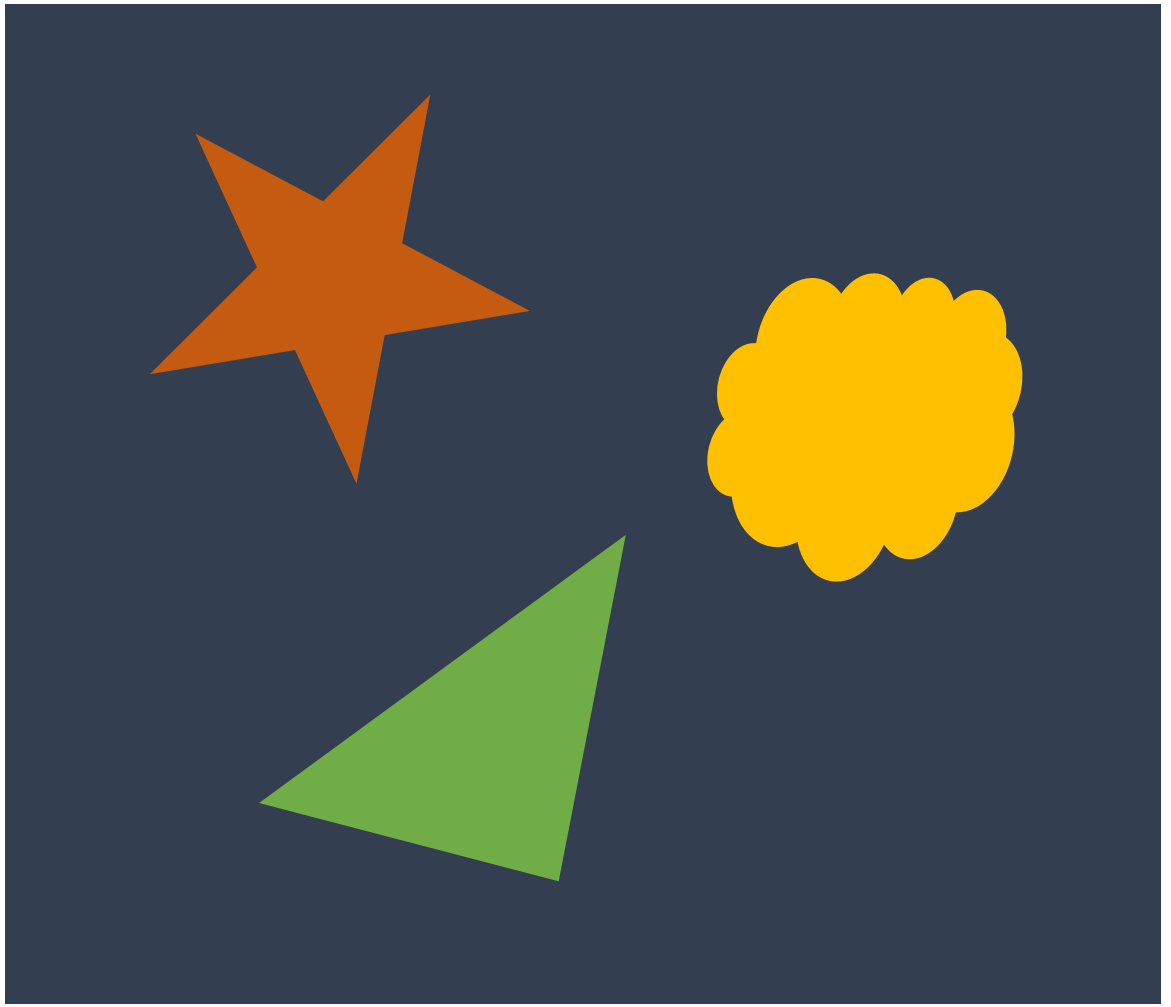
Introduction to image analysis

Quality Data Analysis

COLOURED DIGITAL IMAGE

- Coloured digital images are commonly handled with the red, green, and blue (RGB) colour map.
- An RGB image can be expressed as the combination of three 2D matrices, respectively expressing the intensity of the red, green, and blue channel.
- For each pixel, red, green and blue are assigned a value between 0 and 255 to obtain any colour in the visible spectrum.



GRAYSCALE DIGITAL IMAGE

- RGB images are usually converted to the grayscale colormap to enhance image processing efficiency.
- The conversion from RGB to grayscale occurs as a weighted average of the red, green, and blue channels.
- A grayscale image can be represented by a single 2D matrix where a value between 0 and 255 represents the lightness of each pixel from black, through grey shades, to white.

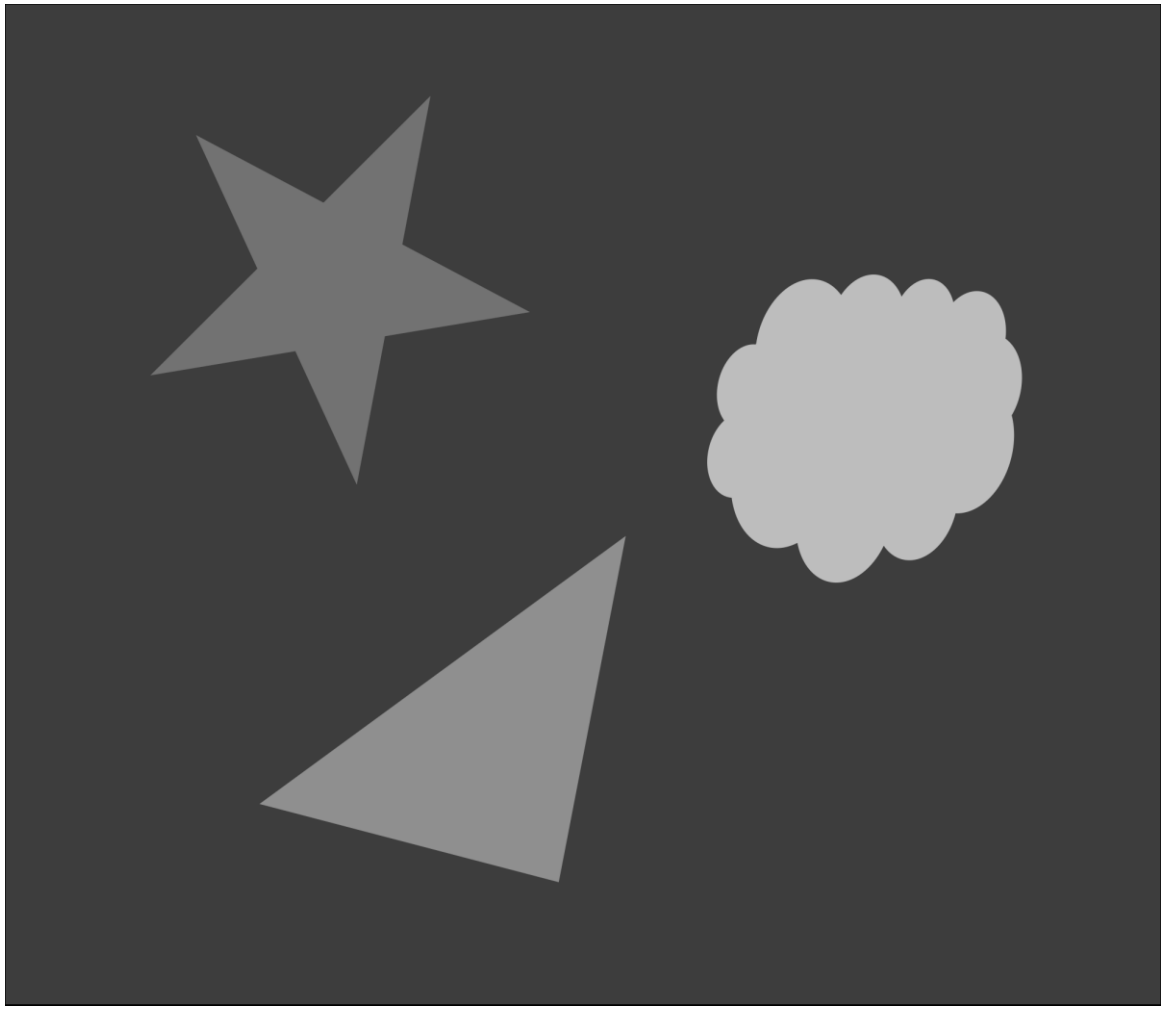
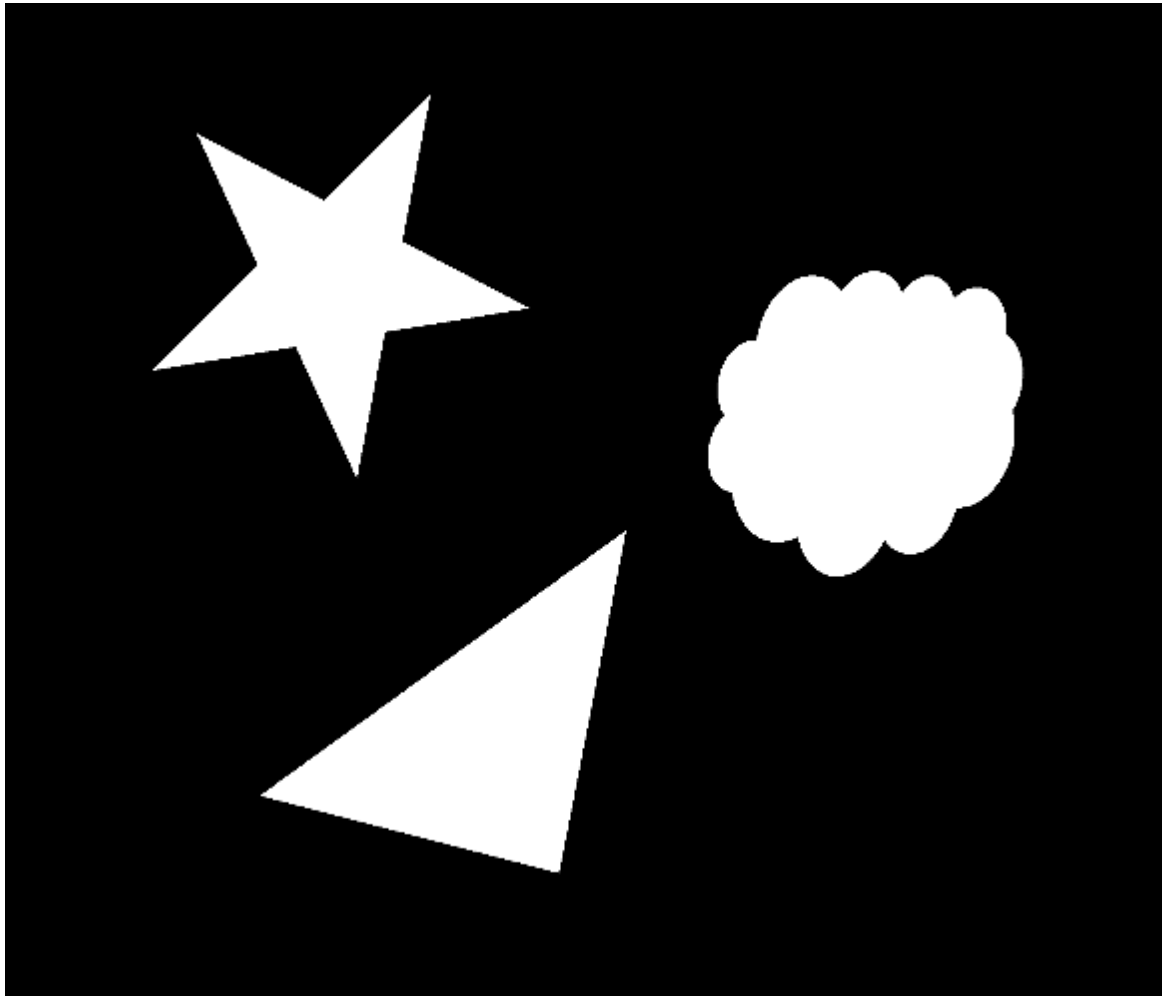


