合成孔徑雷達基礎原理與應用

FUNDAMENTAL PRINCIPLES AND APPLICATIONS OF SYNTHETIC APERTURE RADAR

課程碼: P661000 **分班碼:** None **開課序號:** 009 **學分數:** 3.0

核心能力

☐ 具備特定領域的專業知識及技術能力:大地測量與誤差理論

Possess knowledge and techniques in specific field: Geodesy & Theory of errors.

☐ 具備特定領域的專業知識及技術能力:地理資訊系統與製圖

Possess knowledge and techniques in specific field: Geographic information system and mapping.

■ 具備特定領域的專業知識及技術能力:攝影測量與遙感探測

Possess knowledge and techniques in specific field: Photogrammetry & Remote Sensing.

☐ 具備策劃及執行專題研究之能力

Planning and execute case study ability.

☐ 具備表達專業論文之能力

Present professional papers.

■ 具備創新思考及獨立解決問題之能力

Creative thinking and independent problem-solving ability.

■ 具備與不同領域人員協調整合與溝通之能力

Negotiation with other fields' experts.

■ 具備良好的國際觀

Global vision.

☐ 具備領導、管理及規劃之能力

Leadership, management, arrangement.

■ 具備終生自我學習成長之能力

Lifelong self-learning ability.

基本素養

☐ 倫理與人文素養

Quality of humanism and ethics.

☐ 誠信與務實素養

Integrity and responsibility.

☐ 環保與社會關懷

Environmental protection and care for society.

☐ 國際視野

Global vision.

課程概述

請參考英文簡介

old version:
This course adopts the massive open online course (MOOC) materials on radar remote sensing, developed by SAR-EDU in collaboration with the European Space Agency (ESA). The online course is open to anybody and will introduce the history, the basics and various fields of application of SAR satellite data. Moreover, some supplements are added and some revisions are done by teacher. Also, it includes the teacher's experience on SAR, especially the related issues of SAR application in Taiwan such as 1.how to transform the SAR results defined on WGS84 to TWD97, 2.blunder detection and quality evaluation in SAR produced results. Briefly to say, it is designed to teach the fundamental principles and applications of synthetic aperture radar (SAR). It includes related reference papers and books. This course is available to students from related departments who will apply SAR to their research works. The course includes also some exercises on SAR data processing and analyses.

new version:
This course adopts the SAR lecture materials in the textbook adopted for the course "Fundamentals on Photogrammetry and Remote Sensing" as well as the massive open online course (MOOC) materials on radar remote sensing, developed by SAR-EDU* in collaboration with the European Space Agency (ESA). The online course is open to anybody and will introduce the history, the basics and various fields of application of SAR satellite data. Moreover, some supplements are added and some revisions are done by teacher. Also, it includes the teacher's experience on SAR, especially the related issues of SAR application in Taiwan such as 1.how to transform the SAR results defined on WGS84 to TWD97, 2.blunder detection and quality evaluation in SAR produced results. Briefly to say, it is designed to teach the fundamental principles and applications of synthetic

aperture radar (SAR). It includes related reference papers and books. This course is available to students from related departments who will apply SAR to their research works. The course includes also some exercises on SAR data processing and analyses.

*SAR-EDU - A German education initiative for applied Synthetic Aperture Radar remote sensing

注意事項:

- *表示必填欄位，請盡量不要使用特殊符號如<, >, ", ´
- 若要使用編輯器的剪下/複製功能，請確定您的瀏覽器有存取系統剪貼簿的權限(或使用 ie 瀏覽器)。否則請使用 windows 作業系統預設快捷鍵剪下(Ctrl-x), 複製(Ctrl-c), 貼上(Ctrl-v)
- 請勿同一頁面在多個瀏覽器頁面開啟，以免自動存檔時畫面資料互相覆蓋。
- 複製功能不複製評分標準、調查內容。

