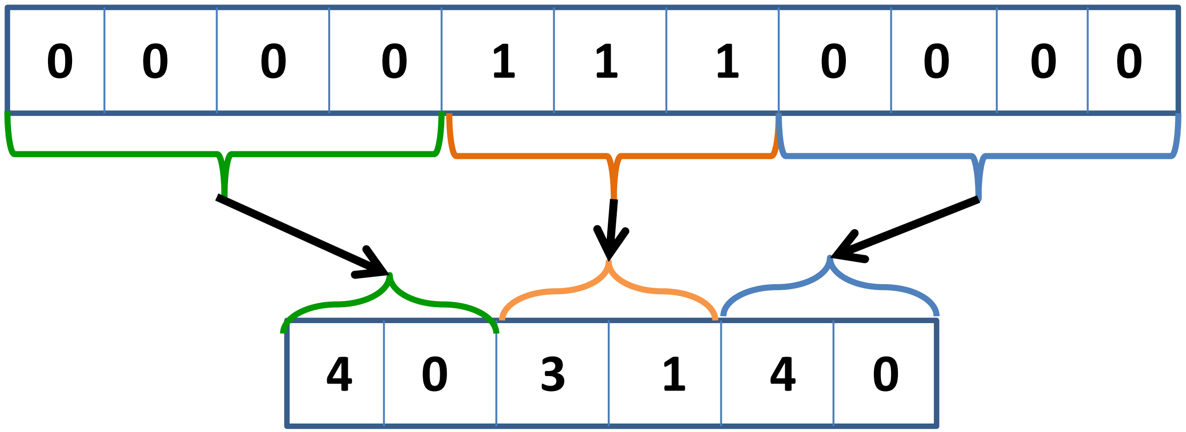
La compression de données

- Opération informatique consistant à transformer une suite de bits A en une suite de bits B plus courte pouvant restituer les mêmes informations

- Sans perte: pas de perte sur l'image d'origine

  Avec perte: image voisine, mais différente

- Sans perte:



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Compression jpeg

- Joint Photographic Expert Group
  - Transformation de couleur
  - Sous-échantillonnage (niveaux de gris)
  - Decoupage de l'image en blocs de 8x8 pixels
  - Application de la transformée en cosinus
(passage en fréquence)
  - Quantification des blocs
  - Codage

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Format des images

- Format Raw = format de base
  - pas d'info sur le codage
- Formats génériques

	Type d'image (bits/pixel)						Compression	
Format	1	8	8+LUT	16	24	32	CAP	CSP
BMP	●	●	●	●	●	●		(●)
GIF			●					●
TIFF	●	●	●	●	●	●		●
PNG	●	●	●	●	●	●		●
JPEG					●		●	
JPEG 2000					●		●	●

[CAP (CSP) = compression avec (sans) perte]

