



Afghanistan Information Management Service (AIMS)  
Internal Capacity Building Initiative

# Introduction to Remote Sensing

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## 1. Introduction

Imagine you have been asked to investigate how land use in the Northern Afghanistan has changed over the past decade. Such projects are very real and very important on a regional scale planning. The information generated from such activities are often used as the basis for policy decisions by local and central governments.

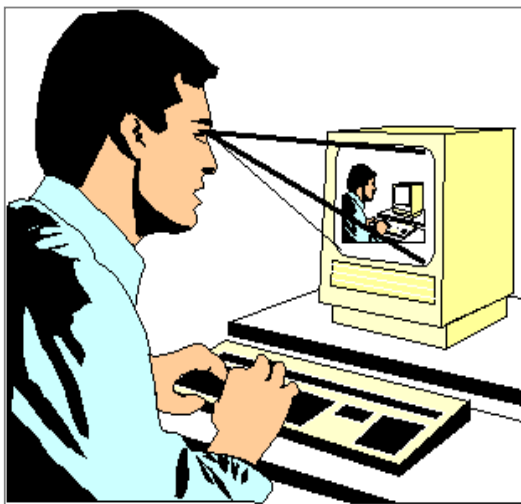
As you consider such a task, numerous questions come to mind. What kinds of measurements would you need to make? How often would you need these measurements? How much area should your research cover? What tools are available for such a research project? What are the costs involved? In many cases the answers to these questions identify a need for measurements and observations on **temporal** (time) and **spatial** scales that are impossible for a single person (or even a well organized group of researchers) to meet. Additionally, the manpower and the funding is often not available to carry out such research using traditional methods of field research.

These problems are increasingly faced by researchers by turning to remote sensing as a cost effective tool for performing environmental research on local and regional scales. Remote sensing is not a new concept and has been used extensively in global environmental, Agricultural, Land Use Planning over the past several decades. However, recent advances in remote sensing technologies, lower cost, and greater availability of remotely-sensed data has made it a much more attractive solution for local and regional governments, schools, and universities interested in performing environmental research that may have real impact on their communities and national planning<sup>1</sup>.

## 2. What is Remote Sensing?

**Remote sensing** can be defined as the study of something without making actual contact with the object of study. More precisely, it can be defined as:

**"Remote sensing is the science (and to some extent, art) of acquiring information about the Earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information."**



In a simple term every human being are actively involved in "Remote Sensing" all the time. Familiar activity like watching a football game or observing birds flying on the sky actually a remote sensing activities. But things get complicated when we change the scale. As you view the screen of your computer monitor, you are actively engaged in remote sensing.

Remote sensing deals with the detection and measurement of phenomena with devices sensitive to electromagnetic energy such as:

- ✓ Light (cameras and scanners)
- ✓ Heat (thermal scanners)
- ✓ Radio Waves (radar)

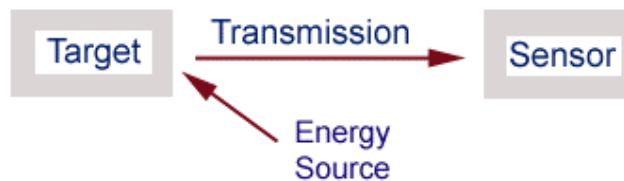
<sup>1</sup> Introduction to Remote Sensing < <http://chesapeake.towson.edu/data/intro.asp>>

### 3. Components of a remote sensing system

While the definition of remote sensing describes a very wide array of technologies and types of research, all remote sensing technologies are based on certain common concepts, and all remote sensing systems consist of the same basic components. These four basic components of a remote sensing system include a target, an energy source, a transmission path, and a sensor.



The **target** is the object or material that is being studied. The components in the system work together to measure and record information about the target without actually coming into physical contact with it. There must also be an **energy source**, which illuminates or provides electromagnetic energy to the target. The energy interacts with the target, depending on the properties of the target and the radiation, and will act as a medium for transmitting information from the target to the **sensor**. The sensor is a remote device that will collect and record the electromagnetic radiation. Sensors can be used to measure energy that is given off (or **emitted**) by the target, reflected off of the target, or transmitted through the target.



Once the energy has been recorded, the resulting set of data must be transmitted to a receiving station where the data are processed into a usable format, which is most often as an image. The image is then interpreted in order to extract information about the target. This interpretation can be done visually or electronically with the aid of computers and image processing software.



