MREL - USC

Temporal Acceleration

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Acceleration

- Sampling below Nyquist rate
- Assumptions about the object…
- … or loss of SNR

Acceleration Methods

- Partial Fourier
- Variable-density sampling
- Parallel imaging
- Reduced FOV excitation
- Compressed sensing
- Temporal acceleration
- etc.

Today

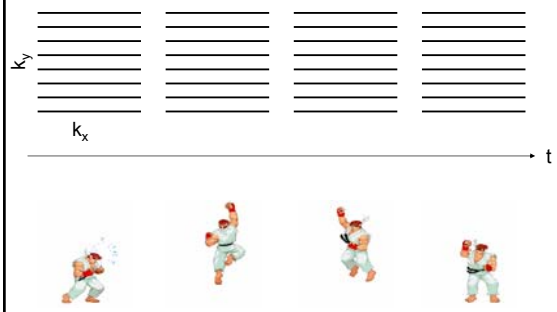
- Temporal acceleration
  - View-sharing
  - UNFOLD
  - k-t BLAST
- Hybrid methods (temporal + parallel)
  - k-t SENSE
  - k-t GRAPPA
  - TGRAPPA

Dynamic Imaging

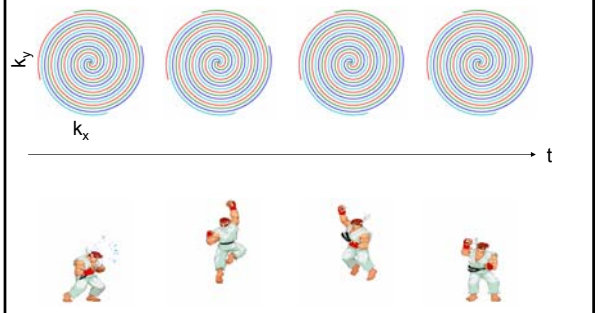
- Cardiac imaging
- fMRI
- Flow imaging
- Time-resolved angiography
- Contrast agent uptake

- Any application where a CINE dataset is useful (time-resolved imaging)

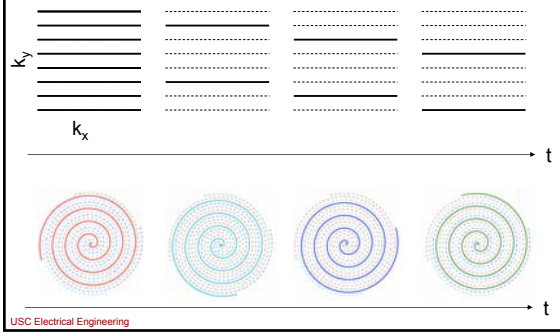
What is k-t ?



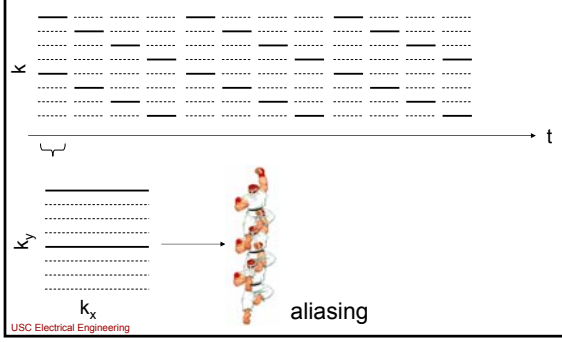
What is k-t ?