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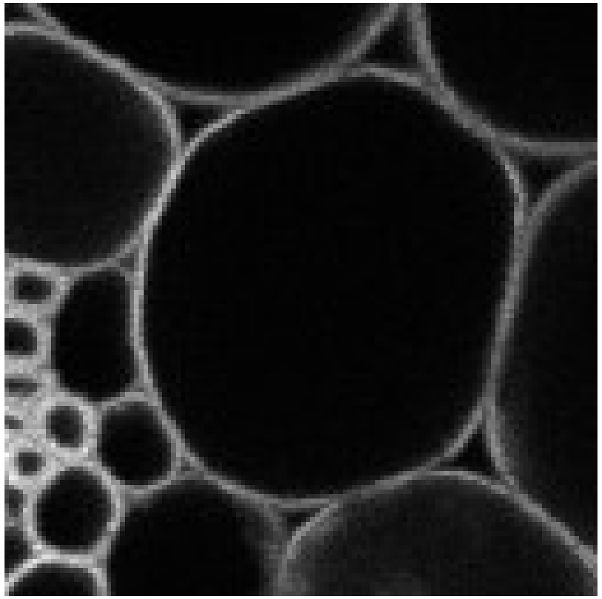
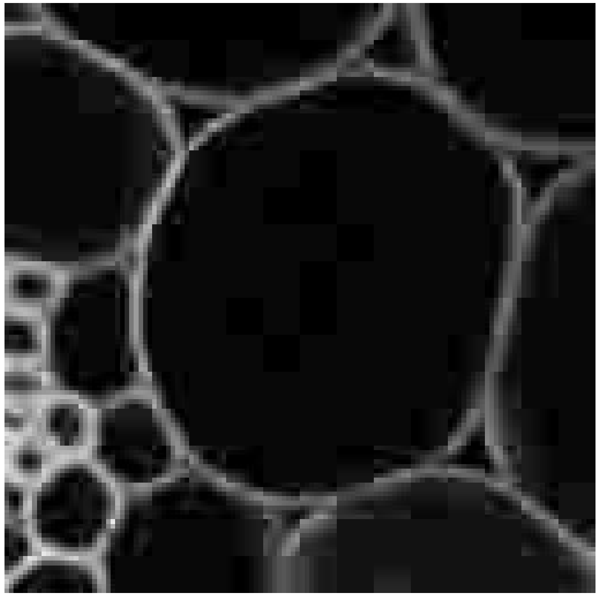
Dégradation par compression

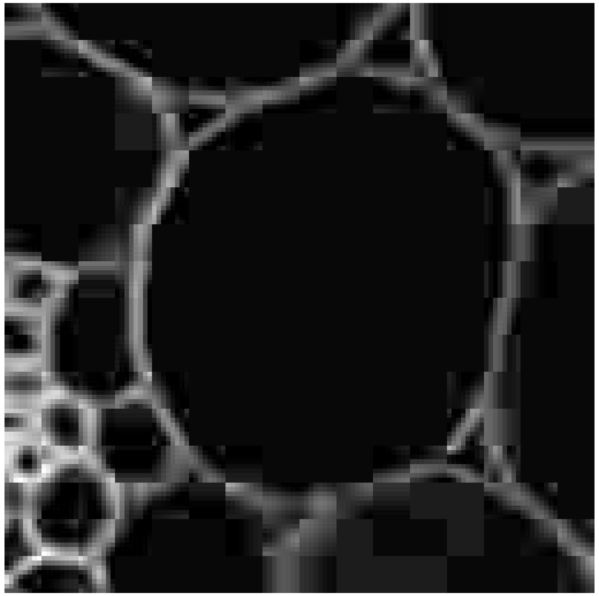
jpeg



Original (100%)



10%



5%

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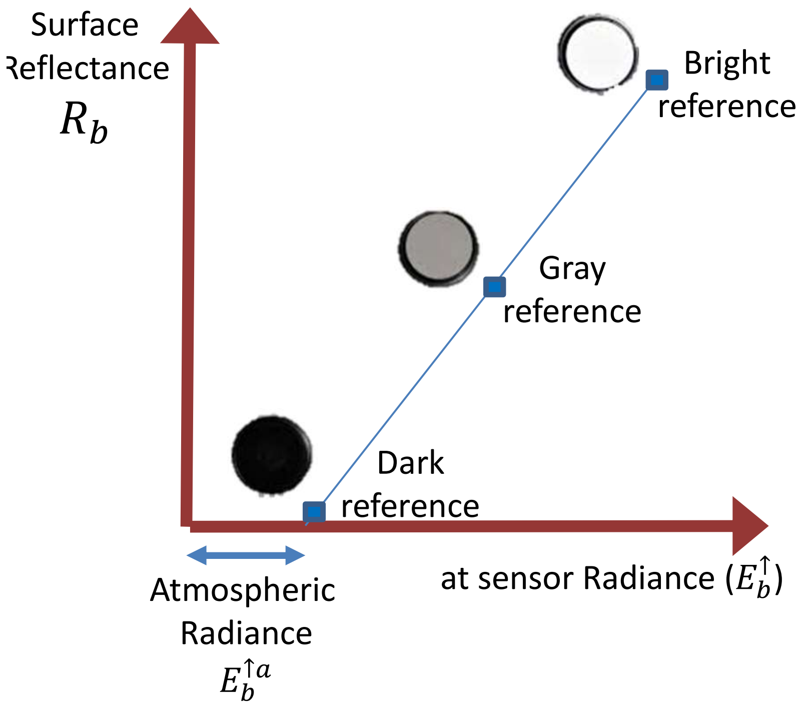
Radiometric calibration: Empirical line method