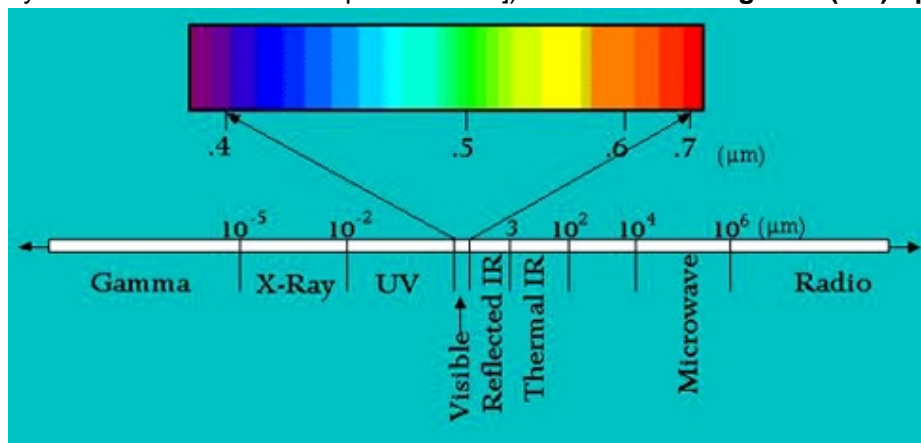
[Infrared Weather Satellite Image over continental U.S.]

Weather satellite imaging of the Earth is a familiar example of a remote sensing system. The target in such a system is the Earth's surface, which gives off energy in the form of infrared radiation (or heat energy). This energy travels through the atmosphere and space and reaches the sensor, which is mounted on a satellite platform. Varying levels of this energy are recorded, transmitted to ground stations on the Earth, and converted into images that depict differences in temperature across the planet's surface. In a similar manner, other weather satellite sensors measure the visible light energy from the sun as it is reflected off the

Earth's surfaces, transmitted through space to the satellite sensor, and recorded and sent to Earth for processing.

Remote sensing is not limited to investigations within our own planet. Most forms of astronomy are examples of remote sensing, since the targets under investigation are such vast distances from Earth that physical contact is impossible. Astronomers therefore must collect and analyze the energy given off by these objects in space by using telescopes and other sensing devices. This information is recorded and used to draw conclusions about space and our universe.

Remote sensing uses instruments that house sensors to view the spectral and spatial relations of observable objects and materials at a distance, typically from above them, or in astronomy, by looking out. Geophysics (mainly gravity, magnetic, and seismic surveys; also external fields) is considered by many to be a form of remote sensing. Most methods are based on sensing of photons (quantum particles that have a wide range of energies; a specific photon will have some energy value that has its own unique corresponding frequency [number of cycles of a sine waveform per unit time]) in the **electromagnetic (EM) spectrum**.. Here is a simple EM Spectrum Chart,



with different wavelength intervals named according to common usage in remote sensing (the wavelength units are in micrometers (μm); a micrometer is

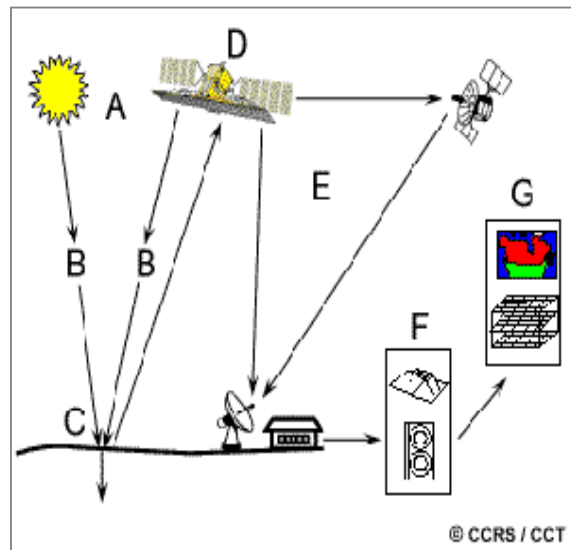
1/1,000,000 of a meter.

#### 4. Process

In much of remote sensing, **the process** involves an interaction between incident radiation and the targets of interest. This is exemplified by the use of imaging systems where the following seven elements are involved. Note, however that remote sensing also involves the sensing of emitted energy and the use of non-imaging sensors.

**i. Energy Source or Illumination (A)** - the first requirement for remote sensing is to have an energy source which illuminates or provides electromagnetic energy to the target of interest.

**ii. Radiation and the Atmosphere (B)** - as the energy travels from its source to the target, it will come in contact with and interact with the atmosphere it passes through. This interaction may take place a second time as the energy travels from the target to the sensor.



© CCRS / CCT

**iii. Interaction with the Target (C)** - once the energy makes its way to the target through the atmosphere, it interacts with the target depending on the properties of both the target and the radiation.

**iv. Recording of Energy by the Sensor (D)** - after the energy has been scattered by, or emitted from the target, we require a sensor (remote - not in contact with the target) to collect and record the electromagnetic radiation.

**v. Transmission, Reception, and Processing (E)** - the energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data are processed into an image (hardcopy and/or digital).

**vi. Interpretation and Analysis (F)** - the processed image is interpreted, visually and/or digitally or electronically, to extract information about the target, which was illuminated.

