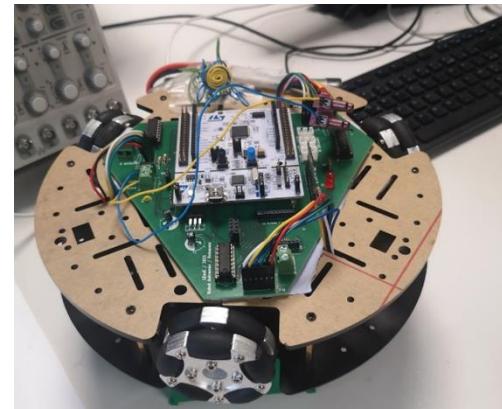
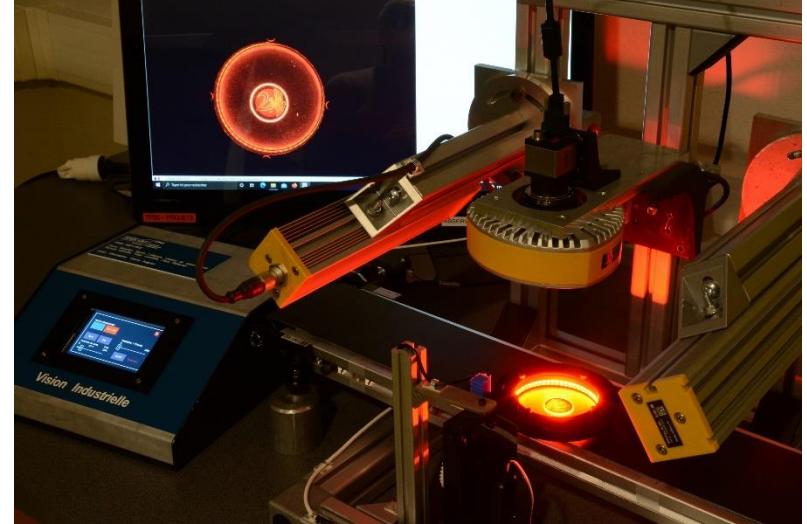
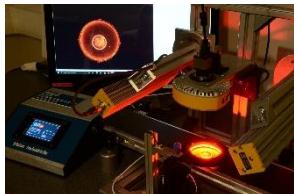


# Interfaçage Numérique

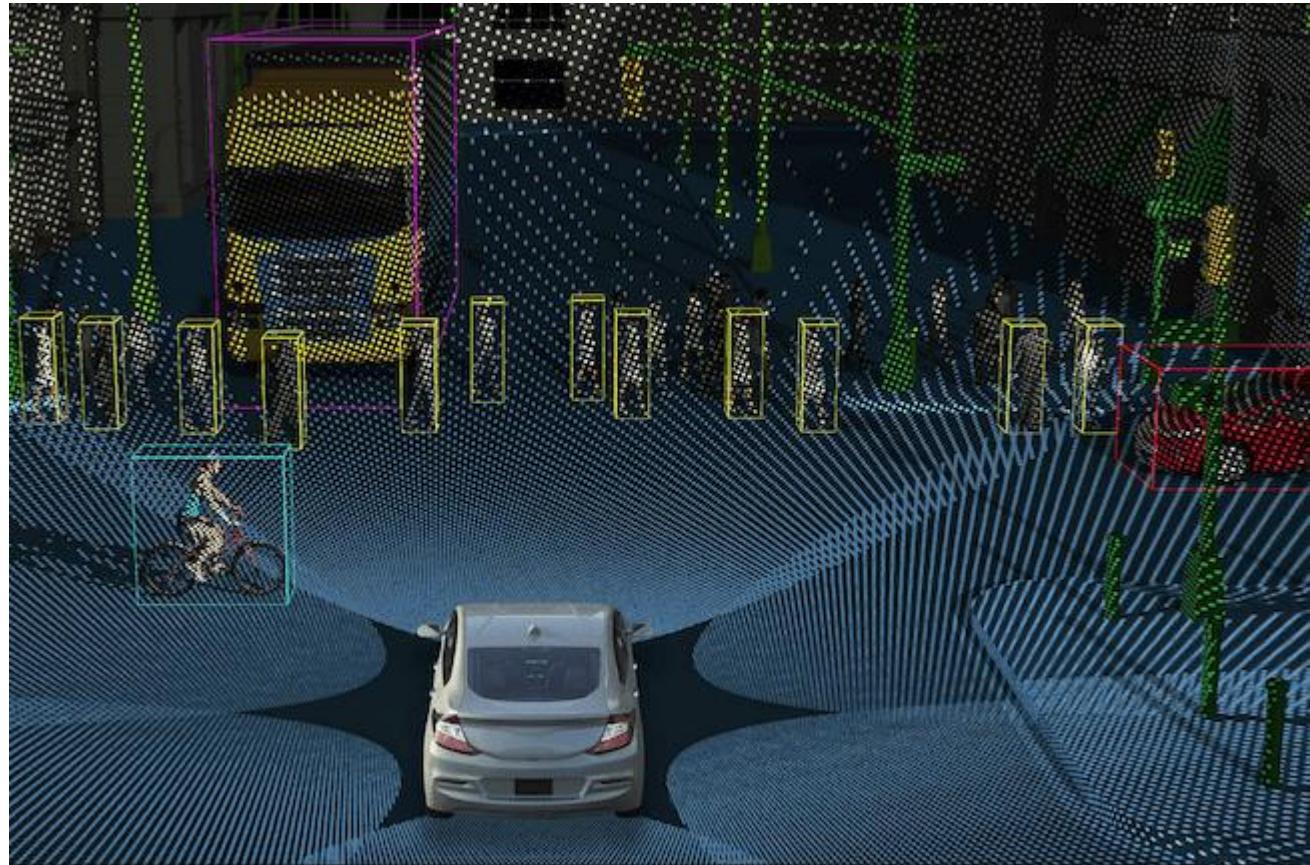
## Vision Industrielle

Julien VILLEMEJANE





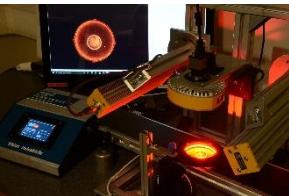
[https://www.keyence.fr/landing/lpc/vision-industrielle\\_fr\\_sem\\_190417.jsp](https://www.keyence.fr/landing/lpc/vision-industrielle_fr_sem_190417.jsp)



<https://www.frenchweb.fr/aeye-16-millions-de-dollars-pour-ameliorer-les-capteurs-lidar-des-voitures-autonomes/296495>

# Vision Industrielle

## Machine Vision



Système basé sur un **système imageant** permettant d'**automatiser les procédés d'inspection** de produits



### Prendre une décision

#### Contrôle Qualité / Tri d'objets

- Déetecter des défauts ou irrégularités
- Vérifier l'uniformité de surface
- Compter ou/et trier des objets

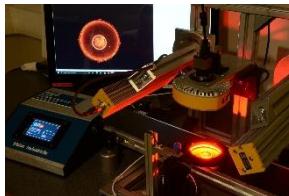
#### Gain en efficacité et en répétabilité

- Inspection en temps réel et à vitesse élevée
- Opérations en continu

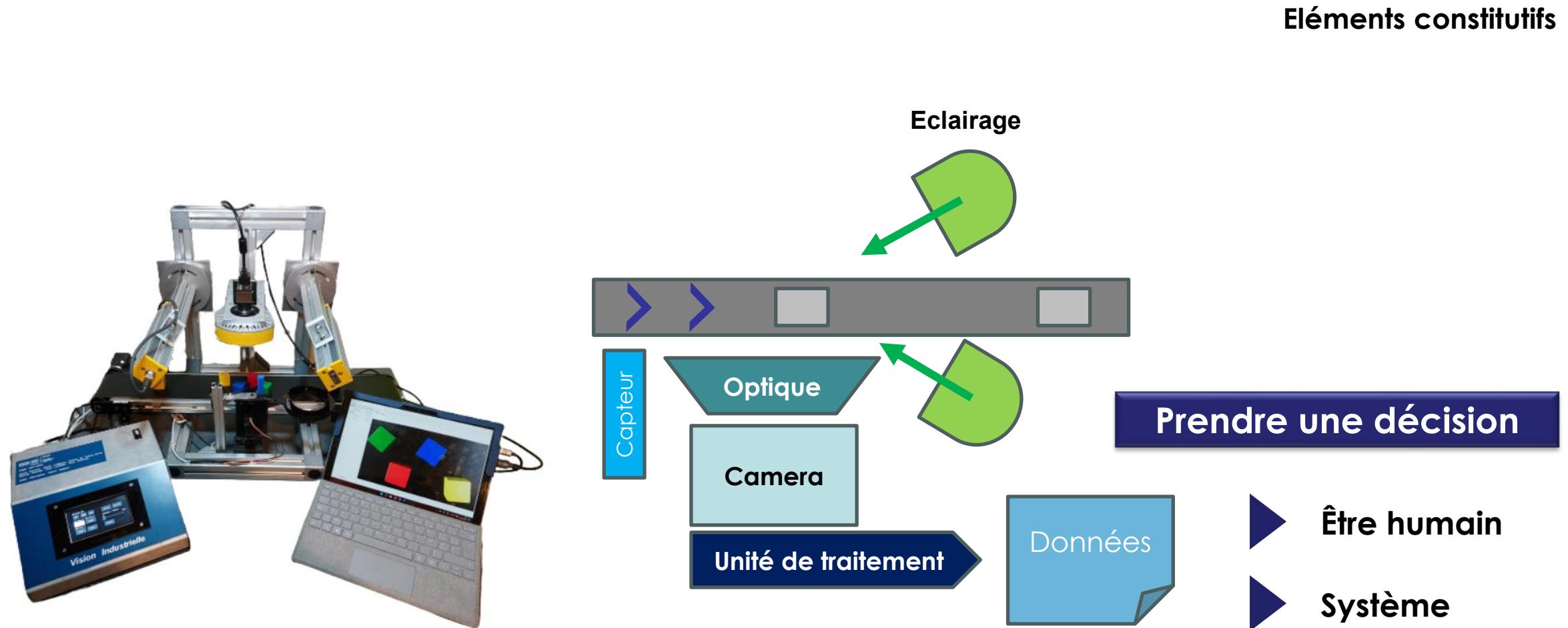


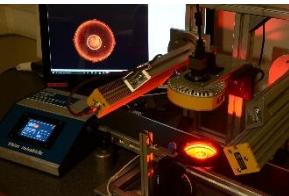
# Vision Industrielle

## Machine Vision



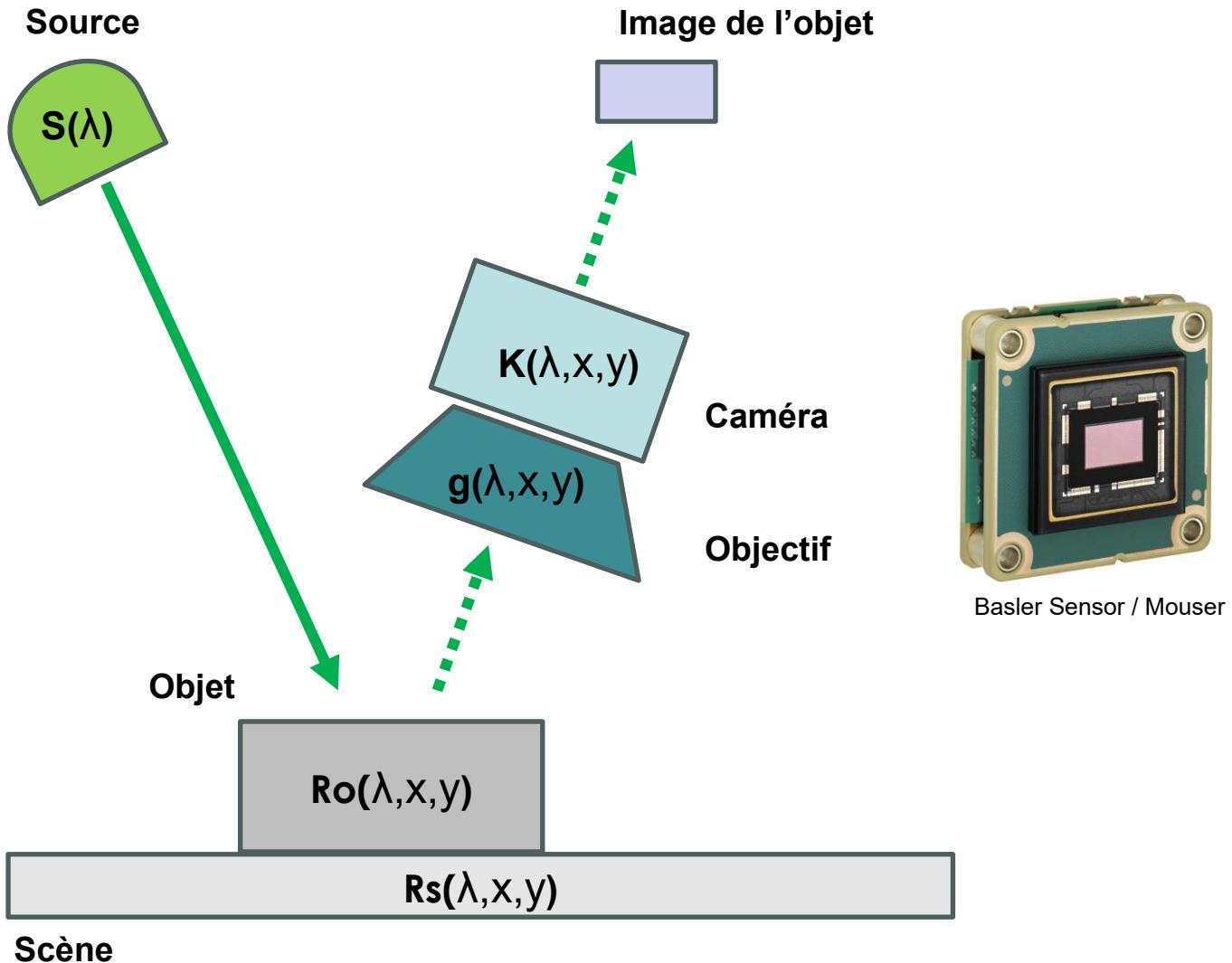
# Vision Industrielle





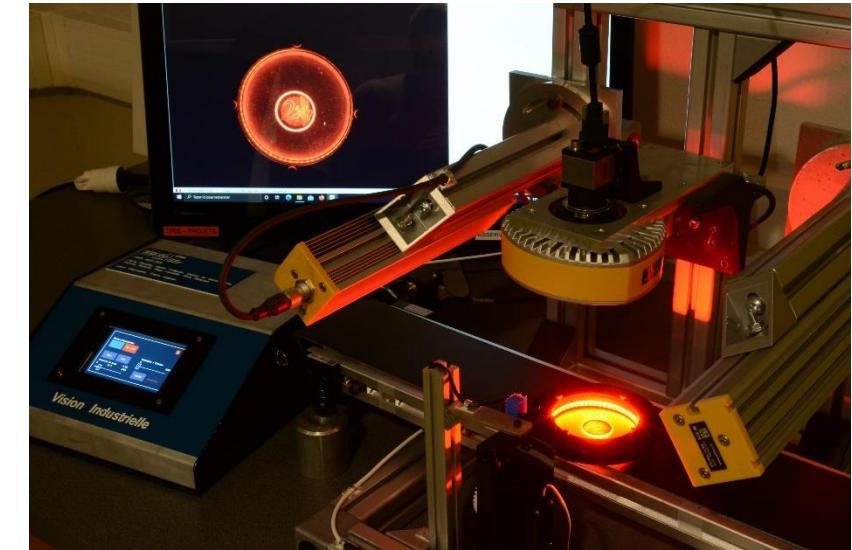
# Vision Industrielle

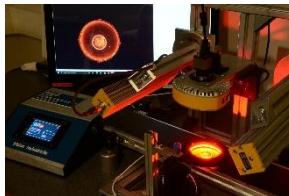
## Modélisation de la chaîne



# Objets / Sources

Eclairage / Colorimétrie

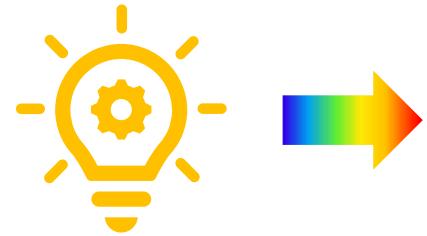




# Sources

## Sources primaires

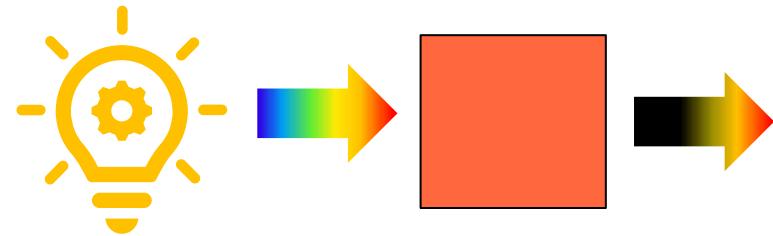
Produisent leur propre lumière



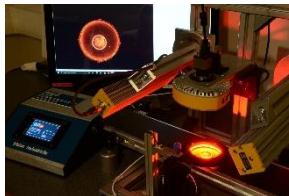
Caractérisées par leur **spectre d'émission**

## Sources secondaires

Diffusent la lumière produite par une source primaire

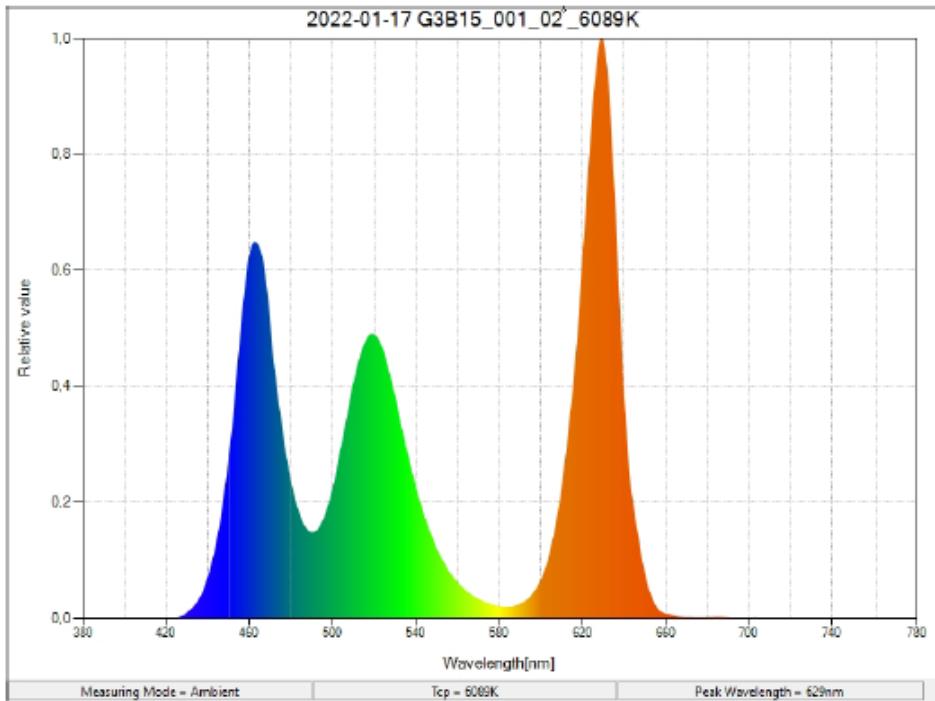


Caractérisées par le **spectre de l'illuminant** et leur **spectre en réflectance**



