ESE 558 DIGITAL IMAGE PROCESSING
Electrical and Computer Engineering, Stony Brook University, 3 Credits
Prof. Murali Subbarao
(Subject to Changes)

Catalog description:
It covers digital image fundamentals, mathematical preliminaries of two-dimensional systems, image transforms, human perception, color basics, sampling and quantization, compression techniques, image enhancement, image restoration, **image reconstruction from projections,** and binary image processing.

Text book:

1. ***Digital Image Processing,***
   R. C. Gonzalez and R. E. Woods, Third Edition,
   Pearson Prentice-Hall, ISBN 0-13-168728-x, 2008.

Reference Material:
Published Papers, Patents, Handouts, online resources.

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Office Hours: Tue. and Thu.: 10 a.m to 11.00 a.m. and 1 pm to 2 pm.
Place: Room 233, Light Engg. Bldg.

Syllabus:

1. **Digital Image Fundamentals:** introduction, and applications.
   Image formation in digital cameras and medical imaging devices, spatial and gray-level resolutions, Human Visual System (structure of the eye and brightness perception characteristics), overview of modern image sensors (RGBD, LIDAR, Medical Imagers), modern computing hardware systems (GPU, cloud computing) and software libraries (OpenCV, Matlab, Python) for image processing.
2. **Color Image Models:** human perception of color, color models (CIE, RGB, HSI, CMYK, etc).
3. **Image Processing: Spatial domain techniques**
   Enhancement (pointwise, local, global, histogram transformations), Geometric transformations (2D and 3D scaling, translation, rotation, affine transform) , Image interpolation, Convolution, separable, and Gaussian filtering, general linear filtering, computational complexity of different filtering techniques. Computing image features (edges, corners, sift vector, etc).
4. **Image Processing: Transform domain techniques**
   Fourier transform: continuous and discrete transforms (1-D, 2-D, N-D), properties and applications to filtering, relation to spatial domain techniques, FFT and computational complexity, related transforms (Discrete Cosine/Sine). Ortho-normal transforms.

5. **Sampling and quantization**
   Optimal quantization, Sampling theorem (1D and 2D), Optimal Sampling (ortho-normal basis and expansions).
6. **Medical Image Processing:**
   a. **X-ray computed tomography (CT)**
      Image formation model, Radon transform, Fourier slice theorem, image reconstruction techniques, Filtered Back Projection algorithm, Total Variation Minimization technique.
   b. **SPECT/PET (Single-Photon/Positron Emission CT):** image formation model and image reconstruction techniques.
   c. **MRI (Magnetic Resonance Imaging):** image formation model, aliasing and unaliasing in parallel MRI.
7. **Image Restoration: image blurring and deblurring**
   Defocus/Optical blur: Point Spread Function (PSF) and related functions (OTF, MTF, PTF, Edge Spread Function), models of PSF (geometric/cylindrical, Gaussian, Calibrated model). Deconvolution/deblurring in the spatial and Fourier domains (inverse filtering), Regularization (e.g. Weiner filtering), Shift-Variant Image blurring and deblurring (by inverting large linear systems of equations) with regularization (SVD/spectral-filtering, regularization based on first and second image derivatives).
   Motion blur and deblurring.
8. **Image/video Compression**
   Coding, spatial, and psycho-visual redundancies, Loss-free compression: Huffman-coding and related techniques, Lossy-compression: Transform coding techniques, Sampling with Discrete Cosine Transform; Wavelet transform; Compression standards-jpeg.
   Video compression: motion estimation and prediction, mpeg.
9. **Image recognition:** image feature vectors, Nearest-Neighbor/Centroid classification, K-nearest Neighbor, Bayesian classification, clustering, Support Vector Machines, Convolutional Neural Nets, transfer learning, deep learning nets.

GRADING

Attending lectures is essential for doing well on written exams. Lectures will specifically prepare students for the exams. There will be 2 tests and a quiz. You will be provided with practice questions that will be similar to the questions on the exams for all the exams.

Test 1 : 30% (2 hrs) (50% open book)

Test 2 : 30% (2 hrs) (50% open book)

Final Quiz/Take-home : 10%

Programming Project : 20% (MATLAB, around 20 hrs long)

Student Presentation: 10 % (15 minutes long presentation of a published paper)

Individual Programming Project: 20%.
Matlab programming language should be learned for completing the project. Project is not difficult and requires about 20 hours of effort.

Student Presentation: 10%.
Each student will read a published paper on a medical imaging topic and present it to class. You will need to prepare around 15 slides and present it for 15 minutes. Estimated effort: about 10 hours.

Grades are assigned based on absolute percentage of total marks as below.
This policy is subject change.

A : 91—100 , A- : 86—90 , B+ : 81—85, B : 76—80, B- : 71--75
C+ : 68—70, C : 64—67, C- : 61—63, D+ : 56—60, D : 51—55, F : 0—50