

EE369C MEDICAL IMAGE RECONSTRUCTION

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DEVELOPE TOOLS FOR IMAGE RECONSTRUCTION

EMPHASIZE COMMON PROBLEMS

EXAMPLES FROM MR, CT, OTHERS

PREREQUISITES

FOURIER TRANSFORMS ESSENTIAL (Z61)

EE369A, B USEFUL (SEE 169)

PROBABILITY USEFUL

MATLAB

BOOKS

AVAILABLE ON-LINE (SEE WEB SITE)

PAPERS, ALSO ON-LINE

MATLAB

MIZ INTERESTS

STUDENTS DEPARTMENTS, YEARS, INTERESTS

EVALUATION

50% ASSIGNMENTS

MOSTLY MATLAB PROGRAMMING

TYPESET, MAT FILE, EMAIL

50% PROJECT

WRITEN 10-15 PAGES

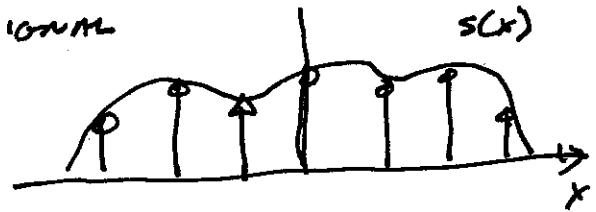
YOUR RESEARCH TOPIC

SUGGESTED TOPICS

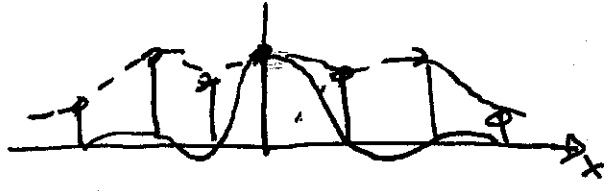
TOPICS

SAMPLING AND RECONSTRUCTION: 1D

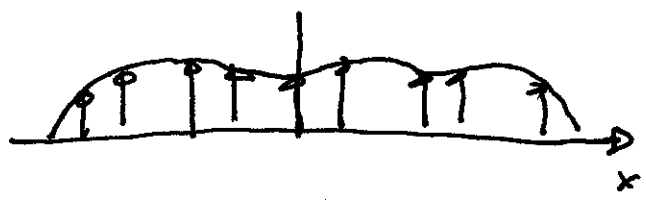
BANDLIMITED SIGNAL



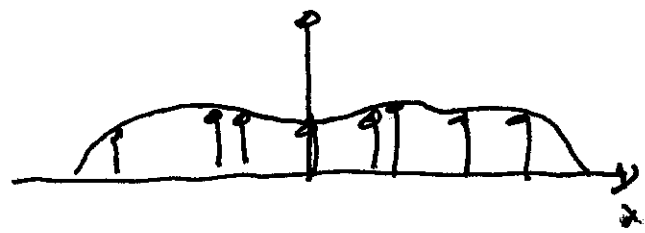
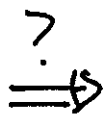
UNIFORM SAMPLING



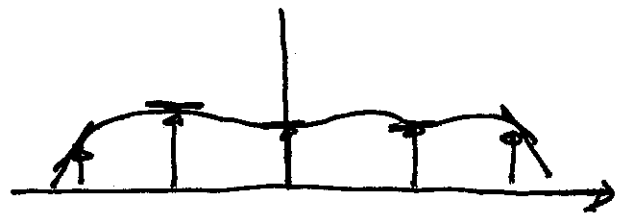
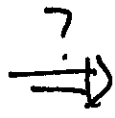
RECONSTRUCTED