**vii. Application (G)** - the final element of the remote sensing process is achieved when we apply the information we have been able to extract from the imagery about the target in order to better understand it, reveal some new information, or assist in solving a particular problem.

These seven elements comprise the remote sensing process from beginning to end.

## 5. Characteristics of Images

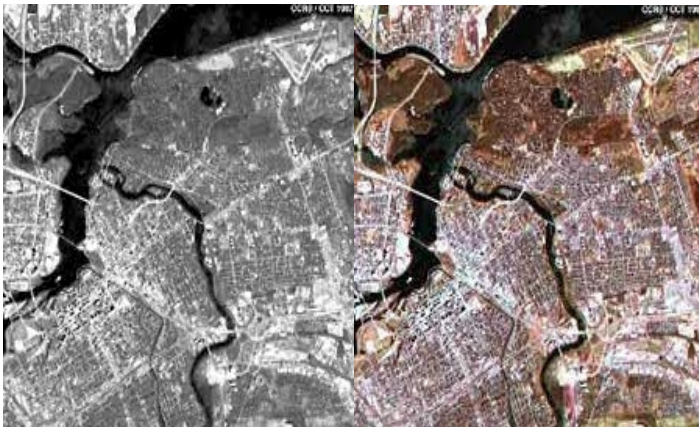
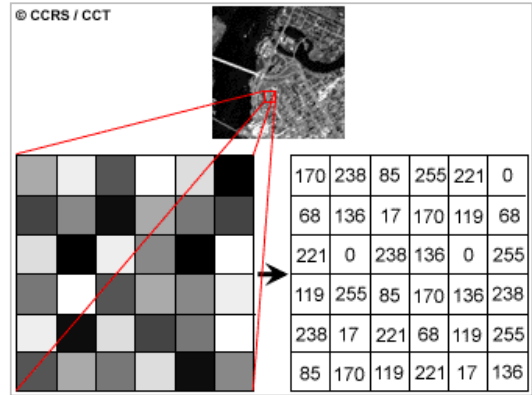
Before we proceed for more detail at sensors and their characteristics, we need to define and understand a few fundamental terms and concepts associated with remote sensing images.



Electromagnetic energy may be detected either photographically or electronically. The photographic process uses chemical reactions on the surface of light-sensitive film to detect and record energy variations. It is important to distinguish between the terms **images** and **photographs** in remote sensing. An image refers to any pictorial representation, regardless of what wavelengths or remote sensing device has been used to detect and record the electromagnetic energy. A **photograph** refers specifically to images that have been detected as well as recorded on photographic film. The black and white photo to the left, of part of the city of Ottawa, Canada was taken in the visible part of the

spectrum. Photos are normally recorded over the wavelength range from 0.3  $\mu$ m to 0.9  $\mu$ m - the visible and reflected infrared. Based on these definitions, we can say that all photographs are images, but not all images are photographs. Therefore, unless we are talking specifically about an image recorded photographically, we use the term image.

A photograph could also be represented and displayed in a **digital** format by subdividing the image into small equal-sized and shaped areas, called picture elements or **pixels**, and representing the brightness of each area with a numeric value or **digital number**. Indeed, that is exactly what has been done to the photo to the left. In fact, using the definitions we have just discussed, this is actually a **digital image** of the original photograph! The photograph was scanned and subdivided into pixels with each pixel assigned a digital number representing its relative brightness. The computer displays each digital value as different brightness levels. Sensors that record electromagnetic energy, electronically record the energy as an array of numbers in digital format right from the start. These two different ways of representing and displaying remote sensing data, either pictorially or digitally, are interchangeable as they convey the same information (although some detail may be lost when converting back and forth).



It is important to know about the visible portion of the spectrum and the concept of colours. We see colour because our eyes detect the entire visible range of wavelengths and our brains process the information into separate colours. Can you imagine what the world would look like if we could only see very narrow ranges of wavelengths or colours? That is how many sensors work. The information from a narrow wavelength range is gathered and stored in a **channel**, also sometimes referred to as a **band**. We can combine and display channels of information digitally using the three primary colours (blue, green, and red). The data from each channel is represented as one of the primary colours and, depending on the relative brightness (i.e. the digital value) of each pixel in each channel, the primary colours combine in different proportions to represent different colours.

