GNR602
Advanced Methods in Satellite Image Processing

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Slot 13

Lecture 1 Course Overview

Jan. 08, 2021 7.00 PM – 8.25 PM

Team

- **Instructor**
  - **Prof. B. Krishna Mohan, CSRE**
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- **Teaching Assistants**
  - Dil Thomas M.Tech. student
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  - Aakash Khanderao M.Tech. student
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Overview of the Course

- Image Classification algorithms
- Genetic Algorithms
- Fuzzy Set Theoretic Image Analysis
- Feature Detectors
- Texture Analysis
- Multiresolution Analysis
- Hyperspectral Image Analysis
- Fusion strategies
- Digital Image Segmentation
- Digital Image Compression
- Deep Learning

Note: Coverage of full list of topics is subject to available time; Order of coverage of topics may vary;

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Pre-requisites for the course

- NR607 or equivalent
- Knowledge of mathematics required to the extent of matrix-vector operations, calculus, probability and statistics
- Knowledge of computer programming one of the standard programming languages for assignment(s)

Lecture Hours: Monday and Thursday

7.00 PM – 8.25 PM

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Text Books and Websites

- Brandt Tso and P.M. Mather**, Classification Methods for Remotely Sensed Data,** Taylor and Francis, 2008
- J.A. Richards and X. Jia, **Remote Sensing Digital Image Analysis**, Springer, 2006
- P. Varshney and M.K. Arora, Advanced Image Processing Techniques for Remotely Sensed Hyperspectral Data, Springer, 2004
- R.C. Gonzalez and R.E. Woods, Digital Image Processing, 4th edition, 2017-18
- R.M. Haralick and L.G. Shapiro – **Computer and Robot Vision**, Addison Wesley, 1991
- Papers from Journals

Course Assessment Pattern

- Mid-term Examination: 20%
- End-semester Examination: 40%
- Assignments: 25% (Paper review, Programming)
- Quizzes: 15%

Note: This is a tentative weightage assigned to different modes of assessment. If there is a variation, it will be announced during the course.

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What is paper review?

- Each student shall carefully read an assigned international journal paper on a topic relevant to this course, make his/her own notes and then discuss it in his/her own words in the class
- The student's own critical evaluation of the approach in the paper is important
- **Note: Reviewer is not the same as a reporter. Student should not merely repeat the authors' equations and statements but comment on their meaning, validity and justification. Student's value addition is important.**

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Elements of a paper review

- **Aim of the paper – proposing a new technique or applying a known technique to a new problem**
- **Methodology – new or extension to *a priori* known technique?**
- **Major mathematical technique/transform used – Novel or well known? If novel what is the novelty?**
- **Sample data used – exhaustive or limited? Applicable to remote sensing image analysis in general? Can it work with small to very large images? Only SAR or only optical or both?**
- **Assumptions made by the authors – Restrictive?**
- **Major findings in the paper – student's comments on the contribution, strengths and weaknesses of paper**

In summary, the student's value addition to the content of the paper will be assessed and marks are awarded for the same.

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Aim of the Course

- This course covers advanced topics in satellite image processing and analysis
- The course builds on concepts learnt in the first course NR607
- Together, NR607 and NR602 provide a wide ranging exposure to satellite image processing, classification, fusion and data transformations
- Makes it easier to follow journal papers on this subject

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Digital Image Segmentation

- Decomposition of the input image into a number of subsets
- Each subset related to some object in the input image
- Segmentation based on thresholding, boundary detection, texture discrimination, region growing, and combination of two or more methods

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Thresholding

Identifying levels to map pixels to different categories

- Categories of thresholding techniques
  - Global
  - Local
  - Dynamic

Edge Detection

- Gradient Operators
- Advanced Detectors
- Multiscale Detectors
- Line Extraction

