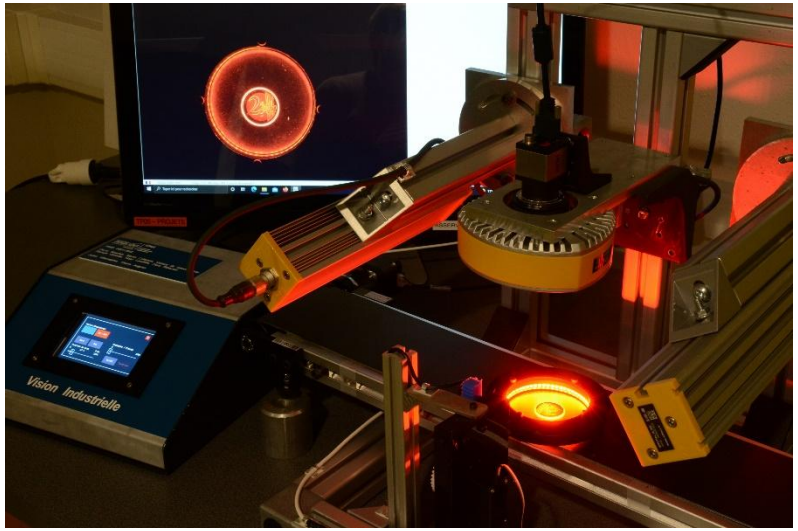
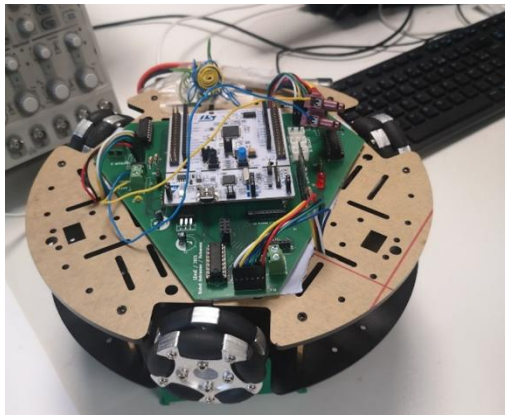
INSTITUT d'OPTIQUE GRADUATE SCHOOL | LEnsE Laboratoire d'Enseignement Expérimental

Interfaçage Numérique

Vision Industrielle

Julien VILLEMEJANE





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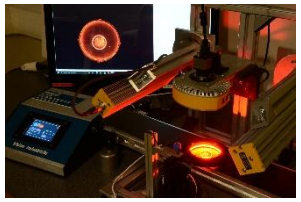

Vision Industrielle

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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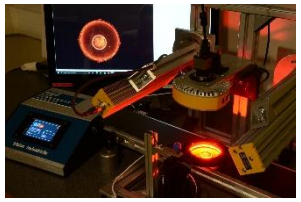
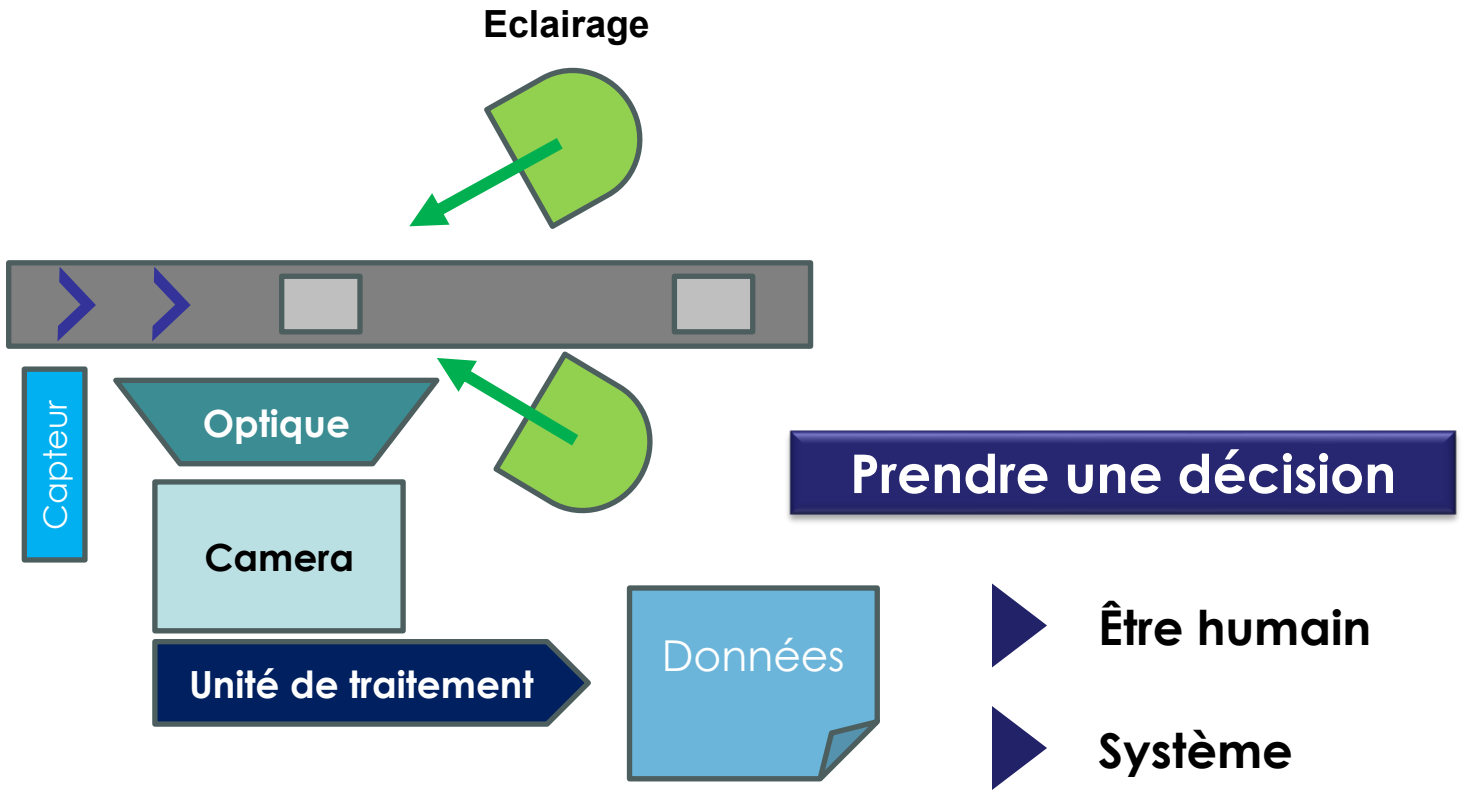


Vision Industrielle

Eléments constitutifs



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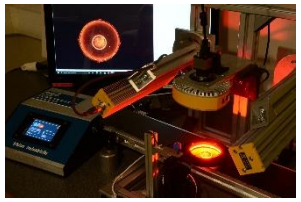
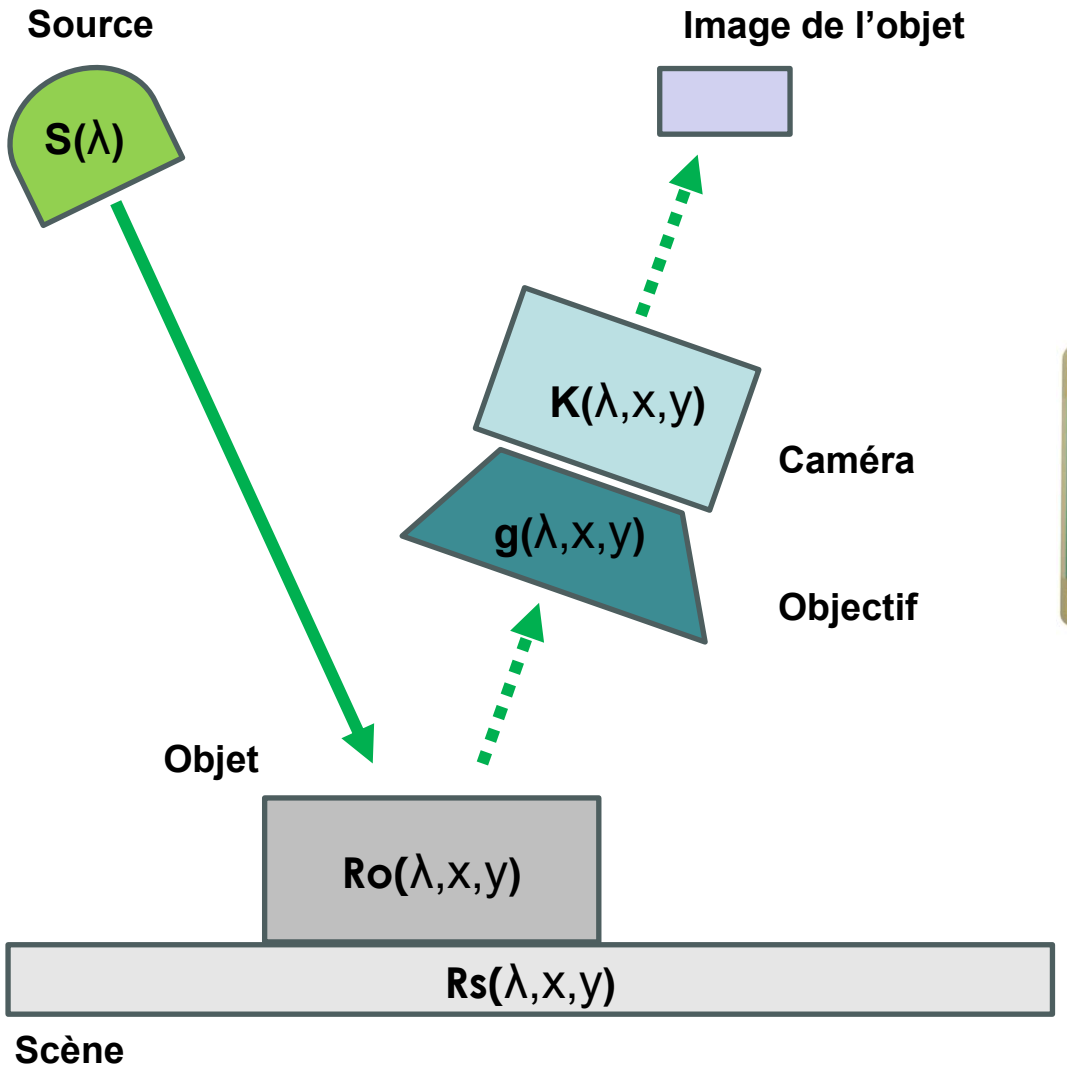
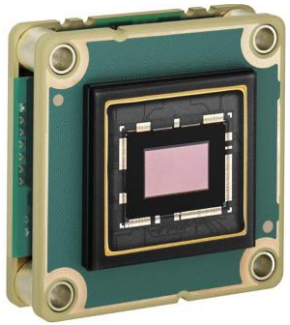


Vision Industrielle

Modélisation de la chaine





Basler Sensor / Mouser

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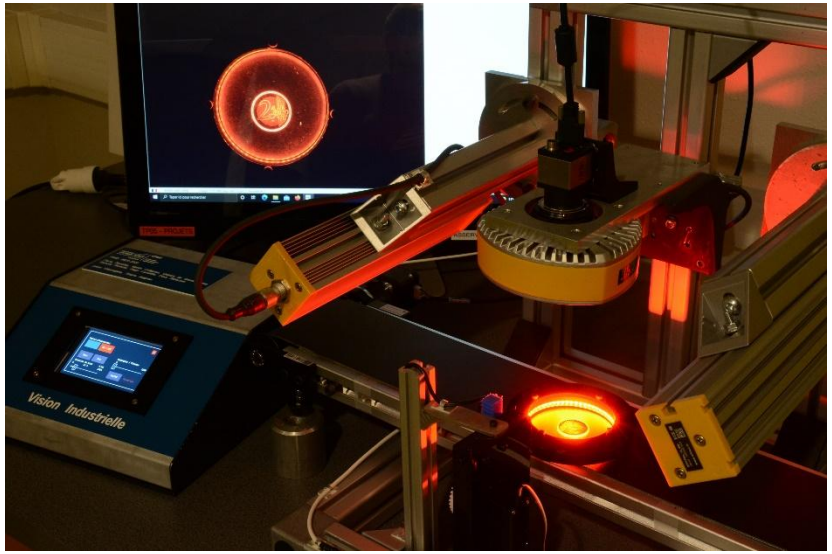
Objets / Sources

Eclairage / Colorimétrie



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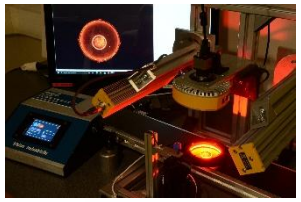
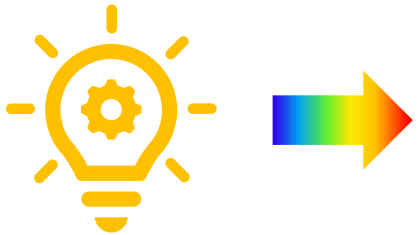


Sources

Sources primaires

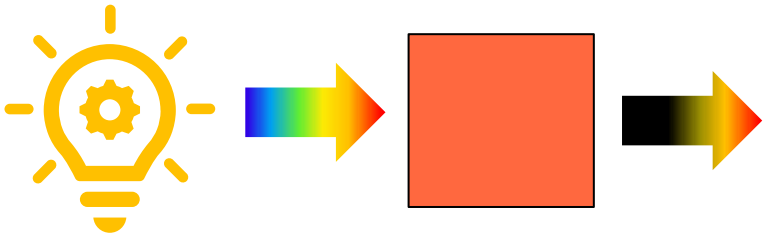
Produisent leur propre lumière



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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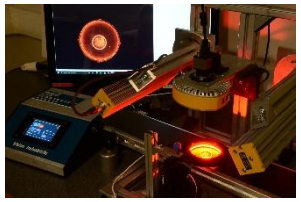
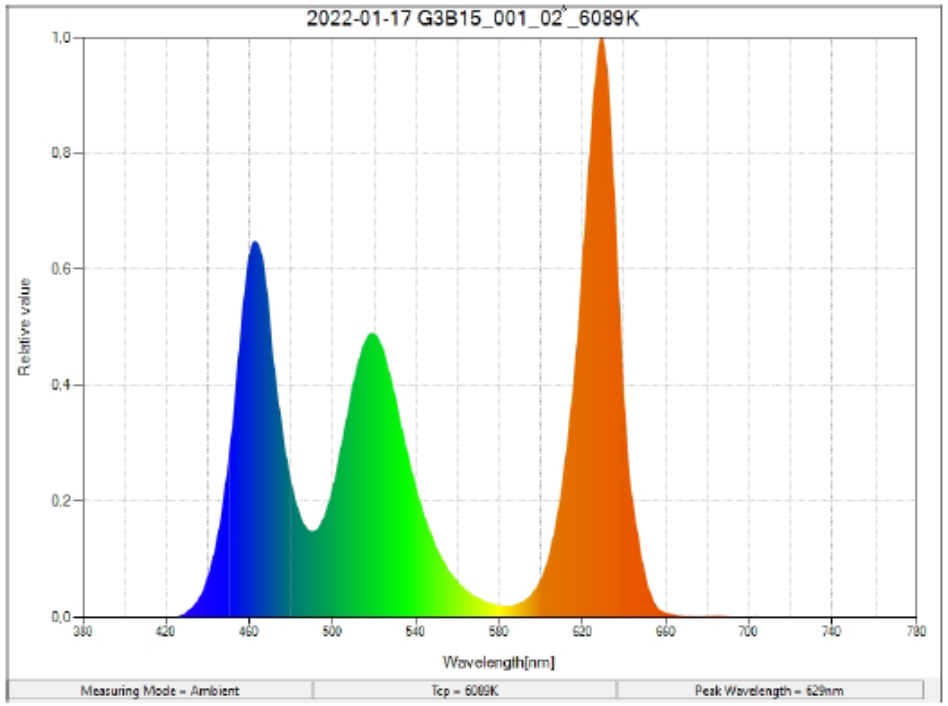
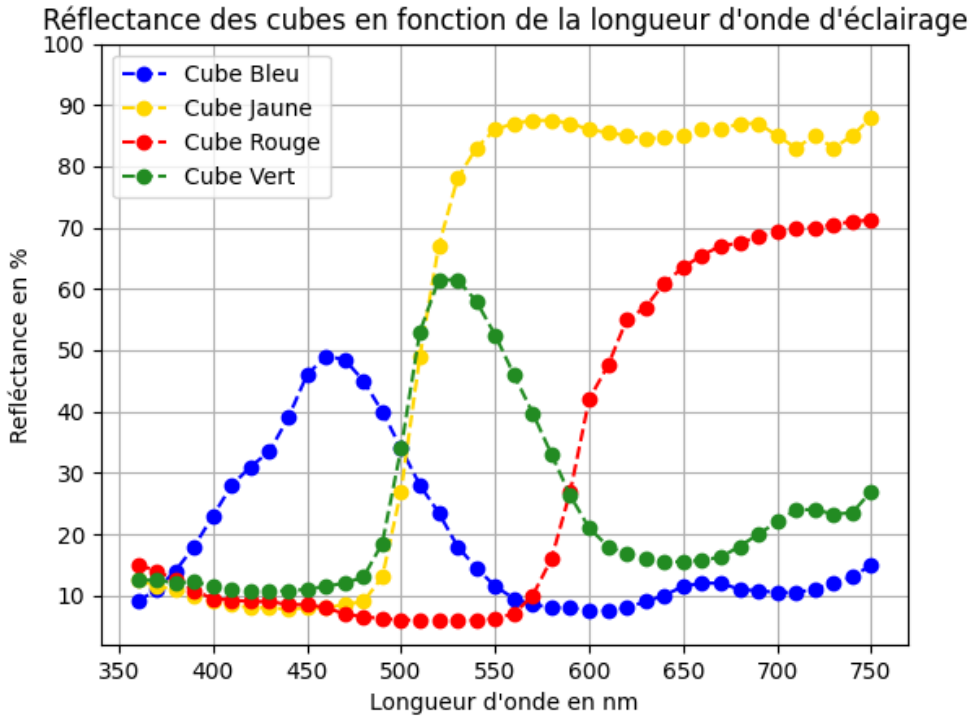


