GNR607 Principles of Satellite Image Processing

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IIT Bombay

Lecture – 1 Course Overview

- Introductory course
- Assumes no background in signal / image processing
- Desired – basic knowledge of linear algebra, probability and random variables, vectors and vector spaces, basic concepts in linear systems

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Assessment Pattern

- Quizzes
- Assignment(s)
- Examinations

The details will be informed later

80% minimum attendance in the course is compulsory, otherwise

DX grade may be given irrespective of performance in exams and assignments

Course Team

PhD students

Koushikey Chhapariya – koushikey.chhapariya@iitb.ac.in

Archana Pai – archanagpai@iitb.ac.in

M.Tech. II Year students

There will be 2-3 M.Tech. students whose email addresses will be shared with you later

Learning Outcomes from the Course

- Basic knowledge of satellite image processing
- Satellite image handling
- Referencing to a ground reference system
- Display and improving visual quality of images
- Image smoothing and sharpening
- Mathematical transformations to facilitate efficient processing
- Retrieving useful indices
- Extracting quantitative information by classification
- Assessing accuracy of operations, monitoring changes
- Writing programs to process satellite images

Text and Reference Material

1. Richards, J.A. and X. Jia, *Remote Sensing Digital Image Analysis,* 4th ed., Springer-Verlag, 2006

2. Gonzalez, R.C. and Woods, R.E., *Digital Image Processing,* 4th ed., Pearson Education, 2018

3. Jensen, J.R., *Introductory Digital Image Processing A Remote Sensing Perspective,* 4th ed., Pearson Education, 2016

4. *http://www.imageprocessingplace.com*

5. *http://geoinfo.amu.edu.pl/wpk/rst/rst/Front/overview.html*

6. *http://www.ccrs.nrcan.gc.ca*

7. *https://webapps.itc.utwente.nl/sensor/default.aspx?view=allsensors*

E-Resources

1. https://www.itc.nl/library/papers_2009/general/principlesremotesensing.pdf
2. https://www.itc.nl/library/papers_2009/general/principlesgis.pdf
3. https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/pdf/resource/tutor/fundam/pdf/fundamentals_e.pdf
4. http://giswin.geo.tsukuba.ac.jp/sis/tutorial/koko/remotesensing/FundamentalRemoteSensing.pdf (booklet)
5. http://www.gdmc.nl/oosterom/PoRSHyperlinked.pdf
6. http://www.intechopen.com/books/land-applications-of-radar-remote-sensing/estimation-of-cultivated-areas-using-multi-temporal-sar-data
7. https://www.nrsc.gov.in/Knowledge_EBooks

Resources Specific to GNR607

1. **https://www.cdeep.iitb.ac.in/previous_courses.php** **(IIT Bombay's archive of video-recorded courses, available through Idap userid and password. Contains video-recording of Autumn 2014 version of this course.**

2. **Last year's course videos will be made available from a suitable location like Google drive or Microsoft One Drive. Details will be communicated shortly**

Mode of Interaction

- Lecture materials (or their links) will be available on
http://moodle.iitb.ac.in
- Use your login and password to get access to lecture materials
- Regular interaction sessions for which details will be announced in due course

ALL DOUBTS/QUERIES/COMMENTS MAY BE POSTED ON MOODLE FOR COMMON BENEFIT;RESPONSE ALSO ON MOODLE

Overview of the Course

1. Introduction to remote sensing and image processing
2. Mathematical Preliminaries
3. Image display and corrections
4. Image enhancement and filtering
5. Mathematical Morphology

6. Image Transforms – Fourier, Color, Principal Component, Hough
7. Texture analysis methods
8. Feature selection and classification
9. Accuracy analysis Techniques
10. Change detection approaches

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Remote Sensing

- Motivation

  – **Images of natural resources such as forests, waterbodies, oceans, soils and hills/mountains are collected by spaceborne sensors**

  – **The governing principle is remote sensing**

  – **Important to understand the choice of sensors, their operation and role of atmosphere to understand the digital image and evolve its processing strategy**

