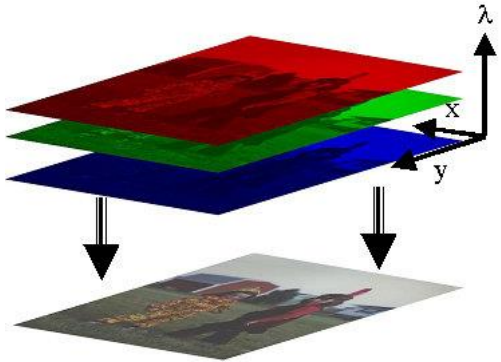
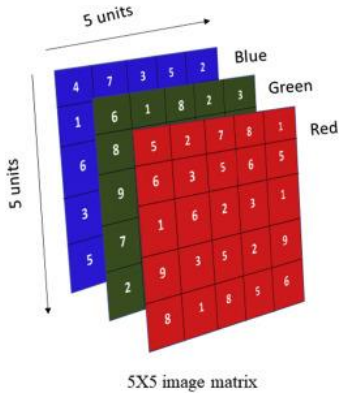
Image Processing

Image Processing

- An image is mathematically represented as a three-dimensional array of pixels
- Each pixel corresponds to a specific **color or intensity** value
- The dimensions of an image refer to its **width** and **height**
- Images can have multiple channels





5X5 image matrix

- **RGB** color images consist of 3 channels (Red, Green, Blue)
- A value close to 0 is **black** and a value close to 255 is white.

Histogram

- Images matrices contains a lots of differents information
- To manually find features in the image a good practice is to analyse image as a signal
- Histogram allow to visualise the color repartition in the image.

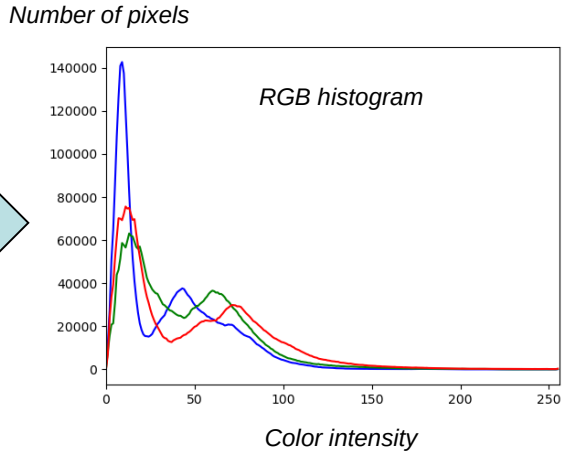


Image Processing

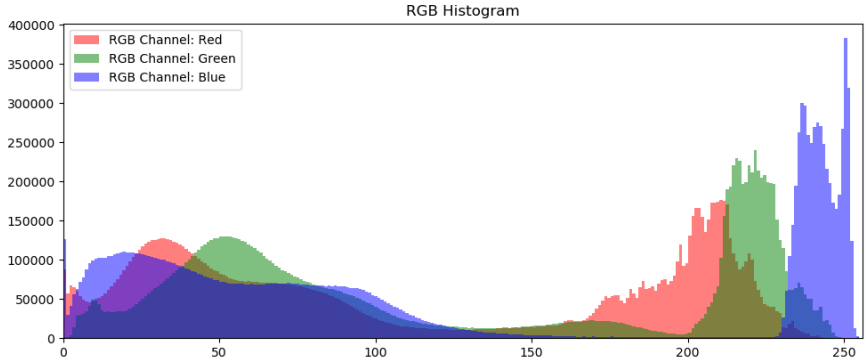
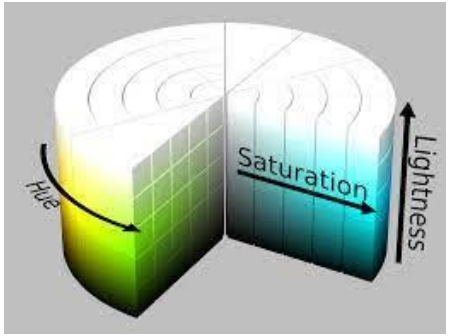
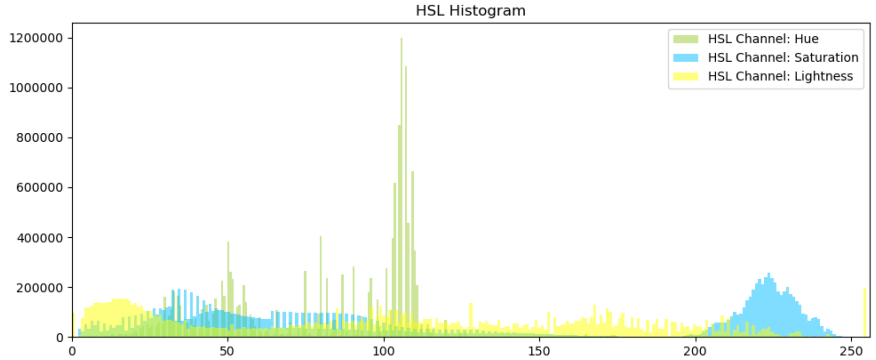
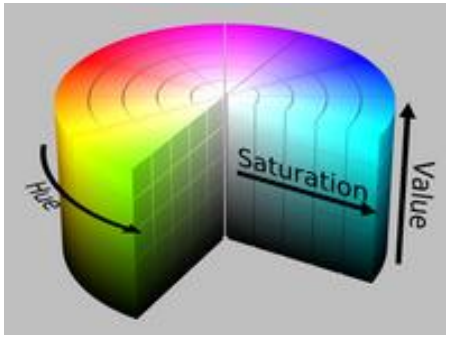
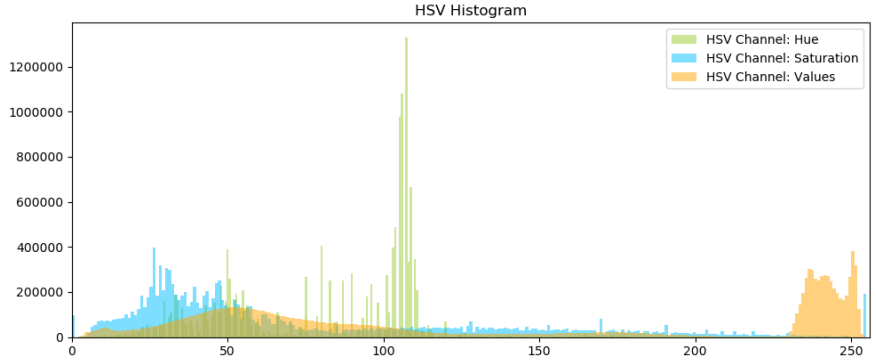