Sources

Spectre d'émission



Réflectance



Source Effilux Ring RGB

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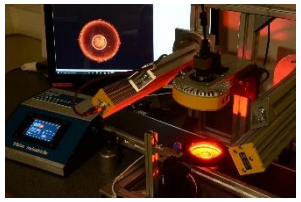
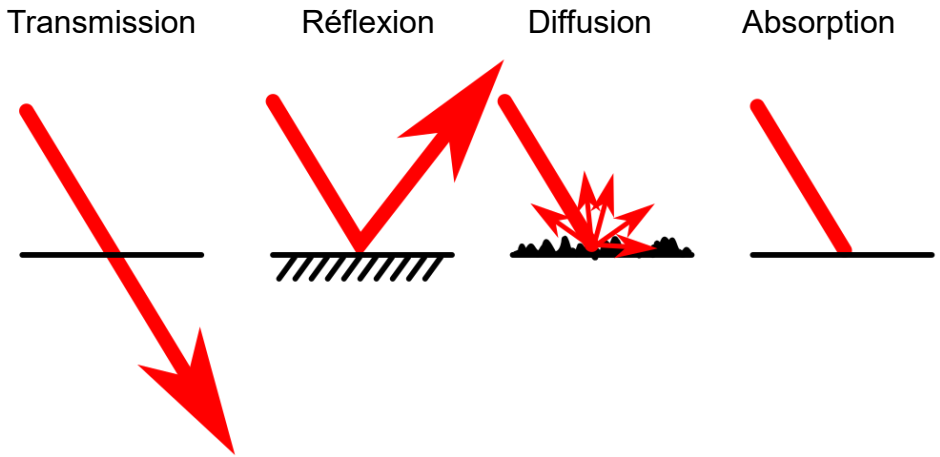


Eclairage

Impact du type d'éclairage / Nature des objets



Directif | Diffus | Rasant | Coaxial | Retro

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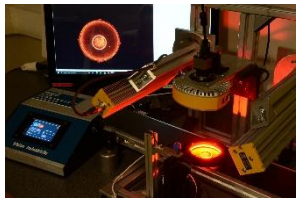
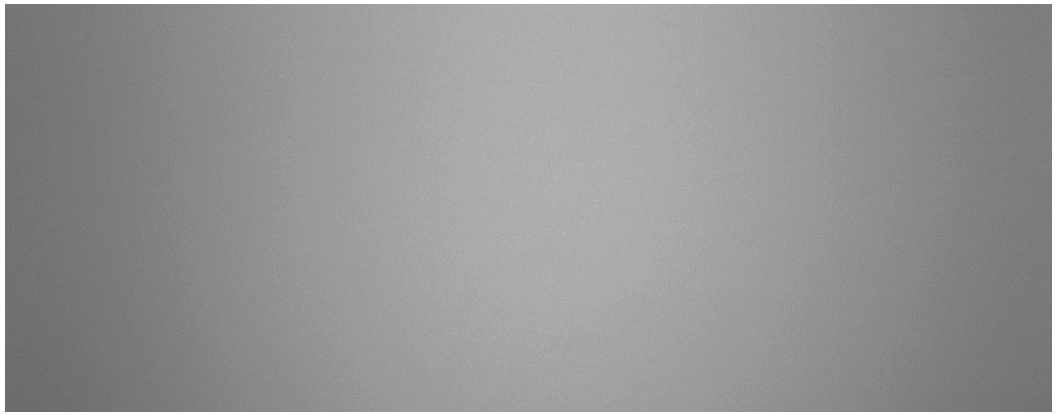
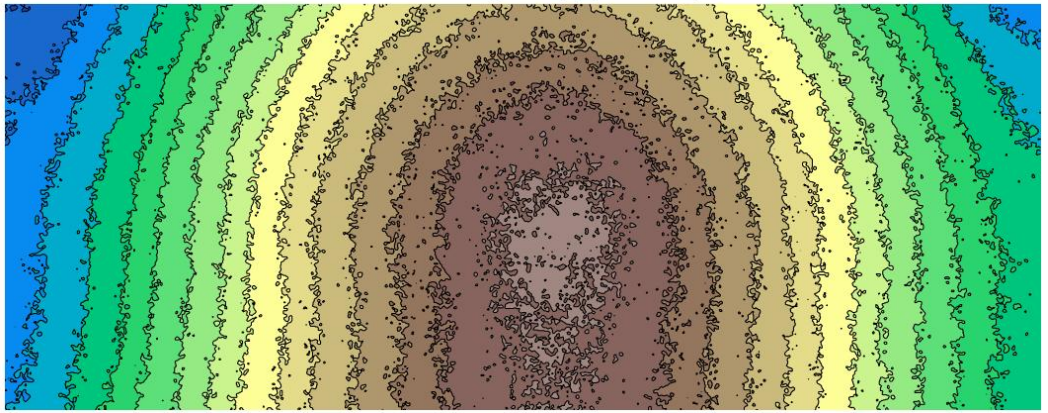
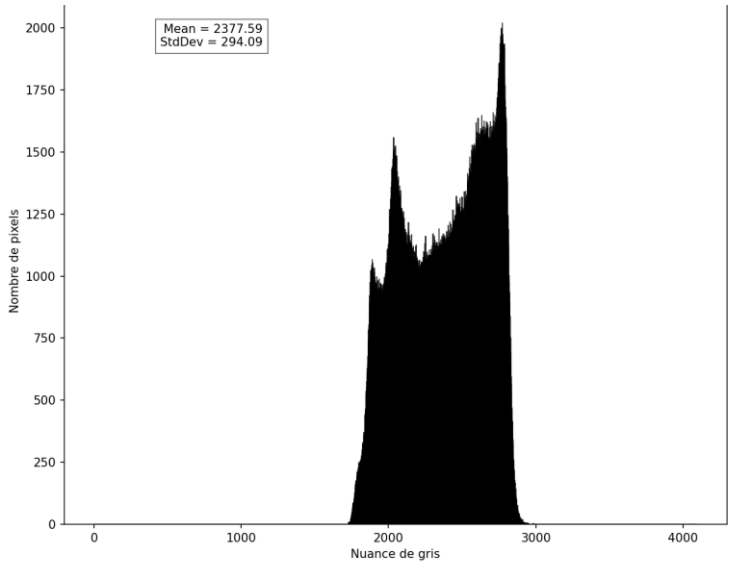


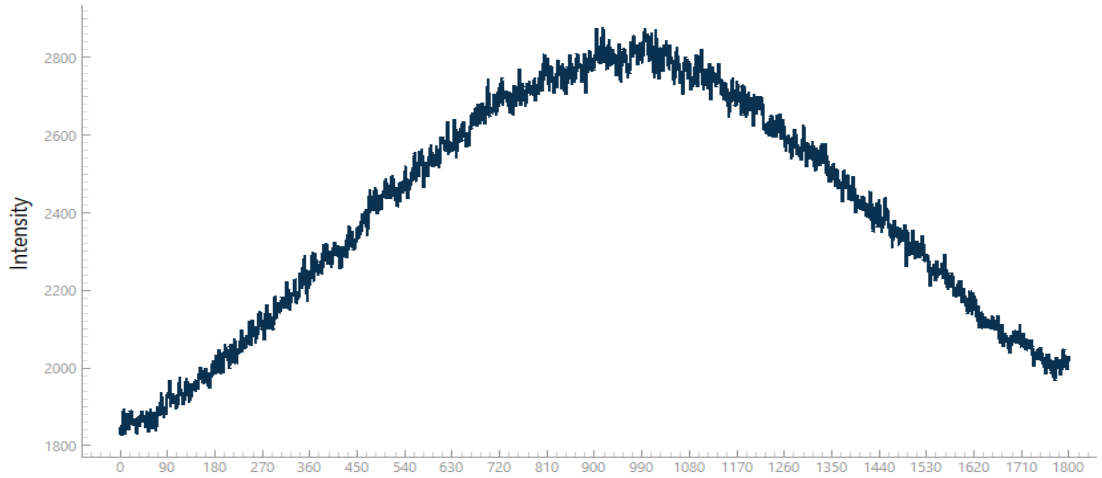
Eclairage

Uniformité de l'éclairage









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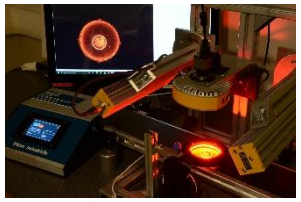

Colorimétrie

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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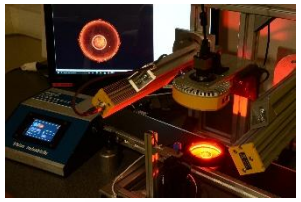
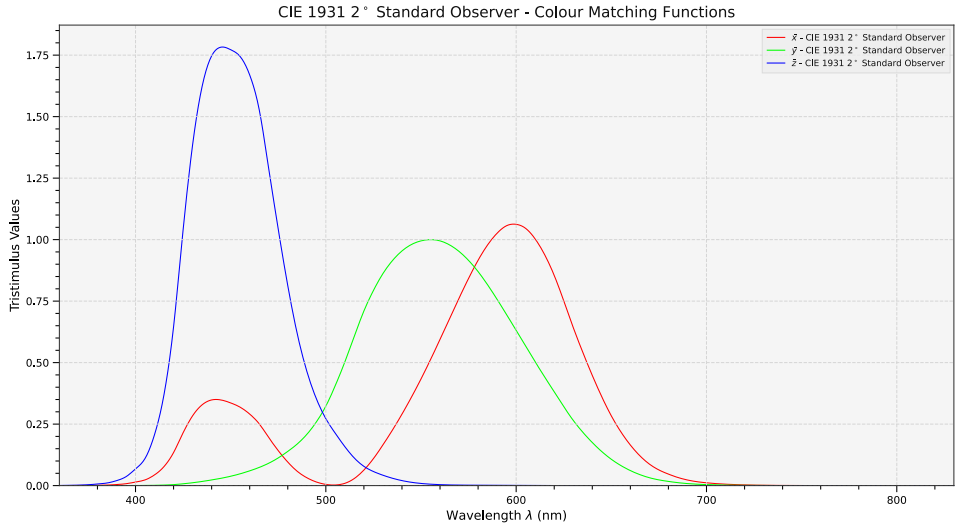
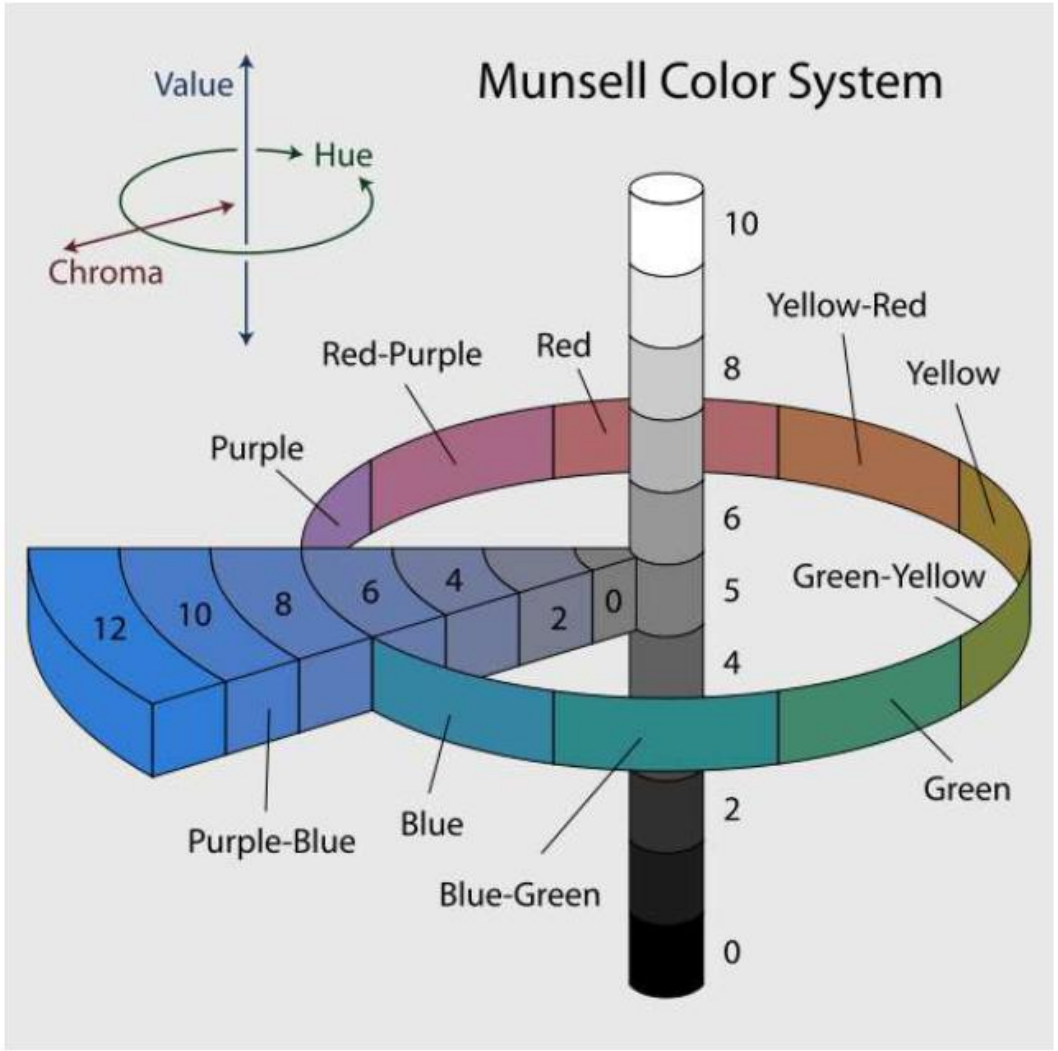


Colorimétrie



$$K_m = 683\ lm/W$$

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



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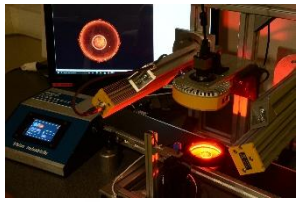
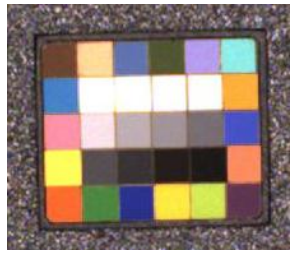


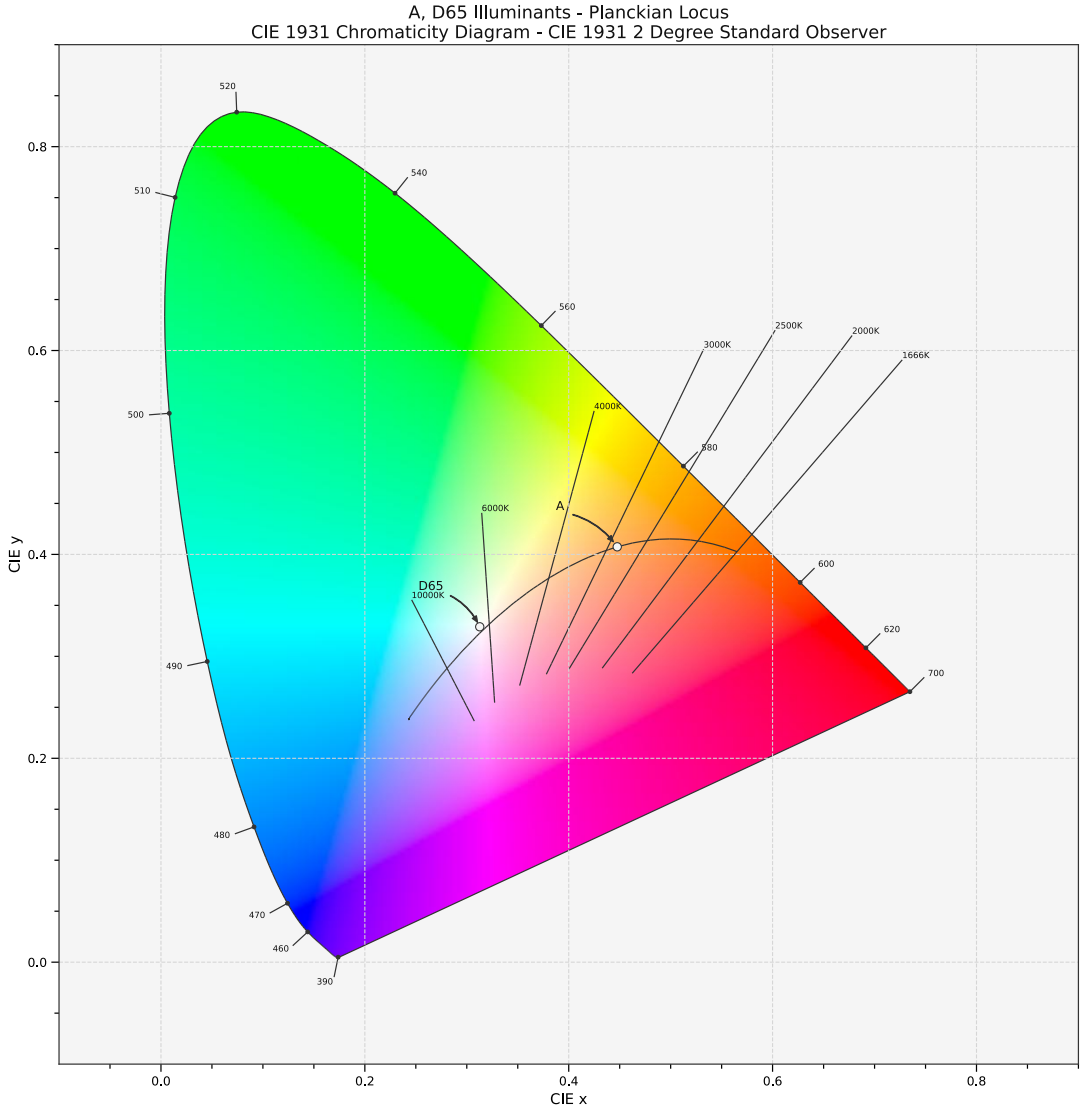
Colorimétrie

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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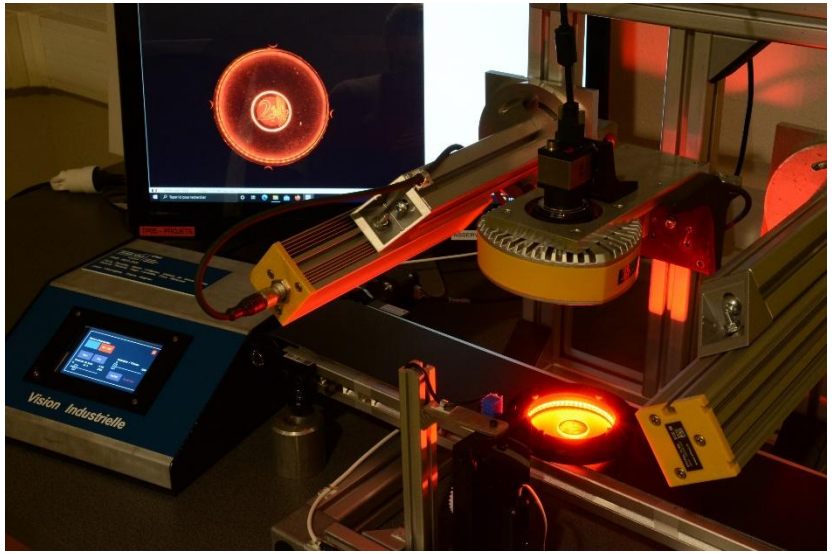
Objectif optique

