EE 369C

MEDICAL IMAGE RECONSTRUCTION

DEVELOP TOOLS FOR IMAGE RECONSTRUCTION

EMPHASIZE COMMON PROBLEMS

EXAMPLES FROM MR, CT, PET, OTHERS

PREREQUISITS

FOURIER TRANSFORMS (261)

EE 369A,B USEFUL (EE 169)

PROBABILITY USEFUL

MATLAB / PYTHON, NUMPY

BOOKS

ONLINE, SEE WEB PAGE

PAPERS, ALSO ONLINE

MATLAB (NOW FREE FOR STANFORD USERS!)

EVALUATION

ASSIGNMENTS (50%)

MOSTLY MATLAB

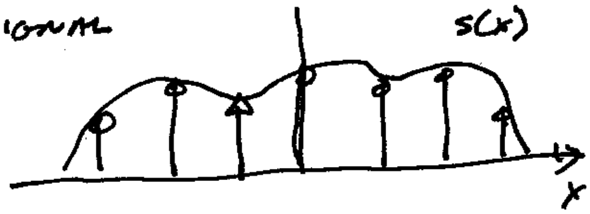
PROJECT (50%)

FOR S/NC, ONLY NEED ASSIGNMENTS

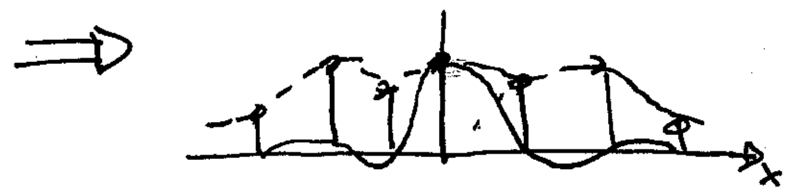
TOPICS

SAMPLING AND RECONSTRUCTION: 1D

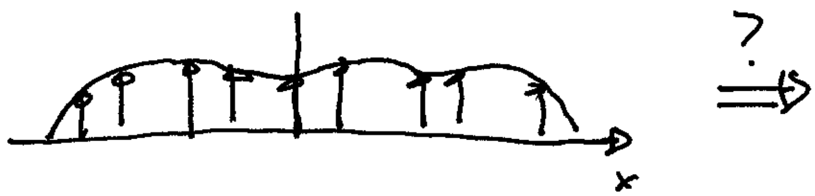
BANDLIMITED SIGNAL



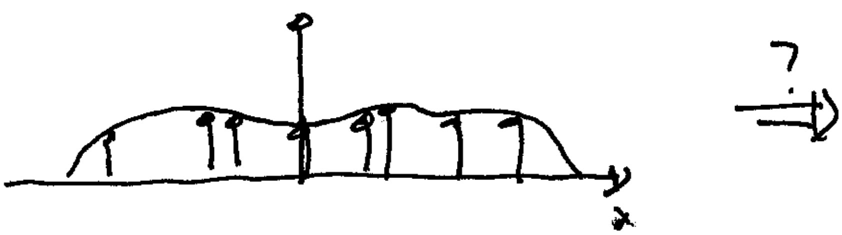
UNIFORM SAMPLING



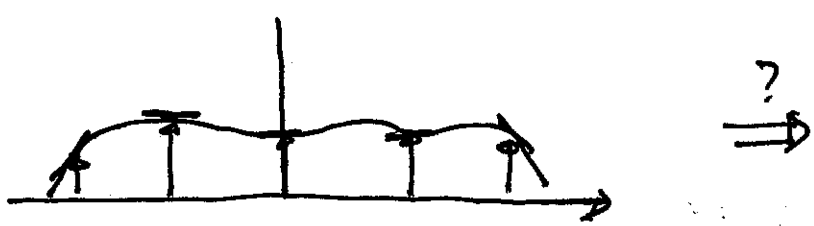
RECONSTRUCTED



NON-UNIFORM



RANDOM

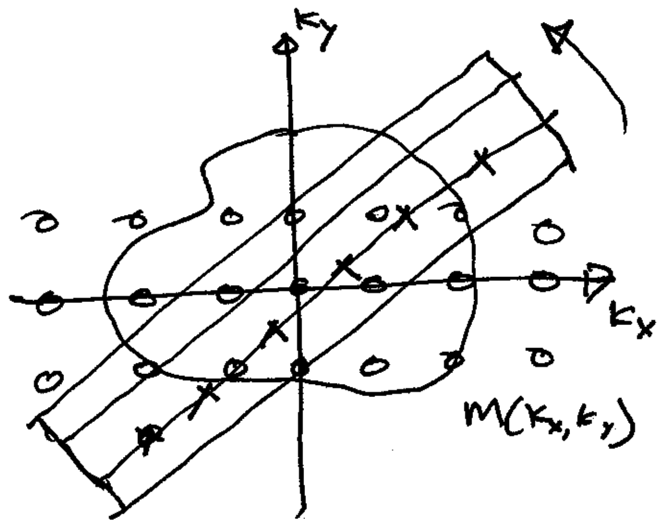


AMPLITUDE + DERIVATIVE

HOW MANY MEASUREMENTS DO YOU NEED? WANT?
HOW DO YOU RECONSTRUCT THE SIGNAL?

