Pre-Symposium Tutorial on "Hyperspectral Remote Sensing and its Applications"

December 6, 2016

Abstract

Hyperspectral remote sensing is an emerging, multidisciplinary field with diverse applications that builds on the principles of material spectroscopy, radiative transfer, imaging spectrometry, and hyperspectral data processing. Hyperspectral remote sensing deals with measurements in a large number of narrow spectral bands over a contiguous spectral range. Because of its ability to detect narrow absorption features hyperspectral data are related to specific vegetation physico-chemical characteristics, ocean biological constituents, soil physical and chemical properties, mineral composition and snow characteristics. Land management issues, such as mapping tree species, recognizing invasive plants, and identifying key geologic features, require an understanding of complex technical issues before the best decisions can be made. Hyperspectral remote sensing is one of the technologies that can help with reliable detection and identification.

However, because of presence of a large number of bands, hyperspectral data needs different analysis approach including feature reduction, feature selection, removal of noise, detection of absorption features, classification and modelling for retrieval of bio-geo-chemical parameters. Before any user starts using hyperspectral data, it is also essential to understand basic physical principles behind spectral features of different targets, data collection procedures and the techniques involved in different image processing approaches.

This tutorial will make the participants aware about hyperspectral remote sensing, hyperspectral data processing and its applications. Tutorial will have ten sessions. While the forenoon sessions will mainly be focused on topics related to hyperspectral remote sensing and processing techniques; the afternoon sessions will focus on application of hyperspectral data in five application areas as well as demonstration of hyperspectral data processing.

First session

Hyperspectral remote sensing is considered as emerging tool suited for the identification of target materials as they can distinguish them primarily by narrow spectral features. This session includes principle of hyperspectral remote sensing and concept of imaging spectroscopy. Due to its capability to detect narrow absorption features for characterizing earth surface features its important to understand various causes of absorption features. Providing comparison of hyperspectral remote sensing with multispectral remote sensing. This session will also include a brief overview of hyperspectral data processing and its processing tools.

Second session

Hyperspectral sensors collect information as a series of narrow and contiguous wavelength bands at 10 to 20 nm intervals which enables detection and identification of minerals, terrestrial vegetation, man-made materials and backgrounds. These sensors

are able to provide unprecedented spectral and radiometric excellence in the data sets and attained a high level of performance in its operational stability. This session will cover historical background of hyperspectral remote sensing as well as various airborne, space borne and ground based hyperspectral sensors and their characteristics.

Third session

This session will deal with the preprocessing of hyperspectral data. The preprocessing includes the sensor error correction such as bad columns, bad band corrections, and atmospheric corrections (includes different atmospheric models FLAASH, QUAC).Data dimensionality reduction techniques includes the reduction of data both spectrally (MNF, ICA) and specially (PPI) to identify the pure pixels for the classification.

Fourth session

One objective of hyperspectral data processing is to classify collected imagery into distinct material constituents relevant to particular applications, and produce classification maps that indicate where the constituents are present. Such information products can include land-cover maps for environmental remote sensing, surface mineral maps for geological applications and precious mineral exploration, vegetation species for agricultural or other earth science studies, or manmade materials for urban mapping. The fourth session will cover hard and soft classification algorithms, role of indices for hyperspectral data as well as accuracy assessment methods for hard and soft classified outputs.

Fifth session

The identification of individual tree species/community has long been of interest using field spectro-radiometric techniques. The different spectral response patterns can typically be related strongly to tree species differentiation (color, leaf morphology, canopy morphology). Species vary by leaf angle, crown structure and color and hyperspectral data is more suitable to identify fine spectral differences. Hyperspectral imagery can be used to classify forest cover based on species composition and foliar chemical characteristics. Hyperspectral imagery can be used to derive estimate of foliar chlorophyll and foliar nitrogen concentrations. Ecological research is likely to benefit from the increased spectral resolution that hyperspectral remote sensing can provide.

Sixth session

In the field of mineral exploration, remote sensing has significant contribution such as mapping of geological faults and fractures and host rock that localize ore deposits based on their spectral signatures. However a major limitation of using remote sensing approaches to mineral exploration with broad-band multispectral sensors is the insufficient spectral resolution to map hydrothermal alteration minerals, which exhibit subtle differences in spectral signatures at narrow band width in electromagnetic spectrum. The advent of new hyperspectral sensor technology, in terms of both sensor and technique development, has provided opportunity to revisit previous remote sensing approaches to mineral exploration as well as development of improved methods. This

session will explain the use of hyperspectral remote sensing for the geological applications such as identification and mapping of minerals.