Image Processing



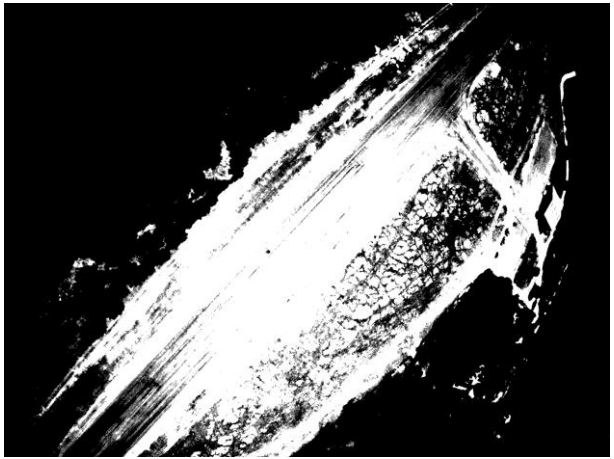






Grayscaling

- To transform an image into a 2 dimensionnal matrice, the image channels need to be fused
- The most easiest way to grayscale is to do an average of the 3 channels

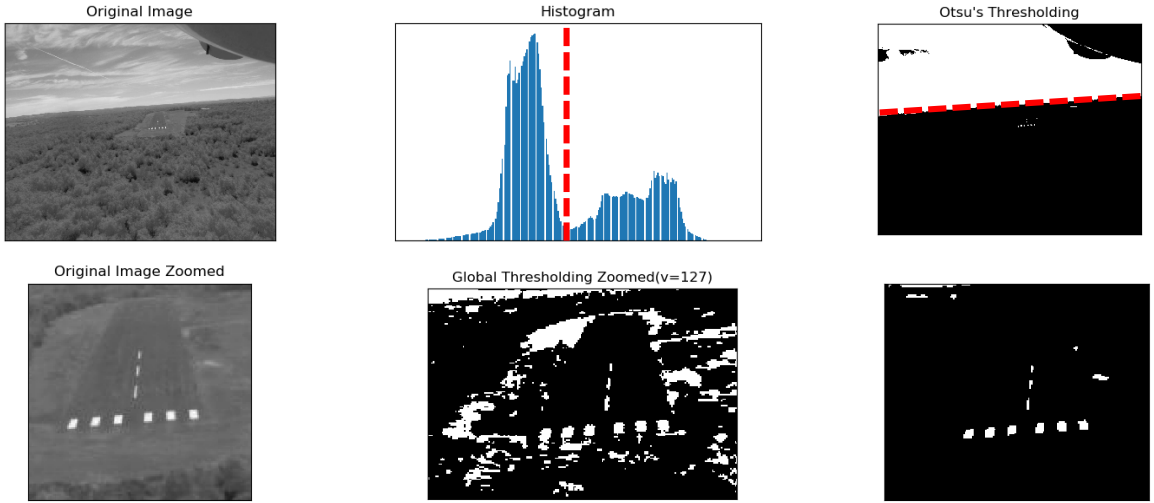


- To go beyond, it can be usefull to threshold the image
- We use the grayscale histogram to find the threshold value
- This create a new black/white image with only 0 and 1