Créer une image exploitable



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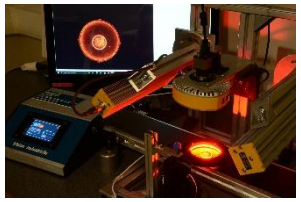
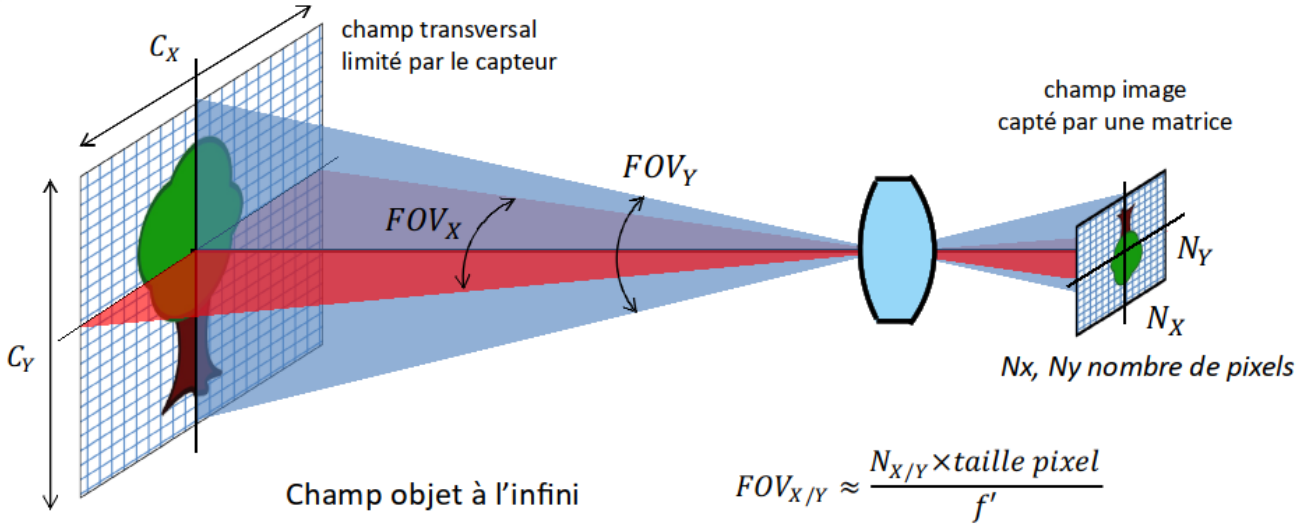
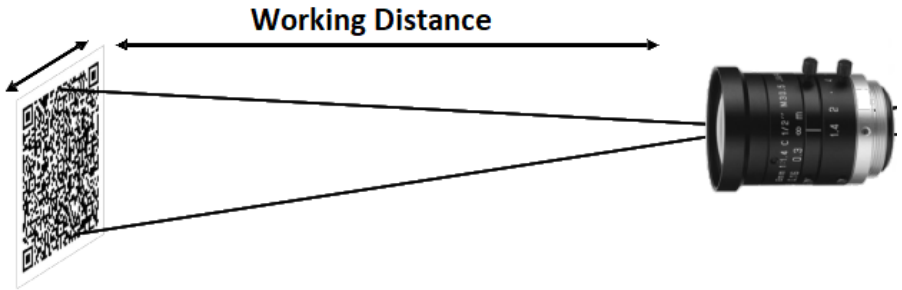


Objectif optique

Créer une image



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



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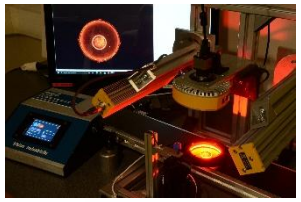
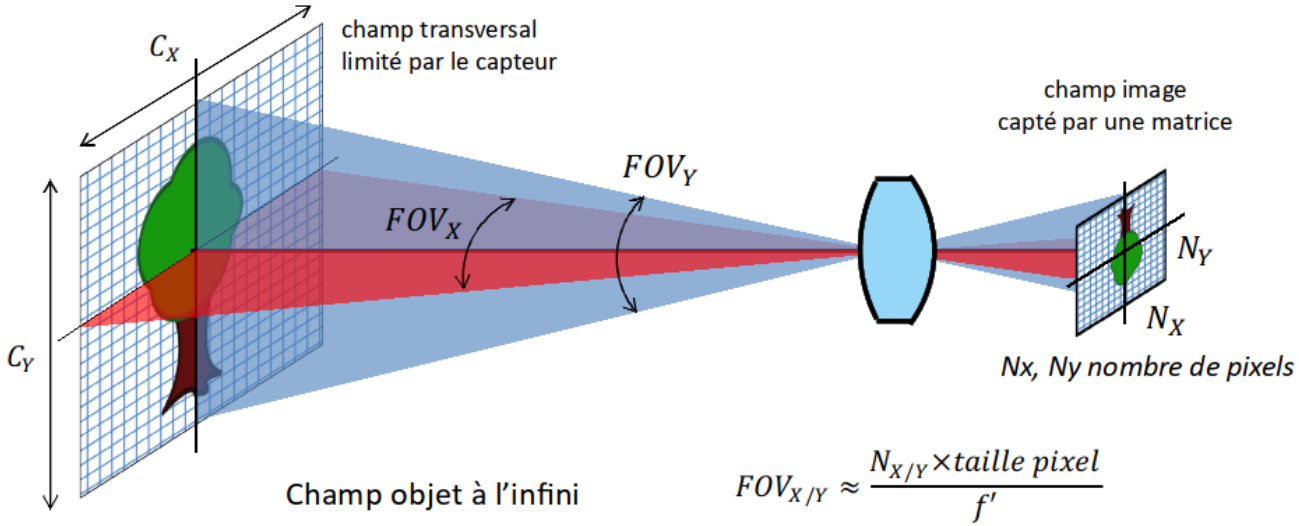


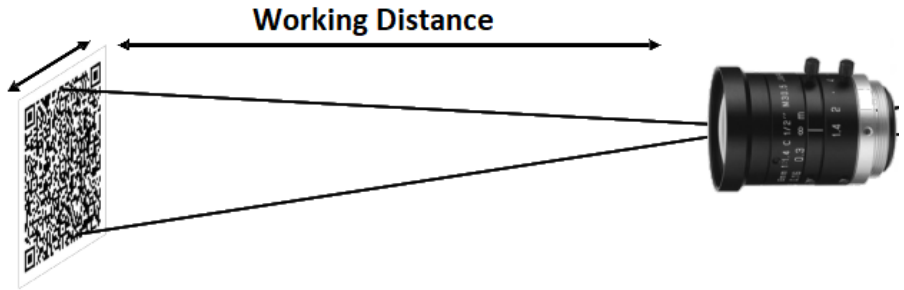
Objectif optique

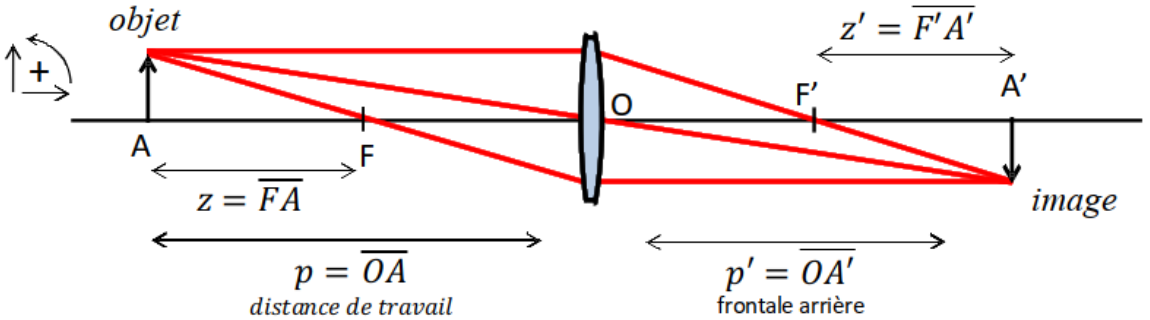
Créer une image



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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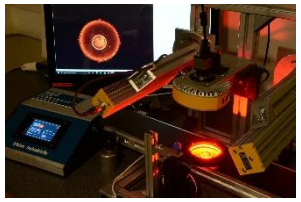
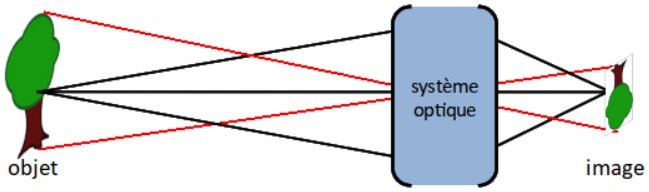


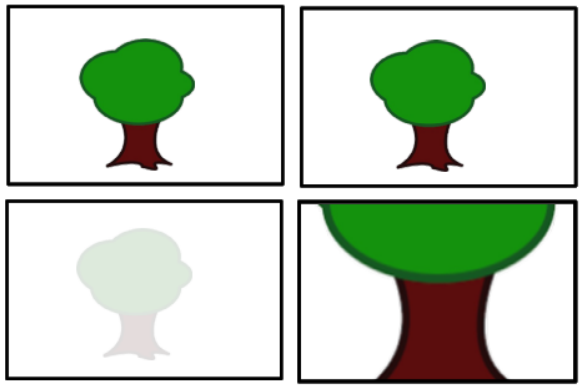
Objectif optique

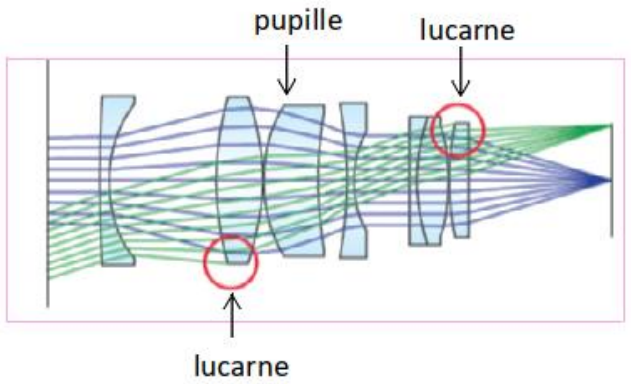
Créer une image

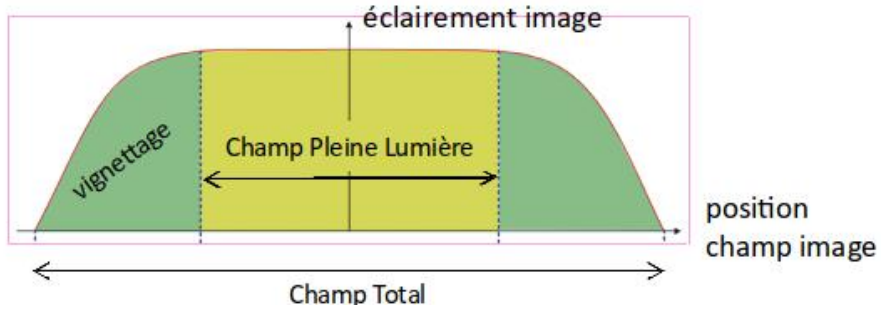


Ouverture
flux collecté

Champ
taille max objet capté







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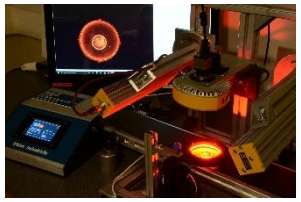

Objectif optique

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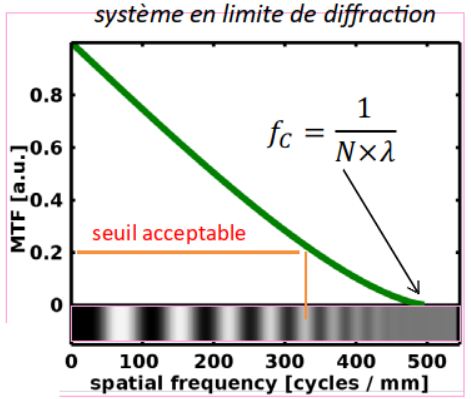

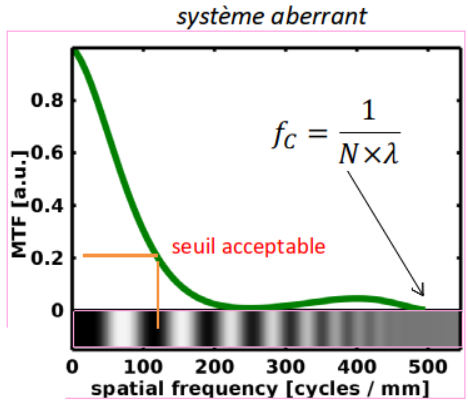

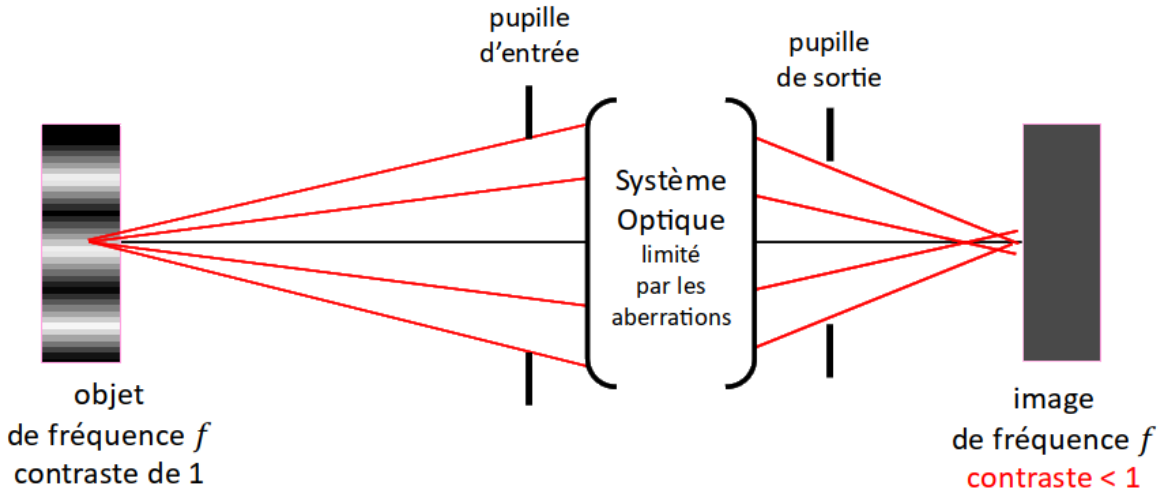

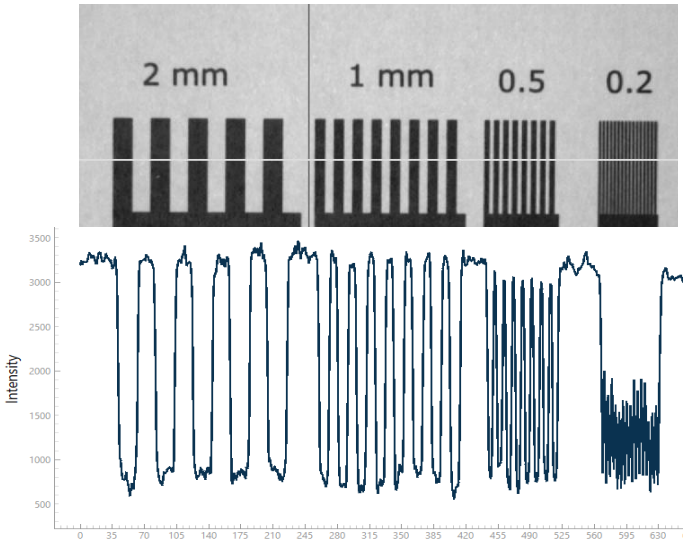

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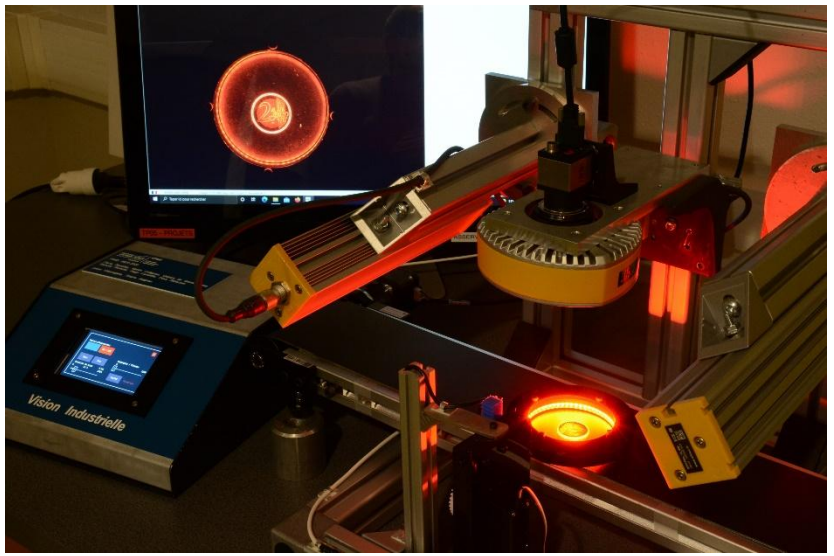
Caméra numérique