Seventh session

The remote sensing technique has been known for providing spatial and temporal information of natural resources. Its application in the field of water quality monitoring and assessment is at nascent stage. With the advancement in the field of sensor technology such as "hyperspectral sensors", remote sensing provides great opportunity to assess and monitor water quality of surface water bodies. The substances in the surface water significantly change the backscattering characteristic. Remote sensing techniques depend on the ability to measure these changes in the spectral signature backscattered from water and relate these measured changes by empirical or analytical models to a water quality parameter. The optimal wavelength used to measure a water quality parameter is dependent on the substance being measured, its concentration, and the sensor characteristics. In similar line, attempts have been made to analyse snow physical parameter like snow grain size mapping using hyperspectral data.

Eighth session

The morphology of cities is very complex spatially due to immense heterogeneity in their structure. With time, the conditions are changing at fast pace within the urban canopy due to changing environments, human movements, and reconstruction and technological advancements. Knowledge about chemical compositions and radiative properties of both novel and older construction materials is required to ensure about their dynamic impacts. This session talks about Hyperspectral Remote Sensing for urban applications for land cover classification based on a priori knowledge about materials' spectral characteristics.

Ninth session

Hyperspectral remote sensing provides near laboratory quality reflectance spectra of each single pixel which helps to extract vital information regarding the chemical constitution of the various materials including soil constituents. Studying the peculiar spectral absorption and reflectance features helps for predictive modelling and quantification of various soil properties like soil salinity, organic matter content, soil clay mineral composition, soil pollution etc. These approaches will help for better assessment of various soil degradation processes as well as soil quality.

Tenth session

Several hyperspectral tools are developed for information extraction from hyperspectral remote sensing data which often includes large data sets. This session will cover demonstration on hyperspectral data processing which includes pre-processing (sensor and atmospheric error correction), spectral library generation and classification of hyperspectral data using ENVI software.

Outline of the Tutorial

Coordinator: **Speakers/ Resource Persons:**	**Time (Hrs)**	**Resource Persons**
First Session: Hyperspectral Remote Sensing (HRS): An Overview and Applications - Principle of Hyperspectral Remote Sensing (HRS) - Terrestrial, Airborne and Space borne HRS - Causes of absorption, - Multispectral Vs Hyperspectral, - Overview of hyperspectral data processing, - Hyperspectral data processing softwares - Limitations of hyperspectral data - ISRO Program on HRS Imaging	9:30-10:15	Dr. A. Senthil Kumar/ Shri. Vinay Kumar
Second Session: Hyperspectral remote sensing: Platform and sensors - Past, Present and Future HRS sensors, - Airborne hyperspectral sensors, - Spaceborne (Earth and Extra-terrestrial) hyperspectral sensors, - Ground based hyperspectral sensors - Future ISRO hyperspectral Sensors and their characteristics	10:15-11:00	Shri Samudraiah/ Mrs. Shefali Agarwal
Tea Break (11:00-11:15)		
Third Session: Hyperspectral Image Pre-processing - Sensor error calibration - Atmospheric correction (relative and absolute) - Data Dimensionality reduction - Endmember selection	11:15-12:15	Mrs. Richa U Sharma / Mrs. Manu Mehta
Fourth Session: Optical and Thermal Hyperspectral Image Classification - Pixel based hard classification algorithms - Pixel based soft classification algorithms - Role of Indices for hyperspectral data classification – showcase of in-house tool - Accuracy assessment methods – hard and soft output	12:15-13:15	Dr. Anil Kumar
Lunch Break (13:15-14:00)		
Fifth Session: Hyperspectral Remote Sensing for Forestry Applications - Plant species/community level detection and discrimination. - Canopy chlorophyll estimation. - Foliar nitrogen content estimation. - Plant stress detection.	14:00-14:30	Dr. Subrata Nandy/ Dr. Hitendra Padalia