# Sources

## Spectre d'émission

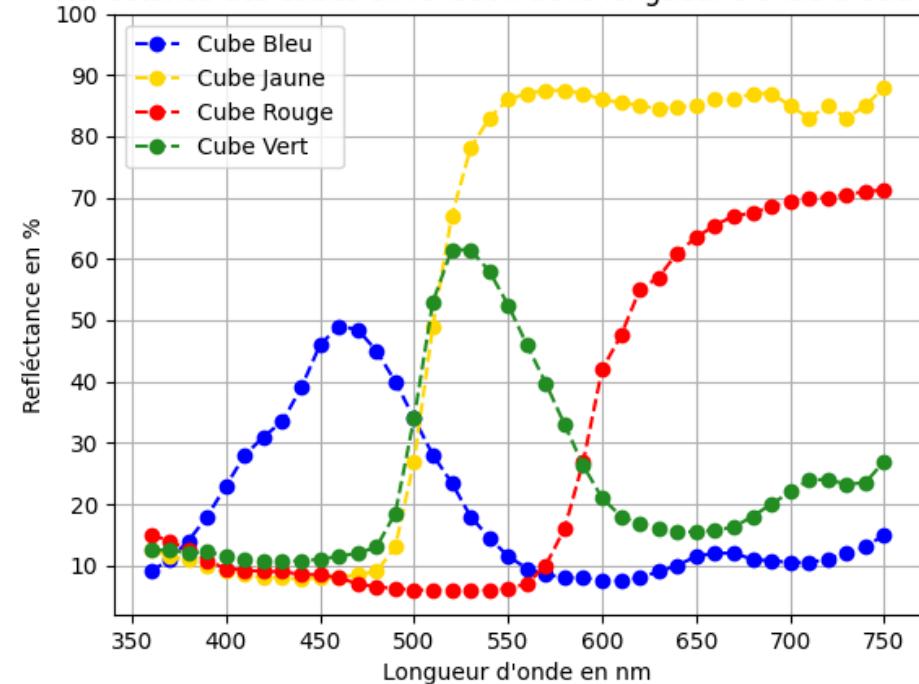


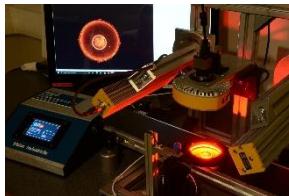
Source Effilux Ring RGB

## Réflectance

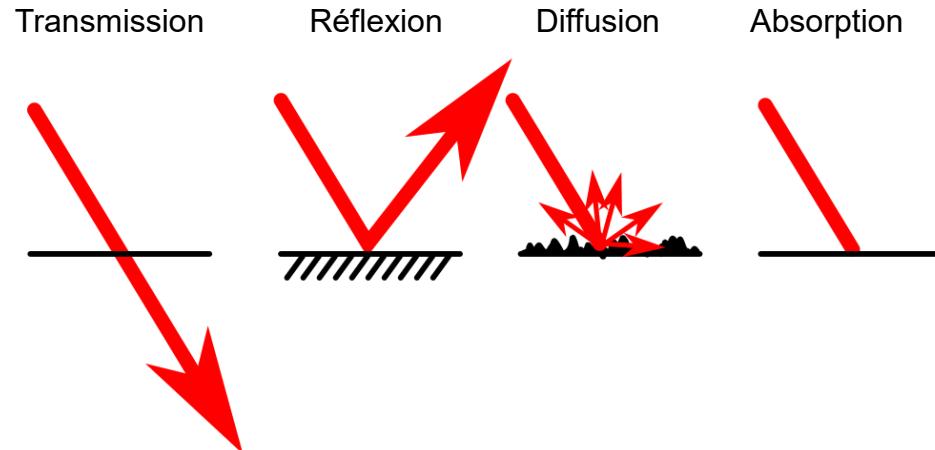


Réflectance des cubes en fonction de la longueur d'onde d'éclairage

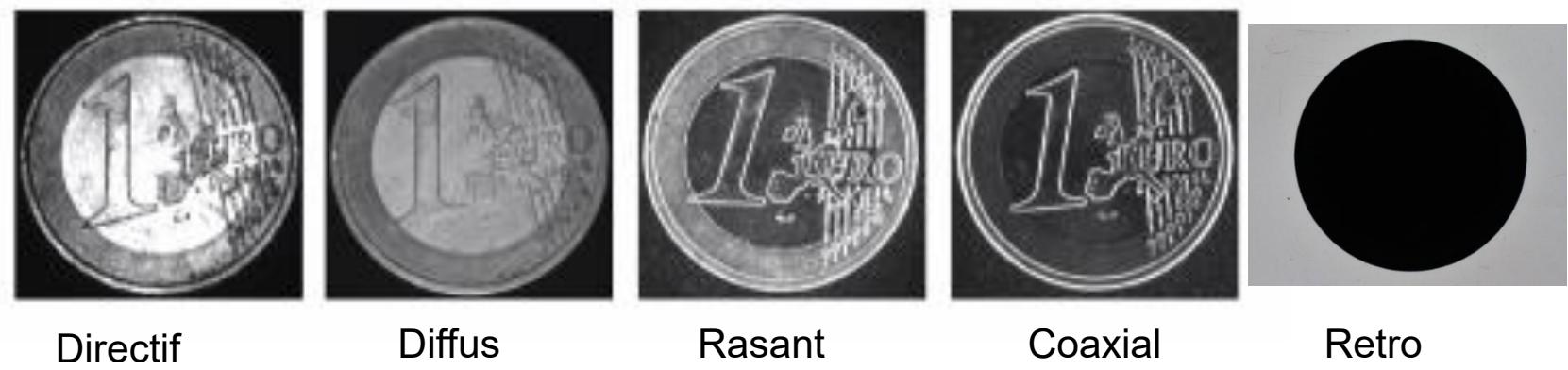




# Eclairage



## Impact du type d'éclairage / Nature des objets



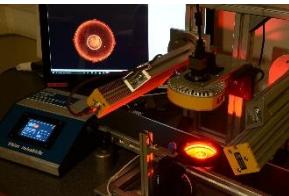
Directif

Diffus

Rasant

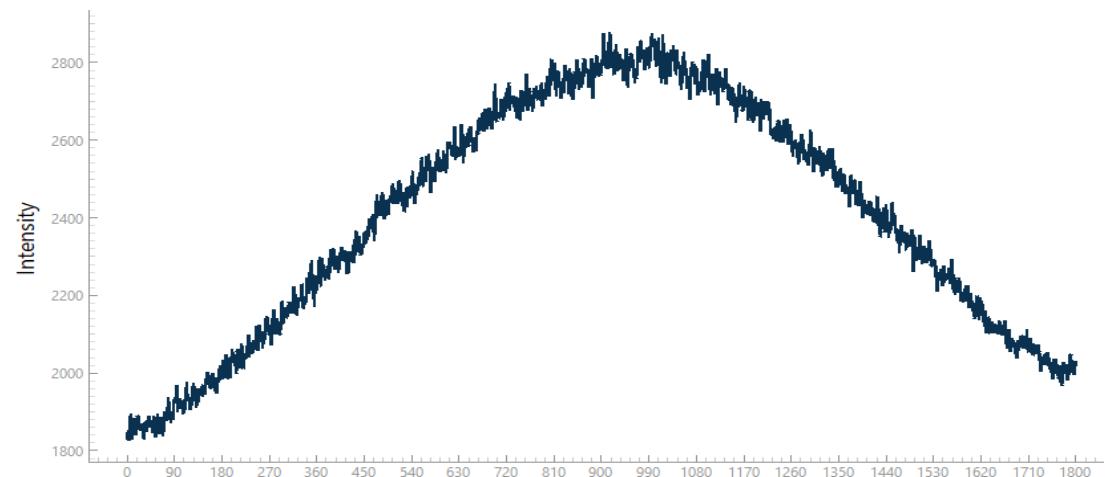
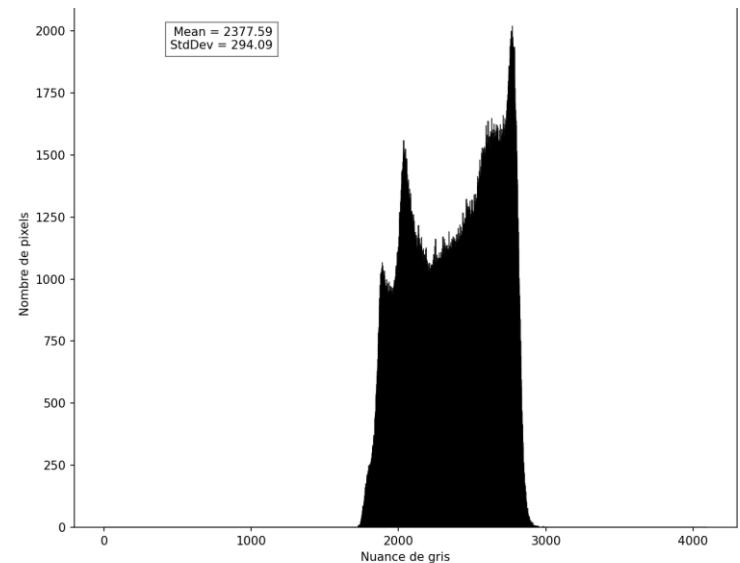
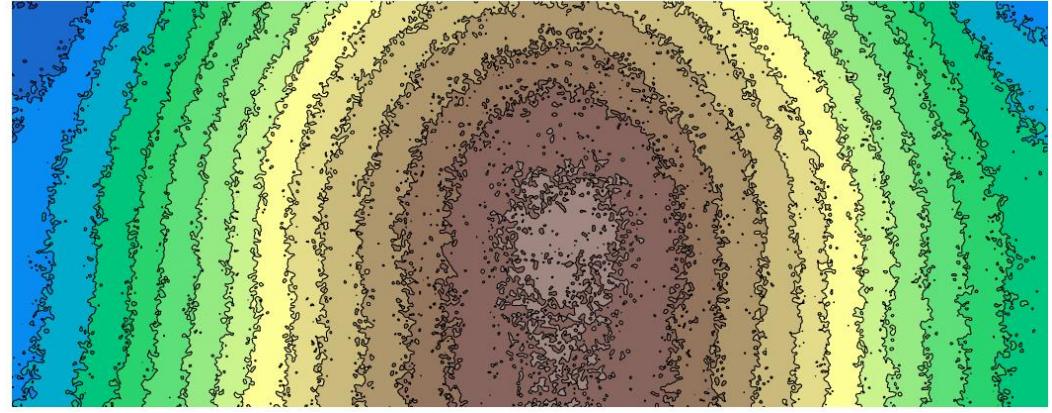
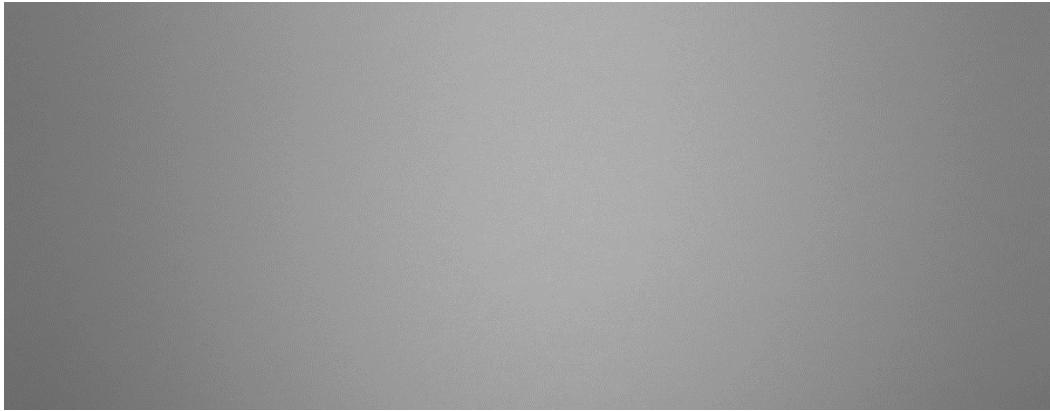
Coaxial

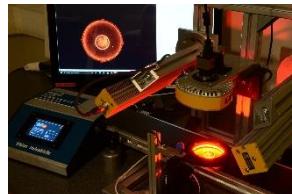
Retro



# Eclairage

## Uniformité de l'éclairage





# Colorimétrie

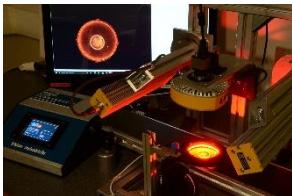
*Image prise par un capteur optique  
(sans balance des blancs)*



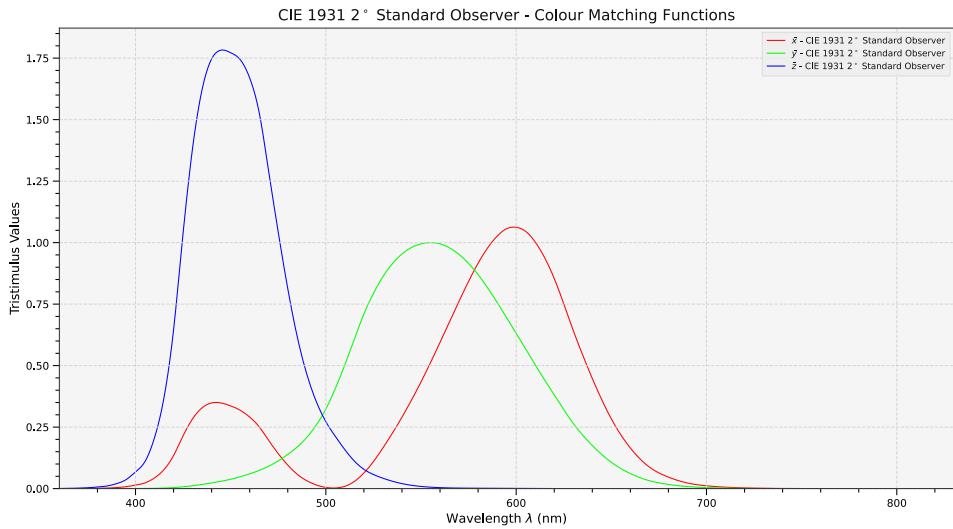
*Image vue par un humain  
(grâce à l'adaptation chromatique)*



► Fairchild, *Color Appearance models*

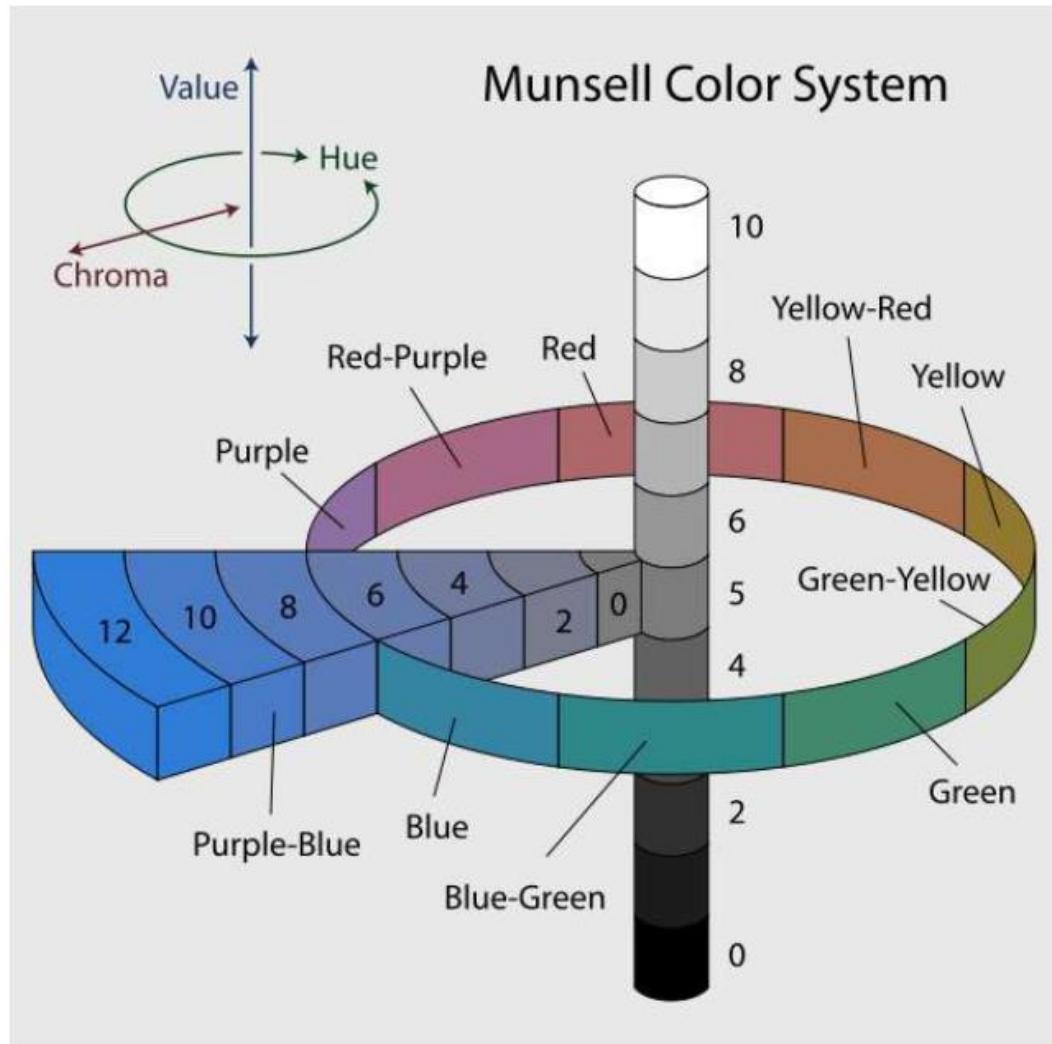


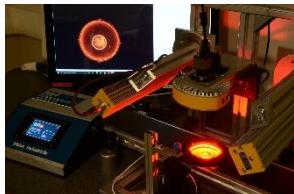
# Colorimétrie



$$K_m = 683 \text{ lm/W}$$

$$\left\{ \begin{array}{l} X = K_m \int_0^{\infty} \bar{x}(\lambda) L_{e,\lambda}(\lambda) d\lambda \\ Y = K_m \int_0^{\infty} \bar{y}(\lambda) L_{e,\lambda}(\lambda) d\lambda \\ Z = K_m \int_0^{\infty} \bar{z}(\lambda) L_{e,\lambda}(\lambda) d\lambda \end{array} \right.$$

