Exercise 2

Image Preprocessing and Feature Extraction

September 28, 2025

Info

Learning objectives After completing the exercises, you should be able to:

- perform image resampling,
- perform noise reduction,
- perform edge detection,
- perform object segmentation,
- extract shape features from an image
- extract intensity/histogram features from an image
- extract texture features from an image

1 Data

- `lenna_original.png` - Original Lenna test image.
- `lenna_snp.png` - Lenna with salt and pepper noise.
- `lenna_gaussian.png` - Lenna with Gaussian noise.
- `rice.png` - grains of rice.
- `image_middle_slice.nii.gz` - CT image slice with lung tumor
- `mask_middle_slice.nii.gz` - lung tumor binary mask

(a) Original (b) Salt & pepper noise (c) Gaussian noise

Figure 1: Lenna test image.

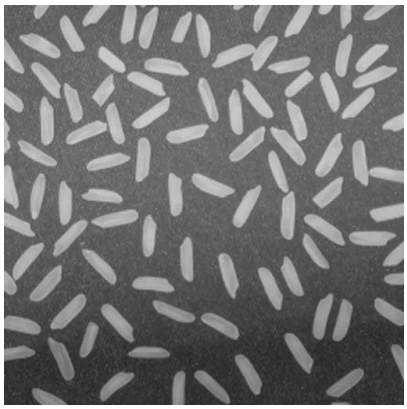

Figure 2: Grains of rice

(a) Image

(b) Tumor segmentation (binary mask)

Figure 3: Lung tumor on CT

2 Image processing

You can use any image of your choice. For image resampling and filtering you can write your own functions from scratch or use functions provided by 3rd party packages, e.g. SimpleITK.

Hint

Using 3rd party image processing libraries (e.g. SimpleITK) is allowed for tasks in this section.

2.1 Noise reduction

Load `lenna_original.png`, `lenna_snp.png`, and `lenna_gauss.png`. Perform noise reduction in all images using the following methods:

- mean (average) filter
- median filter
- Gaussian filter

Useful SimpleITK functions: `Convolution`, `Median`. Compare results. Which filter is the most effective for salt and pepper noise and why?

2.2 Edge detection

Perform edge detection in x and y directions using Sobel filter. You can use provided images or any image of your choice.

2.3 Intensity quantization

Transform `lenna_original.png` to grayscale. Next, perform quantization to 8 bins. Each bin should have the same width.

2.4 Segmentation

Perform segmentation of rice on image `rice.png`. The following operations (and more) might be useful:

- Thresholding
- Casting
- Histogram operations
- Conversion to grayscale
- Dilation
- Erosion
- Closing

3 Radiomic feature extraction

In this section, we are going to extract radiomic features from an image. We will be working on `image_middle_slice.nii.gz` and `mask_middle_slice.nii.gz`.

Warning

Using 3rd party libraries (e.g. pyradiomics, 3D Slicer, Z-Rad, etc.) is NOT allowed for feature extraction exercises.

3.1 Resampling

Resampling is a crucial preprocessing step before Resample both the image and the mask to an isotropic spacing of 1.0 mm in all directions. Use the B-spline interpolation method for the image, and the nearest-neighbor interpolation method for the mask.

Hint

Using 3rd party image processing libraries (e.g. SimpleITK) is allowed for resampling.

3.2 Shape feature

Extract area, perimeter, and roundness of the tumor. Use 2D shape feature definitions from the lecture.

3.3 Intensity/histogram feature

Extract one intensity-based feature from the ROI (e.g. mean, standard deviation, skewness). Use the feature definition from the lecture or IBSI I.

3.4 Texture feature

In this exercise we will extract a GLCM-based texture features. Before calculating the texture matrix we need to perform image quantization. Implement the following pipeline

1. Quantize the image. You can choose fixed bin number or fixed bin size discretization.
2. Calculate GLCM matrix in one direction
3. Extract at least one texture feature or your choice (e.g. contrast, entropy, correlation)

Use the feature definition from the lecture or IBSI I.

Warning

Do not use 3rd party libraries that calculate GLCM, but provide your own implementation.

Useful resources

- IBSI I: https://arxiv.org/pdf/1612.07003
- SimpleITK documentation: https://simpleitk.org/doxygen/v2_4/html/
- SimpleITK examples: https://insightsoftwareconsortium.github.io/SimpleITK-Notebooks/