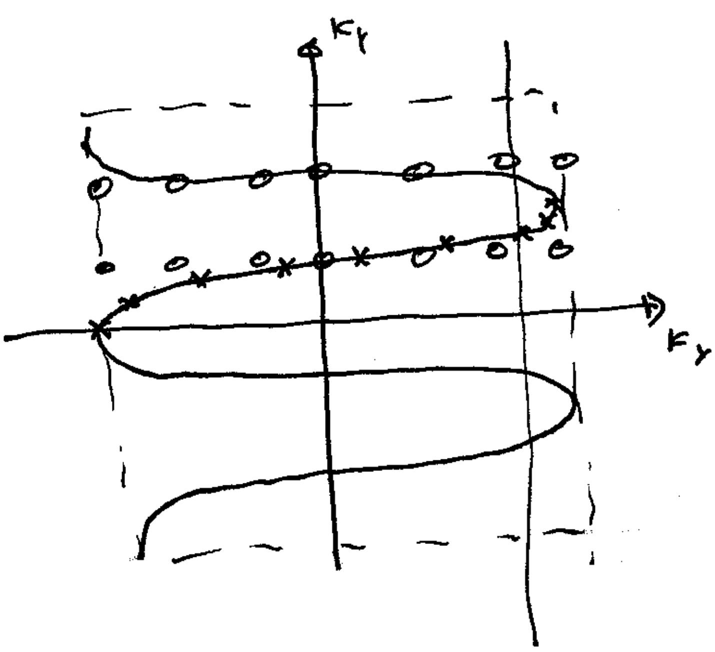
SAMPLING + RECONSTRUCTION : 2D

OFTEN, IT IS CLEAR YOU HAVE ENOUGH DATA,
IT JUST ISN'T WHERE YOU WANT IT.