Thresholding

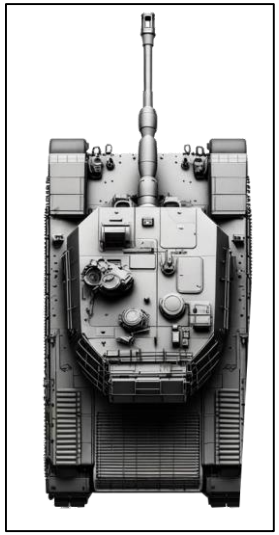
- **Otsu's algorithm** tries to find a threshold value (t) which minimizes the weighted within-class variance.

= **maximizing difference between 2 populations**

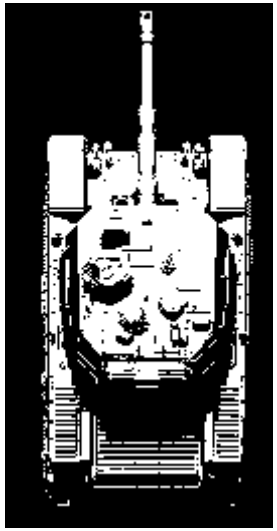


Thresholding

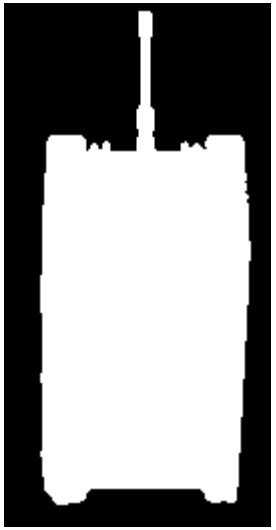
Original Image



Global Thresholding

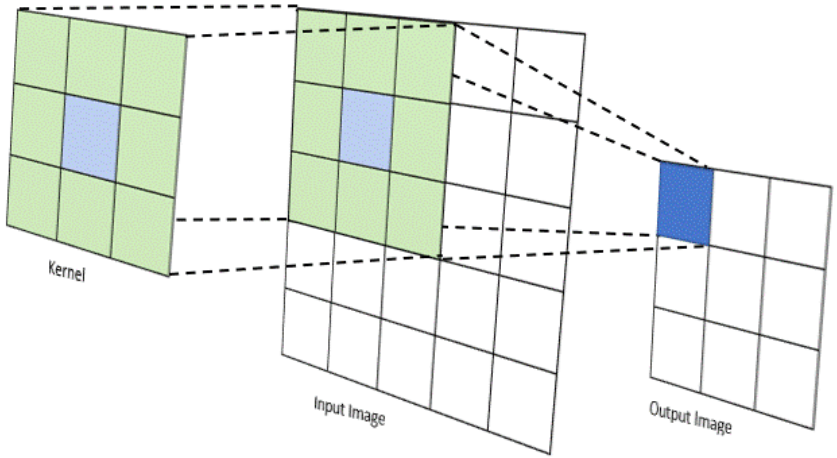


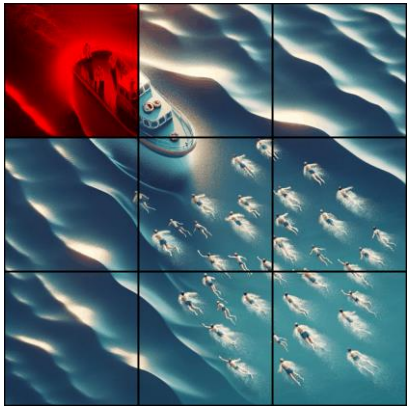
Otsu's Thresholding



Convolution

- The kernel moves across the image. At each position, it multiplies its values with the pixel values it covers and sums them up. This sum replaces the central pixel value.





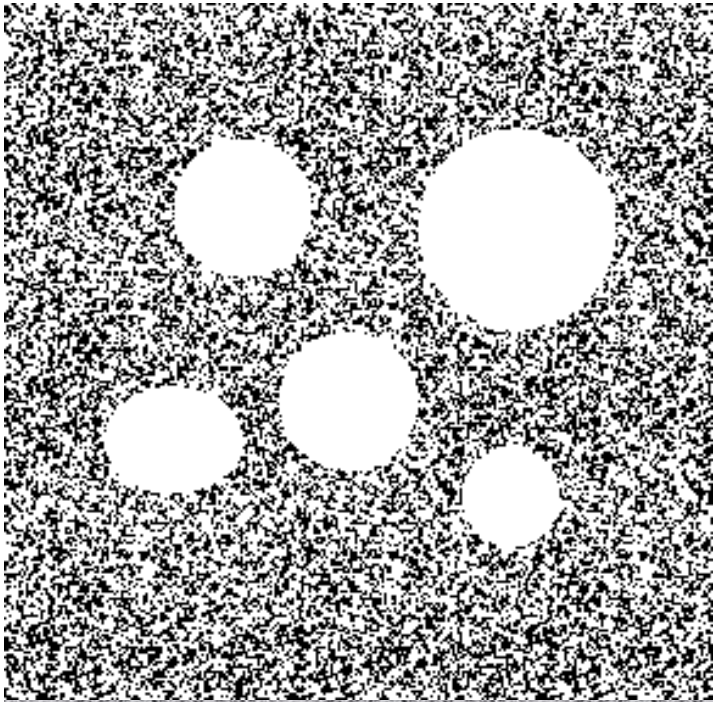
Convolution operation to keep only the red pixel

