Diary

Norah Jones

2025-03-12

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1 Welcome

Updated: 2025-03-12

This is a study note about **CASA0023** Remotely Sensing Cities and Environments

In this note, I will record my weekly study notes and contents weekly.

I believe this book can clearly show my learning results. It may not be **perfect**, but it also represents my efforts.

My goal is to present my own notes while being as interesting as possible and, of course, easy to understand. This is not only for better review, but also for people who have no contact with the field at all to understand and become interested.

2 Week 1 Start

2.1 Summary

This week has taken me from *novice* to *beginner* in remote sensing.

I have learnt

1. The basic concepts of remote sensing, the types of sensors (active and passive), and the process by which electromagnetic waves interact with the earth's surface and the atmosphere.
2. Remote sensing is not only satellite images, but also includes data acquired by drones, aircraft and even handheld devices.
3. the four resolutions of remotely sensed data (spatial, spectral, temporal and radiometric) determine the applicability of the data.

The diversity and complexity of remotely sensed data, while offering potential, can also present challenges.

1. How can remote sensing data of different resolutions be integrated?

(Data fusion may be possible through spatial interpolation, machine learning, etc.)

2. The effects of electromagnetic wave interactions with the atmosphere and surface in practical applications may require corrections to improve the accuracy of the data.

(Initial correction using physical models Second Simulation of the Satellite Signal in the Solar Spectrum, MODTRAN, Ross-Thick-LiSparse model, etc., and then further correction of residual errors or prediction of surface through models such as Random Forest, CNN, etc.) parameters)

2.2 Application

Areas of application:

Environmental monitoring, disaster management and urban planning

Active sensors (SAR…) Can penetrate clouds, suitable for monitoring in cloudy areas.

Passive sensors (optical sensors…) More suitable for high resolution imaging in clear sky conditions.

So by combining these two sensors, all-weather and all-terrain surface monitoring can be achieved.

In the literature

Studies use SAR data for flood monitoring and forest cover change analysis. This is because the penetration capability of SAR gives it a unique advantage in monitoring deforestation in tropical rainforest areas. However, the disadvantage is that the interpretation of SAR data is more complex and needs to be validated in conjunction with ground observations and other remote sensing data.

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In addition to traditional environmental monitoring, remote sensing can be used for social issues.

(Assessing the level of economic development or population distribution by analysing night-time lighting data.)

It may be possible to use remote sensing data to assess meteorological disasters (floods…)

(Assessing the recovery of affected areas by analysing changes in spectral features before and after floods.)

Also combined with other data sources (e.g. social media or sensor networks) to provide a more comprehensive environmental monitoring programme.

(Combining disaster reports in social media and remote sensing data to assess disaster impacts in real time.)

2.3 Reflection

The biggest feeling I got from this week's study is that remote sensing technology is really complex and diverse at the same time, and I feel like I have opened the door to a new world. Although I was a bit confused at first, the more I learnt, the more interesting it became. Especially the SAR data, its penetrating ability simply caught my eyes! In a place like London, where it is always cloudy, SAR is a lifesaver, as it can penetrate the clouds and see what is happening on the ground surface, which will definitely be useful in disaster monitoring and climate change research. Although I am still a bronze player, I think I will be able to reach the gold level one day as long as I keep upgrading my skills!

When it comes to my future research direction, I studied computer science in my undergraduate degree, so I am particularly interested in seeing how machine learning can be applied to remote sensing data analysis. For example, deep learning models can be used to automatically identify the type of ground cover or predict the trend of environmental change. Nowadays, the volume of remote sensing data is so large that manual analysis alone is definitely not enough, and if AI can be used to help, the efficiency will definitely be greatly improved. Moreover, machine learning can also discover some patterns from the data that we can't see with the naked eye, which feels especially cool!

Also, like I mentioned above, can remote sensing technology be used in combination with other fields in the future? For example, combining remote sensing data with social media data to monitor disasters in real time. Or, integrating drone data with satellite data for both a detailed and wide view. These ideas may be premature now, but I think they are definitely possible in the future!