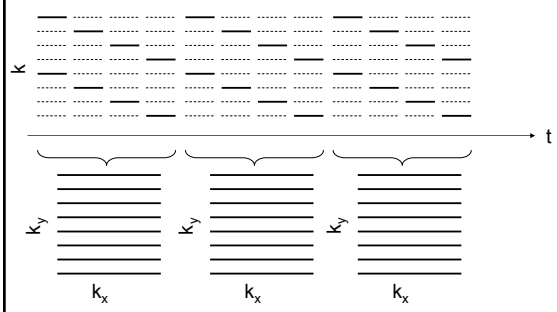
Undersampling k-t



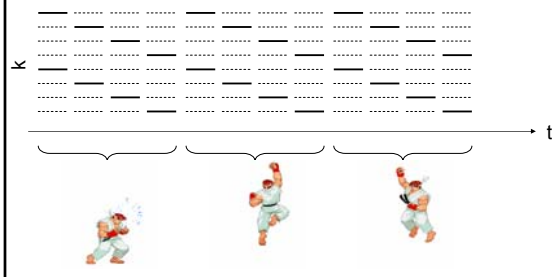
Undersampling k-t



Reconstruction



Reconstruction



Assumption: Ryu doesn't move during acquisiton

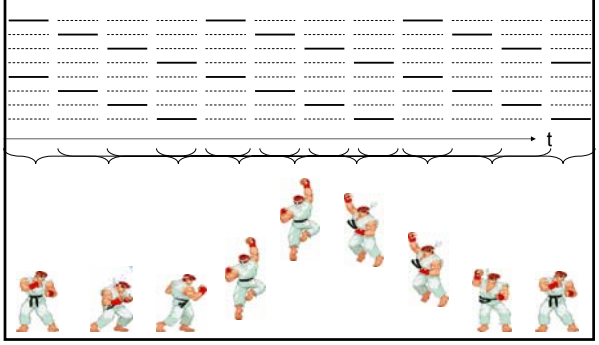
Data inconsistency → motion artifacts (ghosting)

View-sharing

- Also known as:
  - Data-sharing
  - Sliding window
  - Fluoroscopy
- Can increase # of phases (frame rate)

Reference: Riederer *et al.*, MRM 8:1-15 (1988)

View-sharing



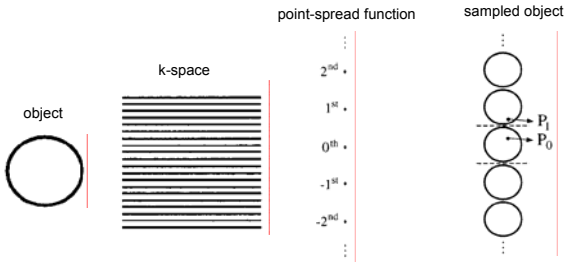
Limitations

- View-sharing is interpolation
  - Similar to low-pass filtering in a D/A converter
- Equivalent to a moving-average filter (low-pass FIR)
- Slow-moving objects → OK
- Very dynamic objects:
  - Temporal blurring (motion is smoothened)
  - Data inconsistency → motion artifacts (ghosting)

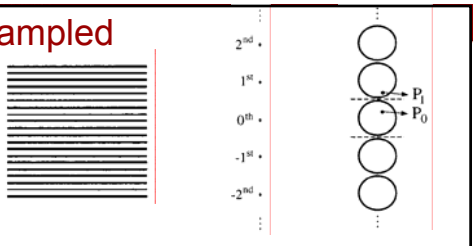
UNFOLD

- Alternative to view-sharing
- Use when:
  - Dynamic region-of-interest
  - Not very dynamic elsewhere
- Examples:
  - Cardiac: heart vs. chest wall
  - fMRI: activated region vs. rest of brain
  - Speech: vocal tract vs. upper head

