ERASMUS-EDU-2023-CBHE
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LAND MANAGEMENT IN CENTRAL ASIA

12.- Sensors and Remote Sensing Platforms

Classification of Remote Sensing Sensors

LM-W12-V78

Classification of Remote Sensing Sensors

OPTICAL

records reflected sunlight

Examples: camera, multispectral, hyperspectral

THERMAL

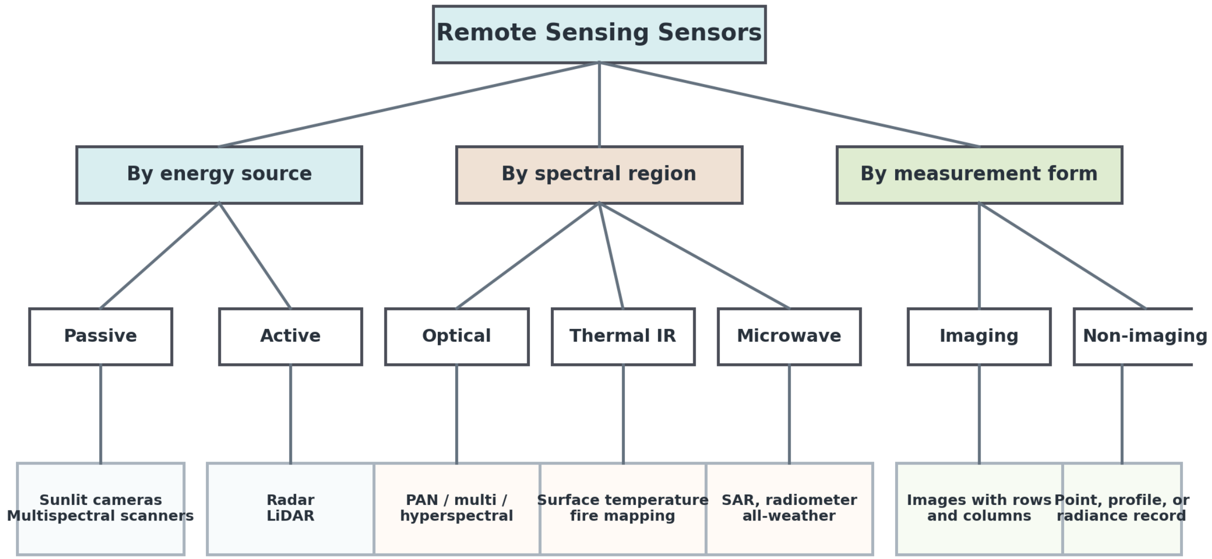
measures surface temperature

Examples: TIRS, thermal camera

MICROWAVE

uses long wavelengths and radar

Examples: SAR, radiometer



Why do we classify remote sensing sensors?

Classification helps us choose the right sensor for the right observation task.

Learning outcomes

Explain the main bases for classifying remote sensing sensors.

Distinguish passive and active sensors.

Identify optical, thermal, and microwave sensor classes.

Recognize imaging and non-imaging instruments.

Select a suitable sensor type for common applications.

Key idea

A single “best” sensor does not exist.

Each class captures different properties of the Earth surface.

Typical decision questions

Do you need sunlight or your own signal?

Do you need temperature, color, moisture, or structure?

Do you need data at night or through clouds?

