REMOTE SENSING

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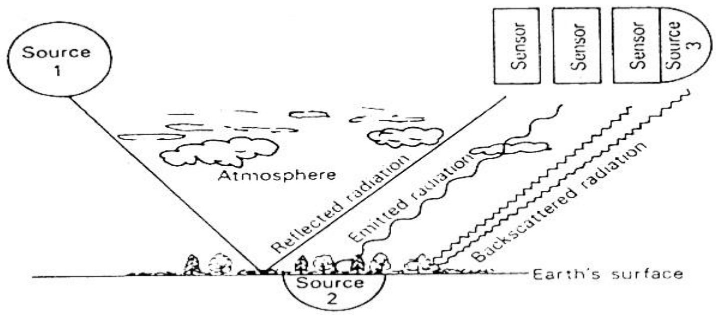
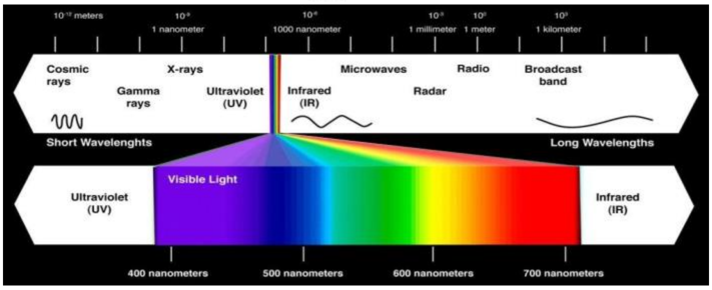
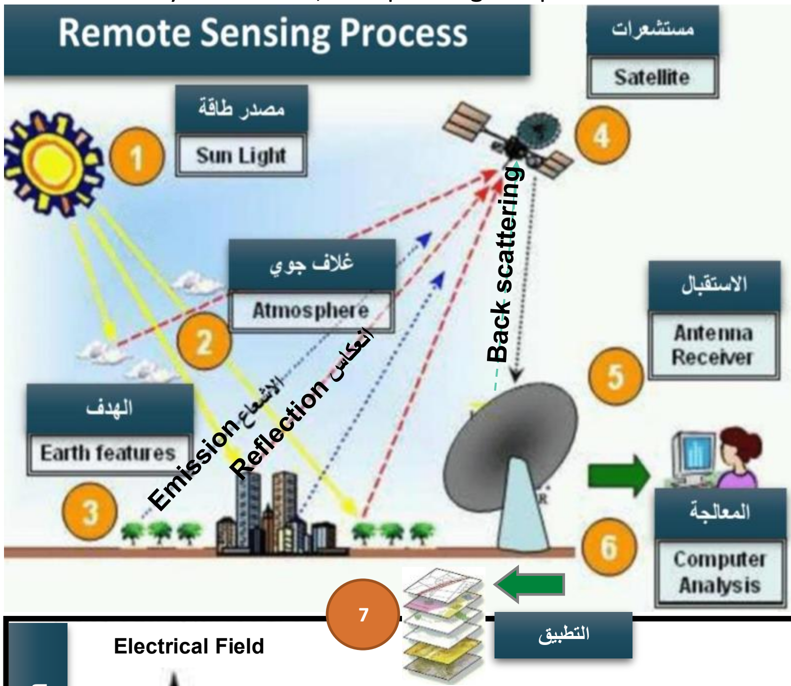
REMOTE SENSING SCIENCE

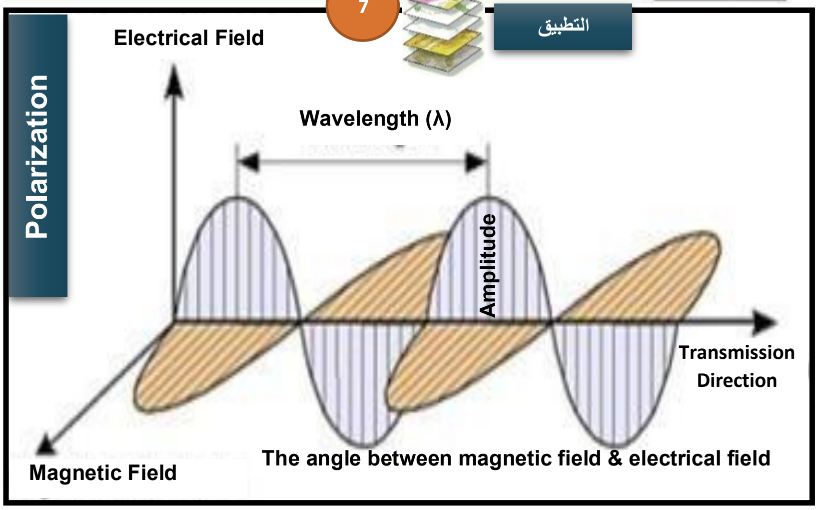
- **Remote Sensing:** is the technology by which the object of interest on the earth can be identified, measured, or analyzed remotely (without physical contact) using sensors that reserved waves & applied of the results data on the map
- يتعامل مع الأهداف المتواجدة فوق سطح الأرض وقد بدأ بصناعة الكاميرات لتصوير الأرض من ارتفاعات معينة، ثم أصبح يعتمد على اختراق الغلاف الجوي وتصنيع اللواقط الفضائية sensor حيث يرصد الموجات المنبعثة والمرتدة عن الاجسام فوق سطح الارض بواسطة اللواقط لذا فهو يعتمد 90% على اللواقط
- **Sensor**: is a device that detects & responds to some type of input from the physical environment (light, heat, motion…)
- **Remote sensing data (معطيات الاستشعار عن بعد)**
  1. **Reflection:** is the reflection of sun waves from opject surface to the sensor & depending on spectral characteristics
  2. **Emission**: is the thermal radiation, by which the source energy is the body itself & depending on thermal characteristics
  3. **Backscattering**: is the reflection of waves back to the direction they came from, & depending on spectral characteristic





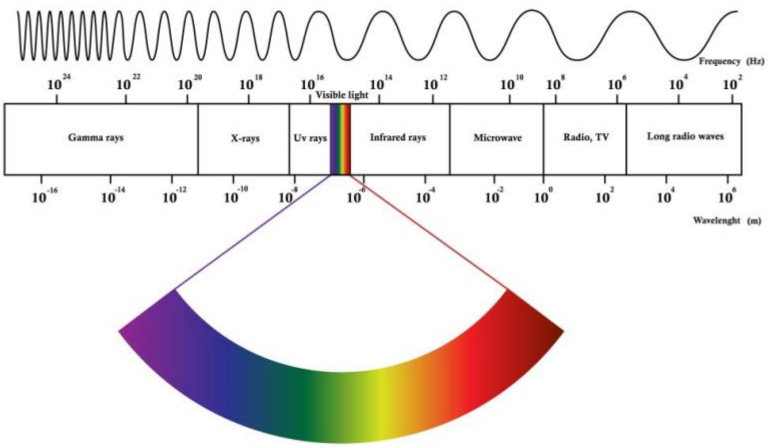


- **Remote Sensing Sciences depends on** Electromagnetic Energy (EM) from sun & wavelength (λ) of sun waves
- **Components of EMR (مكونات الاشعاع الكهرومغناطيسي):**
  1. **Wavelength (λ):** distance between crest & trough
  2. **Amplitude**: distance between axis & crest/trough
  3. **Transmission direction** اتجاه انتشار الموجه
  4. **Polarization Plane** المستوى الذي يحدث عليه الاستقطاب
- **Physical Units of EMR (الوحدات الفيزيائية)**
  1. **Energy (Qe):** the energy carried by EMR in Jules (J)
  2. **Flux (Φ):** is the radiant energy transmitted in a radiant direction per unit of time in Watt (W)
  3. **Intensity (I)**: is the radiant flux radiated from a point source per solid angle in radiant direction, Wat/s (solid angle)
  4. **Total Radiance (Le):** is the radiant intensity per unit projected area in a radial direction in W/m²/s



- ➢ Usually the sensor reserves the total radiance of any romote singing science type (emitted, reflected, or back scattered)
- ➢ **Solid angle**: is the angle between 2 planes or lines