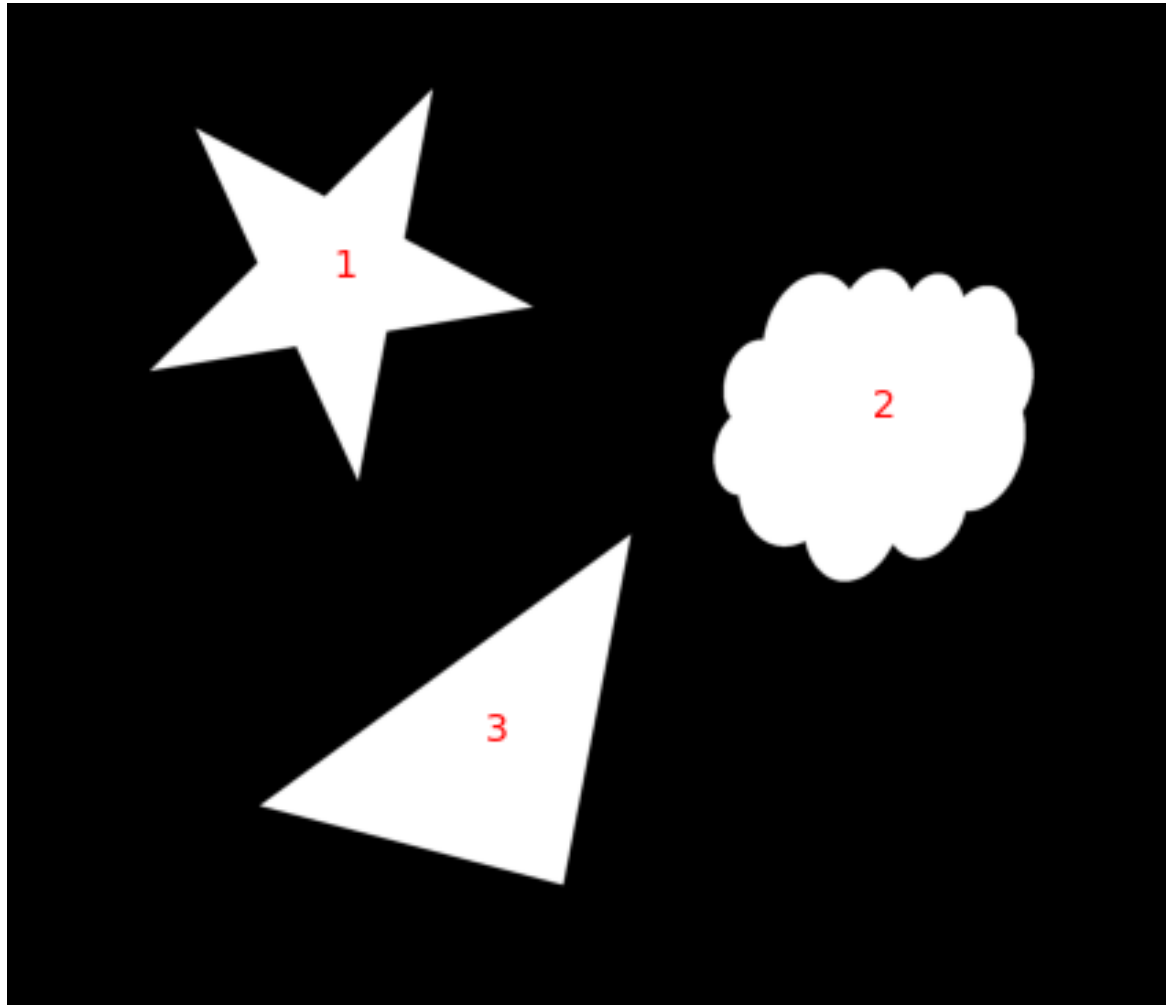
IMAGE SEGMENTATION

- In image processing, segmentation techniques are applied to isolate regions of interest from the rest of the image.
- Image segmentation algorithms work by identifying sharp discontinuities in pixel values or grouping pixels with similar values.
- The result of segmentation is a binary image that contains only white (255 in grayscale) and black (0 in grayscale) pixels, respectively representing the regions of interest and the background.



REGION ANALYSIS

- Region analysis is used to extrapolate statistical data regarding the connected regions identified during segmentation.
- Region analysis algorithms assign a label to each identified connected region.
- For each labelled region, region analysis algorithms extract a set of metrics (properties) of interest.



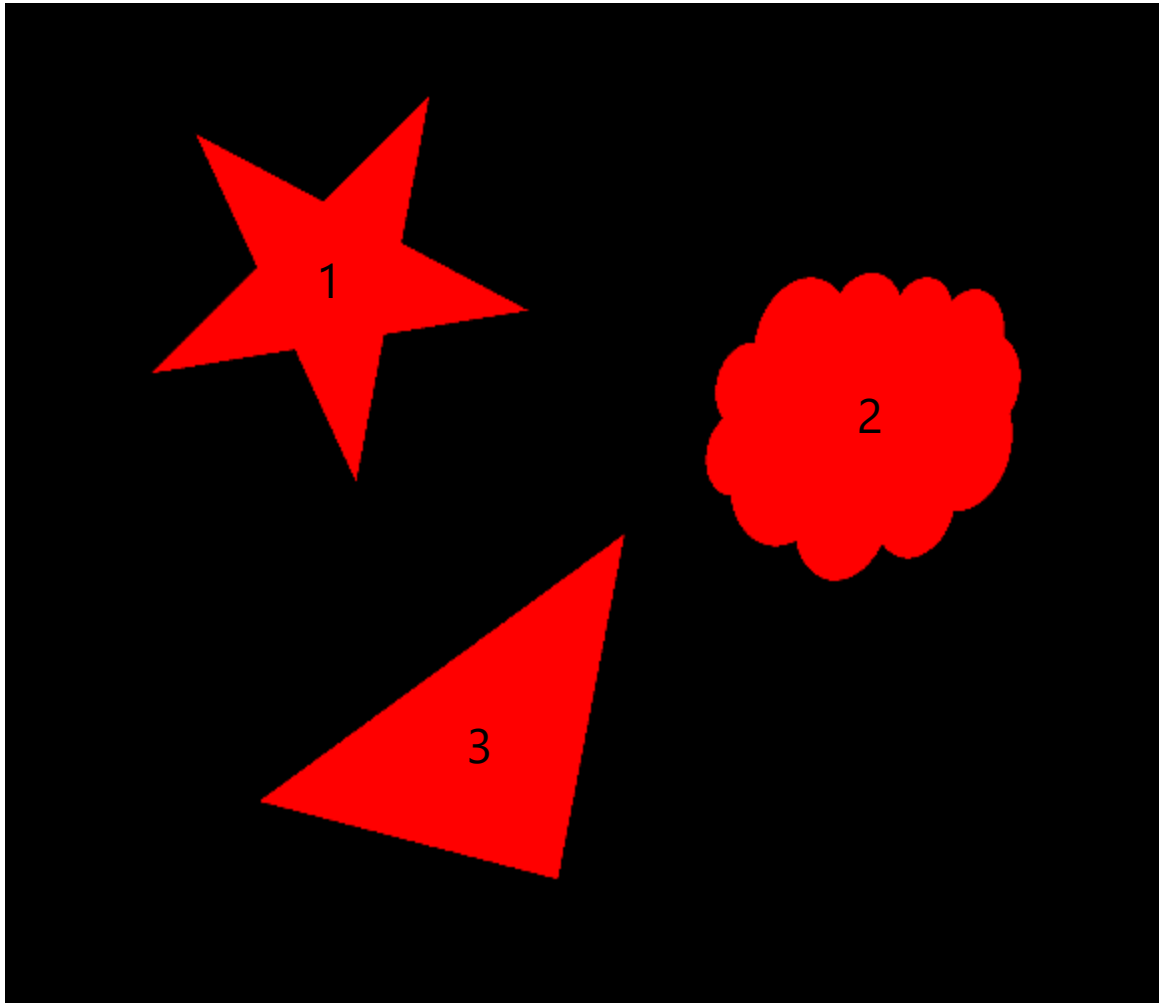
REGION PROPERTIES - AREA

Area of the region, i.e. number of pixels of the region.