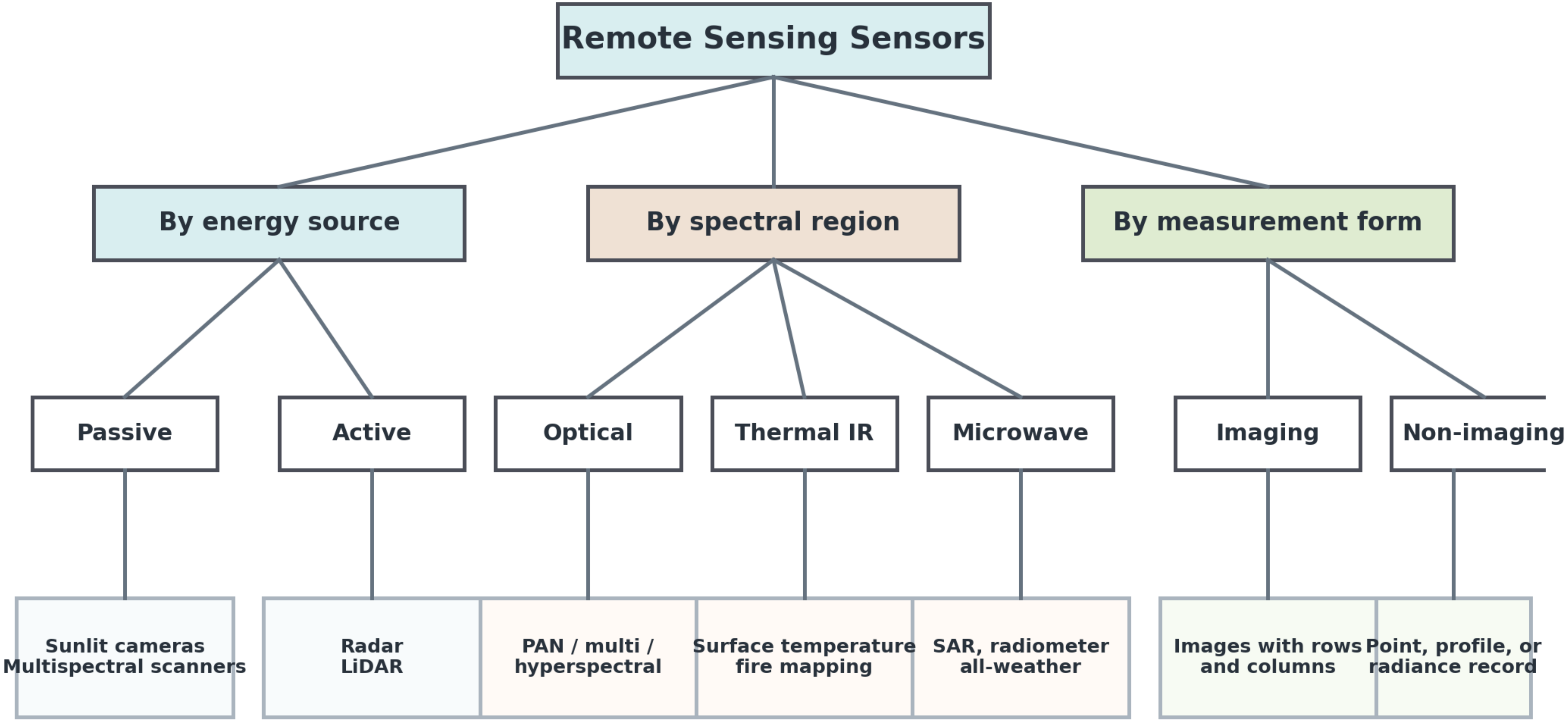
Observe
What physical signal is measured?

Choose
What environment and resolution are needed?

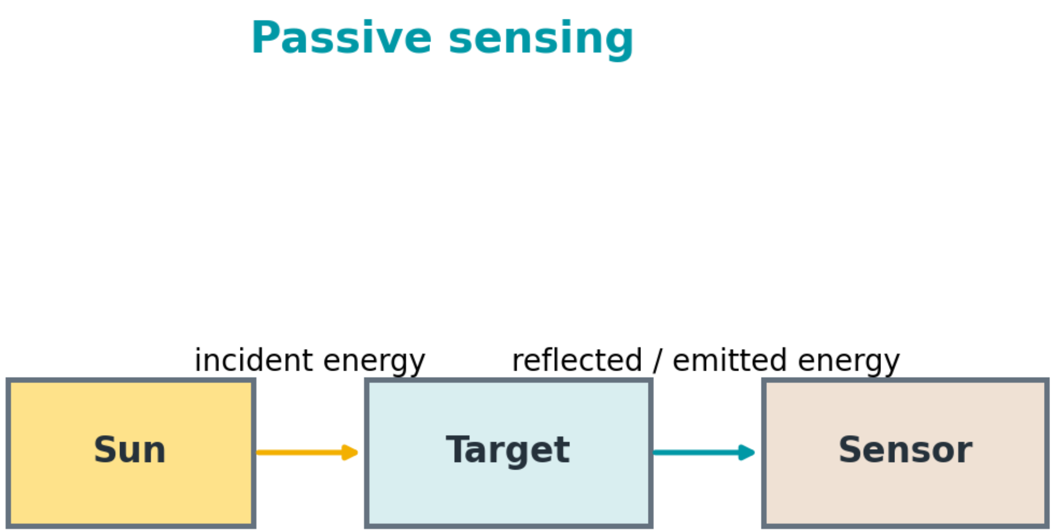
Apply
What real-world problem will be solved?

