Reconstruction of MRI

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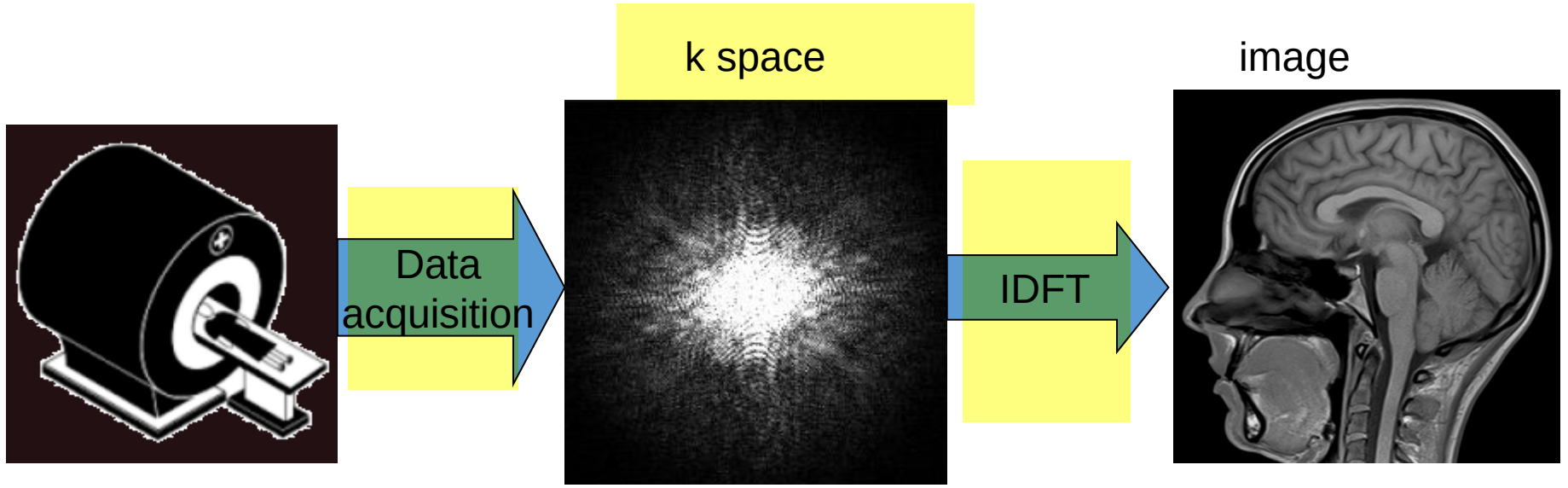
Introduction

- Magnetic Resonance Imaging (MRI) is a fascinating imaging technology for capturing image to visualize inside of the human body.
- Painless and non-invasive procedure.
- MRI does not use any ionizing radiation.

Introduction

- MRI Principle



Introduction

- CT Principle

Data acquisition

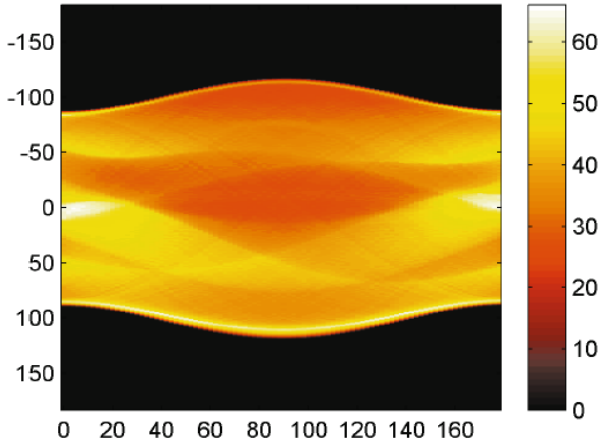


Figure 8-18: Radon Transform of Head Phantom Using 90 Projections

MRI

- Inherent slow data collection
  - Limits spatial resolution
  - Limits temporal resolution
  - Introduces artifacts in image
- Moreover, slow acquisition is uncomfortable for patients, especially-
  - Who are anxious
  - Who can not keep still or motionless
  - Who have limited breath-hold capacity, and
  - Who are uncooperative such as children

CT

- Radiation Exposure
- Harm to unborn babies
- Reactions to contrast material

Motivation: CT

- Acquisition of projections with low dose radiation is a challenge
- Possible solution
  - Reduces number of projections and apply iterative algorithm to reconstruct

Motivation: MRI

- Acquisition of k-space data within reasonable time is a challenge
- Possible solution
  - Enables faster acquisition by reducing sampling data
- These challenges can be solved using compressed sampling

Compressed Sampling

- Compressed Sampling in MRI, while reducing acquisition time, enables high subsampling factors maintaining diagnosable image quality.