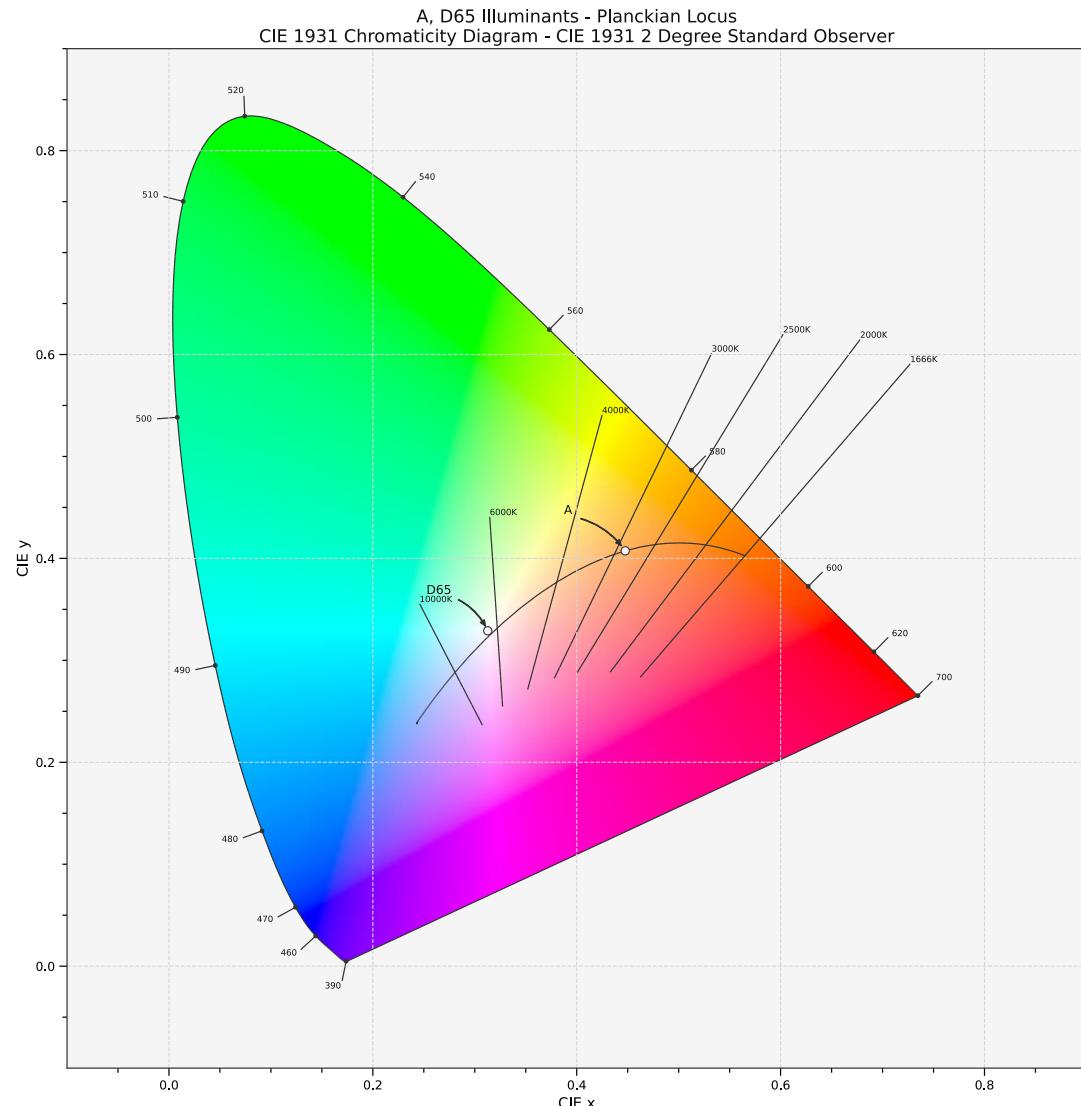
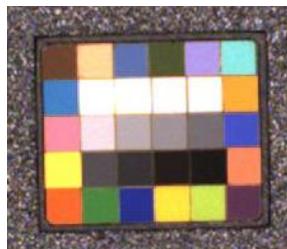




*Diagramme de chromaticité CIE 1931 xy*

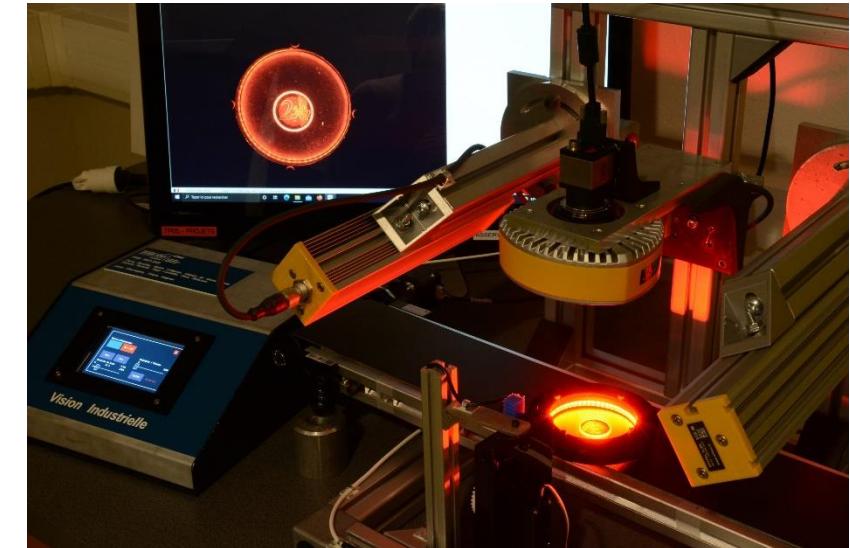
$$\begin{cases} x = \frac{X}{X + Y + Z} \\ y = \frac{Y}{X + Y + Z} \end{cases}$$

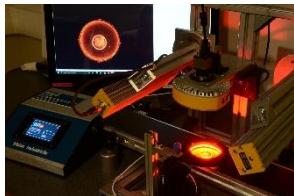
*Les coordonnées (x,y) définissent la couleur de la source échantillon*



# Objectif optique

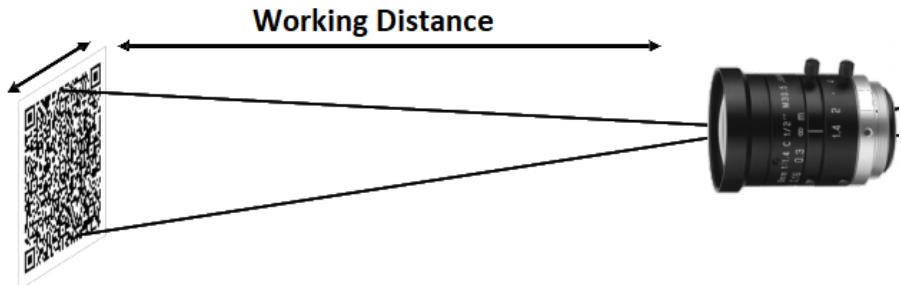
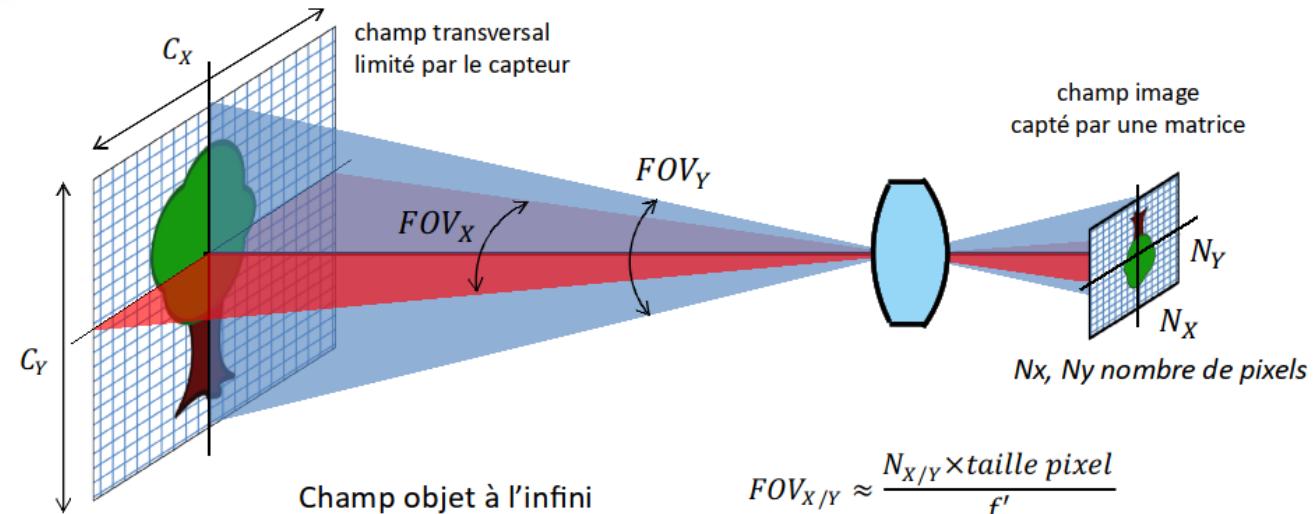
Créer une image exploitable

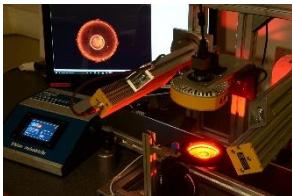




# Objectif optique

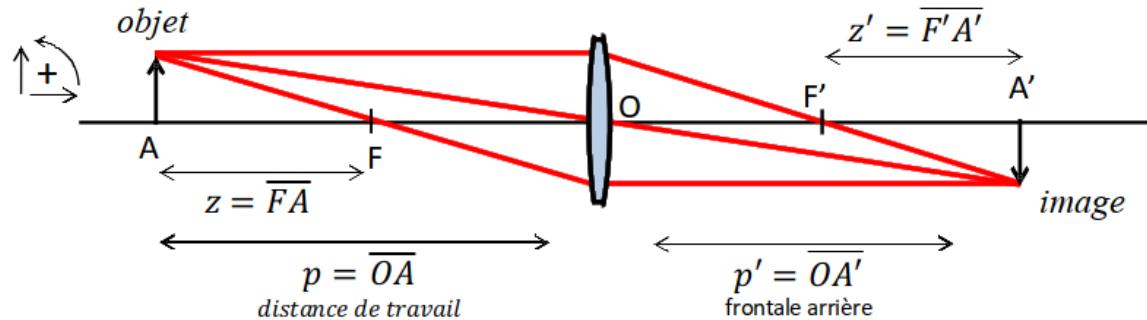
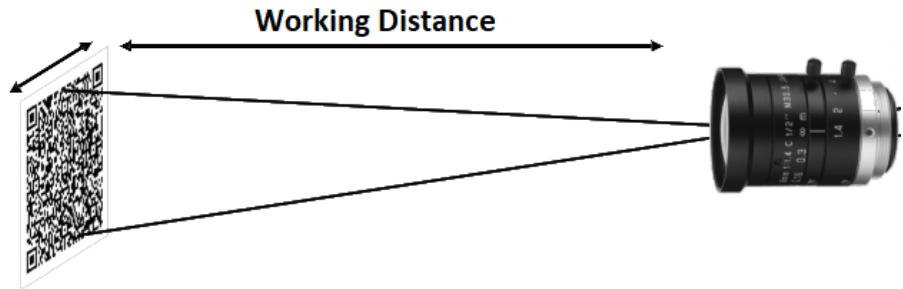
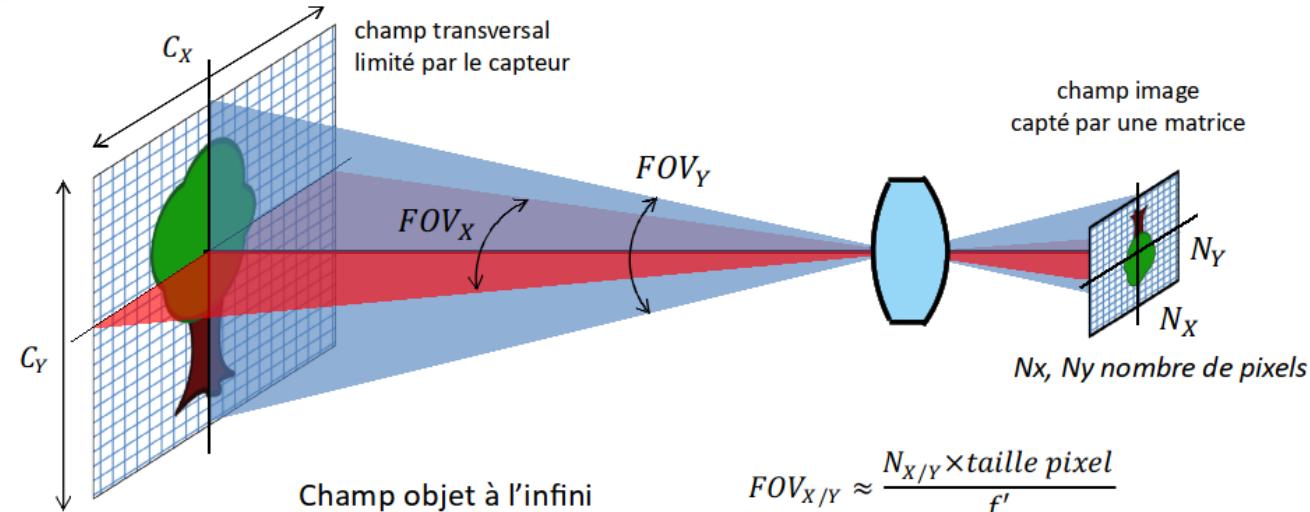
## Créer une image





# Objectif optique

## Créer une image

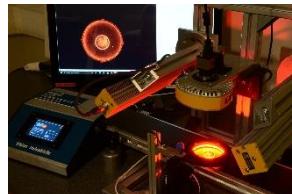


taille image  
grandissement transversal

$$g_y = \frac{y'}{y} = \frac{p'}{p} = -\frac{z'}{f'} = -\frac{f}{z}$$

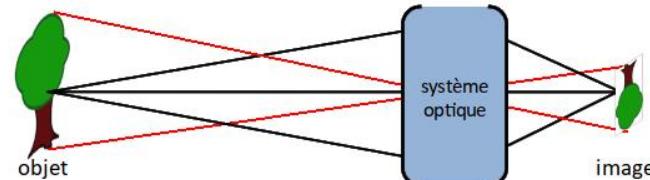
grandissement longitudinal

$$g_z = \frac{\delta p'}{\delta p} = (g_y)^2$$



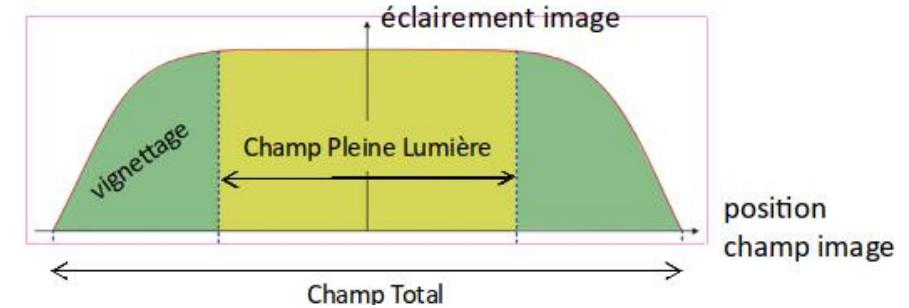
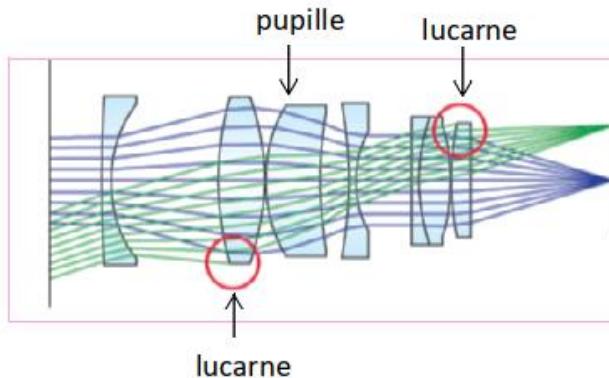
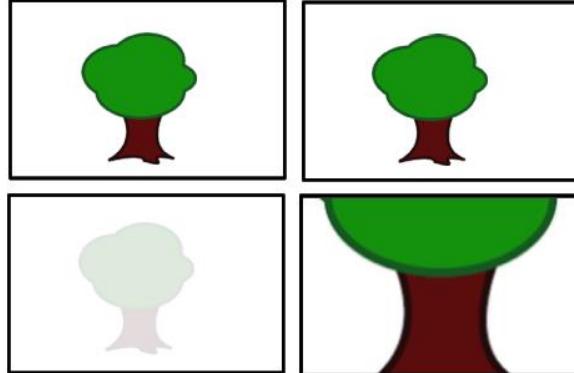
# Objectif optique

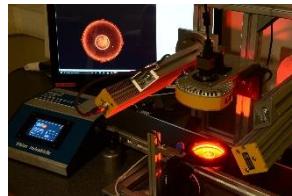
Créer une image



**Ouverture**  
flux collecté

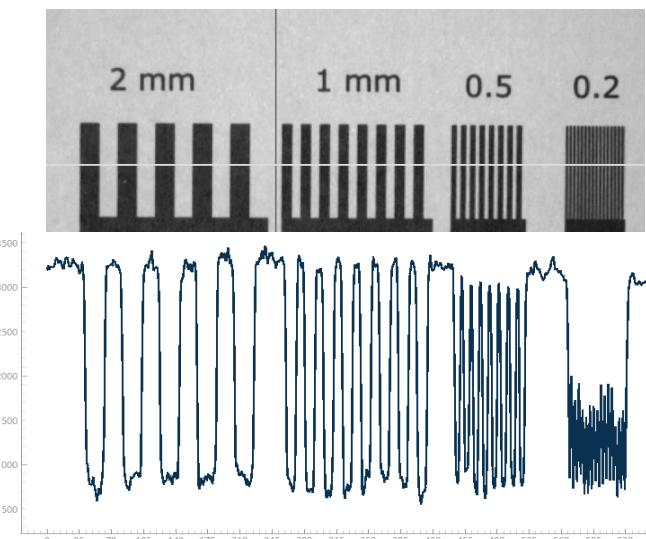
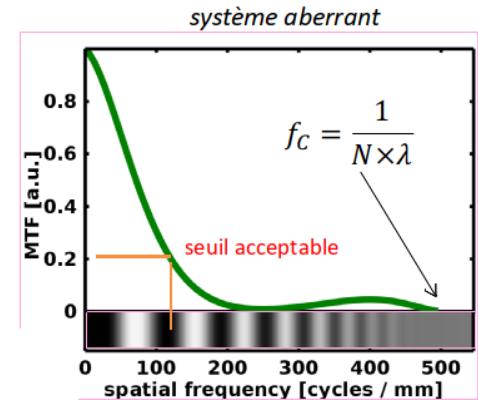
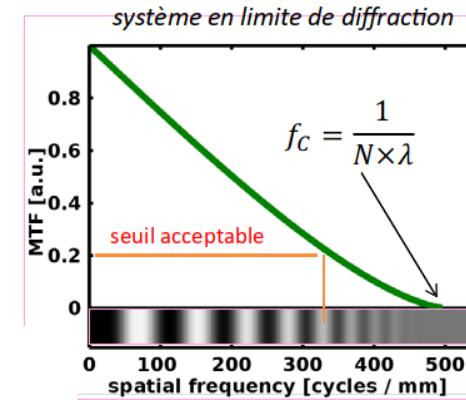
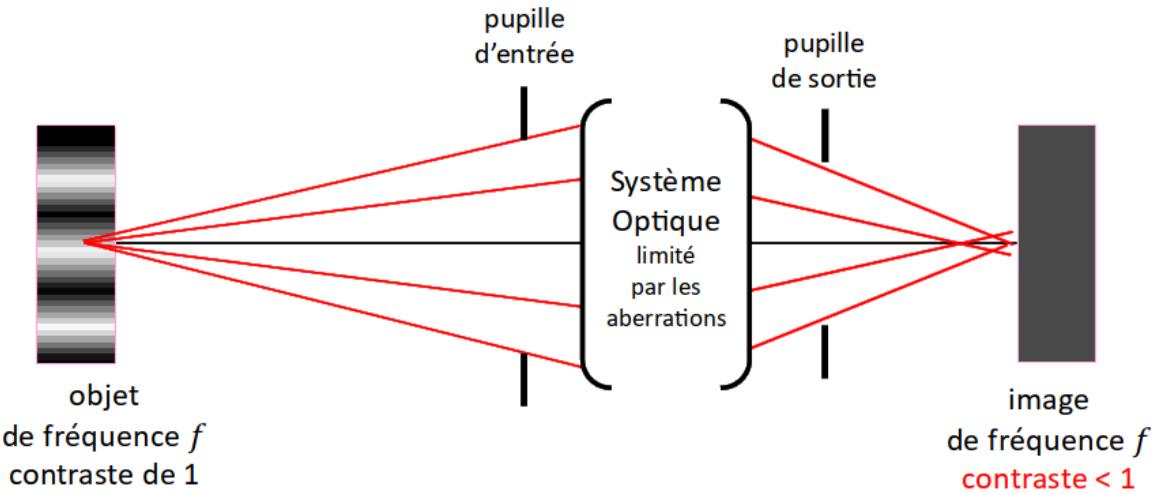
**Champ**  
taille max objet capté