All in all, this week's study has given me a deeper understanding of remote sensing technology and given me more ideas for future research directions. Although there is still a long way to go, I am ready to **fight and upgrade**!

3 Week 2 Protfolio

3.1 Summary

Xaringan is a new way of doing Slides, much simpler and more straightforward, implemented in R Markdown. Xaringan overrides all the functionality of regular Slides and provides some additional functionality. For example: directly implant code, forms, etc

I'll show you my use of Xaringan in the next section(3.2)

Quarto itself supports building slideshows similar to Xaringan. Below here I will show the Slide with the image and code that is not clearly shown above.

3.2 Reflection

The things we learnt this week are very effective in academic research and technical presentations; Xaringan can be used to make clear and concise academic presentations and Quarto is good for writing technical documentation or online books. With GitHub Pages, these resources can be easily shared with others.

In the literature, many studies have used Xaringan and Quarto to present data analysis results or technical methods. For example, some studies have used Quarto to write data analysis reports and then publish them as online books that readers can browse interactively.

However, there are some limitations to these tools, such as lack of support for complex formats and the need for some programming skills to use them well.

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Quarto's support for multiple languages feels like it would be useful in interdisciplinary research, but in practice, how do you make sure that blocks of code in different languages fit together seamlessly and display correctly? For example, combining data analysis in R with machine learning models in Python.

Possibly via the Jupyter Kernel, or some package that supports interconnections (reticulate)?

3.3 Application

3.3.1 Use of Xaringan

In Slide, I recorded what I learned about Xaringan this week, as well as some of my own development. However, the direct display of Slide does not seem to show the results of images and code blocks directly.

3.3.2 Use of Quarto

Import pictures and table ~

This is the description of the image, aligned to the right of the picture.

View the head of iris data (in bold)

Sepal.Length	Sepal.Width	Petal.Length	Petal.Width	Species
5.1	3.5	1.4	0.2	setosa
4.9	3.0	1.4	0.2	setosa
4.7	3.2	1.3	0.2	setosa
4.6	3.1	1.5	0.2	setosa
5.0	3.6	1.4	0.2	setosa
5.4	3.9	1.7	0.4	setosa

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4 Week 3 Corrections

4.1 Summary

The main content of this week is **Correction and Enhancement of Remote Sensing Data**, focusing on the techniques of **Atmospheric Correction**, **Geometric Correction** and **Data Fusion**. Through practice, I mastered how to perform atmospheric correction on remote sensing images using the **Dark Object Subtraction (DOS)** method, and learnt how to stitch (Mosaicking) multiple remote sensing images into a seamless whole. There was also exposure to **Image Enhancement** techniques such as **Filtering**, **Texture Analysis**, and **Principal Component Analysis (PCA)**, which can help us extract more useful information from remotely sensed data.

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1. atmospheric correction is a very important step in remote sensing data processing, but different correction methods (e.g., DOS and COST) are suitable for different scenarios.

DOS is suitable for simple scenarios, while COST is more suitable for complex atmospheric conditions.

2. image enhancement techniques (e.g. PCA and texture analysis) can help us extract more information from the data, but do these methods lead to over-processing or distortion of the information? How can we enhance images while maintaining the fidelity of the data?

(Control the degree of processing during image enhancement, e.g. select principal components with more than the first 95% of variance information instead of all principal components. After enhancement, use the original data for comparison to ensure that the data features have not been overly modified.)

González, R. C., & Woods, R. E. (2018). Digital image processing. also covered in detail in the book Pearson Education.(I haven't finished it yet…)

4.2 Application

The content learnt this week has potential for a wide range of applications in environmental monitoring, land use classification and disaster management. For example, atmospheric correction can be used to improve the accuracy of remotely sensed data, especially in cloudy or heavily atmospherically polluted areas. With image enhancement techniques, we can better identify surface features such as vegetation cover, water distribution and urban sprawl.

In the literature

Many studies have used atmospheric correction and image enhancement techniques to improve the quality of remotely sensed data. For example, some studies have used DOS methods to correct Landsat data to improve the accuracy of vegetation indices such as NDVI. However, there are some limitations to these methods, such as the fact that DOS methods may not be able to completely remove atmospheric effects when atmospheric conditions are complex.

