# Biomedical Image Processing Assignment

You are provided with one slice from a cine cardiac magnetic resonance image acquired using steady state free precession sequences on a healthy subject. The CMR image is named **CMR_slice.mat**.

The image was acquired using a 1.5 T Philips scanner and has the following characteristics

- **Matrix size**: 181x181 pixels
- **Pixel spacing**: 0.7 mm x 0.7 mm
- **Slice orientation:** Short axis

Cine CMR images are usually retrospectively-gated and have intrinsically high contrast due to the relatively high T2:T1 ratio of blood compared to myocardium (see Fig 1).

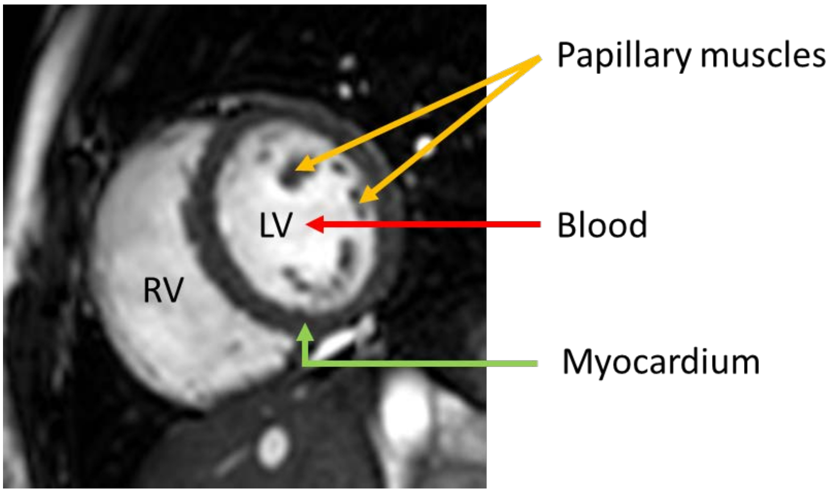


**Fig 1**: example of short axis CMR. LV: left ventricle. RV: right ventricle.

To the aim of quantify the area of the left ventricle blood section, you are requested to perform the following steps:

1. Load and display the original CMR image. **<u>Report this graph in the final report. Please save graphs with an adequate resolution and doublecheck it when saving in pdf format.</u>**

2. Illustrate magnitude and angle of the 2D Discrete Fourier Transform (DFT) of the image in a unique figure and using jet colormap. Shift the zero-frequency component to the center of the output. When plotting 2D DFT magnitude and phase in the spatial frequency domain, axes must always be expressed in spatial frequency units from now on. Specify axis marks and label. **<u>Report this graph in the final report.</u>**

3. The image is corrupted by noise, characterize the noise and provide a detailed description of its proprieties in both spatial and spatial frequency domains. **<u>Report this description in the final report below the graph generated at point two.</u>**

4. Reduce the noise through denoising operations in the frequency domain (correction step #1). Show the CMR image before and after correction #1 and the removed noise in both spatial and spatial frequency domain (2D DFT magnitude only). Display all images in a unique

figure. Axes must always be expressed in spatial or spatial frequency units. Describe the denoising approach used. **Report this description and the graph in the final report.**

5. Reduce any residual noise through denoising operations in the spatial domain (correction step #2). In the same figure, show the CMR image before and after correction #2 and the removed noise. Show the CMR image before and after correction #2 and the removed noise in both spatial and spatial frequency domain (2D DFT magnitude only). Display all images in a unique figure. Axes must always be expressed in spatial or spatial frequency units. Describe the denoising approach used. **Report this description and the graph in the final report.**

6. Maximize the image contrast by processing the histogram of the denoised image (after correction step #2) in order to maximize the difference between myocardium and blood. In the same figure, show the CMR image before and after the operation and the effect of the contrast enhancement and their corresponding histograms. **Report this graph in the final report.** Moreover, describe the type of histogram transformation you performed and calculate the CNR (expressed in the appropriate intensity units) before and after the transformation. **Report this description in the final report.**

   Hint #1: the CNR should be defined as

   $$CNR = \frac{\mu_B - \mu_M}{\sigma_M}$$

   Where, $\mu_B$ represents the average intensity of a region of interest (ROI) composed by blood pixels (green in Fig 2), $\mu_M$ and $\sigma_M$ represent the average and the standard deviation of myocardium ROI (yellow in Fig 2) pixels.

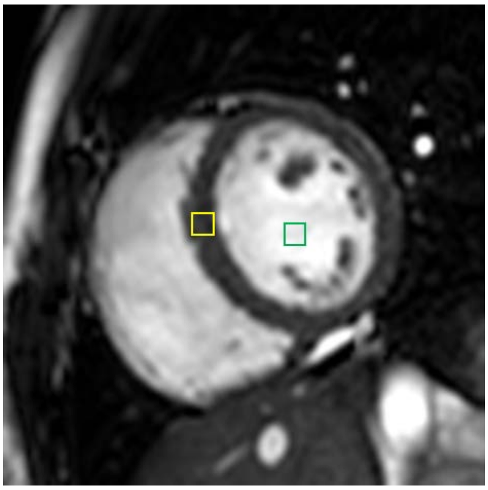

**Fig 2**: example of ROIs selected to calculate the CNR

7. Select a subregion in the restored image (61 x 61 matrix) including the left ventricle section. The coordinates of region of interest center are: $x_c$ = 74.2 mm, $y_c$ = 65.1 mm. Display the cropped image in one figure and its boundaries in the original image in a second figure. **Report these figures in the final report.**

8. Using automatic techniques, segment the blood in left ventricle section and display the obtained binary image. Provide a detailed description of the used technique. Calculate the

blood section area in $mm^2$. **Report segmentation technique description, blood section area and segmentation output in the final report.**

Hint #2: after the segmentation use the *bwlabel* function to isolate the left ventricle blood region in the binary image.

**9.** Using automatic techniques, identify the edge of the segmented region and show it superimposed to the other structures using the red color. Provide a detailed description of the used edge detection approach. **Report the obtained image as well as technique description in the final report.**