Region 1 - Area: 137110 [pixels]

Region 2 - Area: 214568 [pixels]

Region 3 - Area: 160950 [pixels]



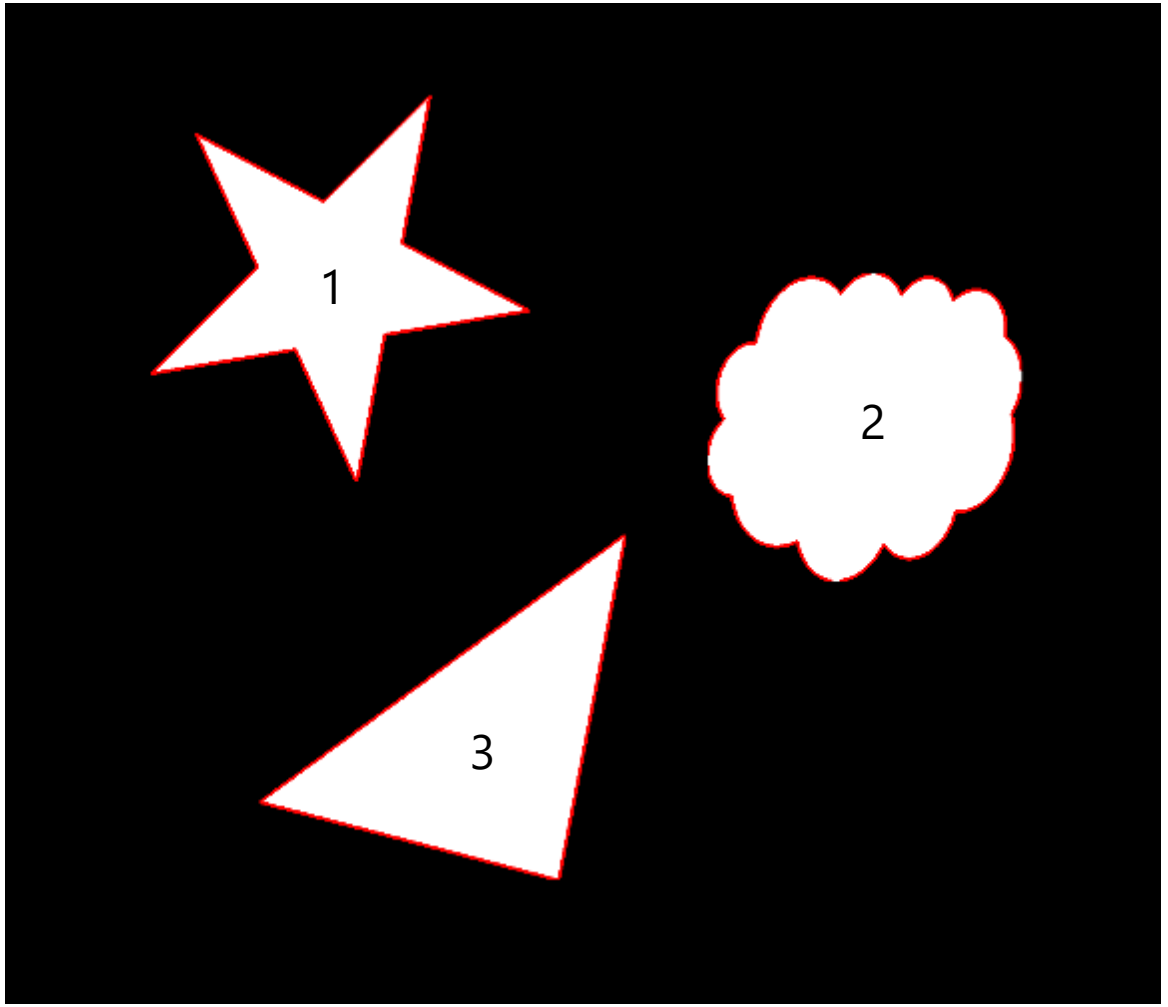
REGION PROPERTIES - PERIMETER

Perimeter in pixels of the object which approximates the contour as a line through the centres of border pixels.

Region 1 - Perimeter: 2658.5 [pixels]

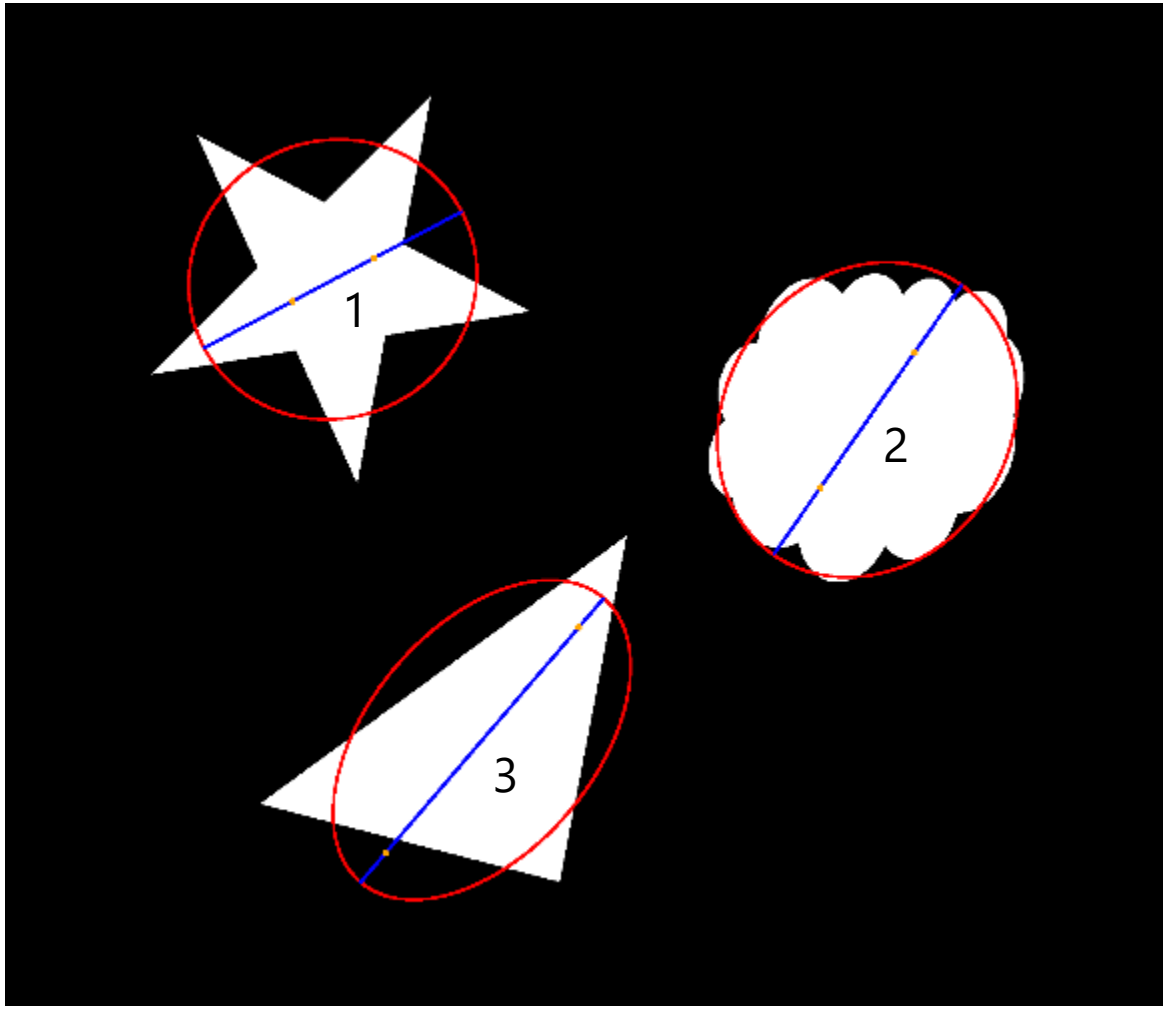
Region 2 - Perimeter: 1962.5 [pixels]

Region 3 - Perimeter: 2029.0 [pixels]



REGION PROPERTIES - ECCENTRICITY

Eccentricity of the ellipse that has the same second-moments as the region. The eccentricity is the ratio of the focal distance (distance between focal points) over the major axis length. The value is in the interval [0, 1). When it is 0, the ellipse becomes a circle.