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Can remote sensing data correction and enhancement techniques be used in areas other than traditional environmental monitoring? For example, in urban planning, corrected remote sensing data are used to assess the urban heat island effect.

There have been some applications in the literature: the surface radiation temperature of Shenzhen City was inverted using the Split Window Algorithm (SWA) and the Atmospheric Correction Method (ARC).

Reference Zhang Xiaomin,Liu Zhiwei,Fang Han,et al. Spatial and temporal distribution of urban heat island effect and land use impacts in Shenzhen based on Landsat 8 TIRS surface temperature data inversion[J]. Climate and Environment Research,2023,28(3):242-250. DOI:10.3878/j.issn.1006-9585.2022.21160.

4.3 Reflection

After this week's study, I feel that the correction and enhancement techniques of remote sensing data are really quite complicated, but also very interesting. Especially the atmospheric correction, although I found it a bit difficult to understand at first, but through the DOS method, I slowly understood its basic principles and was able to get my hands on it.

Can these techniques be combined with **AI** in the future? For example, using AI to automatically identify which areas require more complex atmospheric corrections, or using machine learning models to predict which image enhancement methods are best suited to a particular surface feature. This would not only improve efficiency, but also make the processing of remote sensing data smarter.

It also occurs to me that remote sensing data correction and enhancement techniques could be combined with **VR or AR**?

For example, the corrected remote sensing data can be imported into a VR environment, so that researchers or decision makers can 'walk into' the remote sensing images and visualise the changes on the ground surface. Or using AR technology to overlay remote sensing data onto the real world to help urban planners better understand the impacts of urban sprawl. This combination may make the application of remote sensing technology more intuitive and interesting.

5 Week 4 Policy

5.1 Summary

This week's assignment was based around a city case study, combining remote sensing data and policy objectives to analyse the relationship between them. I chose Singapore because it is a highly urbanised island nation that faces a number of climate and environmental challenges, such as rising sea levels, urban heat island effect, and land resource constraints. To address these issues, the Singapore government has developed the Singapore Master Plan (SMP), one of the key objectives of which is to promote sustainable urban development.

In this process, remote sensing data can play a big role, such as monitoring urban sprawl, evaluating green space coverage, and analysing changes in the coastline. Although I seldom pay attention to these 'macro' issues in my daily life, this assignment made me realise that satellite data are actually closely related to our urban life and can even influence the government's decisions.

5.2 Application

How exactly can remote sensing data help Singapore's sustainable development goals?

Google Earth Engine provides free Landsat and Sentinel data that researchers can use to analyse urban sprawl.

After looking up the information, I think it can be used in the following ways:

1. Monitoring urban sprawl

Singapore's land is very limited, and urbanisation and development can affect natural ecosystems such as forests, wetlands and even coastlines. I found that these changes can be analysed using **Landsat** multi-temporal imagery to see just how much urbanisation is affecting the environment. For example, the government can use this data to decide which areas need ecological protection and which can be used for development.

2. Assessing urban greenery and the heat island effect

Walking on a concrete road in summer, you can really feel the temperature much higher than in a park, which is the Urban Heat Island Effect (UHI). Through the **NDVI (Normalised**

Vegetation Index), we can see the green coverage of Singapore and identify areas with less vegetation and higher temperatures. In this way, the government can target more green spaces, such as planting more trees and promoting rooftop greening, to lower the temperature.

3. Monitoring Sea Level Rise

As an island nation, Singapore's coastline will be affected by climate change. Changes in the coastline can be analysed using **Sentinel-1 SAR** data to see which areas may be threatened by sea level rise. This will enable the government to plan ahead, such as reinforcing seawalls and protecting mangroves, which are natural protective barriers.

Data Reference:

Landsat: Monitoring urban sprawl and land use change.

Sentinel-2: Analysing vegetation cover and assessing urban green spaces.