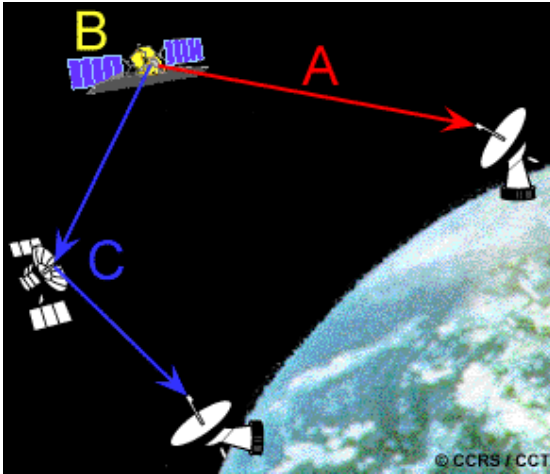
When we use this method to display a single channel or range of wavelengths, we are actually displaying that channel through all three primary colours. Because the brightness level of each pixel is the same for each primary colour, they combine to form a **black and white image**, showing various shades of gray from black to white. When we display more than one channel each as a different primary colour, then the brightness levels may be different for each channel/primary colour combination and they will combine to form a **colour image**

## 6. Data Import and Export

### 6.1 Data Reception, Transmission, and Processing

Data obtained during airborne remote sensing missions can be retrieved once the aircraft lands. It can then be processed and delivered to the end user. However, data acquired from satellite platforms need to be electronically transmitted to Earth, since the satellite continues to

stay in orbit during its operational lifetime. The technologies designed to accomplish this can also be used by an aerial platform if the data are urgently needed on the surface.



There are three main options for **transmitting data** acquired by satellites to the surface. The data can be directly transmitted to Earth if a Ground Receiving Station (GRS) is in the line of sight of the satellite (A). If this is not the case, the data can be recorded on board the satellite (B) for transmission to a GRS at a later time. Data can also be relayed to the GRS through the Tracking and Data Relay Satellite System (TDRSS) (C), which consists of a series of communications satellites in geosynchronous orbit. The data are transmitted from one satellite to another until they reach

the appropriate GRS.

## 7. Image interpretation and Enhancement

In order to take advantage of and make good use of remote sensing data, we must be able to extract meaningful information from the imagery. Image **interpretation and analysis** - the sixth element of the remote sensing process. Interpretation and analysis of remote sensing imagery involves the identification and/or measurement of various targets in an image in order to extract useful information about them. Targets in remote sensing images may be any feature or object which can be observed in an image, and have the following characteristics:

- Targets may be a point, line, or area feature. This means that they can have any form, from a bus in a parking lot or plane on a runway, to a bridge or roadway, to a large expanse of water or a field.
- The target must be distinguishable; it must contrast with other features around it in the image.

Much interpretation and identification of targets in remote sensing imagery is performed manually or visually, i.e. by a human interpreter. In many cases this is done using imagery displayed in a pictorial or photograph-type format, independent of what type of sensor was used to collect the data and how the data were collected. In this case we refer to the data as being in **analog** format. Remote sensing images can also be represented in a computer as arrays of pixels, with each pixel corresponding to a digital number, representing the brightness level of that pixel in the image. In this case, the data are in a **digital** format. Visual interpretation may also be performed by examining digital imagery displayed on a computer screen. Both analogue and digital imagery can be displayed as black and white (also called monochrome) images, or as colour images by combining different channels or bands representing different wavelengths.



When remote sensing data are available in digital format, **digital processing and analysis** may be performed using a computer. Digital processing may be used to enhance data as a prelude to visual interpretation.

Digital processing and analysis may also be carried out to automatically identify targets and



extract information completely without manual intervention by a human interpreter. However, rarely is digital processing and analysis carried out as a complete replacement for manual interpretation. Often, it is done to supplement and assist the human analyst.

Manual interpretation and analysis dates back to the early beginnings of remote sensing for air photo interpretation. Digital processing and analysis is more recent with the advent of digital recording of remote sensing data and the development of computers. Both manual and digital techniques for interpretation of remote sensing data have their respective advantages and disadvantages. Generally, manual interpretation requires little, if any, specialized equipment, while digital analysis requires specialized, and often expensive, equipment. Manual interpretation is often limited to analyzing only a single channel of data or a single image at a time due to the difficulty in performing visual interpretation with multiple images. The computer environment is more amenable to handling complex images of several or many channels or from several dates. In this sense, digital analysis is useful for simultaneous analysis of many spectral bands and can process large data sets much faster than a human interpreter. Manual interpretation is a subjective process, meaning that the results will vary with different interpreters. Digital analysis is based on the manipulation of digital numbers in a computer and is thus more objective, generally resulting in more consistent results. However, determining the validity and accuracy of the results from digital processing can be difficult.

It is important to reiterate that visual and digital analyses of remote sensing imagery are not mutually exclusive. Both methods have their merits. In most cases, a mix of both methods is usually employed when analyzing imagery. In fact, the ultimate decision of the utility and relevance of the information extracted at the end of the analysis process, still must be made by humans.

## 7.1 Visual Interpretation

Analysis of remote sensing imagery involves the identification of various targets in an image, and those targets may be environmental or artificial features, which consist of points, lines, or areas. Targets may be defined in terms of the way they reflect or emit radiation. This radiation is measured and recorded by a sensor, and ultimately is depicted as an image product such as an air photo or a satellite image.