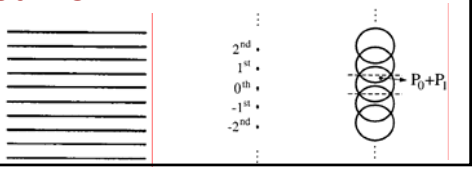
UNFOLD

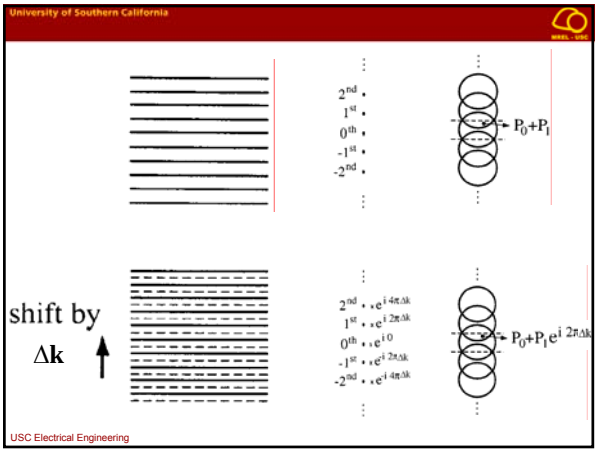


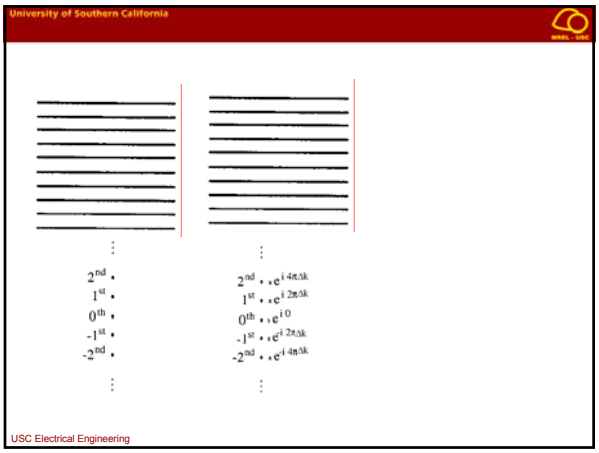
Fully sampled



Reduced FOV



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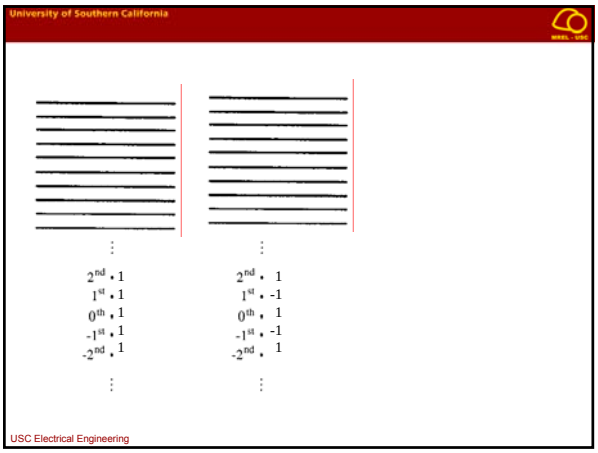
USC Electrical Engineering


