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Matrix of Educational and Training Materials in Remote Sensing

By

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The Laboratory for Applications of Remote Sensing

Purdue University, West Lafayette, Indiana

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by

John C. Lindenlaub[1]
Bruce M. Lube[2]

ABSTRACT

Remote sensing educational and training materials developed by LARS have been organized in a matrix format. Each row in the matrix represents a subject area in remote sensing and the columns represent different types of instructional materials. This format has proved to be useful for displaying in a concise manner the subject matter content, prerequisite requirements and "technical depth" of each instructional module in the matrix.

A general description of the matrix is followed by three examples designed to illustrate how the matrix can be used to synthesize training programs tailored to meet the needs of individual students. A detailed description of each of the modules in the matrix is contained in a "catalog" section.

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ACKNOWLEDGEMENTS

The authors wish to acknowledge the assistance of James D. Russell for his contribution to the development of the matrix concept and to Paula A. Pickett for her help in preparing the catalog of educational materials. Appreciation is also extended to the people who made the concept presented in this document become a reality -- the authors of the educational and training materials which make up the matrix.

INTRODUCTION

Remote sensing is a rapidly expanding, interdisciplinary science. With new people, new techniques and new approaches entering the field constantly, it is important that education and training materials be available to transfer remote sensing technology from the research environment to applications in the field. Furthermore, for these materials to be most useful, the organization inherent in their design must contribute to their use in flexible programs designed to meet specific needs and must be adaptable enough to encompass new technological advances and applications as they arise.

To meet these needs the Laboratory for Applications of Remote Sensing (LARS) has developed a collection of learning units or modules. These materials, developed under both NASA and Purdue University sponsorship, have been organized in a matrix format. The matrix provides a logical organization of the materials, gives insight into the prerequisite requirements for each module and the degree of "technical depth" of each module.

Following a general description of the matrix, examples are given to demonstrate how the matrix may be used to synthesize individual training programs. These are followed by a "catalog" of the instructional modules which contains a summary paragraph for each, a list of recommended prerequisites and any special equipment or instructional aids which may be required to use the modules. In preparing this document no attempt has been made to provide a complete summary of educational materials available in the area of remote sensing. Only those materials developed at LARS under NASA/JSC or Purdue University sponsorship are included in the matrix. The availability of the various materials is also indicated in the "catalog."

MATRIX OF INSTRUCTIONAL MATERIALS IN REMOTE SENSING

Background Needed: **Extensive
*Moderate
None

TOPICS			INSTRUCTIONAL MATERIALS				
			FOCUS (10-20 minutes)	Minicourses (45-75 minutes)	Videotapes (30-60 minutes)	Simulations (3-4 hours)	Case Studies (20-40 hours)
		Introductory, Basic Concepts	F7	M1, E1	V1		
Physical Basis		Electromagnetic Spectrum		M2			
Physical Basis		Atmospheric Effects		M2			
Physical Basis		Spectral Reflectance	F10, F14	M2, M3*, M4*	V9, V10*, V11*		
Physical Basis		Emittance		M2	V11*		
Data Collection	Instruments	Photographic		M9*	V2, V9, V10*		
Data Collection	Instruments	Multispectral Scanners	F1	M9*	V2, V9, V10*		E6**, E7**
Data Collection	Instruments	Radar		M10*			
Data Collection	Instruments	Spectrometers			V12**		
Data Collection	Systems	Mission Planning		M5*	V3**		
Data Collection	Systems	Airborne			V2		E6**
Data Collection	Systems	Satellite	F8, F12	M6*, M7*	V2		E7**
Data Analysis Techniques	Images	Photography		M13*			
Data Analysis Techniques	Images	Scanner Images	F9, F12	M15*			
Data Analysis Techniques	Images	Radar Images		M14*			
Data Analysis Techniques	Computer-Aided	Pattern Recognition	F2, F3, F5, F13	E1, M11*, M12**	V4, V5*, V6**, V7**, V9**	E2*	E6**, E7**
Data Analysis Techniques	Computer-Aided	LARSYS	F6, F11	E4*, E5**	V7**, V9**	E2*, E3*	E6**, E7**
Applications		Agronomy	F4, F10	M18*			E6**
Applications		Forestry		M16*		S1**	E7**
Applications		Geography			V13		E7**
Applications		Geology		M17*			
Applications		Land Use				S2**	E7**
Applications		Hydrology		M19*			E7**

GENERAL DESCRIPT1 MATRIX

Each row in the matrix represents a subject area in remote sensing and the columns represent different types of instructional materials. Moving from left to right, the materials tend to require an increasing amount of student time to complete and to provide a corresponding increase in technical detail and depth.

FOCUS Series

Each FOCUS is a two-page foldout consisting of a diagram or photograph and an extended caption of three to four hundred words treating a single concept. A student typically spends 10 to 20 minutes studying these materials. They are especially useful for general briefings or introductory treatments of remote sensing topics.

Minicourses

Minicourses are prepared at the level which deals with fundamental principles. They may consist of only printed materials or use a combination of media. One series of minicourses uses a printed study guide, color slides and an audio tape to direct the student's study. The student is actively involved manipulating materials associated with remote sensing, completing exercises and solving problems in the study guide. Each minicourse requires about an hour to complete.

Videotapes

The series of videotapes "captures" a subject matter specialist discussing an area of remote sensing. Student viewing notes accompany some of the videotapes. Each videotape runs about thirty minutes. For an extended topic, such as pattern recognition, there is a series of videotapes.

Simulations

Simulation exercises are designed to lead the student through the professional thought and decision-making processes typical of those required by remote sensing analyst/researchers. The simulations, requiring 3 to 4 hours to complete, illustrate and explain the rationale and decision processes of remote sensing analysis.

Case Studies

Case studies require the student to make his own decisions in analyzing remotely sensed data, such as specifying computer analysis requirements and interpreting the analysis results. Intermediate results are reviewed with an instructor, if one is available. Case studies require on the order of 20 to 40 hours of student time. The student uses a computer and the LARSYS software system to solve a remote sensing problem, such as classifying an area or determining the percentage of areal extent of specific ground cover types. Although the study area has already been analyzed by a professional analyst and a model solution is available, the student is not expected to duplicate the exact sequence or arrive at an identical solution.

USE OF THE MATRIX

The matrix is helpful in identifying the areas of remote sensing in which LARS-developed educational materials are available. Individual educational curricula and training programs can be synthesized by selecting various materials from the matrix. Typically a larger number of units is selected from the left side of the matrix with fewer units being selected as the student progresses across the matrix. An individualized program can be designed to meet the needs and interests of a particular class or an individual student.