- Vegetation spectral library		
Sixth Session: Hyperspectral remote Sensing for Geological Applications - Spectra of minerals and their diagnostic absorptions - Mineral Mapping using hyperspectral data - Planetary HRS - Case studies, Planetary Geology	14:30-15:00	Mrs. Richa U Sharma/Dr. Shovan Lal Chattoraj
Tea Break (15:00-15:15)		
Seventh Session: Hyperspectral Remote Sensing for Water and snow cover Studies - Water Quality Mapping - Water Depth - Snow Physical Parameters - Soil Moisture Mapping	15:15-15:45	Dr. Vaibhav Garg/Dr. Praveen Kumar Thakur
Eighth Session: Hyperspectral Remote Sensing for Urban Studies - Road extraction and mapping - Extraction of Impervious surfaces - Hyperspectral classification for urban areas	15:45-16:15	Ms. Asfa Siddiqui/Dr. Vandita Srivastava
Ninth Session: Hyperspectral Remote Sensing of Agriculture and soil Studies - Soil Salinity Studies - Soil Quality Studies - Crop /Crop Stress related studies	16:15-16:45	Shri. Justin George K/Dr S K Saha
Tenth Session: Demonstration on Hyperspectral data processing followed by Summary and Discussion - Sensor error correction (Bad band & bad column removal) - Atmospheric correction using FLAASH - Creation of Spectral Library - Classification using Spectral Angle Mapper (SAM)	16:45-17:30	Shri. Vinay Kumar

Organizer and Speaker(s):

	**Arumugam Senthil Kumar** received his MSc (Engg.) and PhD from IISc, Bangalore, in 1985 and 1990 respectively. He joined ISRO in 1991 at Space Applications Center, Ahmedabad. In 2002, he joined NRSC at Hyderabad as Group Director. He had been focal point for Chandrayaan-1 Data quality assessment of ISRO's electro-optical payloads and also co-principal investigator for a Moon Mineral Mapper (M-cube) developed by NASA. He joined IIRS as Director on February 23, 2015.
	**D.R.M. Samudraiah** did his post-graduation in Physics from Andhra University and joined Space Applications Centre, ISRO, Ahmedabad, in 1976. He started his carrier with Bhaskara-1, the first RS satellite and contributed in the development of more than 50 sensors for observing Earth, Moon and Mars. Post retirement as Deputy Director of Sensor Development Area in 2013, he guided the teams as Prof Satish Dhawan Scientist for 2 years. He is life member of ISRS, ISG, IMSA, INCA, ASI and SSME and contributed as vice president of ISRS.
	**Sudip Kumar Saha** received his M. Sc. and Ph.D in Agricultural Science from Indian Agricultural Research Institute (IARI), New Delhi, in 1979 and 1983 respectively. He joined ISRO in 1983 at SAC, Ahmedabad and later joined IIRS in 1985. He was former Dean (Academics) and Group Director of RS & GIS Applications Group. His research interests include monitoring and quantitative assessment soils and agro-ecosystems resources & processes. Presently he is Emeritus Professor of CSSTEAP Affiliated to UN, Dehradun.
	**Anil Kumar** is Scientist/Engineer-'SF' at Indian Institute of Remote Sensing (IIRS), ISRO, Dehradun, India. He received his B.Tech degree in Civil Engineering from University of Lucknow, India and M.E. degre as well as inservise part time Ph.D in soft computing from Indian Institute of Technology, Roorkee, India. His current research interests are in the area of Soft computing, Digital Photogrammetry, GPS and LiDAR.
	**Hitendra Padalia** is a faculty of Forestry and Ecology Department at Indian Institute of Remote Sensing (IIRS), Dehradun. He possess M. Sc. and Ph.D. degree in forestry from Forest Research Institute (FRI), Dehradun. His research interests include biophysical and biochemical parameter retrieval of vegetation canopies using in-situ and satellite hyperspectral remote sensing and ecological modelling.