Erosion

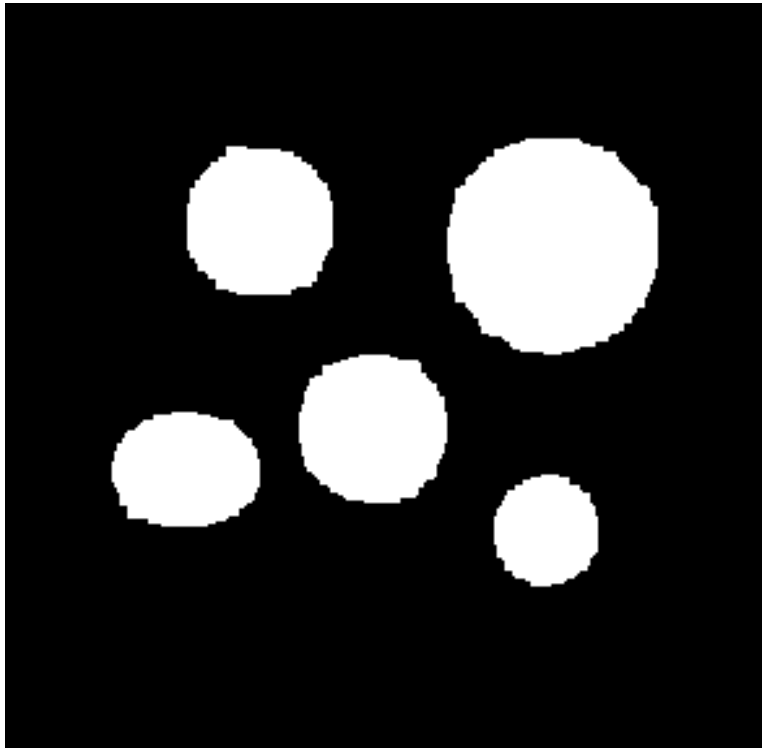
- A kernel moves over the image. If all pixels under the kernel match (e.g., are white), the central pixel is kept; otherwise, it's eroded (made black).

Erosion Kernel Examples

$$\begin{pmatrix} 0 & 1 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & 0 \end{pmatrix} \qquad \begin{pmatrix} 0 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 1 & 0 \end{pmatrix}$$



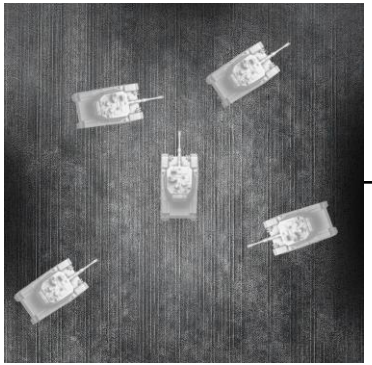
Dilatation



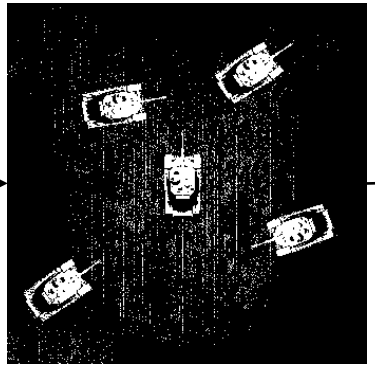
A kernel moves over the image. If at least one pixel under the kernel matches (e.g., is white), the central pixel is made white.