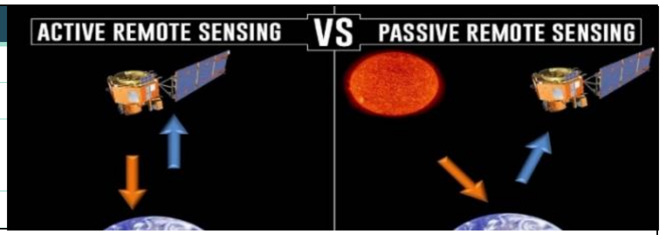
Classification of EMR based on wavelength (λ)			
Ultraviolet UV	λ = 100Å – 0.4μm		
Visible VL	λ = 0.4 μm – 0.7μm		
Infrared IR	λ = 0.7 μm – 1 mm		
		Near (NIR)	0.7μm-1.3μm
		Moderate (MIR)	1.3μm-3.0μm
		Short wave (SWIR)	1.3μm-3.0μm
		Intermediate (IIR)	3.0μm-8.0μm
		Thermal (TIR)	8.0μm-14μm
		Far (FIR)	14μm-1.0mm
Microwave (Radar)	ليس كل موجات الرادار يمكن استخدامها بالاستشعار		
		mm Radar (EHF)	1mm-10mm
		cm Radar (SHF)	1cm-10cm
		dcm Radar (UHF)	1dcm-10dcm



TYPES OF REMOTE SENSING BASED ON WAVELENGTH

Microwave or Radar Remote Sensing science

Sensor	Passive	Active
Source	Sun	Sensor
Wavelength	3cm-30cm	3cm-30cm
Mechanism (Receive)	Reflected	Back Scattering Waves
Uses	Popular	Rare



Thermal Remote Sensing Science

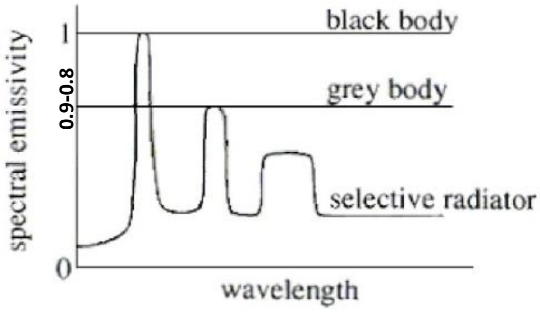
- **Depending on Black Body** idealized physical body that absorb all incident electromagnetic radiation & show the maximum thermal radiation as compared with other opject (perfect thermal radiator)
- **Plank's Low**: thermal radiation of Blackbody (B) is a function of wavelength (λ) & absolute temperature (T)

$$B(\lambda)=\frac{2hc^2}{\lambda^2}\cdot\frac{1}{e^{\frac{hc}{k_B\lambda T}}-1}=\frac{1.19x10^{-16}}{\lambda^2}\cdot\frac{1}{e^{\frac{0.0144}{\lambda T}}-1}\ [if\ T\ in^{\circ}K\ \&\ \lambda\ in\ m]$$

h (Plank's constant) = 6.63x10^{-34}Js, K (Boltizman's constant) = 1.38x10^{-23}J/°K, c (speed of light) = 3x10^{8}m/s

Black Body thermal radiation is directly related to temperature (T), & inversely related to wavelength (λ)

- **Brightness Temperature**: the equivalent temperature of Blackbody, classified on the basis of Emissivity
- **Emissivity**: ratio of object's thermal radiation to blackbody thermal radiation (1 for blackbody, & 0.8-0.9 for graybody)
- **Gray body**: emits radiant energy with <u>*constant emissivity*</u> (<u>*0.8-0.9*</u>) & <u>*lower than black body*</u> & all objects on the earth surface are gray body
- **Selective Radiator**: is the thermal radiator bodies whose spectral emissivity varies with wavelength



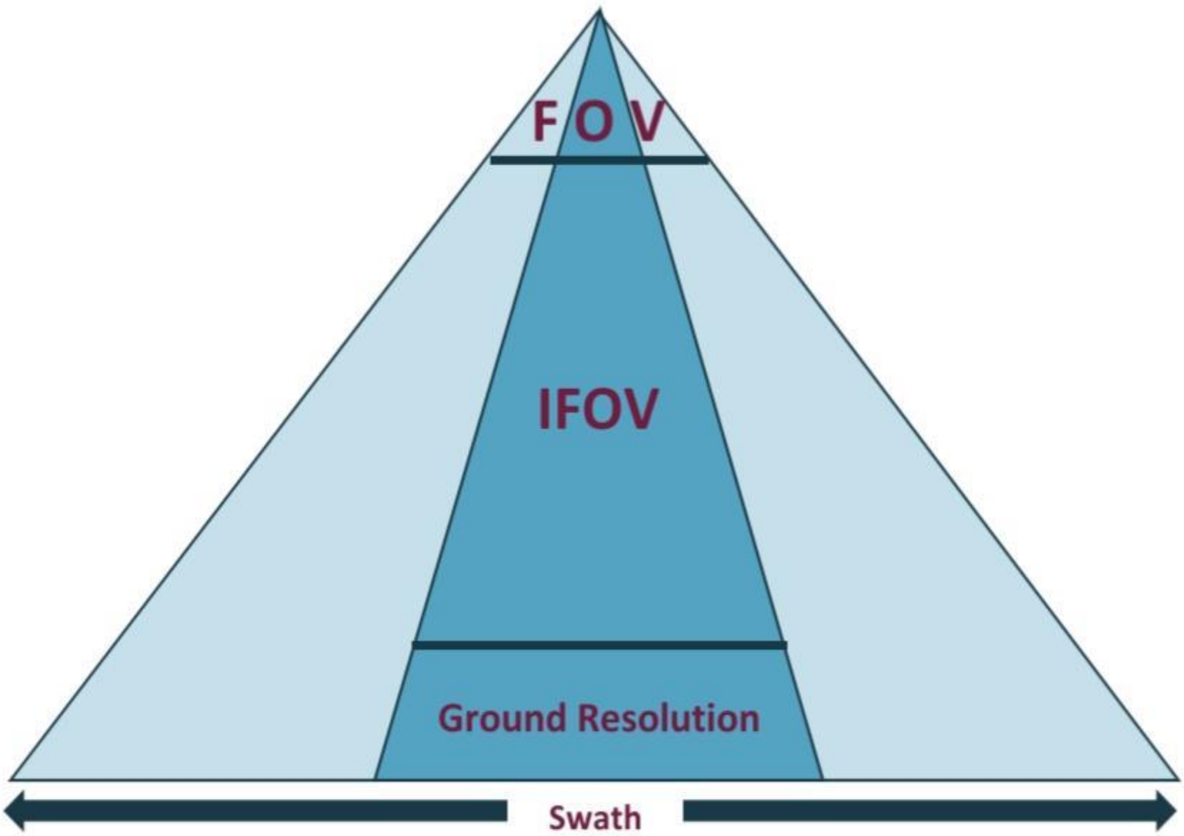
Visible & Reflected IR romote sinsing science

- **Albedo:** is the ratio of incident radiation flux of object surface to radiation flux from same surface if the source of energy is the sun
- **Reflection:** is the ratio of incident radiant flux of object surface to reflected radiation flux from same surface

Radiance → Albedo → Digital number

Energy Source	The sun
λ range	0.4µm – 0.3µm
Mechanism	Reflection
Sensor	Passive Sensor Spectral

TYPES OF REMOTE SENSING BASED ON RESOLUTION



Sensor Operation Concepts

FOV: Field of View maximum angle by which sensor looks at the swath

IFOV: Instantaneous Field of View (unit angle) Angle corresponds to the smallest pixel, cover area called ground resolution

Ground Resolution swath that covered by IFOV (how many pixels correspond to swath?)

