Deep Learning and its Applications
MRI K-Space Sampling
Group-5

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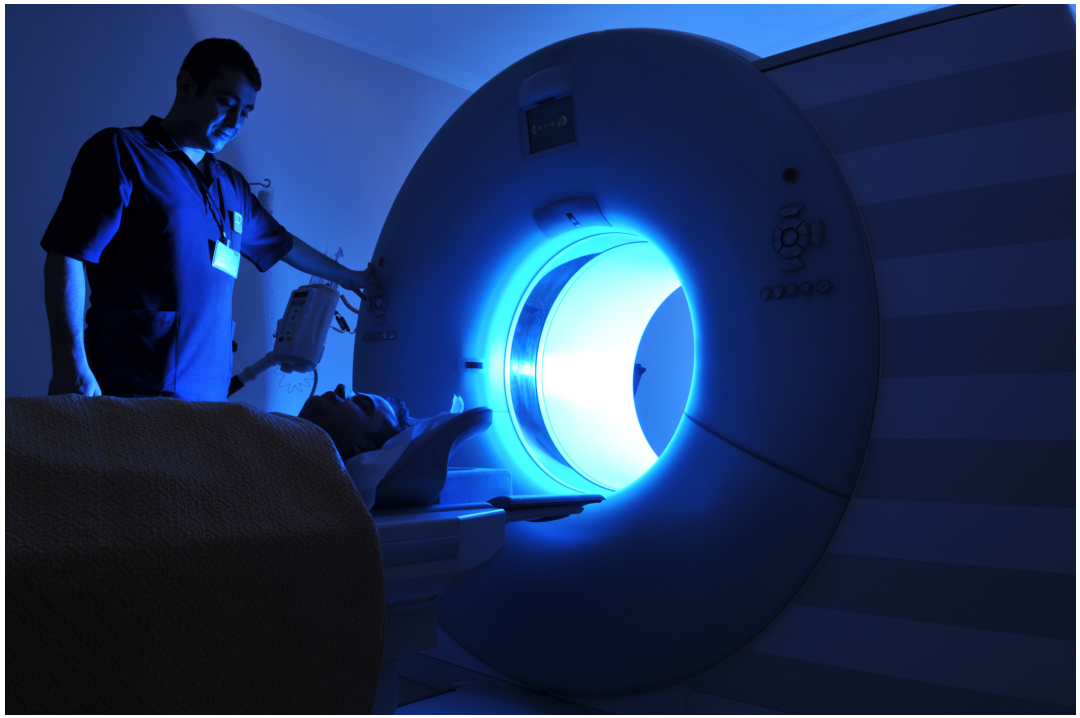
What is MRI scanning?

MRI is a non-invasive method of taking images of any part of the body. It has advantages over other scanning techniques as it provides better soft tissue contrast. It also doesn't involve any ionizing radiation.



Working principle

- Magnetic field is used to excite hydrogen atoms in the body, which get aligned in the applied magnetic field direction.
- Now we apply gradient magnetic field these magnetic field causes the atom to get rotated from their previous orientation.
- Now this gradient magnetic field is turned off this causes the atom to return back to their original state causing energy to be released.
- These energies are then sensed to generate frequencies corresponding to the energies.

Now we have got our K-Space data.