What makes interpretation of imagery more difficult than the everyday visual interpretation of our surroundings? For one, we lose our sense of depth when viewing a two-dimensional image, unless we can view it **stereoscopically** so as to simulate the third dimension of height. Indeed, interpretation benefits greatly in many applications when images are viewed in stereo, as visualization (and therefore, recognition) of targets is enhanced dramatically. Viewing objects from directly above also provides a very different perspective than what we are familiar with. Combining an unfamiliar perspective with a very different scale and lack of recognizable detail can make even the most familiar object unrecognizable in an image. Finally, we are used to seeing only the visible wavelengths, and the imaging of wavelengths outside of this window is more difficult for us to comprehend.

Recognizing targets is the key to interpretation and information extraction. Observing the differences between targets and their backgrounds involves comparing different targets based on any,



or all, of the visual elements of **tone, shape, size, pattern, texture, shadow, and association**. Visual interpretation using these elements is often a part of our daily lives, whether we are conscious of it or not. Examining satellite images on the weather report, or following high speed chases by views from a helicopter are all familiar examples of visual image interpretation. Identifying targets in remotely sensed images based on these visual elements allows us to further interpret and analyze. The nature of each of these interpretation elements is described below, along with an image example of each.

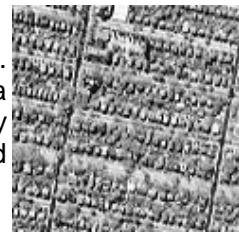
**Tone** refers to the relative brightness or colour of objects in an image. Generally, tone is the fundamental element for distinguishing between different targets or features. Variations in tone also allows the elements of shape, texture, and pattern of objects to be distinguished.

**Shape** refers to the general form, structure, or outline of individual objects. Shape can be a very distinctive clue for interpretation. Straight edge shapes typically represent urban or agricultural (field) targets, while natural features, such as forest edges, are generally more irregular in shape, except where man has created a road or clear cuts. Farm or crop land irrigated by rotating sprinkler systems would appear as circular shapes.

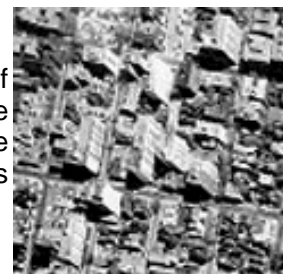


**Size** of objects in an image is a function of scale. It is important to assess the size of a target relative to other objects in a scene, as well as the absolute size, to aid in the interpretation of that target. A quick approximation of target size can direct interpretation to an appropriate result more quickly. For example, if an interpreter had to distinguish zones of land use, and had identified an area with a number of buildings in it, large buildings such as factories or warehouses would suggest commercial property, whereas small buildings would indicate residential use.

**Pattern** refers to the spatial arrangement of visibly discernible objects. Typically an orderly repetition of similar tones and textures will produce a distinctive and ultimately recognizable pattern. Orchards with evenly spaced trees, and urban streets with regularly spaced houses are good examples of pattern.



**Texture** refers to the arrangement and frequency of tonal variation in particular areas of an image. Rough textures would consist of a mottled tone where the grey levels change abruptly in a small area, whereas smooth textures would have very little tonal variation. Smooth textures are most often the result of uniform, even surfaces, such as fields, asphalt, or grasslands. A target with a rough surface and irregular structure, such as a forest canopy, results in a rough textured appearance. Texture is one of the most important elements for distinguishing features in radar imagery.



**Shadow** is also helpful in interpretation as it may provide an idea of the profile and relative height of a target or targets which may make identification easier. However, shadows can also reduce or eliminate interpretation in their area of influence, since targets within shadows

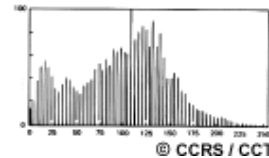
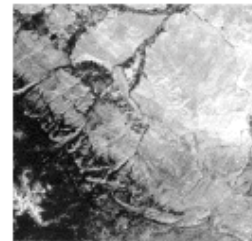
are much less (or not at all) discernible from their surroundings. Shadow is also useful for enhancing or identifying topography and landforms, particularly in radar imagery.

**Association** takes into account the relationship between other recognizable objects or features in proximity to the target of interest. The identification of features that one would expect to associate with other features may provide information to facilitate identification. In the example given above, commercial properties may be associated with proximity to major transportation routes, whereas residential areas would be associated with schools, playgrounds, and sports fields. In our example, a lake is associated with boats, a marina, and adjacent recreational land.