University of Southern California
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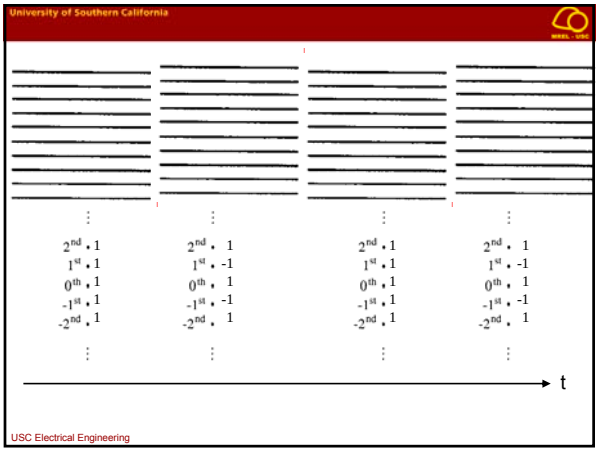
University of Southern California
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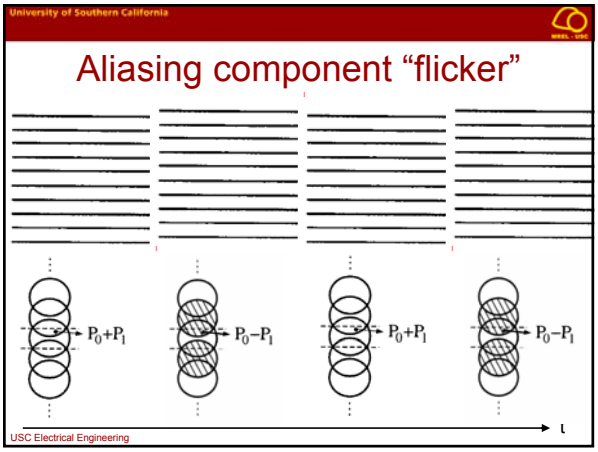
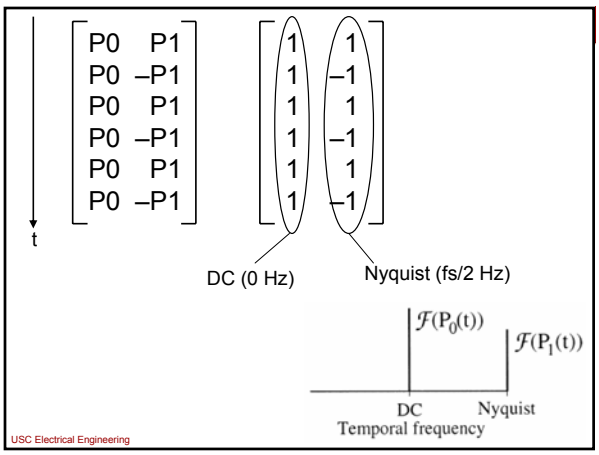
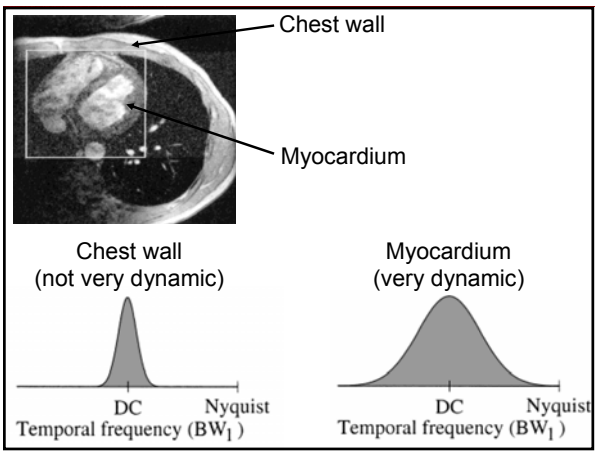
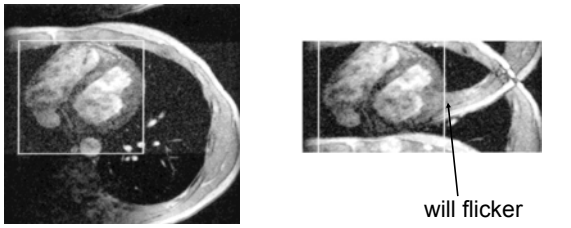
USC Electrical Engineering

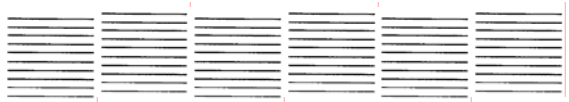

University of Southern California
Aliasing component “flicker”
t
USC Electrical Engineering

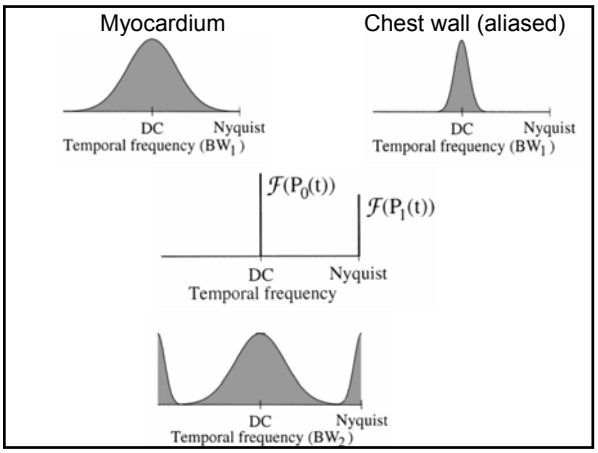

P0 P1
P0 –P1
P0 P1
P0 –P1
P0 P1
P0 –P1
t
DC (0 Hz)
Nyquist (fs/2 Hz)
DC
Nyquist
Temporal frequency
USC Electrical Engineering


