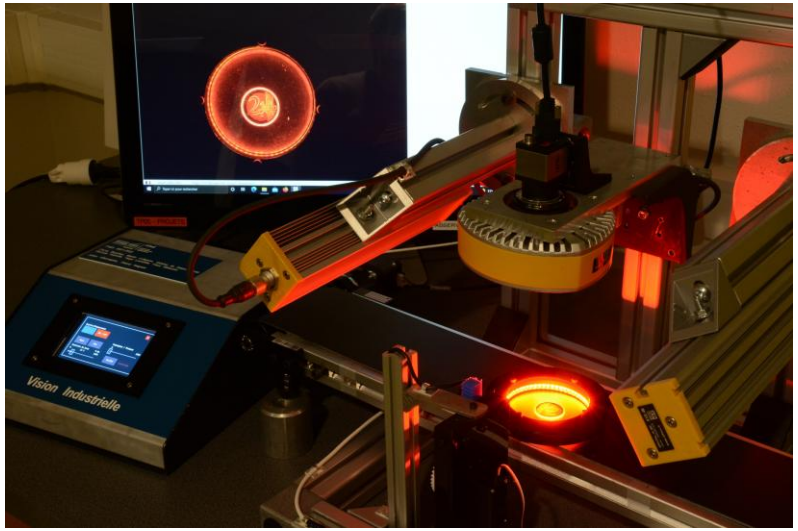
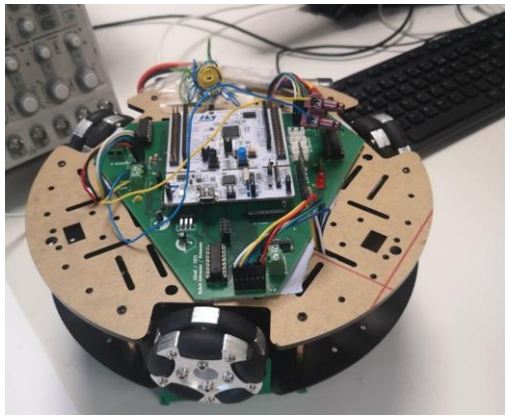
INSTITUT d'OPTIQUE GRADUATE SCHOOL | LEnsE Laboratoire d'Enseignement Expérimental

# Interfaçage Numérique

## Vision Industrielle

Julien VILLEMEJANE



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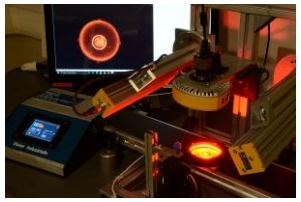

# Vision Industrielle

***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**

- Détecter 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

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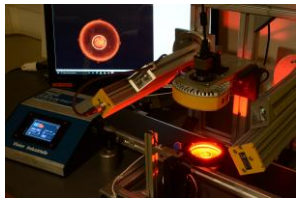
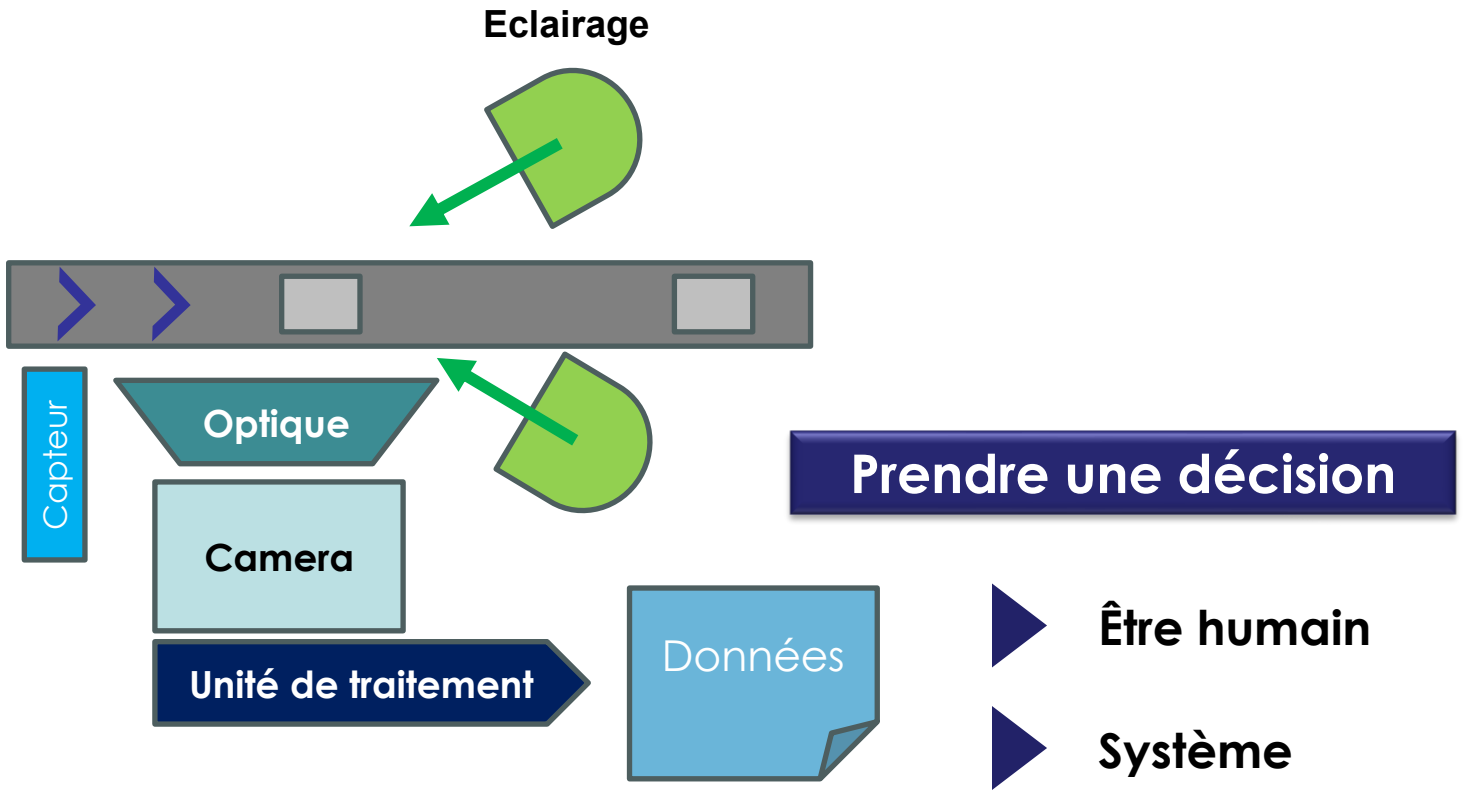


# Vision Industrielle

## Eléments constitutifs

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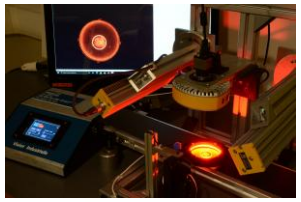
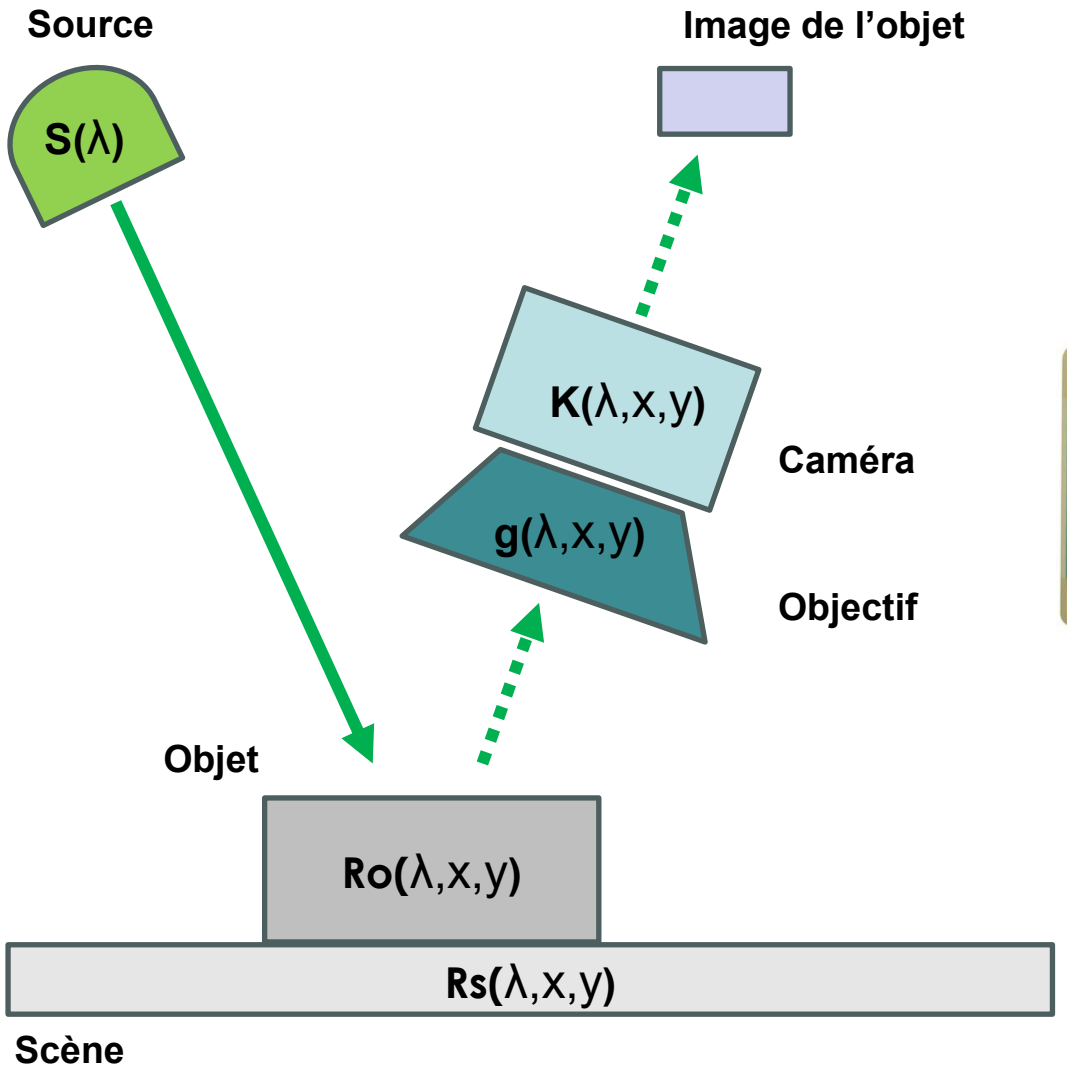
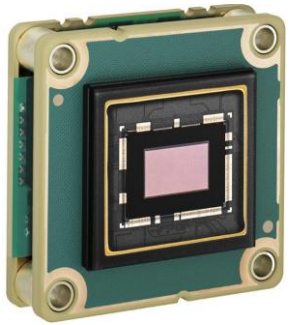


# Vision Industrielle

## Modélisation de la chaine



Basler Sensor / Mouser

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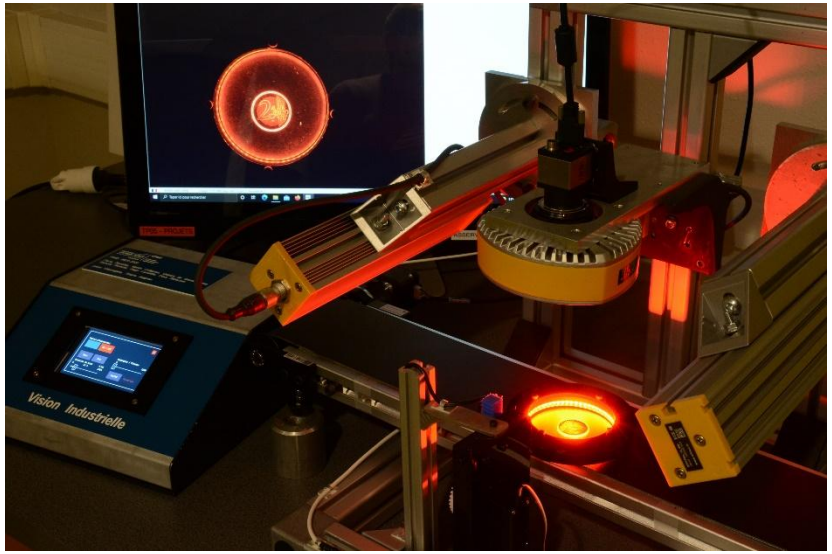
# Objets / Sources

Eclairage / Colorimétrie



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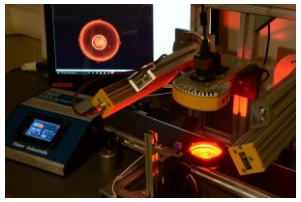
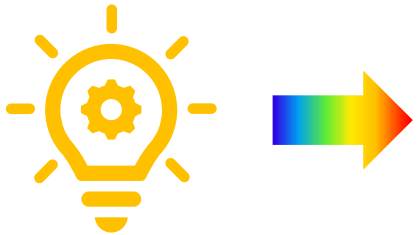