Echantillonnage / Quantification
Colorimétrie



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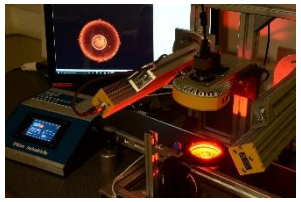
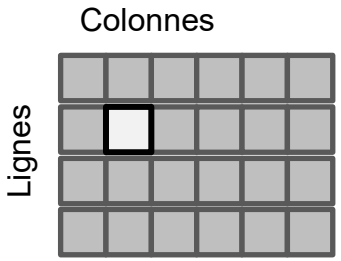


Caméra numérique

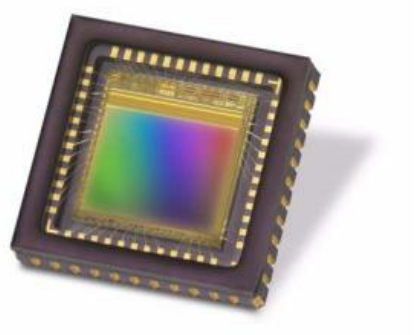
Matrice de pixel



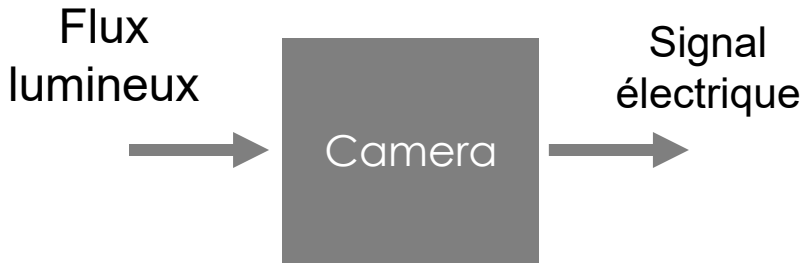
Camera

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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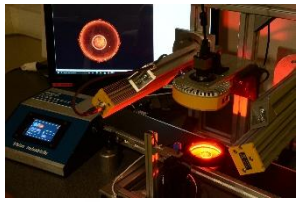
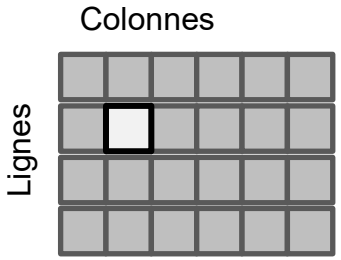
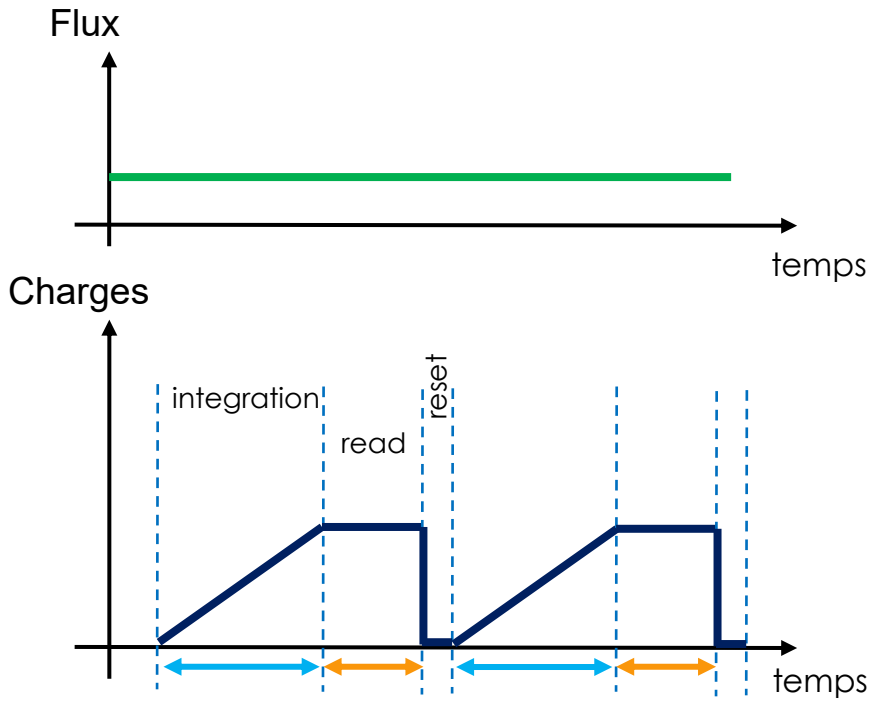


Caméra numérique

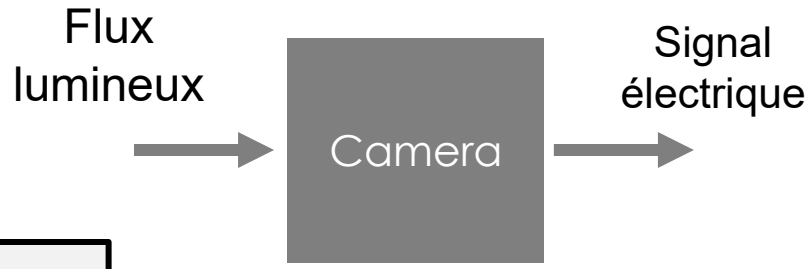
Matrice de pixel

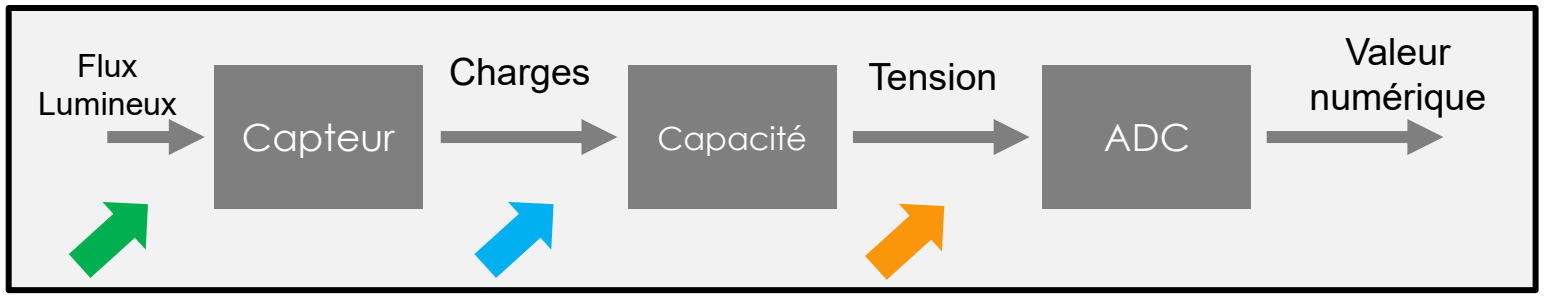




Camera

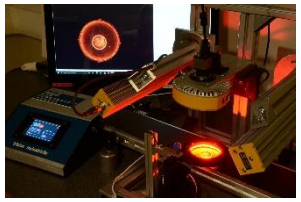
Système qui transforme un **flux lumineux** en un **signal électrique mesurable**





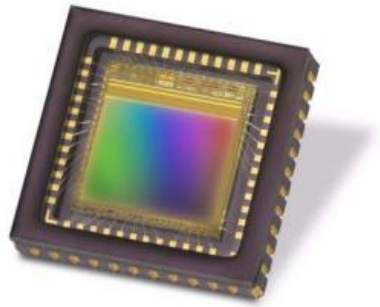
Taille d'un pixel de l'ordre de 2 à 10 um

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

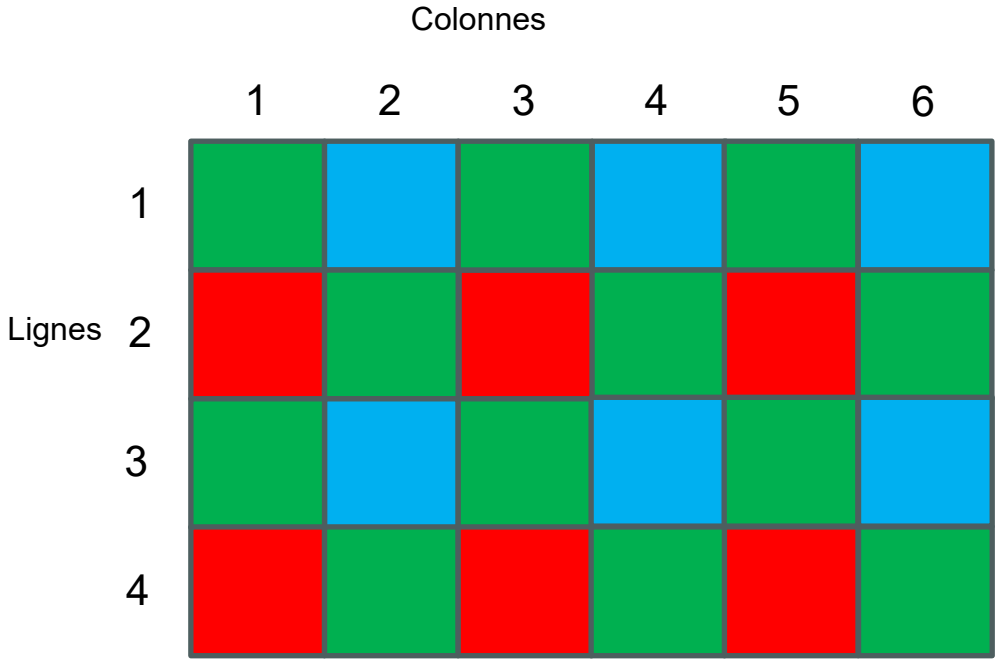


Caméra numérique

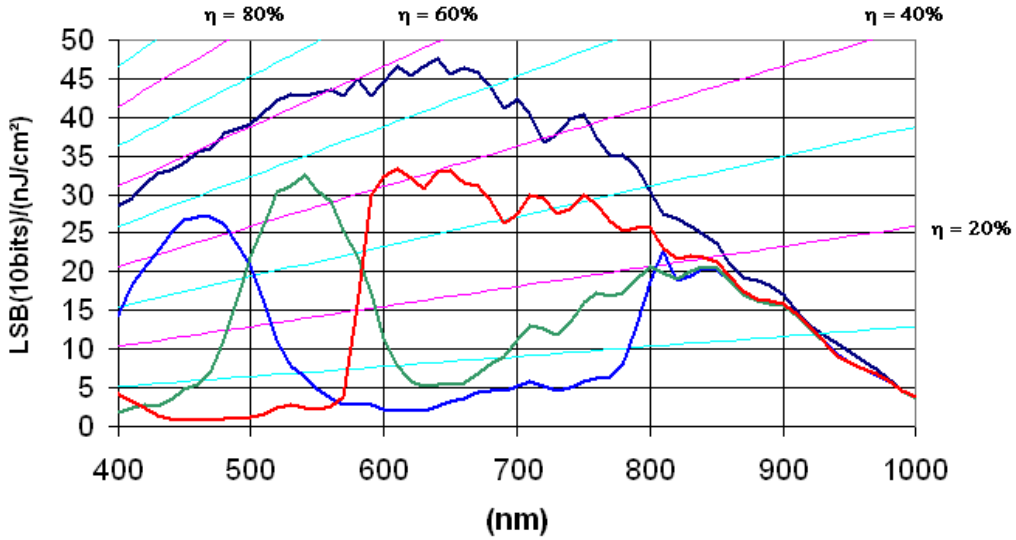
Réponse spectrale



e2v sensor EV76C560ACT



Matrice de Bayer



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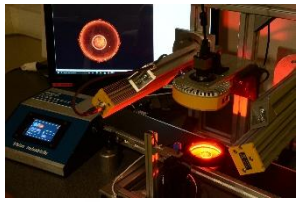
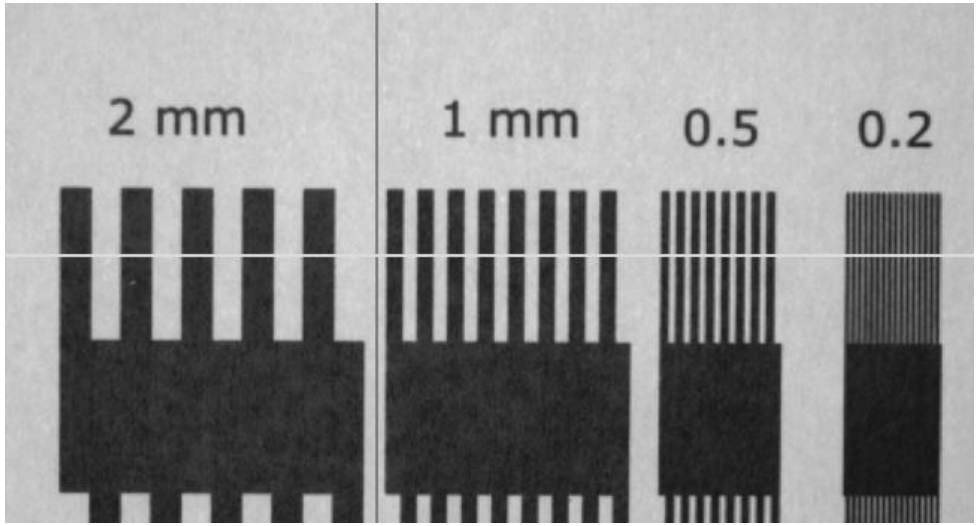
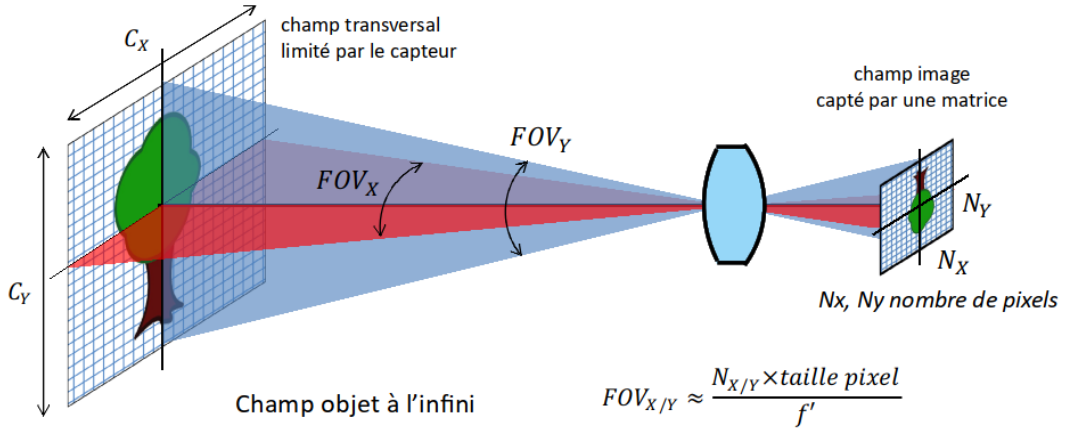