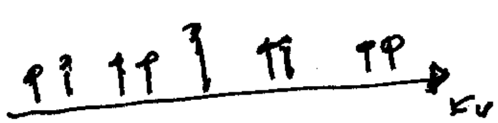
HOW DO WE RESAMPLE
ONTO UNIFORM GRID

PROPELLER



ONE D INTERPOLATIONS
WILL SOLVE THIS

EPI

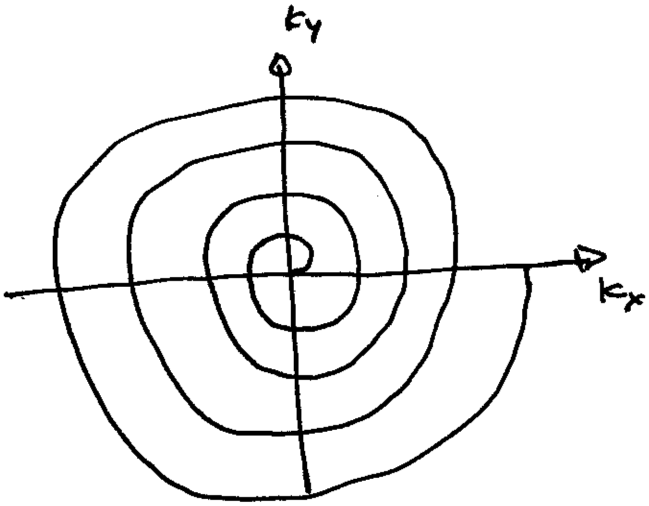


IMPORTANT SPECIAL CASE

INTERPOLATION FOLLOWED BY A FOURIER TRANSFORM

- GRIDDING
- NuFFT

SIMPLIFICATIONS AND TRADE-OFFS



DATA ACQUIRED ALONG A SPIRAL IN SPATIAL FREQUENCY

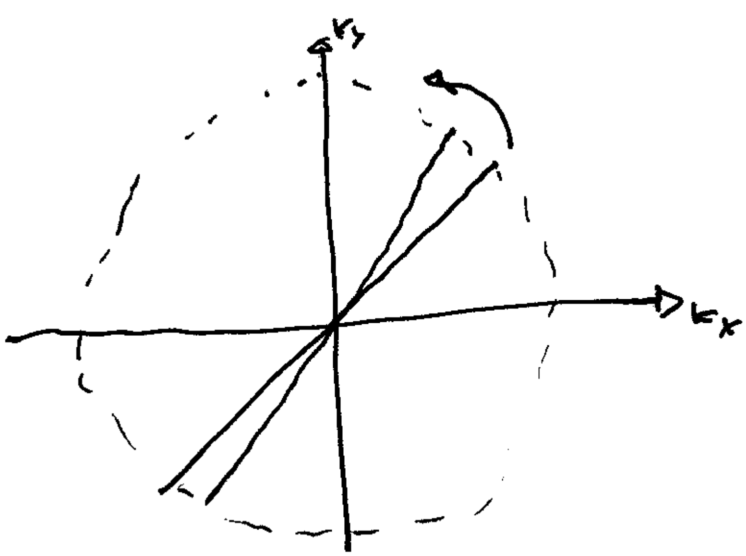
INTERPOLATE ONTO CARTESIAN GRID

2D DFT

INTERPOLATION CORRECTION

SPIRAL MRI

NON-CARTESIAN MRI



DATA ACQUIRED ALONG DIAMETERS

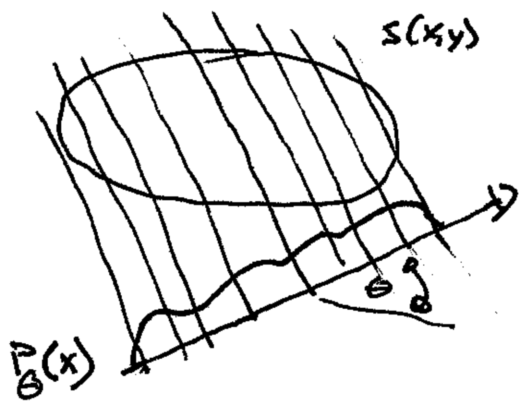
MAIN ISSUE IS NON-UNIFORM WEIGHTING

PROJECTION RECONSTRUCTION WITH CENTRAL SECTION THEOREM

CT, PET, MRI

IMAGE DOMAIN ACQUISITION AND RECONSTRUCTION

SOME IMAGE RECONSTRUCTION PROBLEMS ARE MOST NATURALLY SOLVED IN THE IMAGE DOMAIN

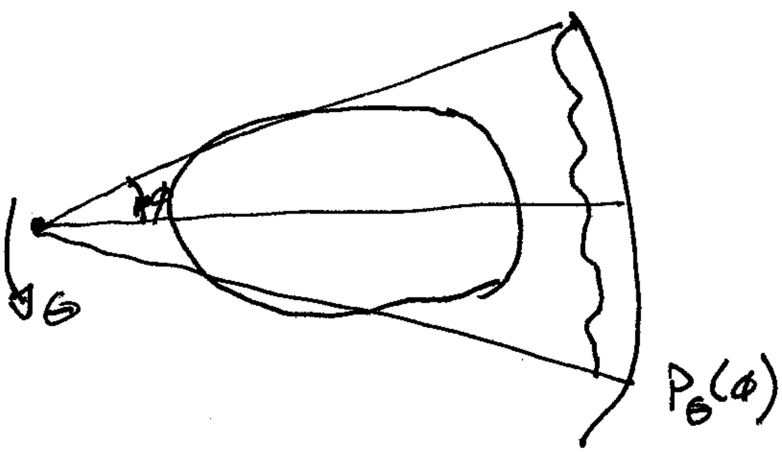


PARALLEL BEAM CT

RECONSTRUCT s(x,y) FROM ITS PROJECTIONS $p_\theta(x)$

PARALLEL BEAM CT, PET

CAN BE SOLVED IN FREQUENCY DOMAIN



FAN BEAM CT

FOURIER RECONSTRUCTION LESS OBVIOUS

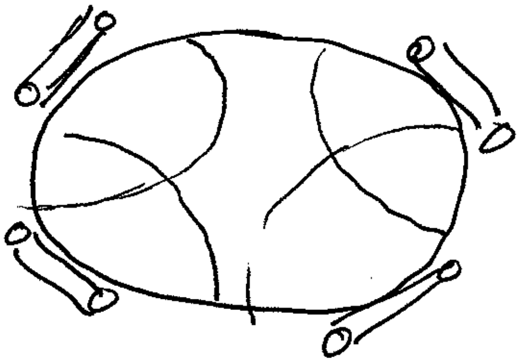
FAN BEAM BACKPROJECTION

REBINNING

IDEA OF IMAGING SYSTEM PROJECTING FROM A DATA SPACE TO A MEASUREMENT SPACE IS QUITE GENERAL AND USEFUL.