指標課程相關

※ 本校於教育部校庫資料以及深耕指標填報課程相關項目與定義如下：

一、程式設計相關：

係教育部鼓勵學校針對不同專業領域及應用型態發展客製化之程式設計課程，使大學因應學生面對數位經濟環境的學習需求，提供學生(不限資訊科技相關專業領域)修讀程式設計課程機會，藉以提升學生俱備運用資訊科技能力，進而增進學生對邏輯運算及程式設計之基本認知。參考認列範疇：課程名稱包含程式設計、程式語言等關鍵字即可納入。課程名稱雖未包含前關鍵字，但大綱中載明包含程式設計、程式語言教學內涵，且於課程中，學生確有實際從事撰寫程式之作業或活動即可算入。

二、專業總整：

係指課程設計以學生為主(老師為 mentor)，由學生整合過去數年學習的經驗、知識與技能，表現實作與解決問題能力，架構出自己的知識承載量。總整課程能對應到多數系上所訂的畢業生核心能力，開課形式包含專題計畫、學士論文、實作專題(含報告)等。

三、創新：

能引發學生學習動機的各式創新課程設計，包含教學法創新、議題創新、合作對象創新、研究議題教學落地、教學空間創新、教學場域創新、評量創新等，如：磨課師線上課程、社區參與實踐型課程或統整性實作課程。

四、實務實作：

是以實務場域為基礎，進行更聚焦的主題學習（問題回應）歷程和學習成果展現。更強調學生之專題 （問題）設定和分析能力、提案規劃能力和實作產出能力等實質培育。

本課程經教學單位確認，非屬上述相關指標填報項目課程。以上如有疑義，請洽教學單位。

先修科目或先備能力 Prerequisite Course(s)

physics, engineering mathematics, remote sensing, computer programming, English

教師聯絡資訊* Contact with Teacher

Associate Prof. Dr.-Ing. Jaan-Rong Tsay
TEL: 63838
Email: tsayjr@mail.ncku.edu.tw

助教資訊 Contact with Tutor

To be determined by the department office.

課程學習目標* Course Objectives

1. To learn the fundamental principles of SAR
2. To learn the fundamental SAR data processing techniques
3. To learn the fundamental applications of SAR

課程進度 Progress Description

Week 1:
A-1 Radiometric Concepts, Terminology, and Units
A-2 SAR Data and Information Resources
A-3 Radar Signal Concepts, Terminology, and Units
=>1 course introduction.pptx
Contents of Lessons written by SAREDUDLR.docx/.pdf
TB (Lillesand et al., 2008. 6th ed.) pp.727-735, 741-745 (14p)

Week 2:
Ch.0 SAR for Beginners
0-1 Introduction
0-2 Radar development
0-3 Side-Looking Radar System Operation
0-4 Synthetic Aperture Radar
0-5 Geometric Characteristics of Radar Imagery
0-6 Transmission Characteristics of Radar Signals
0-7 Other Radar Image Characteristics
0-8 Radar Image Interpretation
0-9 Interferometric Radar
0-10 Radar Remote Sensing from Space
=>TB (Lillesand et al., 2008. 6th ed.) pp.626-686 (61p)

Week 3:
Ch.0 SAR for Beginners
0-11 SEASAT-1
0-12 Shuttle Imaging Radar
0-13 ALMAZ-1

0-14 ERS-1 and ERS-2
0-15 ENVISAT
0-16 JERS-1
0-17 ALOS
0-18 RADARSAT
0-19 HighResolution Spaceborne Radar Systems
0-20 Shuttle Radar Topographic Mission
0-21 Spaceborne Radar System Summary
0-22 Passive Microwave Sensing
=>TB (Lillesand et al., 2008. 6th ed.) pp.686-714 (29p)

Week 4: 1-1 Mathematics - Mathematic Basics
1-2 Mathematics - Time and Frequency
1-3 Mathematics & Physics - Filter Design & Aliasing
1-4 Mathematics & Physics – Physics

Week 5: 1-5 Mathematics - Introduction to Estimation Theory
1-6 Mathematics & Physics - Basic Probability Theory
1-7 Mathematics & Physics – Detection (optional)
1-8 Mathematics & Physics - Parameter Estimation Basics (optional)

Week 6: 1-9 Mathematics & Physics - Optimal Linear Estimation (optional)
2-1 SAR Imaging
Tutorial: SAR image focusing (Python & Matlab)