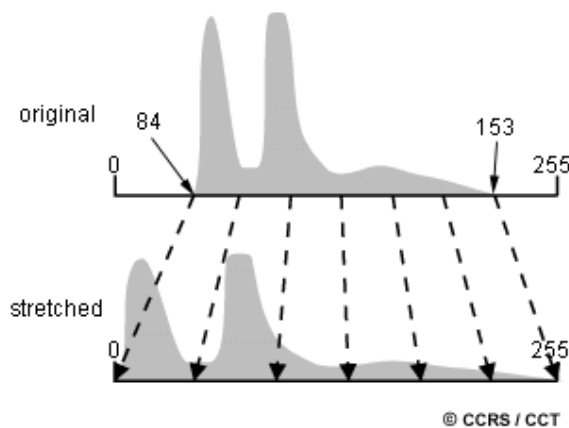


## 7.2 Image Enhancement

Enhancements are used to make it easier for visual interpretation and understanding of imagery. The advantage of digital imagery is that it allows us to manipulate the digital pixel values in an image. Although radiometric corrections for illumination, atmospheric influences, and sensor characteristics may be done prior to distribution of data to the user, the image may still not be optimized for visual interpretation. Remote sensing devices, particularly those operated from satellite platforms, must be designed to cope with levels of target/background energy which are typical of all conditions likely to be encountered in routine use. With large variations in spectral response from a diverse range of targets (e.g. forest, deserts, snowfields, water, etc.) no generic radiometric correction could optimally account for and display the optimum brightness range and contrast for all targets. Thus, for each application and each image, a custom adjustment of the range and distribution of brightness values is usually necessary.

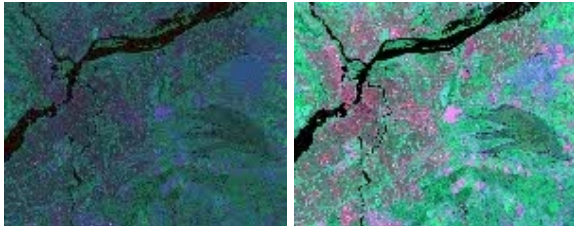


In raw imagery, the useful data often populates only a small portion of the available range of digital values (commonly 8 bits or 256 levels). Contrast enhancement involves changing the original values so that more of the available range is used, thereby increasing the contrast between targets and their backgrounds. The key to understanding contrast enhancements is to understand the concept of an **image histogram**. A histogram is a graphical representation of the brightness values that comprise an image. The brightness values (i.e. 0-255) are plotted on the x-axis of the histogram. The frequency of occurrence of each of

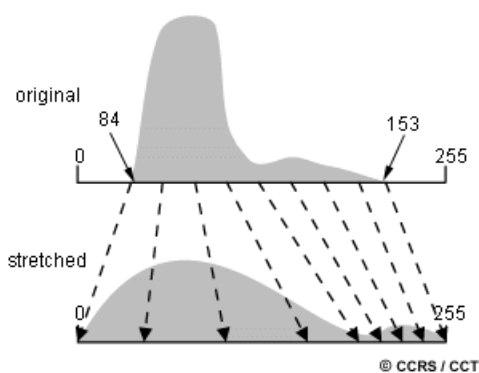


By manipulating the range of digital values in an image, graphically represented by its histogram, we can apply various enhancements to the data. There are many different techniques and methods of enhancing contrast and detail in an image; we will cover only a few common ones here. The simplest type of enhancement is a **linear contrast stretch**. This involves identifying lower and upper bounds from the histogram (usually the minimum and maximum brightness values in the image)

histogram (usually the minimum and maximum brightness values in the image) and applying a transformation to stretch this range to fill the full range. In our example, the minimum value (occupied by actual data) in the histogram is 84 and the maximum value is 153. These 70 levels occupy less than one-third of the full 256 levels available. A linear stretch uniformly expands this small range to cover the full range of values from 0 to 255. This enhances the contrast in the image with light toned areas appearing lighter and dark areas appearing darker, making visual interpretation much easier. This graphic illustrates the increase in contrast in an image before (left) and after (right) a linear contrast stretch.



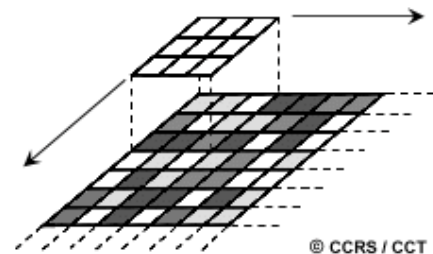
A uniform distribution of the input range of values across the full range may not always be an appropriate enhancement, particularly if the input range is not uniformly distributed. In this case, a **histogram-equalized stretch** may be better. This stretch assigns more display values (range) to the frequently occurring portions of the histogram.