# Sources

## Sources primaires

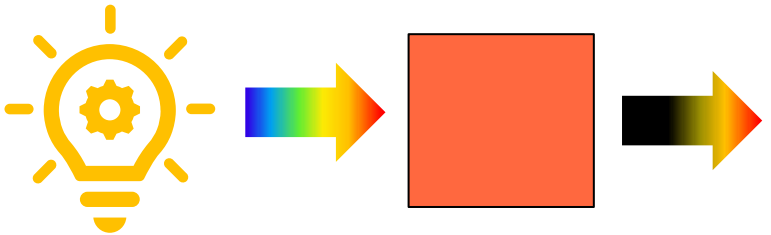
**Produisent leur propre lumière**



**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**

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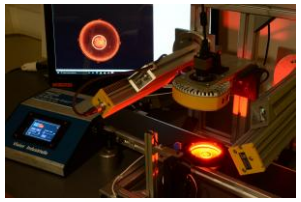
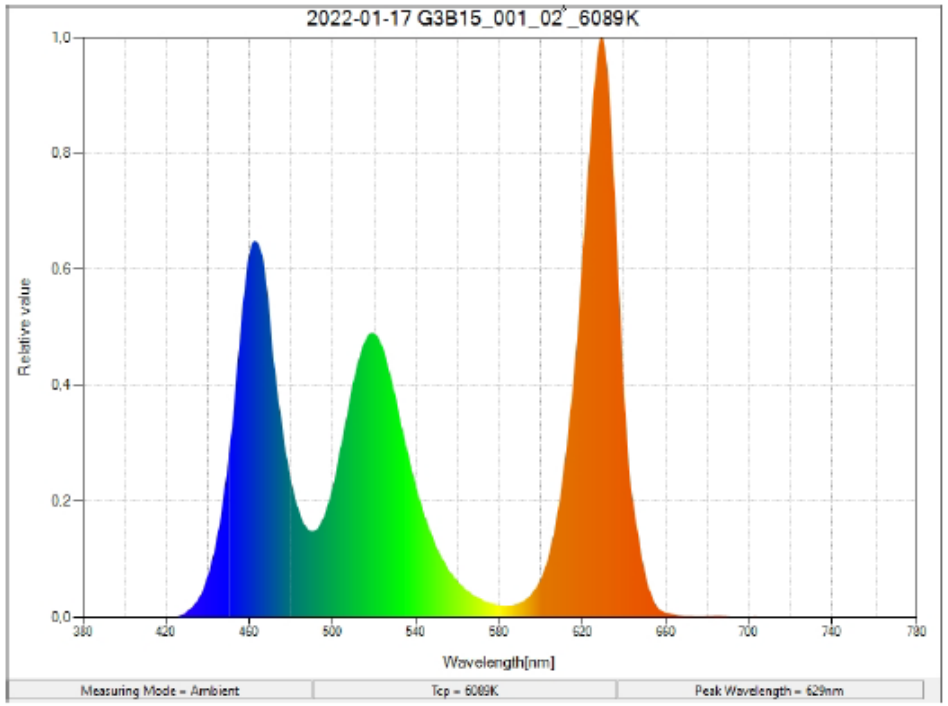
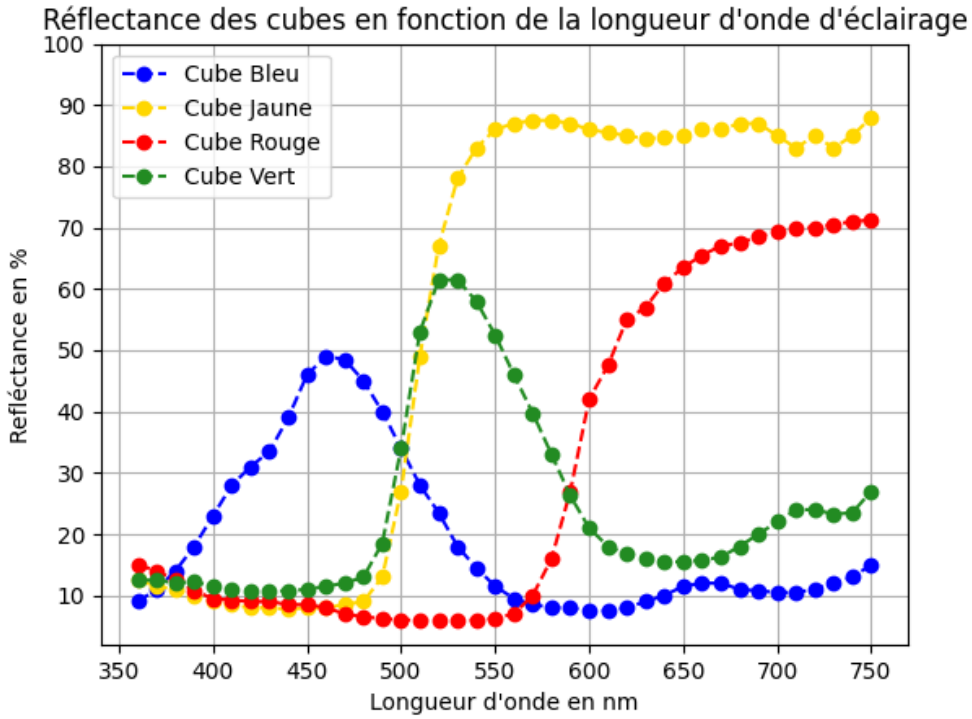


# Sources

## Spectre d'émission




## Réflectance




Source Effilux Ring RGB

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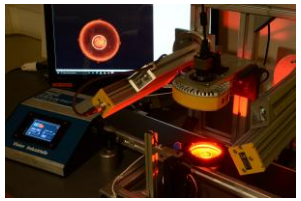

# Eclairage

## Uniformité de l'éclairage

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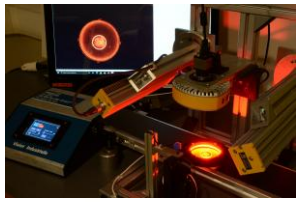
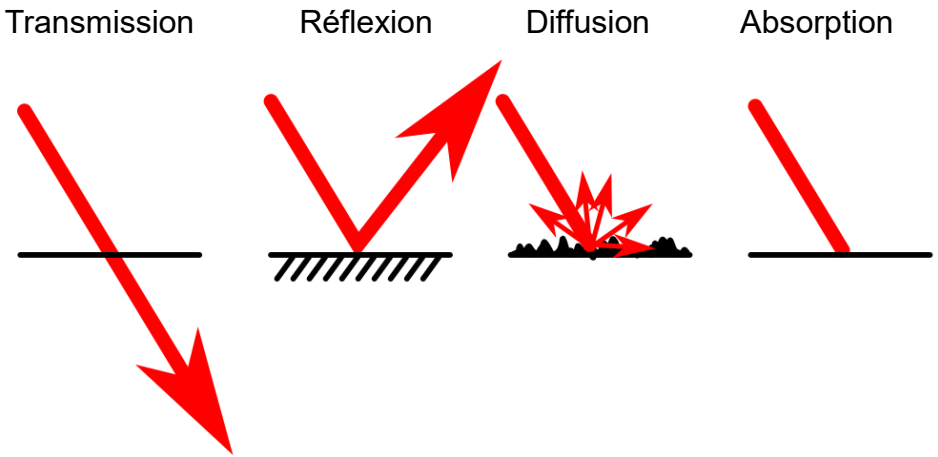
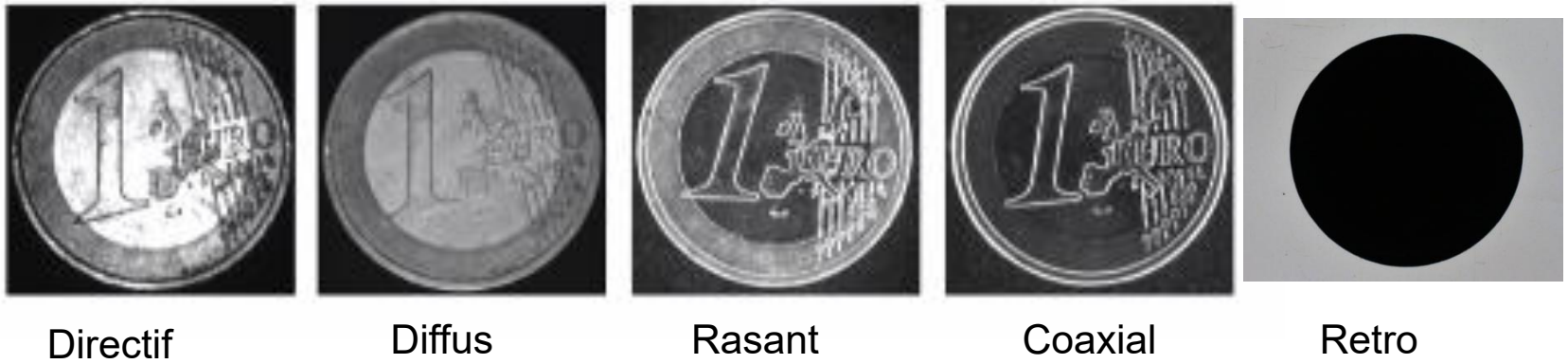


# Eclairage

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



Directif | Diffus | Rasant | Coaxial | Retro

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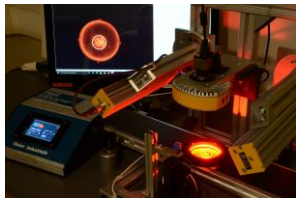

# Colorimétrie

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

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

▶ Fairchild, *Color Appearance models*

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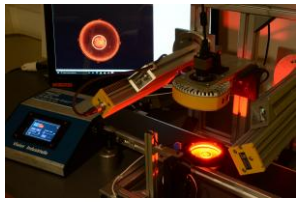
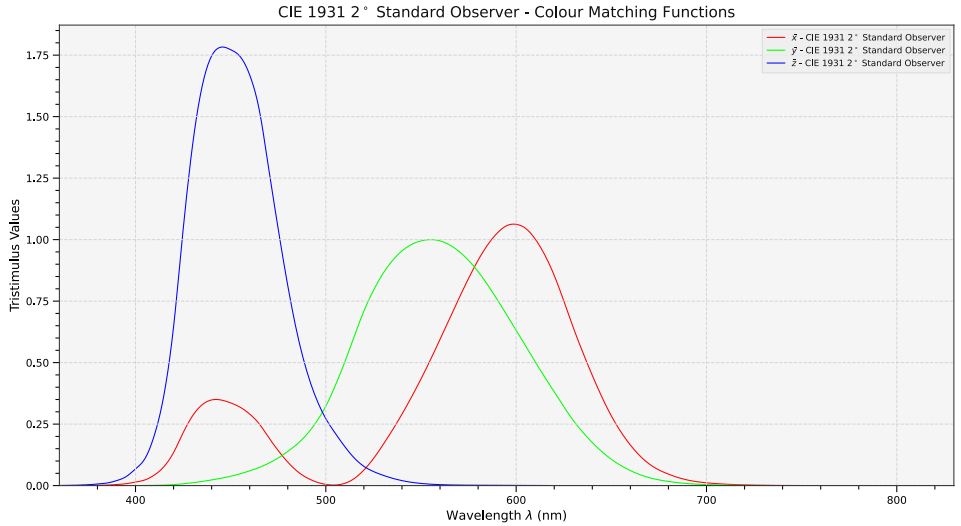
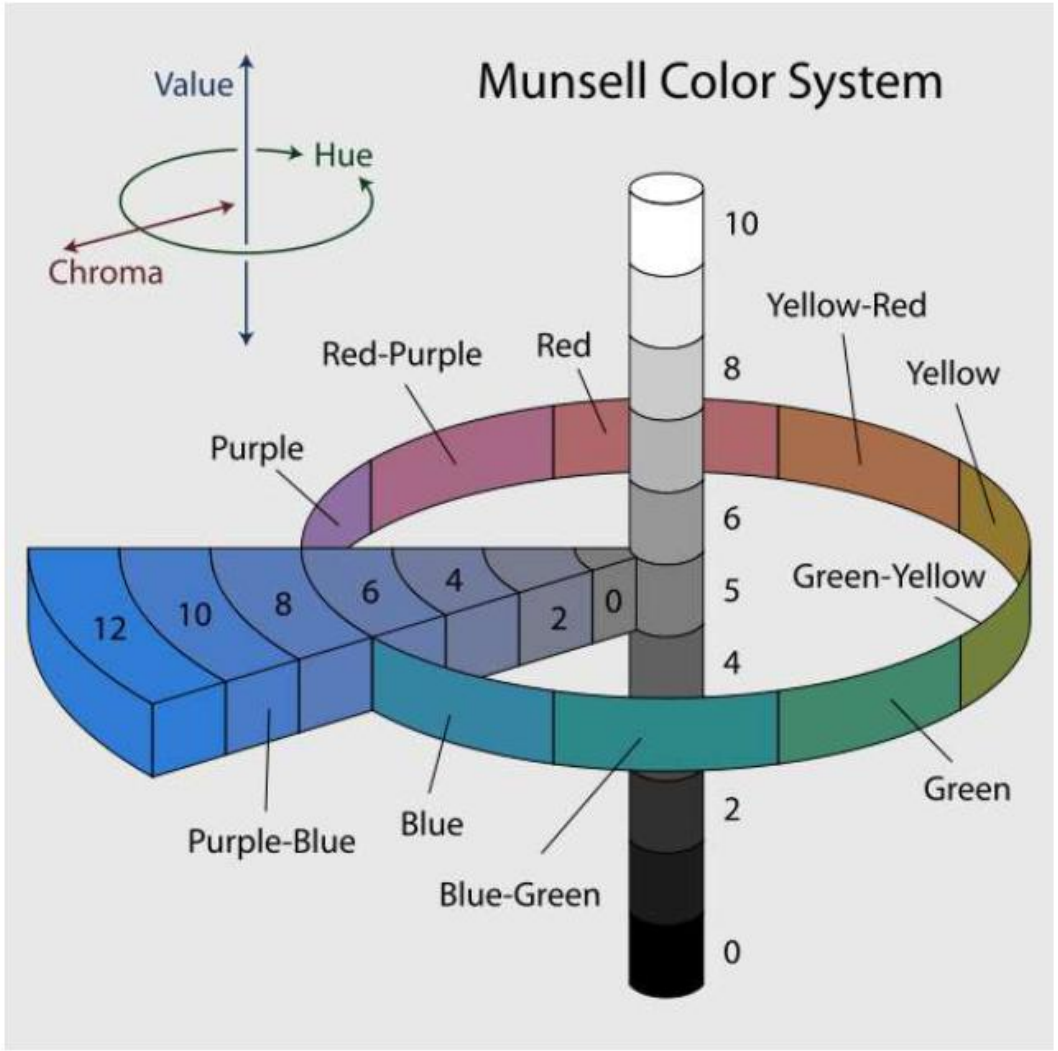


# Colorimétrie




$$K_m = 683\ lm/W$$

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



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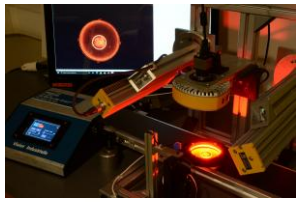
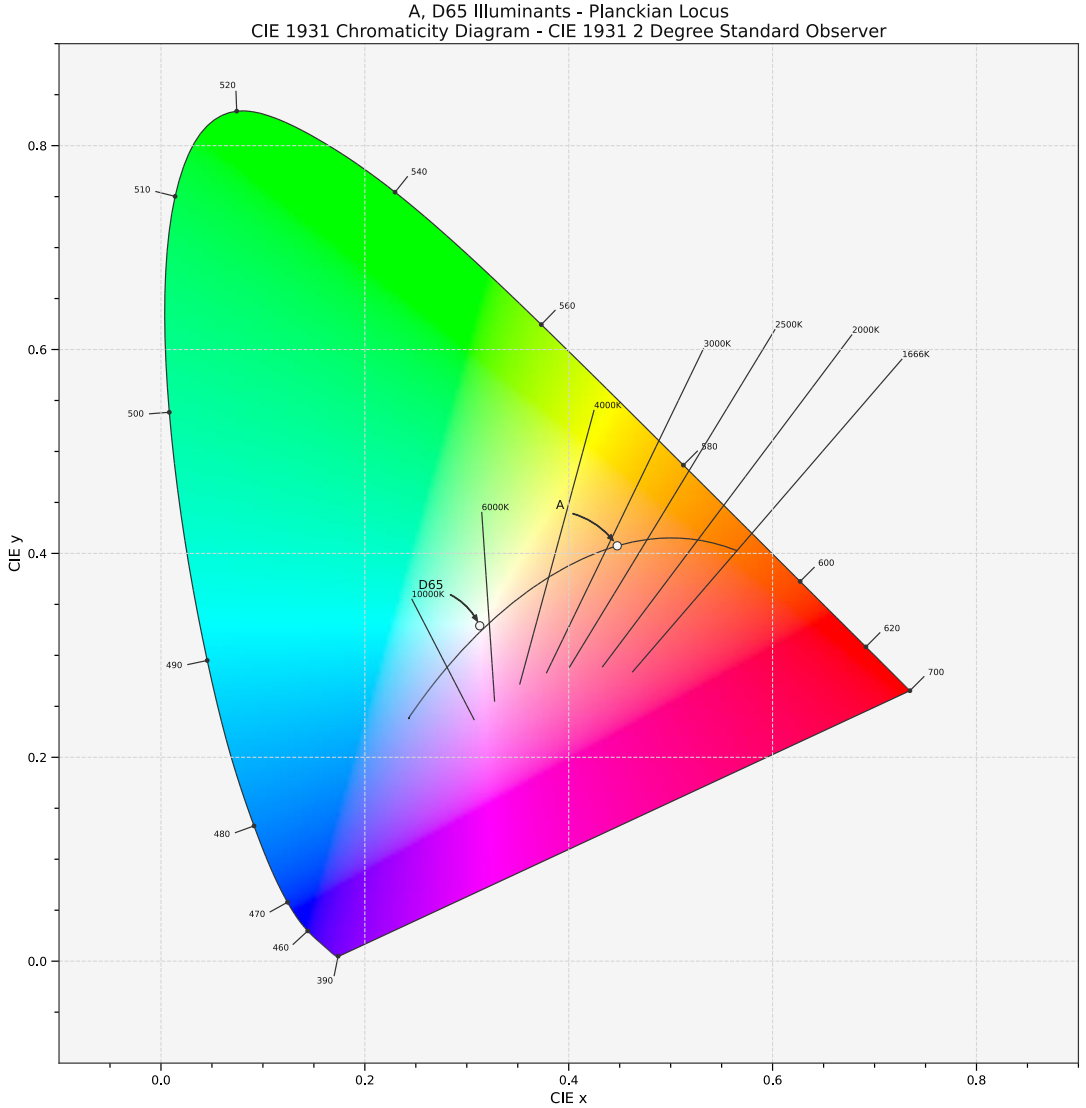