Erosion / Dilatation Example

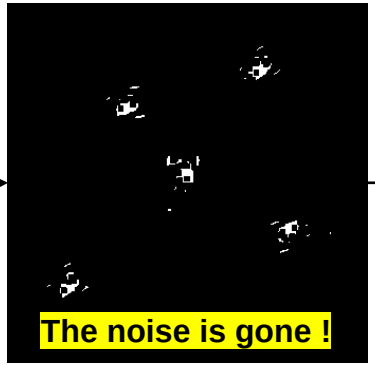
Original Image



Thresholding



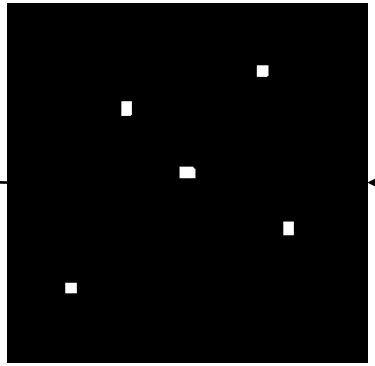
1 · Erosion

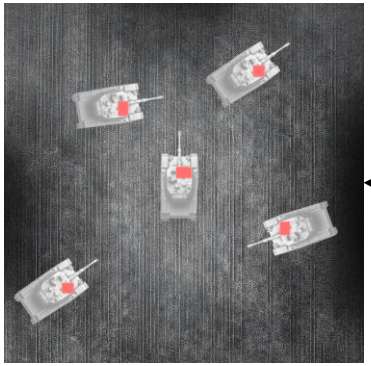


1 · Erosion

2 · Dilations

(Keep the same amount of dilation than erosion)





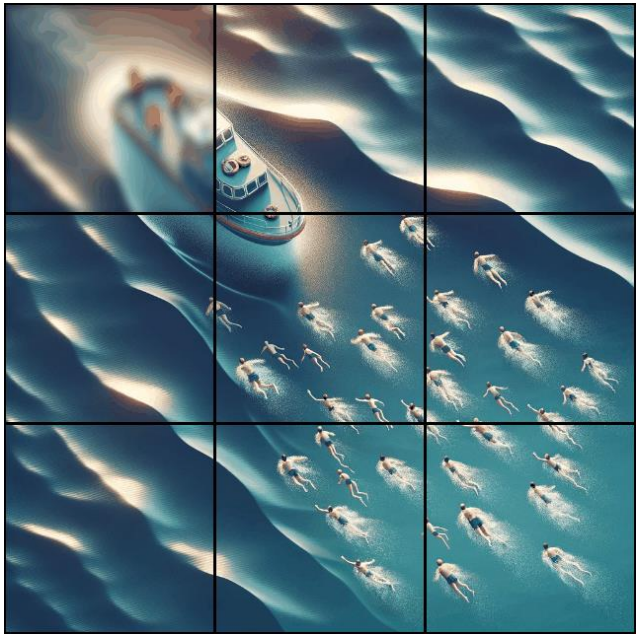
Targets extracted from the image !

Gaussian Filter

- Smoothing technique.
- Uses a Gaussian kernel to blur the image and reduce noise.