Setting several reference panels in the experimental field.

- Panels should be strictly horizontal
- Placed far from obstacles
- Of known reflectance

$$R_b = \frac{\alpha_b\left(E_b^{\uparrow} - E_b^{\uparrow a}\right)}{E_b^{\downarrow}}$$

The atmospheric radiance is neglectable (low altitude flights) : $E_b^{\uparrow a}$=0

-> a single bright reference panel is sufficient

Reference: $R_b^{ref} = \alpha_b \frac{E_b^{\uparrow}(ref)}{E_b^{\downarrow}}$

Target: $R_b^{tar} = \alpha_b \frac{E_b^{\uparrow}(tar)}{E_b^{\downarrow}}$

$$R_b^{tar} = R_b^{ref} \frac{E_b^{\uparrow}(tar)}{E_b^{\uparrow}(ref)}$$

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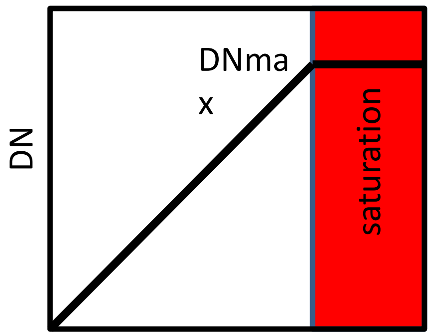
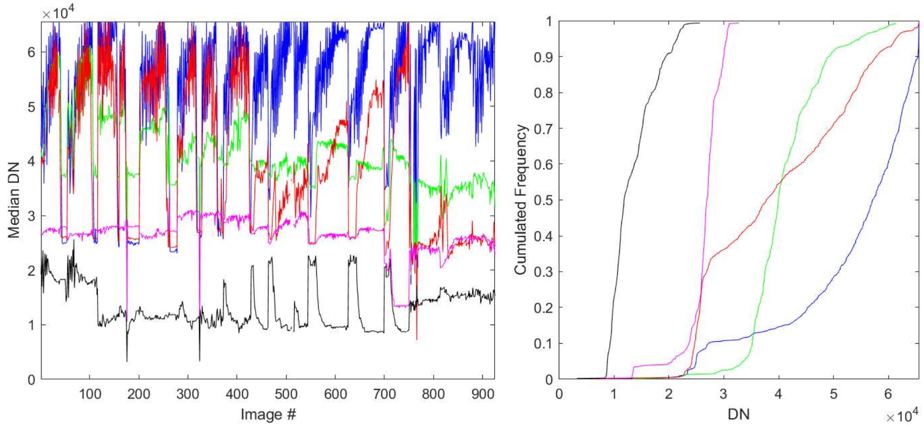
Pixel saturation

The light intensity is transformed into DN (digital numbers) for each pixel of the matrix
Saturation is observed when DN=DNmax





Example of DN values during a flight (AIRPHEN camera 12 bits coding)

Saturation occurs when:

- Too much light
  - Bright sunny conditions
  - Specular reflection
  - Bright target over dark background
- Camera settings:
  - Exposure time too long
  - Gain of the camera (ISO) too large

Saturation pixels: no information except that it is bright!