# Colorimétrie

*Diagramme de chromaticité CIE 1931 xy*

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

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



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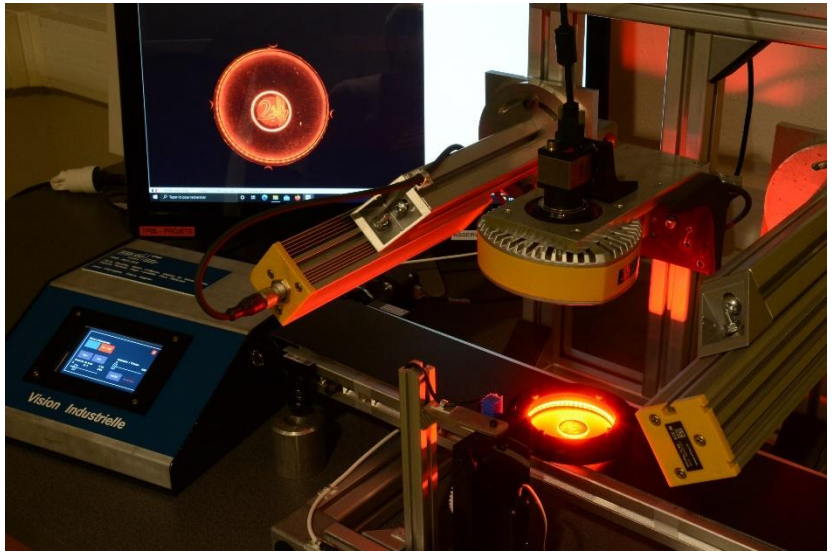
# Objectif optique

Créer une image exploitable



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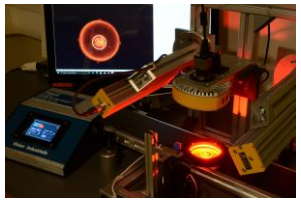
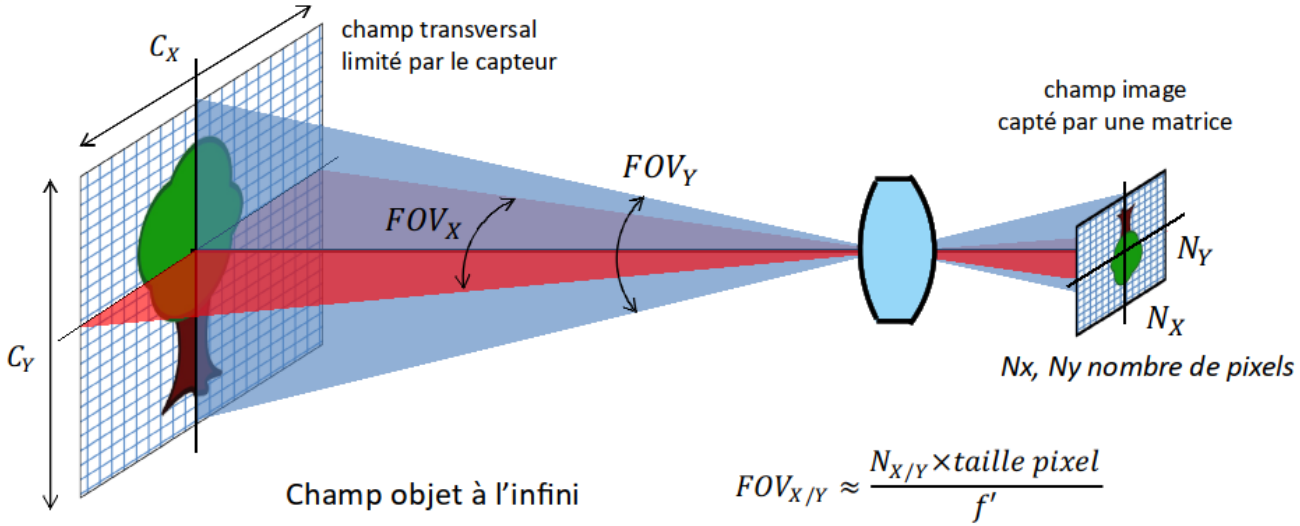
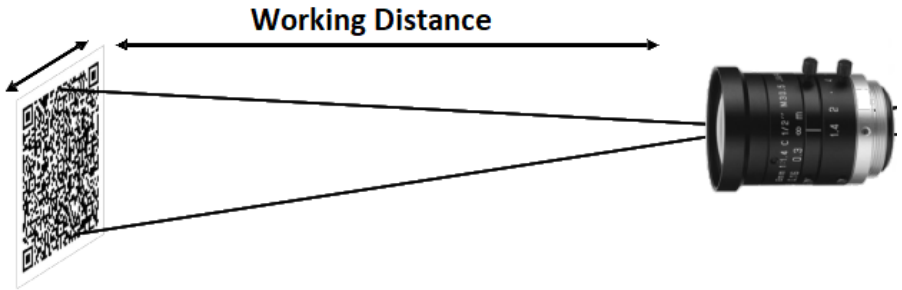


# Objectif optique

## Créer une image




$$FOV_{X/Y} \approx \frac{N_{X/Y} \times taille\ pixel}{f'}$$



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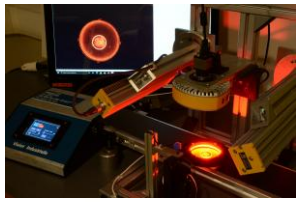
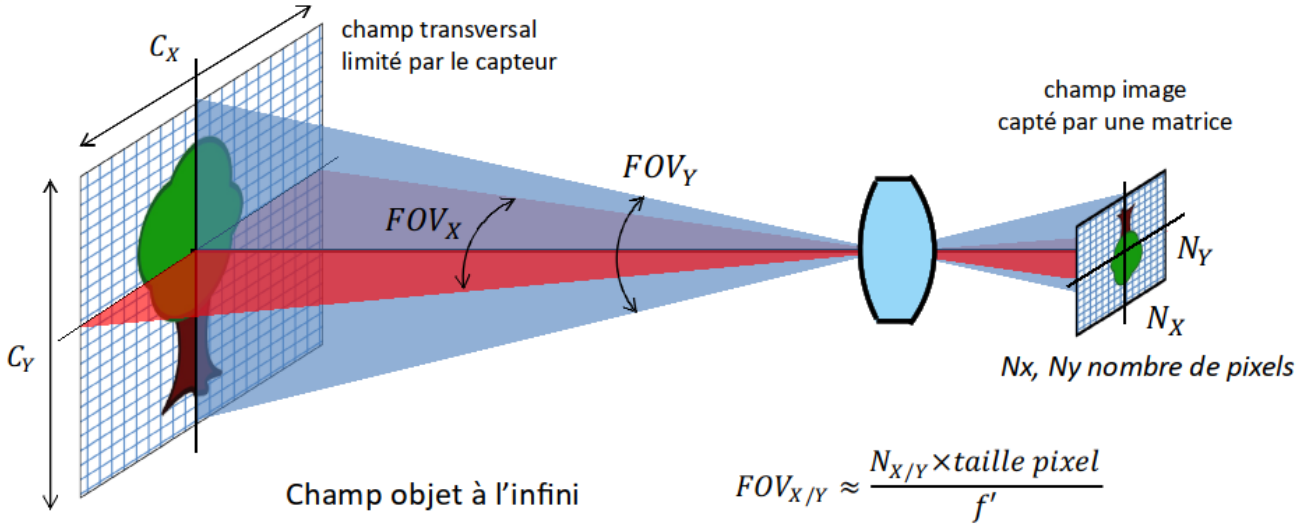


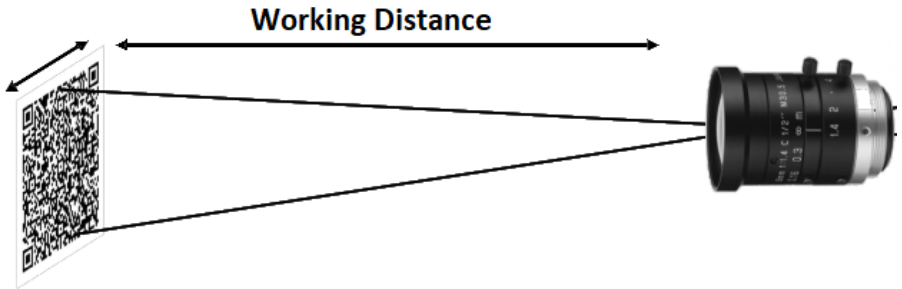
# Objectif optique

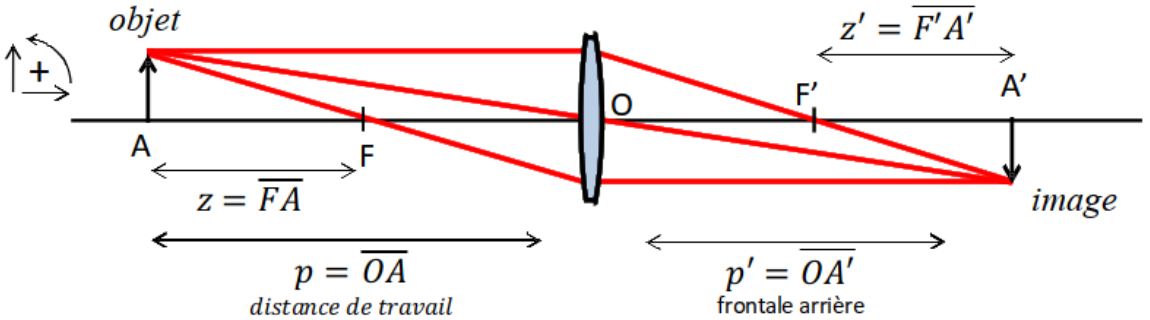
## Créer une image




Champ objet à l'infini

$$FOV_{X/Y} \approx \frac{N_{X/Y} \times taille\ pixel}{f'}$$




taille image
*grandissement transversal*

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

*grandissement longitudinal*

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

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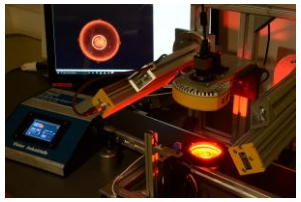
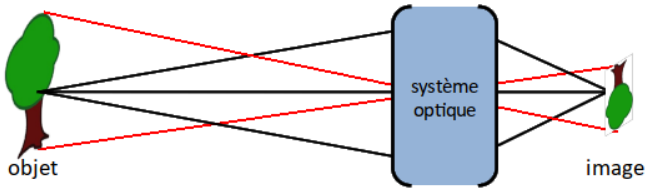


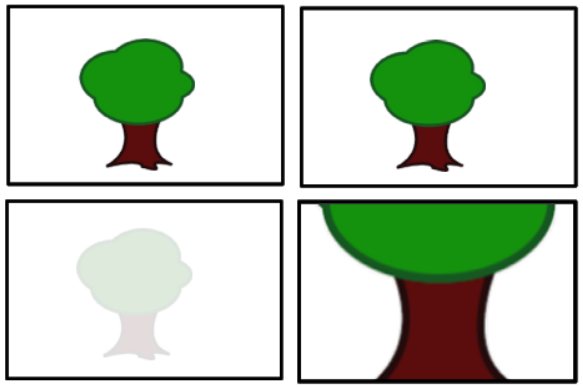
# Objectif optique

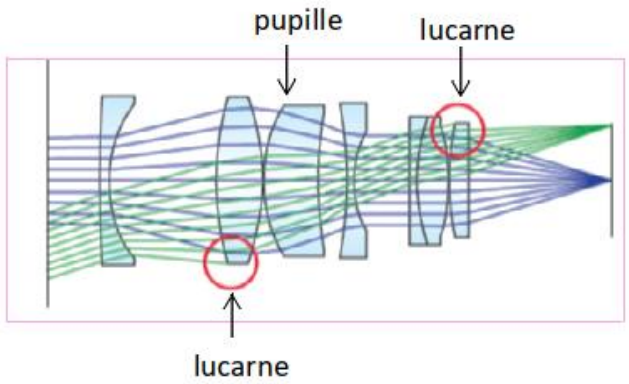
## Créer une image

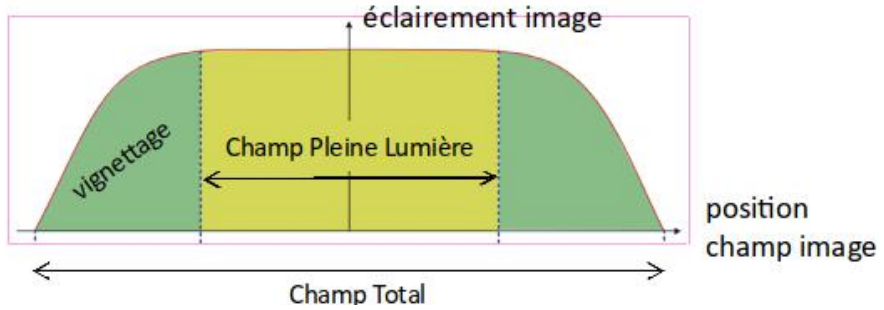



**Ouverture**
*flux collecté*

**Champ**
*taille max objet capté*





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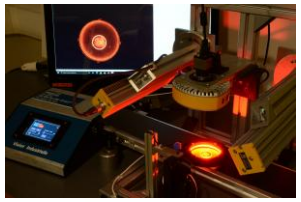
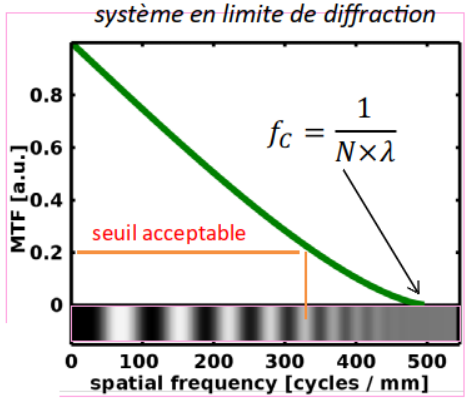
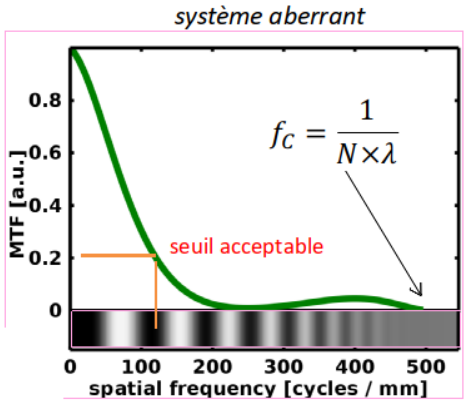