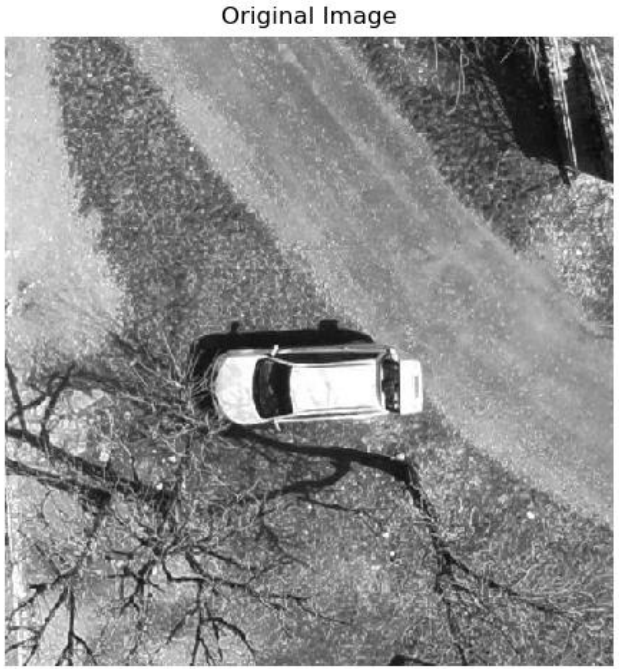
Gaussian Kernel Examples

$$\begin{pmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{pmatrix}$$



Gaussian Filter

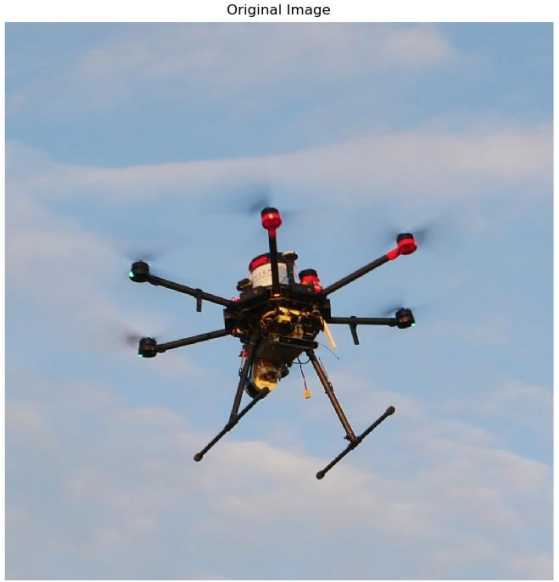
Gaussian Filter

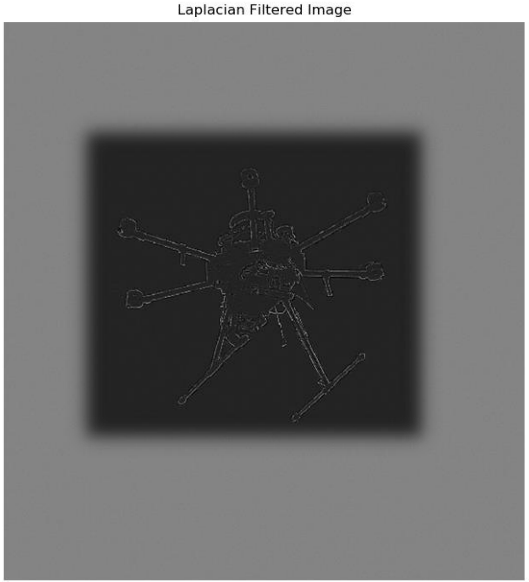


Laplacian Filter

- An edge detection method.
- Applies a Laplacian operator to accentuate regions of rapid intensity change.

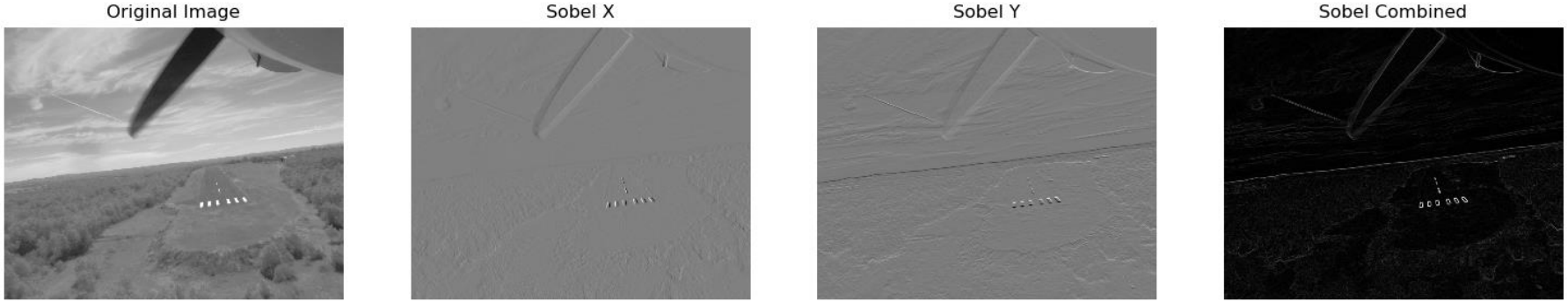
$$L(x, y) = \frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2}$$





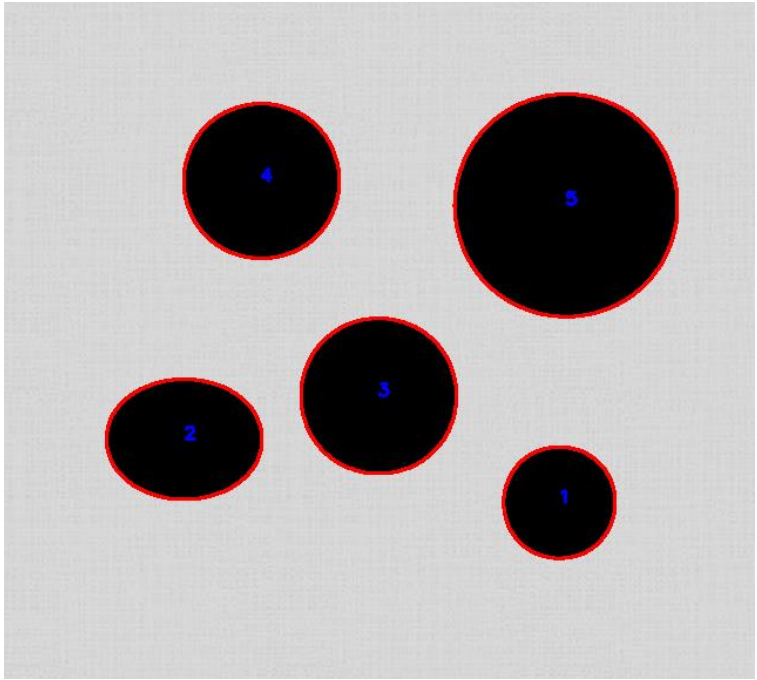
Sobel Operator

- Edge detection in images, highlighting regions where image brightness changes sharply.
- It calculates the gradient of the image intensity, providing both the magnitude and direction of edges.