Region 1 - Eccentricity: 0.31

Region 2 - Eccentricity: 0.49

Region 3 - Eccentricity: 0.79

REGION PROPERTIES - ORIENTATION

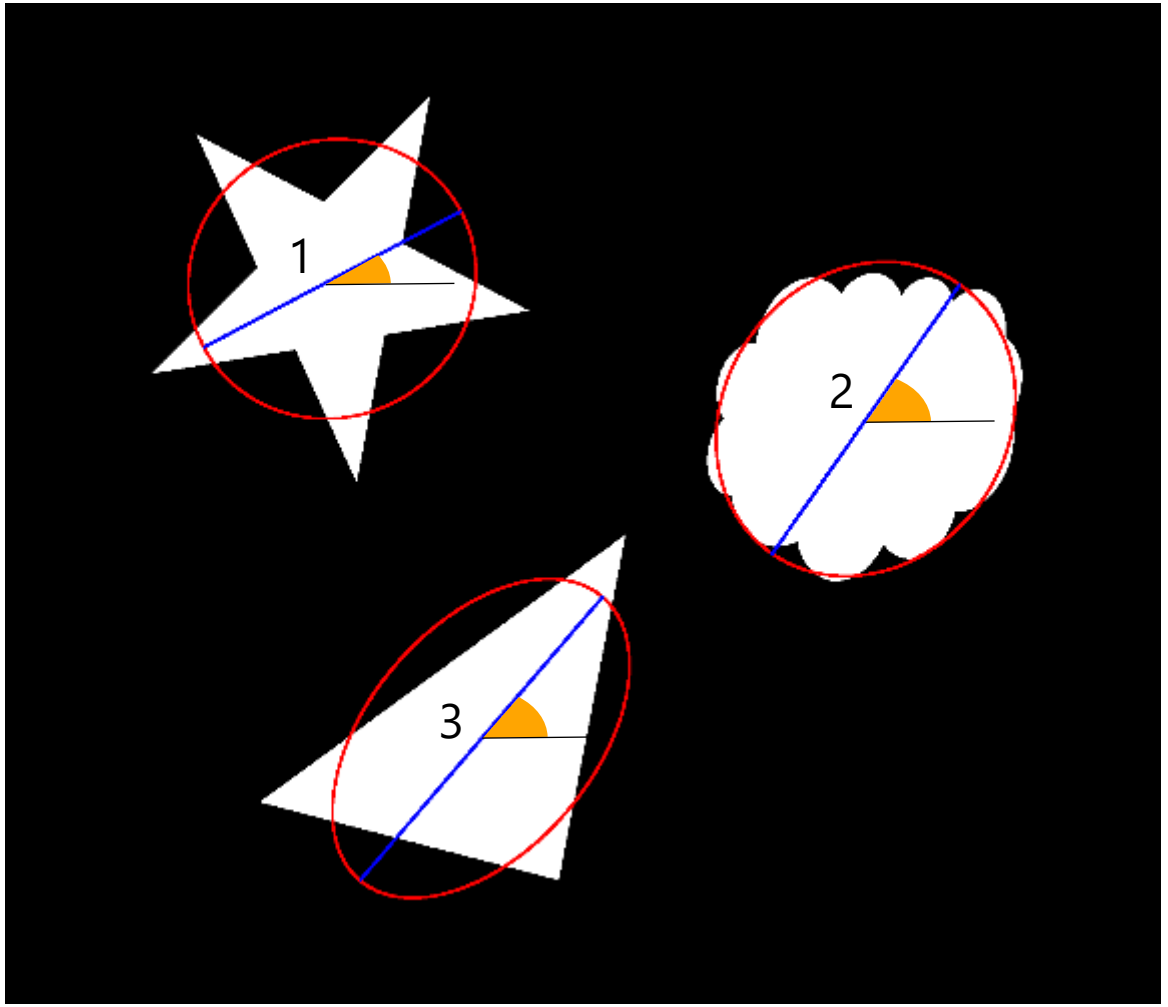
Angle between the 0th axis (rows) and the major axis of the ellipse that has the same second moments as the region, ranging from -pi/2 to pi/2 counter-clockwise.

Region 1 - Orientation: -0.48

Region 2 - Orientation: -0.96

Region 3 - Orientation: -0.86

Please note, the y-axis is inverted in images. The origin (0,0) is at the top-left corner, and the y-coordinates increase downwards as the rows of a matrix. This means that a counter-clockwise rotation with respect to the x-axis can appear as a clockwise rotation when viewed in the image, and vice versa.



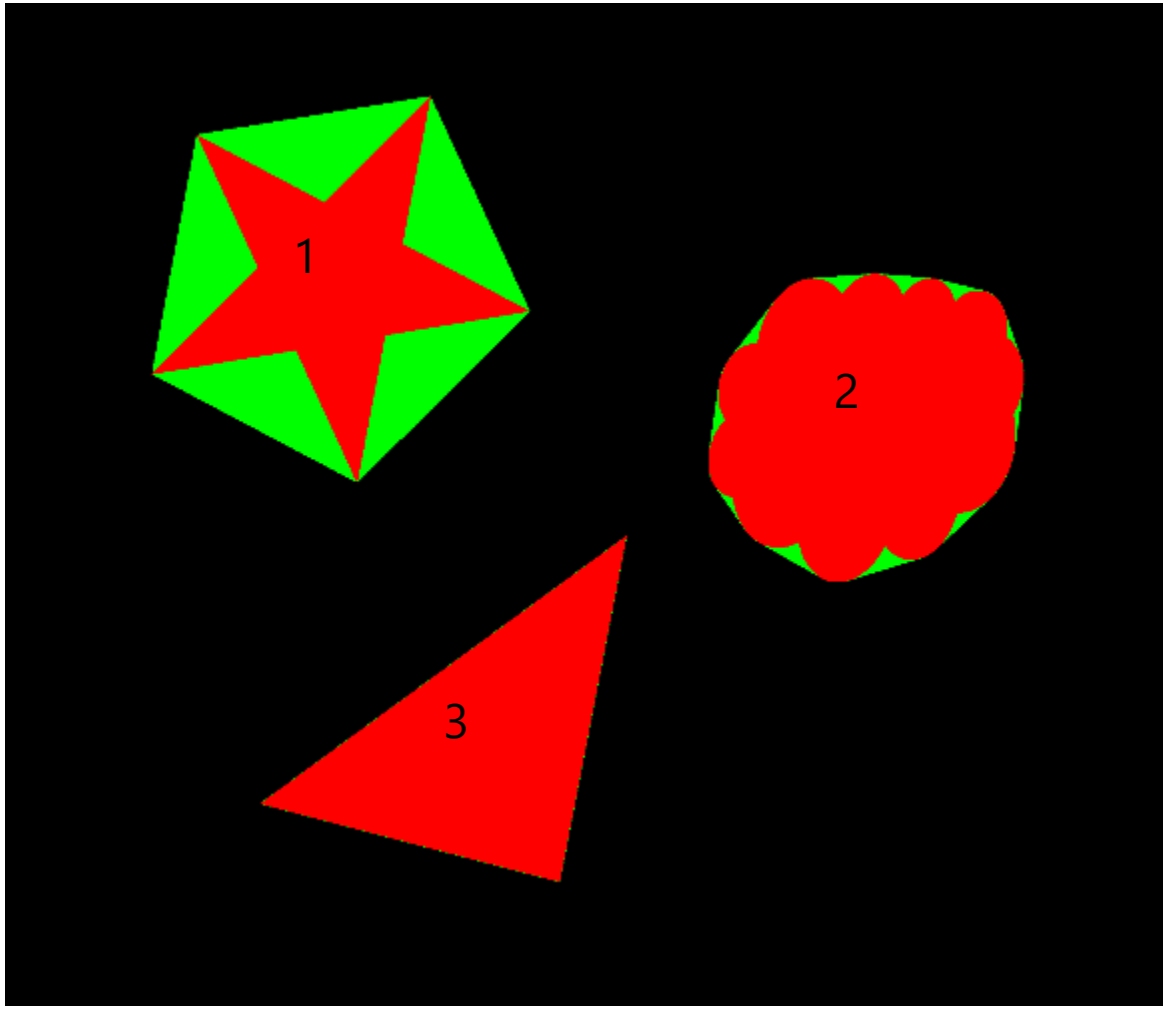
REGION PROPERTIES - SOLIDITY

Ratio of pixels in the region to pixels of the convex hull image.