# Objectif optique

## Créer une image



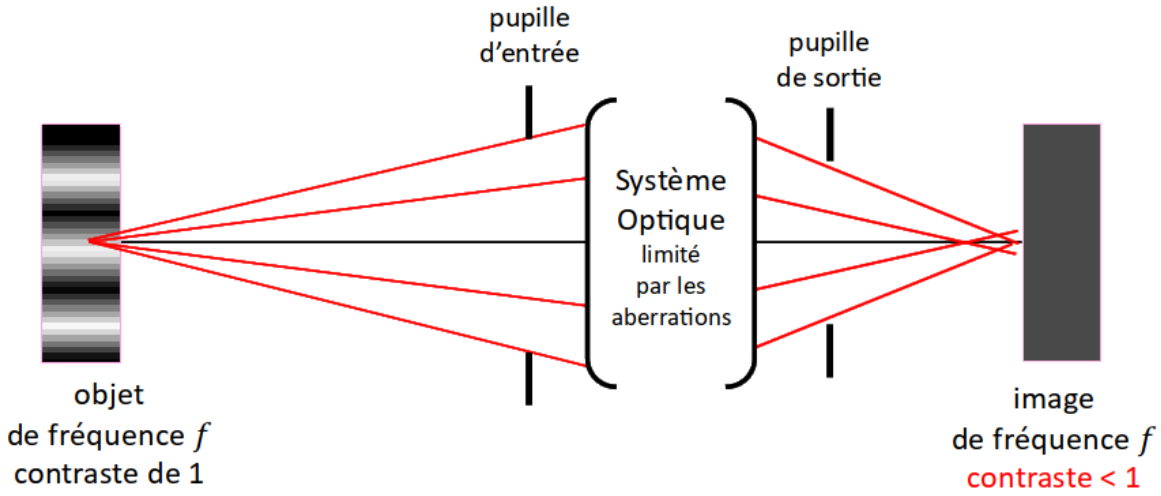




Image mire et profil

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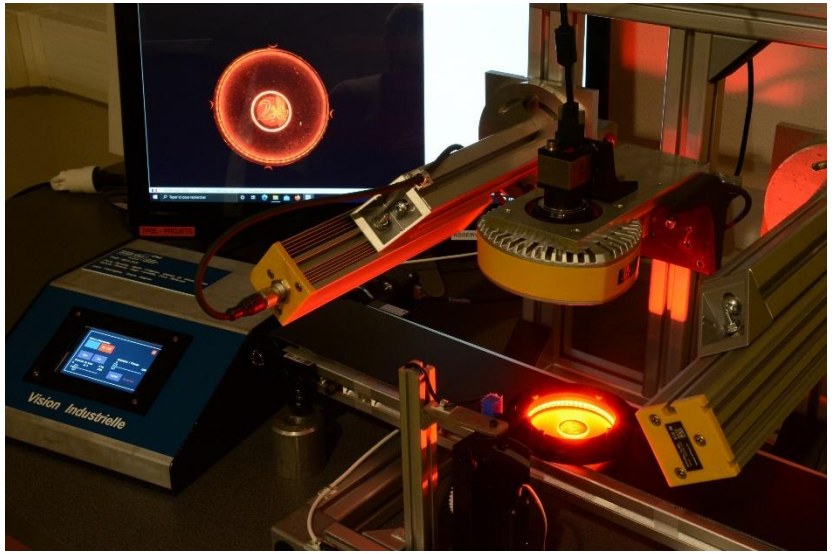
# Caméra numérique

Echantillonnage / Quantification
Colorimétrie



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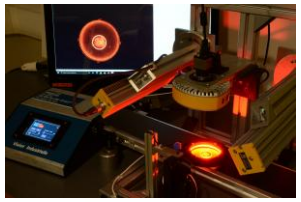
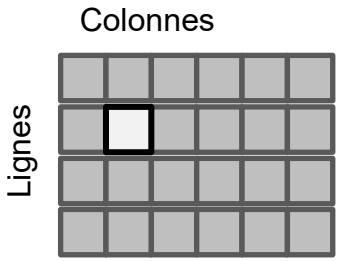


# Caméra numérique

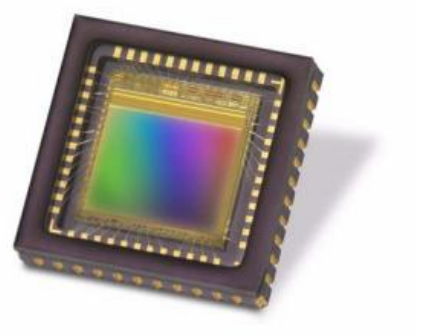
## Matrice de pixel



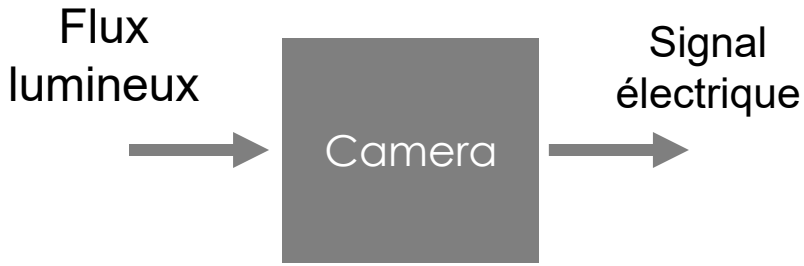

**Camera**

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


IDS UI-1240SE-C-HQ



e2v sensor EV76C560ACT




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

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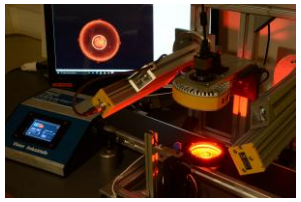
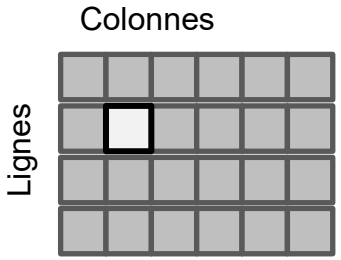
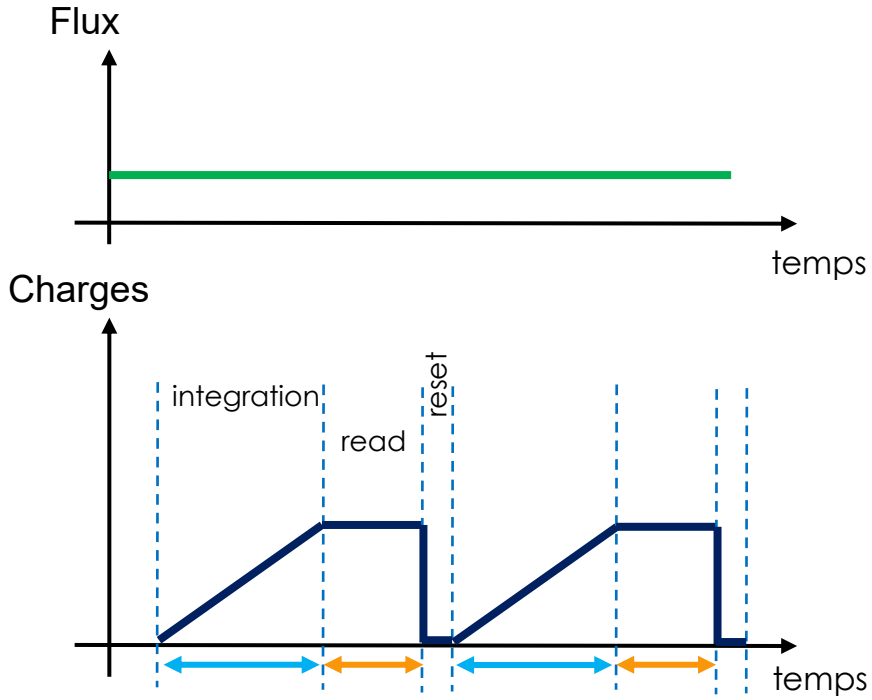


# Caméra numérique

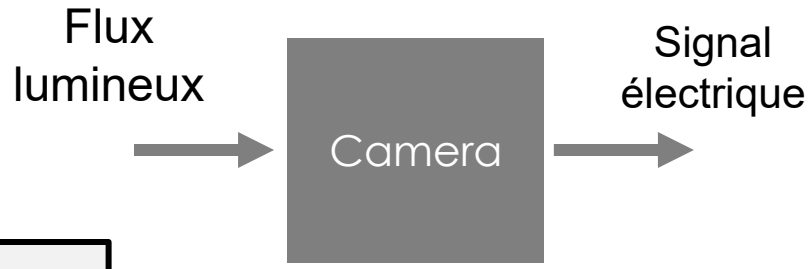
## Matrice de pixel

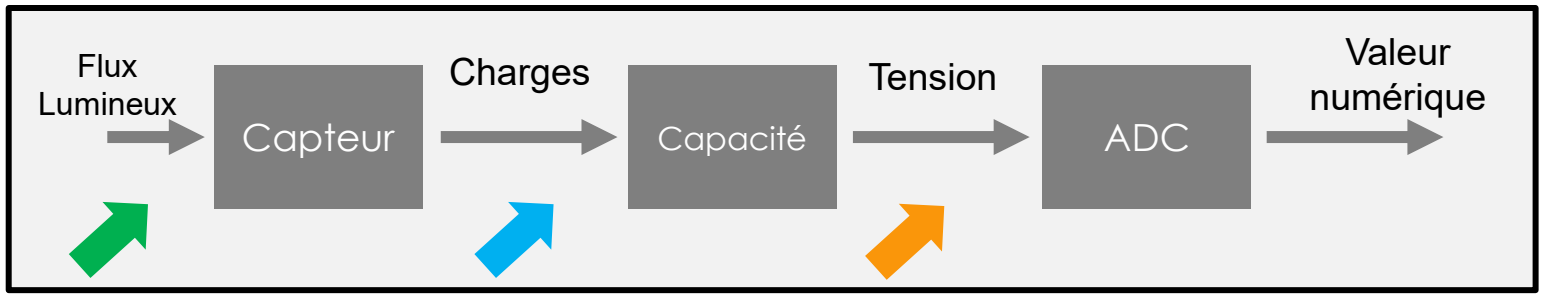



**Camera**

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




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

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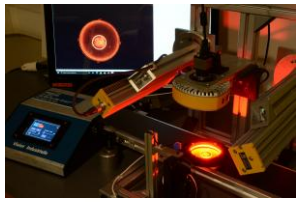
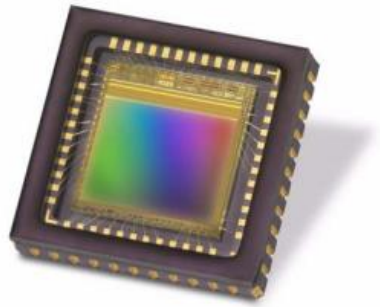
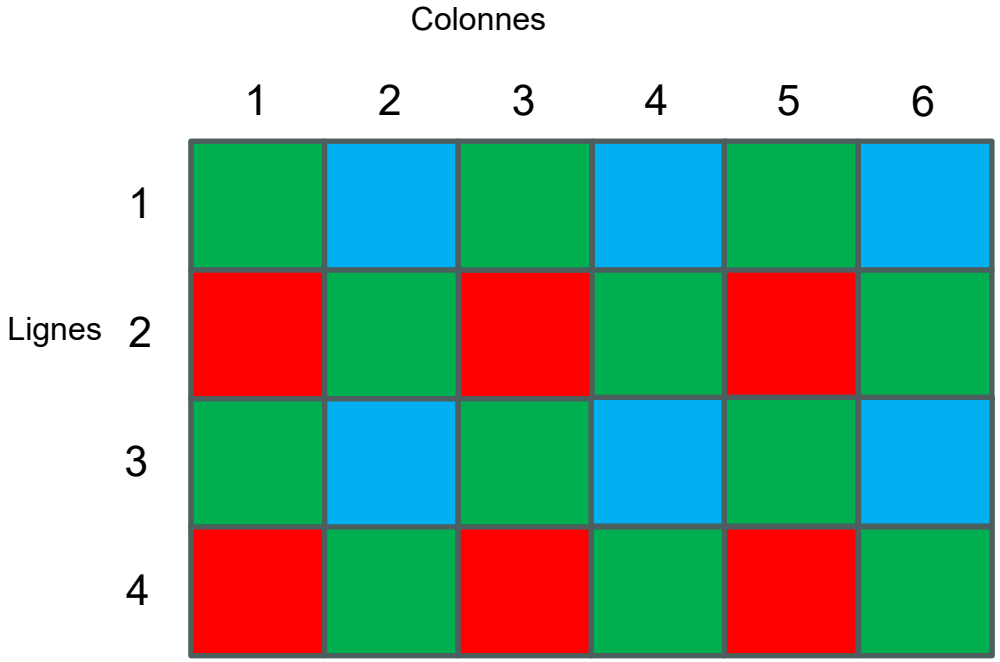