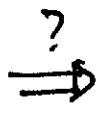
NON-UNIFORM



RANDOM



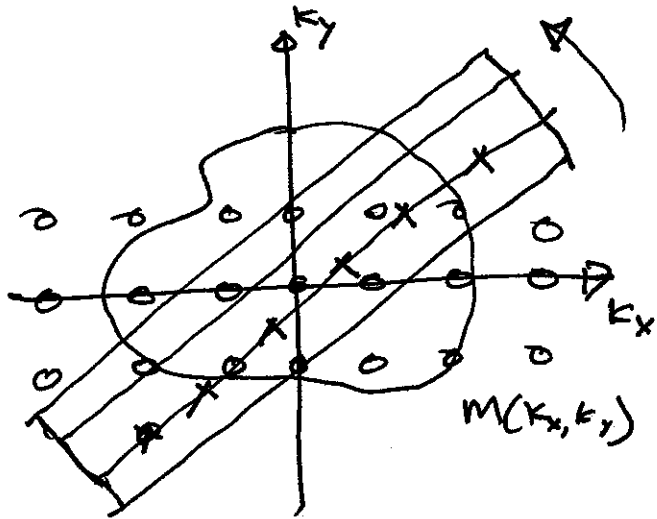
AMPLITUDE + DERIVATIVE



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

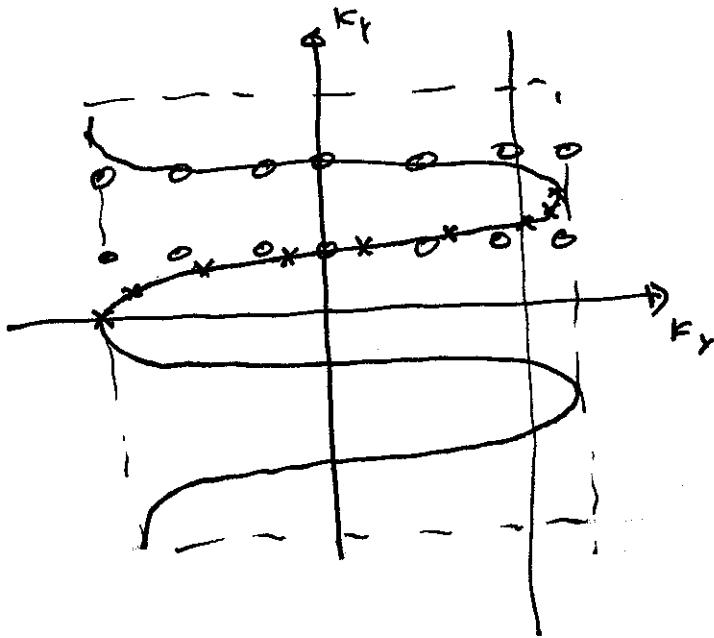
SAMPLING + RECONSTRUCTION : 2D

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



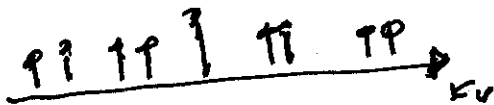
HOW DO WE RESAMPLE
ONTO UNIFORM GRID

PROBLEM



ONE D INTERPOLATIONS
WILL SOLVE THIS

||



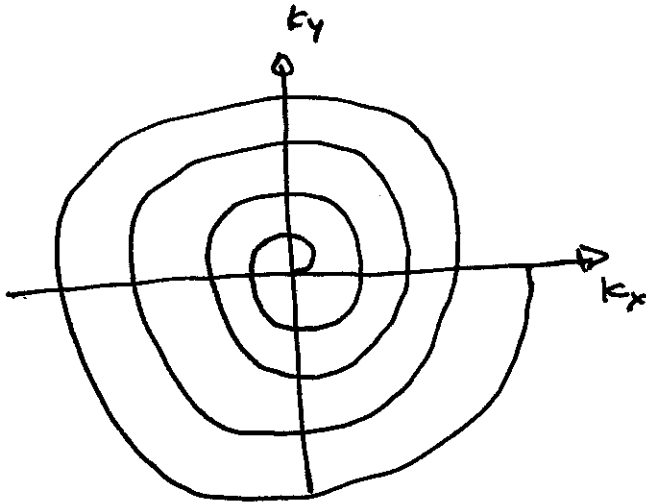
IMPORTANT SPECIAL CASE

INTERPOLATION FOLLOWED BY A FOURIER TRANSFORM

GRIDDING

NUFFT

SIMPLIFICATIONS AND TRADE-OFFS



DATA ACQUIRED ALONG A SPIRAL IN SPATIAL FREQUENCY

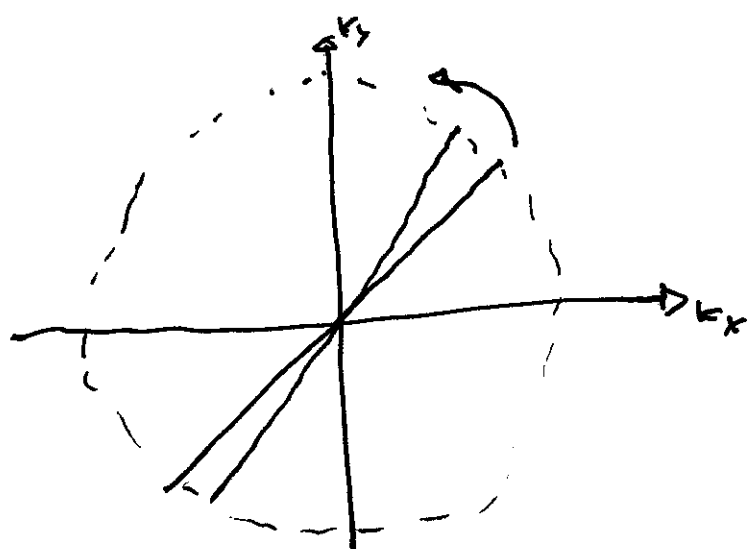
INTERPOLATE INTO CARTESIAN GRID

2D DFT

INTERPOLATION CORRECTION