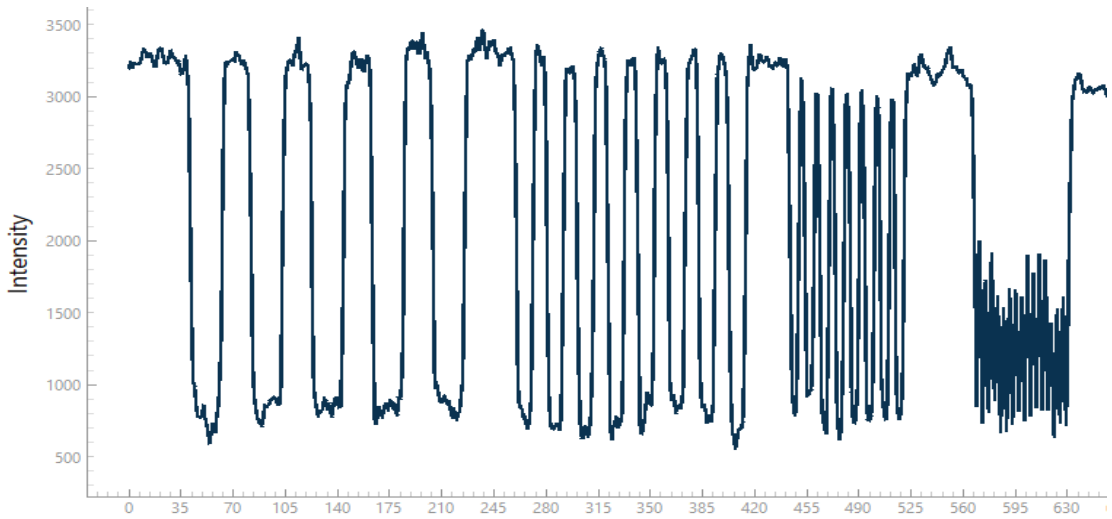
Vision Industrielle

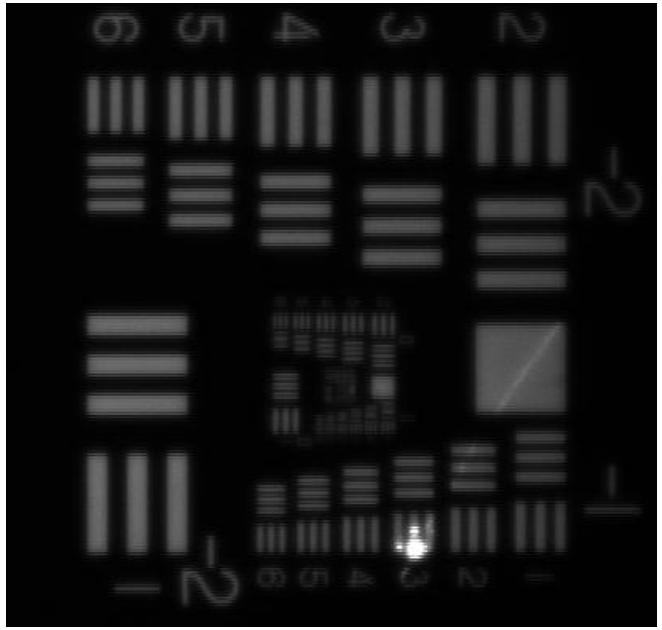
Résolution





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





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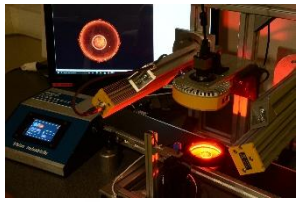
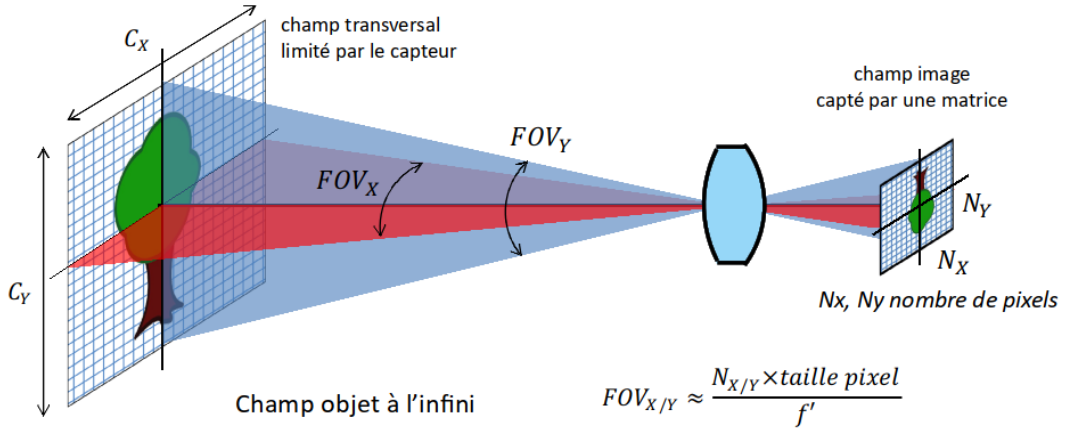
Laboratoire d'Enseignement Expérimental



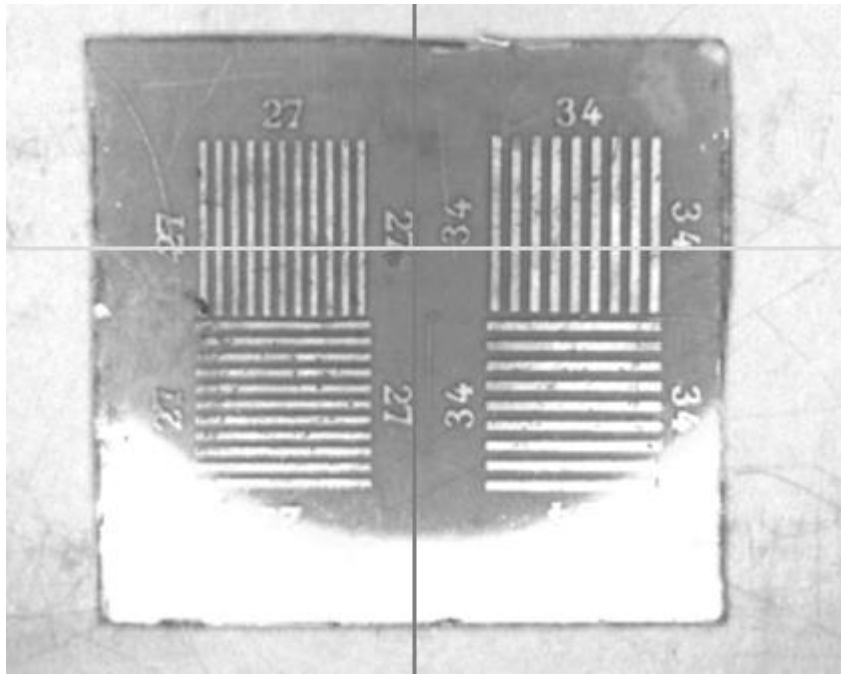
Vision Industrielle

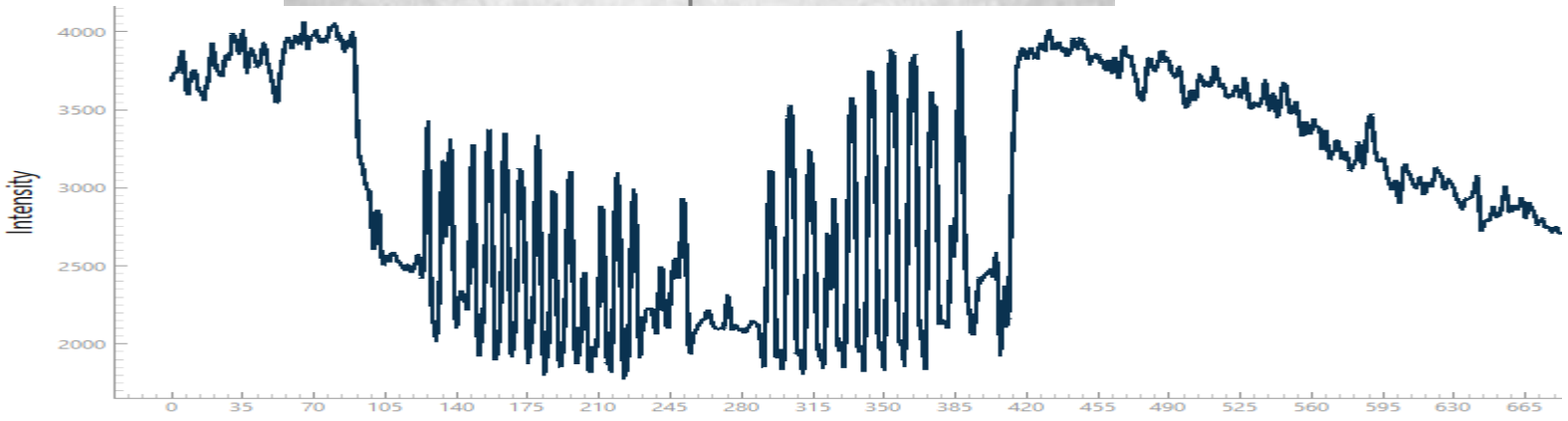
Résolution

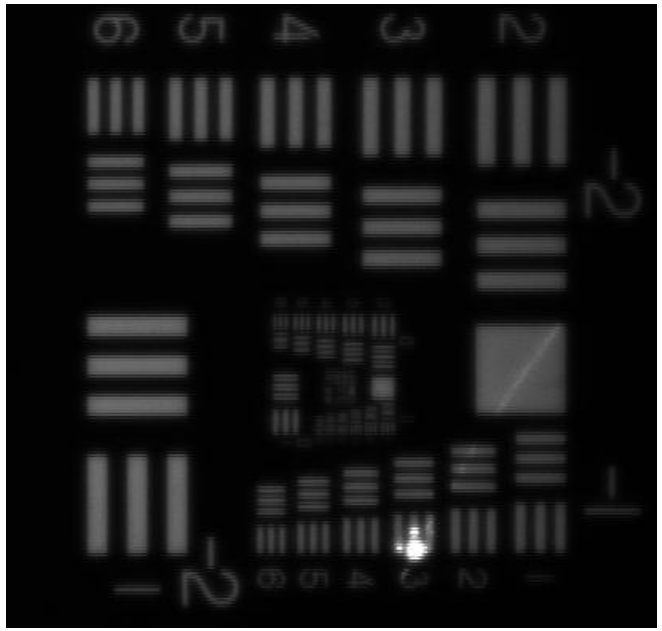


Champ objet à l'infini

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







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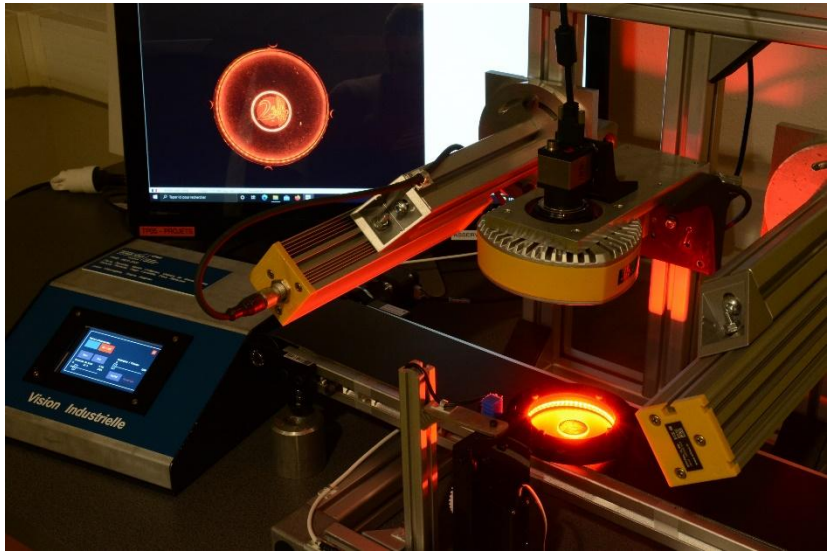
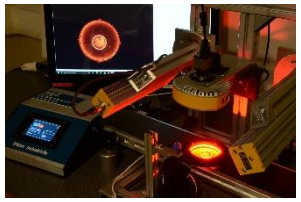
Traitement d'image

Pré-traitement / Segmentation / Classification



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



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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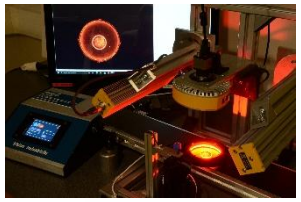
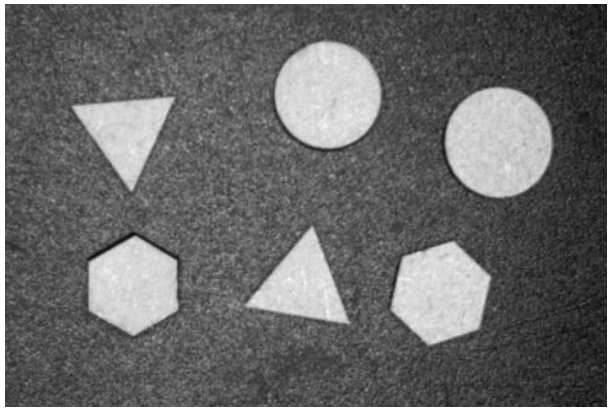
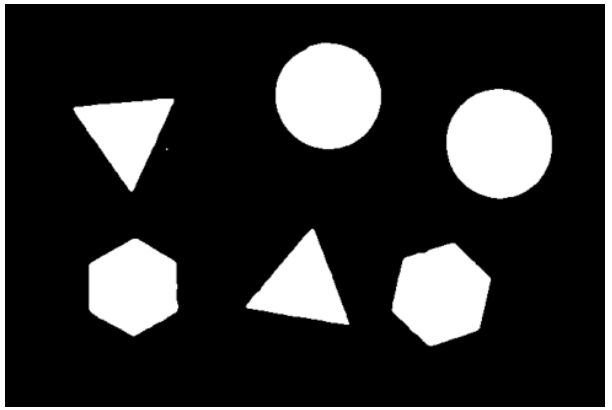


Traitement d'images





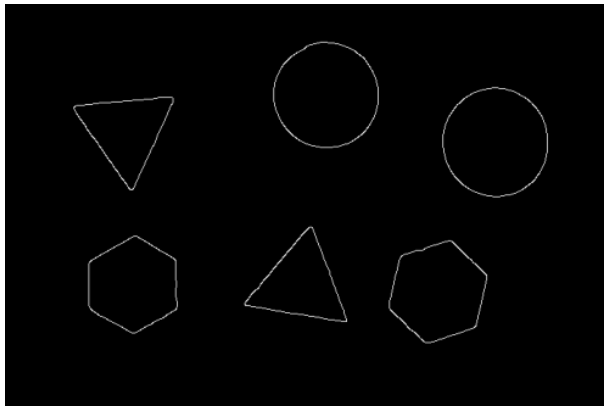


Image brute 'RAW' / Caméra

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

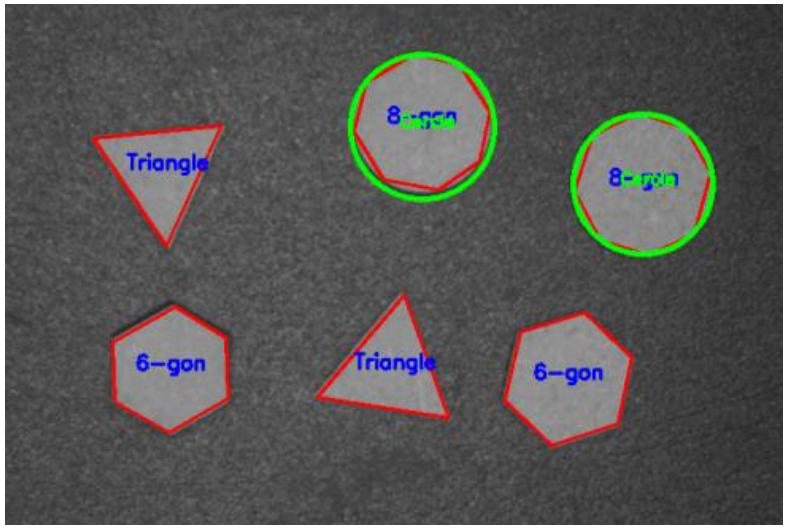


Image souhaitée / Contours bien définis

- Zones homogènes
- Transitions nettes

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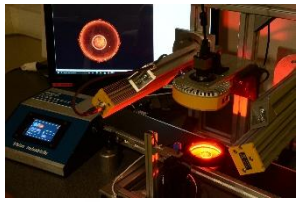
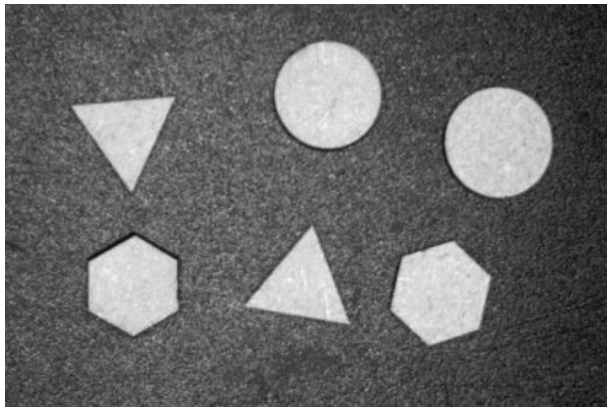
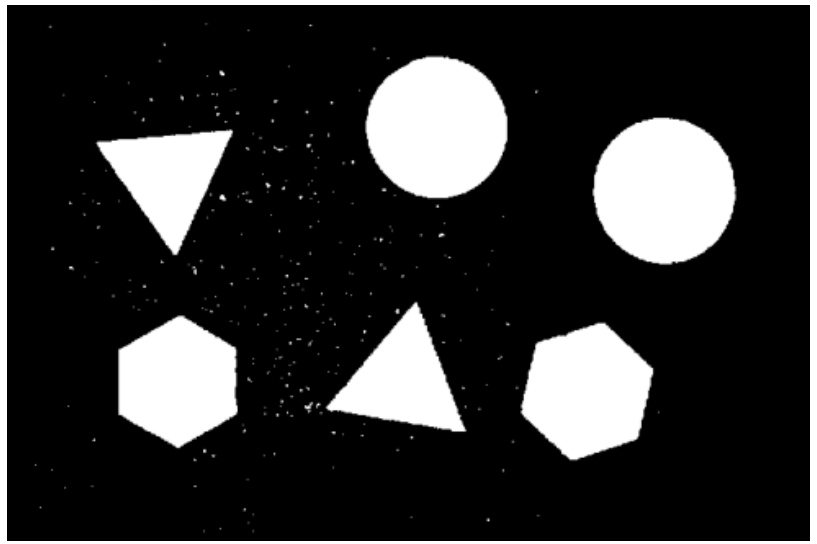
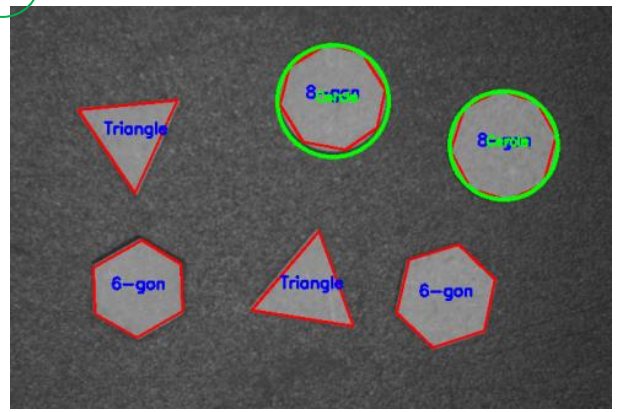