- Better have underexposed than saturated images
- Never get saturation on the radiometric calibration panels!
- Marginal fraction of saturated pixels is acceptable (specular)

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The quantities used (multispectral camera)

- ***DN values.*** The AIRPHEN camera records DN values corresponding to each pixel in an image. The DN values are coded in 12 bits and vary thus between 0 to 65535.

- ***Exposure time (Ex).*** Each image is taken with an exposure time set automatically by each elementary camera. It varies between 0.0005 to 0.0037 seconds.

- ***Flux (F).*** The flux corresponds to the actual radiation intensity that was received by the pixel (in relative units). For each band b, it is thus the ratio between the DN value (proportional to the actual radiation energy captured by the pixel and the exposure time, Ex_b: $F_b = \frac{DN_b}{Ex_b}$

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RGB cameras: white balance

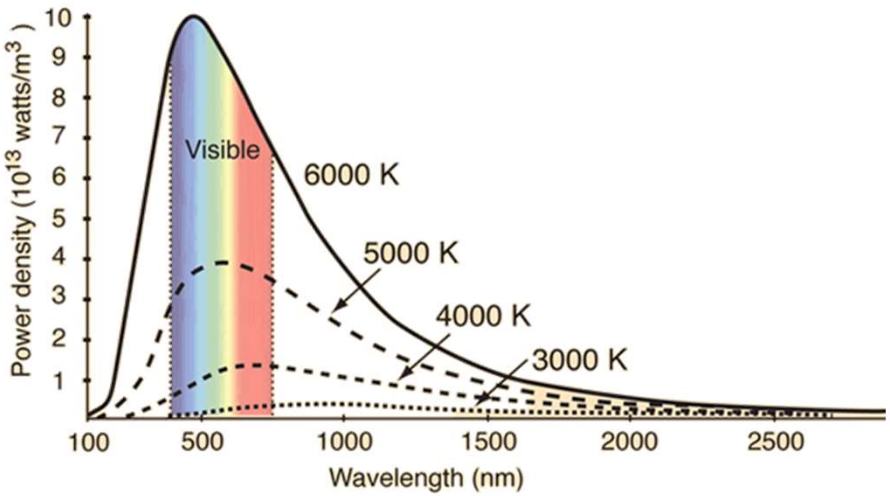
The spectral distribution of incident light depends on the illumination conditions

For RGB cameras, white balance is necessary for better color rendering

$$DN^b_{Correct} = \frac{DN^b_{Raw}}{DN^b_{White}} Scale$$

- $DN^b_{Correct}$: White balance corrected DN value for band b
- DN^b_{Raw}: Raw DN value
- $Scale$: Coefficient to account for the reflectivity of the white panel
- DN^b_{White}: DN value over the white (or gray) panel under the same illumination conditions

WB SETTINGS	COLOR TEMPERATURE	LIGHT SOURCES
	10000 - 15000 K	Clear Blue Sky
	6500 - 8000 K	Cloudy Sky / Shade
	6000 - 7000 K	Noon Sunlight
	5500 - 6500 K	Average Daylight
	5000 - 5500 K	Electronic Flash
	4000 - 5000 K	Fluorescent Light
	3000 - 4000 K	Early AM / Late PM
	2500 - 3000 K	Domestic Lightning
	1000 - 2000 K	Candle Flame



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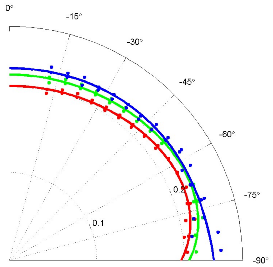
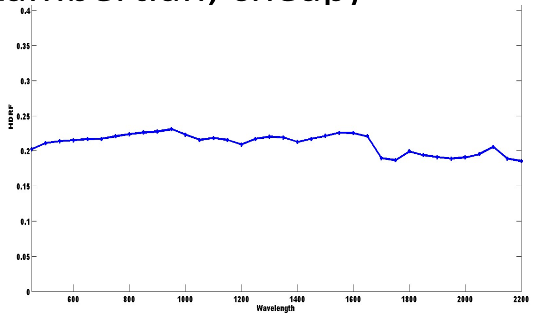
Reference panel