Sentinel-1SAR: Monitoring Sea Level Rise and Assessing Coastal Risks

5.3 Reflection

1. Remote sensing data is useful but has its limitations.

I thought that remote sensing data is 'real time', but in fact it is affected by weather, data update frequency and other factors, sometimes it may not reflect the latest situation immediately. For example, optical remote sensing (Landsat, Sentinel-2) is difficult to use in cloudy weather, which made me realise why **Synthetic Aperture Radar (SAR)** is so important because it is not affected by weather. There is also the fact that data processing is not simple, and after the government acquires the data, it needs professionals to analyse and interpret it before it can really be used for decision making.

2. The Power of Remote Sensing Data

This assignment really made me realise that data can shape a city. Government decisions are not made out of thin air, but are based on a variety of data, such as remote sensing imagery, ground measurements, and even social data. It's like Singapore's master plan is not decided arbitrarily, but through data analysis and trend prediction to find the most reasonable development direction. For example, they use remote sensing to monitor the green coverage rate and find areas where parks need to be added; they use coastline data to predict sea level rise and decide where seawalls need to be built. This makes me think that urban planning is actually a kind of 'data-driven art'.

3. Human-centred

This assignment made me think that although data and technology are important, they ultimately serve people. The government can use remote sensing data to optimise urban planning, but if people are not willing to change their habits, it may be difficult to implement policies.

But if ordinary people are allowed to have access to this data, will it lead to better decision-making?

If everyone can view the greening rate and heat island effect index of their neighbourhood through Google Earth Engine as such, this can raise public awareness of environmental protection. If these data are more transparent, citizens may be more willing to participate in urban planning rather than just passively accepting policies.

6 Week 6 Google Earth Engine I

6.1 Summary

The main task this week is to learn how to analyse remote sensing data using **Google Earth Engine (GEE)**.GEE is a powerful cloud platform capable of handling large-scale remote sensing data and providing fast computational power. With GEE, we can access worldwide remote sensing datasets such as Landsat, Sentinel, etc. and perform complex spatial analyses.

This week focused on the basic operations of GEE, including data loading, image processing, texture analysis and principal component analysis (PCA). And the GEE results are exported and applied to practical problems.

6.2 Application

GEE is widely used in remote sensing data analysis, especially in urban planning and environmental monitoring.

Through relevant literature, I found many studies using GEE to analyse the urban heat island effect and to assess the distribution of urban green space by calculating the **Normalised Vegetation Index (NDVI)**.

In air pollution monitoring, GEE can be used to analyse air pollution data from Sentinel-5P to monitor the trends of pollutants such as PM2.5 and nitrogen dioxide (NO2). Expressed in policy research, GEE data can be used to analyse the relationship between air pollution and urban population density, providing a scientific basis for urban environmental managers.PCA can also be used to downscale multi-band remote sensing data and extract the main components to simplify data analysis. Through PCA analysis, the bands that contribute most to the urban heat island effect can be identified. In this way, it also contributes to the 'prioritisation'.

Another interesting application for me is flood risk assessment. By combining Landsat imagery, DEMs (Digital Elevation Models) and precipitation data, it is possible to monitor in real time the extent of flood damage. Using the reduceRegion() function, it is possible to calculate the historical frequency of floods in a given area and assess the future risk, which is important for emergency management and disaster warning.

6.3 Reflection

This week's study has made me deeply appreciate the advantages of cloud computing in remote sensing data analysis. Compared with traditional local GIS software, GEE greatly improves computational efficiency and is especially suitable for large-scale data processing.

In practice, one of the roadblocks I encountered was adapting to the JavaScript syntax, because in the past I mainly used Python for data analysis. I learnt that GEE's map() function is an important concept for batch processing image data on the server side, avoiding the inefficient computation of traditional for loops. I think this is a great approach.

In the future, I hope to do more in-depth research in conjunction with GEE, especially the application of machine learning to remote sensing image classification. (Seems like I say that every week…) I hope my previous knowledge will come in handy)

For example, exploring **Random Forest (Random Forest) or Support Vector Machines (SVM)** for land cover classification, and combining GEE with deep learning frameworks (e.g., TensorFlow) to further improve the accuracy of image analysis. This will not only expand the application scope of GEE, but also provide more accurate and credible data support for environmental monitoring and sustainable urban development.