In this way, the detail in these areas will be better enhanced relative to those areas of the original histogram where values occur less frequently. In other cases, it may be desirable to enhance the contrast in only a specific portion of the histogram. For example, suppose we have an image of the mouth of a river, and the water portions of the image occupy the digital values from 40 to 76 out of the entire image histogram. If we wished to enhance the detail in the water, perhaps to see variations in sediment load, we could stretch only that small portion of the histogram represented by the water (40 to 76) to the full grey level range (0 to 255). All pixels below or above these values would be assigned to 0 and 255, respectively, and the detail in these areas would be lost. However, the detail

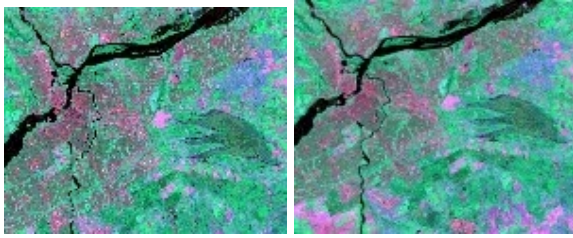
in the water would be greatly enhanced.

**Spatial filtering** encompasses another set of digital processing functions which are used to enhance the appearance of an image. Spatial filters are designed to highlight or suppress specific features in an image based on their **spatial frequency**. Spatial frequency is related to the concept of image texture. It refers to the frequency of the variations in tone that appear in an image. "Rough" textured areas of an image, where the changes in tone are abrupt over a small area, have high spatial frequencies, while "smooth" areas with little variation in tone over several pixels, have low spatial frequencies. A common **filtering procedure** involves moving a 'window' of a few pixels in dimension

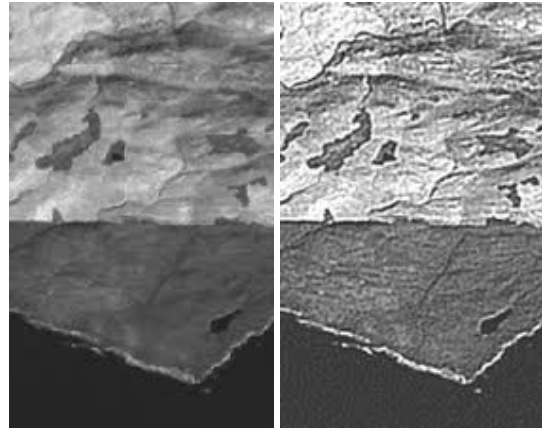


(e.g. 3x3, 5x5, etc.) over each pixel in the image, applying a mathematical calculation using the pixel values under that window, and replacing the central pixel with the new value. The window is moved along in both the row and column dimensions one pixel at a time and the calculation is repeated until the entire image has been filtered and a "new" image has been generated. By varying the calculation performed and the weightings of the individual pixels in the filter window,

filters can be designed to enhance or suppress different types of features.



A **low-pass filter** is designed to emphasize larger, homogeneous areas of similar tone and reduce the smaller detail in an image. Thus, low-pass filters generally serve to smooth the appearance of an image. Average and median filters, often used for radar imagery, are examples of low-pass filters. **High-pass filters** do the opposite and serve to sharpen the appearance of fine detail in an image. One implementation of a high-pass filter first applies a low-pass filter to an image and then subtracts the result from the original, leaving behind only the high spatial frequency information. **Directional, or edge detection filters** are designed to highlight linear features, such as roads or field boundaries. These filters can also be designed to enhance features which are oriented in specific directions. These filters are useful in applications such as geology, for the detection of linear geologic structures.



## **ANNEX: 1 RS Training Proposal**

### OVERVIEW:

Afghanistan is currently at the stage of development and reconstruction, since this country have been suffering crisis for the last two decades, the infrastructure has been damaged. All international communities support the government and build the capacity to run this process in the direction of success.

AIMS is aspiring to contribute in build information management capacity for the government, Geographic Information System is one the major function of this organization. A part from the GIS training AIMS is providing standard GIS base layer to the government and other agencies.

Remote Sensing (RS) data provides reliable, timely, accurate, and periodic data, while Geographic Information System (GIS) provide various methods of integration tools to create different planning scenarios for decision-making. Therefore, studies and practice suggested the use of RS and GIS techniques for meeting the information and analysis needs of urban areas.

### OBJECTIVE:

In order to provide more consistent base layer (shape files) and offer standard services in all regional offices, AIMS is planning to build internal capacity and provide more training for the field assistants.

- Remote Sensing Training for the Field Assistants
- Develop Training Material
- Practical work and Application
- Ground routing

### PARTICIPANTS:

The target members of this training will be Field Assistants and GIS Resource Assistant.

### TRAINING CONTENTS

- Introduction to Remote Sensing
- Data Import and Export
- Image Interpretation and Enhancement
- Image Rectification
- Image Mosaic
- Masking Techniques
- Introduction to Landcover
- Usage of GPS
- Ground Study for Landcover and Classification
- Urban Mapping of Kabul City by Landsat 7TM imagery & IKONOS

Discussing overall usage of remote sensing technology.

- Remote Sensing & Capacity Building.
- Remote Sensing Advantages in improving AIMS resources (Layers and products).

### Place

The training will held at AIMS main office in Kabul.