Region 1 - Solidity: 0.47

Region 2 - Solidity: 0.96

Region 3 - Solidity: 0.99



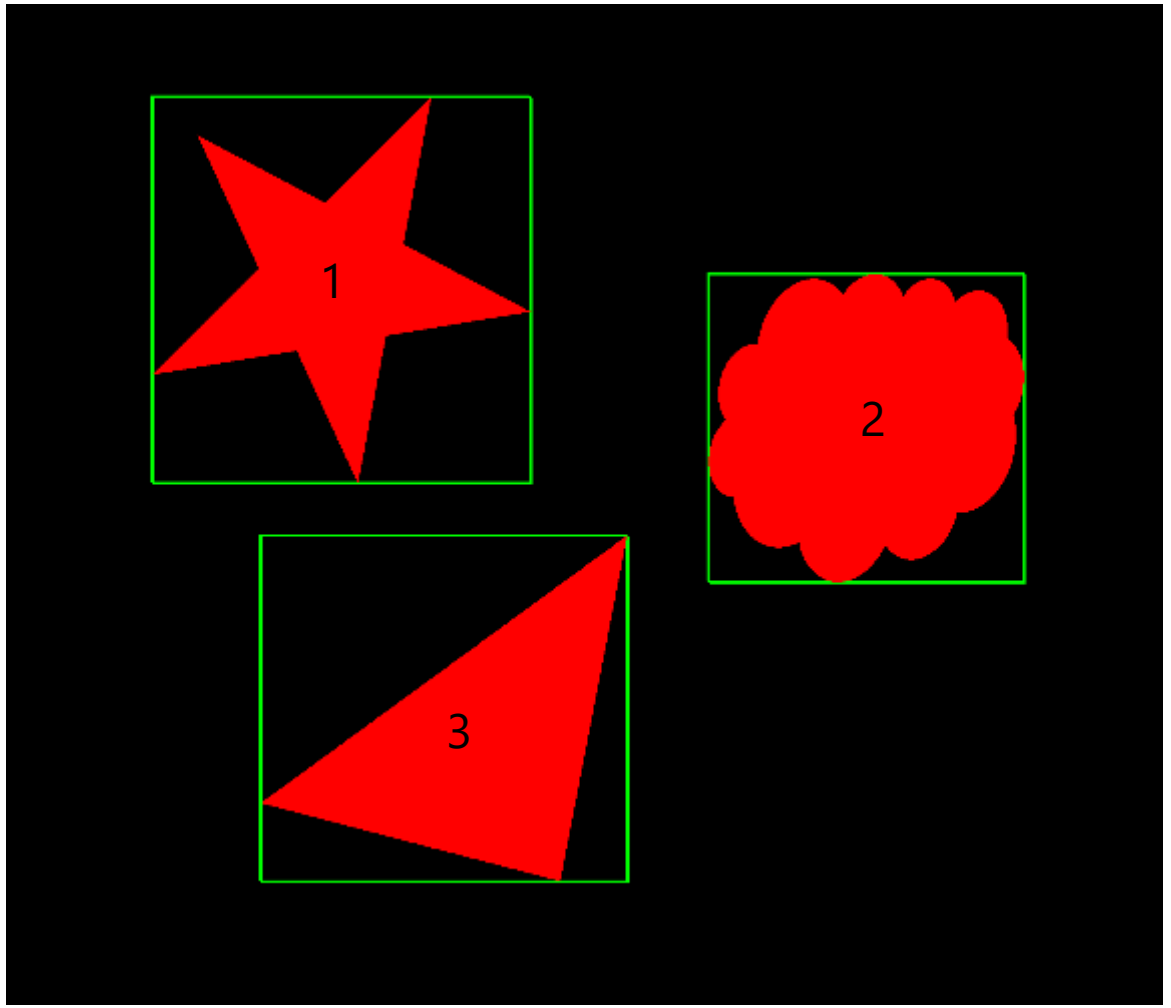
REGION PROPERTIES - EXTENT

Ratio of pixels in the region to pixels in the total bounding box.

Region 1 - Extent: 0.32

Region 2 - Extent: 0.75

Region 2 - Extent: 0.43



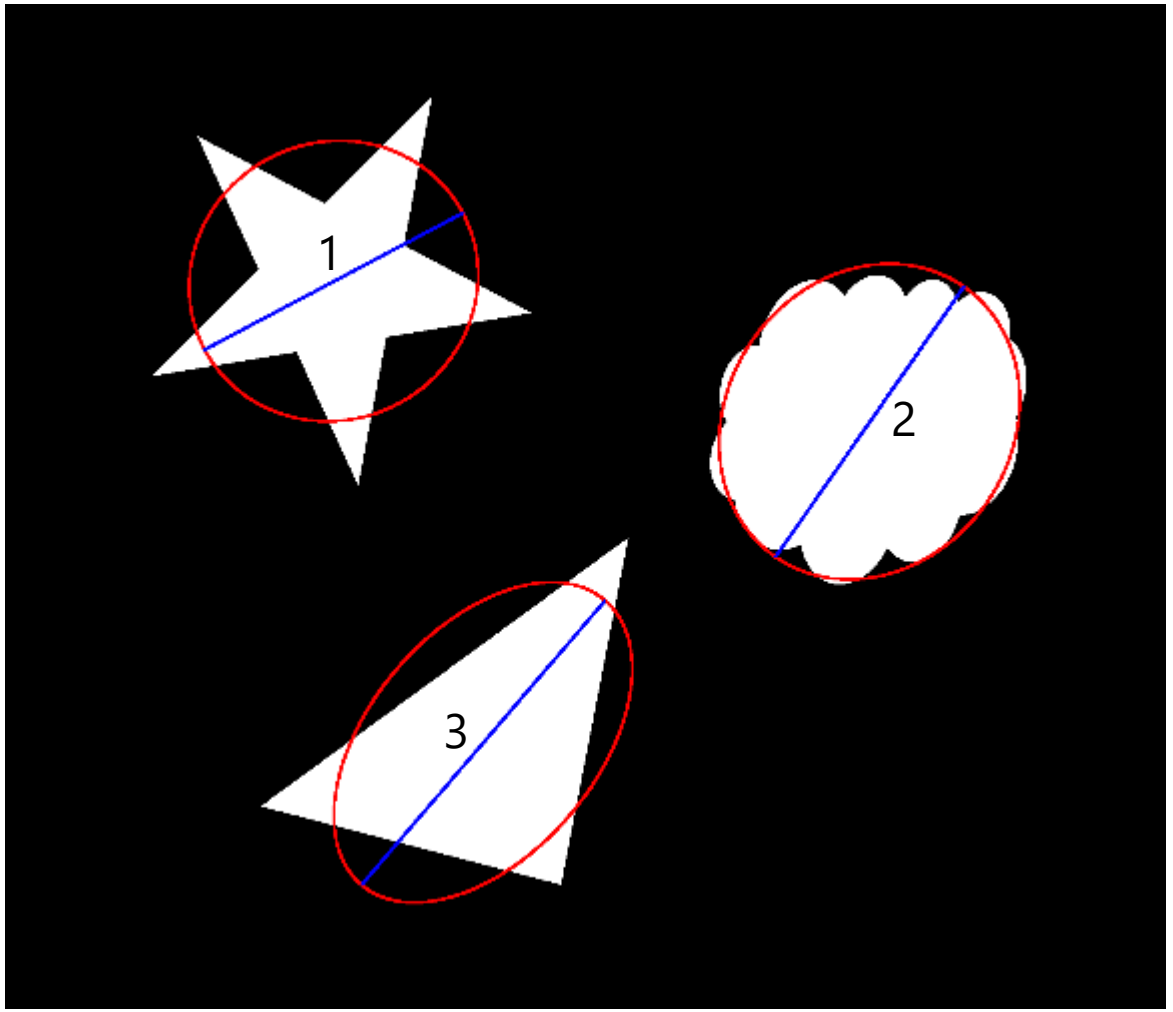
REGION PROPERTIES - MAJOR AXIS LENGTH

The length of the major axis of the ellipse that has the same normalized second central moments as the region.

Region 1 - Major axis length: 499.01 [pixels]

Region 2 - Major axis length: 563.94 [pixels]

Region 3 - Major axis length: 640.54 [pixels]



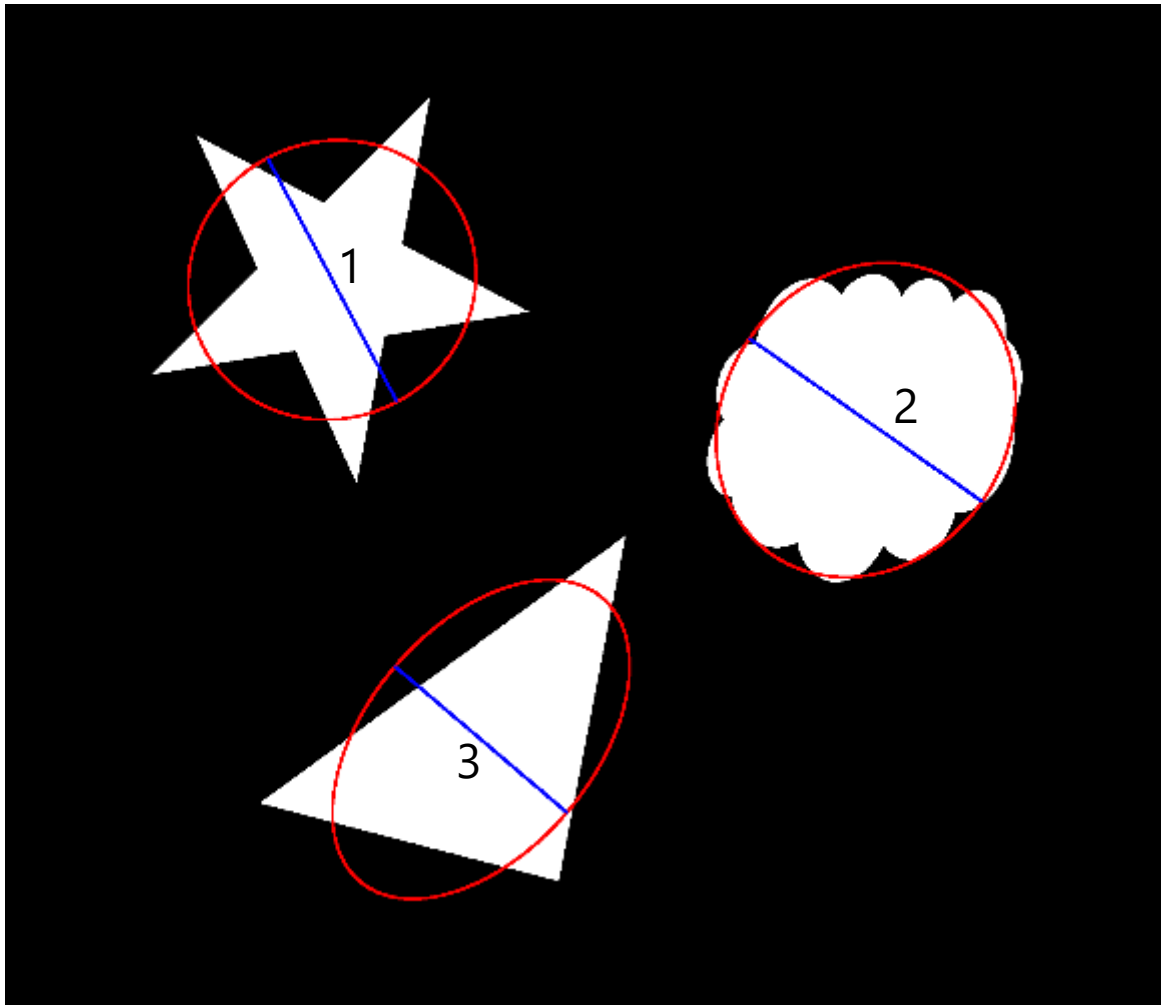
REGION PROPERTIES - MINOR AXIS LENGTH

The length of the minor axis of the ellipse that has the same normalized second central moments as the region.

Region 1 - Minor axis length: 474.80 [pixels]

Region 2 - Minor axis length: 488.80 [pixels]

Region 3 - Minor axis length: 386.87 [pixels]



REGION PROPERTIES - EQUIVALENT DIAMETER

The diameter of a circle with the same area as the region.