	**Vandita Srivastava** is Scientist/Engineer-'SE' at Indian Institute of Remote Sensing (IIRS), ISRO, Dehradun, India. She received her M.Sc. Physics (with distinction) from Dayalbagh Educational Institute, Dayalbagh University Agra, and in-service part time PhD in automating the information extraction from high resolution images from Indian Institute of Technology, Roorkee, India. Her research interests include geospatial modelling, information extraction, spatio temporal analysis, and geoinformation management.
	**Praveen K. Thakur** is Scientist/Engineer-'SE' and faculty member of Indian Institute of Remote Sensing (IIRS), Dehradun. He has been working in SAR based inversion models, DinSAR, Altimeters, hyperspectral and passive microwave applications in water resources and hydrology for the last 12 years. His research areas are in snow and flood hydrology, hydrological modeling, glacier and ice sheet dynamics, dynamic downscaling, data assimilation, flood early warning, groundwater modelling and remote sensing based planetary hydrological studies.
	**Vaibhav Garg** is Scientist/Engineer 'SD' at Indian Institute of Remote Sensing (IIRS), ISRO, Dehradun, India. He is basically a Civil Engineering graduate, he did his masters from MNIT Jaipur with specialisation Water Resources Engineering. He did his phD from Civil Engineering Department, Indian Institute of Technology Bombay, Mumbai, India. His current field of intrest is surface water hydrology and water quality studies.
	**Vinay Kumar** is Scientist/Engineer 'SD' at Indian Institute of Remote Sensing (IIRS), ISRO, Dehradun, India. He received his B.E degree in Mining Engineering from BIT Sindri and M.Tech. degree in Geomatics Engineering from IIT Roorkee. His research interest is in the area of Hyperspectral Remote Sensing (HRS), including automatic end member extraction, simulation of HRS data from multispectral data and fusion of HRS and SAR data.
	**Subrata Nandy** is Scientist/Engineer-SD at Forestry and Ecology Department of Indian Institute of Remote Sensing, ISRO, Dehradun. He received M.Sc. and M.Phil. degree in Ecology from Assam University, Silchar, Assam and Ph.D. degree in Forest Informatics from Forest Research Institute University, Dehradun. His research interests are Forest biomass/carbon assessment, Forest ecology and LiDAR remote sensing in forestry.
	**Manu Mehta** is Scientist/ Engineer-SD at Photogrammetry and Remote Sensing Department of Indian Institute of Remote Sensing, ISRO, Dehradun. She received her M. Tech. degree in Optoelectronics and Optical Communication from Indian Institute of Technology, Delhi. Her current interests include aerosol remote sensing over land and ocean, spatio-temporal analysis, radiative transfer modelling and aerosol retrieval from satellite data.

	**Shovan Lal Chattoraj** is Scientist/Engineer-SD at Geosciences and Disaster Management Science Group of Indian Institute of Remote Sensing, ISRO, Dehradun. He received M.Sc. degree in Geology from Burdwan University, West Bengal and Ph.D. degree in Sedimentary Geochemistry from Indian Institute of Technology Bombay. His current research interests are Hyperspectral Remote Sensing, Mineral Exploration, Spectroscopic characterization of Minerals and Geochemistry, Metallogenesis, Spectral library (Technology) and Engineering Geology, Numerical modeling and simulation of Debris flow, Slope Stability (Application).
	**Richa U Sharma** is Scientist/Engineer-'SD' at Indian Institute of Remote Sensing (IIRS), ISRO, Dehradun, India. She received her B.Sc in Maths Physics, Geology and MSc. in Geology from Govt. Holkar Science College, Indore and Diploma in Geoinformatics form IIRS- ITC joint programme. Her current research interest is hyperspectral remote sensing in geological applications.
	**Asfa Siddiqui** is Scientist/Engineer-'SD' in Urban and Regional Studies Department, IIRS, Dehradun. She did her Bachelors in Architecture from Govt. College of Architecture, Lucknow and Masters in Urban Planning from School of Planning and Architecture, New Delhi. She has also worked in NIT Calicut prior to joining ISRO. Her reesearch interests are in areas of Hyperspectral Remote Sensing, Growth Modeling, Smart Energy and Environment.
	**Justin George K** is Scientist/Engineer – SC at Indian Institute of Remote Sensing (IIRS), ISRO, Dehradun, India. He received his Bachelor's degree in Agriculture from Kerala Agricultural University, India and Master's degree in Soil Science and Agricultural Chemistry from Indian Agricultural Research Institute, New Delhi. His current research interests are in areas of Soil resource Inventory, Land Degradation and Hyperspectral Remote Sensing in Soil studies.