Swath: is the total width imaged on the surface

Pixel: is the smallest controllable element of a picture represented on the screen

The closer the ground resolution to the 1, the more accurate it is
The more the pixels the more clear & details in the image

Low Ground Resolution Remote Sensing Satellite Sensor

MODIS

Moderate Resolution Imaging Spectroradiometer

Altitude	705km
Swath	2330km
Repetitive cycle	1 day
Bands	36 →7

Band	Type	G.R	SR	Spot	Type	G.R	SR	Spot	Type	G.R	SR
250m Ground Resolution				500m Ground Resolution				1000m Ground Resolution			
B1	Red	250	0.62 – 0.67	B3	Blue	500	0.46 – 0.48	B8	–	1Km	0.46 – 0.48
B2	NIR	250	0.84 – 0.87	B4	Green	500	0.55 – 0.57	…	…	…	…
				B5	MIR	500	0.13 – 0.14	…	…	…	…
				B6	MIR	500	0.16 – 0.17	…	…	…	…
				B7	MIR	500	0.21 – 0.22	B36	–	1Km	0.46 – 0.48

Moderate Ground Resolution Remote Satellite Sensor

Spot

Altitude	832km
Swath	60km
Repetitive cycle	26 days
Bands	3 + 1

Band	Type	G.R	SR	Spot	Type	G.R	SR	Spot	Type	G.R	SR
20m Ground Resolution				10m Ground Resolution				2.5m Ground Resolution			
B1	Green	20	0.52 – 0.60	Sp. 1	Pan	10	0.51 – 0.73	Sp. 5	Pan	2.5	0.51 – 0.73
B2	Red	20	0.63 – 0.96	Sp. 2	Pan	10	0.51 – 0.73	Sp. 6	Pan	2.5	0.51 – 0.73
B3	NIR	20	0.76 – 0.90	Sp. 3	Pan	10	0.51 – 0.73	Sp. 7	Pan	2.5	0.51 – 0.73
				Sp. 4	Pan	10	0.51 – 0.73				

ASTER

Altitude	705km
Swath	60km
Repetitive cycle	16 days
Bands	14 (15)

Band	Type	SA	SR	Band	Type	SA	SR	Band	Type	SA	SR
15m Ground Resolution				30m Ground Resolution				90m Ground Resolution			
B1	Green	8.9	0.52 – 0.60	B4	MIR	8.9	1.60-1.70	B10	TIR	8.9	8.12-8.47
B2	Red	8.9	0.63 – 0.96	B5	MIR	8.9	2.14-2.18	B11	TIR	8.9	8.47-8.87
B3n	NIR	8.9	0.76 – 0.90	B6	MIR	8.9	2.18-2.22	B12	TIR	8.9	8.92-9.27
B3b	NIR	24.8	0.76 – 0.90	B7	MIR	8.9	2.23-2.28	B13	TIR	8.9	10.3-11.0
				B8	MIR	8.9	2.29-2.36	B14	TIR	8.9	11.0-21.7
				B9	MIR	8.9	2.36-2.43				

Landsat 8 & Landsat 9

Altitude	705km
Swath	185km
Repetitive cycle	16 days
Bands	11

Band	Type	G.R	SR	Band	Type	G.R	SR	Band	Type	G.R	SR
30m Ground Resolution				15m Ground Resolution				100m Ground Resolution			
B1	Costal	30	0.43 – 0.45	B8	Pan	15	0.50 – 0.68	B10	TIR	100 m	10.6 – 11.2
B2	Blue	30	0.45 – 0.52					B11	TIR	100 m	11.5 – 12.5
B3	Green	30	0.53 – 0.59								
B4	Red	30	0.63 – 0.67								
B5	NIR	30	0.85 – 0.87								
B6	MIR	30	1.57 – 1.65								
B7	MIR	30	2.11 – 2.29								
B9	Cirrus	30	1.36 – 1.38								

Landsat ETM

Altitude	705km
Swath	185km
Repetitive cycle	16 days
Bands	8(7)+1

Band	Type	G.R	SR	Band	Type	G.R	SR	Band	Type	G.R	SR
30m Ground Resolution				60m Ground Resolution				15m Ground Resolution			
B1	Blue	30	0.45 – 0.52	B6a	TIR	60	10.4 – 12.5	B8	Pan	15 m	0.52 – 0.90
B2	Green	30	0.52 – 0.60	B6b	TIR	60	10.4 – 12.5				
B3	Red	30	0.63 – 0.96								
B4	NIR	30	0.76 – 0.90								
B5	MIR	30	1.55 – 1.75								
B7	MIR	30	2.09 – 2.35								

Landsand TM

Altitude	705km
Swath	185km
Repetitive cycle	16 days
Bands	7

Band	Type	G.R	Spectral Resolution [µm]	Band	Type	G.R	Spectral Resolution
30m Ground Resolution				120m Ground Resolution			
B1	Blue	30	0.45 – 0.52	B6	TIR	120	10.4 – 12.5
B2	Green	30	0.52 – 0.60				
B3	Red	30	0.63 – 0.96				
B4	NIR	30	0.76 – 0.90				
B5	MIR	30	1.55 – 1.75				
B7	MIR	30	2.08 – 2.35				

High Ground Resolution Remote Sensing Satellite Sensor

IKONOS

Altitude	681km
Swath	20km
Repetitive C	1.3-3 days
Bands	4+1

Band	Type	G.R	Spectral Resolution [µm]	Band	Type	G.R	Spectral resolution
4m Ground Resolution				1m Ground Resolution			
B1	Blue	4	0.45 – 0.52	B5	Pan	1 m	0.45 – 0.90
B2	Green	4	0.52 – 0.60				
B3	Red	4	0.63 – 0.96				
B4	NIR	4	0.76 – 0.90				

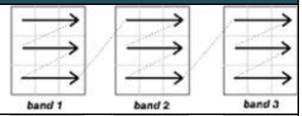
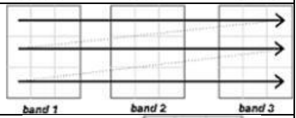
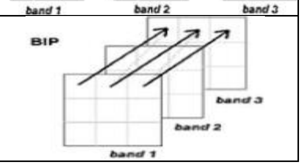
Quick Bird

Altitude	450km
Swath	16.5km
Repetitive cycle	3-7 days
Bands	4+1

Band	Type	G.R	Spectral Resolution [µm]	Band	Type	G.R	Spectral resolution
2.4m Ground Resolution				0.6m Ground Resolution			
B1	Blue	2.4	0.45 – 0.52 µm	B5	Pan	0.6	0.45 – 0.90 µm
B2	Green	2.4	0.52 – 0.60 µm				
B3	Red	2.4	0.63 – 0.96 µm				
B4	NIR	2.4	0.76 – 0.90 µm				

- **Multispectral Band Conditions**: reserved from same sensor by reflection mechanism, have same G.R & different spectral resolution
- **Altitude:** is the distance between the sensor & the earth's surface (measured at the equator)
- **Repetitive Cycle:** is the time required for sensor to back to the same point

MULTISPECTRAL BANDS RECORDING & DIGITAL IMAGES

Methods of Multispectral Bands Recording		
Band Sequential (BSQ)	Data is recorded band by band (e.g Quick Bird) is the most common method • Start at the 1st pixel of the 1st band & then the 2nd pixel of the first band, then 3rd… When finishe the 1st band, goes to the 2nd & repeats the steps	
Band Interleaved by Line (BIL)	The data is recorded Line-by-Line • The first line of each band is recorded (all pixels in the first line of 1st band, then pixels of the 1st line of second band… etc), then the second line… etc	
Band Interleaved by Pixel (BIP)	The first pixels of the first line of each band is recorded then the second pixels from the same line, then the third pixels from the same line….etc & as finish the first line goes to the second line & repeats the steps	

- **Methods of Data Dumping from sensors**: Ground Receiving Stations (GRS) & Space Receiving Stations (SRS)

Media of Remote Sensing Data Storage					
Types	**Storage**	**Notes**	**Types**	**Storage**	**Notes**
Linear Tape Open (LTO)	Up to 4 TB	Used by centers	Digital Versatile Disk (DVD)	Up to 5 GB	Used by users
External Hard Disk (HD)	Up to 2 TB	Used by users	Compact Disk (CD)	Up to 700 MB	Used by users
Flash Memory (USB)	Up to 128 GB	Used by users	Floppy Disk Drive (FDD)	Low	Used in the past