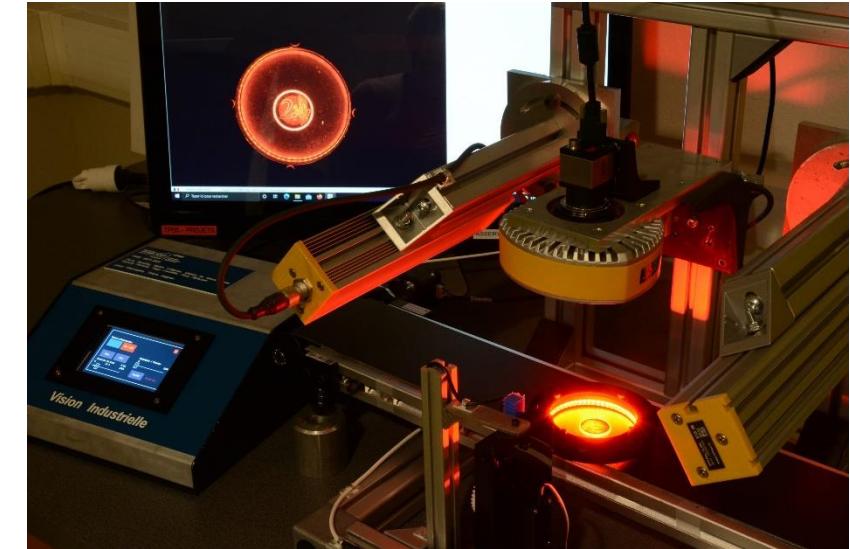
# Objectif optique

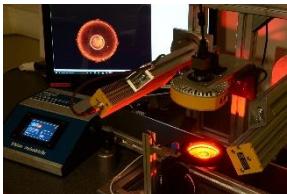
## Créer une image



# Caméra numérique

Echantillonnage / Quantification  
Colorimétrie



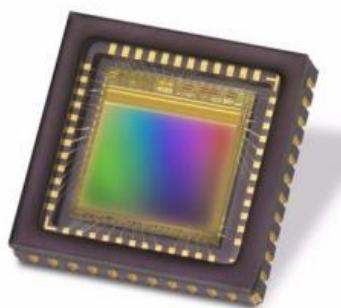


# Caméra numérique

## Matrice de pixel

The image shows a compact industrial camera with a black housing and a silver lens. The brand name "IDS" is printed vertically on the left side of the body. The lens has a red protective cover.

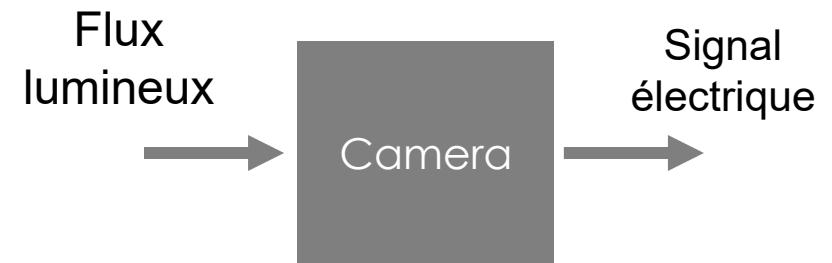
IDS UI-1240SE-C-HQ



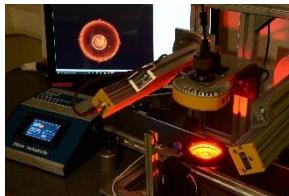
e2v sensor EV76C560ACT

Camera

Système qui transforme un **flux lumineux** en un **signal électrique mesurable**

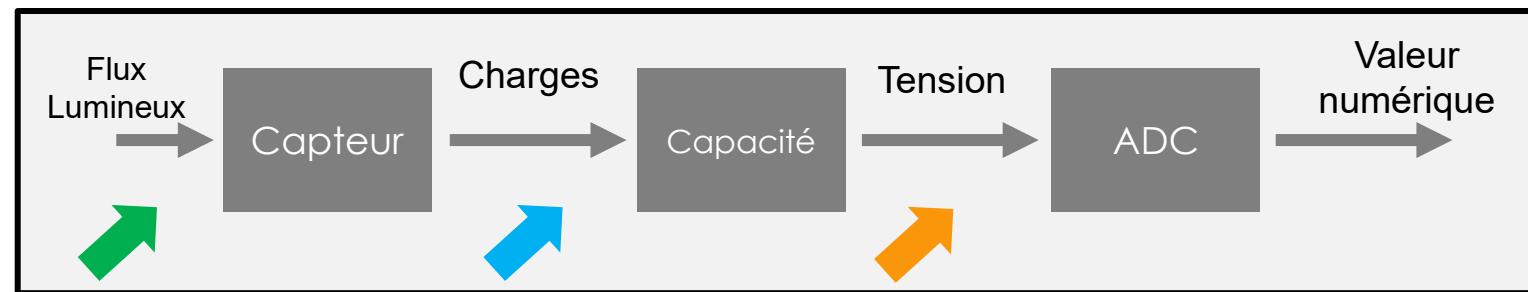
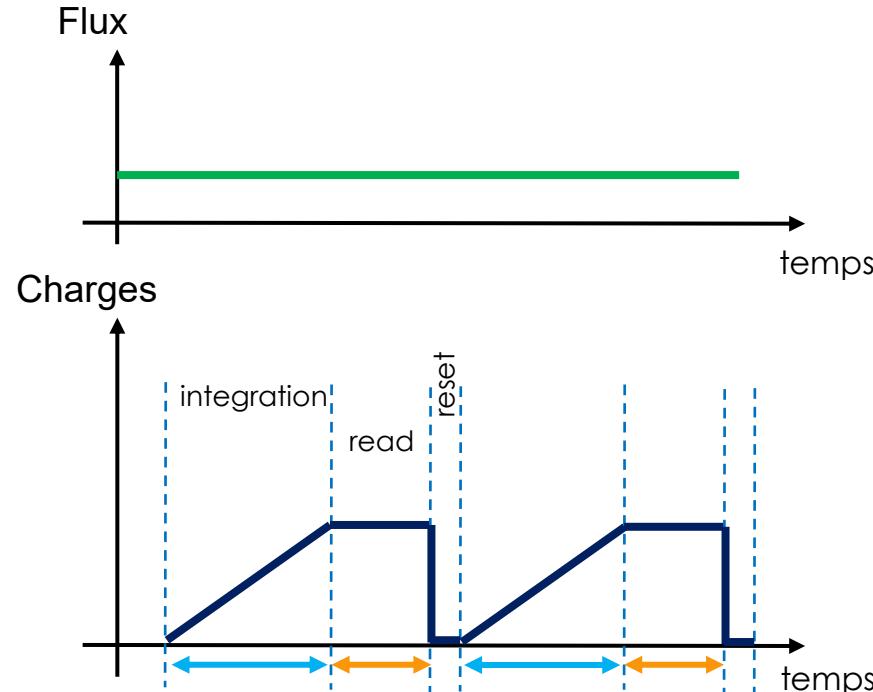
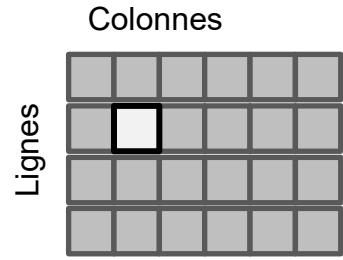


*Taille d'un pixel de l'ordre de 2 à 10 um*

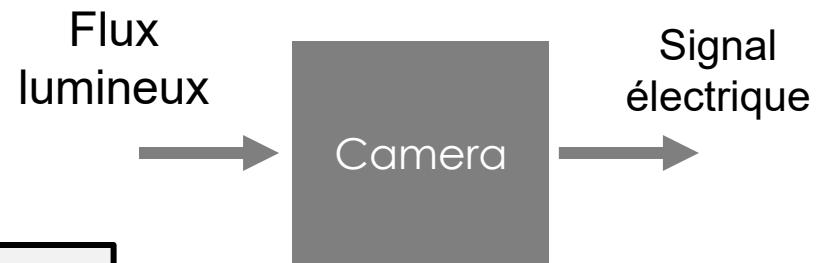


# Caméra numérique

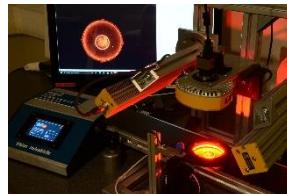
## Matrice de pixel



Système qui transforme un **flux lumineux** en un **signal électrique mesurable**



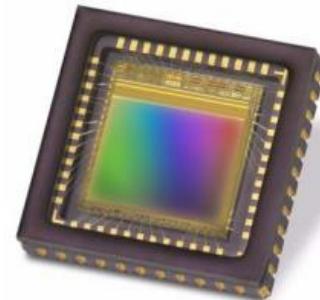
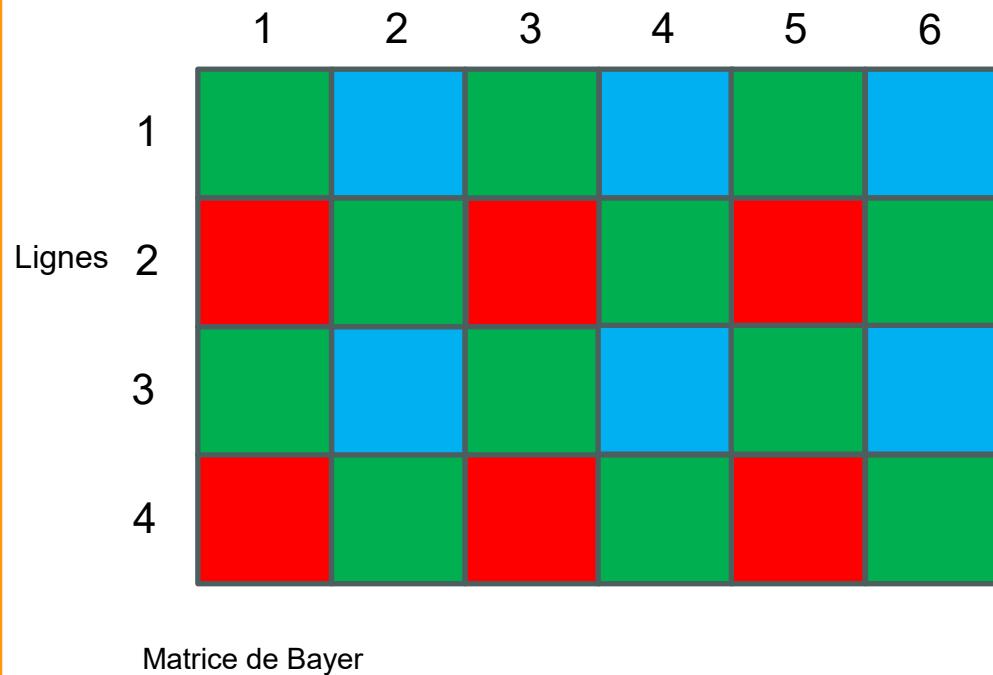
Taille d'un pixel de l'ordre de 2 à 10 um



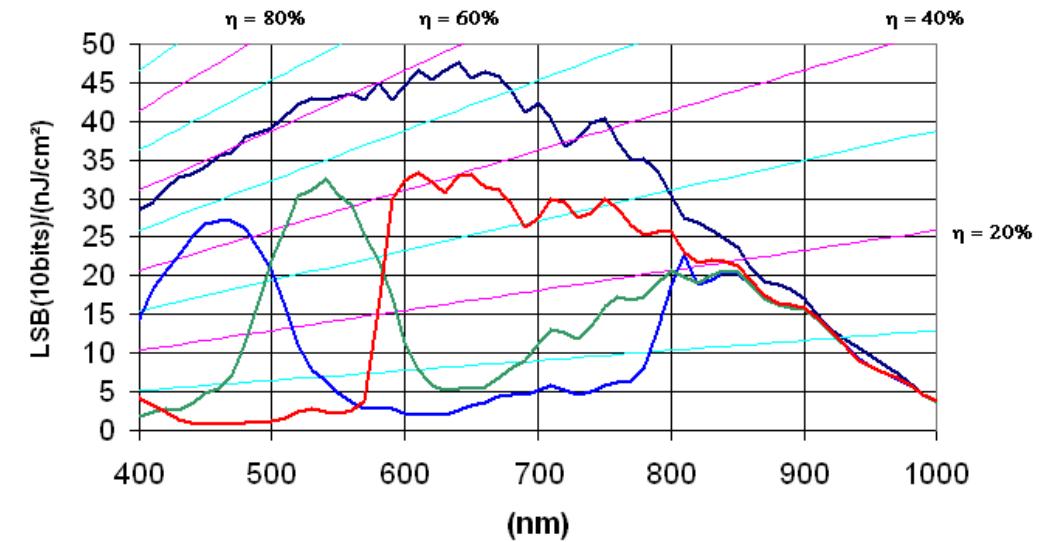
# Caméra numérique

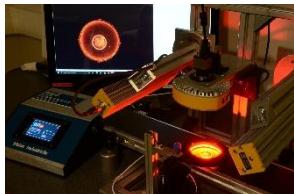
## Réponse spectrale

Colonnes



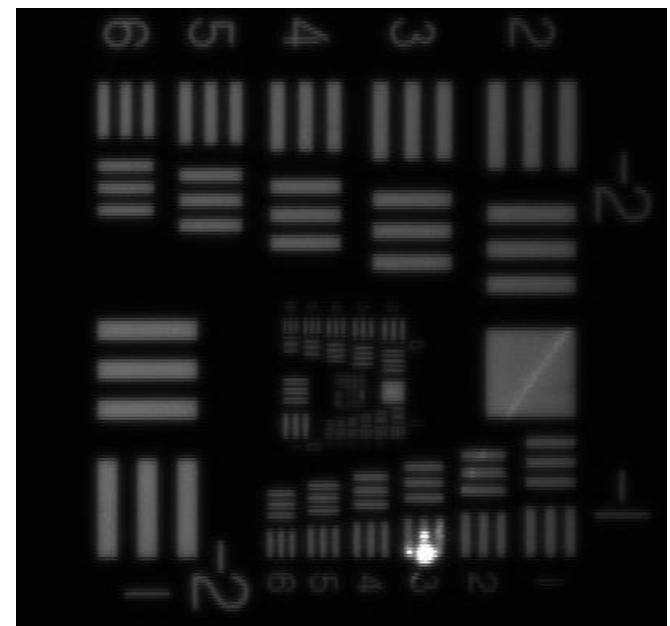
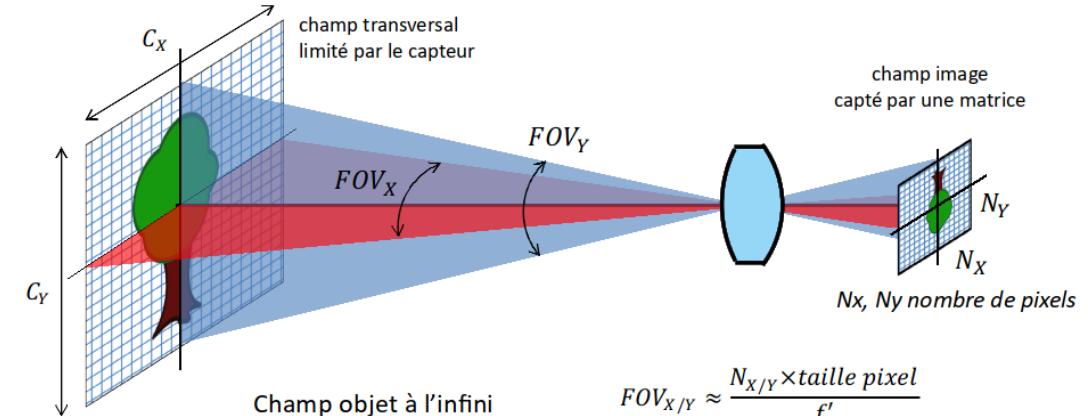
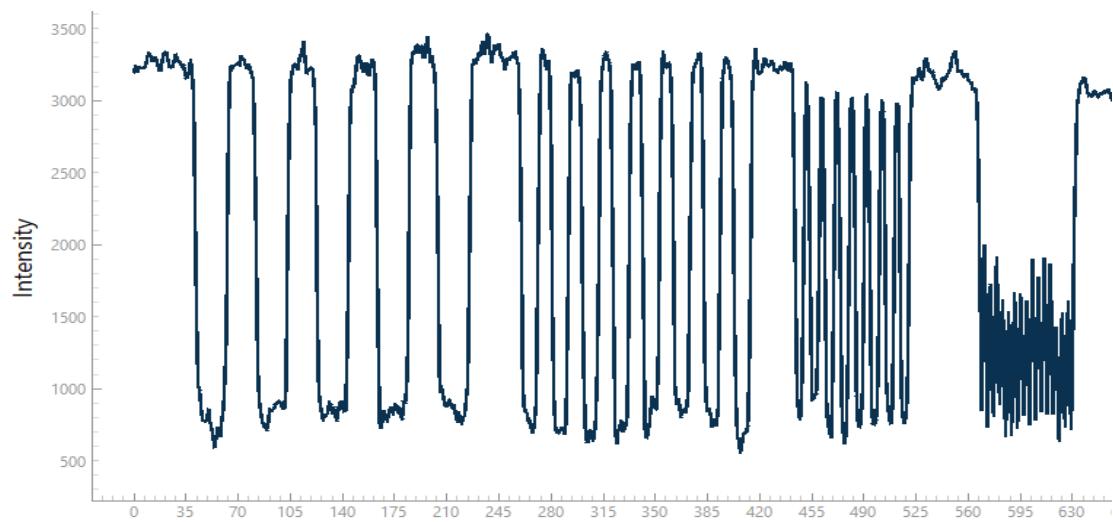
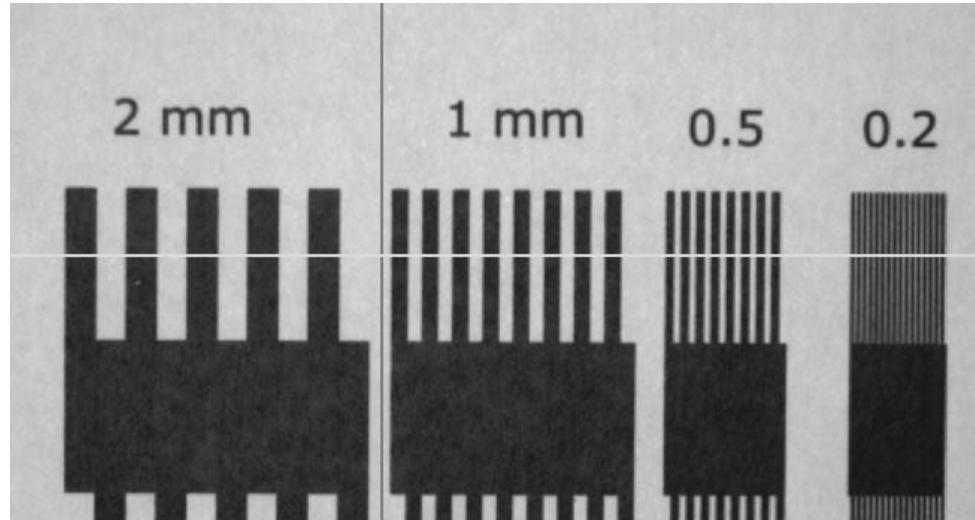
e2v sensor EV76C560ACT

