Bioengineering 208
Magnetic Resonance Imaging

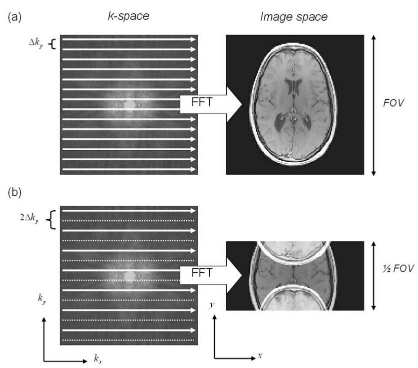
Winter 2008
Lecture 6

- Parallel Imaging
  - Coil Arrays
  - PILS
  - SENSE
  - SMASH
  - GRAPPA

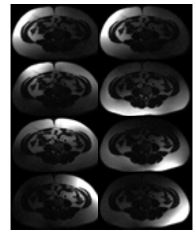
Reasons to image FAST

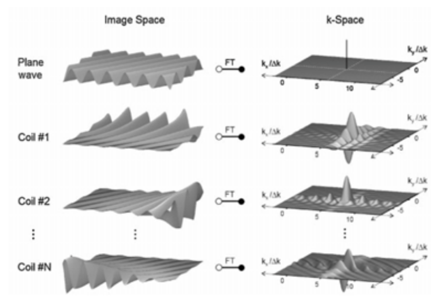
- Physiological motion (cardiac, respiratory, subject)
- Patient throughput ($$$)
- Imaging of moving objects
  - Cardiac
  - Interventional
  - Real-Time (ie joint kinetics)
- Dynamic processes
  - CE MRA - bolus of T_1 shortening agent is short lived
  - GD bolus perfusion
  - fMRI
- Slow scans
  - 3D
  - T_2 or PD Weighted (Long TR)
- Long data acquisition window
  - Reduce T2 and T2* distortion and blurring in EPI/spiral/SSFSE
  - Reduce off-resonance effects in EPI/spiral

Parallel Imaging



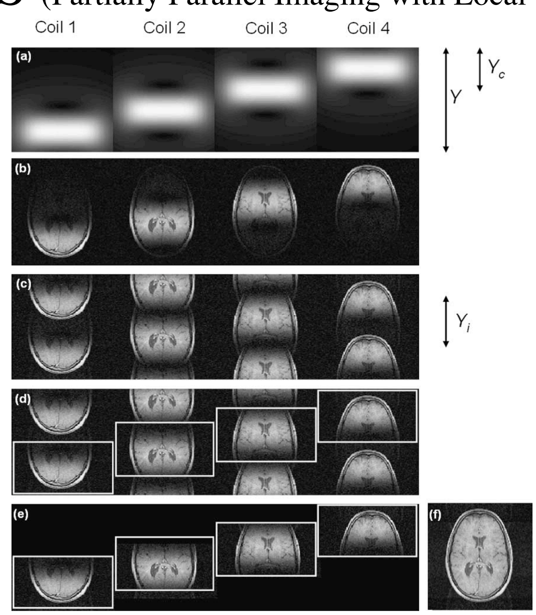
Blaimer et al, Top Magn Reson Imaging 2004;15:223–236





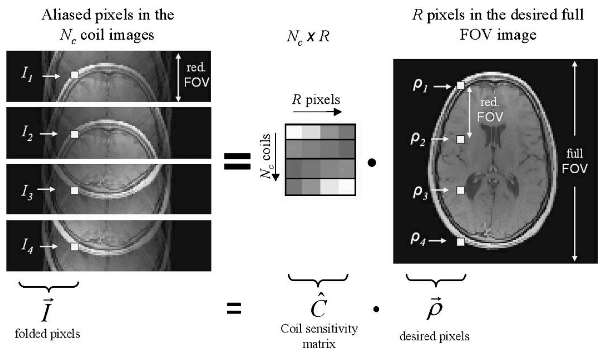
$$S_j(k_x, k_y) = \iint C_j(x, y)\rho(x, y)\exp(-ik_x x)\exp(-ik_y y)\,dx\,dy$$

PILS (Partially Parallel Imaging with Local Sensitivities)



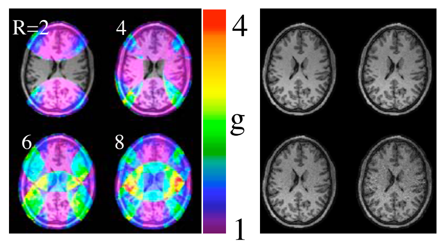
Blaimer et al, Top Magn Reson Imaging 2004;15:223–236

SENSE (Sensitivity Encoding)