IMAGE AND FREQUENCY DOMAIN SAMPLING

SOME SYSTEMS DIVIDE THE WORK OF LOCALIZATION

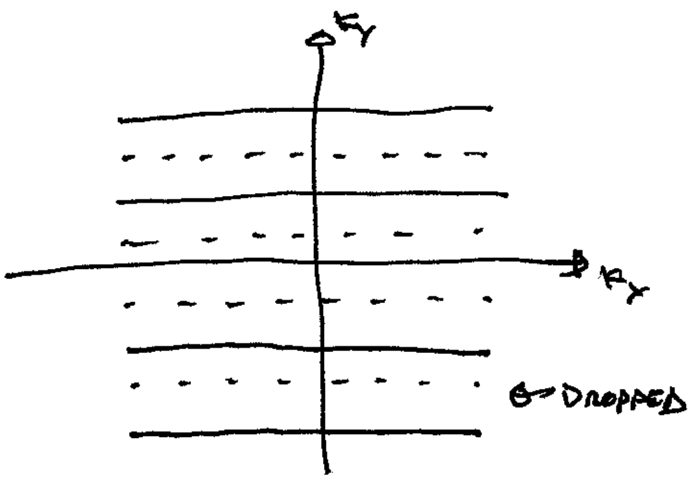


BASIC MRI USES A UNIFORM RF

PARALLEL MRI USES MANY SMALL LOCAL COILS

EACH SEES A SMALLER FOV
LESS PHASE ENCODES NEEDED

PARALLEL MRI COILS



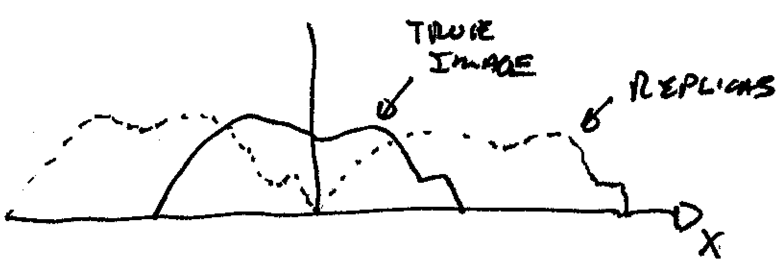
HOW DO WE USE COIL SENSITIVITIES TO FILL IN MISSING DATA?