- **Ground Truth**: is a ground reference data base, or any measured on the ground & earth's surface, قواعد البيانات المرجيعية الارضية هي اي قياسات او قراءات يتم عملها على سطح كوكب الارض سواء قبل عملية اطلاق المستشعر وتشغيله او قبل
- **Data classification:** the data classified into **Primary data** (data from the field), & **Secondary data** (data on a map)

Purposes of Using Ground Truth ل قواعد البيانات المرجيعية الارضية	
Before Operation	**Sensor Design (e.g. NIR Bands)** تصميم المستشعر: يتم قبل اطلاق وتشغيل المستشعر، بعمل نماذج مصغرة عن اجهزة المستشعر وتجربتها على السطح، فتبدأ عملية انشاء قواعد البيانات والاحتفاظ بها ليتم استخدامها عند الحاجة
After Operation	Validation, Calibration, & Supplement 1. **Validation & Calibration**: are pixels check, & if there's something wrong, it's repaired in same band 2. **Supplement:** A. **Analysis**: تجميع نقاط مرجعية ارضية واستخدامها بعملية تحليل بيانات المرئية بزيارة منطقة الدراسة ومقارنتها بالمرئية B. **Geometric Correction**: you must correct north direction & astronomical coordinates

- **Ground Control Points (GCP) نقاط التحكم الأرضية:** part of ground truth, & must be ***Fixed ثابتة*** & ***Distinct مميزة***

ليست كل نقطة ثابتة مميزة فمثلا نقطة منتصف الغرفة ثابتة لكنها غير مميزة (ليست GCP) ولكن زوايا الغرفة ثابتة ومعروفة لذا هي مميزة (GCP)

ليست كل نقطة مميزة ثابتة فمثلا نقطة تعبر عن قارب في نهر ليست ثابتة ولكنها مميزة

- **Ways of collecting GCP:** Field Work (GPS), Topographic Map (Map to Image), Corrected or Geocoded Image (Image to Image)
- **Conditions of Geometric Correction Performance**:
  1. **Enough numbers of GCPs for full scene (full swath)**: for 1 swath we have 6GCP, & for quarter swath we have 15-20GCP
  2. **The data should be well distributed:** separation of the image into 4 parts (4 squares) with equal number of GCP
  3. **Root Mean Square Error (RMSE) must be <0.5pixel**

DIGITAL IMAGE PROCESSING & INTERPRETATIONS

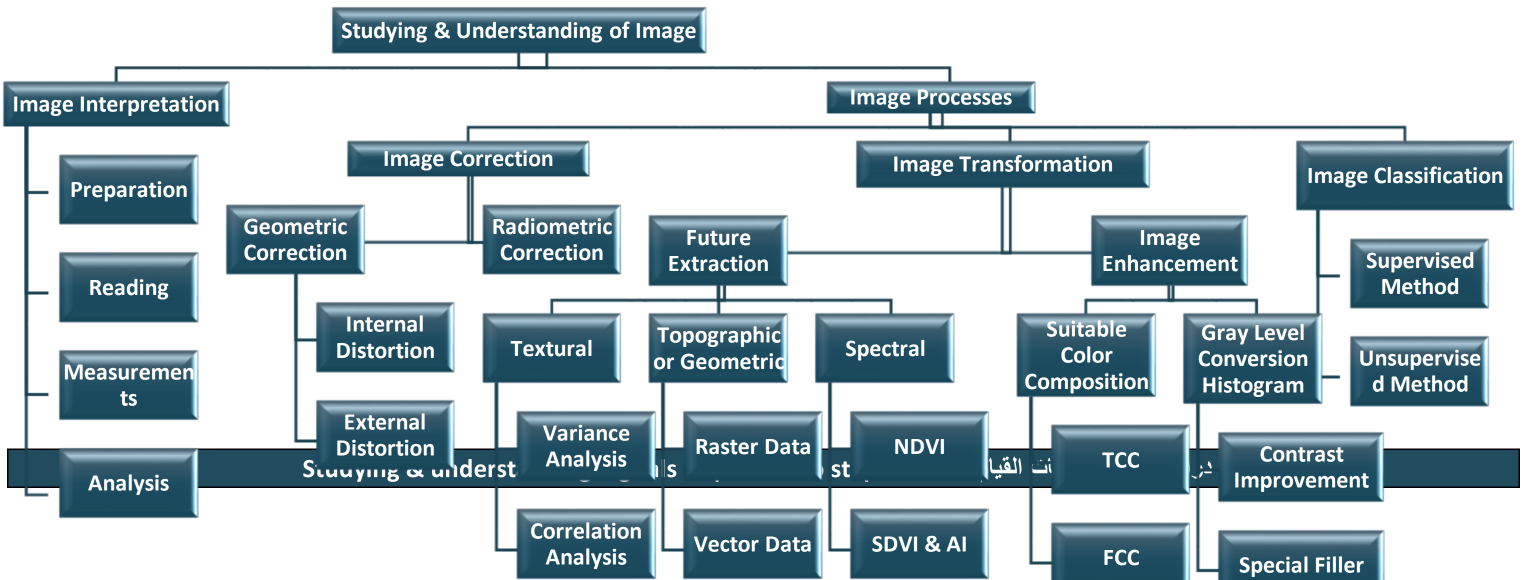


Image Interpretation تفسير المرئيات

Is the extract of quantitative & qualitative information using ***human knowledge***

Extraction Information	Image Classification	Change Detection	Extraction of Indices	Physical Quantities Extraction	Specific Feature Identification
Example	Rock, soil, vegetation…	Land cover / use change	Vegetation index (NDVI)	Height elevation (DEM), thermal remote sensing	Floods & forest fire

Advantage: Knowledge is available, & Interpretation is better | **Disadvantage:** Need specialists, high time; cost; & effort

Procedures	Steps
Preparation (Pre-work)	**Data collection to gain knowldge** **To obtain suitable image:** Goals & Area of the study, Sensor type, & Bands taken into account **Geometric correction:** correction of North direction & astronomical coordinates
Reading	**Interpretation of keys, shape, & pattern**
Measurement	**Length & area**
Analysis	**Determine of object evaluation**
Maping	**Display results of interpretation by thematic map**

Image Processing معالجة المرئيات

Depending on software (skills to use satellite image)

Advantage Short time, Extraction of physical quantity, Standardization | **Dis.** Difficult analysis & transform of knowledge

Image Correction	**Radiometric** or **Geometric** (geometric may external or internal distortion)
Image Transformation	**Features Extraction, & Image Enhancement**
Image Classification	**Supervised, or Unsupervised**

Image Correction: is the correction of north direction & astronomical coordination

Radiometric

- it's not your responsibility (as user) to perform radiometric correction, it is center responsibility (such as NASA)
- **Causes**: Sensor Sensitivity, Solar Angle or Sun Angle, & Conditions of atmosphere

Scale Error

Projection Error

Geometric

Internal

Cause: Problems in sensor design
Types: Scale Error, & Projection Error
It's **center responsibility** to perform correction (not users)

External

Cause platform variation height, Earth curvature
Types: Shift Error, Earth Curvature Error
It's users responsibility: performed using GCPs

Shift Error

Earth curvature Error

Image Transformation : Image Enhancement

Is the increase or improvement in quality of the image & deals with Gray Color Data components

The main objective of image enhancement is to improve the visual interpretation الهدف هو تحسين التفسير بواسطة النظر

Methods: Suitable Color Composition, & Gray Level Conversion Histogram

Suitable Color Composition

The Color Composition Conditions are:

1. **RGB Color Screen:** must have the colored filters (Red R, Green G, Blue B)
2. **Three multispectral Bands:** must use only 3 multispectral bands over the RGB filters
3. **No repetition of same band over 2 filters**

Example: Quick Bird sensor has 4 multispectral bands, so 24 color can be made (by factorial: 4! = 4*3*2*1 = 24)

True Color Composition TCC

To perform TCC (True Color Composition) you must assign on (RGB) filters in which each band should be seen on its filter (red band on red filter, blue band on blue filter, & green band on green filter)

- If all bands are found in the sensor (RGB) you can make a TCC & if one of the bands is lost, there is no TCC
- Each sensor has only & only one TCC & any other composition is FCC
- **Visual Interpretation of TCC:** the colors in image are the same of their natural color