Sample Image
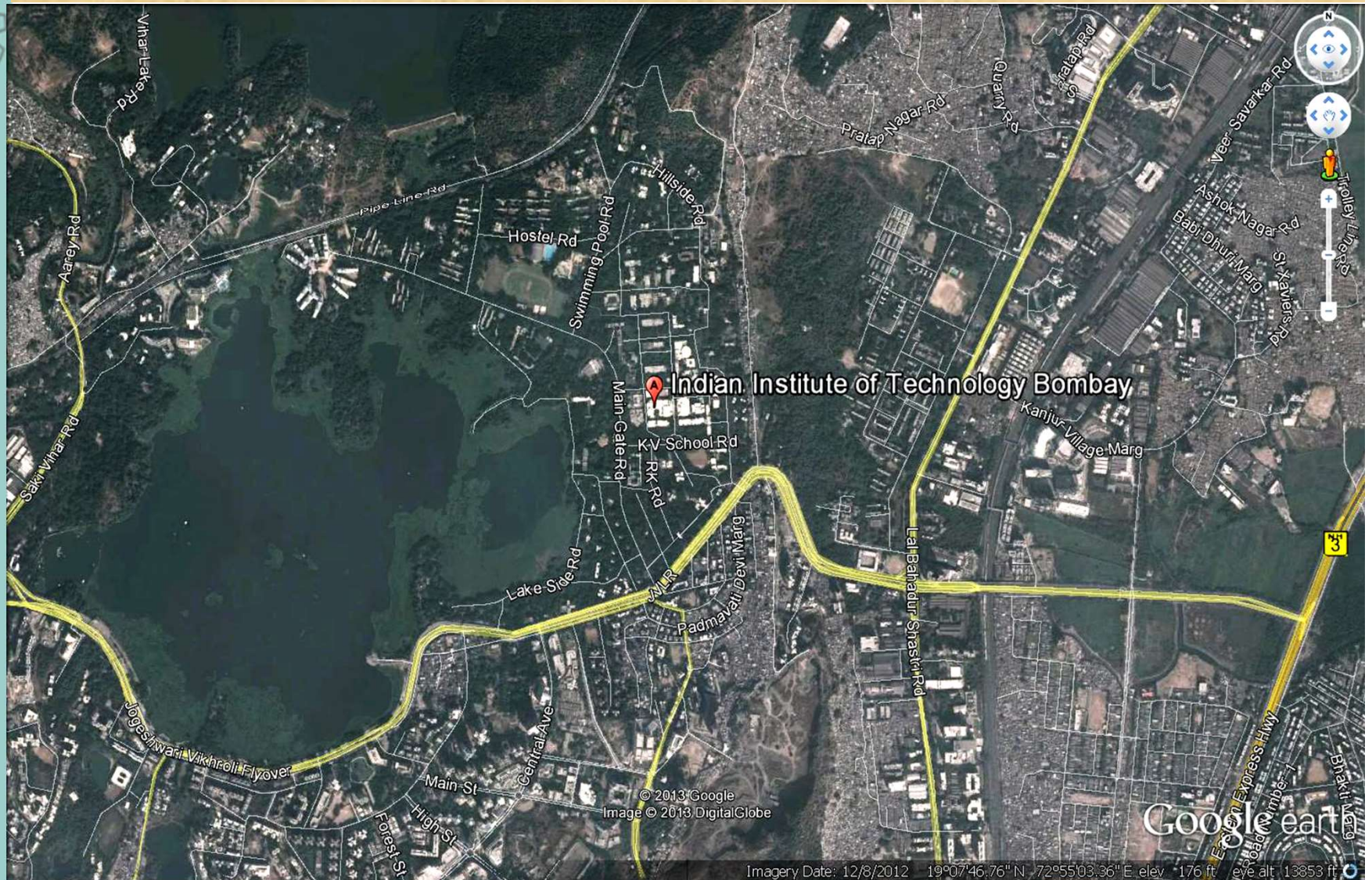
Enlarged View of Previous Image

Remote Sensing

Definition

Remote sensing is the art and science of making measurements about an object or the environment without being in physical contact with it

Image Processing

- **Motivation**
  - Most remote sensing data collected in digital form
  - Digital image processing essential to analyze and extract information
  - Some image processing operations common across domains, some unique to remote sensing
  - An important distinguishing factor - huge data volume, no video, only still images from space

Image Corrections

- **Motivation**
  - Various types of distortions are introduced into the images due to atmosphere, satellite motion, earth rotation and curvature
  - Distortions are modeled and corrected prior to the use of the images
  - Essential for practical use of images, for preserving shape and area of objects on Earth

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Image Enhancement

- **Motivation**

  - Good contrast and brightness essential for visually appreciating the content

  - Image display is modified to improve or enhance the visual quality

  - Often this operation is performed in real time, and users often get a set of options for different types of image enhancement

Neighborhood Operations

- **Motivation**
  - Groups of points are considered together for processing
  - Necessary to suppress sensor or atmosphere induced noise in data
  - Useful to sharpen the image
  - Required to extract boundaries of objects as well as lines from images

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Mathematical Morphology

- **Motivation**
  - **Morphology is the study of form or shape**
  - **Mathematical morphology deals with set theoretic and other mathematical operations to deal with shapes or forms in images**
  - **Useful to perform structure based image analysis**
  - **Powerful tool to highlight object features like smoothness, roughness and so on**

Image Transforms

- **Motivation**

  – Image transformations facilitate certain types of processing operations

  – Can be better for visualizing the color, frequency and other information in a transformed domain