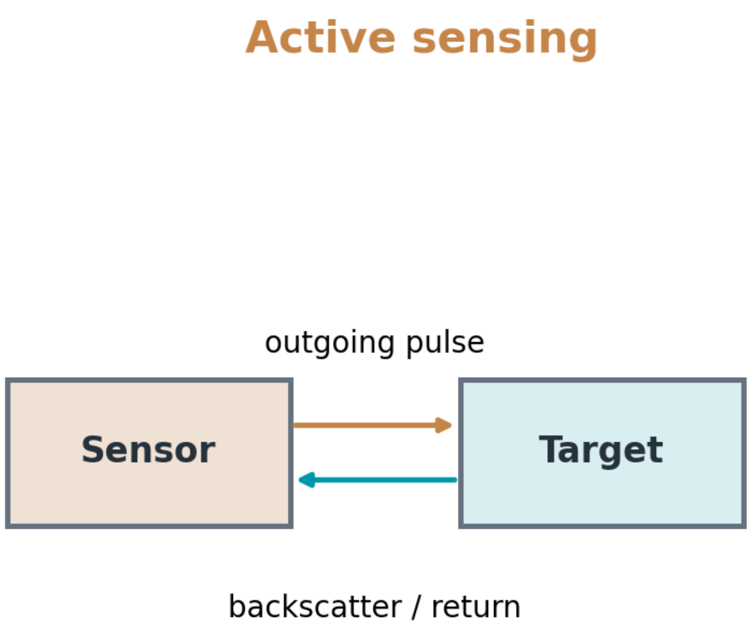
Main ways to classify remote sensing sensors

Three common classification bases are shown below.



The most fundamental distinction is whether the sensor depends on an external energy source.





Passive sensors

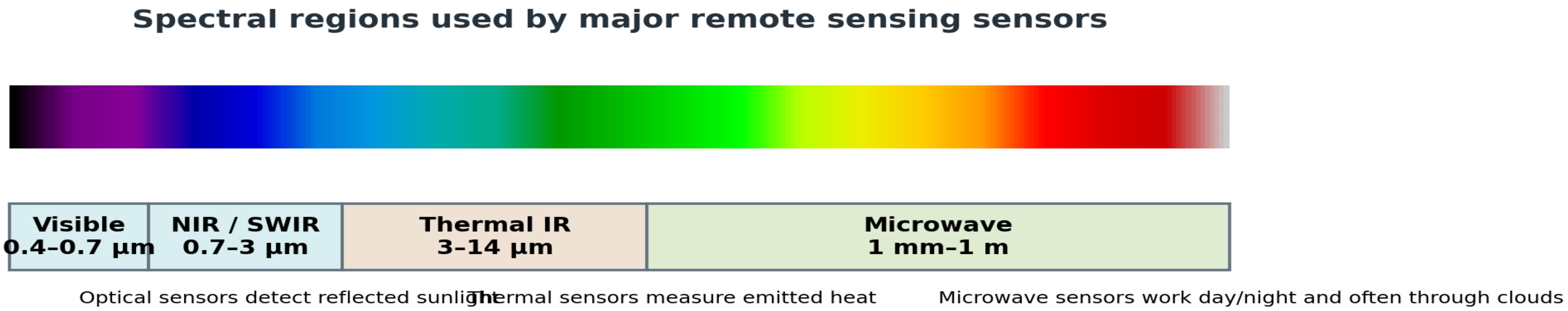
Need natural radiation, usually sunlight or thermal emission from the target.

Active sensors

Transmit their own pulse and measure the returned signal, which is useful at night and in many weather conditions.

Classification by spectral region

Different parts of the electromagnetic spectrum reveal different surface properties.



Optical region

Strong for land cover, vegetation vigor, and water color.

Usually passive and strongly influenced by clouds.

Thermal region

Measures emitted energy related to temperature.

Useful for heat islands, drought stress, and fires.

Microwave region

Sensitive to moisture, roughness, and structure.

Useful day/night and often through clouds.

Some instruments create images, while others produce single measurements, profiles, or time series.

Imaging sensors

- produce a 2-D image with rows and columns
- support mapping and classification
- examples: camera, scanner, SAR image