- Use the 20% gray carpet (no saturation, relatively Lambertian, cheap)

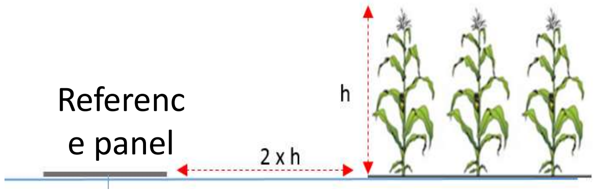


Directional properties



Spectral properties

- Place the reference panel horizontal (very important if absolute reflectance)
- Place the reference panel
  - Close to the take-off place: extract manually the values of the DNs and integration time
  - Within the experiment: take the RTK-GPS coordinates (center)
- Make sure that the reference panel is at least at 2 times distance to the closest obstacle



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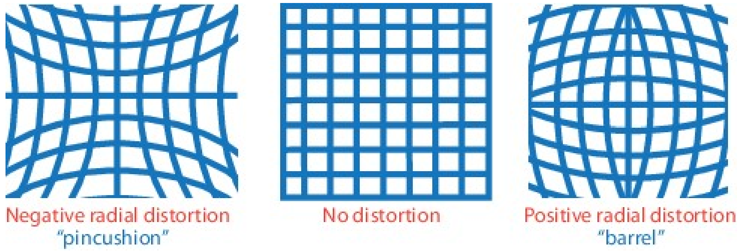
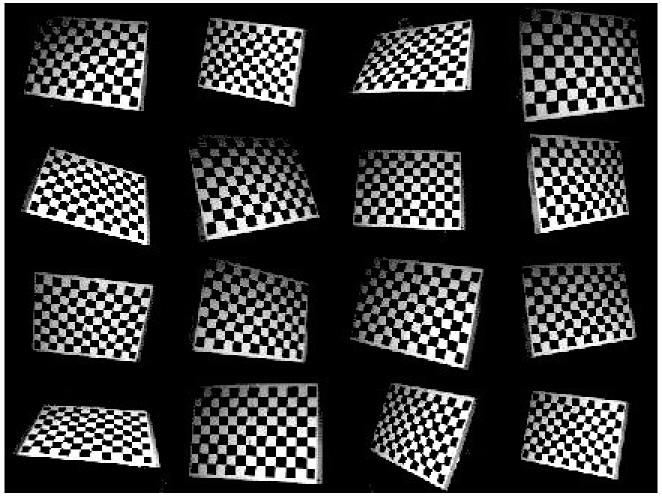
Camera geometric characterization

Cameras (optical system) induces significant deformation of the resulting image



It is possible to characterize the camera and apply corrections.
Several software packages are available for camera characterization using multiple views of a checkboard



Except when using stereophotography, camera characterization is not necessary since the SfM softwares are doing the job

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Vignetting correction

When looking at a uniform surface, the resulting image shows vignetting effects: variation of the DN values within the image

This is due to the optical system, with light on the corners of the image being not normal to the pixel matrix (divergence)

Corrections should be applied by dividing by the image of an homogeneous scene

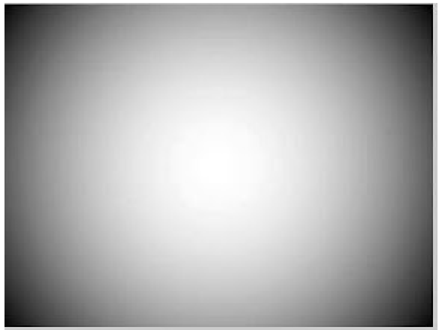
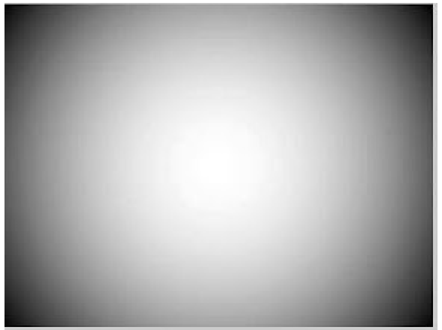