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Satellite Image

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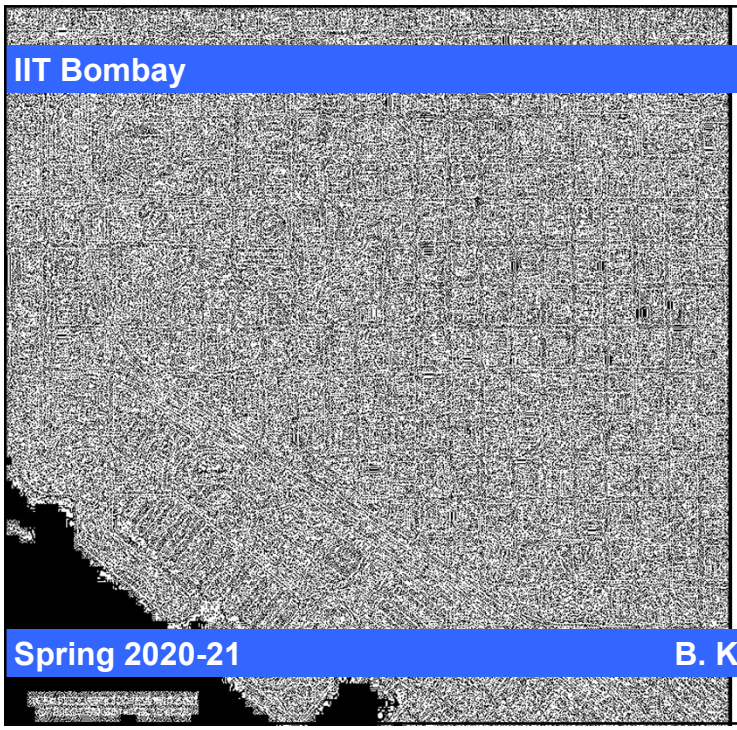

Canny output

Gaussian smoothing

Sigma=1

Hysterisis thresholding

$Thr_{low}=1$

$Thr_{high}=3$

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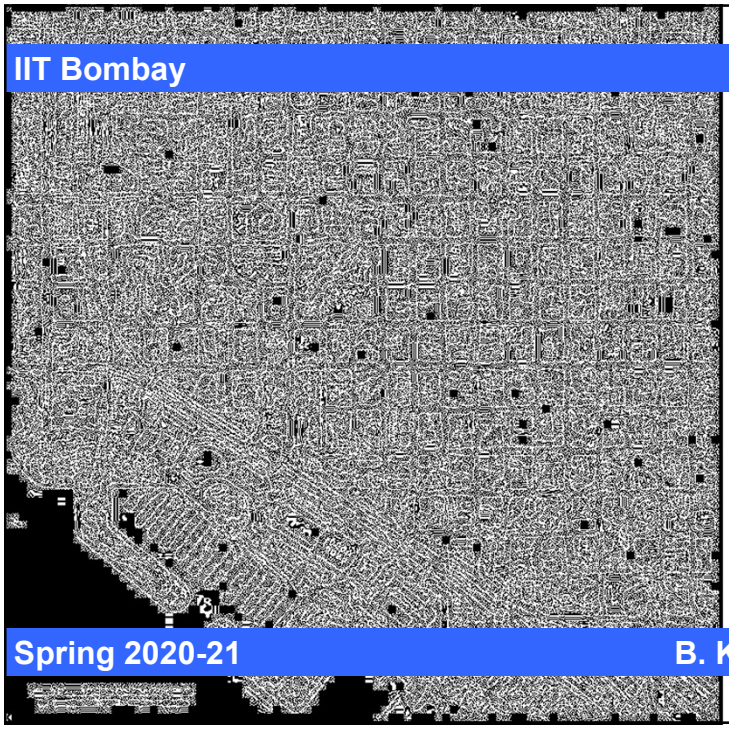

Canny output

Gaussian smoothing

Sigma=2

Hysterisis thresholding

$Thr_{low}=1$

$Thr_{high}=3$

Texture Analysis

- Second order statistics based methods
- Fourier transform domain methods
- Wavelet domain methods
- Other statistical methods