SENSE

GRAPPA

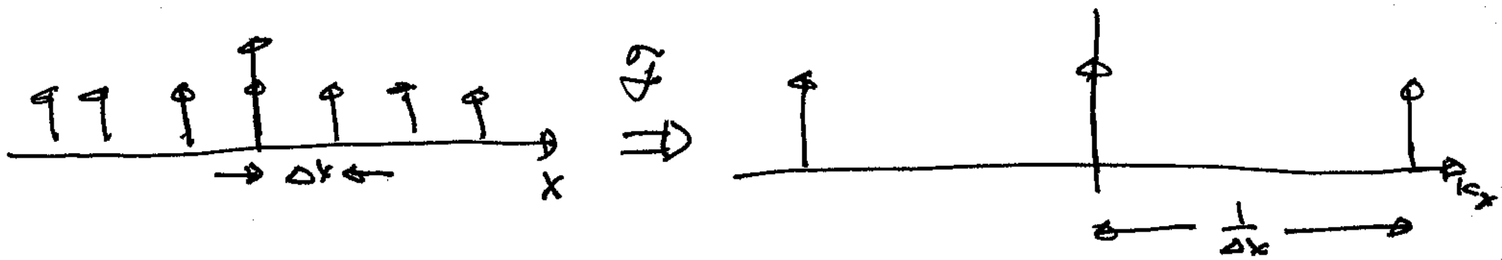
K-SPACE

UNIFORMLY UNDERSAMPLING IN SPATIAL FREQUENCY CAUSES ALIASING IN IMAGE SPACE

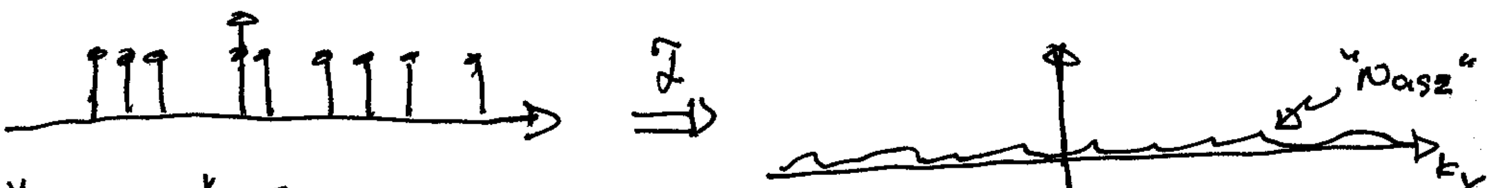


COMPRESSED SENSING

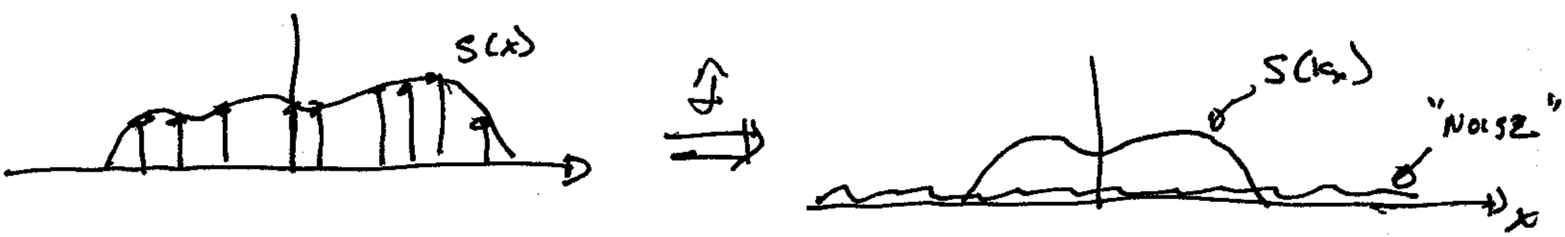
IN PARALLEL MRI, UNIFORM UNDERSAMPLING CAUSES ALIASING, COIL SENSITIVITIES SORT IT OUT



UNIFORM SAMPLING



"RANDOM" SAMPLING



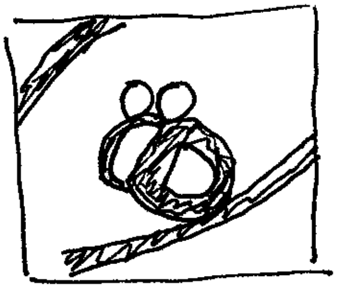
NOISE LOOKS RANDOM, BUT ISN'T. ALIASING ARTIFACTS

CHOOSE SAMPLING PATTERN SO THAT THE STATISTICS OF ALIASING ARTIFACTS DON'T LOOK LIKE IMAGE

SUPPRESS ARTIFACTS BY DE-NOISING
- NON-LINEAR OPERATION
- COMPRESS FOLLOWED BY THRESHOLD

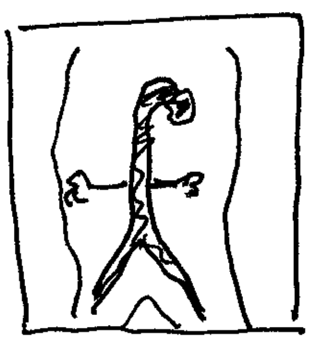
TIME SERIES RECONSTRUCTION

TIME SERIES DATA ADDS ADDITIONAL STRUCTURE



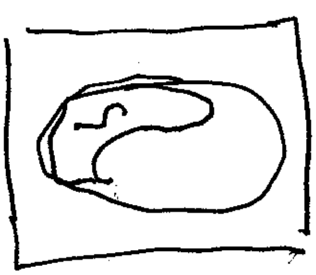
BEATING HEART

- PERIODIC MOTION (ALMOST)
- MOVING + STATIONARY STRUCTURES
- MAXIMIZE TEMPORAL RESOLUTION FOR SMALL, FAST STRUCTURES



CONTRAST ENHANCED ANGIOGRAMS

- STRUCTURES APPROXIMATELY STATIC, OR SLOW MOVING
- CONTRAST CHANGES QUICKLY



INTERVENTIONAL DEVICES

- NOT PERIODIC
- STATIC BACKGROUND
- SMALL, FAST MOVING DEVICE

ADDITIONAL TOPICS

3D PROJECTION SYSTEMS

- SPIRAL CT
- CONE BEAM CT

PET RECONSTRUCTION

- SYSTEM MODELS
- ESTIMATION BASED ITERATIVE RECONSTRUCTION

CLASSIC MR RECONSTRUCTION PROBLEMS

- PARTIAL k-SPACE
- WATER / FAT IMAGING
- AUTOFOCUS FOR NON-CARTESIAN MRI