Region 1 - Equivalent diameter: 417.82 [pixels]

Region 2 - Equivalent diameter: 522.68 [pixels]

Region 3 - Equivalent diameter: 452.69 [pixels]

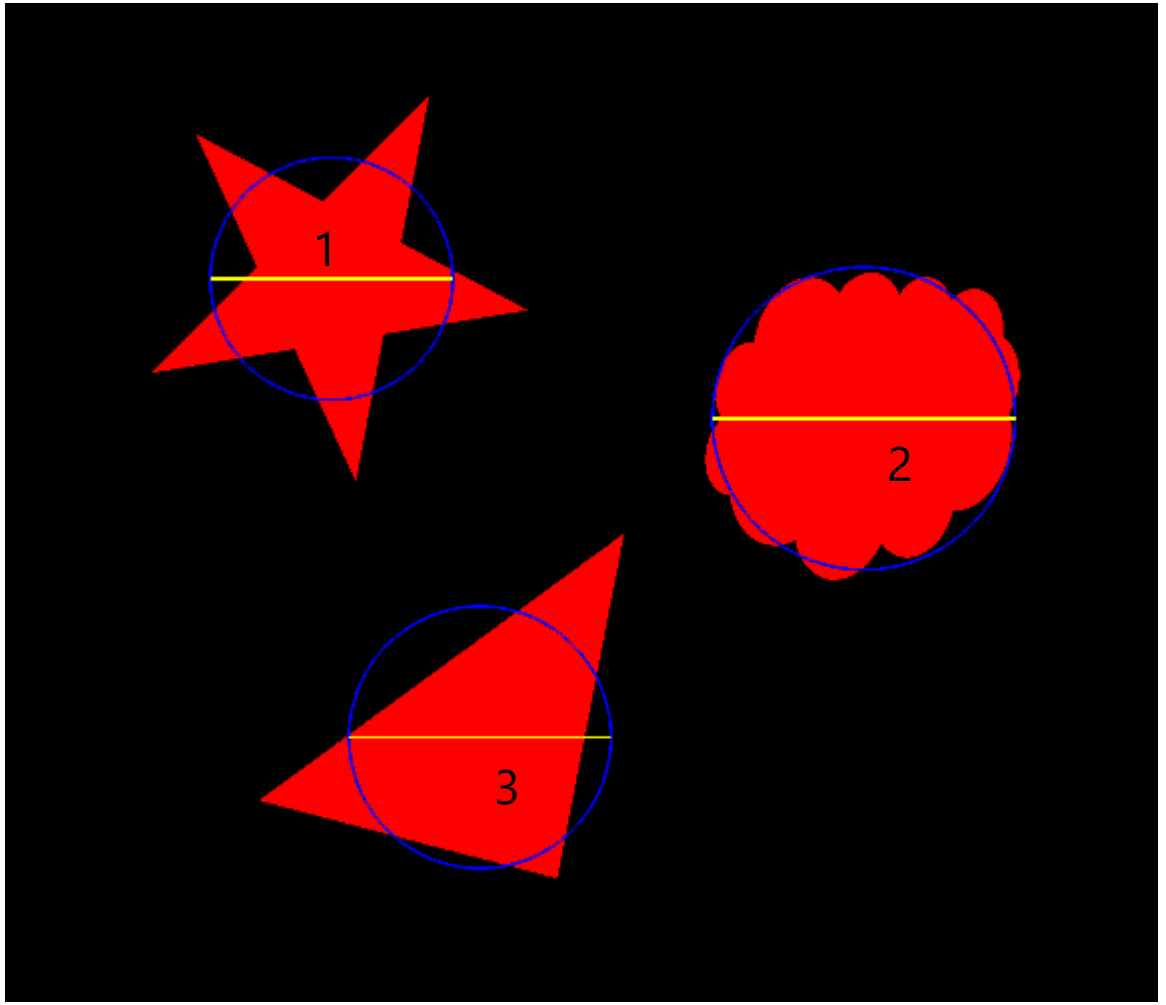


Image analysis and data extraction

Quality Data Analysis

IMAGE ANALYSIS FUNCTION

You have been provided with a simple script `image_analysis_function.py` to perform basic image analysis on the project dataset and extract the statistics with the region properties.

In the following slides, the main steps and the outputs of the function are outlined.

As you gain more confidence with the code, feel free to modify the script as you wish to extract other data.

IMAGE ANALYSIS FUNCTION

Input: Raw image

IMAGE ANALYSIS FUNCTION

Input: Raw image

Data extraction steps

1. Splitting

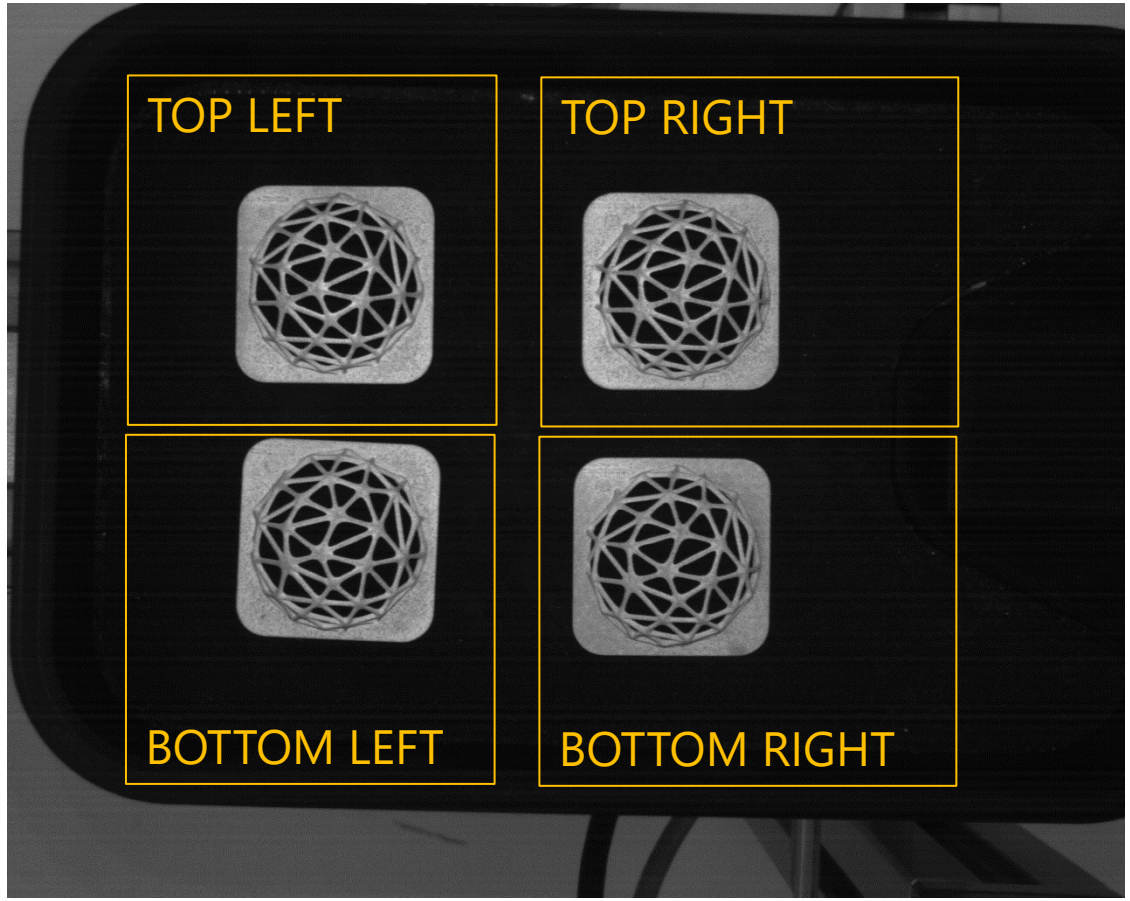
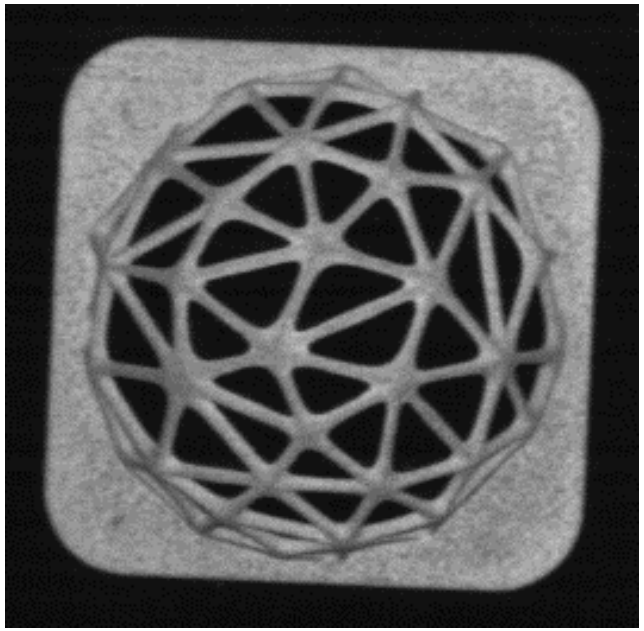