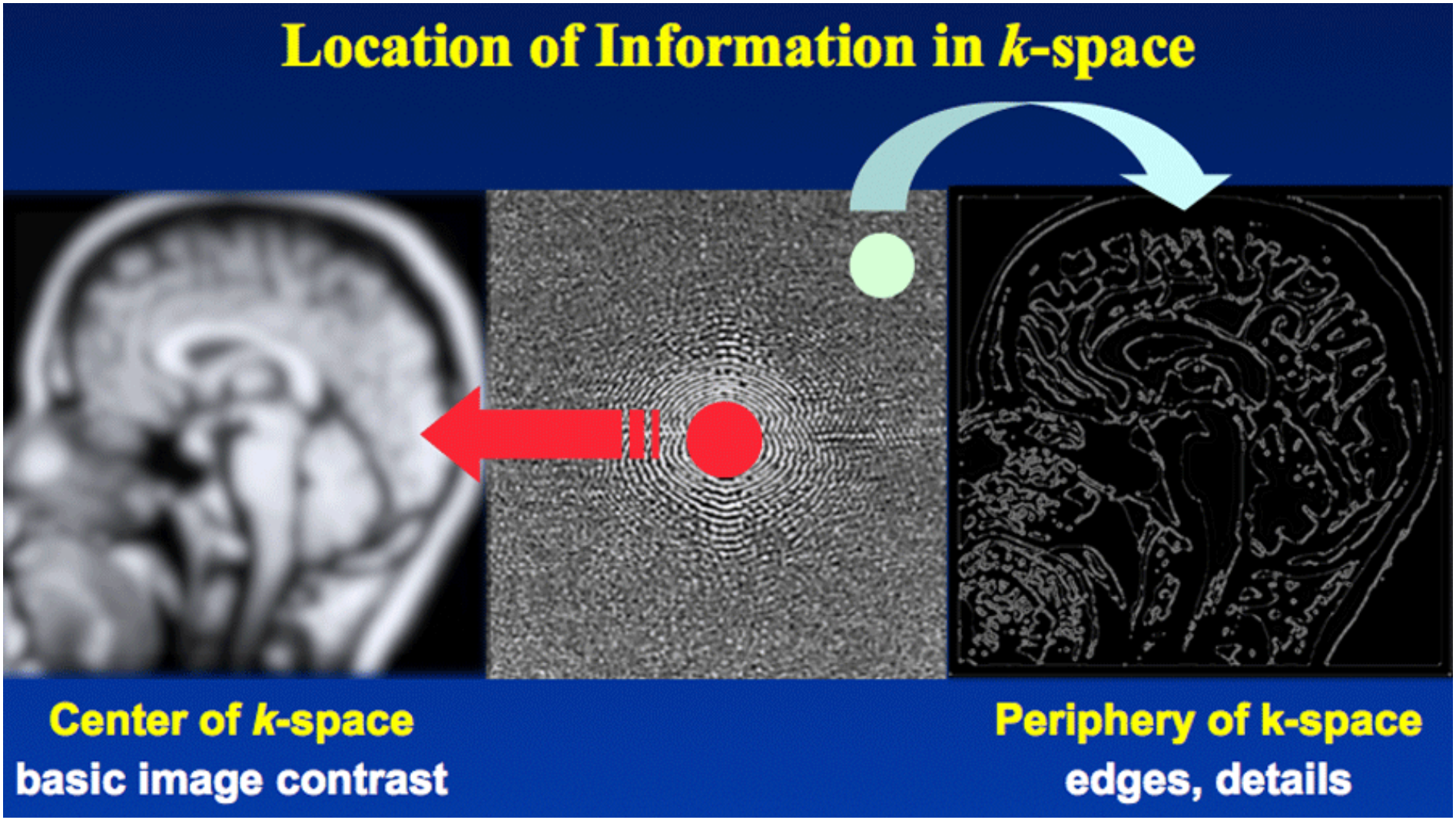
Need for MRI frequency Under Sampling

- Takes huge amount of time to extract all the frequencies.
- Although there are no known health issues caused due to staying for long time in MRI scanner, it causes patient a great deal of discomfort.
- Staying for long time in MRI causes movement artifacts resulting in non clear MRI image.

  Due to the problems stated above it would be very helpful for both patients and doctors if time taken for MRI scan is reduced. In order to reduce the time we have to reduce the number of frequencies we are extracting i.e MRI frequency under sampling.

Challenges

- When we under sample data in k-space it will result in aliasing in image domain.
- If we only select from low frequencies it will give image with average features.
- On the other hand if we take only high frequencies it will give only edges.
- So its required to select frequencies randomly which would be able to produce best image possible.
- The other challenge lies in back propagation in the network.
- We get our loss in image domain which should be back propagated through network in k-space. It is being expected that network would learn this transition in domain for now.


Location of Information in k-space
Center of k-space
basic image contrast
Periphery of k-space
edges, details

Tentative architecture

- The architecture will be a CNN
- The network will be forced to generate a sparse representation(binary values) of our input K-Space Matrix.
- The generated sparse matrix will then be mapped to our input K-Space.
- Now our data has just those frequencies through which the reconstruction is the best.
- The loss function chosen here will take into account the the difference in the inverse Fourier transform of our sparse matrix and the image reconstructed and also the sparsity of the matrix generated. This will force my network to learn to select best frequency with the best possible sparse representation.

Future Goals

- An extension of this network can be designed which learns how to convert under sampled frequencies to best quality image possible.