Despite the diversity of students needing information about remote sensing both as basic content and supplementary information, it is possible to diagnose a student's needs, refer to the matrix and prescribe the appropriate material for his needs. When possible, students with the same needs can be brought together in small groups so that the instructor can encourage group interaction and facilitate discussion of newly learned concepts, principles and procedures.

The general approach taken is to determine and state the objectives of the training program, examine the background, education and experience of the trainees, determine the time available and then choose material and educational experiences which best meet this set of conditions. The catalog section of this document contains a summary paragraph and list of prerequisites for each unit and can be used to select the appropriate modules. Three examples follow which illustrate how individualized training programs can be synthesized.

Training Program Example 1

Training Objective: To be able to use computer-aided analysis techniques to produce a ground cover map showing water bodies, vegetated areas, semi-arid and arid regions of a specified geographic area and to produce a table showing the areal extent of these cover types. The primary data source is assumed to be LANDSAT computer-compatible tapes. A limited amount of three-year-old 1:60,000 aerial photography is available to be used as reference data.

Student Audience: Two students are to be trained to work as an analysis team. One member of the team has a background in statistics and experience in running standard regression analysis computer programs on a batch mode system. The other student is a professional geologist and has had a limited amount of experience in using aerial photography to aid in the identification of geologic features.

Duration of Program: Four work-weeks are available prior to the time the trainees will be expected to apply the techniques they have learned to their own data set.

Design of Training Program: Working with the conditions summarized above, the matrix of available instructional materials and the catalog section of this document, the training coordinator developed a training program.

Note that the two students are to be trained to work as an analysis team and that neither had any experience working with LANDSAT data or remote sensing analysis computer programs. But despite their quite different backgrounds, a common training program was designed for the two students. It was expected that during some segments of the program one student would be in a position to supplement the formal instructional materials for the other student. For instance, when studying the geology minicourse the geologist would not be expected to learn additional geology although he would learn about the application of remote sensing techniques to the solution of geological problems. In addition, his education and experience in geology would enable him to impart to his partner a deeper understanding of both geology and remote sensing. Similarly, the statistician would be able to assist the geologist in the areas of pattern recognition and use of computer programs. This joint experience would tend to build the team relationship required at the completion of the training program.

The training program that was developed is as follows:

Day 1 -

Minicourse - Remote Sensing: What is it?

FOCUS - LANDSAT: An Earth Resources Data Collection System

Videotape - Introduction to Quantitative Remote Sensing

FOCUS - The Multispectral Scanner

Minicourse - The Physical Basis of Remote Sensing

Day 2 -

Videotape - Duality of System Types and the Multivariant Approach

FOCUS - Pattern Recognition

Minicourse - Spectral Reflectance Characteristics of Vegetation

FOCUS - Cover Type Classification

Minicourse - Multispectral Scanners

FOCUS - Role of Images in Numerical Data Analysis

Day 3 -

FOCUS - Mapping Soil Characteristics

Minicourse - Spectral Reflectance Characteristics of Earth Surface Features

Ed. Pkg. I - An Introduction to Quantitative Remote Sensing

Optional - Library reading and review, assigning of computer ID and password

Day 4 -

Minicourse - Interpretation of Multispectral Scanner Imagery

FOCUS - Crop Species Identification

Minicourse - LANDSAT: An Earth Resources Satellite System

FOCUS - What is LARSYS?

Minicourse - Pattern Recognition in Remote Sensing

Day 5 -

Minicourse - Typical Steps in Numerical Analysis

Minicourse - Photographic Sensors

Minicourse - Interpretation of Color Infrared Photography

Optional - Library reading and review

Day 6 -

Ed. Pkg. II - LARSYS Software System - An Overview

Videotape - Introduction to Pattern Recognition for Remote Sensing Applications

Minicourse - Mission Planning: Considerations and Requirements

Optional - Library reading and review

Day 7 -

Ed. Pkg. III - Demonstration of LARSYS on the 2780 Remote Terminal

Videotape - Statistical Characterization of Pattern Classes

Optional - Library reading and review

Day 8 -

Ed. Pkg. IV - The 2780 Remote Terminal: A "Hands-On" Experience

Videotape - Derivation of Discriminant Functions

Optional - Library reading and review

Day 9 -

Ed. Pkg. V - LARSYS Exercises

Videotape - Feature Selection

Optional - Library reading and review

Day 10 -

Videotape - Cluster Analysis and Sample Classification

Simulation - Determining Land Use Patterns through Man-Machine Analysis of LANDSAT Data

Days 11 thru 15 -

Ed. Pkg. VII - A Case Study Using LARSYS for Analysis of LANDSAT Data

Minicourse - Applications of Remote Sensing in Forestry

Videotape - System Parameters Fundamental to Information Extraction

Minicourse - Crop Surveys through Remote Sensing

Minicourse - SKYLAB: Earth Resources Experiment

Optional - Library reading and review

Days 16 thru 20 -

Ed. Pkg. VII - continued

Minicourse - Temperature Mapping of Water by Remote Sensing

Videotape - Mapping Sudan's Resources from Space

Minicourse - Applications of Remote Sensing in Geology

Minicourse - Side-Looking Airborne Radar

Minicourse - Interpretation of Radar Imagery

Completion of Case Study and documentation of procedures.

Training Program Example 2

Training Objective: To describe the underlying principles of pattern recognition as applied to remote sensing and to indicate the potentials of these methods for forestry applications.

Student Audience: A professional forester experienced with color IR photo interpretation and LANDSAT imagery and with some familiarity with multispectral scanner images.

Duration of Program: A one-day program, about 6 hours of on-site training plus 4 hours of independent study.

Design of Training Program: Based upon an initial discussion with the trainee, a one day training program was developed from the materials available.

On-site training -

- Ed. Pkg I - An Introduction to Quantitative Remote Sensing
- FOCUS - The Multispectral Scanner
- Minicourse - Pattern Recognition in Remote Sensing
- Minicourse - Typical Steps in Numerical Analysis

Independent Study -

- Simulation - A Forestry Application Simulation of Man-Machine Techniques for Analyzing Remotely Sensed Data

Training Program Example 3

Training Objective: To prepare scientists/engineers to work with an experienced remote sensing analyst on an operational project during a period of "peak load." The project uses computer aided analysis of LANDSAT data.

Student Audience: Twelve professional scientists and engineers engaged in various activities associated with remote sensing such as computer algorithm research, contract monitoring and project management but having no prior experience in analysis operations.

Duration of Program: Five working days with a limit of 6 hours of instruction per day. In addition 8 hours is available for "independent study."

Design of Training Program: Because of the varied background of the participants, the training was divided into two parts: core materials taken by all participants and individually prescribed materials selected by a training coordinator. The core material is directly related to the operational analysis work for which the participants are being trained. The individually prescribed materials are selected to fill in the background of individual participants. Only the core material is listed below. The prescribed material is selected from the catalog of available materials.