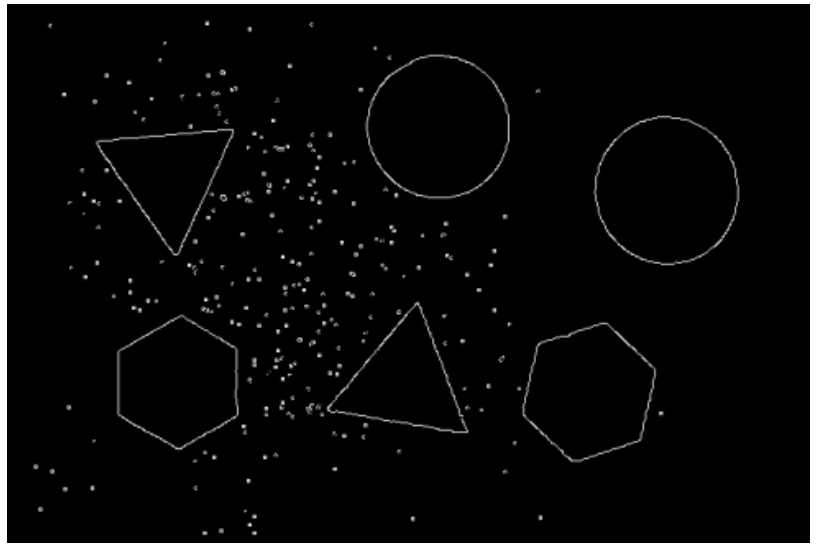
Traitement d'images

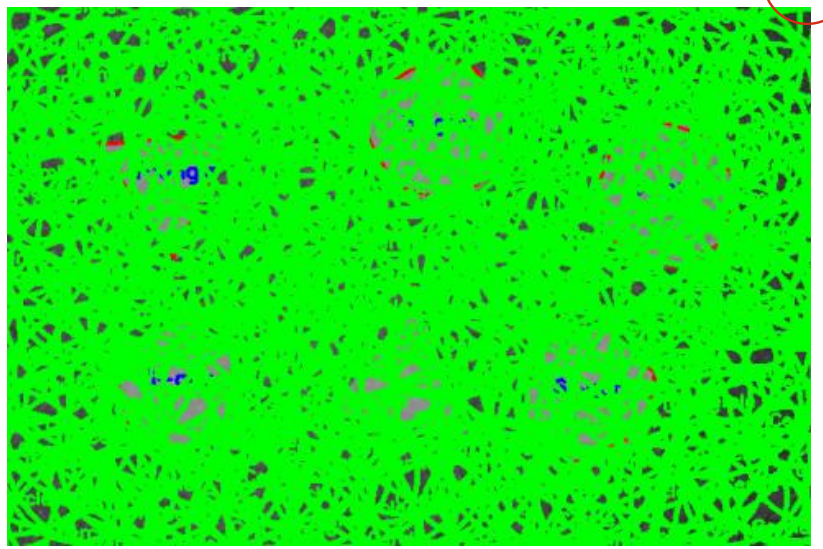
Mauvais traitement











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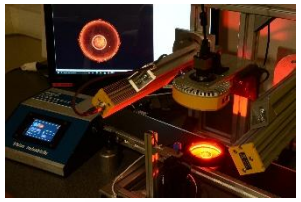
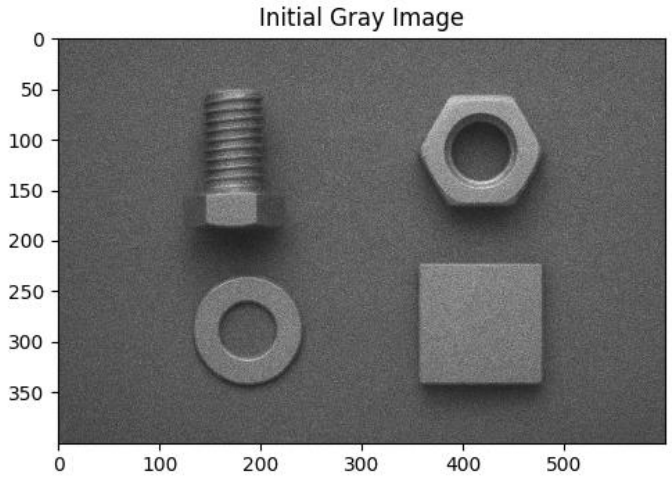
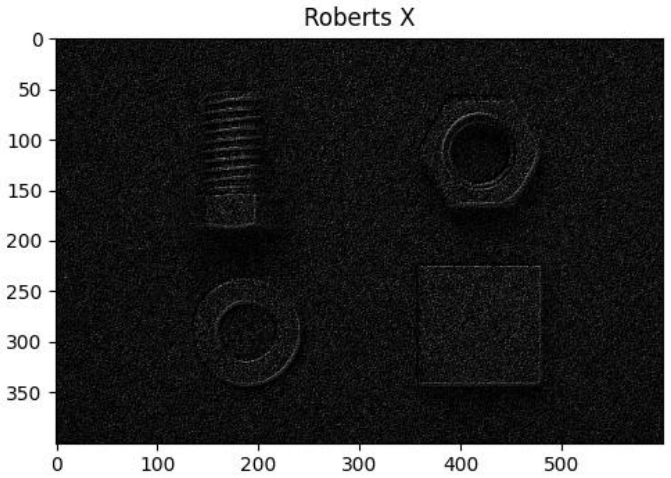
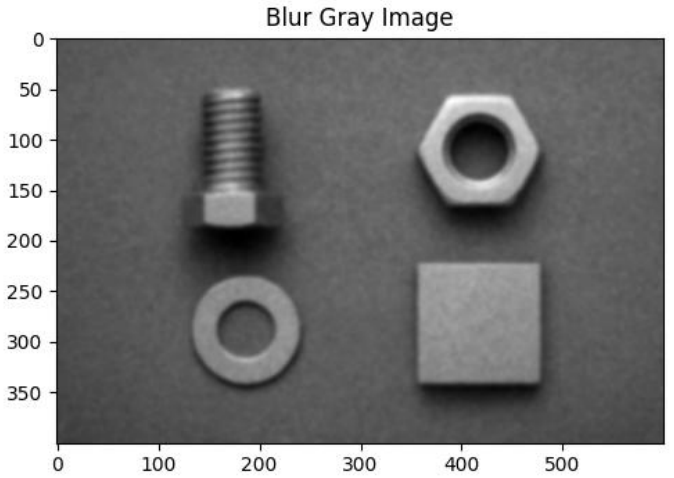


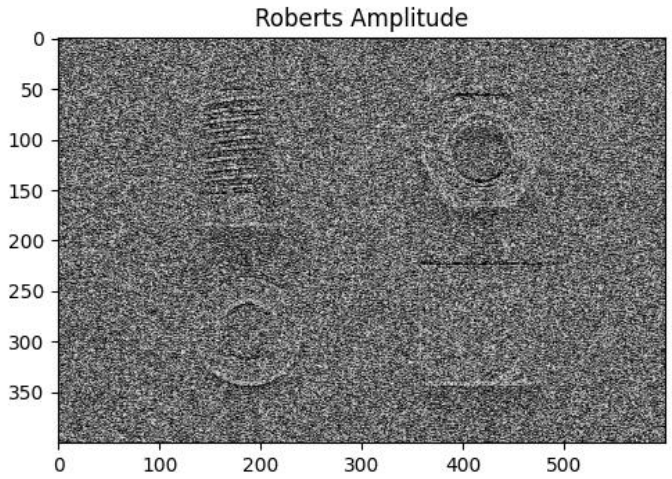
Traitement d'images

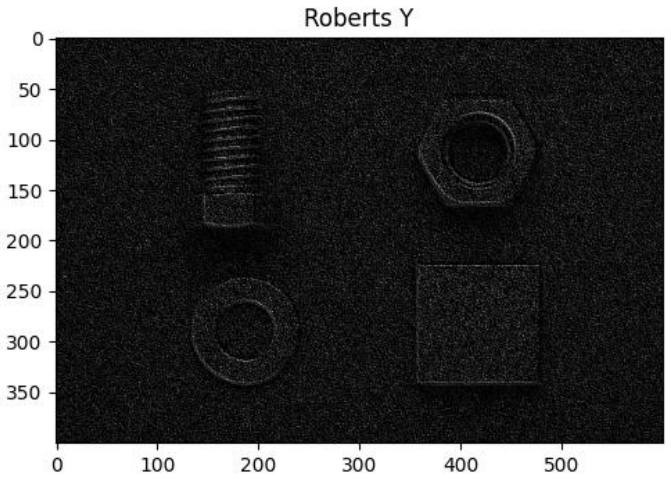
Exemple industriel

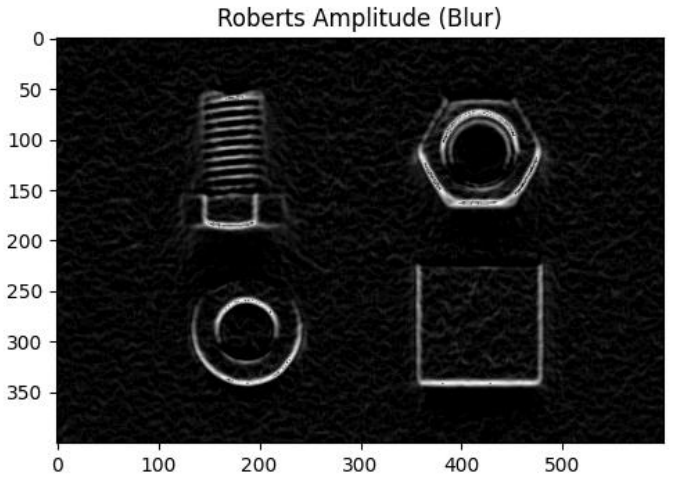












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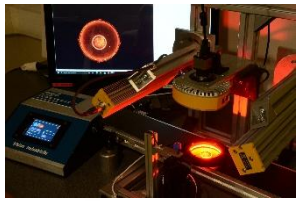

Traitement d'images

Objectif

Acquisition

Eclairage, caméra…

Pré-Traitement

Filtrage / Réduction bruit
Amélioration contraste
Normalisation

Améliorer la clarté de l'image / réduire les informations indésirables
Faire ressortir les caractéristiques d'intérêt
Standardiser l'échelle ou l'intensité de l'image

Segmentation

Seuillage
Détection de contours
Sélection de régions d'intérêt

Isoler les objets de la région d'intérêt (ROI)
Séparer les objets de l'arrière-plan
Identifier les limites et les contours
Se concentrer uniquement sur les parties pertinentes de l'image

Extraction d'informations

Formes géométriques
Analyse de textures
Zones uniformes

Extraire des données (taille, forme, position…)
Reconnaitre des formes, des symboles ou des points d'intérêt

Classification

Détection d'objets
Reconnaissance
Classification

Identifier et nommer des objets
Vérifier si les données mesurées sont en accord avec un cahier des charges
Catégoriser des objets dans des groupes spécifiques

Décision

Tolérances, pièce valide/non valide, retour en temps réel…

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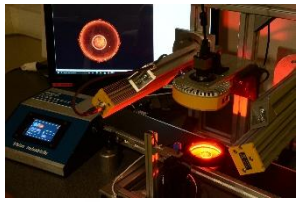


Traitement d'images

Images numériques

Image continue

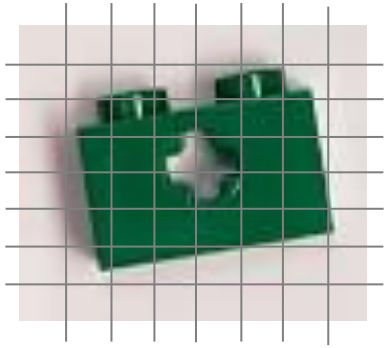
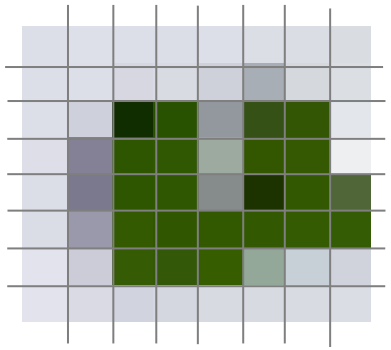
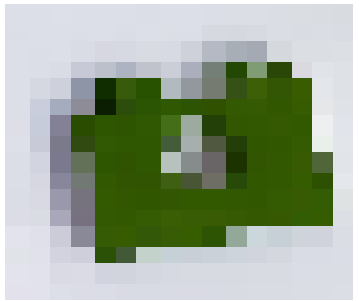


Image numérique : projection sur une matrice d'une image continue



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.*

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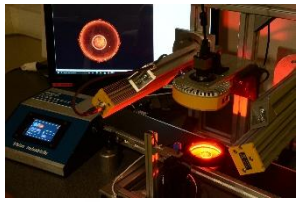
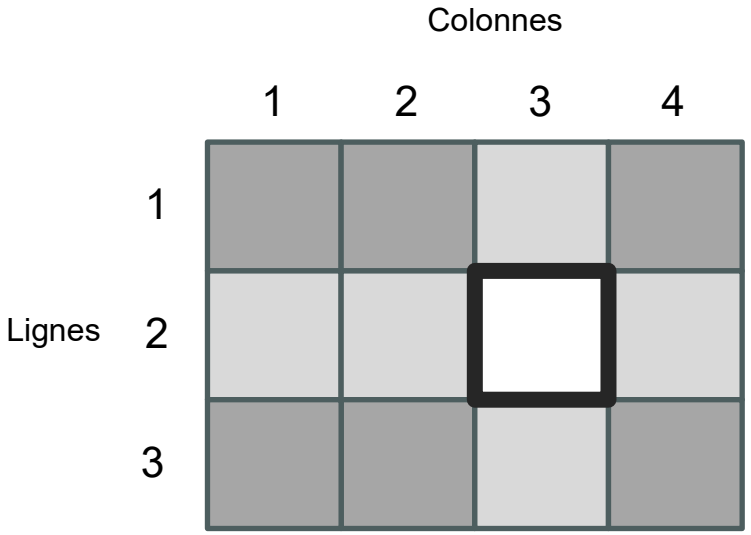


Traitement d'images

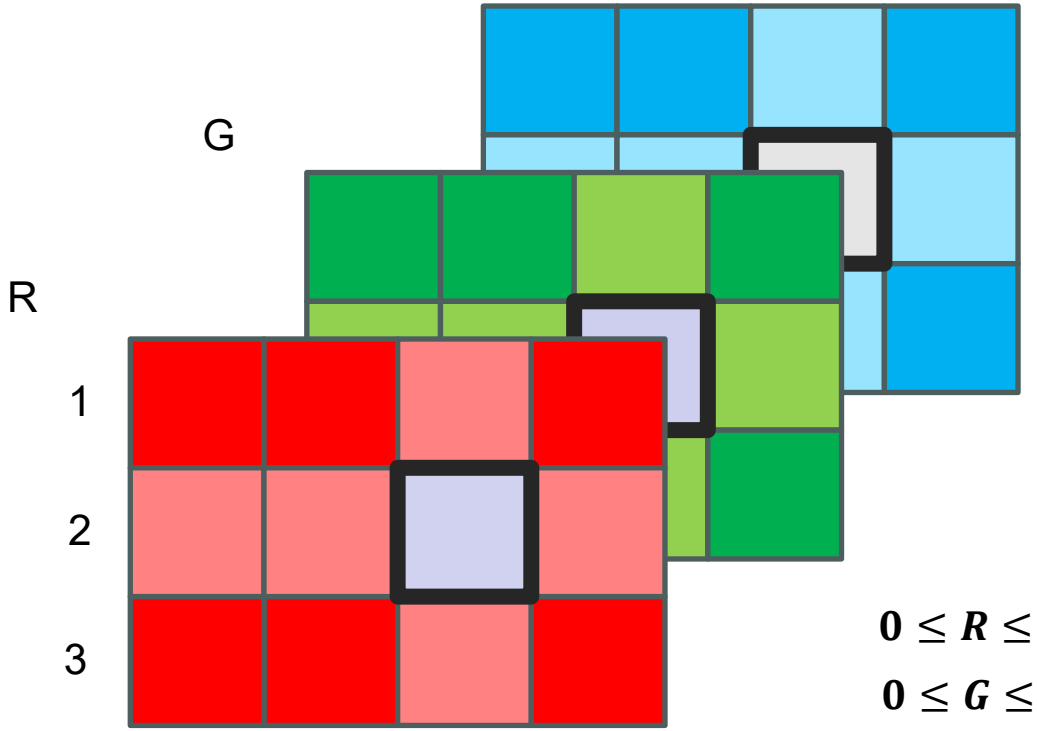
Images numériques / Gris ou RGB

Gris

Nb de pixels = **h** x **v**



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



RGB : 3 canaux de 8 bits

$$0 \leq R \leq 255$$
$$0 \leq G \leq 255$$
$$0 \leq B \leq 255$$

R=200, G=100, G=50

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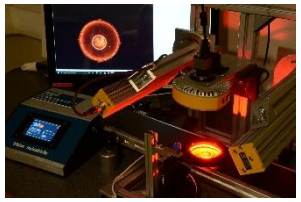


Traitement d'images

OpenCV

Open Source Computer Vision

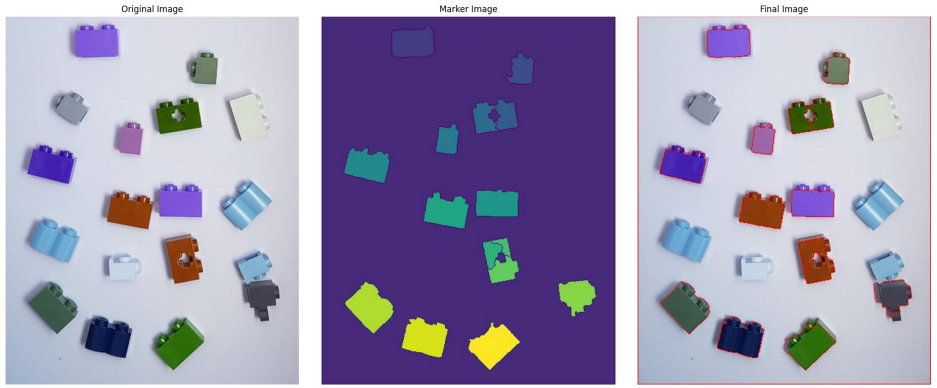
Une bibliothèque de **traitement d'images** et de **Machine learning**