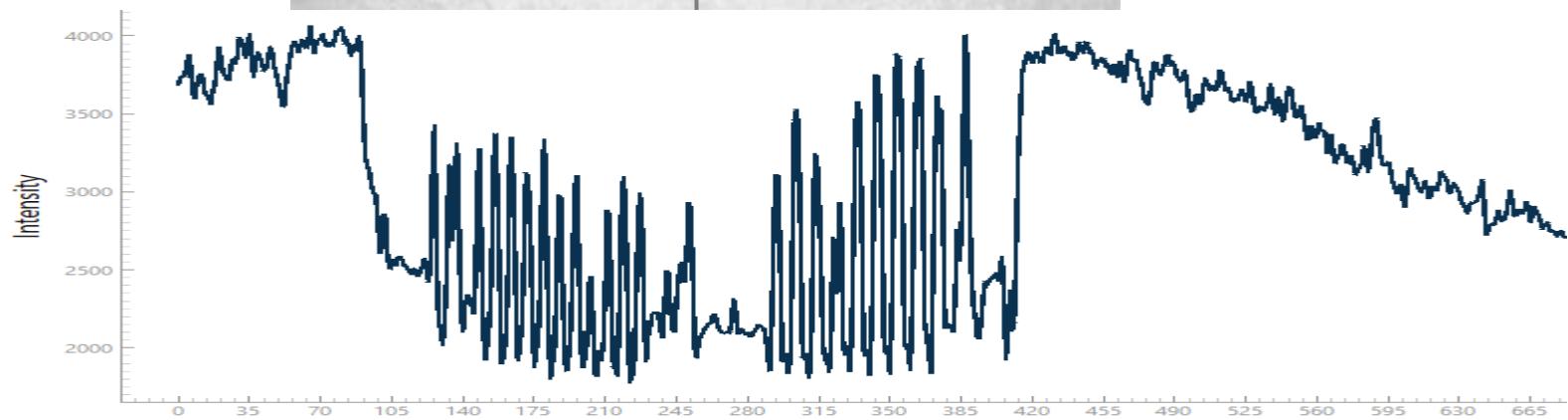
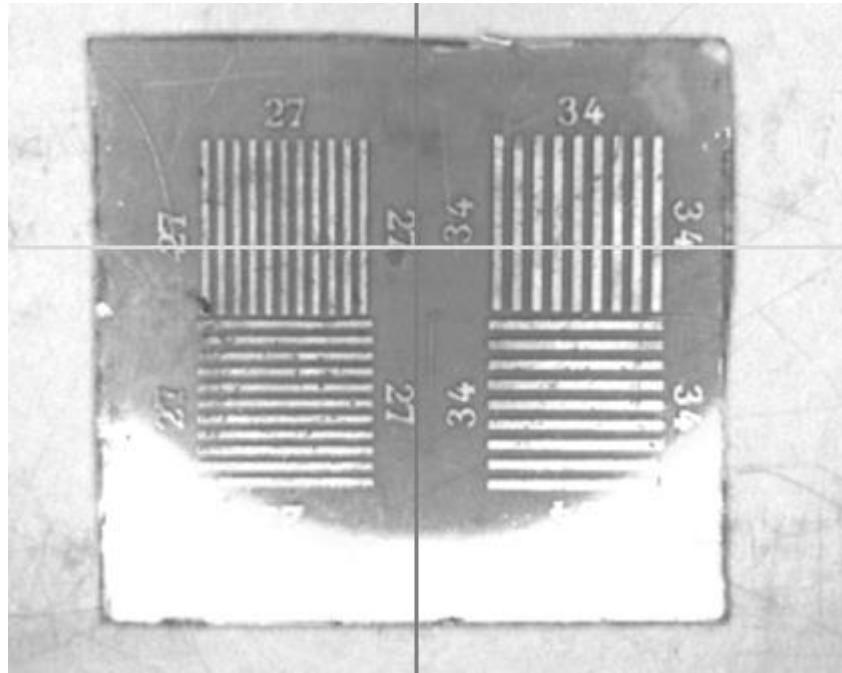
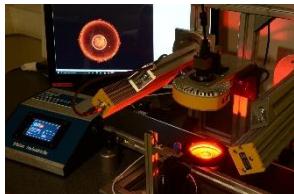




# Vision Industrielle

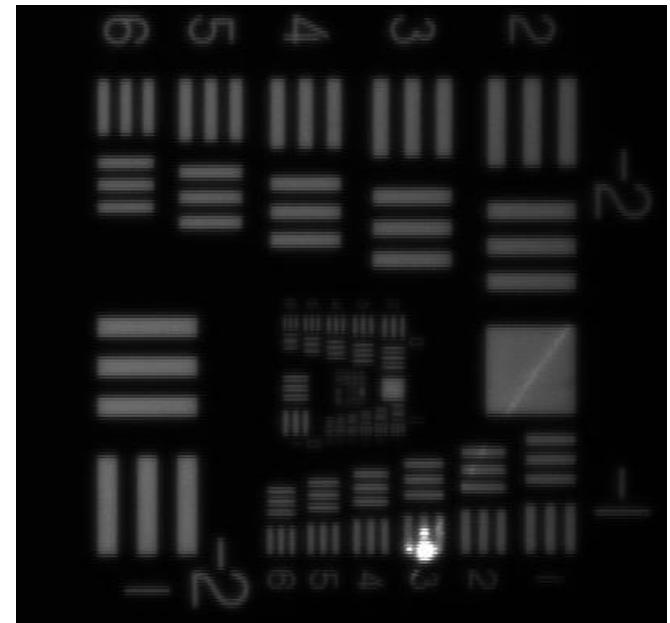
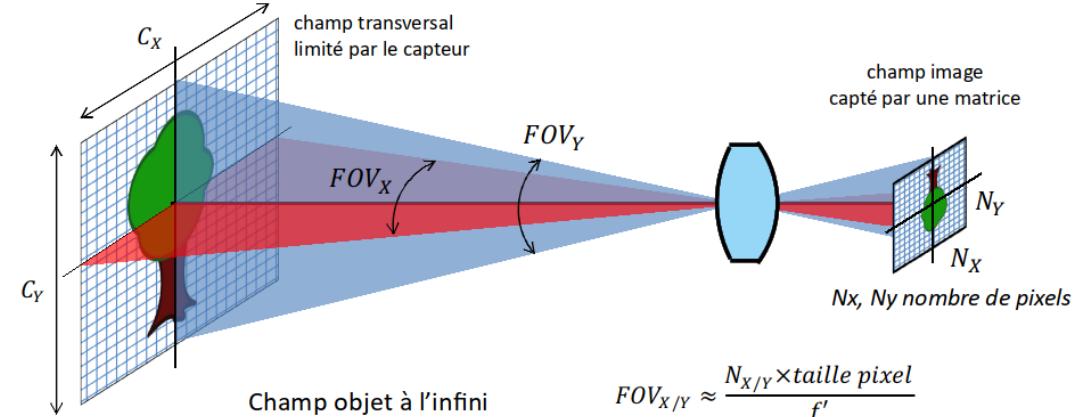
## Résolution





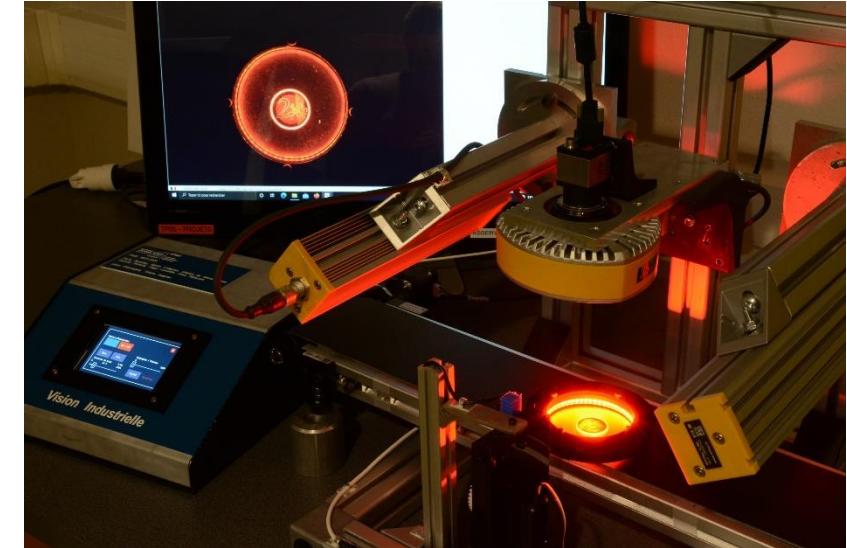
# Vision Industrielle

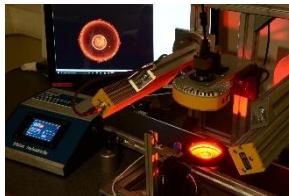
## Résolution



# Traitements d'image

Pré-traitement / Segmentation / Classification





# Traitement d'images



Image brute 'RAW' / Caméra

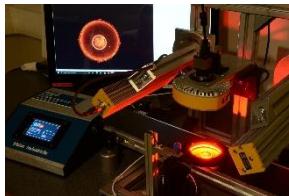
- **Bruitée**
- Mauvais contraste
- Eclairage non uniforme
- ...



Image souhaitée / Contours bien définis

- Zones homogènes
- Transitions nettes

Objectif



# Traitement d'images

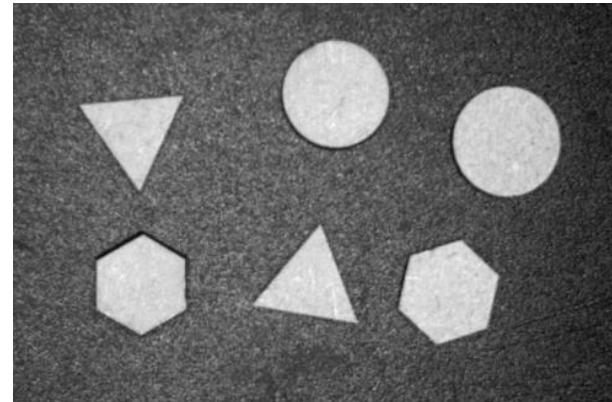


Image brute 'RAW' / Caméra

- **Bruitée**
- Mauvais contraste
- Eclairage non uniforme
- ...

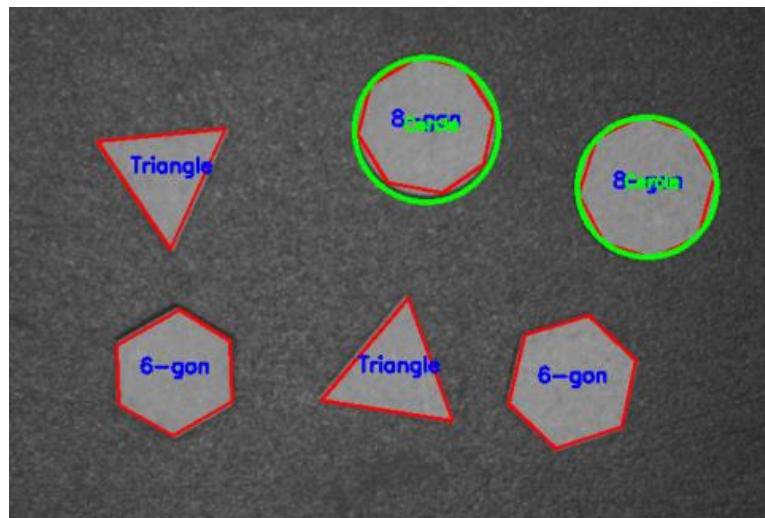
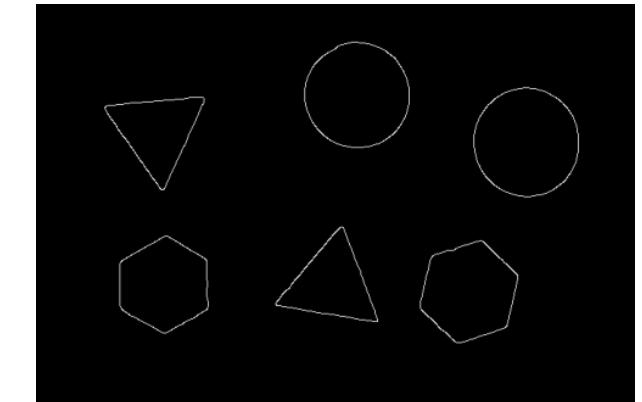
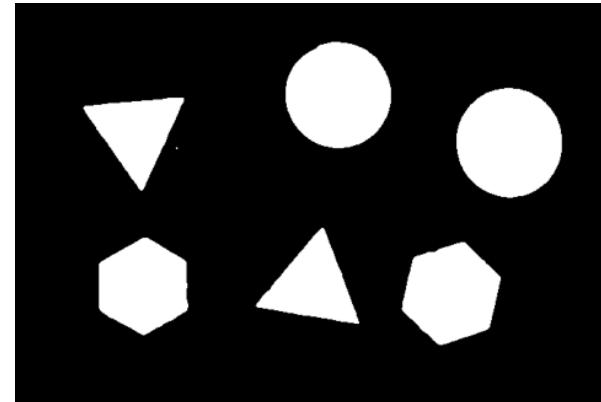
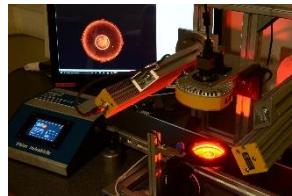
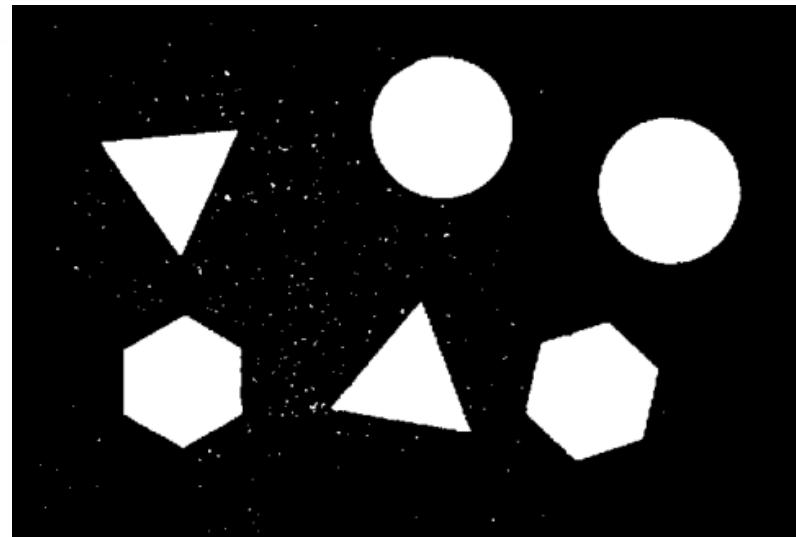
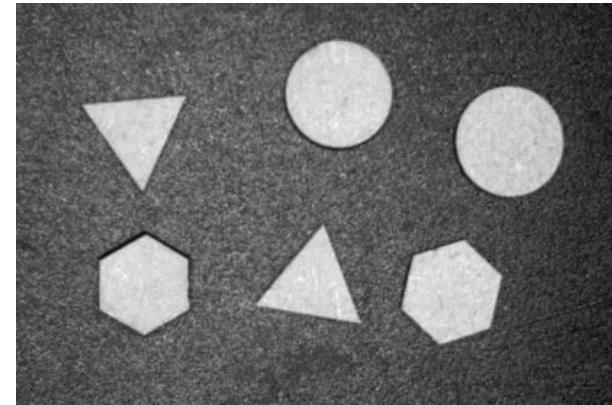


Image souhaitée / Contours bien définis

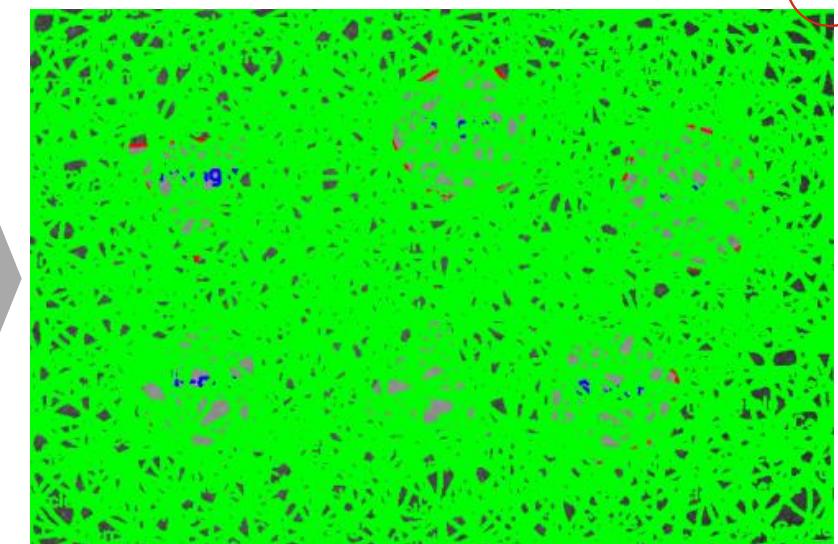
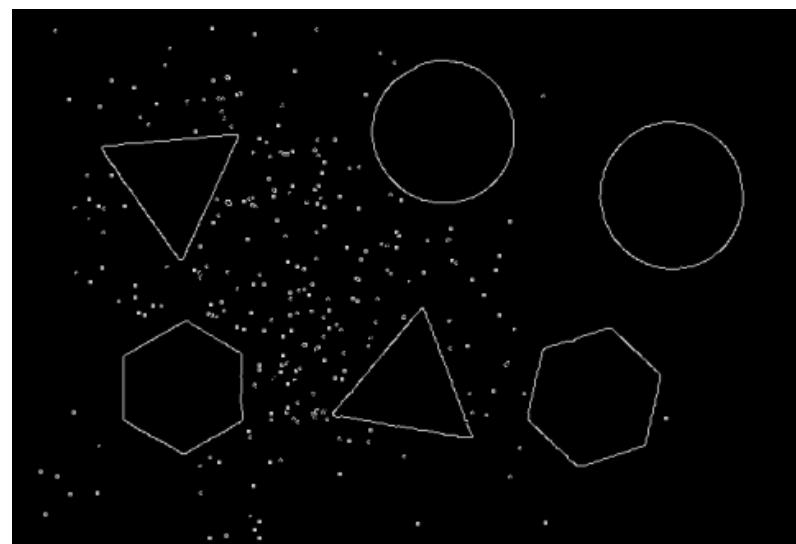
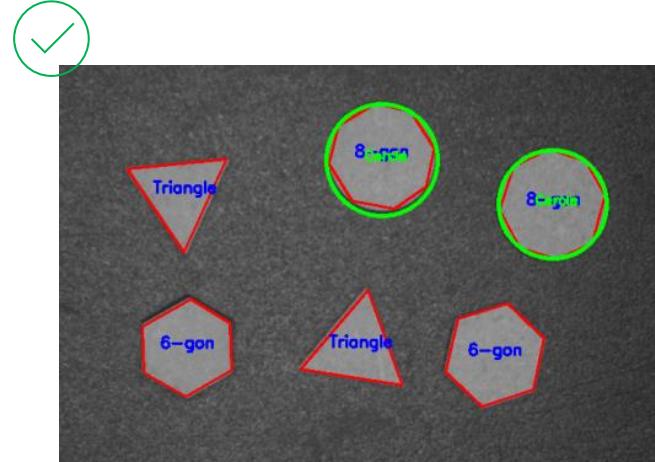
- Zones homogènes
- Transitions nettes