Prerequisite reading -

Ed. Pkg. I - An Introduction to Quantitative Remote Sensing

Day 1 -

Minicourse - The Physical Basis of Remote Sensing

Minicourse - Photographic Sensors

Minicourse - Spectral Reflectance Characteristics of Vegetation

Individually prescribed materials

Day 2 -

FOCUS - Role of Images in Numerical Data Analysis

Minicourse - Spectral Reflectance Characteristics of Earth Surface Features

Minicourse - Interpretation of Color Infrared Photography

FOCUS - The Multispectral Scanner

Individually prescribed materials

Day 3 -

Minicourse - Interpretation of Multispectral Scanner Images

Videotape - Introduction to Pattern Recognition for Remote Sensing Application

Minicourse - Crop Surveys through Remote Sensing

Videotape - Statistical Characteristics of Pattern Classes

Individually prescribed materials

Day 4 -

Videotape - Cluster Analysis and Sample Classification

Minicourse - Typical Steps in Numerical Analysis

Videotape - System Parameters Fundamental to Information Extraction

Individually prescribed materials

Day 5 -

Videotape - Derivation of Discriminant Functions

Simulation - Determining Land Use Patterns through Man-Machine Analysis of LANDSAT Data

MATRIX OF INSTRUCTIONAL MATERIALS IN REMOTE SENSING

Background Needed: **Extensive
*Moderate
None

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		Introductory, Basic Concepts	F7	M1, E1	V1		
Physical Basis		Electromagnetic Spectrum		M2			
Physical Basis		Atmospheric Effects		M2			
Physical Basis		Spectral Reflectance	F10, F14	M2, M3*, M4*	V9, V10*, V11*		
Physical Basis		Emittance		M2	V11*		
Data Collection	Instruments	Photographic		M9*	V2, V9, V10*		
Data Collection	Instruments	Multispectral Scanners	F1	M9*	V2, V9, V10*		E6**, E7**
Data Collection	Instruments	Radar		M10*			
Data Collection	Instruments	Spectrometers			V12**		
Data Collection	Systems	Mission Planning		M5*	V3**		
Data Collection	Systems	Airborne			V2		F6**
Data Collection	Systems	Satellite	F8, F12	M6*, M7*	V2		E7**
Data Analysis Techniques	Images	Photography	F9, F12	M13*			
Data Analysis Techniques	Images	Scanner Images		M15*			
Data Analysis Techniques	Images	Radar Images		M14*			
Data Analysis Techniques	Computer-Aided	Pattern Recognition	F2, F3, F5, F13	E1, M11*, M12**	V4, V5*, V6**, V7**, V8**	E2*	E6**, E7**
Data Analysis Techniques	Computer-Aided	LARSYS	F6, F11	E4*, E5**	V7**, V8**	E2*, E3*	E6**, E7**
Applications		Agronomy	F4, F10	M18*			E6**
Applications		Forestry		M16*		S1**	E7**
Applications		Geography			V13		E7**
Applications		Geology		M17*			
Applications		Land Use				S2**	E7**
Applications		Hydrology		M19*			E7**

CATALOG OF EDUCATIONAL MATERIALS

Individual units in the matrix of educational and training materials developed at LARS under NASA and Purdue sponsorship are designated by a letter and a number. The letter denotes the series as follows:

F	FOCUS
M	Minicourses
E	LARSYS Educational Package
S	Simulations
V	Videotapes

The general prerequisite level for materials in the matrix can be judged by the number of asterisks following the letter-number designation. For instance, V3** identifies the third member of the videotape series and two asterisks indicates that a considerable amount of prerequisite material is recommended. A single asterisk would imply that a moderate amount of prerequisite material is recommended. An entry such as F4 designates the fourth member of the FOCUS series, and the lack of an asterisk means that no prerequisites are suggested.

The following pages contain descriptions of each instructional module. The descriptions include a content summary, list of recommended prerequisites and special aids.

The FOCUS Series

Each FOCUS is a two-page foldout consisting of a diagram or photograph and an extended caption of three to four hundred words treating a single concept. A student **typically** spends 10 to 20 minutes studying these materials. They are especially useful for general briefings or introductory treatments of remote sensing topics.

Copies of FOCUS may be obtained from the **LARS** Support Services, Laboratory for Applications of Remote Sensing, 1220 Potter Drive, West Lafayette, Indiana 47906.

List of FOCUS Titles

- The Multispectral Scanner
- Cover Type Classification
- Pattern Recognition
- Mapping Soil Characteristics
- Sample Classification
- Earth Resources Data Processing System
- Remote Sensing
- LANDSAT: An Earth Resources Data Collection System
- Role of Images in Numerical Data Analysis
- Crop Species Identification
- What is LARSYS?
- LANDSAT Multispectral Scanner Data
- Clustering
- How the Earth Reflects

F1

The Multispectral Scanner

Shirley M. Davis

The basic parts of a multispectral scanner are illustrated and described. The function of the parts and systems as a whole are given in summary form.

Recommended Prerequisites: None

Special Aids: None

F2

Cover Type Classification

Shirley M. Davis

A brief description of the process of computer-aided identification of earth surface features is provided. Illustrations provide examples of the benefit of using multispectral scanner data to locate and identify surface features.

Recommended Prerequisites: None

Special Aids: None

F3

Pattern Recognition

Edward O. Belcher

This FOCUS provides an introduction to the process used by the computer to recognize and identify ground features according to their spectral response. An example of this procedure is provided.

Recommended Prerequisites: None

Special Aids: None

F4

Mapping Soil Characteristics

Shirley M. Davis

The advantages of large-area, rapid, soil classification are discussed. Limitations are enumerated and comparison of the conventional and computer-aided soil classifications are shown.

Recommended Prerequisites: None

Special Aids: None

F5

Sample Classification

Philip H. Swain

A visual comparison of the process of sample and point classification is provided. The higher accuracy of classification and decreased computer time needed by the sample classifier is described.

Recommended Prerequisites: None

Special Aids: None

F6

Earth Resources Data Processing System

Barbara J. Pratt

A brief description of LARS' remote terminal network is provided including the basic computer capabilities and its function in the earth resources data processing system.

Recommended Prerequisites: None

Special Aids: None

F7

Remote Sensing

James D. Russell

This FOCUS includes a basic definition of remote sensing and relates the concept to familiar examples. Examples of applications are also briefly described.

Recommended Prerequisites: None

Special Aids: None

F8

LANDSAT: An Earth Resources Data Collection System

James D. Russell

The LANDSAT satellite, its orbit, and basic parts are illustrated and described. A brief summary of the type of data collected and their use are given.