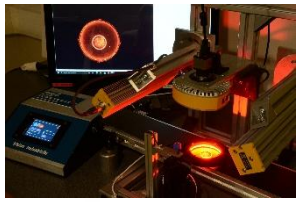
Développés sur de multiple environnement, comme Python, C++, Java, and MATLAB

OpenCV

https://opencv.org

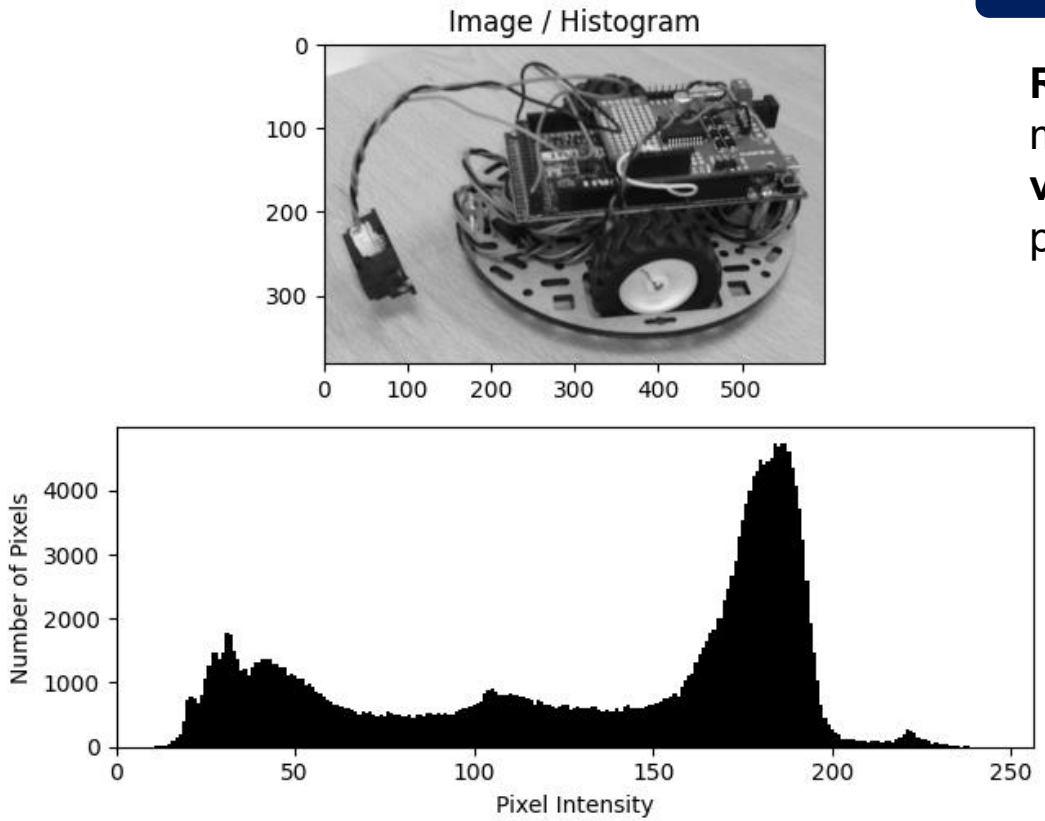
Traitement d'images	*Filtrage, detection de contours, transformations…*
Reconnaissance	*Détection d'objets dans des images et des vidéos*
Algorithmes Vidéo	*Suivi de mouvement, Reconstruction 3D…*
Machine Learning	*Classification d'images, Reconnaissance de formes*





Traitement d'images

Acquisition



Histogramme

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

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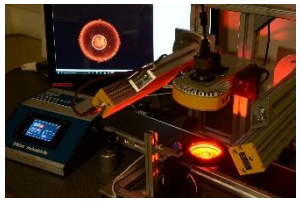
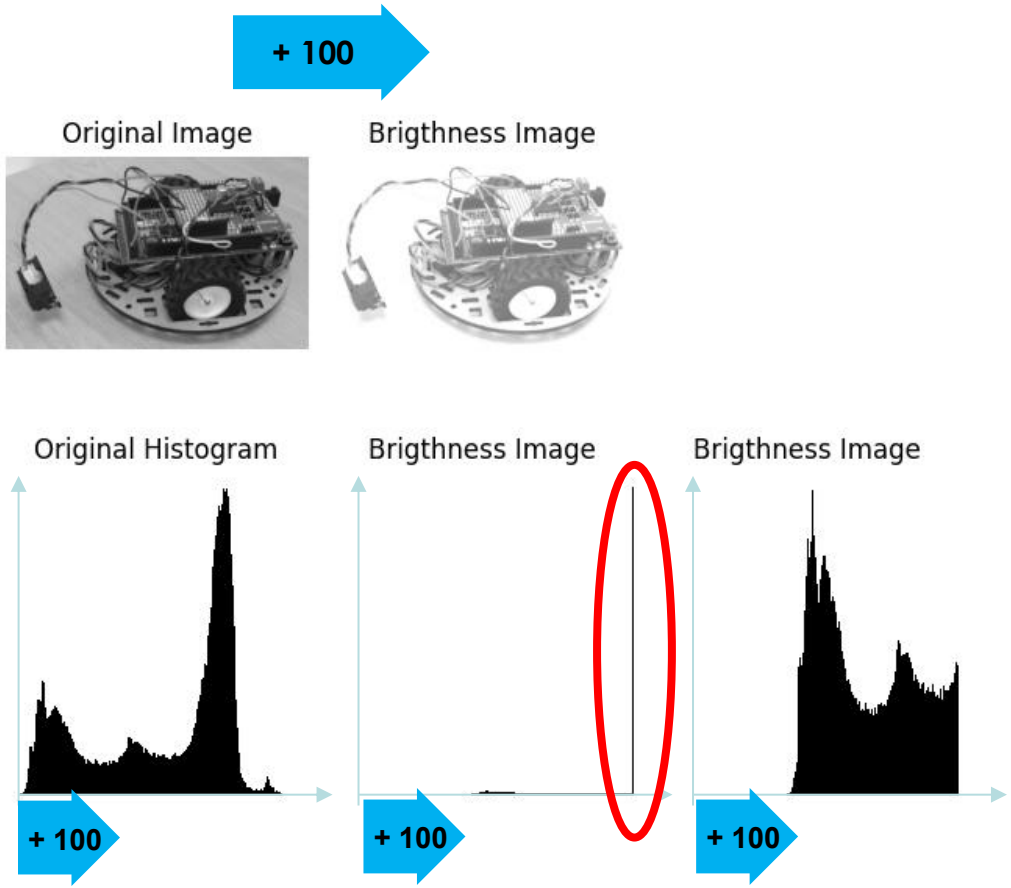


Traitement d'images

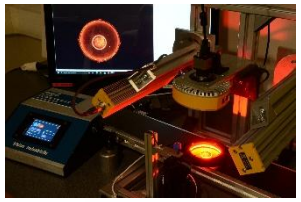
Amélioration de l'image

Acquisition

Pre Processing



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

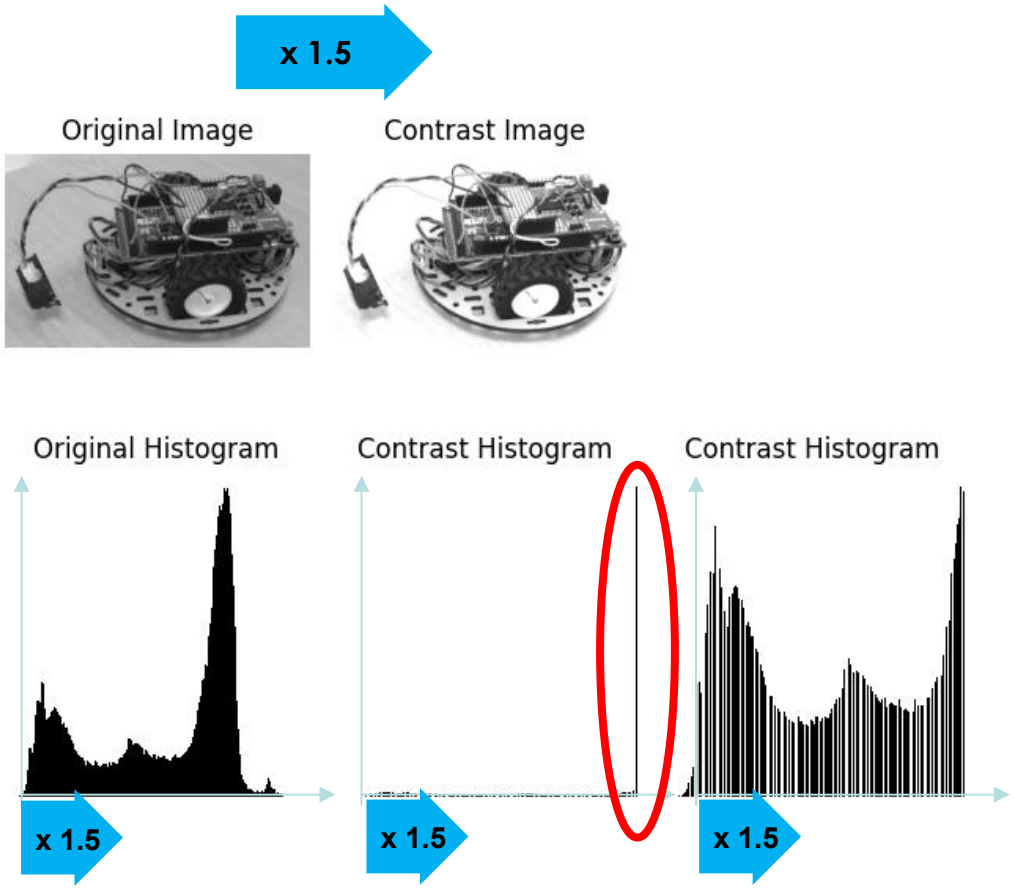


Traitement d'images

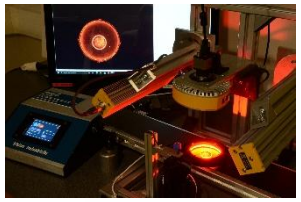
Amélioration de l'image

Acquisition

Pre Processing



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



Traitement d'images

Acquisition

Pre Processing

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 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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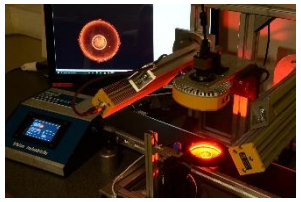


Traitement d'images

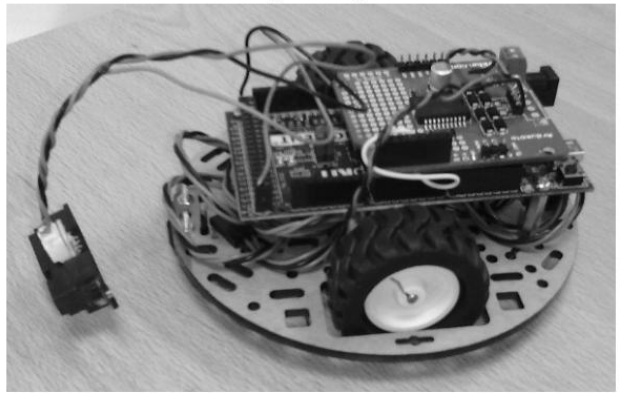
Filtrage / Convolution

Acquisition

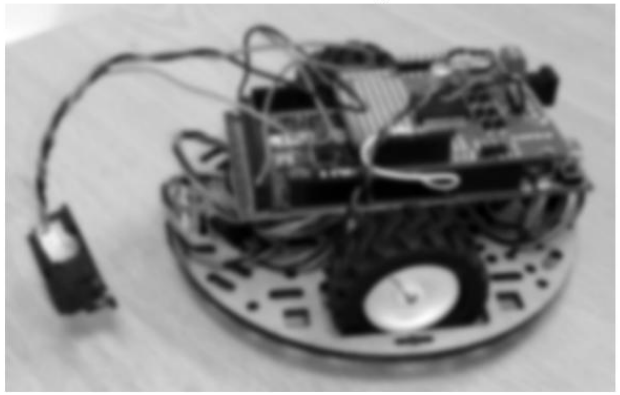
Pre Processing

Suppression de détails insignifiants

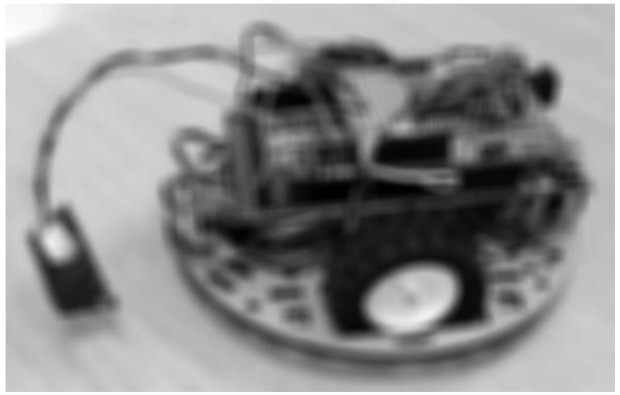
Original Image



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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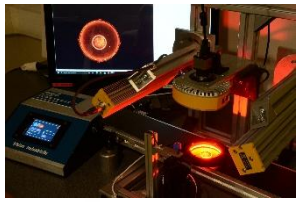
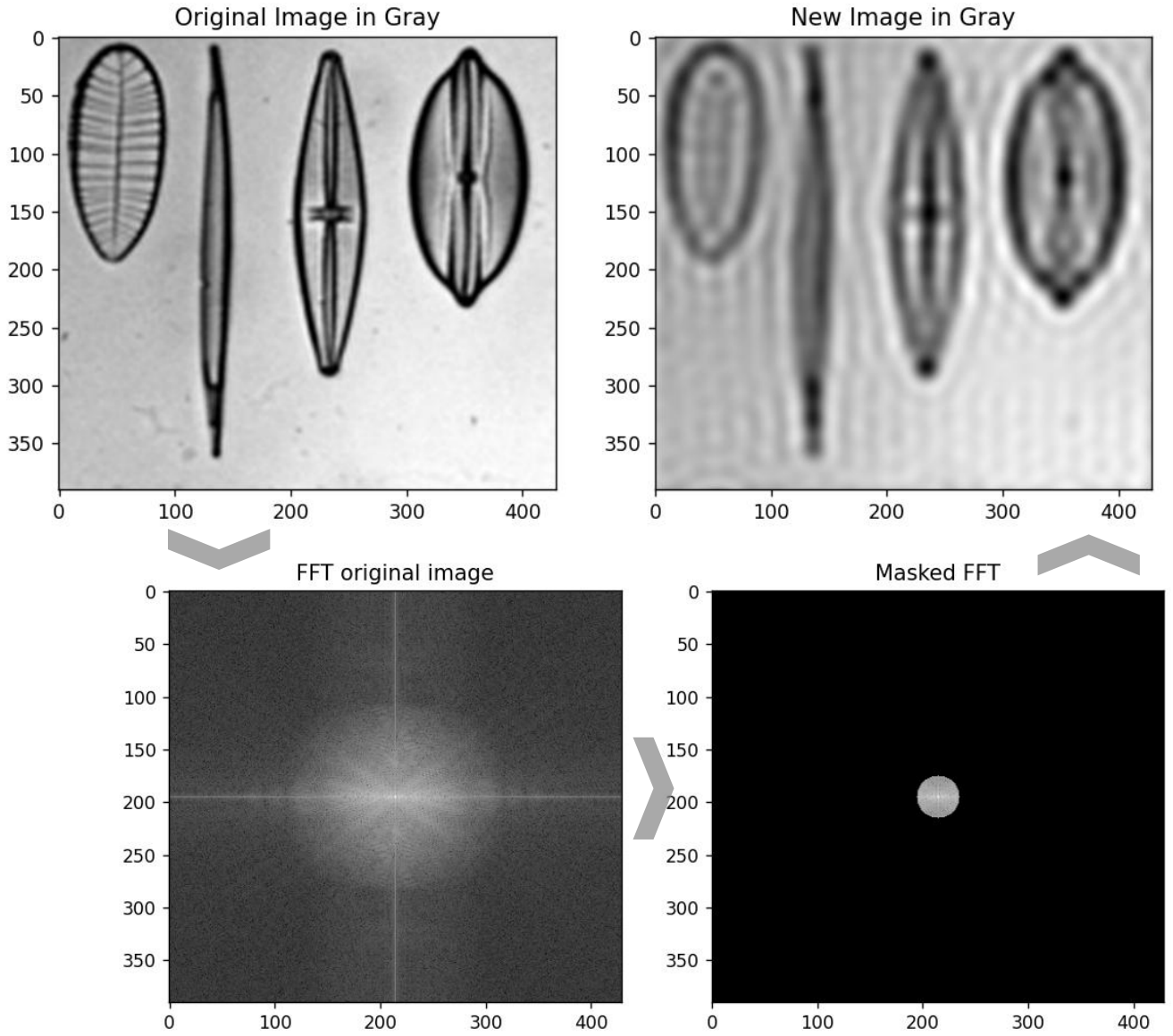