# Caméra numérique

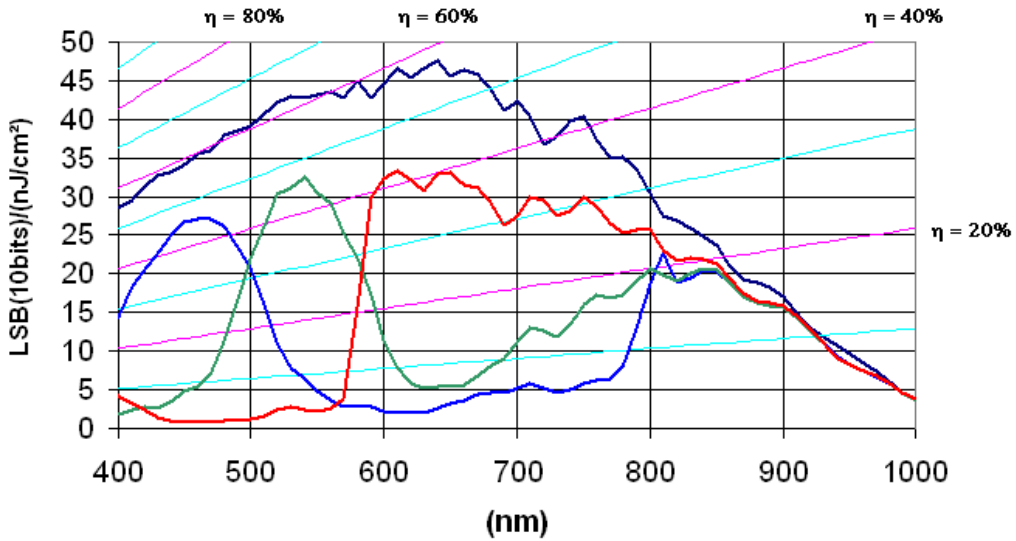
## Réponse spectrale



e2v sensor EV76C560ACT




Matrice de Bayer



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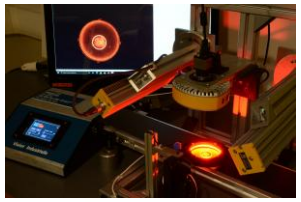
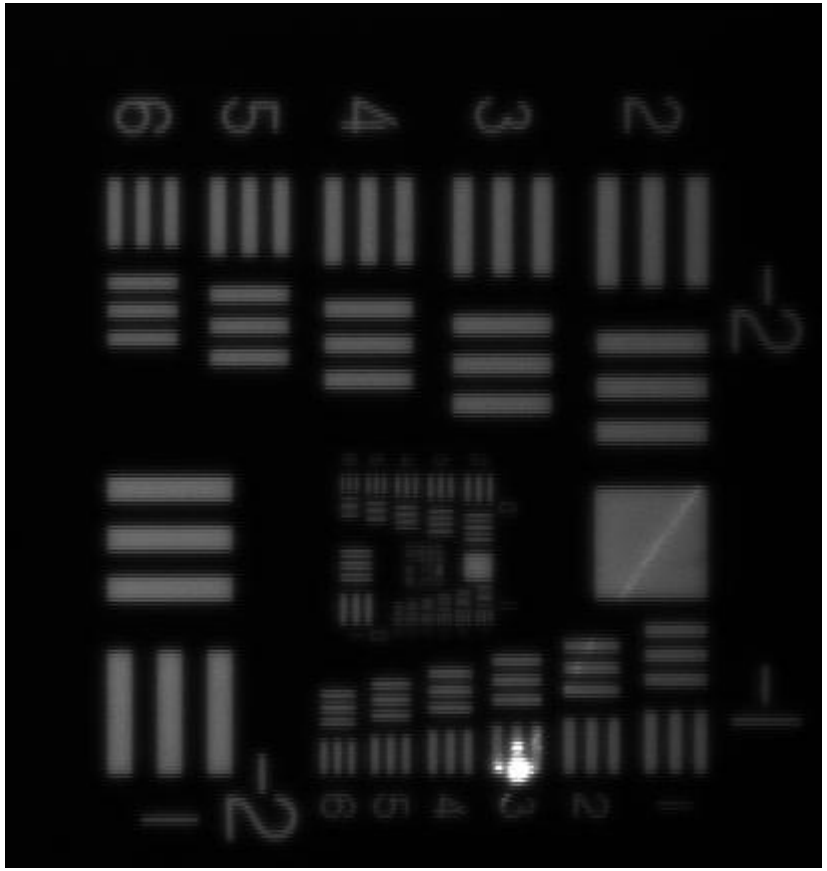


# Vision Industrielle

## Résolution



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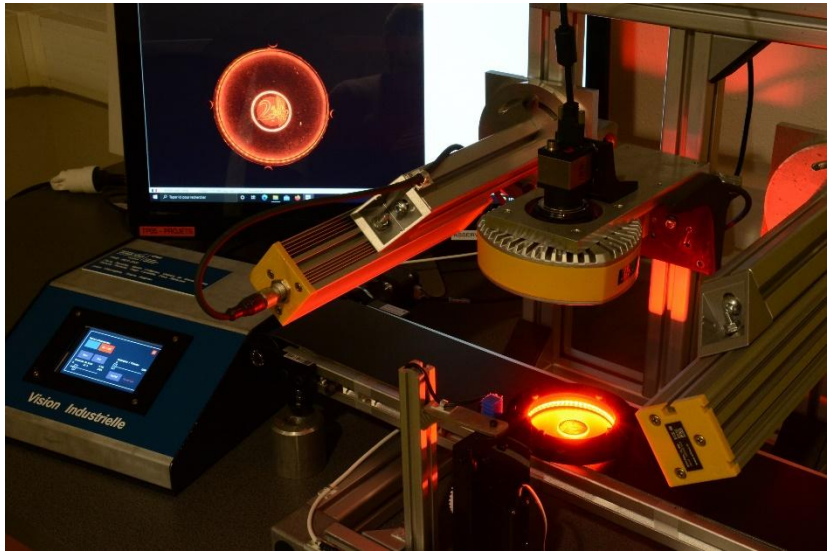
# Traitement d'image

Pré-traitement / Segmentation / Classification



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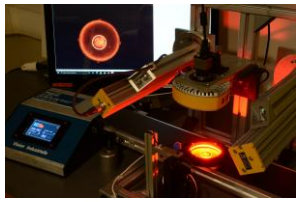

# Traitement d'images

**Objectif**

Image brute 'RAW' / Caméra

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

Image souhaitée / Contours bien définis

- Zones homogènes
- Transitions nettes

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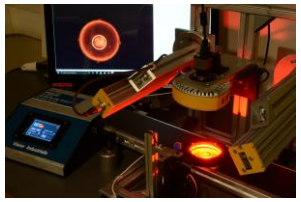
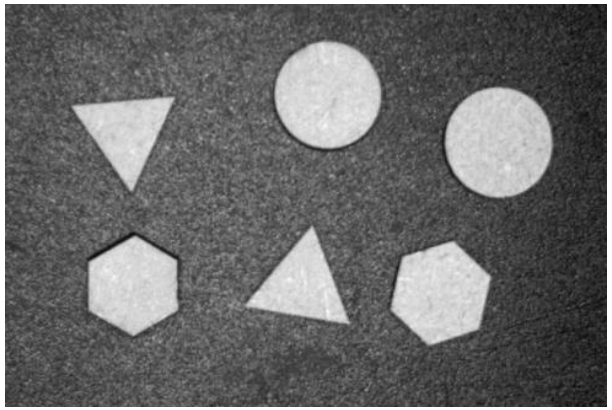
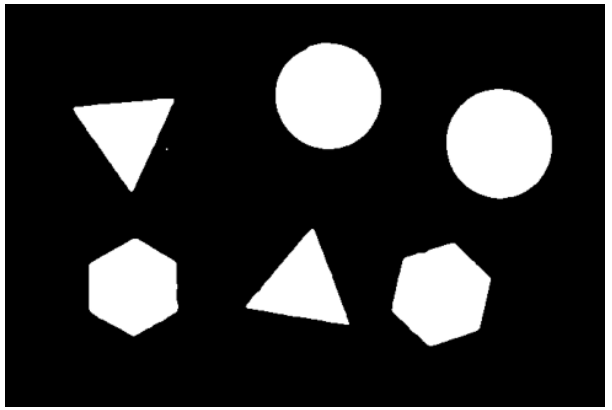


# Traitement d'images





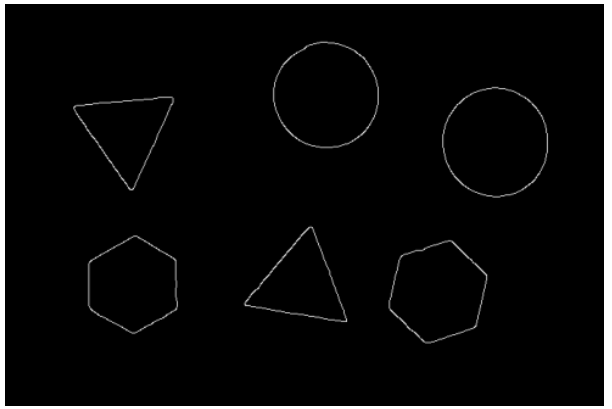


Image brute 'RAW' / Caméra

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

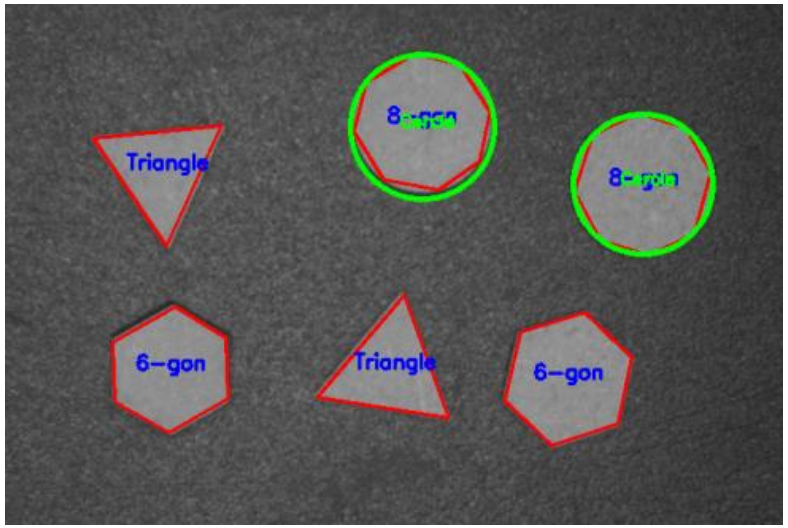



Image souhaitée / Contours bien définis

- Zones homogènes
- Transitions nettes

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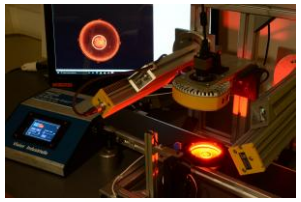
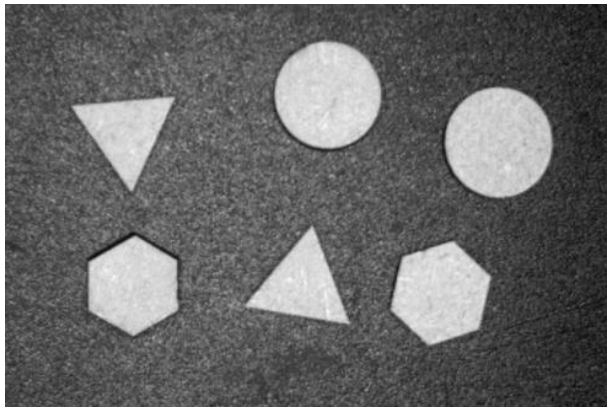
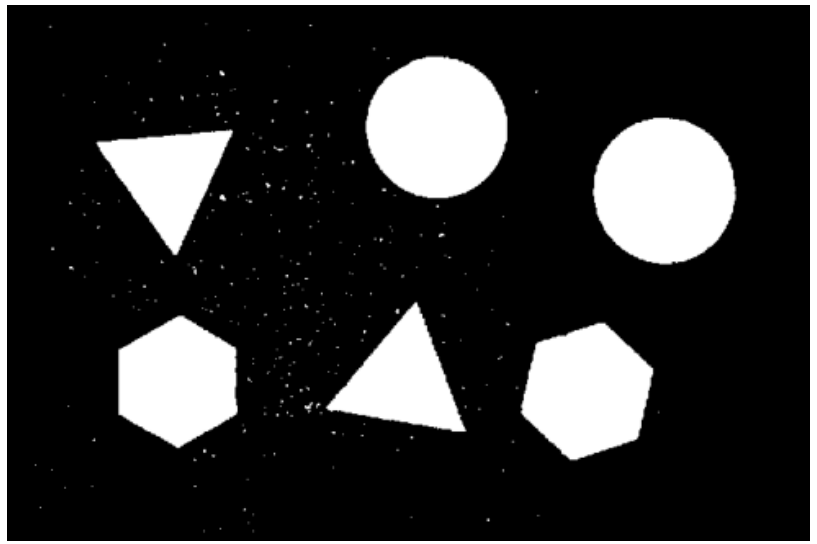
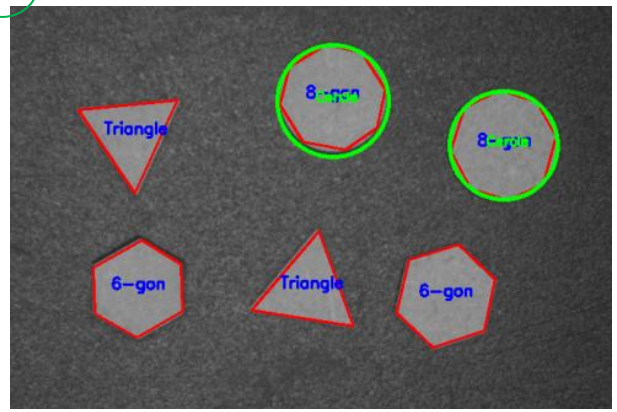