  – Information extraction sometimes is easier through transformations

Texture Analysis Techniques

- **Motivation**
  - **Texture – perceptual attribute of human vision**
  - **Texture can be used to distinguish between objects in image**
  - **Derived feature, to supplement satellite collected data. Very handy when objects are of the same color or shape or size.**
  - **Perceived by humans through vision, touch, taste, and auditory senses**

Feature Selection Methods

- **Motivation**
  - Features are descriptors for each object or each pixel in the image based on which it can be classified as *water / vegetation / cloud / road / building …*
  - Selection and evaluation of features essential for success of digital image classification
  - Rich feature set facilitates sophisticated image analysis processes

Image Classification Methods

- **Motivation**
  - To assign each point in the image to a category or *class* of our interest
  - Guided by statistical procedures that allow estimation of probability of pixel to belong to each class; highest class probability suggests pixel should be assigned to that class

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Accuracy Assessment Techniques

- ## Motivation

  - ### Analysis of satellite images can lead to practically useful outputs

  - ### Before deploying these outputs, accuracy assessment is essential

  - ### Numerical estimates and issues involved – conservative estimate or optimistic estimate?

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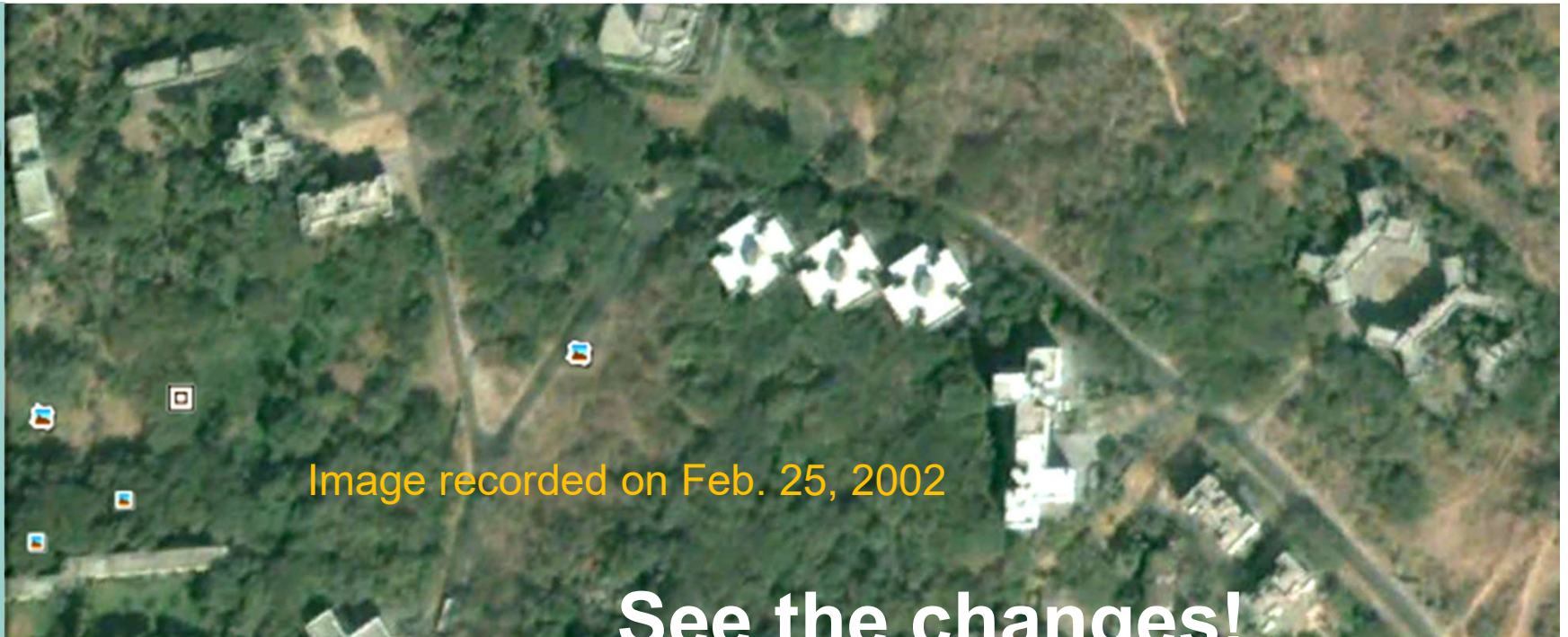
Change Detection

- **Motivation**

  – **Changes on the ground need to be detected and categorized as *what changed*, and *from what to what***

  – **Essential in military, urban and rural planning, afforestation / deforestation, crop monitoring …**

Image recorded on Feb. 25, 2002

See the changes!

Image recorded on Feb. 25, 2015

I live in this bldg. Not there in 2002!

To be continued …