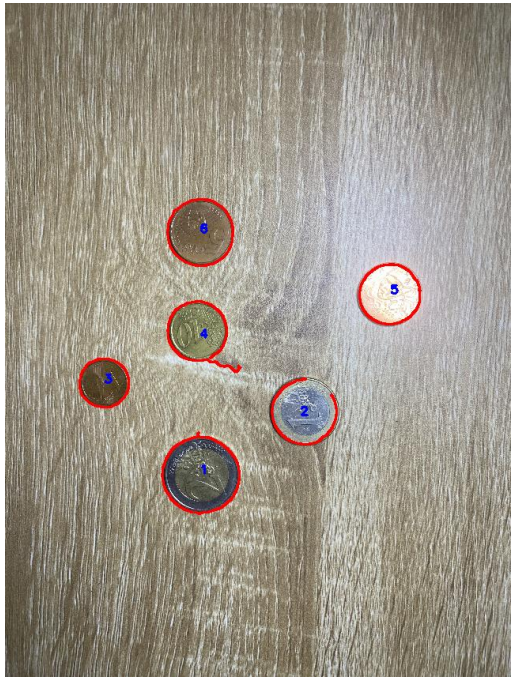


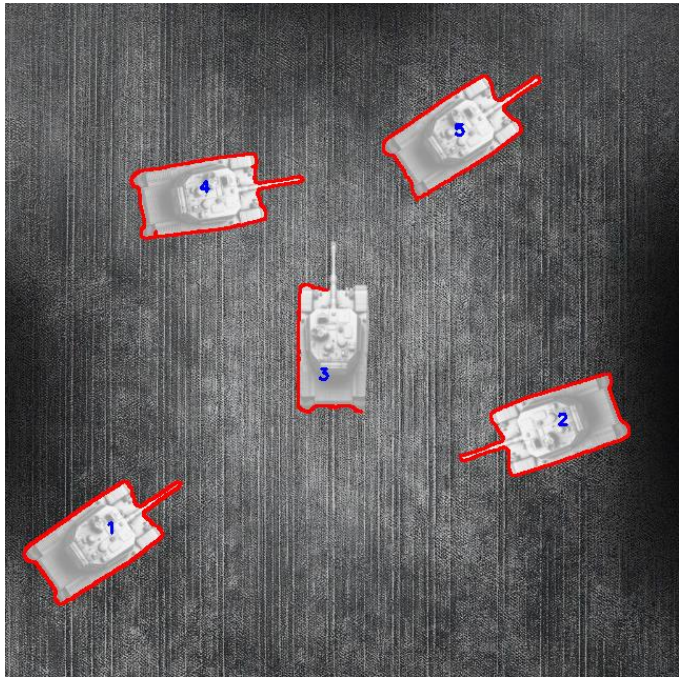
Canny edge detection

- A multi-stage algorithm for edge detection.
- Involves :
  - Smoothing
  - Gradient calculation *(Sobel)*
  - Non-maximum suppression *(Erosion/Dilatation)*
  - Hysteresis thresholding.



Canny edge detection





Harris corner detector

- Identifies corners in images by detecting significant changes in all directions, utilizing the eigenvalues of the second moment matrix.

- Feature extraction, particularly robust in identifying interest points for image matching and 3D reconstruction.

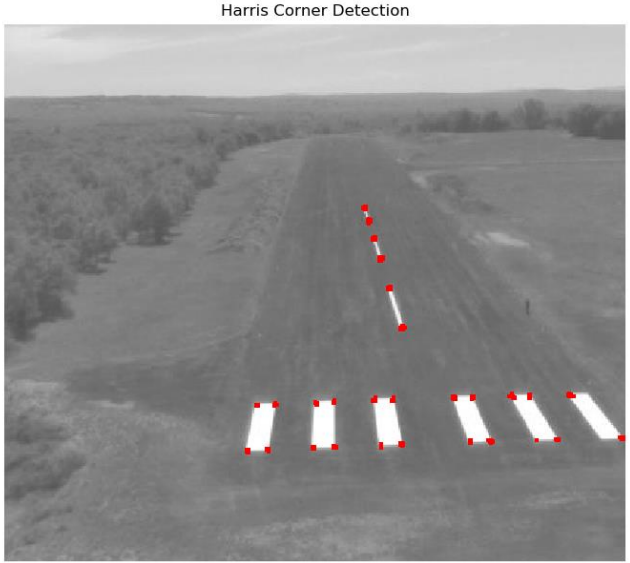
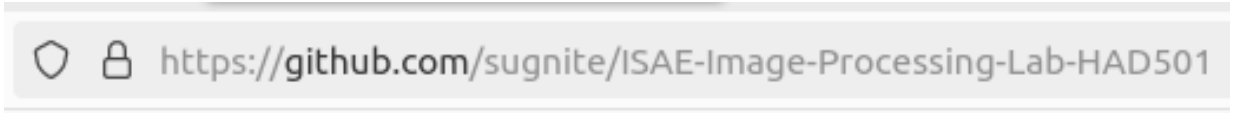