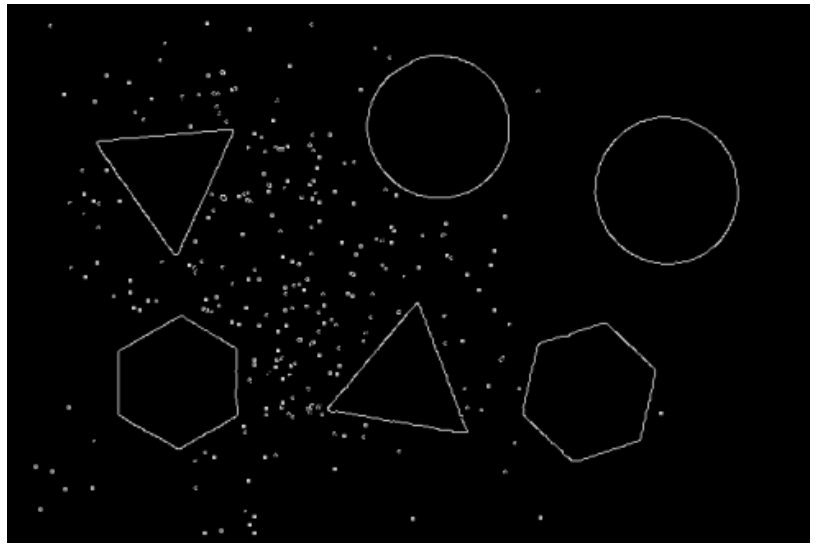
# Traitement d'images

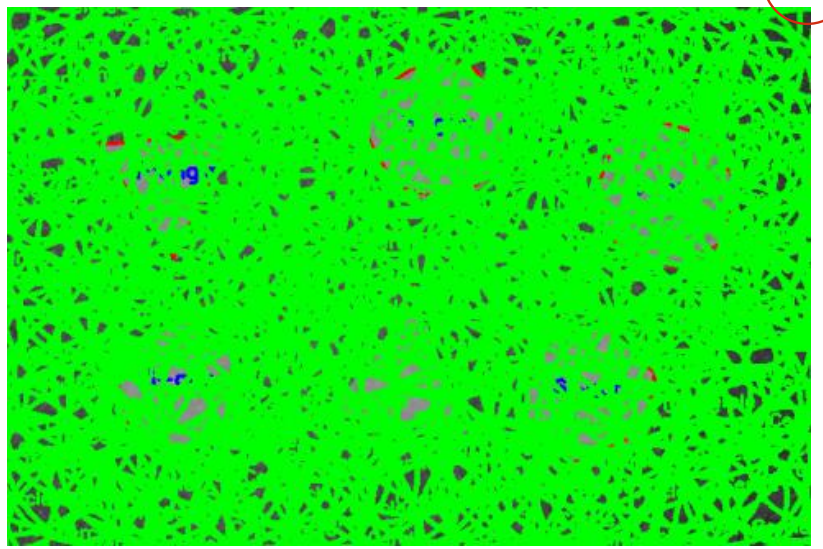
**Mauvais traitement**









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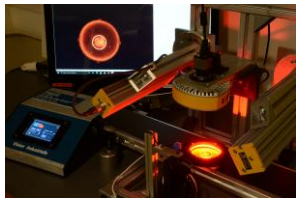
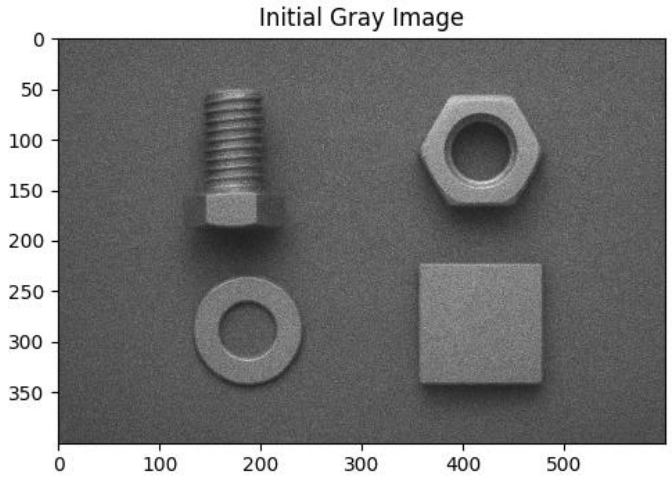
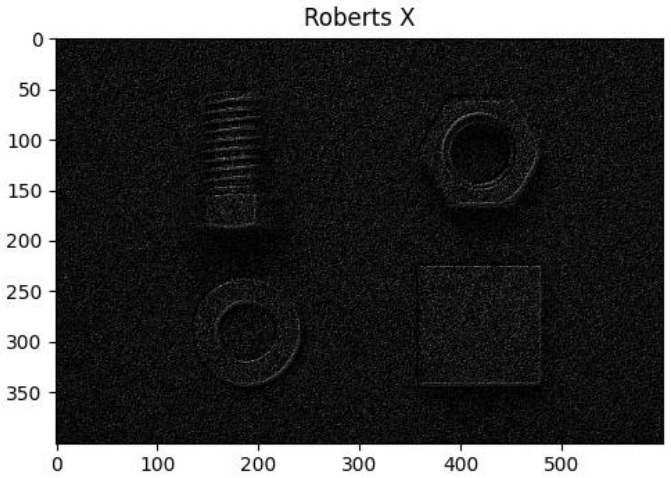
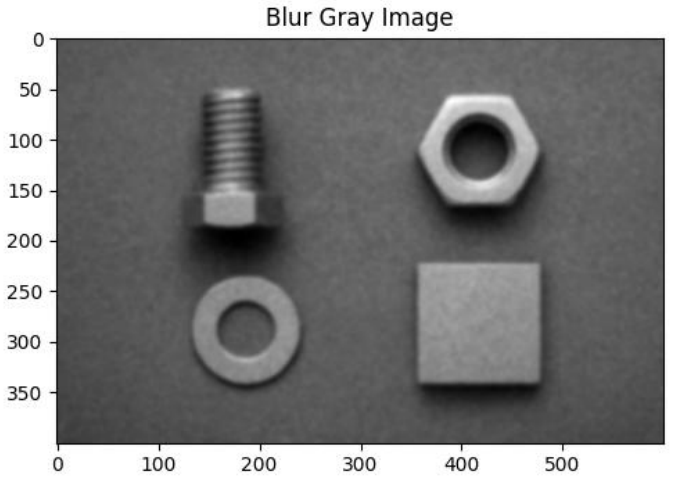


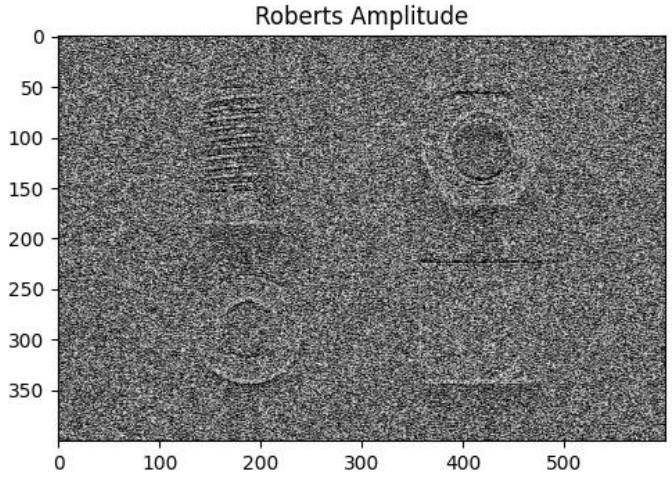
# Traitement d'images

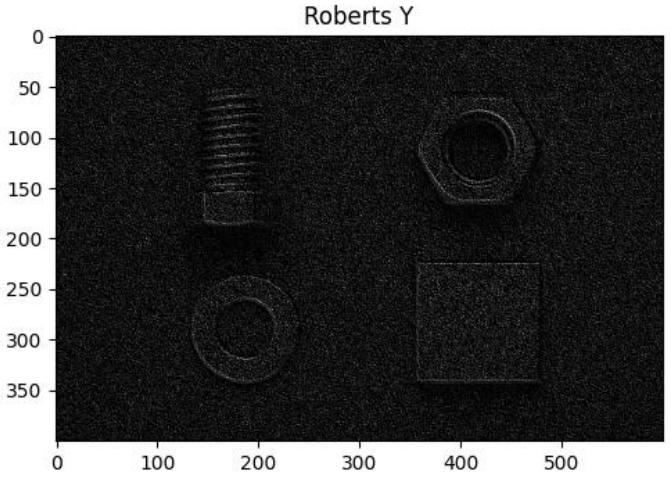
## Exemple industriel

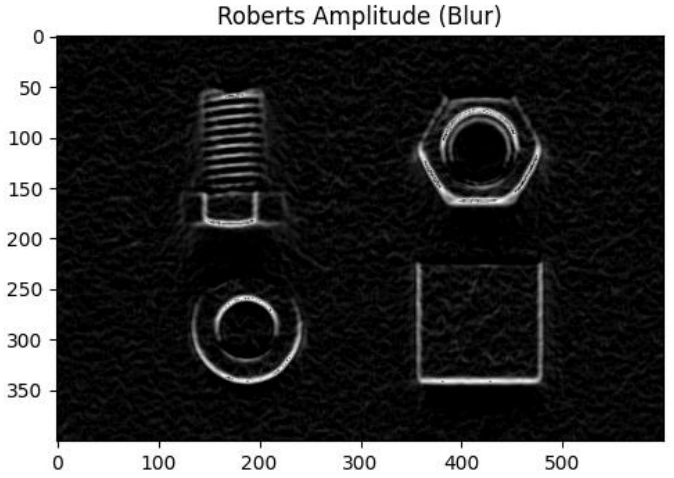


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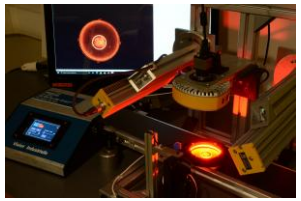

# Traitement d'images

**Objectif**

**Acquisition** — Eclairage, caméra…

**Pré-Traitement** — Filtrage / Réduction bruit
Amélioration contraste
Normalisation

**Segmentation** — Seuillage
Détection de contours
Sélection de régions d'intérêt

**Extraction d'informations** — Formes géométriques
Analyse de textures
Zones uniformes

**Classification** — Détection d'objets
Reconnaissance
Classification

**Décision** — Tolérances, pièce valide/non valide, retour en temps réel…

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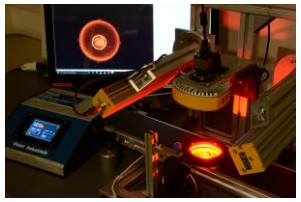
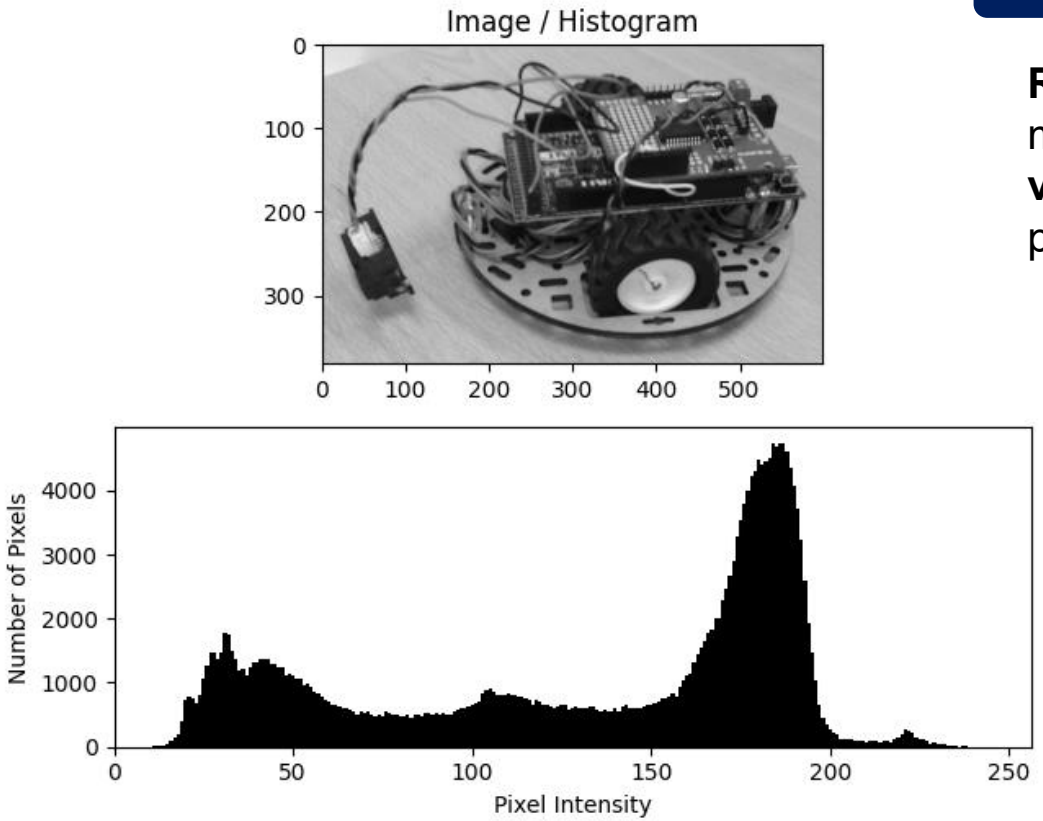


# Traitement d'images

**Filtrage par TF**

## Acquisition




## Histogramme

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

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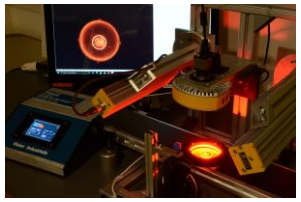
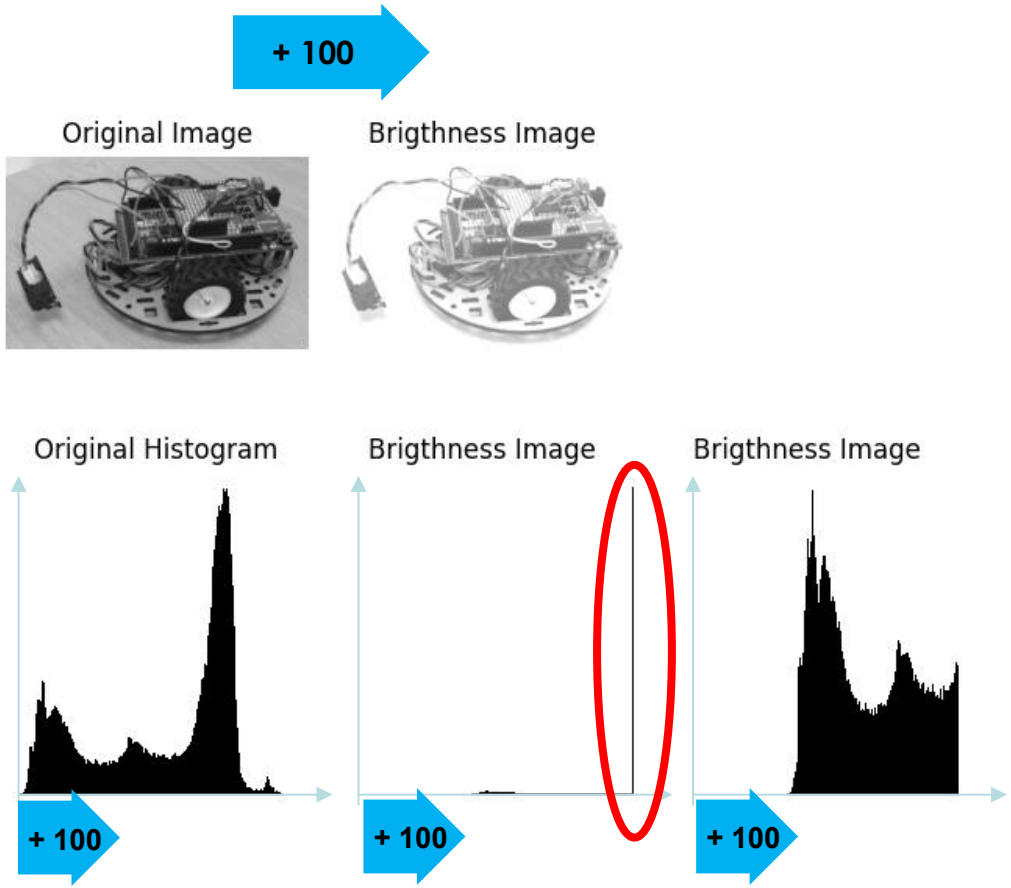