Recommended Prerequisites: None

Special Aids: None

F9

Role of Images in Numerical Data Analysis

Leslie L. Wilson

Three types of images (reconstruction, enhancement, and classification) are illustrated and described. The function of these images in the analysis of remotely sensed data is also defined.

Recommended Prerequisites: None

Special Aids: None

F10

Crop Species Identification

Shirley M. Davis

Illustrated and described is the spectral reflectance of two crop species (corn and soybeans). The impact of moisture and cultivation practices is also discussed. An example is given of the results of a three-county classification compared to ground data figures gathered by the U.S.D.A.

Recommended Prerequsites: None

Special Aids: None

F11

What is LARSYS?

Philip H. Swain

LARS and the evolution of the LARSYS software system are described. The basic philosophy of the man-machine interaction is emphasized during the discussion.

Recommended Prerequisites: None

Special Aids: None

F12

LANDSAT Multispectral Scanner Data

Shirley M. Davis

LANDSAT data in four spectral bands is available on computer compatible tapes and in various image formats. An example of an annotated LANDSAT image product is given.

Recommended Prerequisites: None

Special Aids: None

F13

Clustering

Philip H. Swain

In remote sensing, clustering is used to determine the "natural structure" of the data. It can be used to decompose complex data sets into simpler subsets and to determine data classes based on spectral rather than informational variations.

Recommended Prequisites: None

Special Aids: None

F14

How the Earth Reflects

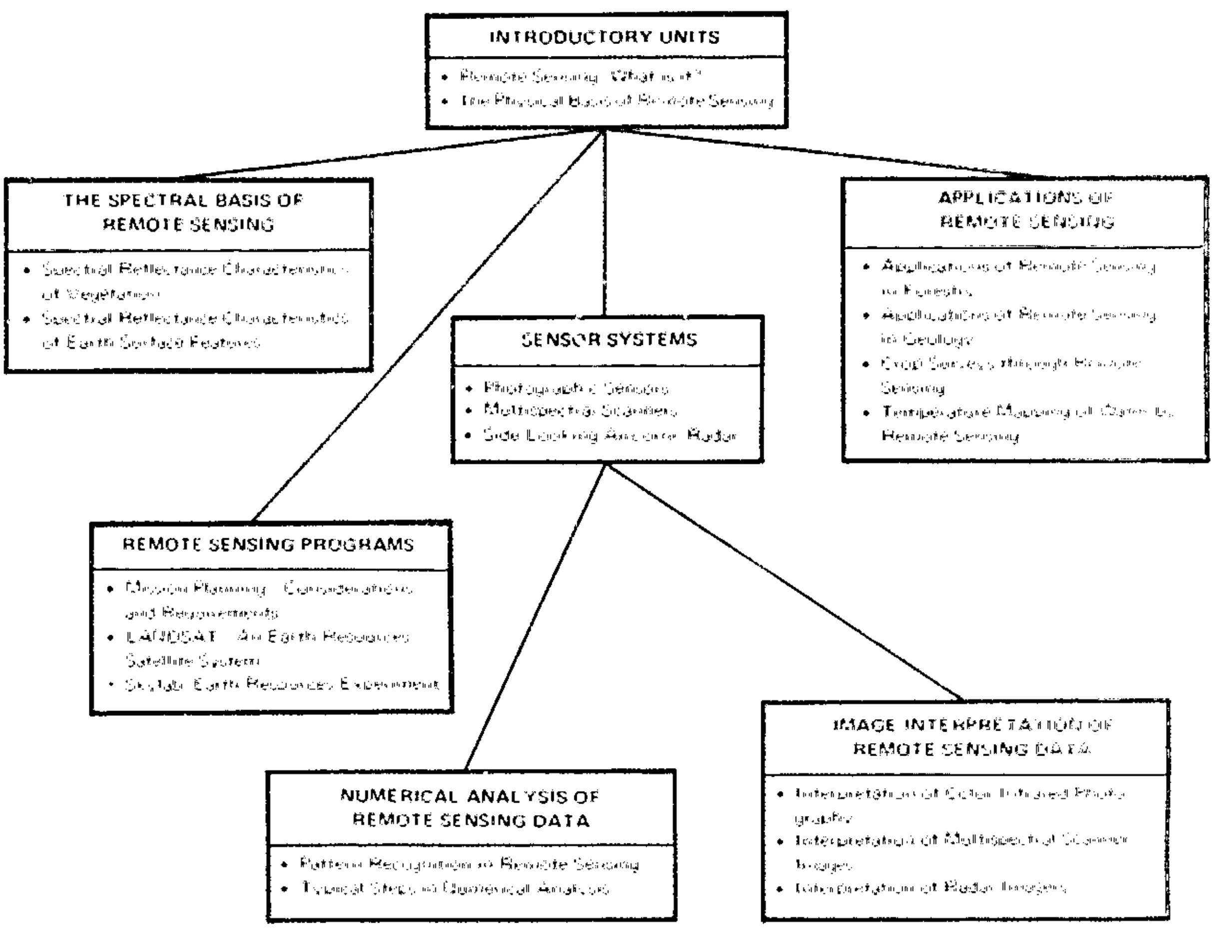
Shirley M. Davis

Energy reflected by materials on the earth's surface varies according to the structure and condition of the materials themselves. Spectral differentiation is possible because vegetation, soil and water reflect energy differently from each other and because subcategories of these materials demonstrate spectral variations as well.

THE FUNDAMENTALS OF REMOTE SENSING, A Minicourse Series

Instructional units in this series consist of printed study guides, a set of 35mm color slides and an audio tape. In addition, for several of the units the Instructor's Guide for the series contains or specifies tangible items which the student uses as he progresses through the minicourses. The series is aimed at the introductory or fundamental principle level. Persons with a background in elementary biology, physics and mathematics can understand and work with the basic concepts and ideas presented in the series. A 35mm slide projector and audio cassette player are required special aids for use with the minicourses.

Development of the minicourse series was carried out under the auspicies of the Continuing Education Administration of Purdue University from whom the courses are available. For further information contact G. W. O'Brien, Continuing Education Administration, 116 Stewart Center, Purdue University, West Lafayette, Indiana 47907, telephone 317/749-2227.



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Introductory Units

M1

Remote Sensing: What is it?

John C. Lindenlaub

The term "remote sensing" as it is used in the minicourse series is defined as the science and art of acquiring information about material objects from measurements made at a distance --- measurements made without coming into physical contact with the materials of interest. These measurements are possible because instruments can be designed to measure spectral, spatial and/or temporal variations in field strength. Several remote sensing data collection systems are illustrated and discussed briefly; basic terminology is presented. To complete the remote sensing process the data must be analyzed; such analysis may be carried out using image interpretation techniques, numerical analysis techniques or a combination of the two.