### Starting Date & Ending Date

This training will start at 28<sup>th</sup> December 2003 and ending by 31<sup>st</sup> December 2003.

**ANNEX: 2 RS Training Schedule**

**Introduction to Remote Sensing  
28 to 31<sup>st</sup> December 2003**

Training Schedule

Day One: 28 <sup>th</sup> December		Resource Person
	<ul style="list-style-type: none"> <li>• Introduction to Remote Sensing</li> <li>• Data Import and Export</li> <li>• Image Interpretation and Enhancement</li> </ul>	Ahadi/Marufa
Day One: 29 <sup>th</sup> December		
	<ul style="list-style-type: none"> <li>• Image Rectification</li> <li>• Image Mosaic</li> <li>• Masking Techniques</li> <li>• Introduction to Landcover</li> </ul>	Ahadi/Marufa
Day One: 30 <sup>th</sup> December		
	<ul style="list-style-type: none"> <li>• Usage of GPS</li> <li>• Visual Interpretation</li> <li>• Ground Study for Landcover and Classification</li> </ul>	Ahadi/Marufa/Nasir
Day One: 31 <sup>th</sup> December		
	<ul style="list-style-type: none"> <li>• History and Applications of Remote Sensing</li> <li>• Urban Mapping of Kabul City by Landsat 7 TM imagery &amp; IKONOS</li> </ul>	Ahadi/Marufa/Golam

## **ANNEX: 3 Remote Sensing Terminology**

### **Band**

One layer of a multispectral image representing data values for a specific range of the electromagnetic spectrum of reflected light or heat (e.g., ultraviolet, blue, green, red, near-infrared, infrared, thermal, radar, etc.). Also, other user-specified values derived by manipulation of original image bands. A standard color display of a multispectral image shows three bands, one each for red, green and blue. Satellite imagery such as LANDSAT TM and SPOT provide multispectral images of the Earth, some containing seven or more bands.

### **Co-ordinate system**

A reference system used to measure horizontal and vertical distances on a planimetric map. A co-ordinate system is usually defined by a map projection, a spheroid of reference, a datum, one or more standard parallels, a central meridian, and possible shifts in the x- and y-directions to locate x,y positions of point, line, and area features. In ARC/INFO, a system with units and characteristics defined by a map projection. A common co-ordinate system is used to spatially register geographic data for the same area.

### **Geo-referencing**

The process of delimiting a given object, either physical (e.g. a lake) or conceptual (e.g. an administrative region), in terms of its spatial relationship to the land; the geographic reference thus established consists of points, lines, areas or volumes defined in terms of some coordinate system (usually latitude and longitude, or UTM northings and eastings, and elevation).

### **Global Positioning System/GPS**

The GPS is a worldwide satellite navigation system that is funded and supervised by the U.S. Department of Defense. GPS satellites transmit specially coded signals. These signals are processed by a GPS receiver that computes extremely accurate measurements, including 3-dimensional position, velocity, and time on a continuous basis. [Woods Hole Field Center]

### **Pixel**

A contraction of the words picture element. The smallest unit of information in an image or raster map. Referred to as a cell in an image or grid.

### **Remote sensing**

Acquiring information about an object without contacting it physically. Methods include aerial photography, radar, and satellite imaging.

### **Satellite image**

A picture of the earth taken from an earth-orbital satellite. Satellite images may be produced photographically or by on-board scanners (e.g., MSS).

### **Thematic map**

A map displaying selected kinds of information relating to specific themes, such as soil, land-use, population density, suitability for arable crops, and so on. Thematic information may be represented as labelled polygons, lines or points, isolines, etc.

### **Mosaic**

An assemblage of overlapping aerial or space photographs or images whose edges have been matched to form a continuous pictorial representation of a portion of the earth surface.

Related term: Edge Matching, and Composite Image

## **Rectification**

A process by which the geometry of an image area is made planimetric. It doesn't remove relief distortion or perspective distortion.

Related Term: Image Correction, Image Distortion, Photogrammetry, and Image Geometry

## **Spectrum**

The total range of wavelengths or frequencies of electromagnetic radiation, extending from the longest radio waves to the shortest known cosmic rays.

Related Term: Gamma Ray, X Ray, Ultraviolet Band, Infrared Band, Thermal Band, Microwave Band, Millimeter Band, Radar Band, Radio Band, Electromagnetic Band, Spectral Window Wave.

## **Image Enhancement:**

**Definition:** Techniques used to emphasize the tonal and textural differences in images.

**Explanation:** Any one of a group of operations that improve the detectability of the targets or categories. These operations include, but are not limited to, contrast improvement, edge enhancement, spatial filtering, noise suppression, image smoothing, and image sharpening.

Related Terms: Contrast Enhancement, Colour Enhancement, Nonlinear Stretch, Linear Enhancement, Radiometric Enhancement, Image Texture, Tone, and Brightness.