SPIRAL MRI

NON-CARTESIAN MRI



DATA ACQUIRED ALONG DIAMETERS

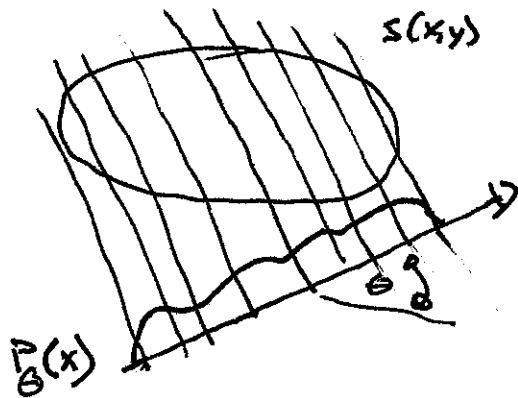
MAIN ISSUE IS

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

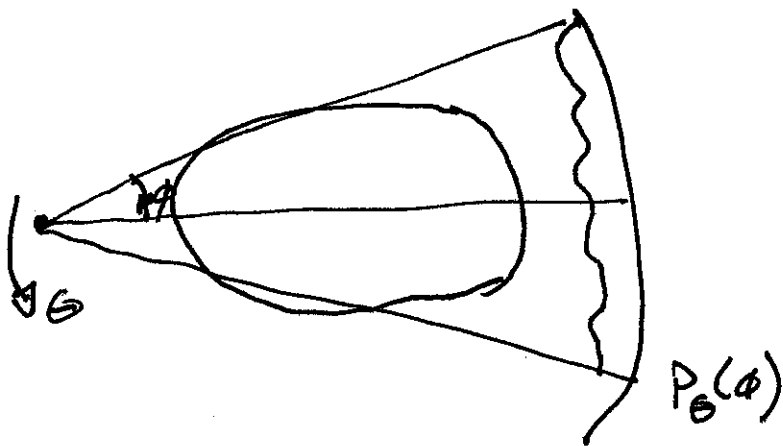


PARALLEL BEAM CT

RECONSTRUCT $S(x,y)$ FROM ITS PROJECTIONS $P_B(x)$

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

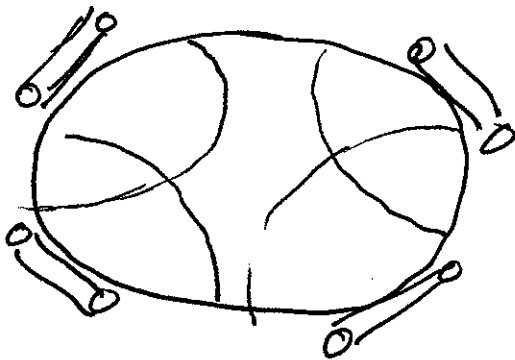
6

SOME SYSTEMS DIVIDE THE WORK OF LOCALIZATION

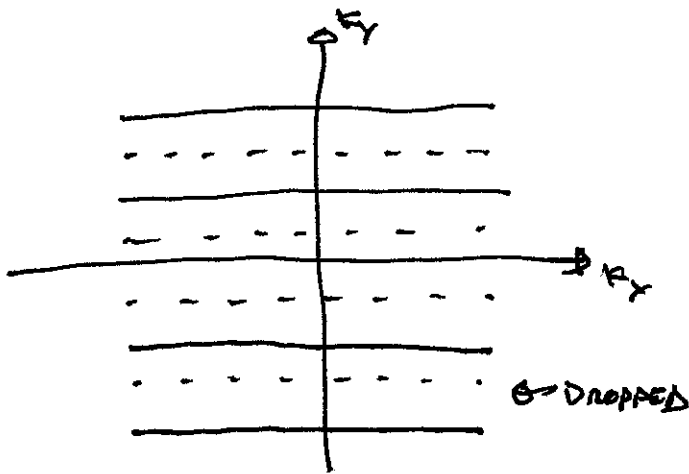
BASIC MRI USES A UNIFORM RF

PARALLEL MRI USES MANY SMALL LOCAL COILS

EACH SEES A SMALLER FOU
LESS PHASE ENCODES NEEDED



PARALLEL MRI COILS



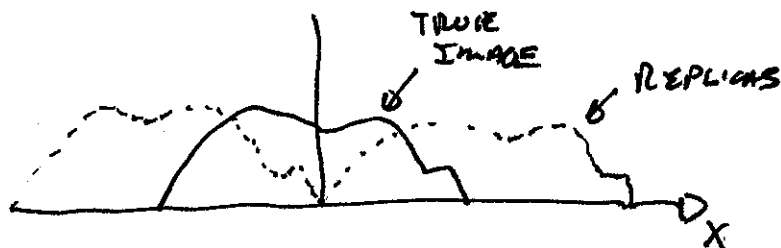
HOW DO WE USE
COIL SENSITIVITIES TO
FILL IN MISSING DATA?

SENSE

GRAPPA

K-SPACE