# Traitement d'images

## Amélioration de l'image

Acquisition

Pre Processing



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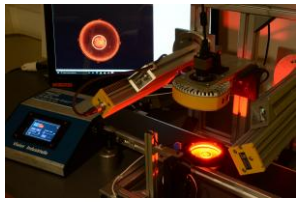
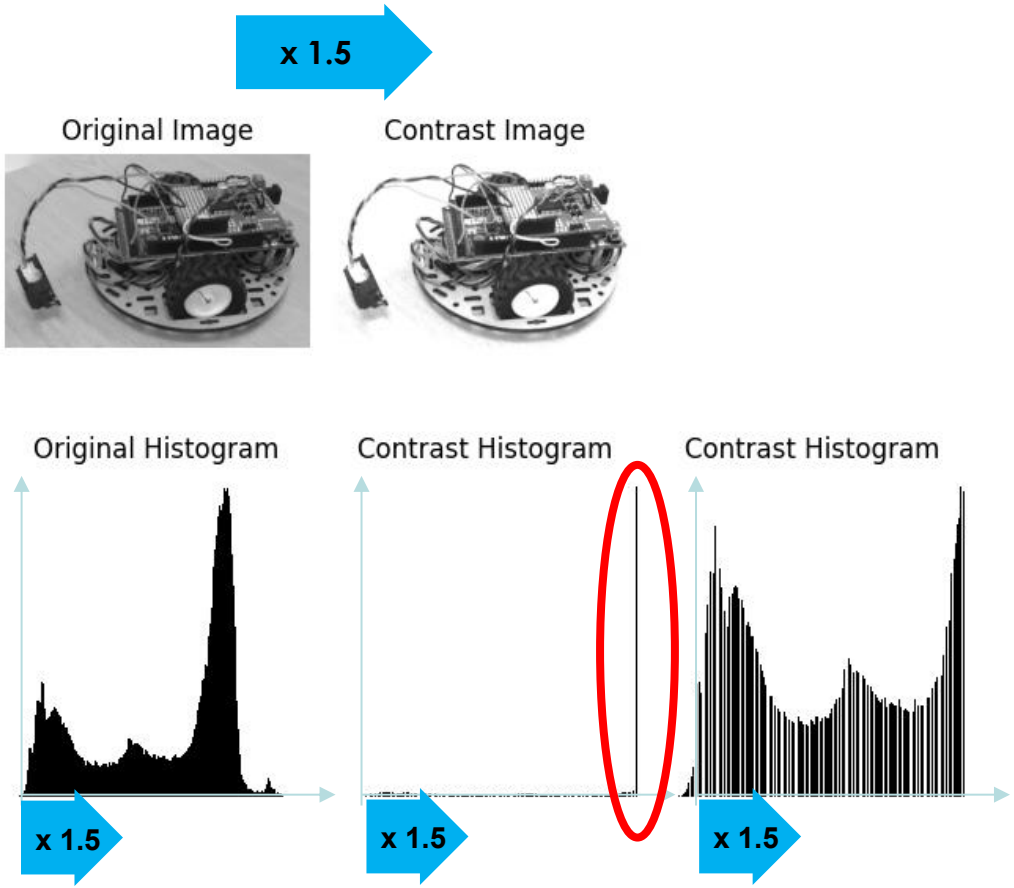


# Traitement d'images

## Amélioration de l'image

Acquisition

Pre Processing



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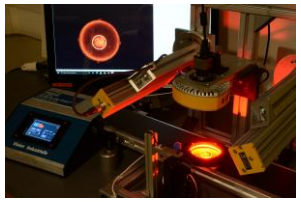

# Traitement d'images

Acquisition

Pre Processing

## Filtrage / Convolution

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 |

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

R = -8 + 0 – 12 + 5 + 30 + 8 – 16 + 0 – 3
R = 4

filtered image

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | 4 | | |
| | | | | | | |
| | | | | | | |

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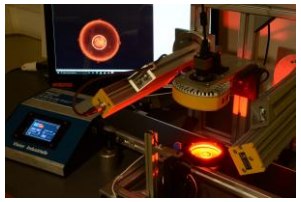


# Traitement d'images

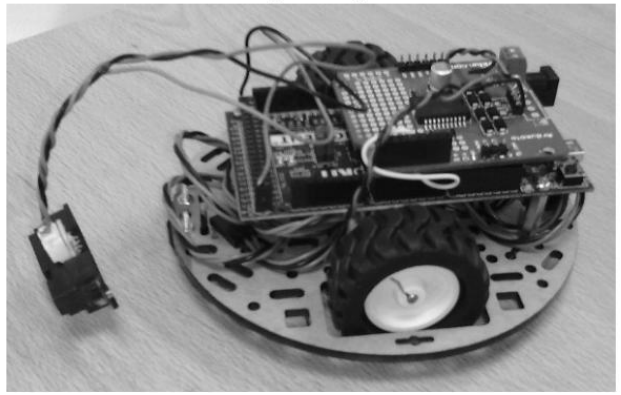
## Filtrage / Convolution

Acquisition

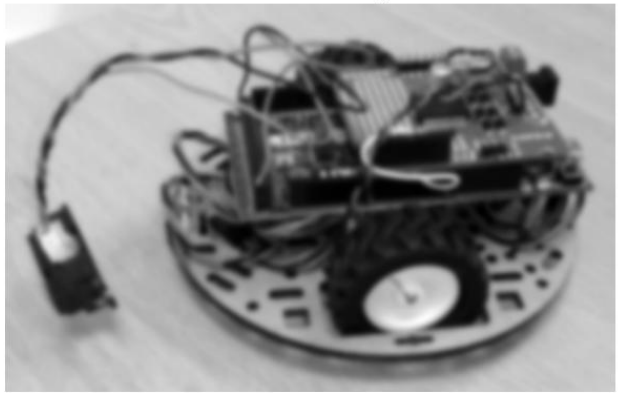
Pre Processing

Suppression de détails insignifiants

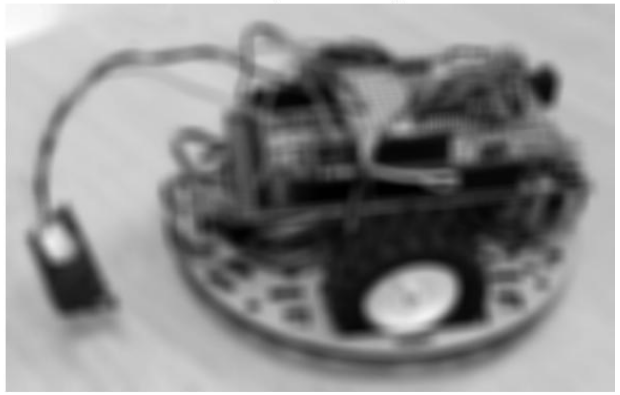
Original Image



Gaussian Blur Image



Median/Box Blur Image



| | | | | |
|---|---|---|---|---|
| 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)

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

| | | |
|---|---|---|
| 1/9 | 1/9 | 1/9 |
| 1/9 | 1/9 | 1/9 |
| 1/9 | 1/9 | 1/9 |

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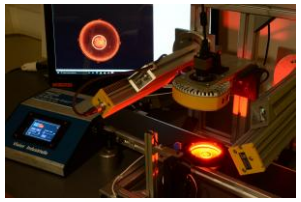
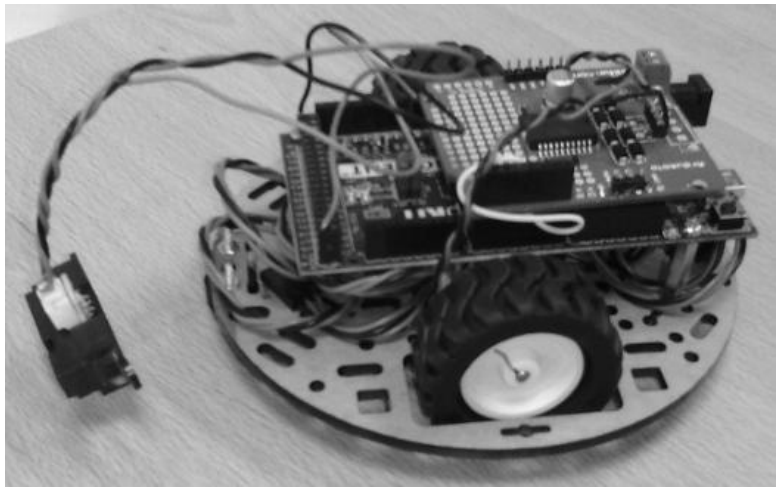


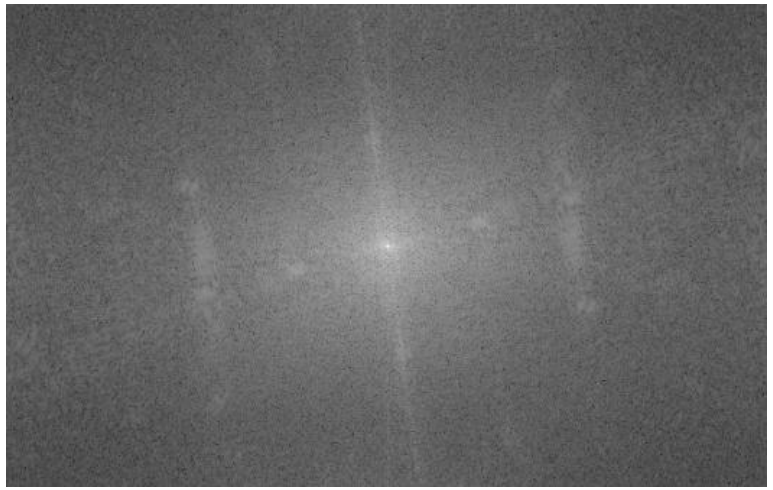
# Traitement d'images

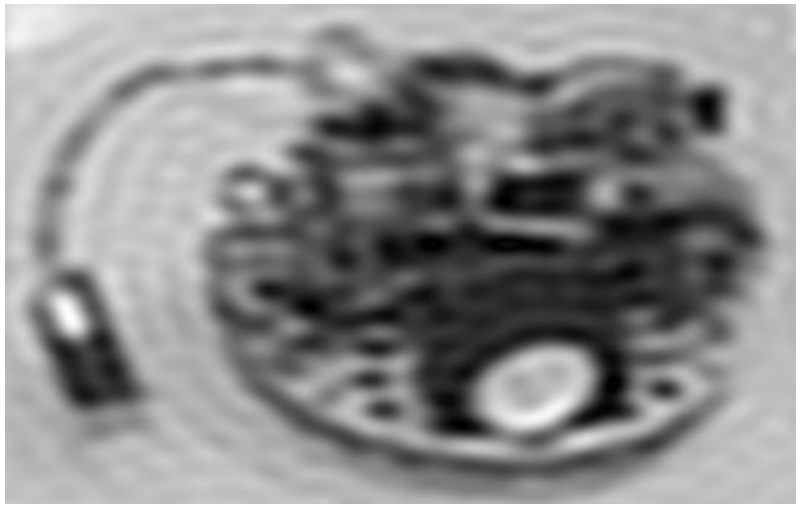
**Filtrage par TF**

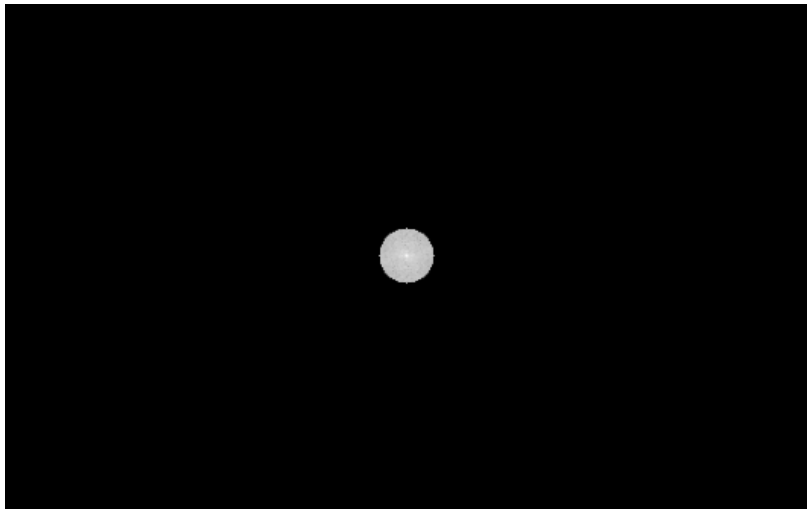
Acquisition

Pre Processing









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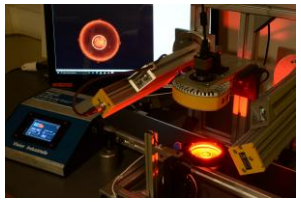
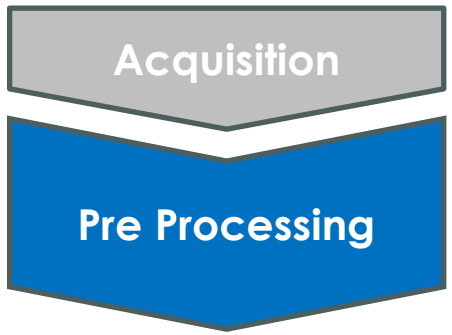
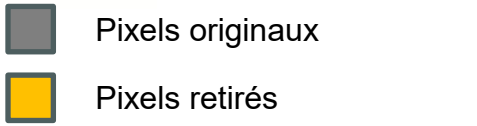
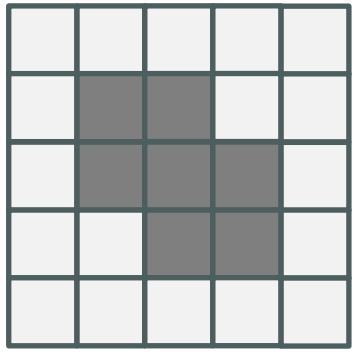


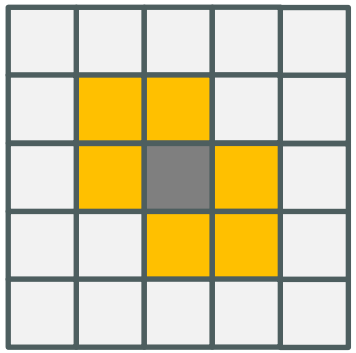
# Traitement d'images

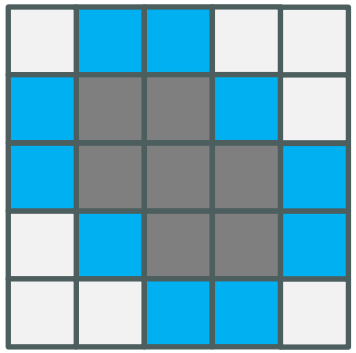
## Erosion / Dilatation





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

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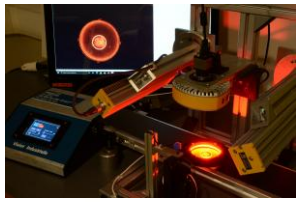
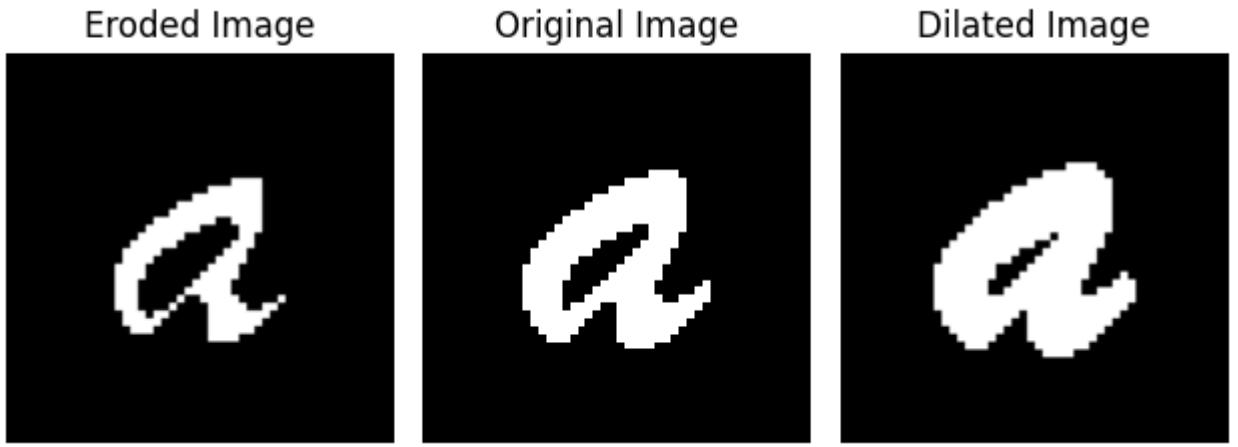


