Magnetic Resonance Imaging

6.003

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MRI is a Fourier Transform

\[ s(t) = \int \int m(x, y) e^{-i 2\pi (k_x x + k_y y) t} dx \, dy \]

\[ M(k_x, k_y) \rightarrow m(x, y) \]

MRI is a Fourier Transform

\[ s(t) = \int \int m(x, y) e^{-i 2\pi (k_x x + k_y y) t} dx \, dy \]

where

\[ k_x(t) = \frac{\gamma}{2\pi} \int_0^t G_x(t') dt' \]

\[ k_y(t) = \frac{\gamma}{2\pi} \int_0^t G_y(t') dt' \]

Single-channel Data Acquisition

Multi-channel Receive Array

Undersampling MRI Data in a Multi-Channel Receive Array
The k-space corresponding to each coil-weighted image, 1-32.

Coil profiles, $c_i(x, y)$, $i = 1, 2, ..., 32$

Or, "Coil sensitivities", "coil maps"
And then, what can we do?

We have data with four-fold aliasing, observed with each of the 32 receive coils.

Objective: Reconstruct unaliased object from a four-times faster acquisition.

\[
S(k_x, k_y) \cdot F_{2D}(c_1(x, y) \cdot m(x, y)) = M_1(k_x, k_y)
\]

Measured k-space data for coil #1

\[
S(k_x, k_y) \cdot F_{2D}(c_2(x, y) \cdot m(x, y)) = M_2(k_x, k_y)
\]

Measured k-space data for coil #2

\[
\vdots
\]

\[
S(k_x, k_y) \cdot F_{2D}(c_{32}(x, y) \cdot m(x, y)) = M_{32}(k_x, k_y)
\]

Measured k-space data for coil #32

\[
c_1(x, y) \cdot m(x, y)
\]

Image-domain, coil #1-weighted \(m(x, y)\)

\[
F_{2D}(c_1(x, y) \cdot m(x, y))
\]

k-space, fully sampled for coil #1-weighted \(m(x, y)\)

Sampling mask, \(S(k_x, k_y)\)

\[
S(k_x, k_y) \cdot F_{2D}(c_1(x, y) \cdot m(x, y))
\]

k-space, undersampled for coil #1-weighted \(m(x, y)\)

\[
S(k_x, k_y) \cdot F_{2D}(c_1(x, y) \cdot m(x, y)) = M_1(k_x, k_y)
\]

Measured k-space data for coil #1

Parallel Imaging Reconstruction Acceleration R=4, with 32 coils

Ground truth, image from fully-sampled k-space

Difference x10

Ground truth, image from fully-sampled k-space

Undersampled k-space
Lab: Coil profiles and parallel imaging

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