Traitement d'images

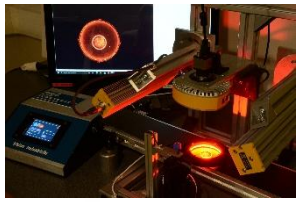
Acquisition

Pre Processing

Filtrage par TF

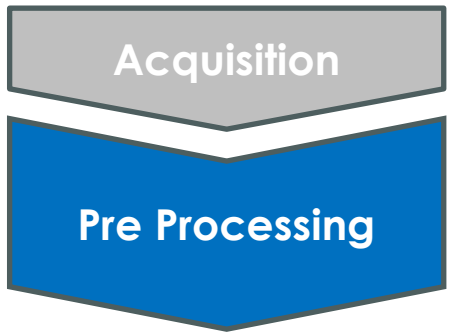


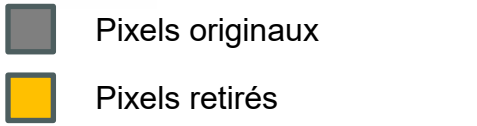
INSTITUT d'OPTIQUE GRADUATE SCHOOL | LEnsE Laboratoire d'Enseignement Expérimental

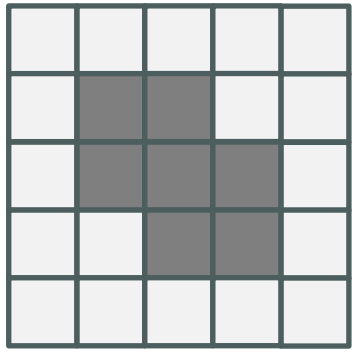


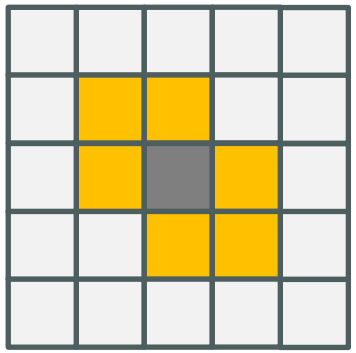
Traitement d'images

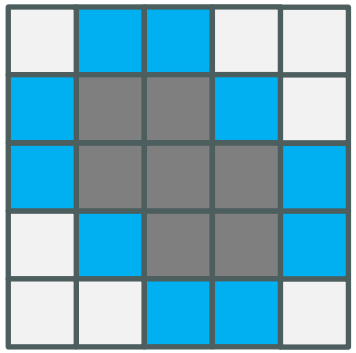
Erosion / Dilatation











kernel

0	1	0
1	1	1
0	1	0

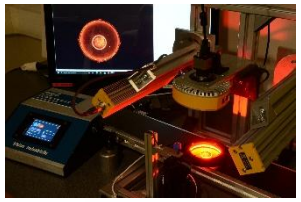
Erosion

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

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

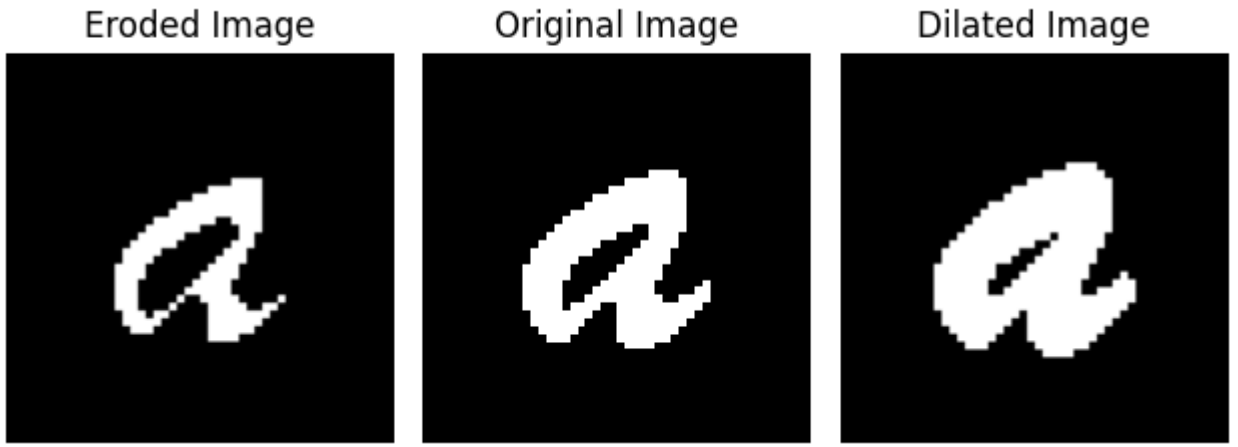


Traitement d'images

Erosion / Dilatation

Acquisition

Pre Processing



kernel

0	1	0
1	1	1
0	1	0

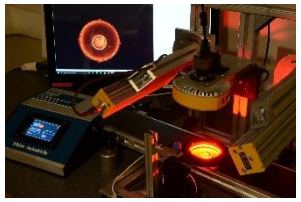
Erosion

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

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



Traitement d'images

Ouverture / Fermeture

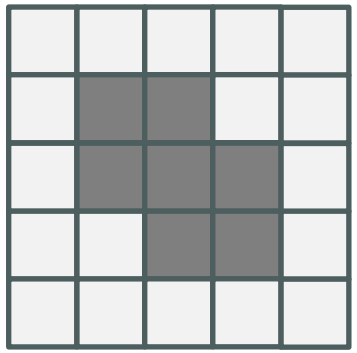
Acquisition

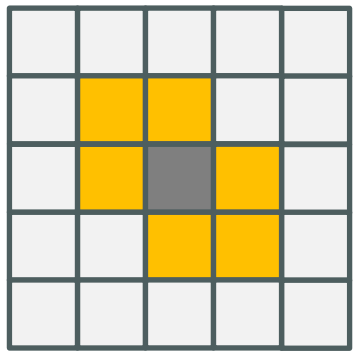
Pre Processing

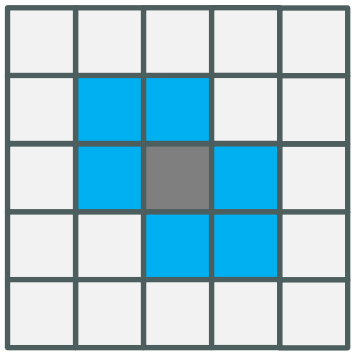
Original pixels

Removed pixels

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

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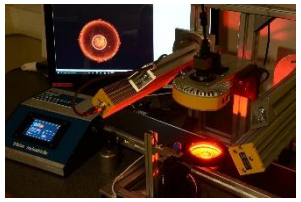
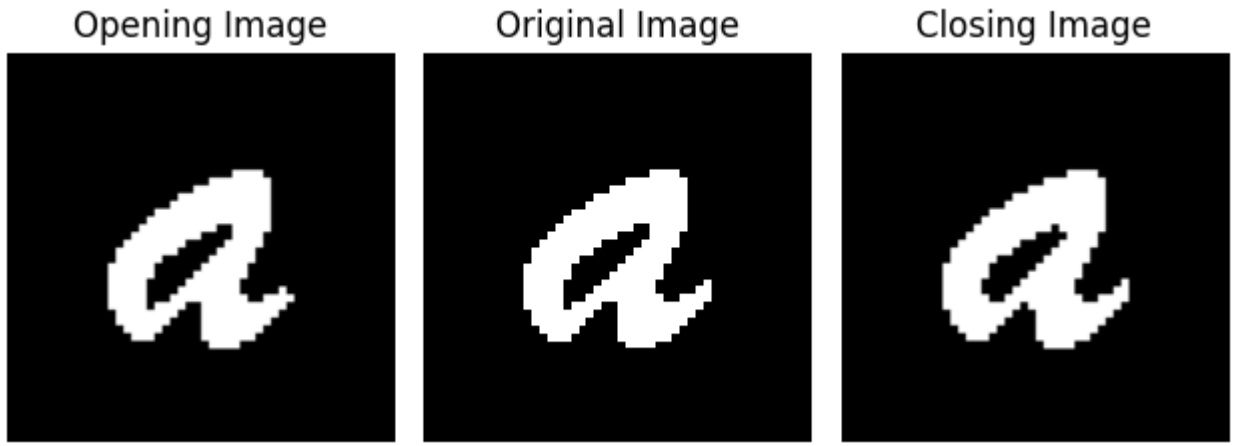


Traitement d'images

Ouverture / Fermeture

Acquisition

Pre Processing



kernel

0	1	0
1	1	1
0	1	0

Ouverture

Erosion puis **Dilatation**

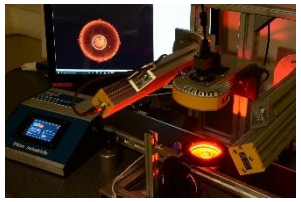
Retire des petits objets

Fermeture

Dilatation puis **Erosion**

Remplit des petites zones

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

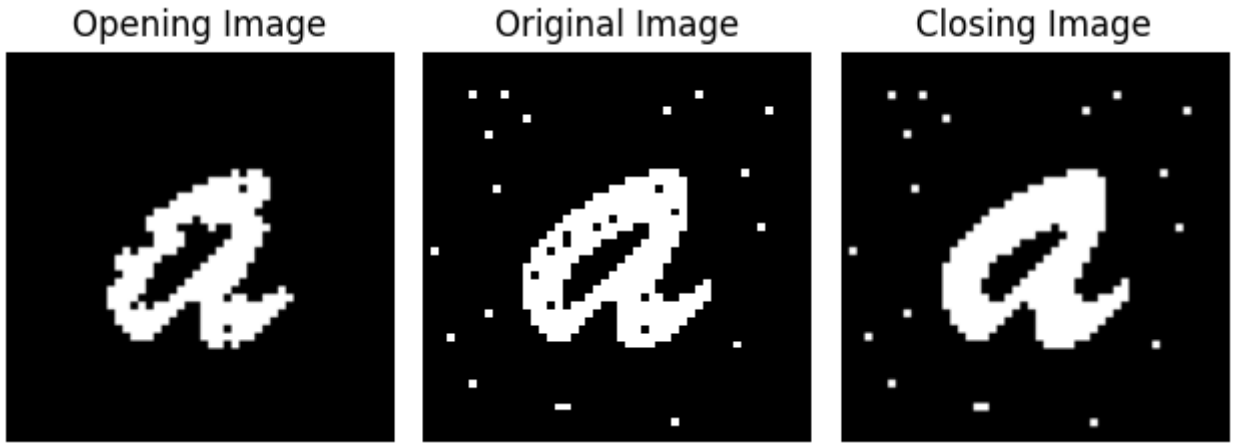


Traitement d'images

Ouverture / Fermeture

Acquisition

Pre Processing



kernel

0	1	0
1	1	1
0	1	0

Ouverture

Erosion puis **Dilatation**

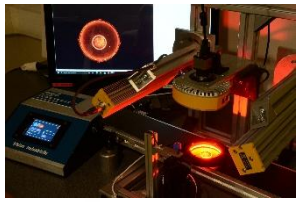
Retire des petits objets

Fermeture

Dilatation puis **Erosion**

Remplit des petites zones

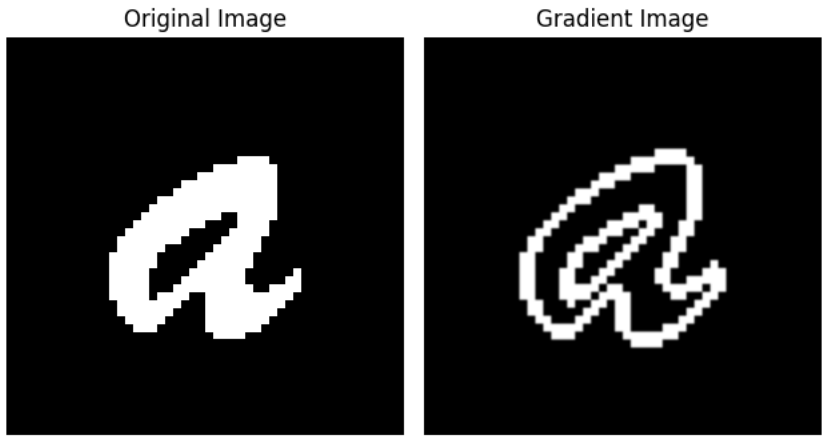
INSTITUT d'OPTIQUE GRADUATE SCHOOL | LEnsE Laboratoire d'Enseignement Expérimental



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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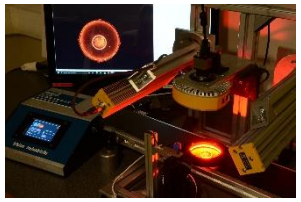


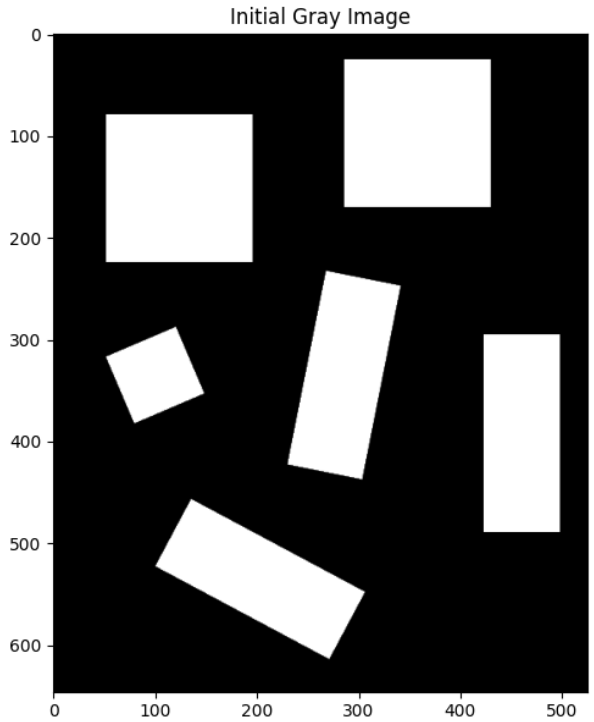
Traitement d'images

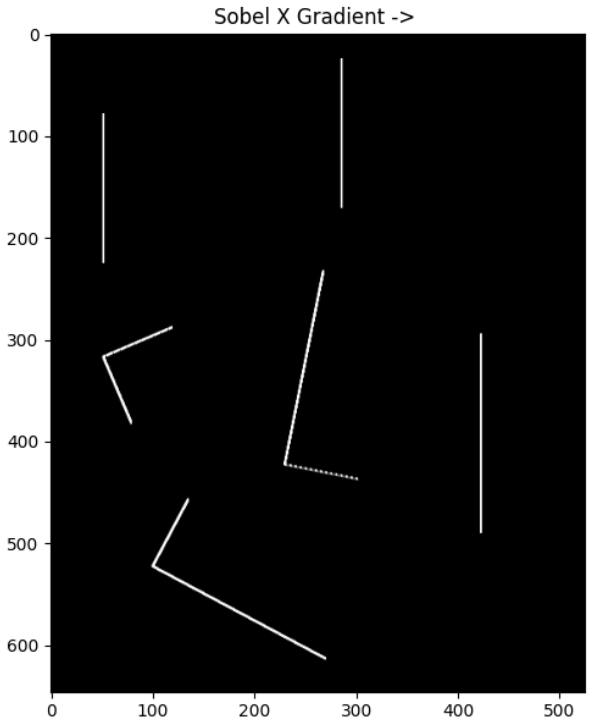
Opérateur de Sobel

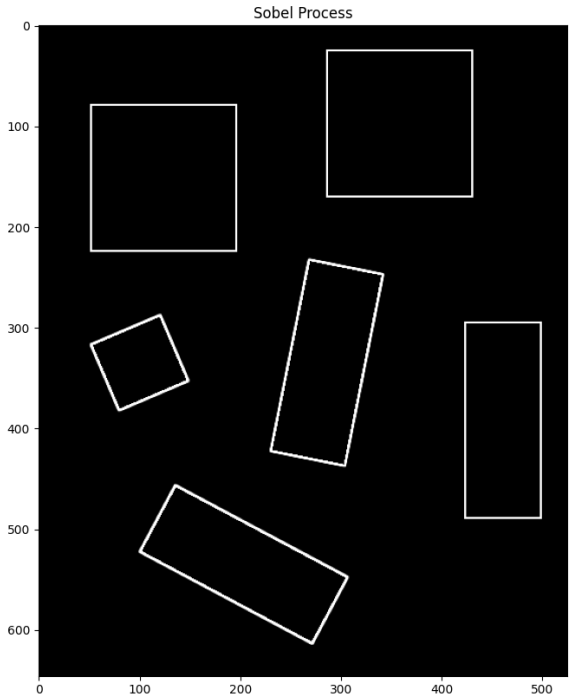
- Acquisition
- Pre Processing
- Segmentation

kernel

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







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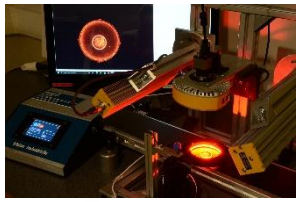
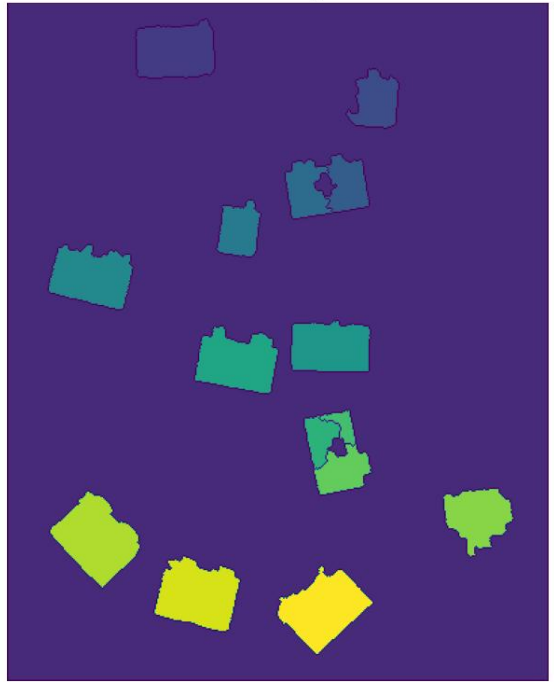


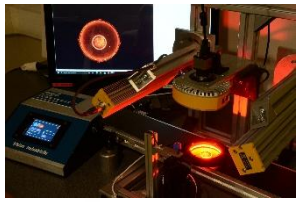
Traitement d'images

Méthode de Watershed

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



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



Traitement d'images

Méthode de Watershed

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