Satellite Image Processing and Analysis

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About CSRE

- Centre of Studies in Resources Engineering at IIT Bombay offers M.Tech. and PhD programmes in the area of Geoinformatics and Natural Resources Engineering
- Started as a Centre of Excellence in 1976 to conduct research and development in remote sensing, GIS, satellite image processing and applications to natural resources exploration and management
- Became a full fledged teaching Centre in 2005
CSRE Faculty Specializations

- Faculty members drawn from multitude of disciplines –
  - Mathematics
  - Physics
  - Electrical Engg.
  - Computer Science
  - Civil Engg.
  - Earth Sciences
  - Agriculture and Soil Sciences
  - Analytical Chemistry
CSRE Research Areas

- **Theory and Algorithms**
  - Optical, Microwave and Hyperspectral Remote Sensing
  - GPS, GI Systems and GI Science
  - Satellite Image Analysis, Stereo vision

- **Applications**
  - Terrain Evaluation and Landuse Planning, Drought
  - Urban Planning, Environment and Applications
  - Surface and Ground Water
  - Snow/Ice mapping
  - Rural Development
  - Agro-informatics and Precision Farming
  - Avalanche and Landslide studies
  - Mineral Systems Studies
AIRBORNE
NATURAL
COLOR
COMPOSITE
Selected Problems in Multispectral Image Analysis

- **Image Segmentation**
  - Texture Analysis – fractal/Radon transform based
  - Edge /line Detection – morphological/neural

- **Image Classification**
  - Neural Network Classification
  - Genetic Algorithm Pre-processing / Contextual Post-processing
  - Fuzzy Integration for ensemble classifier Combination
Fractal Textural Classification

IRS1C PAN Image
Linear features mixed with building outlines
Overlay of Linear feature network on classified image
Radon Principle

Basic Pattern

Radon Spectrum

Sand dunes – IRS1B

Radon Texture
Selected Problems

- **Image Compression**
  - Rate constrained JPEG for custom rate of compression
- **Change Detection**
  - Super-pixel approach
  - Texture based approach
Quantization Tables

```
    1 1 1 1 1 2 3 5
    1 1 1 1 1 2 3 5 5
    1 1 2 2 3 5 5 7
    1 2 2 3 5 5 6 7
    2 2 3 4 6 6 7 23
    2 3 4 6 6 7 20 32
    3 4 6 6 9 16 38 68
    4 6 6 12 15 65 67 71
```

Uncompressed MUMBAI (11 BIT)  CR = 3.5

CR = 6

CR = 9.5
High Spatial Resolution Image Analysis

- Development of a Generic Framework
  - Complete System to address requirements of high spatial resolution image analysis

- Development of tools
  - Segmentation
  - Component Labeling
  - Feature Computation
  - Classification
Generic High Spatial Resolution Image Analysis Framework

Pre-process

Decompose image

Segment image at Different Resolutions

Link Segments

Connected Comp. Labeling

Spatial Features

Spectral Features

Texture Features

Context

Object Specific Classification

General purpose LU/LC classification

Single stage segmentation
Building Extraction

Road Extraction

General Image Segmentation and Classification
Hyperspectral Image Analysis

- Development of a Generic Framework
  - System to address requirements of high spatial resolution image analysis
- Development of selected tools
  - Dimensionality Reduction
  - Classification
- Ongoing work
  - Search Techniques for Feature Selection
  - Super-resolution
Hyperspectral Image Window and Spectrum of Vegetation near Powai Lake
High Spectral Resolution Image Analysis

- Dimensionality Reduction
- Pure Pixel / Training Data Identification
- Supervised Classification
- General Purpose classification
- Atmospheric Correction
- Mixture Modeling
- Spectral Matching
- Classification
- Abundance Mapping
- Spectral libraries

High spectral resolution image
Kernel Classification

- Class 1 Black – Water
- Class 2 Blue – Barren land
- Class 3 Green – Vegetation
- Class 4 Red – Moist land
- Class 5 Yellow – Vegetation 2
Educational Content Development

- Multimedia Image Processing Tutor
  - Content
  - Demonstrations
  - Resources
  - Dedicated Image Processing Package
- Virtual Lab
  - Collection of software experiments
  - Cover theory, procedure, execution and self-assessment
  - Optical/infrared part ready
  - Work in progress on SAR
  - Work on Hyperspectral Image Analysis at planning stage
- http://vlabs.ac.in/siplabs (also,
  - http://virtual-labs.ac.in/siplabs)
Aim of Experiment

1. Viewing images in different bands
2. Contrast Enhancement
3. Smoothing
4. Principal Component Analysis
5. Edge Detection
6. Discrete 2D Fourier Transform
7. Mathematical Morphology
8. Indices
9. K-Means Clustering
10. Color Transform

To get edge magnitude image from the corresponding input raw satellite image or image with general formats through various edge operators such as Robert operator, Sobel operator, Prewitt operator, etc.
DIGITAL IMAGE PROCESSING FOR REMOTE SENSING

Subject Content
- Basic concepts of DIP for RS
- Advanced concepts of DIP for RS (35 chapters)

Animated Demo
- FCC Enhancement
- Filtering
- Classification
- Compression

Hands-on Software
- ReSIPro Software

Additional Resources
- Links to online resources
- List of books, journals and IP products
- Case studies

Glossary and Exercises
- RS and IP terminology
- Hands-on with ReSIPro for IP exercises

Key features: 1. Relevant to typical university syllabi; 2. More than an awareness CD; 3. Useful as a detailed self-study material; 4. Self-contained with software, demonstrations, case studies, sample data, references, links to online resources, hands-on exercises and self-assessment quizzes and suggested student projects.
Educational Outreach

- Introductory Short Term Courses for College Teachers
  - Basic Course to expose potential of remotely sensed images
  - Introductory Satellite Image Processing
  - Hands-on Sessions

- Advanced Courses for College Teachers
  - Modern Tools like Neural Networks, Support Vector Machines
  - Image Segmentation Tools
  - Multiresolution Image Analysis
  - Image Registration and Change Detection
Educational Outreach

- Invited Lectures in different colleges/universities
  - Introduction to satellite image processing
  - Texture analysis methods
  - Image classification techniques
  - Image compression for spaceborne applications
  - Neural Networks, Support Vector Machines
  - Image Segmentation
  - Hyperspectral image analysis
GIS Related Research

INDIGENOUS TECHNOLOGY APPLICATION RESEARCH
GIS Related Research

- Geospatial Data Security
  - Vector data watermarking
  - Raster data watermarking
Challenges

- Vector data watermarking
  - Strategies for point, line and polygon layers
  - Determining capacity of a layer for watermarking
  - Single and multiple watermarking
Challenges

- Raster data watermarking
  - Efficient data structures for handling large sized spatial data
  - Single and multiple watermarks
  - Strategy for multiple watermarking
Summary

- CSRE is a vibrant academic unit of IIT Bombay
- Research and development in the multidisciplinary area of geospatial technologies
- Extensive user of IRS series data of all types
- Applications to natural resources, environment, engineering problems, disaster management
- Capacity building
- Active industry interaction through consultancy
- Bright students for M.Tech. and PhD are welcome!
THANK YOU!