Remote sensing

Unit 4

Thermal remote sensing

Thermal remote sensing is based in the infrared portion of the spectrum and measures emitted thermal energy. Thermal remote sensing is a type of passive remote sensing since it detects naturally emitted radiation. Most thermal remote sensing in conducted in the 3-5 µm and 8-14 µm wavelengths. Thermal remote sensing is the branch of remote sensing that deals with the acquisition, processing and interpretation of data acquired primarily in the thermal infrared (TIR) region of the electromagnetic (EM) spectrum. In thermal remote sensing we measure the radiations 'emitted' from the surface of the target, as opposed to optical remote sensing where we measure the radiations 'reflected' by the target under consideration.

Thermal radiation principles

Thermal radiation is one of the three principal mechanisms of heat transfer. It entails the emission of a spectrum of electromagnetic radiation due to an object's temperature. Other mechanisms are convection and conduction.

Radiation heat transfer is characteristically different from the other two in that it does not require a medium and, in fact it reaches maximum efficiency in a vacuum. Electromagnetic radiation has some proper characteristics depending on the frequency and wavelengths of the radiation. The phenomenon of radiation is not yet fully understood. Two theories have been used to explain radiation; however neither of them is perfectly satisfactory.

Atmosphereic windows

Atmospheric window

The general atmospheric transmittance across the whole spectrum of wavelengths is shown in Figure 6. The atmosphere selectively transmits energy of certain wavelengths. The spectral bands for which the atmosphere is relatively transparent are known as atmospheric windows. Atmospheric windows are present in the visible part (.4 µm - .76 µm) and the infrared regions of the EM spectrum. In the visible part transmission is mainly effected by ozone absorption and by molecular scattering. The atmosphere is transparent again beyond about λ= 1mm, the region used for microwave remote sensing

Advantage and disadvantage

Basic training in the use of the camera doesn't really make someone a thermographer either. Much like passing your driving test, it is not because you have a new driving licence that you instantly become a skilled driver like Lewis Hamilton. A thermographer may understand the physics behind the image and can understand the thermal colours – but have no idea about the thermodynamic properties of a portal frame, composite clad building. Knowledge of construction techniques and materials in use is essential. Being able to provide an accurate analysis of the images is a skill that few companies have. Quantifying the images is even a less common service offered.

Thermal infrared images provide information about the near-surface physical state of geologic materials, particularly, the density, water content, and heat transfer. Nonterrestrial planetary studies, conducted at fairly coarse resolution, have been useful primarily in determining the distribution of rock fragments.

Assuming you decide you have a need for infrared and you find a building specialist with the right experience, training and equipment, you next challenge is the weather. This is probably the most common frustration we experience. Taking infrared thermal images outside on a hot day is a no-no. Taking them on a cold night when it's raining is also a no-no.

The cold weather season is for us the busiest one and we are one of these few people who actually look forward to the mercury going down. We want and need the conditions to be "just right". This means:

- at night,
- no sunlight,
- no solar gain on the fabric,
- dry outside,
- cold,
- low wind,
- heating on in the building.

Things like shadows from trees look exactly like delaminating render if you take the images at the wrong time of day, or if the surveyor doesn't note the fact that there is a 100 foot oak tree adjacent to the south elevation that has been casting a shadow over the wall all day long. It makes a difference. That difference could lead you to scaffold the building and start doing destructive testing or worse – taking it at face value and tendering a Refurb when the fabric is okay. If you are a surveyor, you will look mighty silly if you convince your client to part with £500K to refurb his dangerous walls only to find out they are solid and you are acting upon a shadow from a tree. This is an extreme example to illustrate a point, but it could happen if you don't carry out a survey diligently.

SLAR

Side-looking airborne radar (**SLAR**) is an aircraft- or satellite-mounted imaging radar pointing perpendicular to the direction of flight (hence *side-looking*).[1] A squinted (nonperpendicular) mode is possible also. SLAR can be fitted with a standard antenna (real aperture radar) or an antenna using synthetic aperture.

Principle

The platform of the radar moves in direction of the x-axis. The radar "looks" with the looking angle ϑ (or so called off-nadir angle). The angle α between x-axis and the line of sight (LOS) is called cone angle, the angle φ between the x-axis and the projection of the line of sight to the (x; y)-plane is called azimuth angle. Cone- and azimuth angle are related by $\cos\alpha = \cos\varphi \cdot \cos\varepsilon$. On the earth surface the wave comes in at the (nominal ellipsoidal) incident angle β with respect to the vertical axis at this point. (In some publications the incident angle is denominated to as ϑ_i.) The antenna illuminates an area, the so-called footprint. The direction of the incoming wave relative to the horizontal plane may be measured also. This angle $\gamma = 90° - \beta$ is called grazing angle. The angle $\vartheta = \varepsilon + 90°$ is used for a mathematical description in a spherical coordinate system.