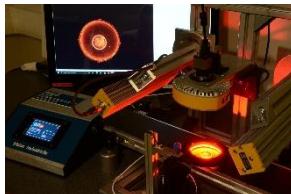


# Traitement d'images



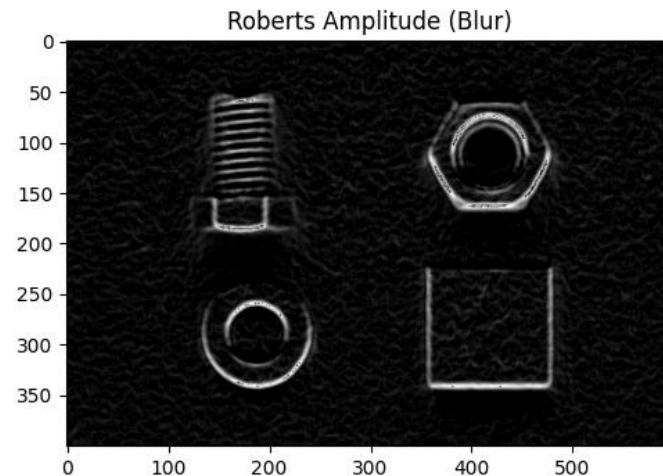
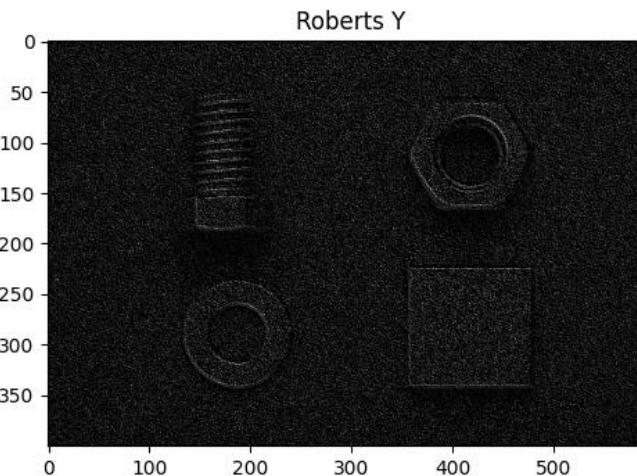
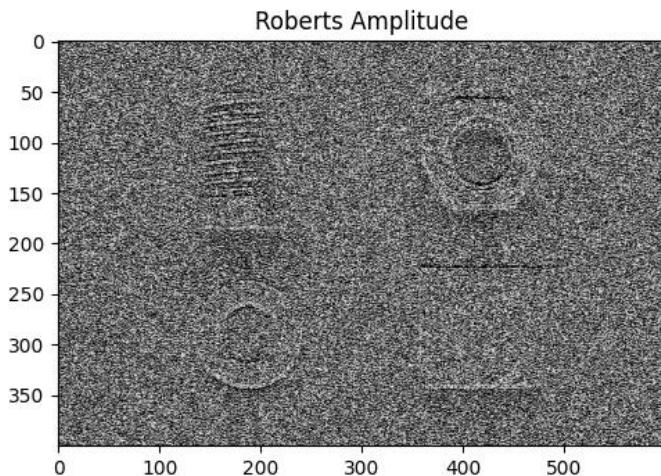
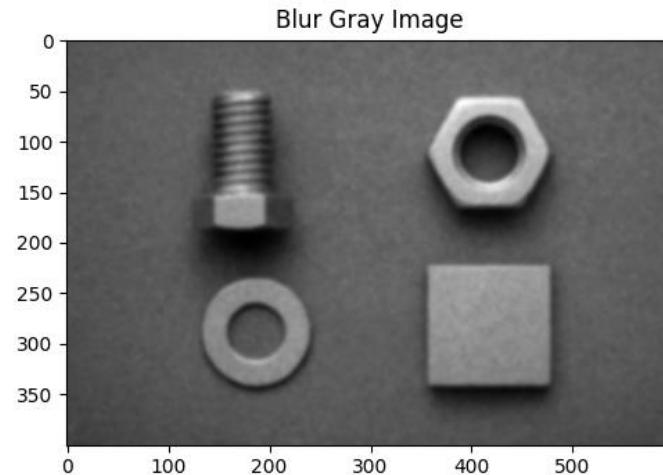
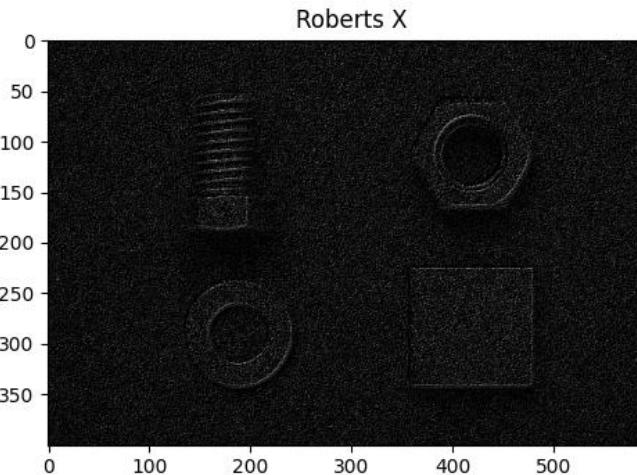
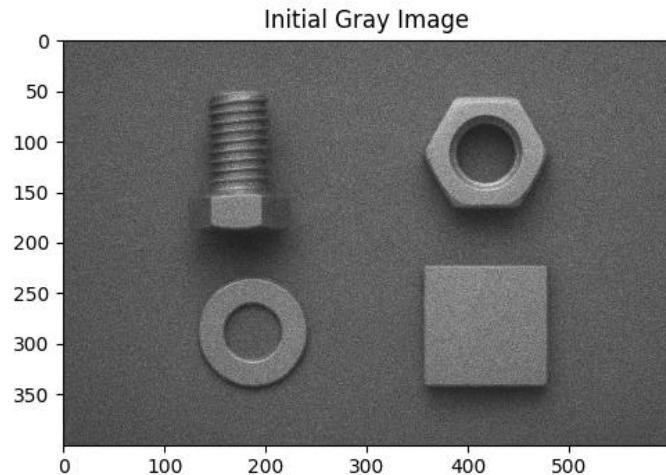
Mauvais traitement

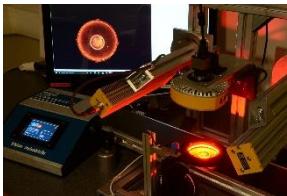




# Traitement d'images

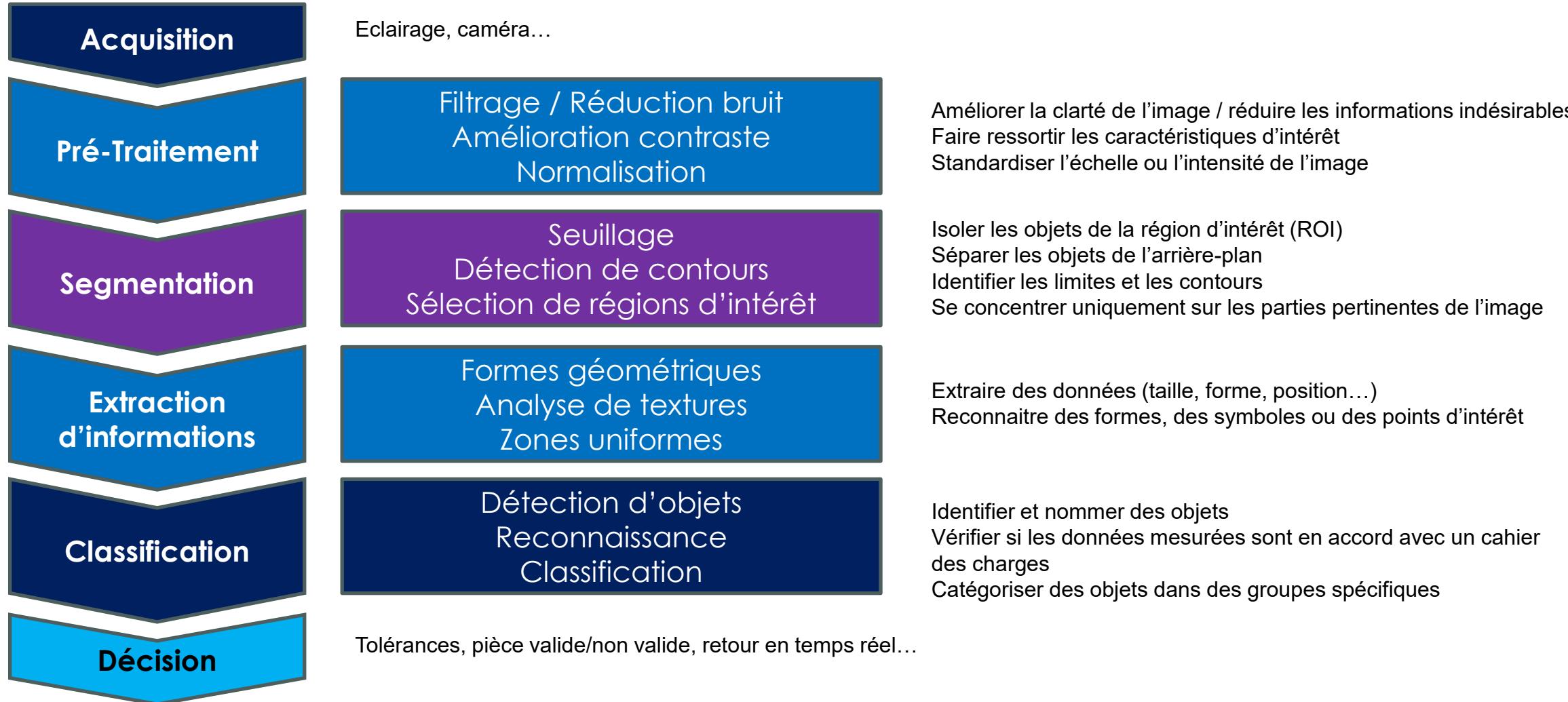
## Exemple industriel

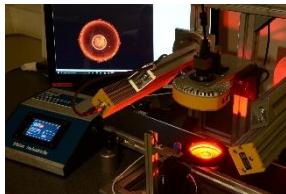




# Traitement d'images

Objectif





# Traitement d'images

## Images numériques

Image continue

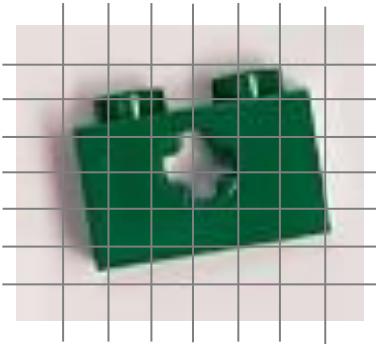
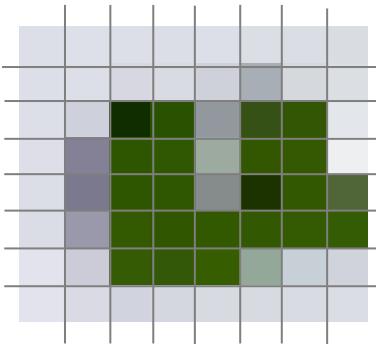


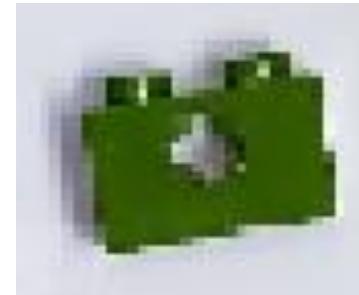
Image numérique : projection sur une matrice d'une image continue



8 x 8 grid



16 x 16 grid

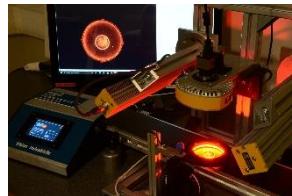


32 x 32 grid

Image numérique

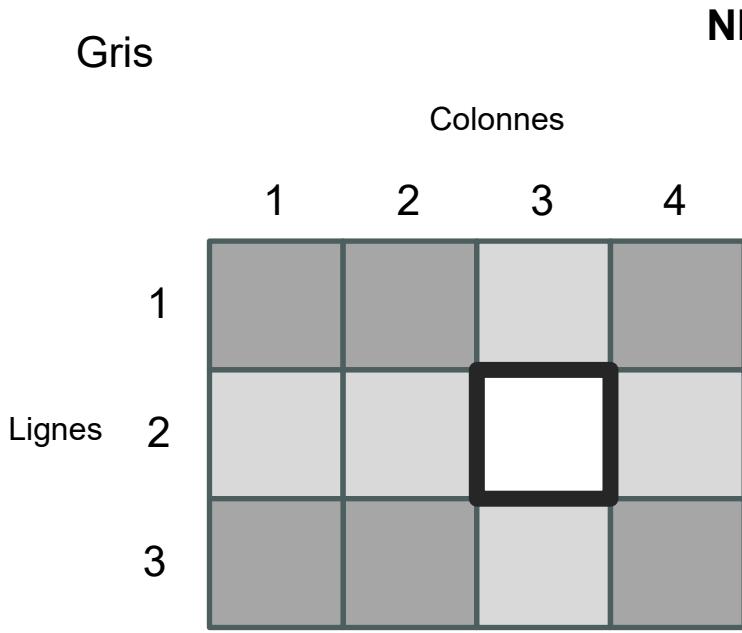
Représentation d'une **image sous forme numérique**

*Pour être **sauvegardée, traitée et affichée** par des ordinateurs ou des systems numériques.*

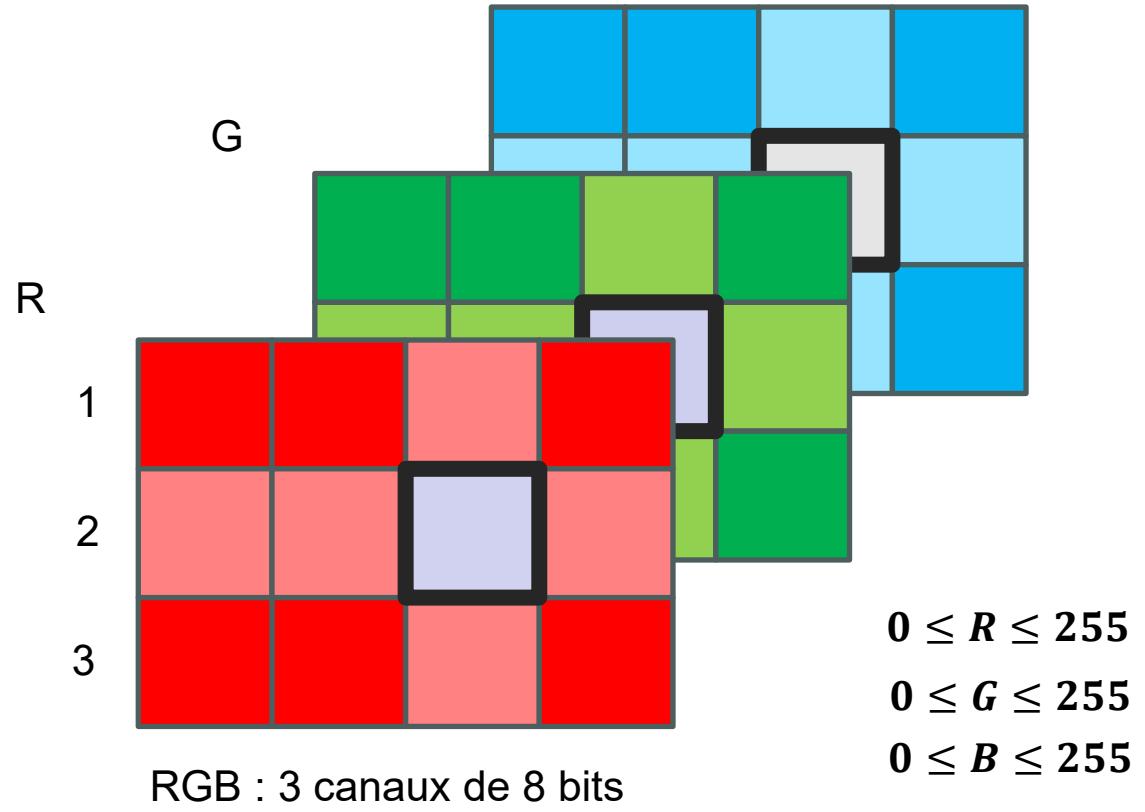


# Traitement d'images

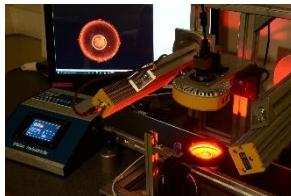
Images numériques / Gris ou RGB



Chaque pixel est converti sur **n** bits.



R=200, G=100, B=50



# Traitement d'images

OpenCV

## Open Source Computer Vision

Une bibliothèque de **traitement d'images**  
et de **Machine learning**

Développés sur de *multiple environnement*,  
comme Python, C++, Java, and MATLAB

- Traitement d'images**
- Reconnaissance**
- Algorithmes Vidéo**
- Machine Learning**

- Filtrage, detection de contours, transformations...*
- Détection d'objets dans des images et des vidéos*
- Suivi de mouvement, Reconstruction 3D...*
- Classification d'images, Reconnaissance de formes*

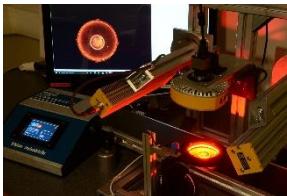


<https://opencv.org>



OpenCV 4.5.0 and higher versions are licensed under the [Apache 2 License](#).