Image of an homogeneous scene

/



Correction factor

=

Corrected image

Correction factor: homogeneous panel imaged outside. Better rotate and move the camera over the panel and average all the images. The smooth the resulting image

Possibility to characterize the vignetting by a radial function (polynom)

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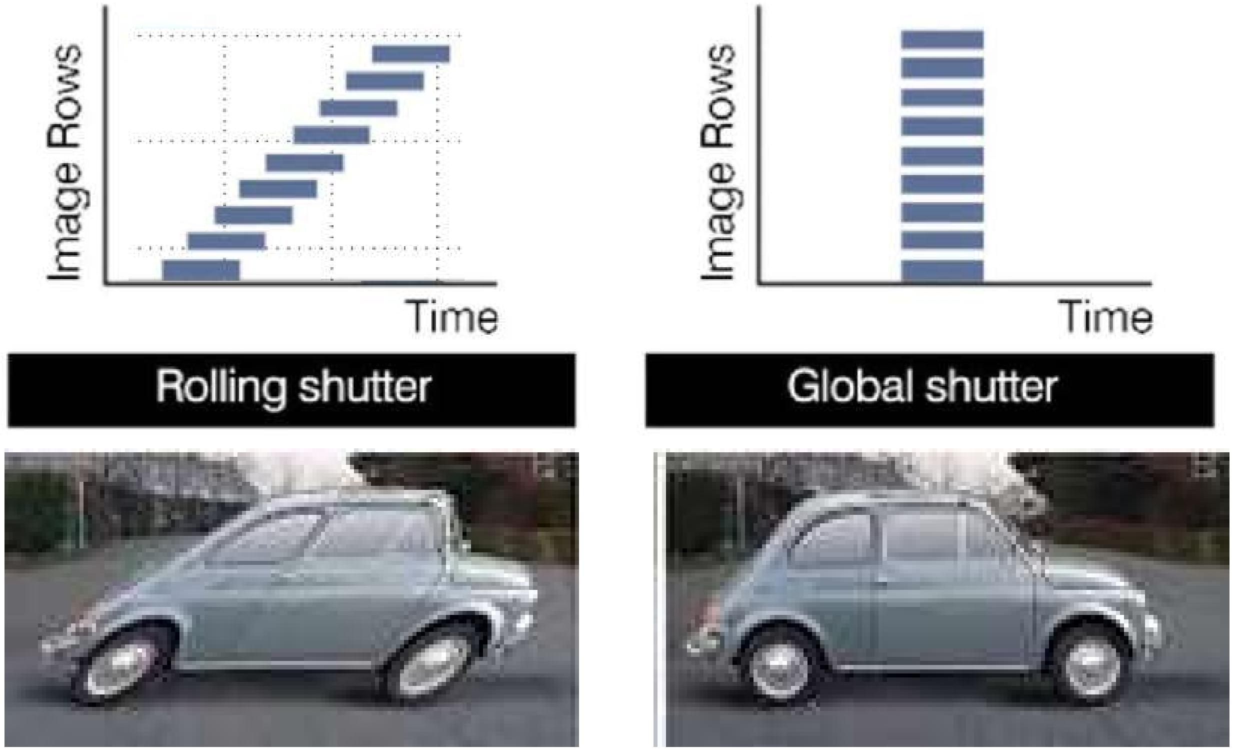
Camera: Global shutter / rolling shutter