For the approximation of a flat earth – which is usual for airborne radar with short to medium range – the grazing angle and the depression angle can be assumed to be equal $\gamma = \varepsilon$ and the incident angle is $\beta = 180° - \vartheta$. The so-called LOS-vector

is a unit vector (in the figures shown as a red arrow) pointing from the antenna to a ground scatterer. The variables *u, v, w* are directional cosines with respect to the x; y; z axes. The variable u is $u = \cos\alpha$ with α as the azimuth angle between the line of sight and the x-axis (direction of flight).

Application

A Side-Looking Airborne Radar (SLAR) has been developed at the Space Applications Centre, Ahmedabad for remote sensing applications. First campaign of this unit was carried out using a DC-3 aircraft from 22nd May—30 May 1980 over Gujarat. The quality of the data/imagery obtained is highly satisfactory. Resolution on the imagery is around 20 metres. Water land boundaries, man-made structures, vegetated lands, hilly areas etc. could be easily identified on the imagery. The paper deals with the principles of operation, details of the system developed, the campaign and the results.SLAR projects were contracted on a yearly basis and multiple contractors were involved in processing and delivering data to the USGS. The SLAR project areas corresponded to one or more 1:250,000-scale topographic maps. Each 1:250,000-scale area is generally 1 by 2 degrees for the conterminous U.S. and 1 by 3 degrees for Alaska.

Near Range has shorter shadow, better detail, shows vegetation and flat lands. Far Range has more exaggerated shadow. It shows elevations of land and relief better than near range.

SLAR products available from the USGS include radar mosaics of most of the project areas. Coverage exists over 25% of conterminous United States and covers more than 10% of Alaska.

LANDSAT

The **Landsat program** is the longest-running enterprise for acquisition of satellite imagery of Earth. It is a joint NASA/USGS program. On July 23, 1972 the **Earth Resources Technology Satellite** was launched. This was eventually renamed to Landsat. The most recent, Landsat 8, was launched on February 11, 2013. The instruments on the Landsat satellites have acquired millions of images. The images, archived in the United States and at Landsat receiving stations around the world, are a unique resource for global change research and applications in agriculture, cartography, geology, forestry, regional
planning, surveillance and education, and can be viewed through the U.S. Geological Survey (USGS) 'EarthExplorer' website. Landsat 7 data has eight spectral bands with spatial resolutions ranging from 15 to 60 meters (49 to 197 ft); the temporal resolution is 16 days.[2] Landsat images are usually divided into scenes for easy downloading. Each Landsat scene is about 115 miles long and

115 miles wide (or 100 nautical miles long and 100 nautical miles wide, or 185 kilometers long and 185 kilometers wide).

SPOT

SPOT (French: *Satellite Pour l'Observation de la Terre*, lit. "Satellite for observation of Earth") is a commercial high-resolution optical Earth imaging satellite system operating from space. It is run by Spot Image, based in Toulouse, France. It was initiated by the CNES (*Centre national d'études spatiales* – the French space agency) in the 1970s and was developed in association with the SSTC (Belgian scientific, technical and cultural services) and the Swedish National Space Board (SNSB). It has been designed to improve the knowledge and management of the Earth by exploring the Earth's resources, detecting and forecasting phenomena involving climatology and oceanography, and monitoring human activities and natural phenomena. The SPOT system includes a series of satellites and ground control resources for satellite control and programming, image production, and distribution. Earlier satellites were launched using the European Space Agency's Ariane 2, 3, and 4 rockets, while SPOT 6 and SPOT 7 were launched by the Indian PSLV.

Indian remote sensing satellite

IRS-1A, the first of the series of indigenous state-of-art operating remote sensing satellites, was successfully launched into a polar sun-synchronous orbit on March 17, 1988 from the Soviet Cosmodrome at Baikonur.