Image Processing Lab

Go to the project's page



References

Images: Introduction

Tesla	https://static-assets.tesla.com/configurator/compositor?context=design_studio_2?&bkba_opt=1&view=STUD_3QTR&size=1400&model=m3&options=$APBS,$IPB2,$PPSW,$SC04,$MDL3,$W38A,$MT351,$CPF0&crop=1400,850,300,130&
Tiktok	https://assets.espace-autoentrepreneur.com/ruche_articles/developpement-microentreprise-tiktok/developpement-microentreprise-tiktok_original.jpeg
Google Translate	https://cdn1.oxatis.com/Files/112496/dyn-images/23/apps-google-translate.jpg?w=1200&h=1200
Chat GPT	https://bocir-prod-bucket.s3.amazonaws.com/medias/UBL5BgYYYQ/image/openAI_chat_gpt_1168077635423 1.jpg
Stockfish IA Player	https://images.chesscomfiles.com/uploads/v1/images_users/tiny_mce/ColinStapczynski/phpuNaem2.png
Chair	https://i.pinimg.com/originals/82/34/5d/82345d989630d9b4b8dcca81eb317c46.png
3 foots chair	https://www.design-market.eu/1415167-large_default/vintage-triangle-3-foot-chair-by-farma.jpg

Sofa	https://furnituretogocatalogs.com/cdn/shop/products/086fed5c-a617-4af2-b95f-e15d7ae7cc45_1dfa16d9-281f-40dc-826a-59c78774f4f7_1946x.jpg?v=1699937509
Desk Chair	https://www.amazon.fr/MZLEE-Ergonomique-Pivotante-Rabattable-Confortable/dp/B0BG2BCV6W

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References

Images: Machine Learning & Networks

Bayes Network	https://www.biorxiv.org/content/biorxiv/early/2020/07/01/2020.02.04.934174/F1.large.jpg
Sofa n° 2	https://atlas-content-cdn.pixelsquid.com/stock-images/grey-sofa-xwLkAEF-600.jpg
Conv Network	https://miro.medium.com/v2/resize:fit:1400/1*uAeANQIOQPqWZnnuH-VEyw.jpeg
Deep Network	Anguraj, Dinesh Kumar et al. "Analysis of influencing features with spectral feature extraction and multi-class classification using deep neural network for speech recognition system." Int. J. Speech Technol. 25 (2022): 907-920.
Feed forward and Recursive network	https://commons.wikimedia.org/wiki/File:RecurrentLayerNeuralNetwork_english.png
LSTM	Bulut, Mehmet. "Hydroelectric Generation Forecasting with Long Short Term Memory (LSTM) Based Deep Learning Model for Turkey." ArXiv abs/2109.09013 (2021): n. pag.
Auto Encoder	https://iq.opengenus.org/implementing-autoencoder-tensorflow

Semantic Segmentation Example	Jagannathan, J. and C. Divya. "Deep learning for the prediction and classification of land use and land cover changes using deep convolutional neural network." Ecol. Informatics 65 (2021): 101412.
Convolutionnal Encoder Illustration	Zhang, Linyu. "Application of Lightweight Deep Learning Model in Landscape Architecture Planning and Design." International Journal of Advanced Computer Science and Applications (2023): n. pag.
Restricted Boltzman Machine (RBM)	https://upload.wikimedia.org/wikipedia/commons/thumb/e/e8/Restricted_Boltzmann_machine.svg/1200px-Restricted_Boltzmann_machine.svg.png

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References

Images: Image Processing

Image Matrice Layout	https://www.researchgate.net/publication/235036523/figure/fig5/AS:668621785292808@1536423264475/Data-cube-representation-of-the-RGB-components-of-a-digital-image.jpg
5x5 Image Matrix	https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.sciencedirect.com%2Ftopics%2Fengineering%2Frgb-image&psig=AOvVaw33-iNdB1yfxZBle_YYnxms&ust=1705053064816000&source=images&cd=vfe&opi=89978449&ved=0CBIQjRxqFwoTCLC8r-aH1YMDFQAAAAAdAAAAABAw
Convolution Gif operation	https://medium.com/@timothy_terati/image-convolution-filtering-a54dce7c786b
HSV	https://upload.wikimedia.org/wikipedia/commons/thumb/3/33/HSV_color_solid_cylinder_saturation_gray.png/197px-HSV_color_solid_cylinder_saturation_gray.png
HSL	https://fr-academic.com/pictures/frwiki/72/HSL_color_solid_cylinder_alpha_lowgamma.png

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