Week 7: 3-1 Digital (SAR) Image Processing basics
3-2 Classification of remote sensing data – methods and algorithms
3-3 Change Detection
3-4 Data Fusion of Optical & SAR Data
3-5 Introduction to Object Based Image Analysis (OBIA)
3-6 Speckle Filtering

Week 8: 3-7 Texture - An Element of (SAR) Image Interpretation
4-1 SAR Interferometry (InSAR) Basics
Tutorial: SAR Interferometry – Generation of a Digital Elevation Model (MATLAB)

Week 9: mid-term exam
Week 10: 4-2 SAR Interferometry Error Sources

Week 11: 5-1 SAR Polarimetry

Week 12: 5-1 SAR Polarimetry

6-1 Passive Microwave Remote Sensing
7-1 Radargrammetry - Basics and Methods

Week 13: 8-1 Anthroposphere – SAR Interferometry
Tutorial: You know basic functions of the NEST software
Tutorial: Measurement of surface subsidences caused by underground hard coal mining activities

Week 14: 9-1 Biomass estimation using SAR data
9-2 Biosphere - Agricultural Applications with SAR Data

Week 15: 9-2 Biosphere - Agricultural Applications with SAR Data
Tutorial: You know basic functions of the NEST software(Tutorial: Data processing with ‚NEST')
Tutorial: Extraction of temporal crop signatures and crop type classification using multitemporal C-band data acquired over Nordhausen, Thuringia, Germany (Nest software)
10-1 Cryosphere – Physical Principles

Week 16: 10-2 Cryosphere – Snow Cover
Tutorial: You know basic functions of the NEST software
Tutorial: Snow cover extent on ice-free areas on King George Island, Antarctica
10-3 Cryosphere – Glaciers & Ice Sheets (incl. InSAR & DInSAR elevation change)

Week 17: 10-4 Cryosphere – Sea Ice & Icebergs
10-5 Cryosphere – Permafrost (incl. Subsidence from DInSAR)
11-1 Hydrosphere – Introduction
11-2 Hydrosphere – Soil Moisture

Week 18: Term exam

以上每週進度教師可依上課情況做適度調整。The schedule may be subject to change.

The following lecture materials will be available for students to read after class:

Week 13: 11-2 Hydrosphere – Soil Moisture
Tutorial: Soil moisture from ASCAT based on I.P.F. change detection approach
11-3 Hydrosphere – Wetlands, Waterbodies, Floods, Precipitation & River Velocity
Tutorial: Mapping of waterbodies using Envisat ASAR IM data - lake Uluabat (Turkey)

Week 14: 11-4 Hydrosphere – Sensors, Missions and Data
12-1 Lithosphere – Application of SAR Interferometry to Monitor Crustal Deformation

Week 15: 12-1 Lithosphere – Application of SAR Interferometry to Monitor Crustal Deformation
Tutorial: Doris short course – software for interferometric SAR processing.

Tutorial: StaMPS/MTI short course – software for PS and SBAS processing.

Week 16: 13-1 Oceanography
13-2 Surface winds
13-3 Ocean surface waves

Week 17: 13-4 Surface ocean currents
13-5 Oil detection

教學方法* Teaching Strategies

講授 lecture 80%
實作 Workshop 20%

課程教材 Course Material

※成大圖書館電子書查詢 (https://weblis.lib.ncku.edu.tw/search*cht/f) (校外連線設定)
圖書
Remote Sensing and Image Interpretation, Thomas M. Lillesand, Ralph W. Kiefer, and Jonathan W. Chipman, 2008, 6th edition, ISBN 978-0-470-05245-7, John Wiley & Sons, Inc.

其他敘述 (包含講義、期刊、課程說明等)
This course adopts the massive open online course (MOOC) materials on radar remote sensing, developed by SAR-EDU in collaboration with the European Space Agency (ESA). The online course is open to anybody and will introduce the history, the basics, and various fields of application of SAR satellite data. Moreover, some supplements are added and some revisions are done by teacher. Also, it includes the teacher's experience on SAR, especially the related issues of SAR application in Taiwan such as 1.how to transform the SAR results defined on WGS84 to TWD97, 2.blunder detection and quality evaluation in SAR produced results. Briefly to say, it is designed to teach the fundamental principles and applications of synthetic aperture radar (SAR). It includes related reference papers and books. This course is available to students from related departments who will apply SAR to their research works. The course includes also some exercises on SAR data processing and analyses. Course materials are available on NCKU MOODLE for all students who select this course.