The successful launch of IRS-1A was one of the proudest moments for the entire country, which depicted the maturity of satellite to address the various requirements for managing natural resources of the nation. Its LISS-I had a spatial resolution of 72.5 meters with a swath of 148 km on ground. LISS-II had two separate imaging sensors, LISS-II A and LISS-II B, with spatial resolution of 36.25 meters each and mounted on the spacecraft in such a way to provide a composite swath of 146.98 km on ground. The IRS-1A satellite, with its LISS-I and LISS-II sensors quickly enabled India to map, monitor and manage its natural resources at coarse and medium spatial resolutions. The operational availability of data products to the user organisations further strengthened the operationalisation of remote sensing applications and management in the country.

IRS-1A was followed by the launch of IRS-1B, an identical satellite, in 1991. IRS-1A and 1B in tandem provided 11-day repetivity. These two satellites in the IRS series have been the workhorses for generating natural resources information in a variety of application areas, such as agriculture, forestry, geology and hydrology etc.

From then onwards, series of IRS spacecrafts were launched with enhanced capabilities in payloads and satellite platforms. The whole gamut of the activities from the evolution of IRS missions by identifying the user requirements to utilisation of data from these missions by user agencies is monitored by National Natural Resources Management System (NNRMS), which is the nodal agency for natural resources management and infrastructure development using remote sensing data in the country.

Apart from meeting the general requirements, definition of IRS missions based on specific thematic applications like natural resources monitoring, ocean and atmospheric studies and cartographic applications resulted in the realisation of theme based satellite series, namely, (i) Land/water resources applications (RESOURCESAT series and RISAT series); (ii) Ocean/atmospheric studies (OCEANSAT series, INSAT-VHRR, INSAT-3D, Megha-Tropiques and SARAL); and (iii) Large scale mapping applications (CARTOSAT series).

IRS-1A development was a major milestone in the IRS programme. On this occasion of 30 years of IRS-1A and fruitful journey of Indian remote sensing programme, it is important to look back at the achievements of Indian Space Programme particularly in remote sensing applications, wherein India has become a role-model for the rest to follow. Significant progress continued in building and launching the state-of-the-art Indian Remote Sensing Satellite as well as in operational utilisation of the data in various applications to nation.

Today, the array of Indian Earth Observation (EO) Satellites with imaging capabilities in visible, infrared, thermal and microwave regions of the electromagnetic spectrum, including hyper-spectral sensors, have helped the country in realising major operational applications. The imaging sensors have been providing spatial resolution ranging from 1 km to better than 1m; repeat observation (temporal imaging) from 22 days to every 15 minutes and radiometric ranging from 7 bit to 12 bit, which has significantly helped in several applications at national level. In the coming years, the Indian EO satellites are heading towards further strengthened and improved technologies, taking cognizance of the learnings/ achievements made in the yester years, while addressing newer observational requirements and the technological advancements including high agility spacecrafts.

Indian Space Mission

The Indian Space Research Organisation has carried out 109 spacecraft missions, 77 launch missions and planned several missions including the Aditya, Gaganyaan and MOM 2.

Mission Name		Start date	End date	Details
Chandrayaan programme	Chandrayaan-1	22 October 2008	28 August 2009	Chandrayaan-1 was India's first lunar probe. It was launched by the Indian Space Research Organisations in October 2008, and operated until August 2009. The mission included a lunar orbiter and an impactor. The mission was a major boost to India's space program, as India researched and developed its own technology in order to explore the Moon. The vehicle was successfully inserted into lunar orbit on 8 November 2008.[3][4]
	Chandrayaan-2	22 July 2019	Orbiter functional; the lander crashed onto Moon's surface due to loss of	Chandrayaan-2 was launched from the second launch pad at Satish Dhawan Space Centre on 22 July 2019 at 2.43 PM IST (09:13 UTC) to the Moon by

			control during the final phase of descent.	a Geosynchronous Satellite Launch Vehicle Mark III (GSLV Mk III). The planned orbit has a perigee of 169.7 km and an apogee of 45475 km. It consists of a lunar orbiter, lander and rover, all developed in India. The main scientific objective is to map the location and abundance of lunar water.

Interplanetary

Mission Name	Start date	End date	Details
Mars Orbiter Mission	5 November 2013	Ongoing	Mars Orbiter Mission (MOM), also called Mangalyaan, is a spacecraft orbiting Mars since 24 September 2014. It was launched on 5 November 2013 by the Indian Space Research Organisation (ISRO). It is India's first interplanetary mission and ISRO has become the fourth space agency to reach Mars, after the Soviet space program, NASA, and the European Space Agency. India is the first Asian nation to reach Mars orbit, and the first nation in the world to do so in its first attempt

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