IMAGE ANALYSIS FUNCTION

Input: Raw image

Data extraction steps

1. Splitting
2. Part segmentation



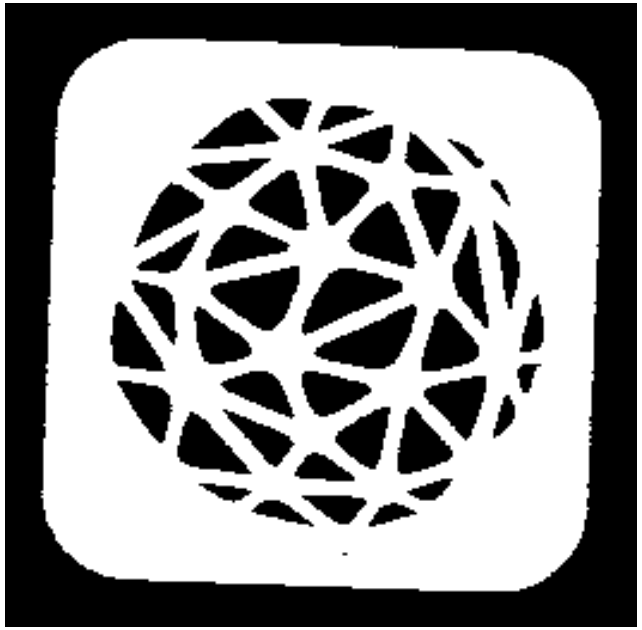
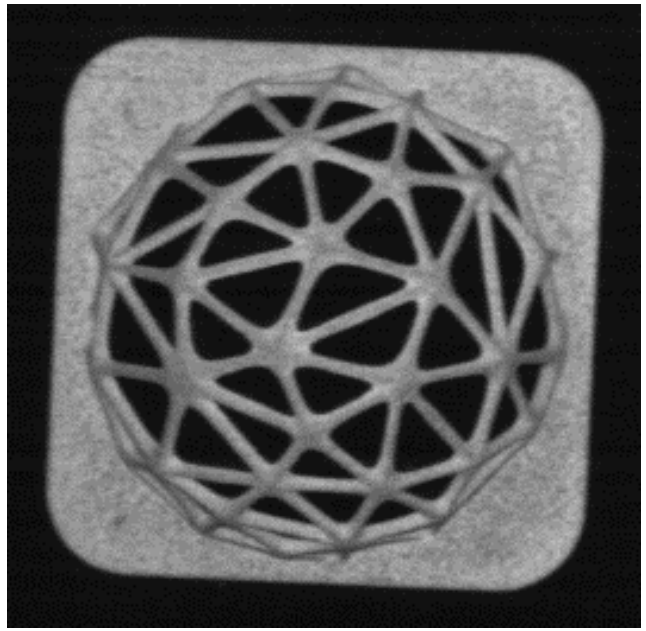


IMAGE ANALYSIS FUNCTION

Input: Raw image

Data extraction steps

1. Splitting
2. Part segmentation
3. Part data extraction



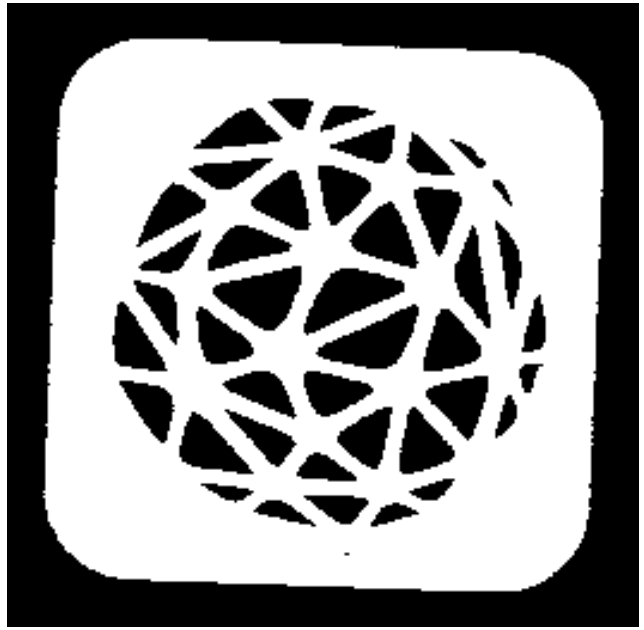


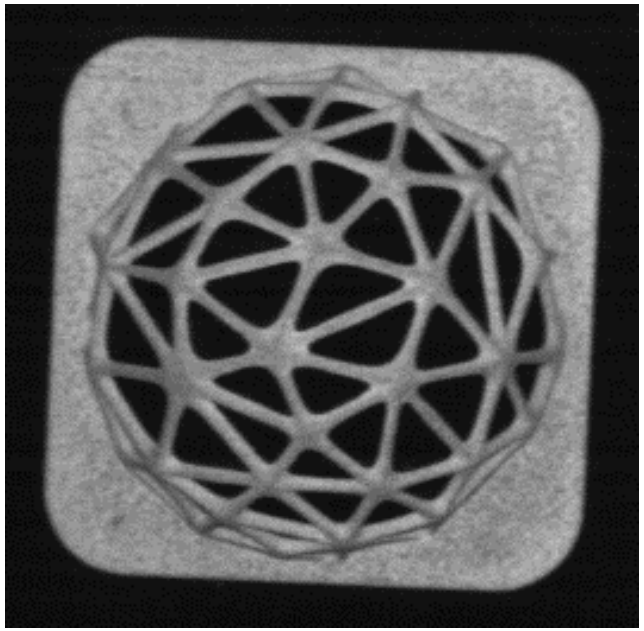
Image	Position	Region type	ID	Area [pixels]	Perimeter [pixels]	Eccentricity	Orientation [radians]	Solidity	Extent	Major Axis Length [pixels]	Minor Axis Length [pixels]	Equivalent Diameter [pixels]
img_name .bmp	bottom_left	Part	0	37452	546	0.767	0.894	0.821	0.	120	102	42

IMAGE ANALYSIS FUNCTION

Input: Raw image

Data extraction steps

1. Splitting
2. Part segmentation
3. Part data extraction
4. Voids segmentation



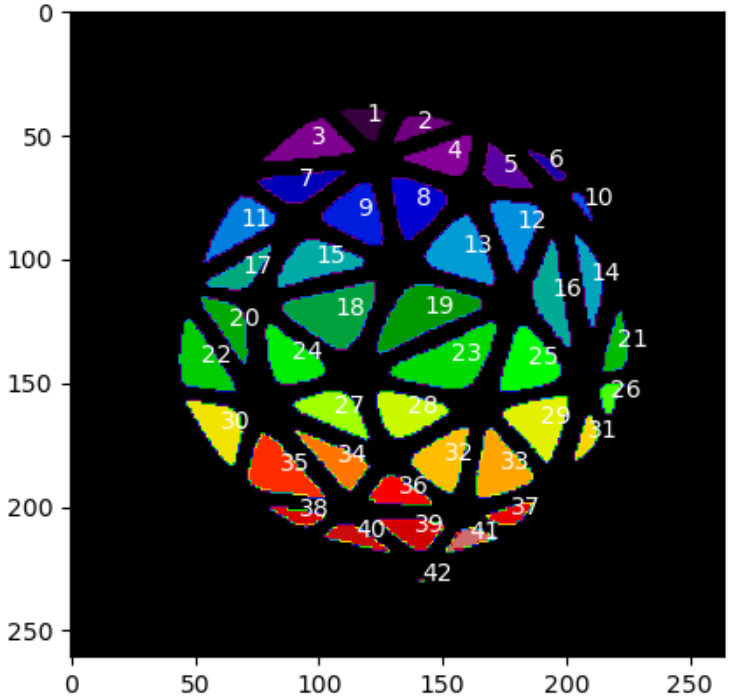
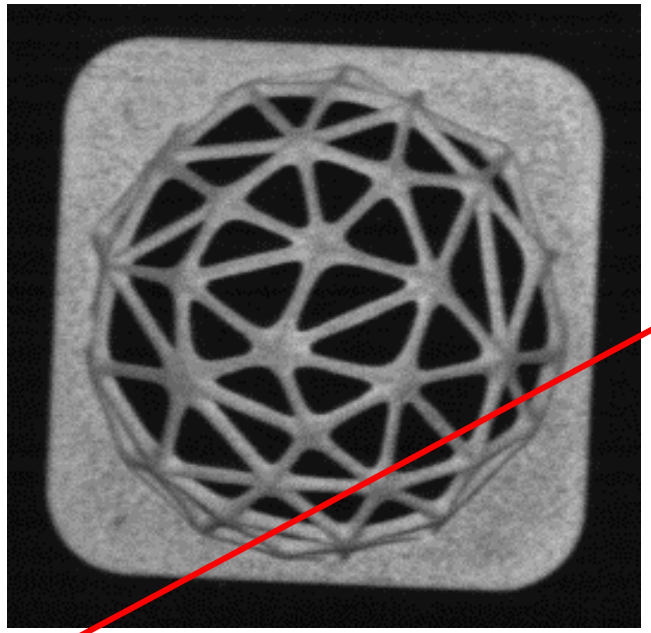