Non-imaging sensors

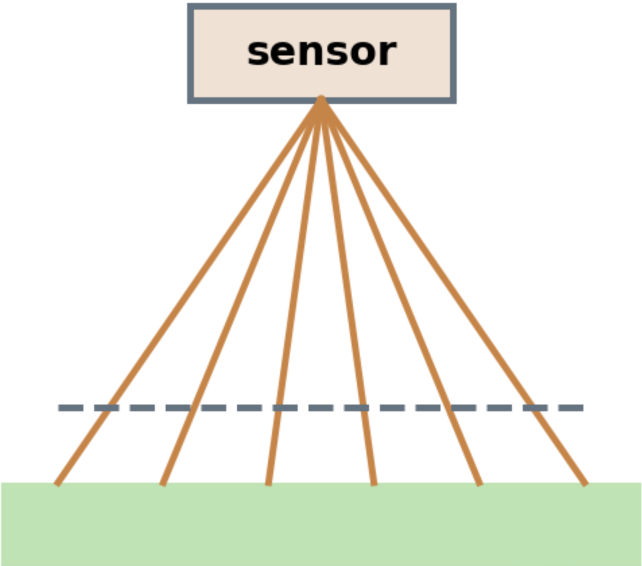
- measure a point, a profile, or a time series
- often used for physics and atmospheric studies
- examples: radiometer, altimeter, spectrometer

Classroom reminder

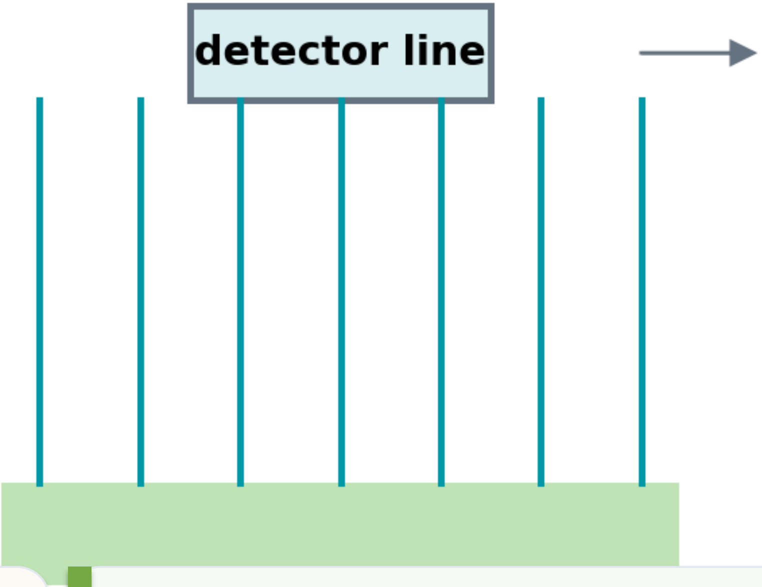
Most satellite maps you see in GIS are generated from imaging sensors, but non-imaging instruments are also essential for atmospheric, oceanic, and calibration studies.

How the sensor acquires lines or frames influences image geometry and data quality.

Across-track (whiskbroom)



Along-track (pushbroom)



Across-track

Older optical scanners often use an oscillating mirror.

Along-track

Modern pushbroom systems use a linear detector array.

Frame sensors

Digital cameras capture a 2-D scene in one exposure.

The optical sensor family

Within the optical class, sensors are often grouped by the number and width of spectral bands.

Panchromatic

One broad band.

Strong spatial detail.

Often used for image sharpening and base mapping.

Multispectral

Several discrete bands.

Balances spectral information and data volume.

Common for agriculture, land cover, and water studies.

Hyperspectral

Dozens to hundreds of narrow bands.

Captures fine spectral signatures.

Excellent for material identification and advanced analysis.

Thermal and microwave sensor classes

These classes extend observation beyond visible appearance.

Thermal sensors

Measure emitted radiant energy related to surface temperature.

Can indicate plant stress, urban heat islands, active fires, and warm/cool water differences.

Examples: Landsat TIRS, airborne thermal cameras.

temperature

Microwave sensors

Can be passive (radiometers) or active (radar/SAR).

Sensitive to moisture, roughness, geometry, and canopy structure.

Valuable for flood mapping, soil moisture, deformation, and ice studies.

all-weather

backscatter

Important active sensor examples

Active instruments are powerful because they control the signal that is transmitted.

RADAR / SAR

Transmits microwave pulses.

Measures backscatter related to roughness, moisture, and structure.

Useful for floods, land deformation, and crop monitoring.

LiDAR

Transmits laser pulses.

Measures distance and elevation precisely.

Useful for topography, forestry, and 3-D city models.

Altimeters & scatterometers

Measure sea-surface height or wind-related scattering.

Important for oceanography and climate studies.

Comparing major sensor classes

A comparison matrix helps summarize strengths and limitations.

Sensor class	Energy	Day / night	Clouds	Main signal	Typical products	Typical examples
Optical	Passive	Day only	Weak	reflected sunlight	true/false color, indices	OLI, MSI
Thermal	Passive	Day + night	Weak	emitted heat	temperature maps	TIRS, thermal camera
Microwave radiometer	Passive	Day + night	Good	microwave emission	soil moisture, SST	SMAP radiometer
Radar / SAR	Active	Day + night	Very good	backscatter	flood, deformation, texture	Sentinel-1, RADARSAT
LiDAR	Active	Day + night	Moderate	laser return	DEM, canopy height	airborne LiDAR

Matching sensor classes to real applications

The choice of sensor should follow the physical property you want to measure.