Recommended Prerequisites: None

Special Aids: 35mm slide projector, audio cassette player

M2

The Physical Basis of Remote Sensing

John C. Lindenlaub

The four major components of a remote sensing system - radiation source, target, sensor and transmission path - are used to explain the physical basis of remote sensing. Terms associated with the electromagnetic spectrum are introduced, and the wavelength variations of the solar spectrum, reflectance characteristics of common earth surface cover types and properties of the atmospheric transmission path are presented. The concept of an ideal black body may be used to model both emissive radiation from the earth and solar radiation. These topics are all discussed with reference to a simple pictorial model of a remote sensing system which serves as a point of departure for succeeding minicourses in this series.

Recommended Prerequisites: M1

Special Aids: 35mm slide projector, audio cassette player and tangible materials supplied with Instructor's Guide

The Spectral Basis of Remote Sensing

M3

Spectral Reflectance Characteristics of Vegetation

Roger M. Hoffer

This minicourse is the first of two discussing spectral characteristics of earth surface features. In this one we will examine the fundamentals involved in the reflection of energy from vegetation, and we will see that the reflection is controlled by absorption - particularly by absorption due to the pigments present in the leaf and by the moisture content of the leaf. As we study these fundamentals involved in plant leaf reflectance, we will also take a look at their impact on remote sensor imagery, in order to interpret remote sensor data more knowledgeably and effectively.

Recommended Prerequisites: M1 and M2

Special Aids: 35mm slide projector, audio cassette player

M4

Spectral Reflectance Characteristics of Earth Surface Features

Roger M. Hoffer

This minicourse is intended to follow the unit on Spectral Reflectance Characteristics of Vegetation. Together, these two units form the basis for effective interpretation of multispectral scanner data and color IR photography. In the first unit, we restricted the discussion to fundamentals of vegetative reflectance, whereas in this unit we examine the factors influencing reflectance from soils and water. Finally, vegetation, soil and water reflectances are combined and the spectral interrelationships of these basic cover types are compared.

Recommended Prerequisites: M1, M2 and M3

Special Aids: 35mm slide projector, audio cassette player

Remote Sensing Programs

M5

Mission Planning -- Considerations and Requirements

Roger M. Hoffer and Shirley M. Davis

Before planning remote sensing missions, the project director first determines what information he needs and then, if remote sensing can help meet those needs, he can decide which data collection systems and analysis methods are most appropriate for the task. Reference data or ancillary data necessary to the analysis can be collected in a number of ways. Such data is especially useful in understanding and limiting the spectral variability that might be encountered in the primary data.

Recommended Prerequisites: M1 and M2

Special Aids: 35mm slide projector, audio cassette player

M6

LANDSAT: An Earth Resources Satellite System

Shirley M. Davis

The first Earth Resources Technology Satellite was launched in 1972 with the expectation that the data it collected would be useful in acquiring needed information about the resources of the earth. Both LANDSAT-1 (formerly ERTS-1) and LANDSAT-2 have collected large quantities of high-quality multispectral data which have been applied to a variety of resources-related tasks--for example, surveying crops and forests, mapping land use patterns, and monitoring water and air quality. This minicourse discusses the characteristics of the sensors aboard the satellites, the orbits they follow, and the data they collect. Some of the types of information that have been derived from LANDSAT data are also presented.

Recommended Prerequisites: M1 and M2

Special Aids: 35mm slide projector, audio cassette player, Single LANDSAT Coverage Map and tangible items supplied with Instructor's Guide

M7

SKYLAB: Earth Resources Experiment

Shirley M. Davis

In presenting an overview of the SKYLAB Earth Resources Experiment Package, this minicourse describes the satellite's flight characteristics and the sensor systems designed to be a part of this package. The results of several data analysis experiments are described to highlight some important characteristics of SKYLAB data and their utility in earth resources studies.

Recommended Prerequisites: M1 and M2

Special Aids: 35mm slide projector, audio cassette player

Sensor Systems

M8

Multispectral Scanners

John C. Lindenlaub

Multispectral scanners, an important class of remote sensing data gathering instruments, are introduced in this minicourse. The operation of a multispectral scanner is explained by means of a simple simulation. Features of this class of instruments are discussed and in many cases compared to corresponding properties of photographic systems. System parameters are defined and discussed so as to give an understanding of the basis upon which engineers and application scientists make decisions regarding scanner design and mission planning. The parameters of several typical scanners are presented and examples of multispectral scanner imagery are shown.

Recommended Prerequisites: M1 and M2

Special Aids: 35mm slide projector, audio cassette player, two large diameter (about 1/4 inch) drinking straws, one about 3" long and one about 6" long, map of Bloomington, Indiana and tangible materials supplied with Instructor's Guide

M9

Photographic Sensors

John C. Lindenlaub

Photographic sensors have been used for remote sensing applications for many years. The capabilities and limitations of this type of data collection system are governed to a large extent by the optical properties of the film and filters used. By properly combining films and filters, photographic methods may be used to produce a set of multiband, or multispectral, images. When combined with knowledge about the reflectance properties of earth surface features, these multiband images yield considerably more information than is available from a single image. The use of color film is one method of combining three spectral bands to form a single image. An understanding of this process is important for proper interpretation of color and color infrared photography.

Recommended Prerequisites: M1 and M2

Special Aids: 35mm slide projector, audio cassette player

M10

Side-Looking Airborne Radar

John C. Lindenlaub

This minicourse introduces you to side-looking airborne radar as a sensor system. Radar systems operate in a different portion of the spectrum than photographic or multispectral scanners which results in radar having certain advantages over other sensor systems. The resolution of radar systems is determined by the duration of the radar pulse and the length of the antenna. Improved resolution properties can be achieved by using synthetic aperture antennas. A discussion of the manner in which images are produced from radar signals leads into a brief discussion of typical imagery. Analysis of radar imagery is the subject of another minicourse in this series.

Recommended Prerequisites: M1 and M2

Special Aids: 35mm slide projector, audio cassette player

Numerical Analysis of Remote Sensing Data

M11

Pattern Recognition in Remote Sensing

John C. Lindenlaub and Philip H. Swain

This minicourse introduces you to the way in which a computer views the data from a multispectral scanner, namely as a set of numbers called a data vector for each ground resolution element. The data vector concept is then used in an example to illustrate the ideas of training data, "distance" between training samples and decision boundaries. After a discussion of a pattern recognition model, several classification rules are presented. The application of computer-aided analysis of multispectral data is illustrated using results of a research study.