TCC for all sensors	Sensor	MODIS			LandSat 8-9			LandSat ETM			LandSat TM			IKONOS			Quick Bird		
	Filters	R	G	B	R	G	B	R	G	B	R	G	B	R	G	B	R	G	B
	Bands	1	4	3	4	3	2	3	2	1	3	2	1	3	2	1	3	2	1

SPOT & ASTER sensors don't have TCC, because lack of blue band

False Color Composition

FCC is important because some sensors (SPOT & ASTER) don't include TCC

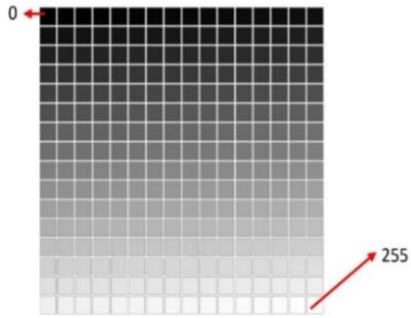
If we put NIR band in the Green filter regardless of other filters	>98% of green color are represent the vegetation areas because leaves have high response for NIR (higher albedo)
If we put NIR band in the Blue filter regardless of other filters	>98% of blue color are represent the vegetation areas because the leaves have high response for NIR (higher albedo)
If we put NIR band in the Red filter regardless of other filters	>98% of red color are represent vegetation because the leaves have high response for NIR (higher albedo)

يمكن استخدام الNIR لمعرفة مثلا وجود امراض في النباتات حيث يمكن الاستدلال على ذلك من اختلاف درجات اللون في الحقل الواحد

Gray Levels Conversion Histogram

Image as a binary format use 1 or 2 bytes & satellite image use 1 byte

1byte = 8 bit = 2^8 or 256 levels of Gray color or LGC



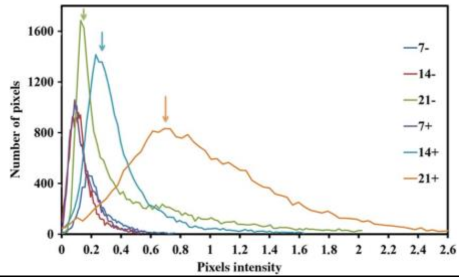
- **Color Table**: is a table on the computer software represents the levels of the colors & for gray color the gray color fixed at 128 & if moves towards 0 the gray become darker until reaches black at 0, if we move toward 256 the gray color become lighter until reaches the weight color at 256

  256 LGC (light gray color) → Digital Number (DN) → 0 to 256 (integer DN)
- **As we select enhancement we are force the software to use highest gray color levels as possible in order to improve visual interpretation**

Steps of Gray Levels Conversion

Contrast Improvement

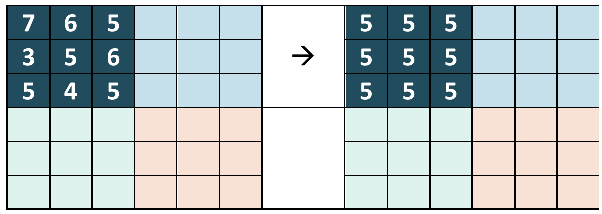
Is the improves the contrast in the curved pattern by histogram stretching using linear or non linear mathematical equations that leads to force software to use the highest gray level as possible (which are not used before) then the image becomes clear in order to improve visual interpretation



Spatial Filters

Spatial filters: filter used to make visual interpretation for images with speckle noise possible

- **Speckle noise (salt & pepper):** black & white points on the digital image that make interpretation difficult
- Used for microwave (radar) images, because images of active radar system have speckle noise



لو اخترنا نافذة (3*3) وفلتر Average فإن البرمجية ستقسم المرئية لنوافذ كل واحدة (3*3) وتطبق المعادلة على كل نافذة

Working conditions of Spatial filters:

1. **Choose window size**: should be odd number (3*3pixels, 5*5pixels, 7*7pixels,..., 33*33pixels)
2. **Choose filter type** (Statistical equation): e.g. Median Filter, Mode Filter, Mean Filter...

بهذه الطريقة نحن نخسر بعض المعلومات عن ال gray levels وبالتالي يجب أن نبقيها بأقل حجم ممكن لتقليل الخسائر بالمعلومات

Image Transformation : Future Extraction

Spectral Features

- Very important because represents spectral characteristics of object & can be studied by Vegetation Indices

NDVI: Normalized Difference Vigitation Index, used for vegetation type classification & land degradation studies

$$\textbf{NDVI (Normalized Difference)} = \frac{\textbf{NIR} - \textbf{Red}}{\textbf{NIR} + \textbf{Red}} = (-1, +1)$$

$$+\text{ve for area with vegetation cover} \quad -\text{ve if there's no vegetation}$$

The equation is applied in the form of pixel based that mean all corresponding pixels between 2 bands (Red & NIR)

$$\textbf{SAVI (Soil Adjusted Vegetation Index)} = \frac{\textbf{NIR} - \textbf{Red}}{\textbf{NIR} + \textbf{Red} + \textbf{L}} = (-1, +1)$$

L= 0 for area with denser planets, L=1 for rare planets, L= ½ for arid to simi-arid areas (e.g. Jordan)

يعتمد تطبيق إحدى المعادلتين (SAVI & NDVI) على تصنيف منطقة الدراسة من ناحية مناخية (مناطق جافة او رطبة) وحتى نستطيع تصنيف المناطق نعتمد على معادلة Aridity Index (AI) على ان تكون القراءات على الاقل ل 20 سنة مضت

$$AI = \frac{Avg\ Rainfall}{Avg\ Evapotranspiration}$$

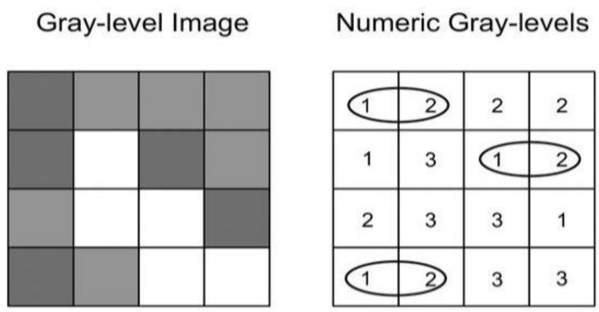
AI	Area Classification	Zones
≤0.05	Hyper Arid Area	Arid Zone SAVI & L =0.5
0.05-0.2	Arid Area	
0.2-0.5	Simi-Arid Area	
0.5-0.65	Sub-Humid Area	Humid Zone NDVI
≥0.65	Humid Area	

- **Benefets of NDVI**: used to indecate the area of vegitation, the vegetation density, classification of vegetation, & used for some environmental issues such as land degredation studies

Textural Features

The texture of the image is the relationship between spectral data & gray levels. If you have a homogeneous object in a part of an image, the Gray levels of pixels that should have the same (almost the same) Gray levels

- In order to to analyze phenomena, statistical laws must be used & statistical relationship between objectives must be found & laws are applied in the size of odd window (e.g. 3*3)



Correlation Texture Analysis: Inter Low (0) or High (1) Correlation

Variance Texture Analysis: Inter low(0) or high (1) variance

Topographic Features or Geometric Features

Topographic features (Area, Length, Width, & geomorphological analysis) extracted directly by tracing over features using satellite image

Types of data structures using in romote sensing

Raster Data

Raster Data: digital aerial photographs with regular grid cells (consist of pixels), & stores data that represents real-world phenomena

- **Represents using** astronomical (x,y) or graphical coordination (e.g. 3,2 or 9,6…)
- **Rasterization:** is the transformation any data from vector form to raster form