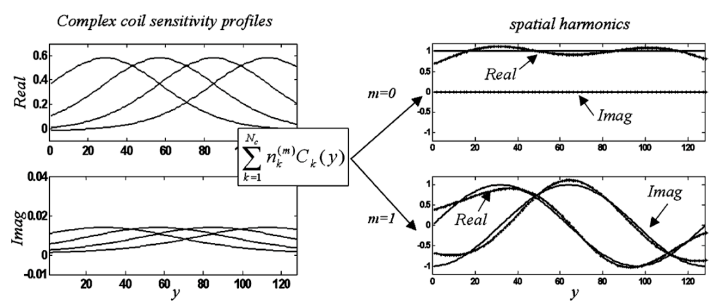
$$\vec{\rho} = (\hat{C}^H \hat{C})^{-1} \hat{C}^H \bullet \vec{I}$$

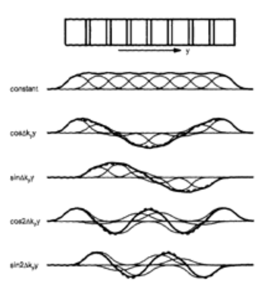
$$SNR \propto \frac{1}{g\sqrt{R}}$$



Blaimer et al, Top Magn Reson Imaging 2004;15:223–236

SMASH (Simultaneous Acquisition of Spatial Harmonics)





$$S_j(k) = \int C_j(r) M_t(r) e^{-ik \bullet r} dr$$

Find w: $\sum_j w(j, \Delta k) C_j(r) \approx e^{-\Delta k \bullet r}$

Then: $S(k + \Delta k) = \int M_t(r) e^{-i(k+\Delta k)\bullet r} \approx \sum_j w(j, \Delta k) S_j(k)$

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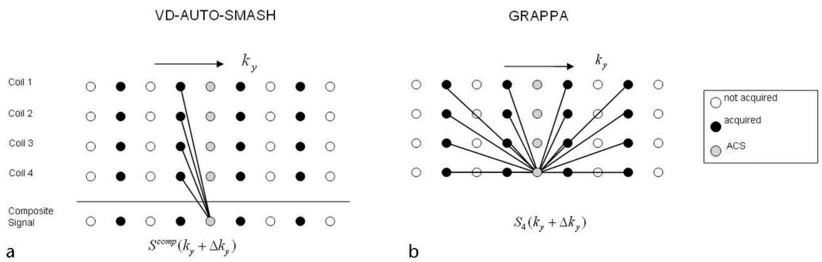
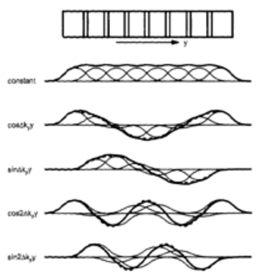
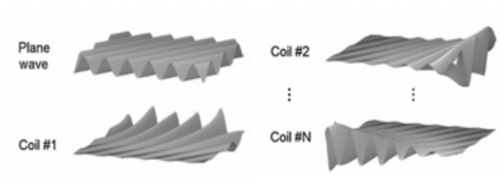
GRAPPA (Generalized Autocalibrating Partially Parallel Acquisitions)







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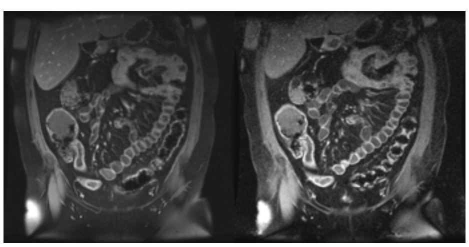
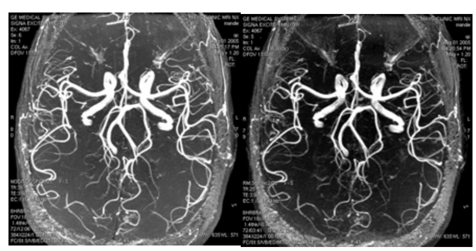
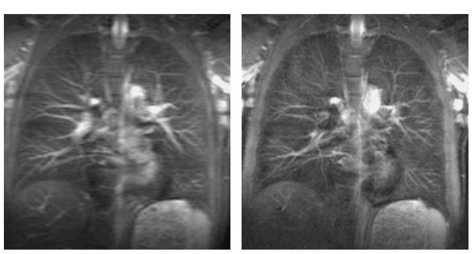
Examples



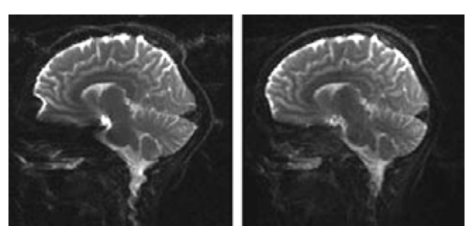
Less Motion



Fewer Slabs



Less T_2 Decay



Less Distortion

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