Recommended Prerequisites: M1, M2 and M8

Special Aids: 35mm slide projector, audio cassette player
and centimeter ruler at least 15 cm long

M12

Typical Steps in Numerical Analysis

John C. Lindenlaub

Procedures typical of those used to anlayze multispectral scanner data using numerical pattern recognition techniques are presented and discussed in this minicourse. These procedures include defining the objectives of the analysis, examining the quality of the data, specifying the areas to be analyzed, selecting training samples, classifying the data, displaying the results, and evaluating the results of the analysis. The relationship between man (the analyst) and machine (the computer) for each step of the procedure is stressed so as to reveal this complex partnership.

Recommended Prerequisites: M1, M2, M8 and M11

Special Aids: 35mm slide projector, audio cassette player and tangible materials supplied with Instructor's Guide

Image Interpretation of Remote Sensing Data

M13 Interpretation of Color Infrared Photography

Roger M. Hoffer

This minicourse discusses a number of the fundamentals involved in proper interpretation of color infrared film. Pairs of slides show the same scene with regular color film and then with color infrared film. A number of the advantages and limitations in the use of color infrared film for various applications will be discussed. When finished, you should be able to interpret the tonal characteristics seen on color infrared film nearly as well as the colors you see on regular color film.

Recommended Prerequisites: M1, M2 and M9

Special Aids: 35mm slide projector, audio cassette player

M14 Interpretation of Radar Imagery

Roger M. Hoffer

This minicourse provides insight into the fundamentals of interpretation of radar imagery. It introduces you to the basic energy-matter interactions and to the characteristics of radar systems that must be taken into account when interpreting radar imagery. These fundamental concepts are discussed using a series of graphic sketches and then demonstrated by means of radar image examples. When finished, you should be able to interpret many earth surface features that appear on radar imagery.

Recommended Prerequisites: M1, M2 and M10

Special Aids: 35mm slide projector, audio cassette player

M15

Interpretation of Multispectral Scanner Images

Roger M. Hoffer and John C. Lindenlaub

The general procedures used to generate images from multispectral scanner data are introduced, and the techniques used by remote sensing analysts to interpret multispectral images are illustrated by means of three examples. While an experienced analyst will attempt to make simultaneous use of spatial, spectral and temporal variations when analyzing multispectral scanner images, the examples used here have been selected to illustrate interpretations based on a single type of variation in order that the underlying principles can be emphasized. Activities are incorporated in the minicourse to give the student an opportunity to make interpretations based on spatial, spectral and temporal information.

Recommended Prerequisites: M1, M2 and M8

Special Aids: 35mm slide projector, audio cassette player, picture from newspaper (approximately 3" x 5"), punched computer card with 7 numbered holes and tangible materials supplied with Instructor's Guide

Applications of Remote Sensing

M16

Applications of Remote Sensing in Forestry

Roger M. Hoffer and Shirley M. Davis

Remote sensing is a useful tool for obtaining information about forested areas. Forest resource managers can draw on a wide variety of remote sensing data, choosing the data collection system best able to provide the kind of information they are seeking. In this minicourse, a list of typical information needs for effective timber management provides the framework for a discussion of ways in which both photo-interpretation and the analysis of numerical data can help foresters.

Recommended Prerequisites: M1 and M2

Special Aids: 35mm slide projector, audio cassette player, stereo photograph, Pocket Stereo Viewer and tangible materials supplied with Instructor's Guide

M17

Applications of Remote Sensing in Geology

Shirley M. Davis and Donald W. Levandowski

Geology is a broad field, and hence the information needs of the geologist cover a wide range. Spectral data gathered through remote sensing can provide information about many features of the earth's surface that are of interest to the geologist. Furthermore, by combining surface observations with geologic knowledge and insights, he is able to make valid inferences about subsurface materials. Several examples are given that demonstrate how geologists can use information available through remote sensing.

Recommended Prerequisites: M1 and M2

Special Aids: 35mm slide projector, audio cassette player

M18

Crop Surveys through Remote Sensing

Shirley M. Davis and Marvin E. Bauer

Effective production and management of the world's food supply depends in part on man's knowledge of the current and potential food supplies and their location throughout the world. Remote sensing has been successfully used for making various kinds of crop surveys both in research and in operational projects. Both image-oriented and numerically oriented analysis approaches have been used to identify crops, to assess their vigor, and to determine the ground area of specific crops. This information is used to calculate production forecasts and production estimates.

Recommended Prerequisites: M1 and M2

Special Aids: 35mm slide projector, audio cassette player and tangible materials supplied with Instructor's Guide

M19

Temperature Mapping of Water by Remote Sensing

Louis A. Bartolucci and Roger M. Hoffer

In order to make decisions about water quality, rapid and accurate means of evaluating water pollution levels must be readily available. Remote sensing and computer-aided data processing offer a satisfactory method for determining water quality parameters, such as temperature, in a quantitative manner and over large geographic areas in a relatively short time. Internal calibration methods alleviate the need for ground gathered data.

Recommended Prerequisites: M1, M2 and M5

Special Aids: 35mm slide projector, audio cassette player

The LARSYS Educational Package

The LARSYS Educational Package is a set of instructional materials developed to train people to analyze remotely sensed multispectral data using LARSYS, a computer software system developed at Purdue/LARS. A variety of media is used depending on the nature of the subject matter and objectives of each unit. Reinforcement of certain basic concepts, such as the multispectral concept and the multidimensional statistical approach, is interwoven throughout the package.

Essential to the effective use of the educational package is a "LARSYS expert." Persons experienced with LARSYS should be assigned to serve as instructor-consultants. At Purdue/LARS the "LARSYS expert" would probably be a fellow researcher from within the same program area. At remote terminal sites, the "site expert" would be an individual who has spent several days or weeks at LARS learning about LARSYS.

The LARSYS Educational Package may be obtained from LARS Support Services, Laboratory for Applications of Remote Sensing, 1220 Potter Drive, West Lafayette, Indiana 47906.

THE LARSYS EDUCATIONAL PACKAGE

UNIT I

Title: An Introduction to Quantitative Remote Sensing

Purpose: Orientation to remote sensing terminology, principles and pattern recognition.

Time estimate: 4 hours

UNIT II

Title: LARSYS Software System - An Overview

Purpose: Summary of LARSYS data analysis capabilities.

Time estimate: 1 hour

UNIT III

Title: Demonstration of LARSYS on the 2780 Remote Terminal

Purpose: Orientation to terminal hardware and terminal procedures.

Time estimate: 1.5 hours

UNIT IV

Title: The 2780 Remote Terminal: A "Hands-On" Experience

Purpose: Experience in transmitting cards, receiving punched and printer output, and running a LARSYS program when given the control card listings.

Time estimate: 4.5 hours

UNIT V

Title: LARSYS Exercises

Purpose: Practice in using the terminal, writing and executing simple LARSYS programs.

