Example Project Topics

- A topic of your choice
  - With approval of instructor

Reconstruction - CT

- CT Reconstruction (2D)
  - Modeling as a linear system
  - Reconstruction by matrix inversion
    - With/without edge-preserving priors
  - Radon-transform-matrix analysis (SVD, null-space)
- CT Reconstruction (3D)
  - Modeling as a linear system, MRF prior in 3D
  - Iterative MAP estimation using Poisson noise model
- CT recon using ART and variants
  - https://en.wikipedia.org/wiki/Algebraic_Reconstruction_Technique
- PET reconstruction
  - https://en.wikipedia.org/wiki/Ordered_subset_expectation_maximization

Reconstruction - MRI

- Reconstruction of MRI
  - Sparse image representation
    - http://math.lanl.gov/Research/Publications/Docs/chartrand-2008-iteratively.pdf
  - Iteratively re-weighted least squares (IRLS)
- Reconstruction of Dynamic MRI (space + time)
  - Choice of image-acquisition (Fourier sampling) strategies
  - Sliding-window reconstruction algorithm
    - http://www.ncbi.nlm.nih.gov/pubmed/11870913
  - Reconstruction via Bayesian estimation
- Reconstruction of Diffusion-Tensor MRI
  - Multi-dimensional MRI
  - Fidelity + MRF-smoothness + Tensor-model fit

Denoising

- Denoising using patch-based statistics
  - Non-local-means algorithm, Gaussian noise
    - http://en.wikipedia.org/wiki/Non-local_means
  - Adapting for speckle noise
    - http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=4982678&tag=1
- Denoising DTI
  - Rician noise model + MRF-smoothness + Tensor-model fit
  - http://www.ncbi.nlm.nih.gov/pubmed/17354881
- Denoising MRI / CT
  - Soft-thresholding algorithm
  - Using wavelet transform for image representation
  - Analysis performance with different wavelets
  - http://eeweb.poly.edu/iselesni/WaveletSoftware/denoise.html

Surface Processing / Visualization

- Mesh smoothing
  - “Edge”-preserving smoothing
- Surface smoothing using level sets in ITK
  - http://www.itk.org/ItkSoftwareGuide.pdf
- 'Marching Cubes' for 3D anatomical visualization
  - http://dl.acm.org/citation.cfm?id=37422

Segmentation

- Clustering of time series in functional-MRI (space + time)
  - Time-series data at each voxel
  - Modeling distributions of normalized (zero mean, unit variance) time-series on hypersphere
  - Estimation
  - http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3513676/
- Segmentation of multimodal brain MRI
  - Denoise T1 + T2 MRI images, of same person, jointly
  - Extend 1D Gaussians to multi-D Gaussians
  - Model Gaussian covariances
  - Optimization via EM
- Fuzzy-C-means based brain-segmentation algorithms
  - http://link.springer.com/article/10.1007%2Fs10462-012-9318-2

Segmentation

- Spectral clustering for medical image segmentation
  - http://www.na-mic.org/publications/item/view/139
  - http://www.kyb.mpg.de/fileadmin/user_upload/files/publications/attachments/Luxburg07_tutorial_4488%5B0%5D.pdf
- Level-set segmentation using ITK
  - http://www.itk.org/ItkSoftwareGuide.pdf
  - http://www.itksnap.org/pmwiki/pmwiki.php?n=Documentation.TutorialSectionIntroductionToAutomatic
- Image segmentation using graph cuts
  - http://www.csd.uwo.ca/~yuri/Papers/miccai00.pdf
- Segmentation of diffusion-tensor images
  - e.g., http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1514547

Shape Analysis

- Statistical shape analysis of anatomical structures (2D)
  - e.g., an anatomical structure in brain
  - http://webdocs.cs.ualberta.ca/~nray1/CMPUT615/Snake/cootes_cviu95.pdf
- Segmentation with a shape prior

Statistical Analysis

- Algorithms for sampling images from a MRF model
  - Gibbs sampling for label images
    - http://dx.doi.org/10.1109%2FTPAMI.1984.4767596
    - http://en.wikipedia.org/wiki/Gibbs_sampling
  - Simulating ultrasound / CT / MR images from (i) a segmentation and (ii) texture models
    - Multiple texture sampling
    - http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=790383
- Algorithms for sampling shapes from a shape model

Image Registration

- Building an anatomical atlas via image registration using ITK
  - http://www.itk.org/ItkSoftwareGuide.pdf

Machine Learning in Medical Vision

- Conference on Machine Learning in Medical Imaging (MLMI)
  - http://mlmi2015.web.unc.edu
- Decision Forests for Classification, Regression, Density Estimation, Manifold Learning and Semi-Supervised Learning
  - http://research.microsoft.com/apps/pubs/default.aspx?id=155552

GPU based Medical Image Processing

- Medical image processing on the GPU – Past, present and future
  - http://www.sciencedirect.com/science/article/pii/S1361841513000820
- A survey of GPU-based medical image computing techniques
  - http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3496509

Aid for Searching for Topics

- Literature
  - https://en.wikipedia.org/wiki/Medical_image_computing
  - Conferences
    - http://www.miccai.org/
    - http://ipmi2013.ipmi-conference.org/
    - http://biomedicalimaging.org
    - http://www.medicalcomputervision.org
  - Journals
    - http://www.ieee-tmi.org/
    - http://www.journals.elsevier.com/medical-image-analysis/
    - http://www.medphys.org/
  - Microsoft research
    - http://research.microsoft.com/en-us/projects/medicalimageanalysis/

Finalize by April 2

- What algorithm(s) ?
- What data ?
  - Simulated (simple, 2D / 3D)
  - Real-world (2D / 3D)
- Evaluation strategy ?
  - How to measure success or failure on simulated / real-world data ?
  - How to measure performance ?
- Final project presentations + report submission around end-sem exam