- The shutter allows to control the exposure time of the image



Better use global (total) shutter cameras to avoid deformations in the image
Photoscan and Pix4D account for this effect (to some extent)

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Motion blur

When the scene is significantly moving during image acquisition (exposure time)

P: pixels size (cm)
S: vector speed (m/s)
Ti: exposure time
D: displacement during Ti

D=S . Ti

D << P **Displacement should be smaller than P**

Example
P = 5 cm
S = 10 m/s (36 km/h)
Ti = 1 ms
D = 10 m/s . 10^{-3} s = 10^{-2} m = 1cm
D (1 cm) << P (5 cm)

To decrease the motion blur for a given resolution:

- **Decrease the speed**
- **Decrease the exposure time**

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Métadonnées

- Renseignent l'image
  - Base: nombre de lignes/colonnes/canaux, taille du pixel, profondeur
  - Informations sur le capteur: système, marque, calibration,…
  - Conditions d'acquisition (Date, ouverture,…)
  - Niveau de compression
  - Informations spécifiques au type d'image

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Format spécifiques

- Particulièrement adaptés à un domaine d'application
  - Format hdf : télédétection et extension….
  - Format zvi : microscopie
  - …….

- Métadonnées associées spécifiques
  - Contenues dans l'image elle-même (exif, geotiff)
  - Contenues dans un fichier auxiliaire (ascii, xml)

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Exemples de fichier de métadonnées

```
ENVI
description = {
  Create New File Result [Fri Nov 21 12:
samples = 1200
lines   = 1200
bands   = 2
header offset = 0
file type = ENVI Standard
data type = 5
interleave = bsq
sensor type = MODIS
byte order = 0
map info = {Sinusoidal, 1.0000, 1.0000,
projection info = {16, 6371007.2, 0.00000
coordinate system string = {PROJCS["Sinu
wavelength units = Unknown
data ignore value = 2.55000000e+002
```

- Fichier ascii

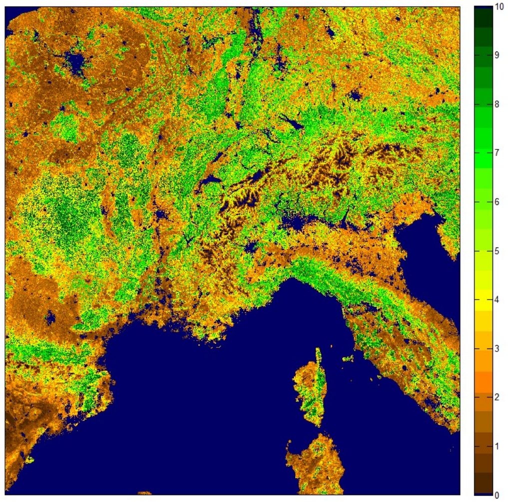

Image du 12 juillet 2010
LAI = indice foliaire
(surface de feuilles/m²)


```
<?xml version="1.0" encoding="UTF-8" ?>
  <!DOCTYPE GranuleMetaDataFile (View Source for full doctype...)>
- <GranuleMetaDataFile>
  <DTDVersion>1.0</DTDVersion>
  <DataCenterId>EDC</DataCenterId>
- <GranuleURMetaData>
  <GranuleUR>SC:MOD15A2.005:2080313584</GranuleUR>
  <DbID>2080313584</DbID>
  <InsertTime>2010-07-21 19:19:33.447</InsertTime>
  <LastUpdate>2010-07-22 02:32:26.026</LastUpdate>
- <CollectionMetaData>
  <ShortName>MOD15A2</ShortName>
  <VersionID>5</VersionID>
  </CollectionMetaData>
- <DataFiles>
- <DataFileContainer>
<DistributedFileName>MOD15A2.A2010193.h18v04.005.2010203001450.hdf</DistributedFileName>
  <FileSize>3192793</FileSize>
  ……..
```


- Fichier xml

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