# Digital Image Processing *“DIP”*

**L-4**

#### Introduction

After data is collected and transmitted to the ground station, it must be *processed* and *converted* into a format that is usable by the researcher who will interpret the data. Often satellite-derived data is converted into ***imagery*** (***image***) that provides a visualization of the data collected by the sensor.

#### Digital Image Processing (DIP)

Often, the data must be *processed*, *enhanced*, and *manipulated* to provide a useful set of information. The technique, which is part science and part art, is called ***digital image processing.***

#### Converting data stream to an image

Satellite image data is sent from the satellite to the ground station in a ***raw digital format***, which is essentially a stream of ***numerical data***. The smallest unit of digital data is a ***bit***. A ***bit*** is represented by a binary number, which has only two possible values, ***0*** or ***1***. A ***bit*** can be used to represent any piece of data that has two states, such as on/off, true/false, or open/closed. With only two potential values, a bit does not offer much flexibility in representing data that is more complex than a binary number. Therefore, data is often stored as a collection of eight bits (***8 bits***), resulting in a unit of data called a ***byte***.

A ***byte*** is a unit of data that is comprised of ***8 bits***, thus providing a data element with up to 256 potential values (2^8).***Radiometers*** in a ***sensor*** that measure the intensity of EMR will generally convert the detected energy levels into a value that ranges from ***0-255.***

**Image processing**

Most of the common image processing functions available in image analysis systems can be categorized into the following four categories:

1. Preprocessing
2. Image Enhancement
3. Image Transformation
4. Image Classification and Analysis

#### Preprocessing

Before digital images can be analyzed, they usually require some degree of preprocessing. This may involve two types of corrections: ***radiometric corrections*** and ***geometric corrections***.

* **Radiometric corrections** which attempt to remove the effects of sensor errors and/or environmental factors that attempt to adjust DN values that have been affected by atmospheric interference or absorption.
* **Geometric Corrections** are also a very important form of pre-processing, which is a process by which points in an image are registered to corresponding points on a map or other image that has already been rectified. The goal of geometric correction is to put image elements in their proper coordinates positions (lat & long).

#### Image Enhancement

*Raw satellite* data often contain a vast amount of information that is not readily apparent to the analyst. ***Image enhancement*** techniques are used to highlight features of interest and expose subtle differences in the spectral signature of the components of the target.

#### Image Transformation

A ***transformation*** is an image which is created by transforming raw image data into an entirely new image using mathematical formulas (or algorithms). NDVI, TCG, TCW, TCB, LST, etc are types of the image transformation to extract a useful information for one feature of the land cover, such as vegetation cover, soil moisture, land surface temperature, etc.

#### Image Classification

***Classification*** is a process by which a set of items is grouped into classes based on common characteristics.

* Classification of satellite image data is based on placing pixels with similar values into groups and identifying the common characteristics of the items represented by these pixels.
* The result of a classification is that all pixels in an image are assigned to classes or themes (e.g. water, coniferous forest, deciduous forest, corn, wheat, etc.).

There are ***two types*** of image classification; 1) ***supervised*** and 2) ***unsupervised***.

## Supervised Classification

* A ***supervised classification*** is performed when some prior knowledge of the classes in a scene is used to identify representative samples (***training sites***) of different surface land cover types.
* The determination of ***training sites*** is based on the analyst's knowledge of the geographical region and the surface cover types present in the image.
* Once the training sites have been established, the numerical information in all of image's spectral bands is used to define (spectral signature) of each class.
* Once the computer has determined the signatures for each class, it will compare every pixel to the signatures and label it as the class that it is mathematically closest to.
* Each pixel in the image is then assigned to the class which it most closely resembles.

## Unsupervised Classification

* An ***unsupervised classification*** is essentially the opposite of a supervised classification. The pixels in an image are examined by a computer and classified into spectral classes.
* The grouping is based solely on the numerical information in the data and the spectral classes are later matched by the analyst to information classes.
* In order to create an unsupervised classification the analyst typically determines the number of spectral classes to identify and a computer algorithm will find pixels with similar spectral properties and group them accordingly.

**Spatial Filtering**

***Spatial filters*** are designed to **highlight or suppress features** in an image based on their ***spatial frequency***. Spatial filters are used to suppress 'noise' in an image, or to highlight specific image characteristics.

* ***Low-pass Filters:*** These are used to emphasize large homogenous areas of similar tone and reduce the smaller detail. Low frequency areas are retained in the image resulting in a smoother appearance to the image.
* ***High-pass Filters:*** allow high frequency areas to pass with the resulting image having greater detail resulting in a sharpened image.
* ***Directional Filters:*** are designed to ***enhance linear features*** such as roads, streams, faults, etc. The filters can be designed to enhance features which are ***oriented in specific directions***, making these useful for ***radar imagery*** and for **geological applications.** Directional filters are also known as edge detection filters.