Chest wall
Myocardium
Chest wall
(not very dynamic)
Myocardium
(very dynamic)
DC
Nyquist
Temporal frequency (BW1)
DC
Nyquist
Temporal frequency (BW1)

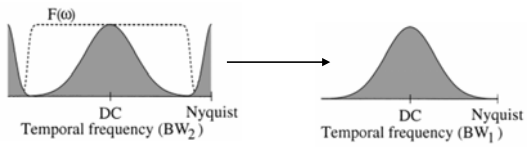
Reduce FOV







Apply filter to remove aliasing

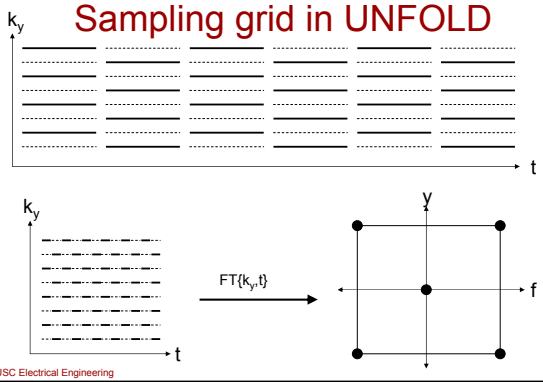


Reference: Madore *et al.*, MRM 42:813 (1999)

"On the UNFOLD Method"

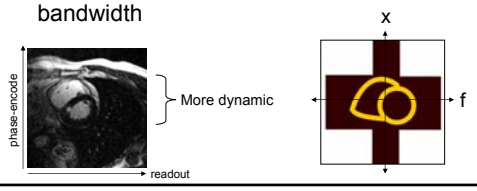
- Jefrey Tsao, MRM 47:202 (2002)
- Graphical formalism to UNFOLD
- Provided new intuition

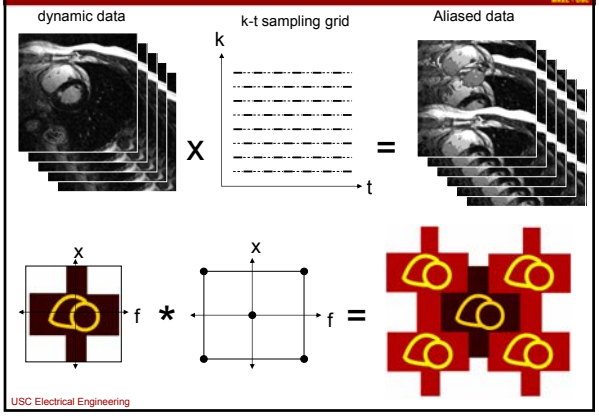
Sampling grid in UNFOLD



x-f space

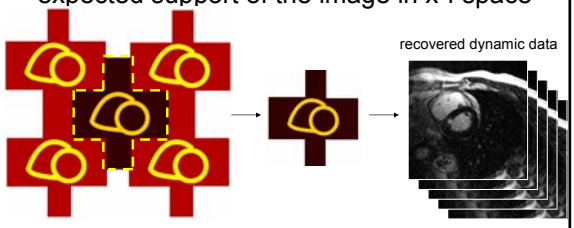
- x : spatial dimension
  - phase-encode dimension in 2DFT
  - radial dimension in spirals
  - etc.
- f: temporal frequency
  - dynamic objects have wider temporal bandwidth





Recovering data

- Use a filter designed based on the expected support of the image in x-f space



Conclusions

- Temporal undersampling
  - Use to acquire dynamic data faster
- View-sharing
  - Increase number of temporal frames
  - May cause ghosting and temporal smoothening
- UNFOLD
  - Use when the ROI is more dynamic
  - Maximum acceleration determined by how much you can pack the data in x-f space without overlap
  - Know the expected shape of the object in x-f space!
  - Design view-ordering scheme accordingly

Next

- k-t BLAST
- k-t SENSE