參考書目 References

※成大圖書館電子書查詢 (https://weblis.lib.ncku.edu.tw/search*cht/f) (校外連線設定)
圖書
Principles & Applications of Imaging Radar, Manual of Remote Sensing, Volume 2, Floyd M. Henderson, Anthony J. Lewis, 1998, 3rd edition, ISBN 0-471-29406-3, John Wiley & Sons, Inc..

其他敘述 (包含講義、期刊、課程說明等)

評量方式* Grading

1. 作業 Assignments (Homeworks & Exercises): 50%

2. 期中考 Mid-term exam: 25%
3. 期末考 Term exam: 25%

學習規範 Course Policy

1. No cheating in the exam, homework, and exercise.
2. No use of mobile phones during class time.
3. Don't miss class, be late, or leave early.

課程網址 Course Website

https://moodle.ncku.edu.tw/course/view.php?id=26433

備註 Remarks

N.A.

課程與聯合國永續發展目標關聯程度調查 Survey of the course content relevent to UN SDGs

SDGs 參考網站 reference website: https://sustainabledevelopment.un.org/sdgs

本課程內涵是否與永續發展目標相關，若有相關請勾選。

Is the content of this subject concerning the following United Nations Sustainable Development Goals (SDGs)? If Yes, Please click.

	Yes
消除貧窮 (No poverty)	☑
消除飢餓 (Zero hunger)	☑
健康與福祉 (Good health and Well Being)	☑
教育品質 (Quality Education)	☐
性別平等 (Gender Equality)	☐
淨水與衛生 (Clean water and sanitation)	☑
可負擔能源 (Affordable and clean energy)	☑

就業與經濟成長 (Decent work and Economic growth)	☐
工業、創新與基礎建設 (Industry Innovation and infrastructure)	☐
減少不平衡 (Reduced Inequalities)	☐
永續城市與社區 (sustainable cities and communities)	☑
責任消費與生產 (Responsible consumption and production)	☐
氣候行動 (climate action)	☑
海洋生態 (Life below water)	☑
陸地生態 (Life on land)	☑
和平與正義制度 (Peace justice and strong institutions)	☐
全球夥伴 (partnerships for goals)	☐

若以上皆無相關 (請勾選)There is no concerning items above.(Please click) ☐

有關課程其他調查 Other Inquiries

1.本課程是否規劃業界教師參與教學或演講? ☐ 否 No ☐ 是 Yes ，約 ____ 次 times
Is there any industry specialist invited in this course? How many times?

2.本課程是否規劃含校外實習 (並非參訪)? ☐ 否 No ☐ 是 Yes ，約 ____ 小時 hours
Are there any internships involved in the course? How many hours?

*3.本課程是否可歸認為學術倫理課程? ☐ 否 No ☐ 是 Yes ，含學術倫理課程 ____ 小時 hours
Is this course recognized as an academic ethics course? In the course how many hours are regarding academic ethics topics?

4.本課程是否屬進入社區實踐課程? ☐ 否 No ☐ 是 Yes ，社區名稱 (Community

name) ☐

Is this course recognized as a Community engagement and Service learning course? Which community will be engaged?

*5.本課程是否邀請國外學者參與? ☐ 否 NO ☐ 是 Yes (填是者續填 If Yes, continue answering) ，總計參與時數 total participating ☐ 小時 hours.

Does this course in this semester invite foreign scholar(s) to participate in teaching?

*6.本學期課程是否有線上授課? ☐ 否 NO ☐ 是 Yes (填是者續填 If Yes, continue answering,"0" is OK)，

Does this course in this semester apply on line teaching?