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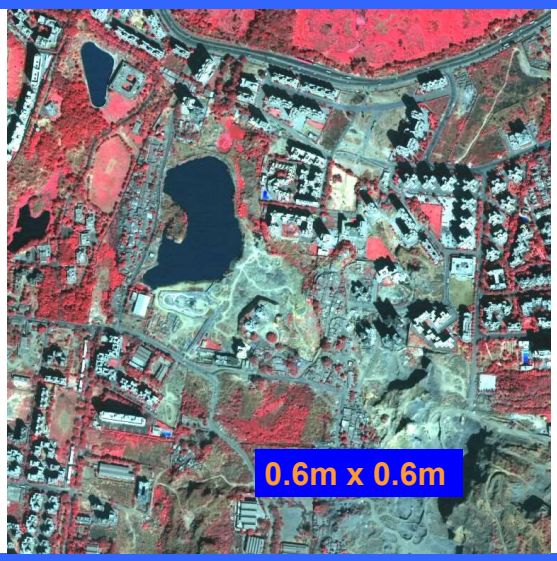
Object Oriented Segmentation

- Modeling an image as a collection of objects
- Decomposing the image into the set of objects by image segmentation
- Generally applied to high resolution satellite images and aerial images
- Computing properties of objects
- Supervised Classification of objects

Object Oriented Segmentation

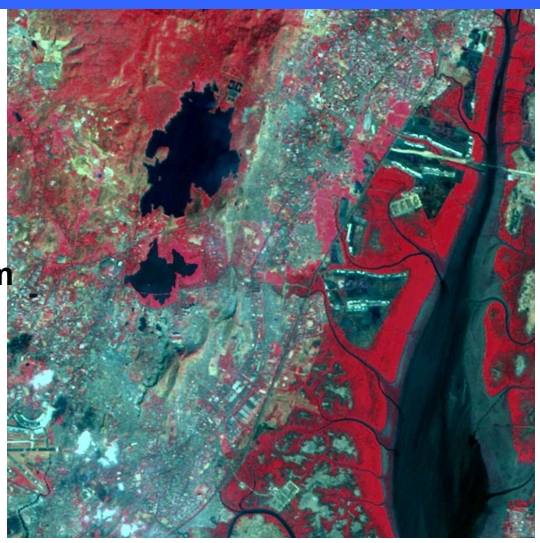
- Unsupervised segmentation imposes conditions of high inter-object variability, low intra-object variability, and (based on nature of problem) smooth and elongated objects (such as roads and canals), compact rectangular objects (such as buildings), circular objects (such as tree crowns) etc.



Partially Supervised Learning

- Ground truth may not be available for some classes
- In case of multitemporal images, ground truth may not be available for all dates
- Partially supervised learning combines labelled and unlabelled data for optimum classification

23.25m x 23.25m



Fusion

- Fusion is a generic term, which may happen at different levels:
  - Data fusion – Merging of multispectral data of lower resolution with panchromatic data of high spatial resolution is one example of data fusion
  - Feature fusion
  - Decision fusion

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Digital Image Compression

- Motivation for image compression
- Predictive image compression
- Transform domain compression
- Wavelet transform based compression
- Current standards – JPEG and JPEG2000
- Evaluation of image compression

This topic is discussed in two stages, one part initially and another part subsequently after relevant background is built up.

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Example

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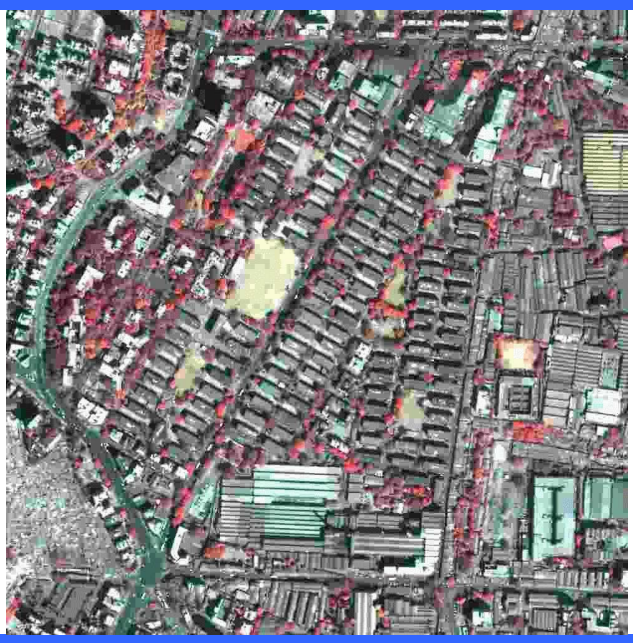
Example After 1:70 com-pression