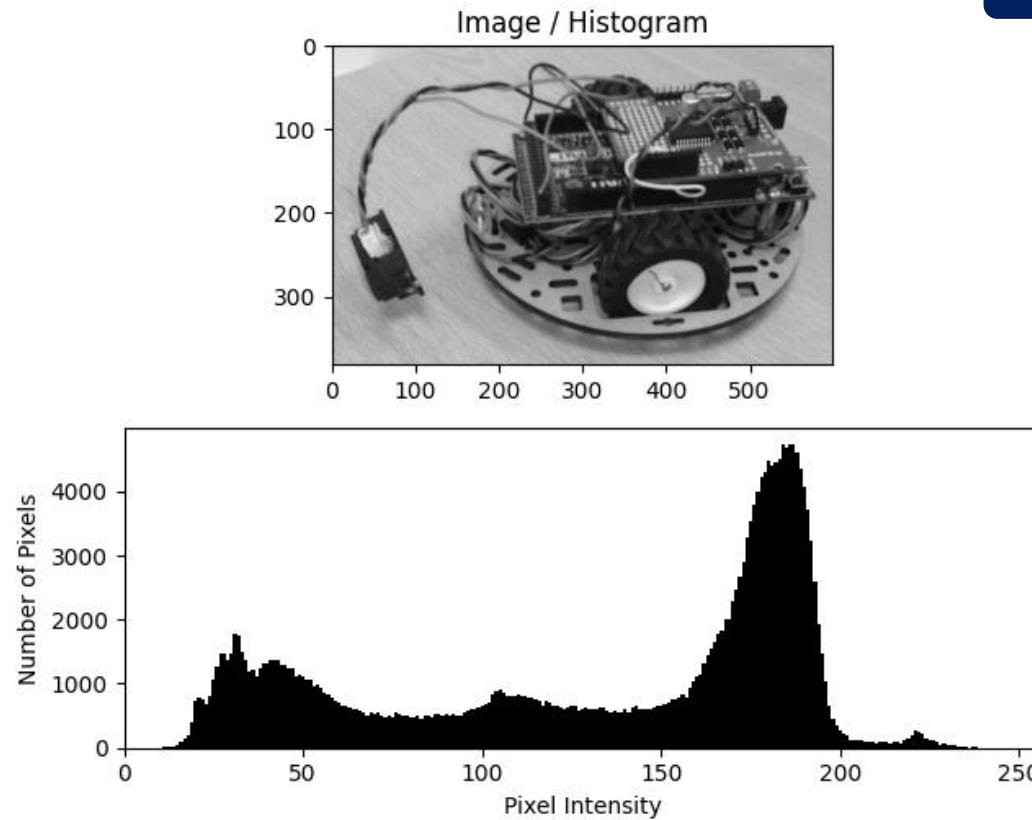
OpenCV 4.4.0 and lower versions, including OpenCV 3.x, OpenCV 2.x, and OpenCV 1.x, are licensed under the [3-clause BSD license](#).



# Traitement d'images

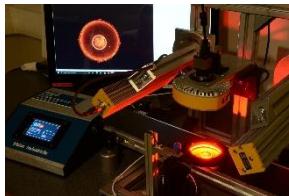
Filtrage par TF

## Acquisition

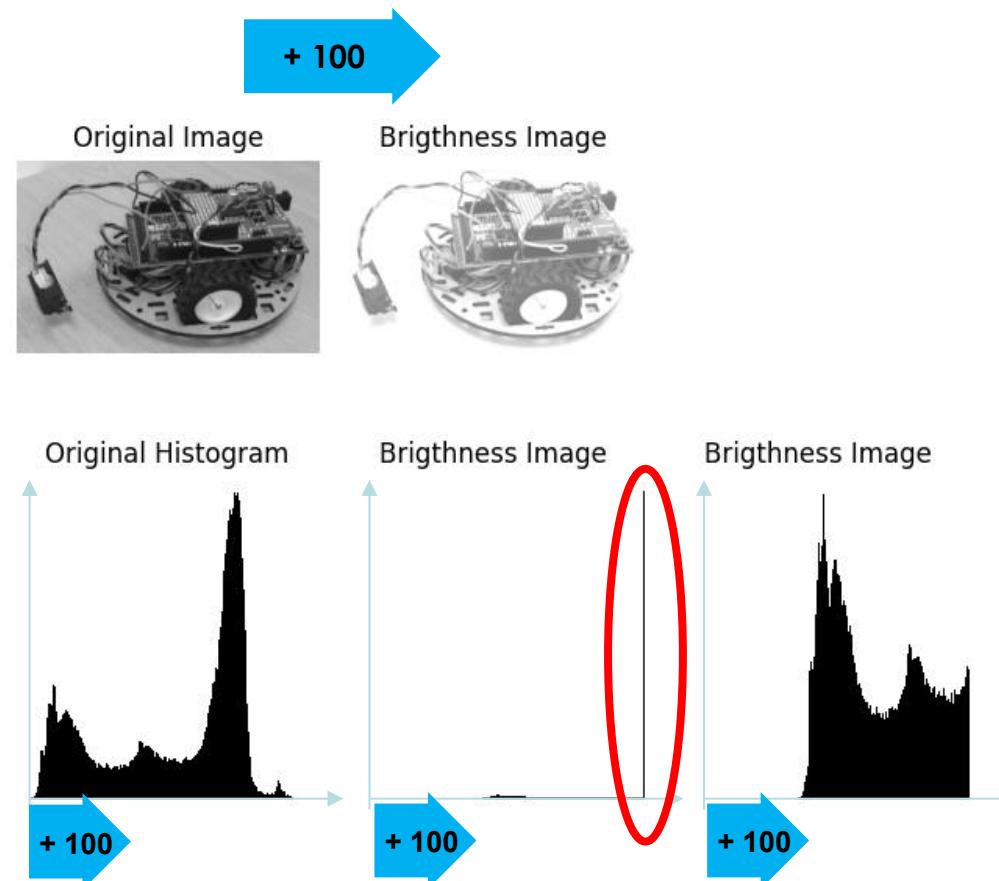


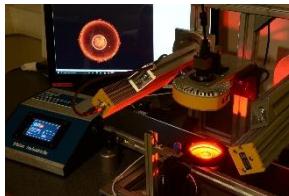
## Histogramme

**Représentation graphique**  
montrant la **distribution des valeurs de niveaux de gris** des pixels de l'image

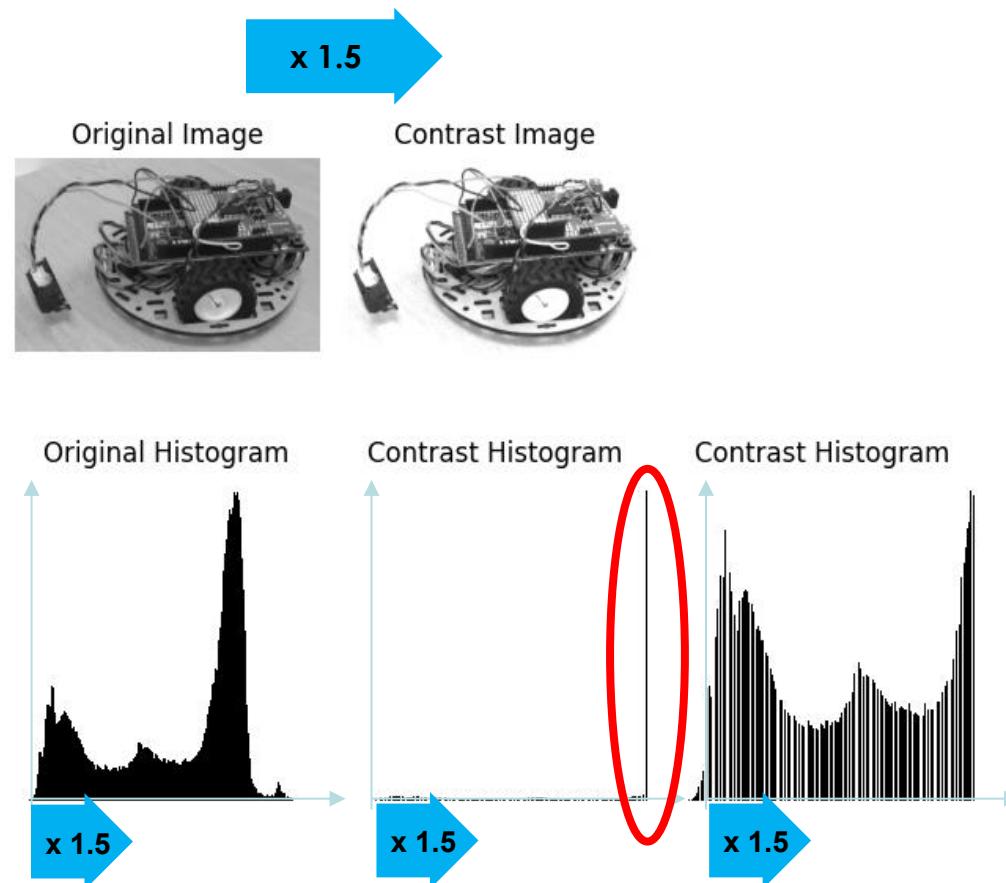


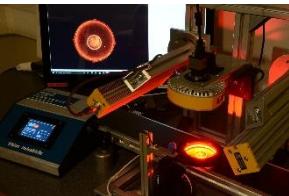
# Traitement d'images





# Traitement d'images





# Traitement d'images



## kernel

-1	0	-2
1	5	1
-2	0	-1

## original image

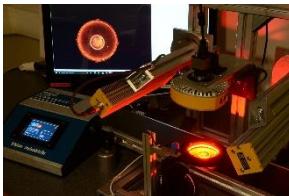
5	8	4	2	3	1	5
9	5	1	8	7	6	2
5	7	1	5	6	8	7
5	8	2	8	4	3	3
5	6	6	7	2	5	1

# Filtrage / Convolution

5	8	4	2	3	1	5
9	5	1	8	7	6	2
x -1	x 0	x -2	5	6	8	7
5	7	1	x 1	x 5	x 1	
8	4	3	x -2	x 0	x -1	3
5	6	7	2	5	1	
5	6	6	7	2	5	1

## filtered image

$$\begin{aligned} R &= -8 + 0 - 12 + 5 + 30 + 8 - 16 + 0 - 3 \\ R &= 4 \end{aligned}$$

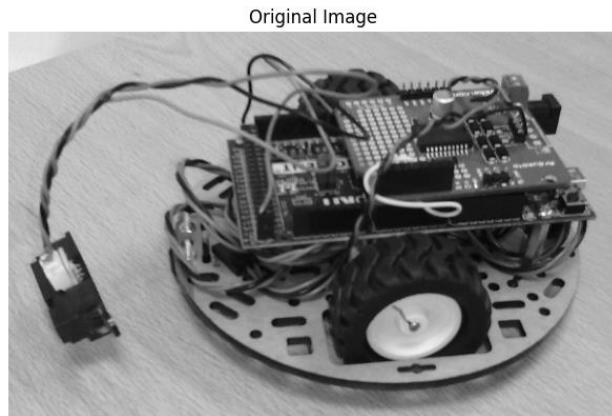


# Traitement d'images

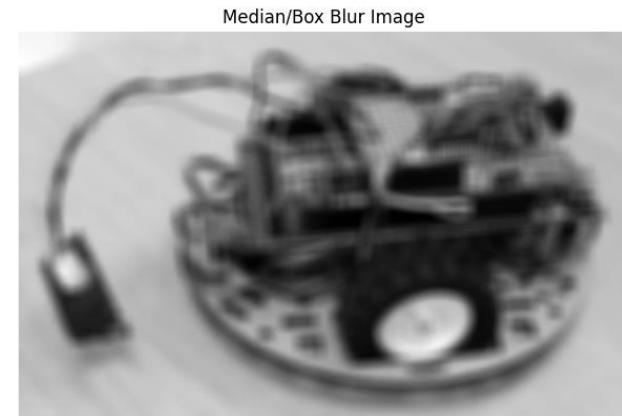
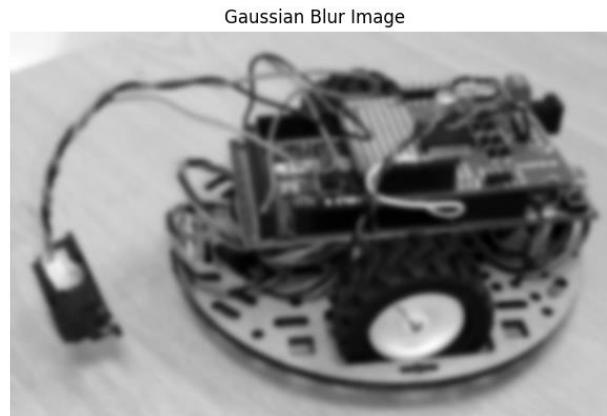
## Filtrage / Convolution

Acquisition

Pre Processing



Suppression de détails insignifiants

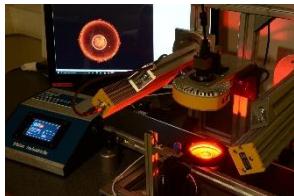


1	4	7	4	1
4	16	26	16	4
7	26	41	26	7
4	16	26	16	4
1	4	7	4	1

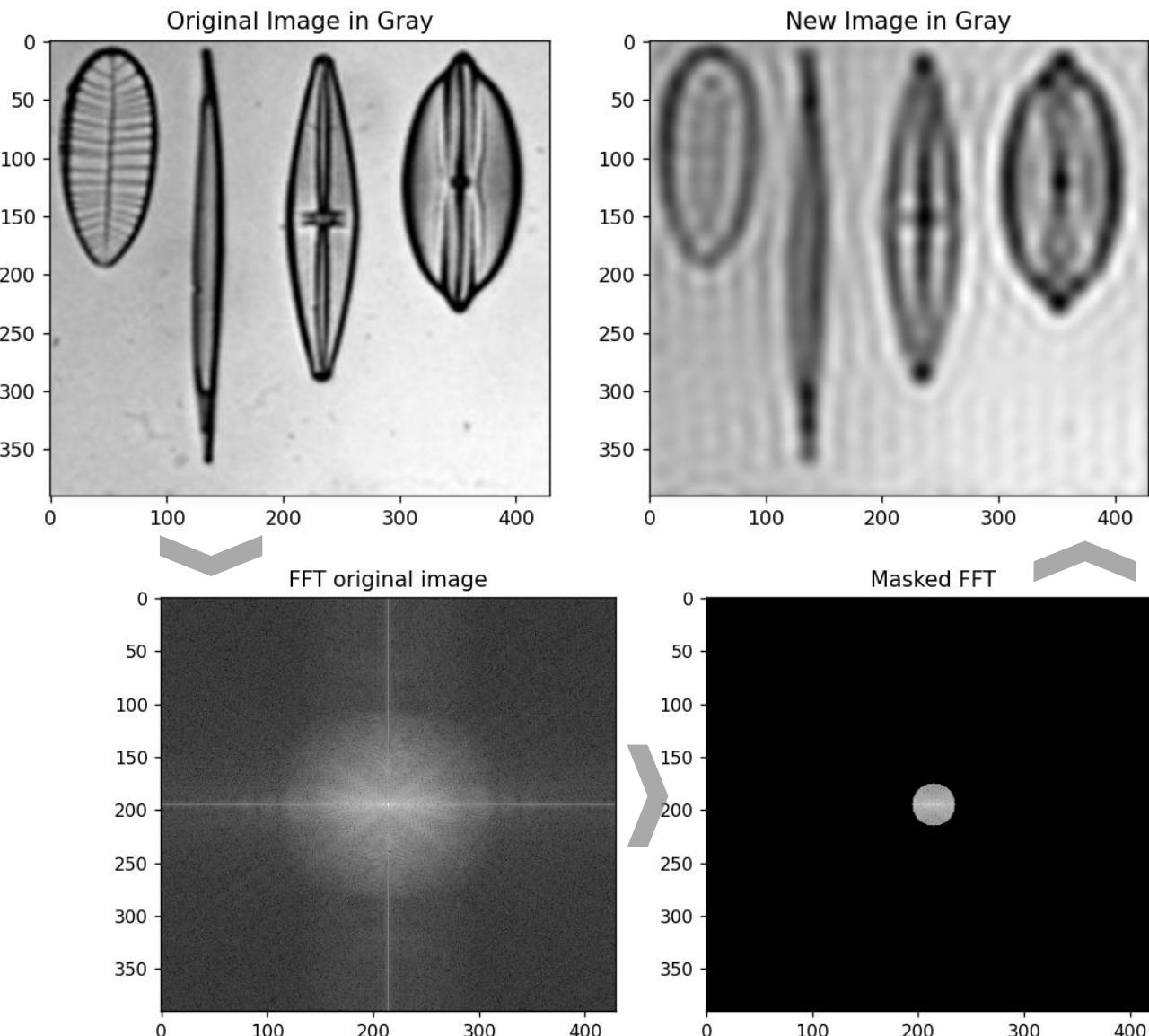
**Gaussian Kernel**  
(x 1/273)

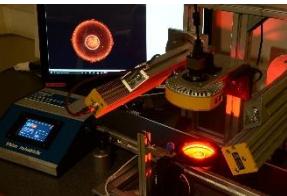
1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

**Mean Kernel** ( x 1/(N\*M) )



# Traitement d'images

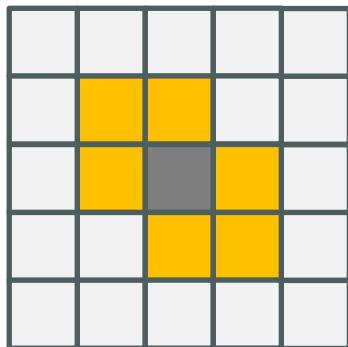




# Traitement d'images



- Pixels originaux
- Pixels retirés

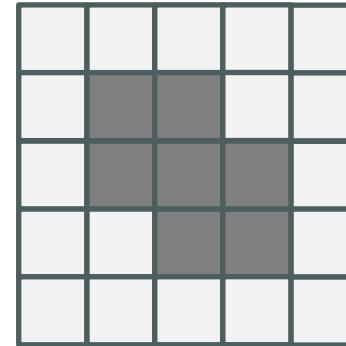


## Erosion

**Réduire le premier plan** en retirant progressivement les pixels le long des contours des objets

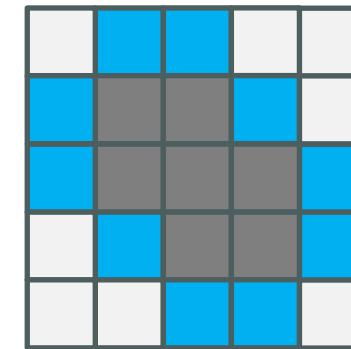
kernel

0	1	0
1	1	1
0	1	0



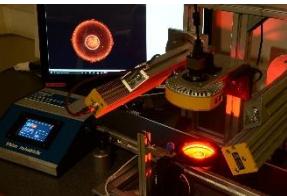
## Erosion / Dilatation

- Pixels ajoutés



## Dilatation

**Étendre le premier plan** en ajoutant des pixels le long des contours des objets



# Traitement d'images



Eroded Image



Original Image



Dilated Image



kernel

0	1	0
1	1	1
0	1	0

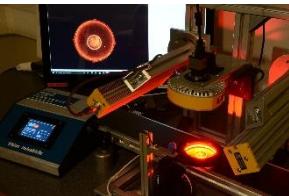
## Erosion

**Réduire le premier plan** en retirant progressivement les pixels le long des contours des objets

## Dilatation

**Étendre le premier plan** en ajoutant des pixels le long des contours des objets

Erosion / Dilatation



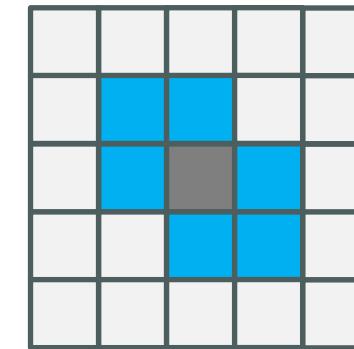
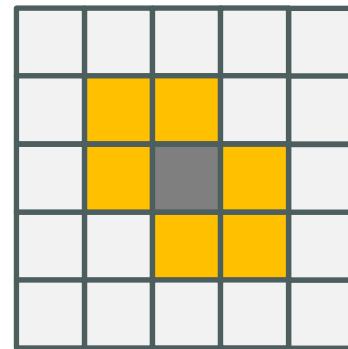
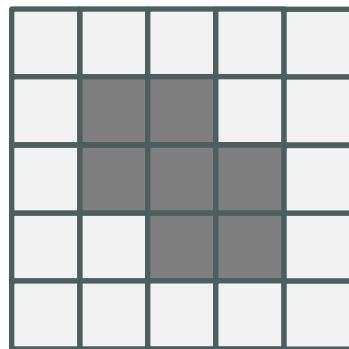
# Traitement d'images