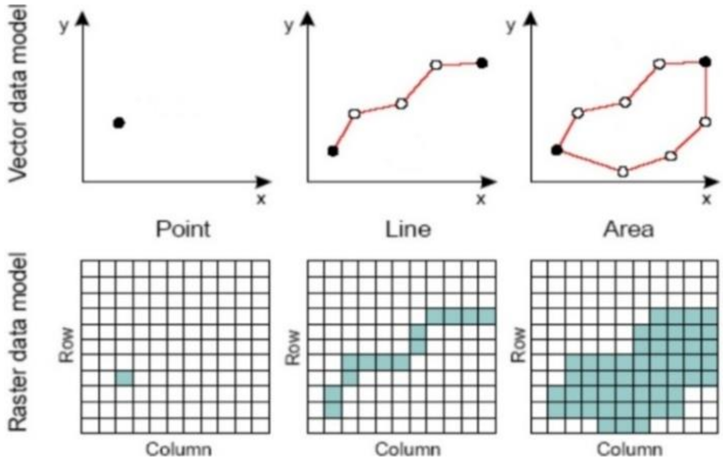
Vector Data

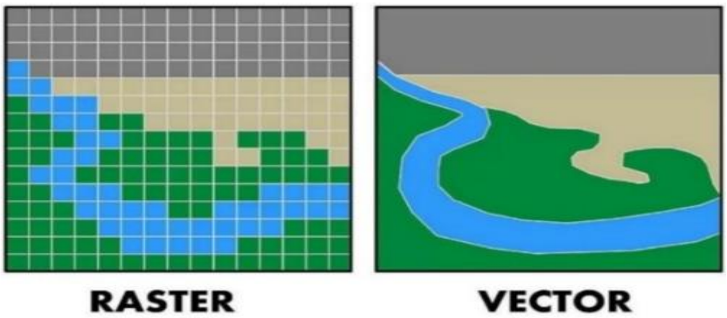
Vector Data: has a special distribution, & is the data representation of the world using points, lines, & polygons

- **Represents** by astronomic coordination
- **Vectorization:** is the transformation data from raster form to vector form

Type	Defined
Points	Point Id code, (x, y), Attribute table
Line	Line Id code, start & end points, Attribute table
Polygon	Polygon Id code, series of line in clockwise, Attribute table

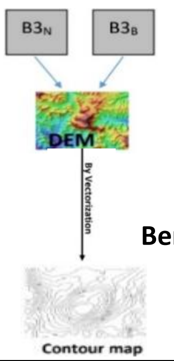
- **e.g.** If the colleges is ***point,*** the Street or Gates is ***Line,*** & Car parking is ***Polygon***





- **Geomorphology**: is the study of landforms, their processes, form & sediments at the surface of the Earth
- **Stereotypic Image:** is the image that created by taking two photographs of the same subject, from viewpoints approximately the same distance apart as human eyes

يمكن استخدام المرئيات الفضائية لتمثيل أي ظاهرة كبيانات خطية، مثلاً نستطيع رسم خط فوق الوادي أو الصدع وحساب طوله. أو polygon حول عينة معدن ومعرفة مساحتها ولعمل تحليل جيومورفولوجي نحتاج لنموذج ارتفاع رقمي ونحصل عليه من المرئية الستيريوسكوبية



Geomorphology → DEM → Stereoscopic image

لعمل المرئية الستيريوسكوبية Stereoscopic image يجب توفر مرئيتين لمنطقتين متجاورتين ولها شرطين ان تكون منطقة مشتركة overlap area مع وجود اختلاف بزاوية المسح scanning (يتوفر الشرطين فقط بـ ASTER بالباندين B3N & B3B)

يتم عمل وإنشاء DEM بخطوات باستخدام البرمجيات ويصنف على أنه Raster Data وبعد إنشائه نستطيع استخدام عمليتين:

Vectorization (transform raster to vector data) & **Rasterization** (transform Vector to Raster data)

لو طابقنا الصورة الأصلية مع خطوط الكنتور نستطيع إخراج ranks of drainage لترتيب المجاري المائية السطحية

Benefits of Topographic (Geometric) Features

1. Analyzing of Drainage Basin & surface water
2. Determining the best land use of the study area
3. Studying some Environmental Problems (Floods)

Image Classification

used to assign each pixel into groups (classes) & each group must have homogeneous spectral characteristics (depending on spectral characteristics), the number of groups determined by the user based on the previous stage (Transformation)

Supervised Method

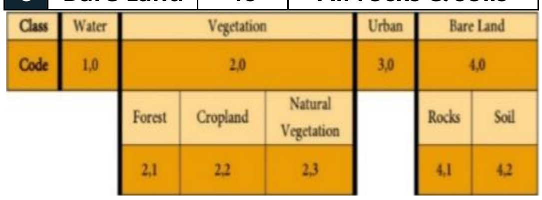
Depending on users (by >80%), & Related to training area collection

Procedures:

1. General Definition of Classes by Coding
2. Specification Definition of Each Class
3. Training Area Samples Collection
4. Selection of Classification Algorithm (e.g. Maximum likelihood algorithm): اختيار قانون احصائي معرف داخل البرمجية
5. Classification Performance: تعتمد على المستخدم
   بالضغط على Classify للحصول على صورة ملونة ويمثل كل لون صنف معين
6. Accuracy assessment of the results

Training Area: a few homogeneous pixels (20-30) represent the pure class, assembled by human knowledge or field work (e.g. GPS), to enable the software to recognize class spectral characteristics

#	Class	Code	Specific Definition
1	Water	10	All water bodies
2	Forest	21	All type of forests
3	Cropland	22	Vegetable & Fruit
4	Vigitation	23	Grazing Vigitation
5	Urban	30	All construction
6	Bare Land	40	All rocks & soils



Unsupervised Method	
Unsupervised Method	Depending on Software (by >80%), & Related to Cluster Method (ترتبط بطريقة المجاميع وتعتمد على النظام) يقوم المستخدم بتحديد الأصناف التي يريد أن تقوم البرمجية بعمل تصنيف غير موجه لها وإعطاء العوامل التي سوف يستند عليها ويرتبها من خلال البرمجية **Procedure:** 1. Define the number of classes 2. Define the number of iteration (المحاولات) 3. Select the algorithm (statistical equation): such as K-mean algorithm 4. Classification performance 5. Accuracy assessment of the results **Example:** For a مرئية consisting of 5 classifications, the software must be given the data: Number of classes = 5, Number of iterations = 10, Algorithm = k – mean algorithm, then Classify, then the next steps must be taken 1. يتم عمل مجاميع واستخدام k-mean وتصنيف البكسل لـ 5 أصناف لكل صنف صفات طيفية لكن بعض البكسلات لن تصنف لتداخل صفاتها 2. يتم عمل تداخل في الصفات الطيفية للمجاميع الخمسة والبدء بالتصنيف وإذا كان هناك بكسل لم يصنف لتداخل الصفات يبدأ بالمحاولة الثالثة 3. يتم زيادة تداخل الصفات الطيفية لتصنيف كل البكسل ويجب ان تتصنف كل البكسلات في مجاميع Clusters بحسب صفاتها 4. **النتيجة:** صورة ملونة وبحاجة لتحديد وحساب دقة التصنيف لها لاعطاء مصداقية للتصنيف وذلك بانشاء مصفوفة الاخطاء Error Confusion Matrix بحيث يجب ان تصل الدقة الى 85٪ ونسبة الخطأ اقل من 15٪ (اي 85٪ من العينات تصنف بشكل صحيح) 5. **اذا كانت نتيجة الحساب للدقة <85%**: نقوم بإعادة عملية التصنيف مع زيادة عدد الأصناف أو تقليلها ثم حساب الدقة مرة أخرى

Accuracy assessment or classification accuracy in the image classification (supervised & unsupervised methods)

- You must use the classification accuracy calculation to give the results credibility, that can be done using deffrent methods such as confusion matrix or error matrix (مصفوفة الخطأ او مصفوفة الالتباس)
- **Confusion matrix or Error matrix**: is the mathematical matrix that used to calculate the overall accuracy of the resulted data, it should be > 85% (error < 15%), if the overall accuracy < 85% you must re-classify the data either by increasing the number of items or reducing the number of items & recalculating again.