Time estimate: 5 hours

UNIT VI

Title: Guide to Multispectral Data Analysis Using LARSYS (with accompanying Example and Case Study)

Purpose: Analysis of a detailed example and a case study using aircraft data.

Time estimate: 40 hours

UNIT VII

Title: A Case Study Using LARSYS for Analysis of LANDSAT Data

Purpose: Analysis approach of a detailed example and a case study.

Time estimate: 45 hours

E1

Unit I
An Introduction to Quantitative Remote Sensing

John C. Lindenlaub and James D. Russell

This unit is an introduction to remote sensing stressing the role of pattern recognition in numerically oriented remote sensing systems. Its specific purpose is to provide a common background and orientation to the LARSYS computer software system. For newcomers to remote sensing, this manual introduces concepts and terminology which are needed later. Others will be introduced to numerically oriented remote sensing data analysis.

Recommended Prerequisities: None

Special Aids: None

E2

Unit II
LARSYS Software System: An Overview

James D. Russell and John C. Lindenlaub

The second unit consists of a recorded tape which accompanies a display book and student notes. It takes the viewer through a typical remote sensing data analysis sequence and illustrates the commonly used features of the LARSYS processing functions.

Recommended Prerequisites: E1

Special Aids: Audio cassette tape player

E3

Unit III
Demonstration of LARSYS on a 2780 Remote Terminal

Technology Transfer Staff

Unit III provides the student with an introduction to the data processing hardware that he will be using and introduces him to some additional aspects of the LARSYS software system. He will observe several LARSYS jobs run at the 2780 remote terminal. The demonstration requires an instructor to present the material and guide the student.

Recommended Prerequisites: E1 and E2

Special Aids: A "LARSYS expert" and on-line access to LARSYS through a 2780 remote terminal and 2741 typewriter terminal

E4

Unit IV
The 2780 Remote Terminal: A "Hands-On" Experience

Technology Transfer Staff

Students are instructed in the use of the terminal by means of an audio-tutorial lesson. The student is guided by an audio tape on how to use the terminal off-line as a card lister, login to the computer and initiate the LARSYS system, run sample LARSYS jobs and transmit data to and receive data from the main computer. The audio tape is accompanied by a set of student notes.

Recommended Prerequisites: E1, E2 and E3

Special Aids: A "LARSYS expert" (recommended, but not essential), an audio cassette tape player and on-line access to LARSYS through a 2780 remote terminal and 2741 typewriter terminal

E5

Unit V
LARSYS Exercises

Technology Transfer Staff

Unit V consists of short problems which the student solves using the computer terminal and LARSYS processing functions. The purpose of these problems is to increase the student's experience in the use of LARSYS for multispectral data analysis and to help him develop an appreciation for the capabilities and limitations of the LARSYS software system.

Recommended Prequisites: E1 thru E4

Special Aids: A "LARSYS expert" and on-line access to LARSYS through a 2780 remote terminal and 2741 typewriter terminal

E6

Unit VI
Guide to Multispectral Data Analysis Using LARSYS

John C. Lindenlaub

This unit provides a detailed discussion of the philosophy behind quantitative analysis methods. Using data from an aircraft multispectral scanner, it describes the steps in a supervised analysis, why they are necessary and how they are carried out. A detailed example parallels the description and the student has the opportunity to carry out an analysis of his own through a case study.

Recommended Prerequisites: E1 thru E5

Special Aids: A "LARSYS expert" and on-line access to LARSYS through a 2780 remote terminal and 2741 typewriter terminal

E-7

Unit VII
A Case Study Using LARSYS for Analysis of LANDSAT Data

Tina K. Cary and John C. Lindenlaub

This unit provides a detailed discussion of the philosophy behind quantitative analysis methods. Using examples and data from the LANDSAT-1 satellite it describes the steps in an analysis sequence which combines both supervised and unsupervised approaches. A detailed example parallels the description and the student has the opportunity to carry out an analysis of his own through a case study.

Recommended Prerequisites: E1 thru E5

Special Aids: A "LARSYS expert" and on-line access to LARSYS through a 2780 remote terminal and 2741 typewriter terminal

Simulation Exercises

Simulation exercises are designed to lead the student through the professional thought and decision-making processes typical of those required by remote sensing analyst/researchers. The simulations, requiring 3 to 4 hours to complete, illustrate and explain the rationale and decision processes of remote sensing analysis.

Copies of the simulation exercises may be obtained from LARS Support Services, Laboratory for Applications of Remote Sensing, 1220 Potter Drive, West Lafayette, Indiana 47906.

List of Simulation Exercise Titles

S1 A Forestry Application Simulation of Man-Machine Techniques for Analyzing Remotely Sensed Data

S2 Determining Land Use Patterns through Man-Machine Analysis of LANDSAT Data

S1

A Forestry Applications Simulation of Man-Machine Techniques for Analyzing Remotely Sensed Data

John S. Berkebile, James D. Russell and Bruce M. Lube

A detailed step-by-step description of an actual analysis of remotely sensed data performed by a forester for a portion of the Hoosier National Forest. The decisions made during the analysis and their rationale are described. The importance of the man-machine interactions is emphasized. The steps are documented with illustrations and examples.

Recommended Prerequisites: E1, E2, M1, M2 and M16

Special Aids: None

S2

Determining Land Use Patterns through Man-Machine Analysis of LANDSAT data

Steven J. Kristof, James D. Russell, Tina K. Cary and Bruce M. Lube

An over-the-shoulder look at each step in the analysis of remotely sensed data for land use applications. The decisions made and the rationale for each man-machine interaction are described and illustrated. The area under study was a portion of the Texas coastal zone. The objective was to be able to classify this diverse and changing area. The results provided information useful for persons responsible for land use management decisions.

Recommended Prerequisites: E1, E2, M1, M2 and M3

Special Aids: None

The Videotape Series

The videotapes in this series "capture" a subject matter specialist discussing a remote sensing topic. The tapes are a refinement of a seminar or series of lectures given by the authors. Each tape runs about thirty minutes. Student viewing notes have been written for some of the videotapes.

These videotapes were developed by LARS staff members in conjunction with Purdue University graduate program and short course activities. Inquiries regarding the availability of the tapes for use external to the University should be addressed to Dr. John C. Lindenlaub, Program Leader, Technology Transfer, Laboratory for Applications of Remote Sensing, Purdue University, 1220 Potter Drive, West Lafayette, Indiana 47906.