Agriculture

Optical: crop vigor and canopy cover

Thermal: stress and irrigation need

Radar: crop structure and wet conditions

Water

Optical: turbidity and water extent

Thermal: thermal plumes and temperature

Radar: floods under cloudy conditions

Urban & engineering

Optical: land use and urban growth

Thermal: heat islands

LiDAR / SAR: 3-D form and deformation

Hazards

Thermal: active fire fronts

Radar: flood mapping and landslides

Optical: burn scars and damage overview

Short case examples

The same landscape may be viewed differently by different sensor classes.

Case 1: crop monitoring

Optical multispectral imagery shows green biomass differences.

Thermal data reveals water stress before visible wilting becomes obvious.

Radar helps when clouds block optical images during the growing season.

Case 2: flood event

Optical images can map clear-sky flood water.

Radar is often the most reliable choice because it penetrates cloud cover.

Thermal data may support water–land temperature contrast analysis.

Case 3: city analysis

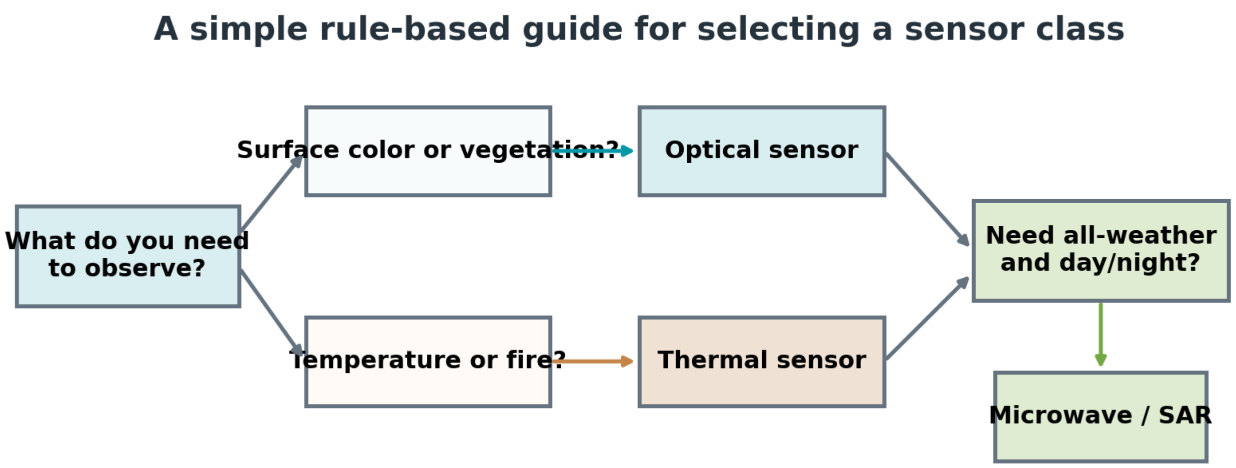
Optical images classify urban land cover.

Thermal imagery maps heat islands.

LiDAR provides building height and detailed 3-D structure.

How to choose an appropriate sensor class

A simple decision guide and review summary



Review summary

Sensors can be classified by energy source, spectral region, and measurement form.

Passive sensors depend on natural radiation; active sensors transmit their own signal.

Optical, thermal, and microwave sensors reveal different physical properties.

No single sensor is best for every task—selection depends on the target and study conditions.

References

Selected introductory and authoritative sources

Lillesand, T., Kiefer, R. W., & Chipman, J. (2015). Remote Sensing and Image Interpretation. Wiley.

Jensen, J. R. (2016). Introductory Digital Image Processing: A Remote Sensing Perspective. Pearson.

Campbell, J. B., & Wynne, R. H. (2011). Introduction to Remote Sensing. Guilford Press.

NASA Earth Observatory / NASA Earthdata. Remote sensing fundamentals, spectral regions, and sensor basics.

USGS Landsat Missions. Sensor overviews for OLI and TIRS.

European Space Agency (ESA) Sentinel Online. Mission and sensor descriptions for Sentinel series.

FAO and USGS educational materials on land observation and Earth observation basics.

Independent study suggestion

Students are encouraged to explore NASA, USGS, and ESA mission pages to compare real sensor specifications such as wavelength, revisit time, and spatial resolution.

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