- Original pixels
- Removed pixels

## Ouverture / Fermeture

- Added pixels



kernel

0	1	0
1	1	1
0	1	0

Ouverture

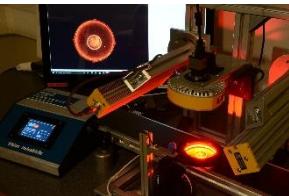
**Erosion puis Dilatation**

Retire des petits objets

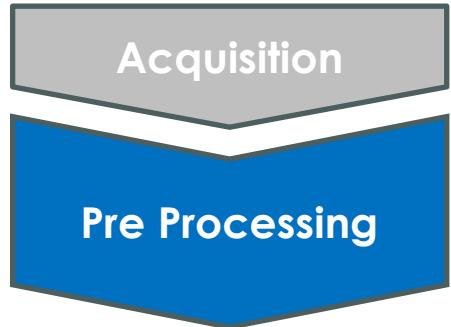
Fermeture

**Dilatation puis Erosion**

Remplit des petites zones



# Traitement d'images



Opening Image



Original Image



Closing Image



kernel

0	1	0
1	1	1
0	1	0

Ouverture

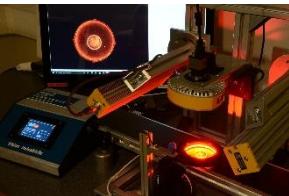
Erosion puis Dilatation

Retire des petits objets

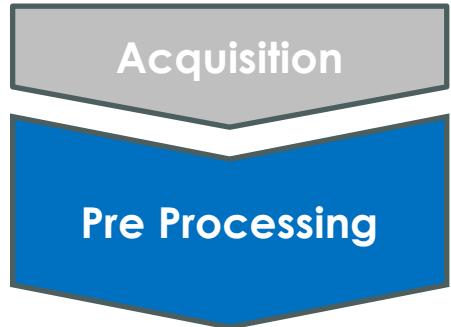
Fermeture

Dilatation puis Erosion

Remplit des petites zones



# Traitement d'images



Opening Image



Original Image



Closing Image



kernel

0	1	0
1	1	1
0	1	0

Ouverture

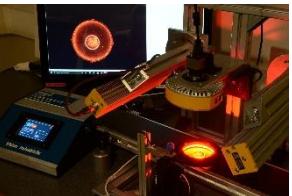
Erosion puis Dilatation

Retire des petits objets

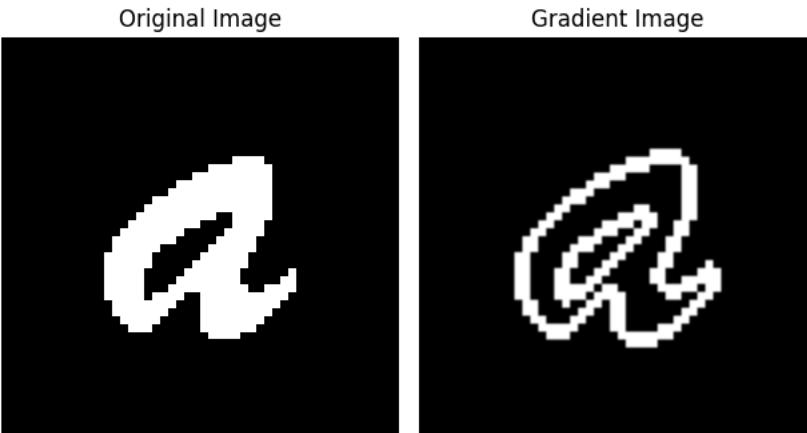
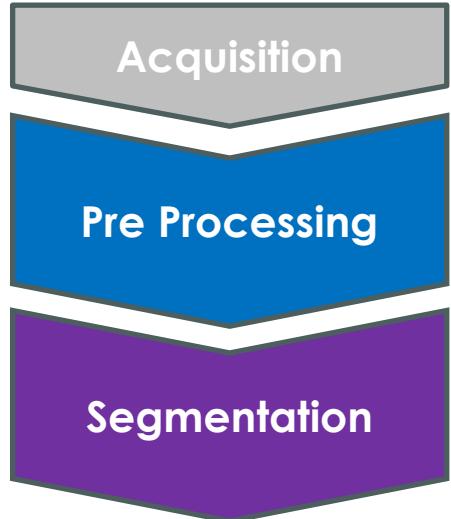
Fermeture

Dilatation puis Erosion

Remplit des petites zones



# Traitement d'images



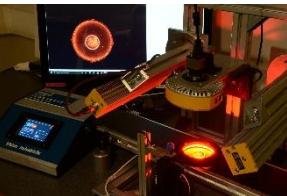
kernel

0	1	0
1	1	1
0	1	0

Gradient

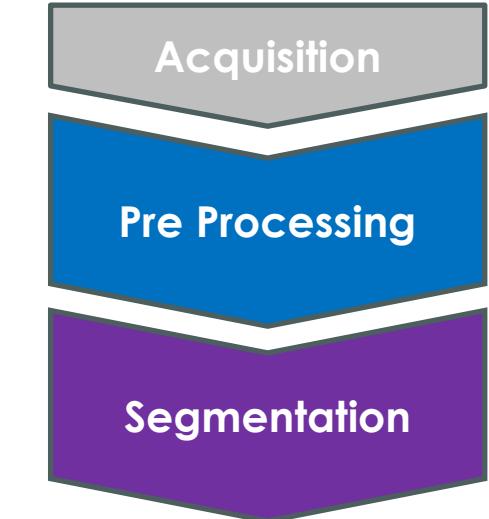
Difference entre une **dilatation** et une **érosion**

*Classification des pixels : scène (background) ou objets (foreground) ?*



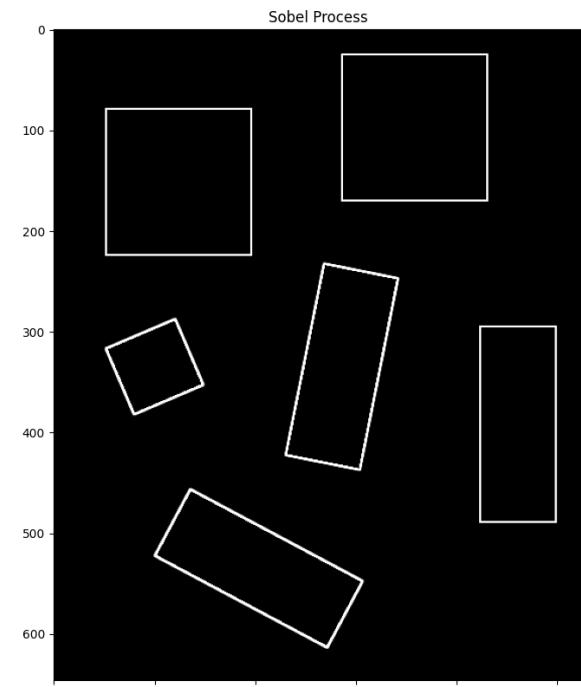
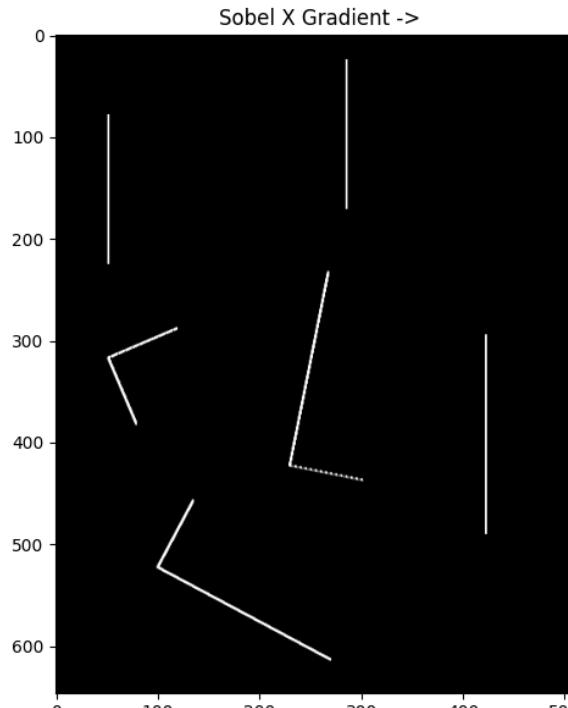
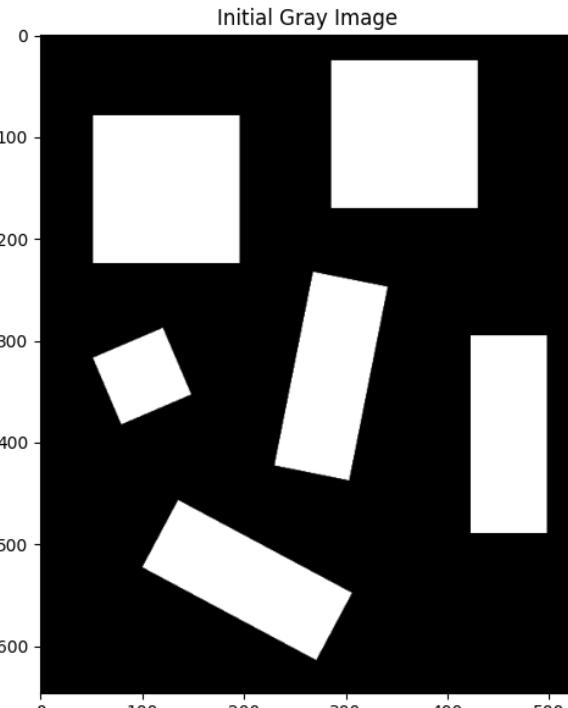
# Traitement d'images

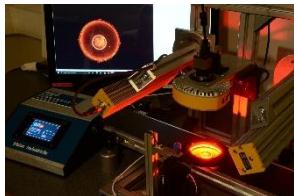
## Opérateur de Sobel



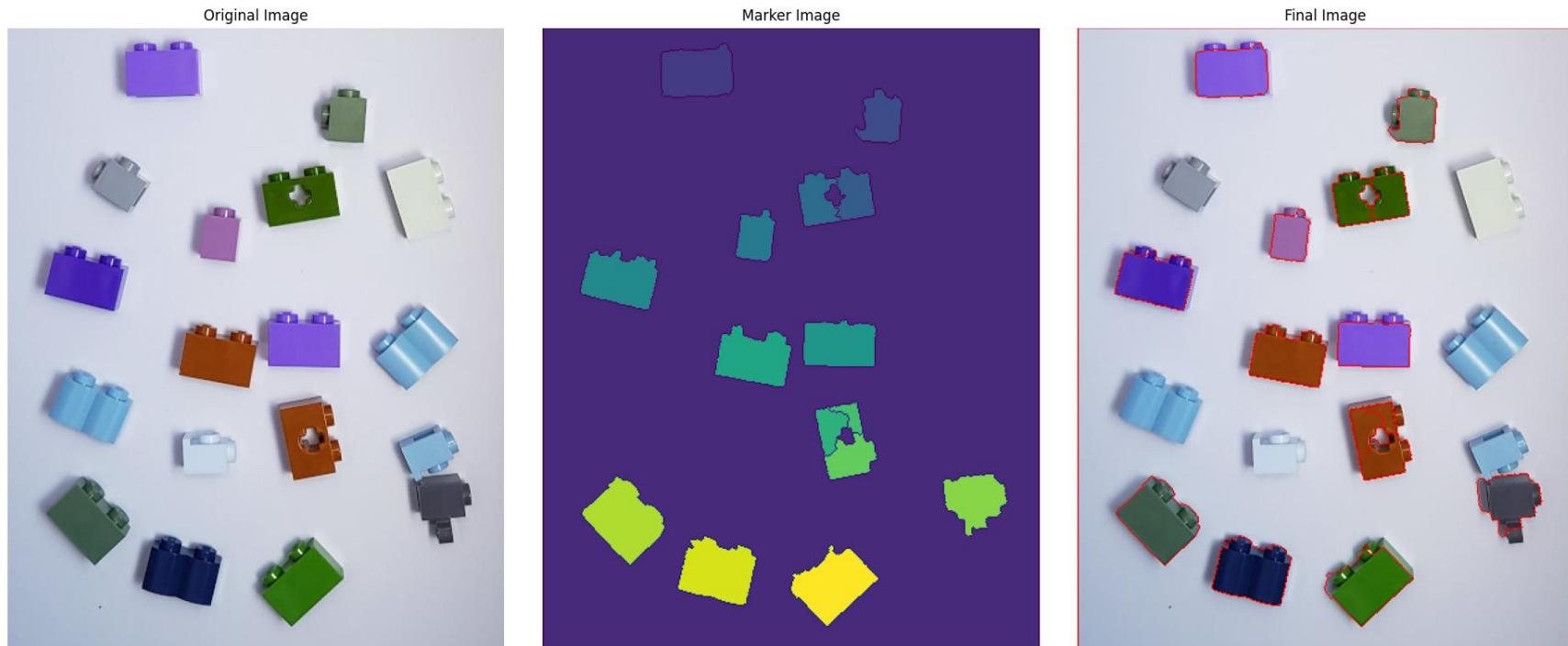
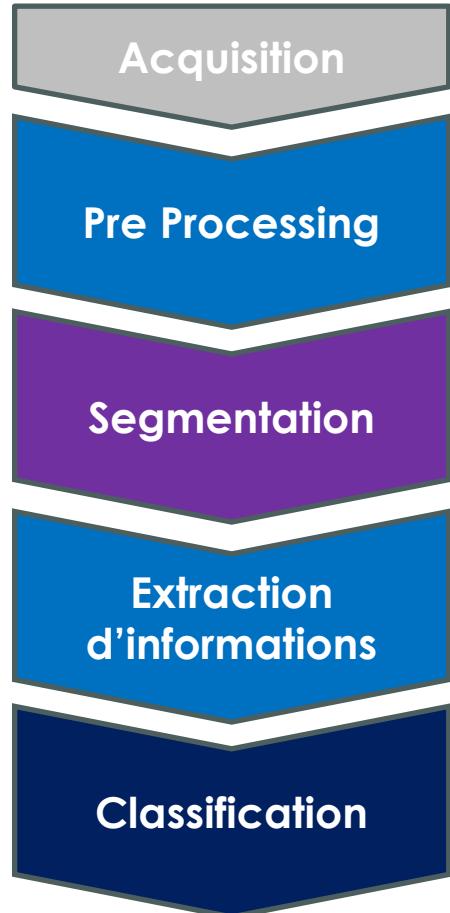
kernel

-1	0	1
-2	0	2
-1	0	1

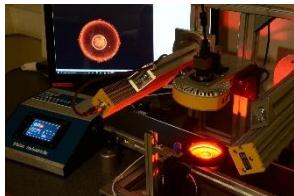




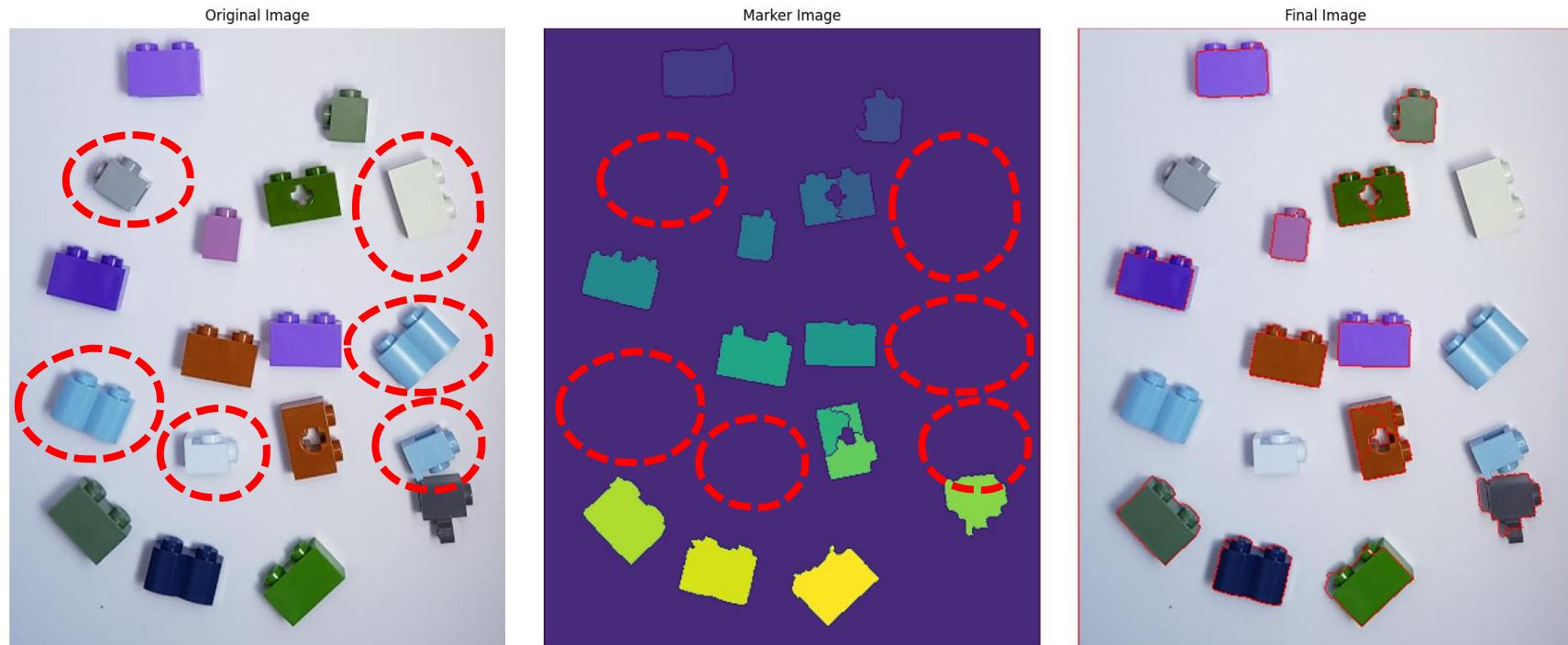
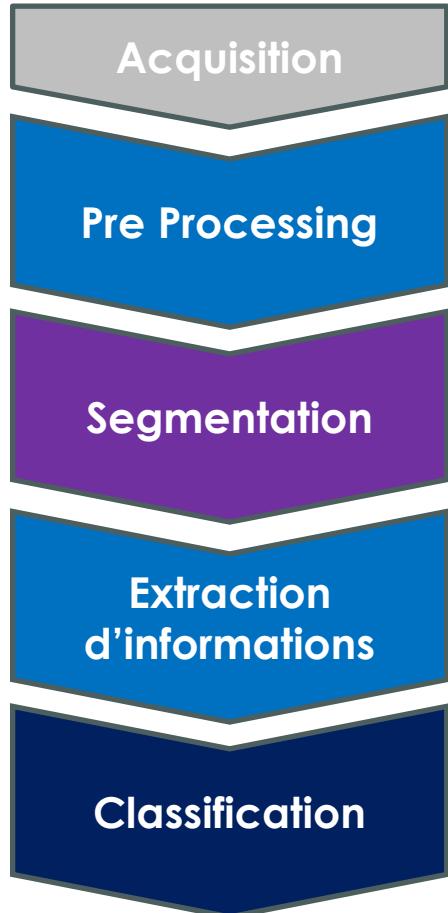
# Traitement d'images



Méthode de Watershed



# Traitement d'images



## Méthode de Watershed