List of Videotape Titles

Remote Sensing: Infromation from Data

- Introduction to Quantitative Remote Sensing
- Duality of System Types and the Multivariant Approach
- System Parameters Fundamental to Information Extraction

Pattern Recognition for Remote Sensing Applications

- Introduction to Pattern Recognition for Remote Sensing Applications
- Statistical Characterization of Pattern Classes
- Derivation of Discriminant Functions
- Feature Selection
- Cluster Analysis and Sample Classification

Measurements in Remote Sensing

- Introduction to Radiation in Remote Sensing
- Reflectance in Remote Sensing
- Emission in Remote Sensing
- Fundamentals of Remote Sensing Instrumentation

Remote Sensing Applications

- Mapping Sudan's Resources from Space

Remote Sensing: Information from Data

V1

Introduction to Quantitative Remote Sensing

David A. Landgrebe

(32 minutes, black-and-white)

The method by which remote sensing is carried out from a quantitative standpoint is presented. Fundamentals of information extraction including an explanation of spatial, spectral and temporal information are given and necessary steps in the numerical analysis procedures are listed and briefly discussed.

Recommended Prerequisites: None

Special Aids: Videotape player and monitor

V2

Duality of System Types and the Multivariant Approach

David A. Landgrebe

(26 minutes, black-and-white)

A review of system types is given. A diagram of the overall scanner system as well as the effects of "noise" upon data are also discussed. Various aspects of the electromagnetic spectrum as well as the nearest-neighbor approach, the Gaussian distribution assumption and other principles fundamental to numerical analysis are presented.

Recommended Prerequisites: V1

Special Aids: Videotape player and monitor

V3

System Parameters Fundamental to Information Extraction

David A. Landgrebe

(33 minutes, black-and-white)

A diagram of the overall scanner system is presented as a means of review. System parameters fundamental to information extraction are listed and then discussed individually. Such parameters as spatial resolution, spectral resolution, signal-to-noise ratios, ancillary information and others are included.

Recommended Prerequisites: V2

Special Aids: Videotape player and monitor

Pattern Recognition for Remote Sensing Application

V4

Introduction to Pattern Recognition for Remote Sensing Applications

Philip H. Swain

(27 minutes, black-and-white)

The concepts basic to application of pattern recognition to remote sensing data analysis and a rationale for the statistical approach taken are discussed. Data vectors and decision regions and surfaces in the measurement space are defined. A model of a pattern recognition system and an example of a simple statistical process are provided.

Recommended Prerequisites: M1 or F7

Special Aids: Videotape player and monitor, viewing notes

V5

Statistical Characterization of Pattern Classes

Philip H. Swain

(18 minutes, black-and-white)

The method by which classes of ground cover in remote sensing problems can be characterized statistically is presented. Single-channel and multi-channel distributions as well as univariate and multivariate normal probability functions are discussed. An explanation of the use of probability functions as discriminants is also given.

Recommended Prerequisites: V4

Special Aids: Videotape player and monitor, viewing notes

V6

Derivation of Discriminant Functions

Philip H. Swain

(27 minutes, black-and-white)

This videotape discusses the derivation of discriminant functions based on statistical decision theory. Other concepts presented are loss functions, Bayes' strategy, and "thresholding" the resulting decision.

Recommended Prerequisites: V4 and V5, basic statistics

Special Aids: Videotape player and monitor, viewing notes

V7

Feature Selection

Philip H. Swain

(27 minutes, black-and-white)

This videotape consists of a presentation of how subsets of available features or channels can be selected to optimize classifier performance. Statistical distance measures as indicators of error and selection strategies for the two-class and multi-class cases are also discussed.

Recommended Prerequisites: V4 and V5, basic statistics

Special Aids: Videotape player and monitor, viewing notes

V8

Cluster Analysis and Sample Classification

Philip H. Swain

(28 minutes, black-and-white)

A basic definition of clustering and an explanation of interpoint and intercluster distance measures are given. Isolating clusters, classifying samples (aggregates of data points), and cluster distinctness tests are discussed. In addition, a definition as well as a rationale and methodology for sample classification are provided.

Recommended Prerequisites: V4 and V5, basic statistics

Special Aids: Videotape player and monitor

Measurements in Remote Sensing

V9

Introduction to Radiation in Remote Sensing

LeRoy F. Silva

(25 minutes, black-and-white)

The remote sensing model and its components are explained by comparing a scanner system to a more familiar instrument a 35mm camera. The spectral characteristics of solar radiation, idealized and actual, are shown. Radiometric units are contrasted with photometric units and their relation to spectral quantities is explained. The effect of view on projected area is shown and plane angle measures and solid angle measure are discussed. Field stop and aperture stop are differentiated.

Recommended Prerequisites: Some knowledge of cameras and how they work

Special Aids: Videotape player and monitor

V10

Reflectance in Remote Sensing

LeRoy F. Silva

(25 minutes, black-and-white)

A discussion of reflectance parameters and quantities in terms of the optical characteristics of remote sensors. The effect that lens size, aperture opening and focal length have upon the light gathering power and the field of view of a lens are discussed. Geometric radiation calculations in remote sensing systems as well as the concepts of Lambertian surfaces, bi-directional reflectance, directional reflectance and hemispherical reflectance (albedo) are also described.

Recommended Prerequisites: V9, familiarity with camera construction and basic calculus

Special Aids: Videotape player and monitor

V11

Emission in Remote Sensing

LeRoy F. Silva

(27 minutes, black-and-white)

The definition of emission and how it differs from reflectance is given. The wavelength and frequency form of Planck's law, their differences, and relation to emission are explained. The portion of the spectrum in which emissive effects dominate reflective effects is shown and the factors responsible are explained. A precision radiation thermometer is demonstrated to tie together many perviously presented concepts.

Recommneded Prerequisites: V10, basic calculus

Special Aids: Videotape player and monitor

V12

Fundamentals of Remote Sensing Instrumentation

LeRoy F. Silva

(26 minutes, black-and-white)

The monochrometer (fixed wavelength) and the spectrometer (adjustable wavelenght) are identified as the fundamental instruments of remote sensing and typical components are discussed and shown. Terminology used to describe spectrometers used in different configurations is introduced and explained. The facts responsible for there being an upper wavelength which a given detector is sensitive to are presented, and quantum and thermal detectors are contrasted. Some common detectors and their characteristics are discussed. Infrared system design considerations are also given.

Recommended Prerequisites: V11, basic physics

Special Aids: Videotape player and monitor

Remote Sensing Applications

V13

Mapping Sudan's Resources from Space

Marion F. Baumgardner

The LANDSAT satellite and its data collection capabilities are reviewed. The geogra hic features of the area of interest within the Sudan are then shown by means of a "mosaic" (a three-channel false color composite) as well as with a classification derived from LANDSAT data. The types of information most needed by the Sudanese are also explained.

Recommended Prerequisites: M1 or F7

Special Aids: Videotape player and monitor