EXAMPLE: Confusion Matrix & Accuracy Matrix Calculation

$$\begin{array}{c} \\ a \\ b \\ c \end{array} \begin{array}{c} \begin{array}{ccc} A & B & C \end{array} \\ \begin{bmatrix} 37 & 3 & 7 \\ 9 & 25 & 5 \\ 11 & 2 & 43 \end{bmatrix} \end{array}$$

How we can reding the matrix? columns are the ground truth classes; rows are the classes of the classified image to be assessed, & cells show number of pixels for all the possible correlations between the ground truth & the classified image. The values shaded in yellow color are correctly classified values (A-a, B-b, C-c), & A, B, C, a, b, c are items (e.g., A & a = Rock, B & b = Vegetation, C & c = Water)

To calculate overall accuracy? Calculate the total of each class, then calculate the overall accuracy by dividing the correctly classified values by total values, then calculate the accuracy of each class by dividing coorectly classified values in the class over total values of a class

	A	B	C	Total	Acc
a	37	3	7	47	$\frac{37}{47} = 79$
b	9	25	5	39	$\frac{25}{39} = 64$
c	11	2	43	56	$\frac{43}{56} = 77$
Total	57	30	55	142	
Acc	$\frac{37}{57} = 65$	$\frac{25}{30} = 83$	$\frac{43}{55} = 78$		

$$\textbf{Overall Accuracy} = \frac{\textbf{Correctly Classified Values}}{\textbf{Total Number of Values}} = \frac{\mathbf{37 + 25 + 43}}{\mathbf{142}} = \frac{\mathbf{105}}{\mathbf{142}} = \mathbf{0.74 \rightarrow 74\%}$$

هذه القيمة غير مقبولة ويجب اعادة التصنيف مرة اخرى (لانها اقل من 85٪)

EXAMPLE: Area Calculation

If the size of the image 0, 0, 8429, 8431 calculate the total area

The first step is determine the type of the image (e.g., QuickBird, 2.44Km GR), then calculate the Image Percentage (% image), then calculate the total area, then calculate the area in each class

$$\%\textbf{Image} = \frac{\textbf{Pixels in class}}{\sum \textbf{Pixels}} \boldsymbol{x}\textbf{100}\%$$

$$\textbf{Total area} = \textbf{PxLxGR}^{2}$$

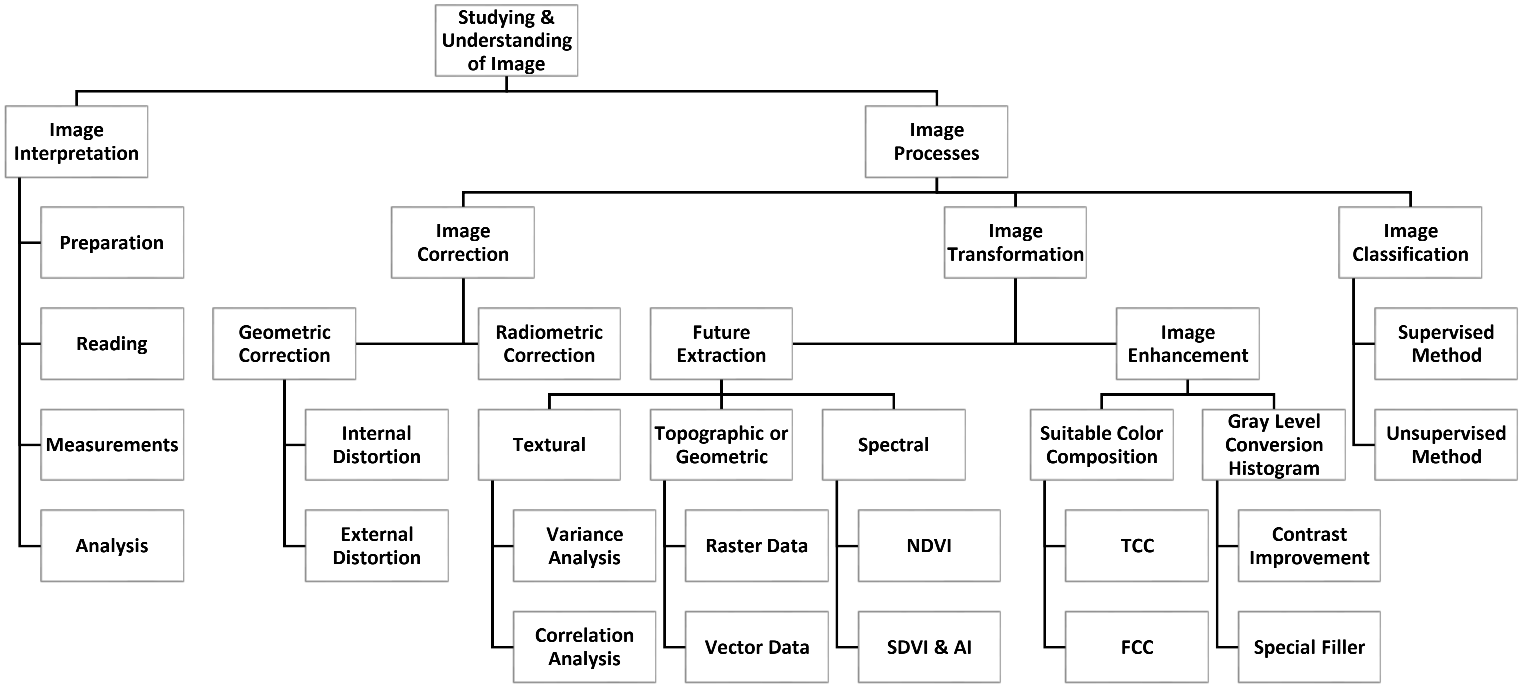
$$\textbf{Class Area} = \frac{\%\boldsymbol{Image}\ \ \boldsymbol{x}\,\boldsymbol{Total\ Area}}{\textbf{100}\%}$$

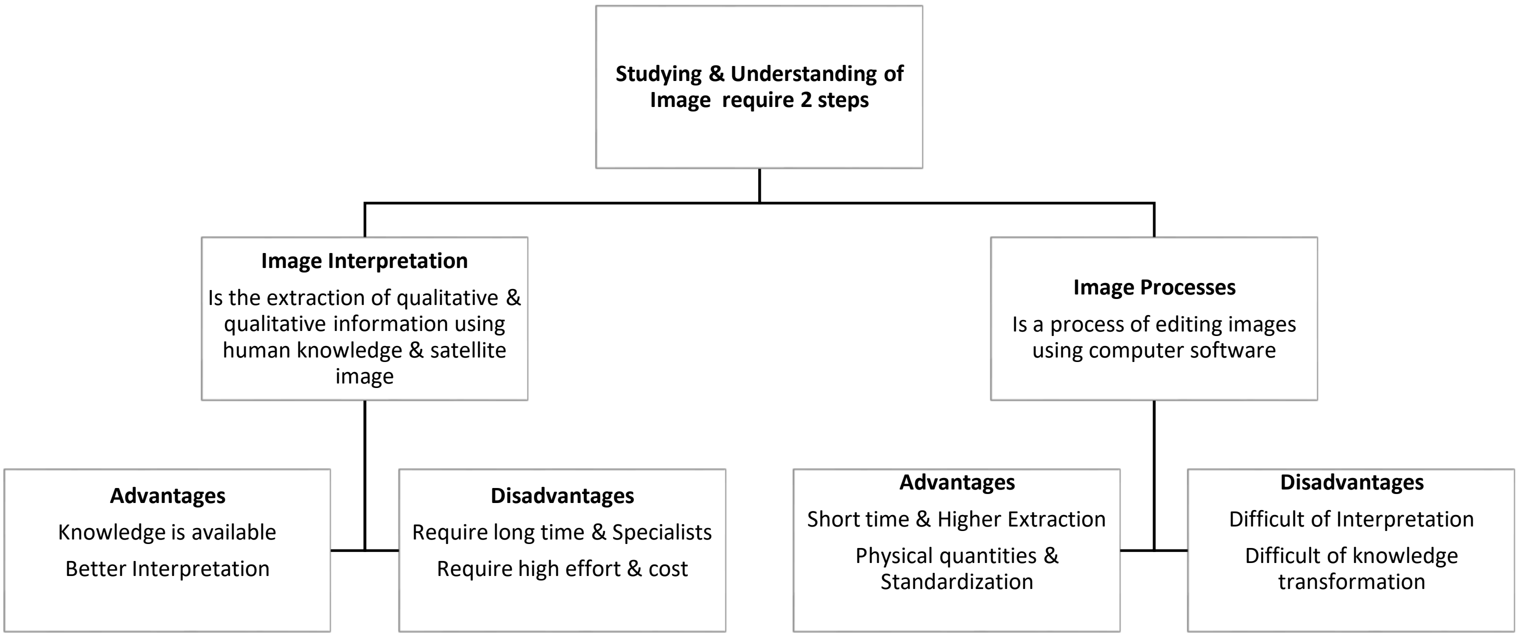
```
Number of Clusters: 4

Cluster          Pixels      Mean Position   Std Dev :

(  1)           18239240       20.23125        11.47457
                               20.93345        13.16216
                               19.56831        13.05808
                               19.26643        12.96863

(  2)           28368562       69.61281        11.46781
                               85.75694        11.77103
                               90.70627        14.76839
                              155.82958        50.38782

(  3)           19887503      104.24466        14.07138
                              118.76809        14.17626
                              130.38841        15.73658
                              141.96898        24.72298

(  4)            4569594      166.80290        29.72977
                              185.72487        28.02513
                              198.18117        26.42585
                              198.14843        27.21994

                --------
Total            71064899
```

