Distance Learning Course on 'Hyperspectral remote sensing and its Applications'
Indian Institute of Remote Sensing (ISRO), Dehradun
18th to 21st September, 2017

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 physio-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 course will make the participants aware about hyperspectral remote sensing, hyperspectral data processing and its applications. This course will have thirteen sessions. First to eighth sessions will mainly be focused on topics related to hyperspectral remote sensing, ground spectro-radiometer and processing techniques; while ninth to thirteenth sessions will focus on application of hyperspectral data in five application areas.

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 Hyperspectral remote sensing capability to detect narrow absorption features for characterizing earth surface features, its important to understand various causes of absorption features and providing comparison of hyperspectral remote sensing with multispectral remote sensing. This session will include a brief overview of hyperspectral remote sensing, Multi-spectral verses with hyperspectral remote sensing, overview on 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
The hyper-spectral data is subject to radiometric errors which can be at sensor level, random errors, striping, bad bands, smile effect etc. Atmosphere, also on other hand, introduce noise in the images, thereby affecting the data quality. To this end, this session will deal with pre-processing of hyperspectral data. The pre-processing includes the sensor error correction such as bad columns, bad band corrections, and atmospheric corrections, includes different atmospheric models FLAASH, QUAC.

Fourth 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).

Fifth session
This session will cover data dimensionality reduction techniques including the reduction of data, both spectrally with MNF, ICA and specially using Pixel Purity Index to identify pure pixels for the classification.

Sixth 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, surface mineral maps, vegetation species for agricultural or other earth science studies, or manmade materials for urban mapping. This sixth session will cover hard and soft classification algorithms, role of indices for hyperspectral data as well as accuracy assessment methods while focusing on specific class extraction.

Seventh session
This session covers about demonstration on ground spectro-radiometer for spectral data collection of various earth surface features. This session also includes generation of spectral library collected using spectro-radiometer and spectral resampling of spectral library with respect to pre-processed hyperspectral image.

Eighth session
This session covers about land cover classification of hyperspectral data with the help of collected ground spectra using per pixel (Spectral Angle Mapper) and sub pixel (Linear Spectral Unmixing) techniques in the ENVI software.

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

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.

Eleventh 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.

Twelfth 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.

Thirteen 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.

Outline of the Course

Coordinator: **Speakers/ Resource Persons:**	**Time (Hrs)**	**Resource Persons**
Day 1 (18.09.2017)		
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	11:00-12:00	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 - ISRO Program on HRS Imaging - Future ISRO hyperspectral Sensors and their characteristics	12:00-13:00	Shri. Vinay Kumar
Lunch Break (13:00-14:00)		
Third Session: Hyperspectral Image Pre-processing - Radiometeric errors (sensor, atmospheric related) - Bad band and bad column removal - Atmospheric correction (relative and absolute)	15:00-16:00	Mrs. Manu Mehta
Fourth Session: Demonstration on Hyperspectral Data Pre-processing - Sensor error correction (Bad band & bad column removal) - Atmospheric correction using FLAASH	16:00-17:00	Shri. Vinay Kumar
Day 2 (19.09.2017)		
Fifth Session: Data dimensionality reduction - Data Dimensionality reduction - Endmember selection	11:00-12:00	Mrs. Richa U Sharma

Sixth 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	12:00-13:00	Dr. Anil Kumar
Lunch Break (13:00-14:00)		
Seventh Session: Demonstration on spectro-radiometer and spectral library creation - Spectral Data collection using ground spectro-Radiometer - Creation of Spectral library	15:00-16:00	Shri. Vinay Kumar
Eighth Session: Demonstration on Hyperspectral data classification - Classification using Spectral Angle Mapper (SAM) and Linear Spectral Unmixing (LSU)	16:00-17:00	Shri. Vinay Kumar
Day 3 (20.09.2017)		
Ninth Session: Hyperspectral Remote Sensing for Agriculture and soil Studies - Soil type Studies - Soil fertility Studies - Crop related studies	11:00-12:00	Shri. Justin George K
Tenth Session: Hyperspectral Remote Sensing for Forestry Applications - Plant species/community level detection and discrimination. - Canopy chlorophyll estimation. - Foliar nitrogen content estimation. - Vegetation spectral library	12:00-13:00	Dr. Hitendra Padalia
Lunch Break (13:00-14:00)		
Eleventh 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	15:00-16:00	Mrs. Richa U Sharma
Twelfth Session: Hyperspectral Remote Sensing for Urban Studies - Road extraction and mapping - Extraction of Impervious surfaces - Hyperspectral classification for urban areas	16:00-17:00	Ms. Asfa Siddiqui

Day 4 (21.09.2017)		
Thirteenth Session: Hyperspectral Remote Sensing for Water and snow cover Studies - Water Quality Mapping - Snow Physical Parameters - Recent attempts on Soil Moisture Mapping	11:00-12:00	Dr. Vaibhav Garg
Panel discussion(12:00-13:00)		

Organizer and Speaker(s):

	Anil Kumar is Scientist/Engineer 'SG' 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 Scientist/Engineer 'SF' at Forestry and Ecology Department of Indian Institute of Remote Sensing, ISRO, Dehradun. He received M.Sc. in Forest: Economics and Management and Ph.D. degree in Forestry from from FRI University, Dehradun. His research interests are hyperspectral microwave RS and modelling applications for forestry and ecological studies.
	Vaibhav Garg is Scientist/Engineer 'SE' 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.
	Manu Mehta is Scientist/ Engineer 'SE' 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.

	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.
	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, Digital Soil Mapping, Land Degradation and Hyperspectral Remote Sensing in Soil studies.