Fuzzy Set Theoretic Approaches

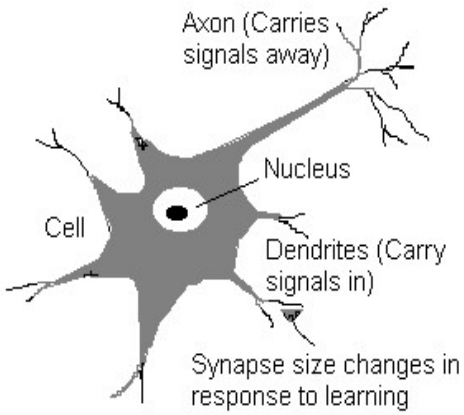
- Concept of Fuzzy Set
- Modeling images in terms of fuzzy sets
- Membership functions
- Modeling the ambiguity in the image in terms of fuzziness indices
- Applications to image processing and classification

Artificial Neural Networks

- Based on a distributed classifier paradigm
- Collection of several simple computing elements networked according to different topologies
- Supervised and unsupervised learning mechanisms
- Applications to image classification

Inspiration from Neurobiology

- A neuron: many-inputs / one-output unit
- Output can be *excited* or *not excited* based on incoming signals from other neurons
- Output subject to attenuation in the *synapses*, which are junction parts of the neuron
- The contribution of the signals depends on the strength of the *synaptic* connection



Issues in neural computing

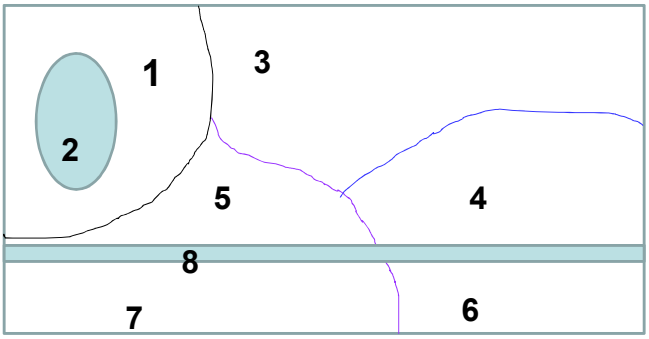
- Network topologies
- Training algorithms
- Ensemble networks
- Modular hierarchical neural networks
- Applications

Contextual Image Classification

- Issues in per-pixel classification
- Role of spatial context in improving per-pixel classification
- Relaxation labeling methods for contextual refinement

Contextual Image Classification

Neighboring classes constrain a region from having any arbitrary class; it has to be consistent with classes present in the neighborhood



Wavelet Transforms and Image processing Applications

- Concept of a wavelet
- Relationship between wavelet and Fourier transforms
- Discrete Wavelet Transform
- Wavelet image processing
  - Noise removal
  - Edge extraction
  - Texture analysis

Genetic Algorithms

- The underlying principle of genetic algorithms is random optimization based on a population of candidate solutions
- Modeled on genetic evolution principles of crossover, mutation and reproduction
- Used in a wide range of image analysis applications

Support Vector Machines

- Concept of a support vector machine
  - Support
  - Vector
  - Machine
- Nonlinear mapping kernels
- Solving SVM optimization problem
- Applications to satellite image classification

Hyperspectral Image Analysis

- Concept of hyperspectra
- Spectroscopic approach
- Image Analysis approach
- Issues in pre-processing
- Feature selection
- Pure pixel (training data) extraction
- Mixture modeling and abundance mapping
- Classification

Change Detection

- Comparison of multitemporal images for identification of change
  - Accurate registration of images
  - Detection of change
  - Location of change
  - Classification of change
  - Computational strategies
  - Features suitable for comparison for different categories of images

Feature Detectors

- Detect edges, corners, and key points that can be detected irrespective of scaling, rotation and translation
- Harris corner detector
- Histogram of oriented gradients
- SIFT

Deep Learning

- Advanced tools for supervised and unsupervised classification
- Comparison to basic classifier

To be continued …