Cluster	Pixels	Image %	Area
1	**18239240**	25.66561025	108.3722863
2	**28368562**	39.91923214	168.5577866
3	**19887503**	27.98498736	118.1657881
4	**4569594**	6.430170259	27.15120528
Total	**71064899**	**100**	**422.2470663**

Total Area = 422.24706630672

SMARTARTS


Studying & Understanding of Image
Image Interpretation
Preparation
Reading
Measurements
Analysis
Image Processes
Image Correction
Geometric Correction
Internal Distortion
External Distortion
Radiometric Correction
Image Transformation
Future Extraction
Textural
Variance Analysis
Correlation Analysis
Topographic or Geometric
Raster Data
Vector Data
Spectral
NDVI
SDVI & AI
Image Enhancement
Suitable Color Composition
TCC
FCC
Gray Level Conversion Histogram
Contrast Improvement
Special Filler
Image Classification
Supervised Method
Unsupervised Method


Studying & Understanding of Image require 2 steps
Image Interpretation
Is the extraction of qualitative & qualitative information using human knowledge & satellite image
Advantages
Knowledge is available
Better Interpretation
Disadvantages
Require long time & Specialists
Require high effort & cost
Image Processes
Is a process of editing images using computer software
Advantages
Short time & Higher Extraction
Physical quantities & Standardization
Disadvantages
Difficult of Interpretation
Difficult of knowledge transformation

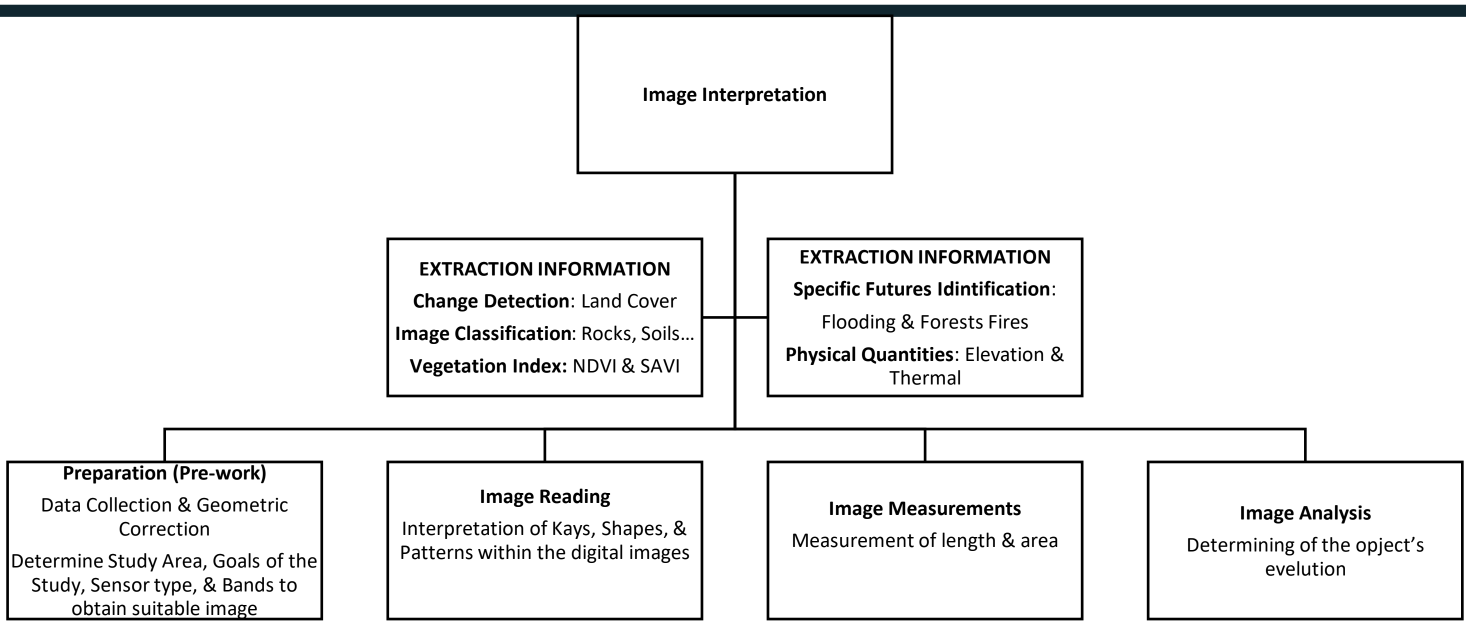


Image Interpretation
EXTRACTION INFORMATION
Change Detection: Land Cover
Image Classification: Rocks, Soils…
Vegetation Index: NDVI & SAVI
EXTRACTION INFORMATION
Specific Futures Idintification:
Flooding & Forests Fires
Physical Quantities: Elevation & Thermal
Preparation (Pre-work)
Data Collection & Geometric Correction
Determine Study Area, Goals of the Study, Sensor type, & Bands to obtain suitable image
Image Reading
Interpretation of Kays, Shapes, & Patterns within the digital images
Image Measurements
Measurement of length & area
Image Analysis
Determining of the opject's evelution

Image Correction

Is the correction of north direction & astronomical or geographic coordination

Geometric Correction

Applied if there is internal or external distortion & may be user or center responsibility, include curvature, shift, scale, or projected errors

Radiometric Correction

It's centers responsibility, applied if the distortion caused by solar angle, atmospheric conditions, or sensor sensitivity

Eternal Distortion

Caused By: problems in sensors design

Types: Scale Error & Projection Error

Performed by: Center Responsibility

External Distortion

Caused By: Variation heights of platform, & Earth curvature condition

Types: Earth's Curvature Error & Shift Error

Performed by: User Responsibility, by collect enough numbers of GCPs

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Image Enhancement

increas or improvement quality of image to improve the visual interpretation, & deals with Gray Color Data components

Suitable Color Composition

The Color Composition Conditions are: RGB Color Screen, must use only 3 multispectral bands over the RGB filter, & No repetition of same band over 2 filters

Gray Level Conversion Histogram

Color Table: gray color fixed at 128 (LGC) & towards 0 become darker, & toward 256 become lighter

True Color Composition(TCC)

you must assign on (RGB) filters in which each band should be seen on its filter

False Color Composition (FCC)

important because some sensors don't include TCC

You can determine the area of vegetation using the NIR band

Contrast Improvement

improve the contrast in the curved pattern using equations that force software to use the highest gray level as possible (which are not used before) in order to improve visual interpretatio

Special Filler

filter used to make visual interpretation for images with speckle noise (radar) but may be leds to losing information

Used for microwave (radar) images, because images have speckle noise

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Spectral Features Extraction

represents spectral characteristics of object & can be studied by Vegetation Indices

NDVI

Normalized Difference Vigitation Index, used for vegetation type classification & land degradation studies

NDVI = $(B_{NIR} – B_{Red})/(B_{NIR} + B_{Red})$

SAVI

Soil Adjusted Vegetation Index

NDVI = $(B_{NIR} – B_{Red})/(B_{NIR} + B_{Red} + L)$

AI

Aridity Index

AI = Avg.Rainfall/Avg. Evapotranspiration