同步 synchronous online teaching ☐ 小時 hours

非同步 asynchronous online teaching ☐ 小時 hours

同步與非同步混成 synchronous and asynchronous hybrid online teaching ☐ 小時 hours

以上總計線上授課 Total above on line teaching ☐ 小時 hours，其餘為實體課程 in-person teaching ☐ 小時 hours

調查問題 Please complete the following survey:

課程替代方案相關調查，以下為預先規劃方案調查，選課期間並不會列印於大綱公布，於疫情(相關特殊緊急狀況)發生時，請老師於 Moodle 系統公告所採取的不中斷學習措施，週知所屬學生。

This survey of course instruction alternatives from the NCKU Syllabus System is conducted to ensure students continue to study under special circumstances (such as epidemic prevention). Please note that course instruction alternatives will not be published on the NCKU Syllabus System during the course enrollment period. Instructors are required to publish their alternatives on Moodle should an epidemic or a special circumstance occur.

*1.授課教師是否有線上教學經驗? ☐ 是 Yes ☐ 否 No

Do you have any experience in online instruction?

*2.使用軟體 Applicable software： ☐ Moodle ☐ 其他 others ☐ ☐

無 No

*3.使用平台 Applicable platform： ☐ Moodle ☐ 其他 others ☐

無 No

4.相關需求與建議 Related needs and recommendations：

希望學校能繼續提供線上教學所需的週邊設備(含軟硬體)和平台，俾讓老師使用熟悉的線上教學系統Webex，可以有更多時間專注於教學內容的設計編輯準備，提升教學品質。

The hardware systems, software packages and digital learning platforms are expected to be also available and managed by the University. The teacher can continue to use the well-known Webex online teaching system. Thus, teachers could have much time to focus on the preparing the teaching materials and methods in order to give the teaching with as best quality as possible.

註 Notes：

1. 依據 109 年 3 月 19 日教育部通報關於因應疫情採遠距教學注意事項略以：為確保學生學習成效，進行遠距教學時應注意學生線上出席狀況，觀課與討論情形、評量方式等各面向情形，並保留相關紀錄，以利未來稽考。

According to the notice issued by the Ministry of Education on March 19, 2020, regarding distance learning during the epidemic prevention of COVID-19, instructors providing online course instruction for distance learning should keep track of students online in terms of attendance, participation, discussion, and performance to ensure their learning effectiveness. Related academic records shall be preserved to facilitate future verification.

2. 線上課程請依課程表訂時間授課，並請點名(可應用彈性作法，例如簡答題)保留學生參與線上學習紀錄。

Please conduct your online instruction according to the designated course schedule and make roll-calls (flexibly, such as asking a simple yes-no question). Online records of students participating in the course should be preserved.

3. 實體課程請依課程表訂時間授課，並請以 moodle 點名系統勾選出席學生紀錄。

Please conduct your classroom instruction according to the designated course schedule and keep a record of student attendance on the Moodle roll-call system.

4. 請將影音內容上傳至本校 Moodle 平台，提供學生於課後非同步線上學習與復習，提升學習成效。

Please upload your course videos to NCKU Moodle for students to study asynchronously or review after class to enhance their learning effectiveness.

5. 有關著作權問題，請多留意避免違法。

Please be cautious to avoid any infringement upon intellectual property rights.

6. 遠距教學設備操作問題請洽推廣教育中心王小姐，分機 51010

For information on equipment operation for distance education, please contact Miss Wang at ext. 51010 in the Center for Continuing Education.

7. 數位 TA 申請請洽教學發展中心楊小姐，分機 50202#24
If you intend to apply for teaching assistants for digital education, please contact Miss Yang at ext. 50202#24 in the Center for Teaching and Learning Development.
8. 以上 B 類課程，為符合教育部遠距課程上傳資料規定，尚需填寫申請表，表格下載網址:請於填寫核章後送課務組 http://cid.acad.ncku.edu.tw/p/412-1042-24595.php?Lang=zh-tw
In line with the regulations of the Ministry of Education on distance learning, those offering Type B course instruction are required to complete an application form (available at http://cid.acad.ncku.edu.tw/p/412-1042-24595.php?Lang=zh-tw), which shall be approved and submitted to the Curriculum Division.