UNIFORMLY UNDERSAMPLING IN SPATIAL FREQUENCY CAUSES
ALIASING IN IMAGE SPACE

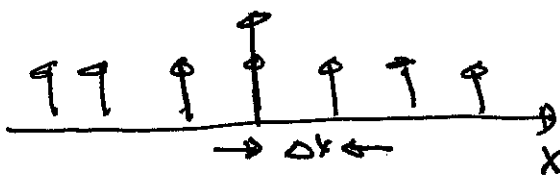


L1

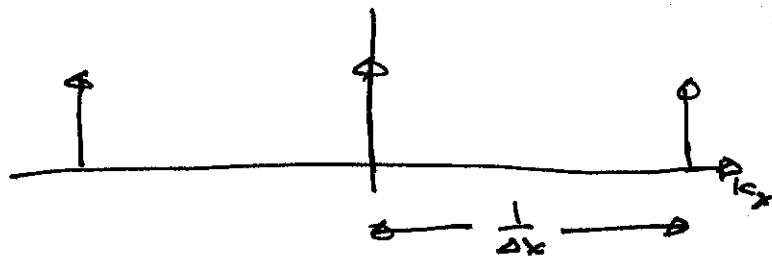
COMPRESSED SENSING

(7)

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



\mathcal{F}
 \Rightarrow



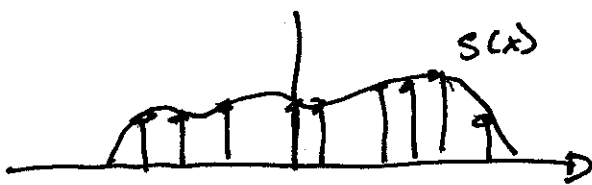
UNIFORM SAMPLING



\mathcal{F}
 \Rightarrow



"RANDOM" SAMPLING



\mathcal{F}
 \Rightarrow



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

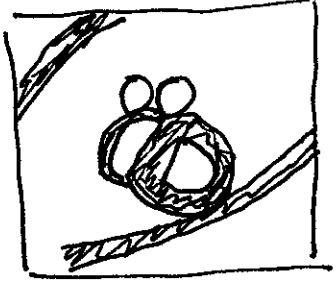
NON-LINEAR OPERATION

COMPRESS FOLLOWED BY THRESHOLD

L1

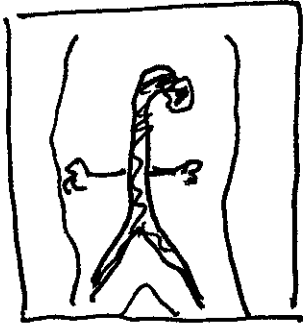
TIME SERIES RECONSTRUCTION

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

6

3D PROJECTION SYSTEMS

SPRAL 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