IMAGE ANALYSIS FUNCTION

Input: Raw image

Data extraction steps

1. Splitting
2. Part segmentation
3. Part data extraction
4. Voids segmentation
5. Voids data extraction



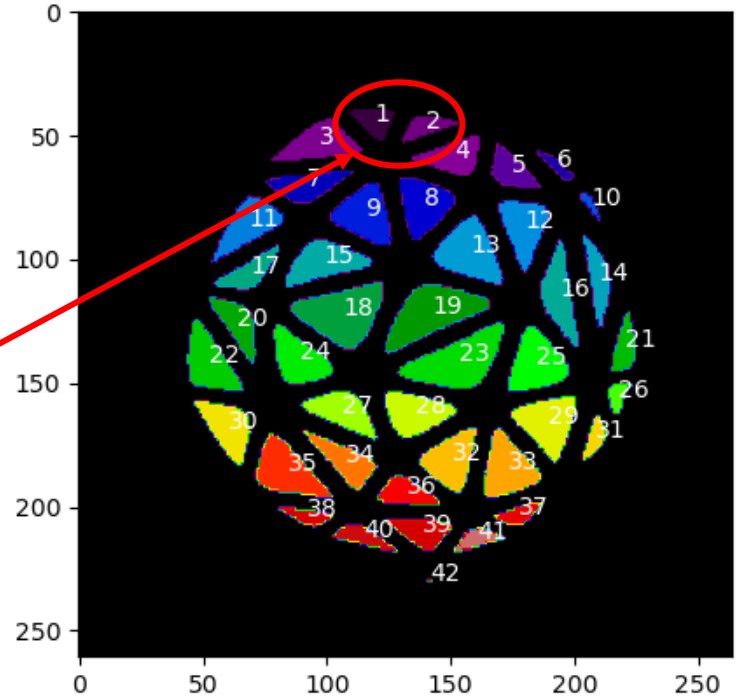
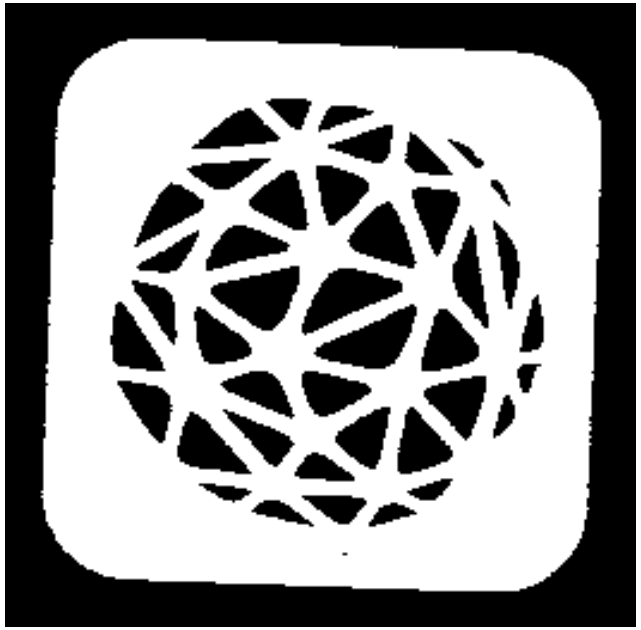
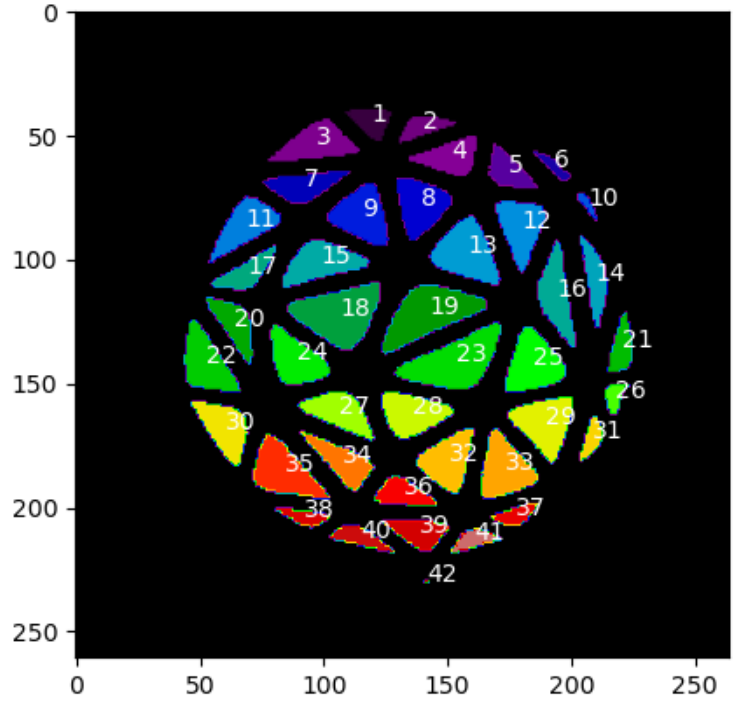


Image	Position	Region type	ID	Area [pixels]	Perimeter [pixels]	Eccentricity	Orientation [radians]	Solidity	Extent	Major Axis Length [pixels]	Minor Axis Length [pixels]	Equivalent Diameter [pixels]
img_name .bmp	bottom_left	Void	1	593	56	0.767	0.894	0.821	0.854	12	11	13
img_name .bmp	bottom_left	Void	2	821	32	0.568	0.546	0.542	0.765	13	10	19

IMAGE ANALYSIS FUNCTION





Output

- Segmented regions of interest.
- CSV table with the parts and voids-related data extracted from all the images.

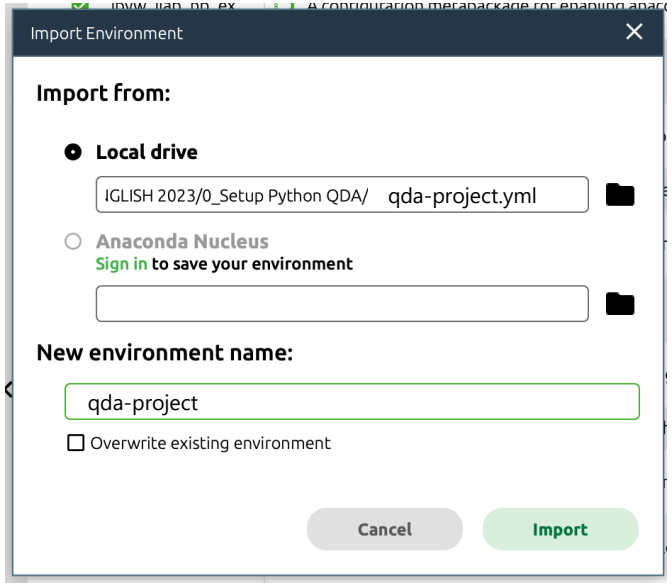
Image name	Position	Region type	ID	Area [pixels	Perimeter [	Eccentricit	Orientation	Solidity	Extent	Major Axis l	Minor Axis l	Equivalent
2024-03-26_09	top_left	part	0	37969	4153.992	0.13	-0.788	0.754	0.737	278.949	276.595	219.872
2024-03-26_09	top_left	void	1	94	38.349	0.766	-1.443	0.913	0.653	14.113	9.07	10.94
2024-03-26_09	top_left	void	2	97	47.556	0.94	-1.338	0.851	0.513	20.362	6.967	11.113
2024-03-26_09	top_left	void	3	220	74.148	0.951	-1.306	0.891	0.476	31.675	9.757	16.737
2024-03-26_09	top_left	void	4	201	63.799	0.89	-1.478	0.91	0.595	25.007	11.401	15.998
2024-03-26_09	top_left	void	5	158	55.698	0.889	0.974	0.935	0.494	22.149	10.16	14.184
2024-03-26_09	top_left	void	6	188	68.491	0.949	-1.339	0.9	0.505	29.076	9.152	15.472
2024-03-26_09	top_left	void	7	354	74.77	0.223	0.777	0.949	0.641	22.574	22.006	21.23
2024-03-26_09	top_left	void	8	377	79.598	0.522	1.125	0.942	0.604	25.004	21.334	21.909

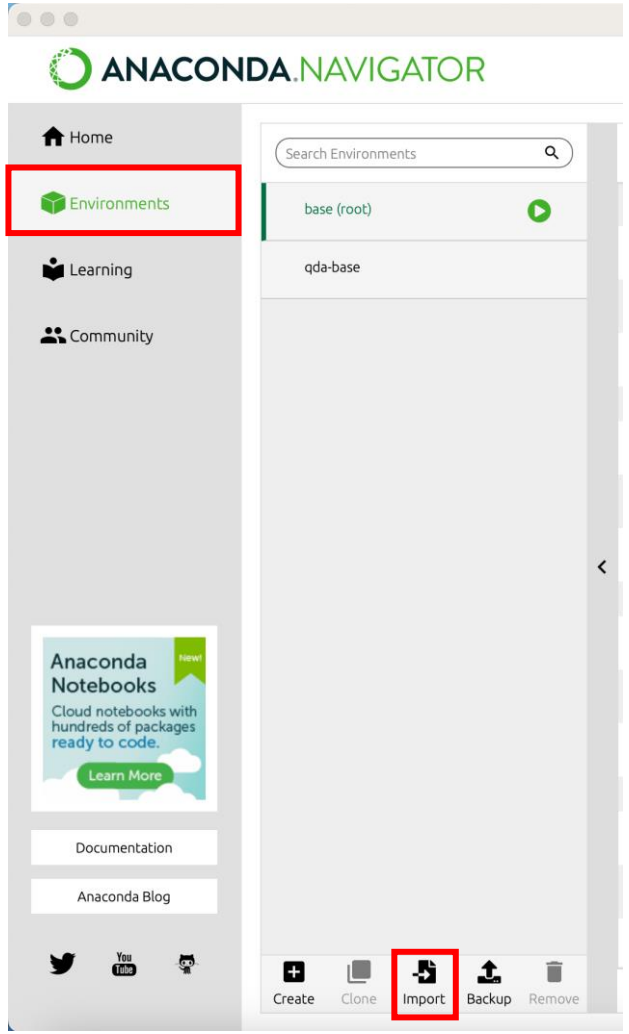
How to run image_analysis_function.py

Quality Data Analysis

PROJECT ENVIRONMENT SETUP

1. Open Anaconda Navigator
2. Go to *Environments* section
3. Press Import and load the `qda-project.yml` file for your platform (WIN or MAC).





4. Wait a few minutes until the environment finishes installing.

IMAGE ANALYSIS FUNCTION

The script requires you to input:

- the path to the folder with the original images (line 6)

```
# EDIT THE PATH OF THE FOLDER CONTAINING THE ORIGINAL IMAGES
folder_path = “path/to/original/images/folder"
```

- The path to the folder to store the output of the script (line 14)

```
# EDIT THE PATH OF THE FOLDER IN WHICH YOU WANT TO OUTPUT THE STATISTICS
output_folder = "path/to/output/folder"
```

IMAGE ANALYSIS FUNCTION

- Select the qda-project environment
- Run the script (click on the play icon)