**Computational MR imaging**
**Laboratory 6: k-space parallel imaging**

Report is due on Wednesday before the next lab session at 23:50. Please upload your report on StudOn.

**Learning objectives**

- Reconstruct regularly undersampled data using the GRAPPA algorithm

1. **Prepare data:** Load the file data_brain_8coils.mat used from the previous lab5. Keys for the dataset are the same ('d': fully-sampled kspace [PE, RO, nCoil], 'c': coil sensitivity maps [PE, RO, nCoil], 'n': noise-only scan [RO, nCoil]).

2. **Implement GRAPPA reconstruction** as a class. The Python class GRAPPA receives fully-sampled kspace, the number of calibration lines, and the kernel size as initializing parameters. The Python class GRAPPA contains the following features:
    a. Undersample the kspace at the given acceleration factor $R \in [2,3,4]$.
        i. Keep the original shape of the kspace.
        ii. Fill zeros in every other R-1 lines (PE direction).
    b. Extract autocalibration signal (ACS) from the kspace.
    c. Extract the source and target matrix from ACS to calibrate the kernel.
    d. Interpolate missing points (zeros in the ksapce).

    (hint 1: to understand easier, start to implement with ACS lines of 24, the kernel size of 2x3 and R=2)

3. **GRAPPA reconstruction:**
    a. Reconstruct the 8-coil data with simulated $R \in [2,3,4]$ and different kernel size $\text{size}_{kernel} \in [(2 \times 3), (4 \times 5), (6 \times 7)]$ at 24 ACS lines. Compute RMSE with respect to the matched-filter combination of the fully-sampled kspace, and compare results with different parameter setups. What do you see over different Rs and kernel sizes? How does kernel size affect GRAPPA reconstruction? Why image quality, as well as RMSE, are different for different kernel sizes?
    b. Do the same experiment as (3.a) but different ACS lines, such as ~~36~~, ~~48~~, and 60. How can you interpret the results depending on different ACS lines? What is the trade-off for the ACS lines and filter sizes?
    c. Compare GRAPPA reconstructions to your SENSE results from lab4 at different Rs.

Normalise when measuring RMSE