# Traitement d'images

## Erosion / Dilatation

Acquisition

Pre Processing




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

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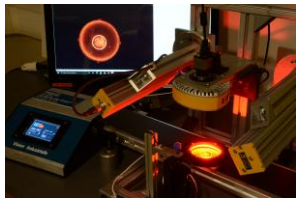


# Traitement d'images

## Ouverture / Fermeture

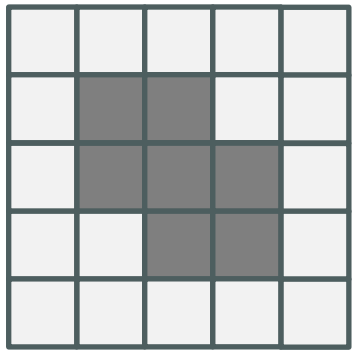
Acquisition

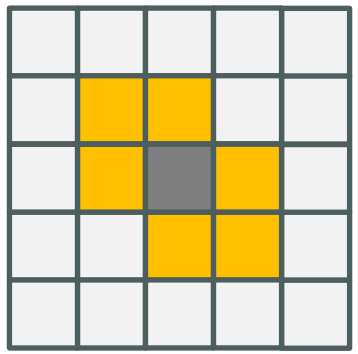
Pre Processing

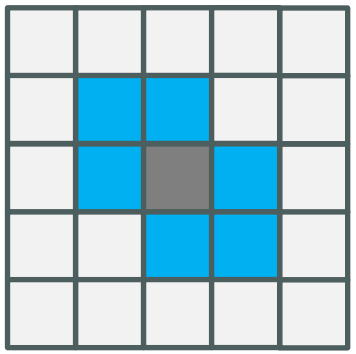
Original pixels

Removed pixels

Added pixels







Ouverture

Fermeture

**Erosion** puis **Dilatation**

Retire des petits objets

**Dilatation** puis **Erosion**

Remplit des petites zones

kernel

| | | |
|---|---|---|
| 0 | 1 | 0 |
| 1 | 1 | 1 |
| 0 | 1 | 0 |

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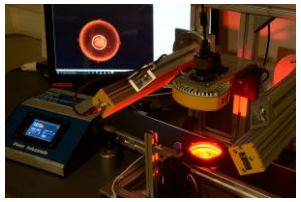
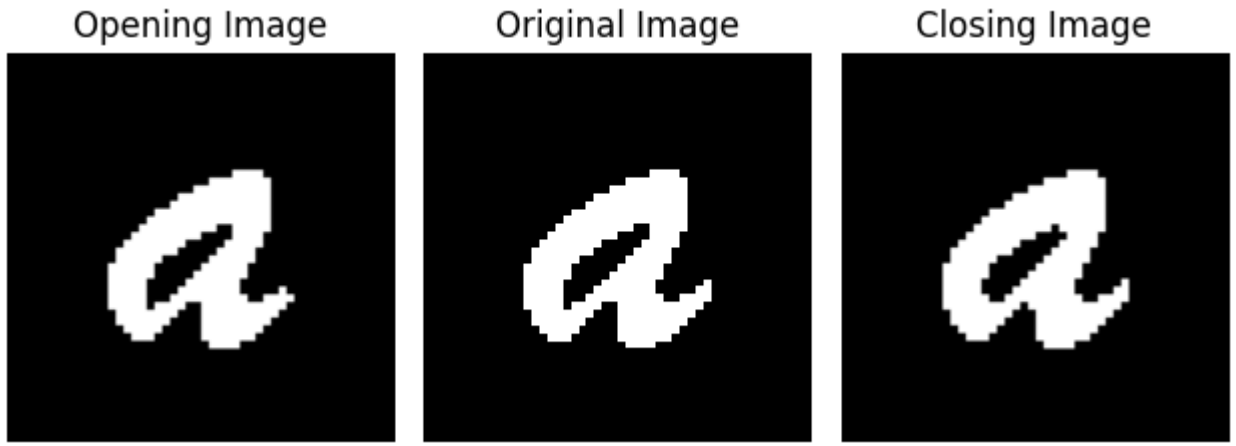


# Traitement d'images

## Ouverture / Fermeture

Acquisition

Pre Processing




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

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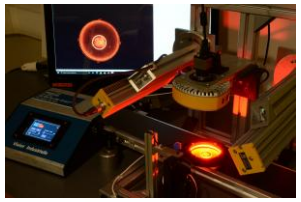
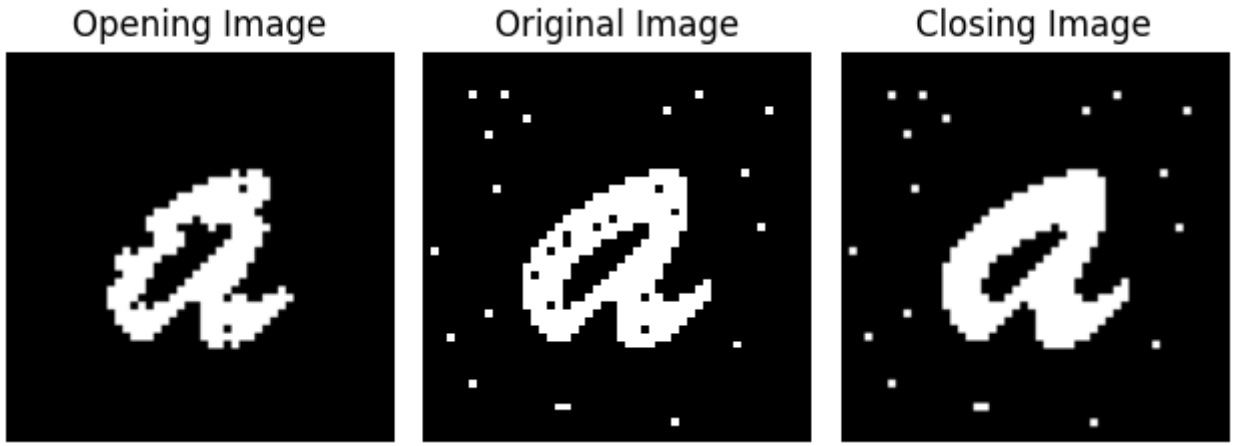


# Traitement d'images

## Ouverture / Fermeture

Acquisition

Pre Processing




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

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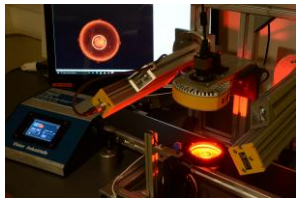
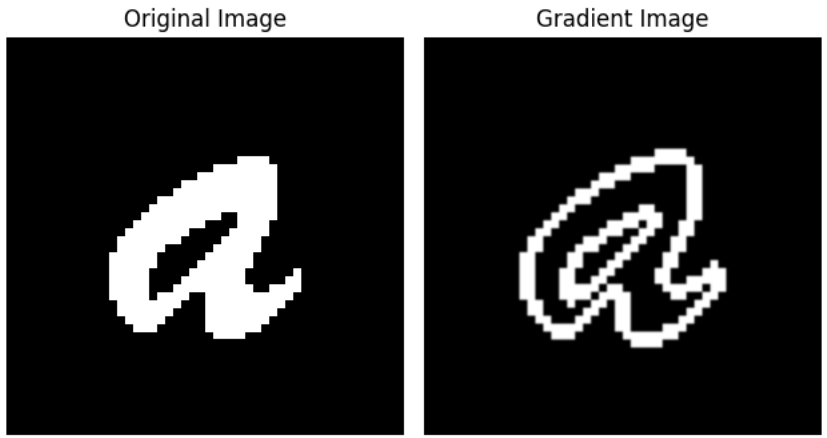


# Traitement d'images

## Gradient

- Acquisition
- Pre Processing
- Segmentation




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) ?*

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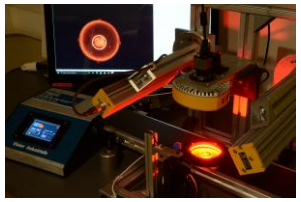


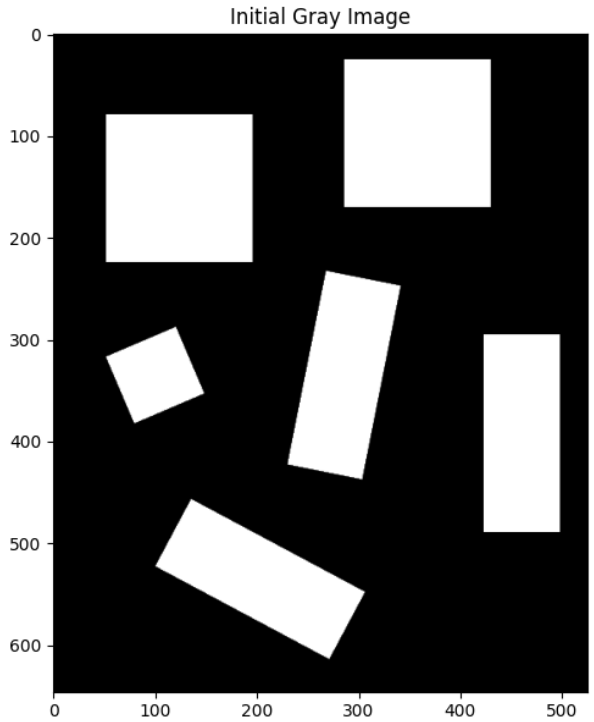
# Traitement d'images

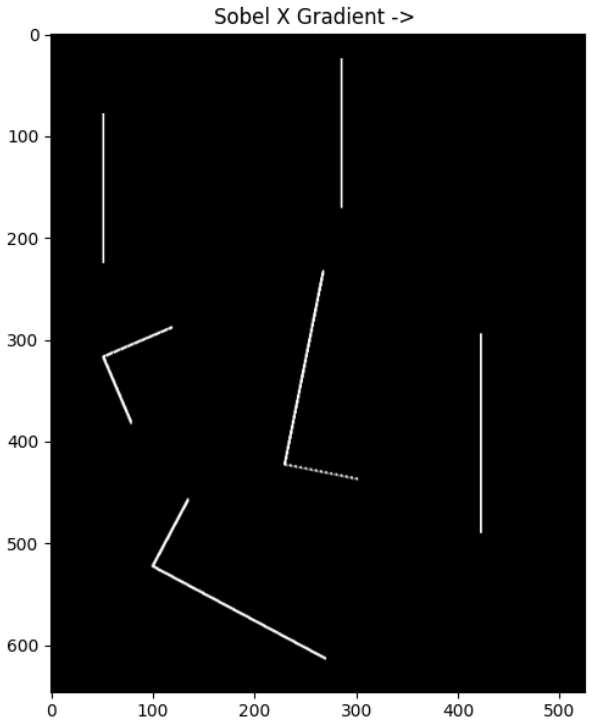
## Opérateur de Sobel

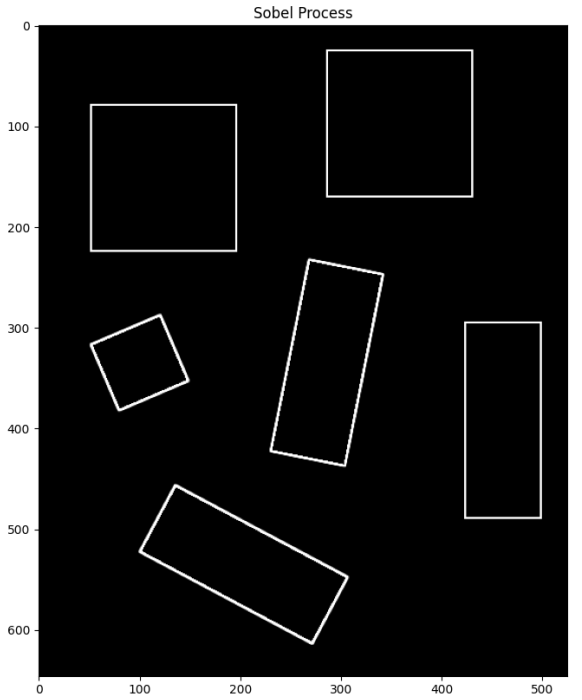
- Acquisition
- Pre Processing
- Segmentation

kernel

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



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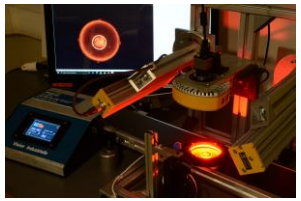
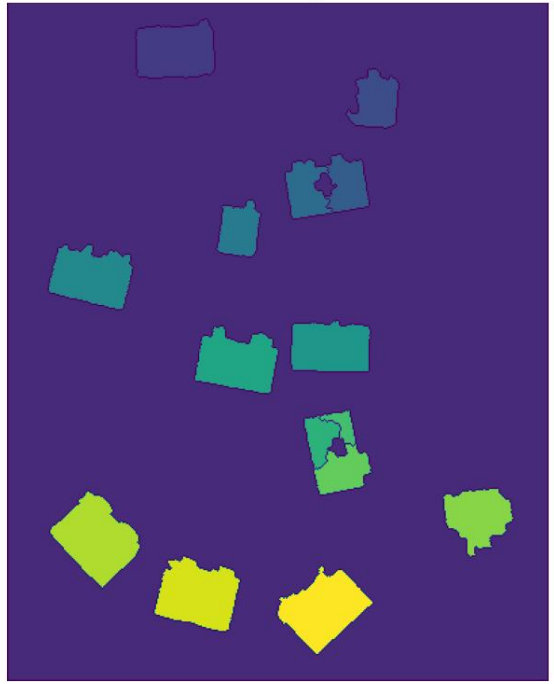


# Traitement d'images

## Méthode de Watershed

- Acquisition
- Pre Processing
- Segmentation
- Extraction d'informations
- Classification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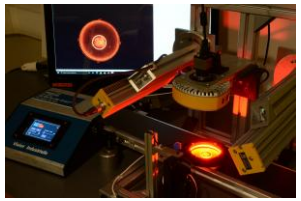

# Traitement d'images

## Méthode de Watershed

- Acquisition
- Pre Processing
- Segmentation
- Extraction d'informations
- Classification