- This technique changes the goal based on three golden rules:
  1. Incoherent sub-sampling
  2. Transform sparsity
  3. Non-linear iterative reconstruction technique

Compressed Sampling

	Nyquist's Sampling	**Compressed Sampling**
Sampling Frequency		
Reconstruction	Low pass filter	Non-linear reconstruction

Non-linear Iterative Reconstruction

- Basic formulation of CS technique:

$$y = \Phi_c x + b$$

- Objective function:

$$\mathrm{J(x)} = \frac{1}{2}\|\Phi_c \Psi x - y\|_2 + \tau\|\Psi x\|_1$$

  - $\Phi_c \Psi x$ generates low coherence

- Our goal is to achieve and optimal balance of data consistency and sparsity

Non-linear Iterative Reconstruction

- Iterative Algorithm
- Denoising/ regularization based algorithm
- Wavelet domain regularised based algorithm
- Deep Learning based algorithm

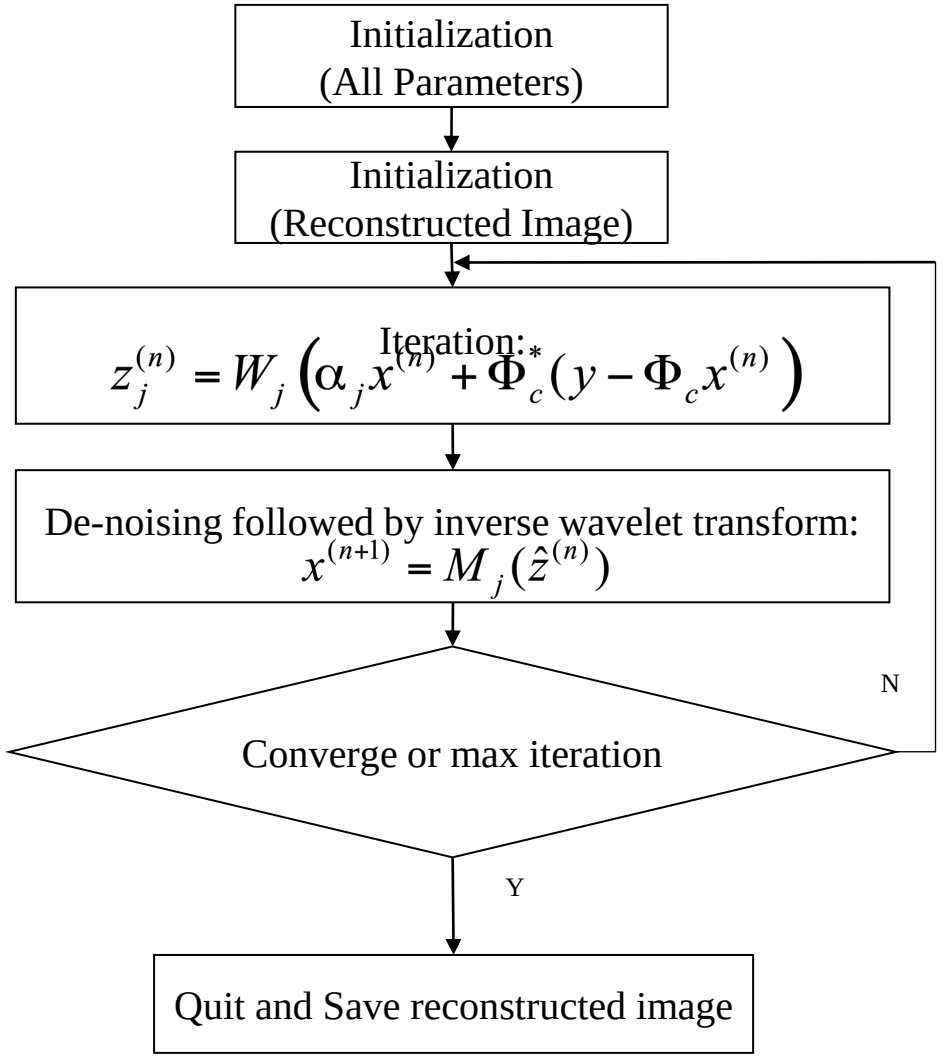
Algorithm

- Initialization: Reconstructed Image (x0), Other parameters
- Start: Loop
- Update Image: $$z_j^{(n)} = W_j\left(\alpha_j x^{(n)} + \Phi_c^*(y - \Phi_c x^{(n)}\right)$$
- Perform de-noising: $$x^{(n+1)} = M_j(\hat{z}^{(n)})$$
- End: Loop

Denoising Algorithm

- Total Variation
- Soft-thresholding
- Gaussian Mixture Model

Algorithm Flowchart



Thank you

Any Questions?