GEOG 371

ADVANCED REMOTE SENSING TECHNIQUES

Course Syllabus – Fall 2017

OVERVIEW

Remote sensing is an important technique for environmental monitoring and scientific analysis. Remote sensing is used for global change studies (e.g. environmental change) and for more local scale applications such as urban landscape mapping, precision farming, and many other day-to-day activities. This course introduces and develops advanced remote sensing information extraction techniques that are increasingly used by municipalities, environmental consultancies, federal agencies, and industry. It builds on the fundamentals of remote sensing science and Earth observation systems (e.g. optical and microwave systems) introduced in GEOG 271. It focuses on current information extraction processes used by government and non-government organizations and by professional Earth and Environmental system science researchers to provide information about human and physical environments.

INSTRUCTOR

Dr. Su-Yin Tan

Office:	EV1-227
Phone :	519-888-4567, Ext. 38772
E-mail:	su-yin.tan@uwaterloo.ca (use LEARN mail system)
Office hours:	Friday, 12:00 p.m. - 1:30 p.m. (subject to change). By appointment if necessary.

LECTURES

Location:	Arts Lecture Hall (AL), Room 208
Time:	Friday, 2:30-4:20 p.m.

COURSE DESCRIPTION

This course focuses on the use of remote sensing to map key environmental states. Emphasis is placed on the application of remote sensing methods and data processing for analysis of physical and human environments. The course presents advanced multispectral and high resolution techniques for further remote sensing and Earth observation work and gives the student a strong basis from which to develop their analytical skills.

Course Learning Goals:

- Build upon material introduced in GEOG 271 and GEOG 165/181.
- Deepen student understanding of the physical principles underlying remote sensing measurements.
- Develop expertise in applying appropriate image processing and data modeling techniques for selected applications (e.g., land cover classification, urban form mapping, Earth system mapping).
- Be able to understand the uncertainties throughout the information extraction process.
- Develop an awareness of current remote sensing themes through directed readings.
- Understand how a remote sensing product can be integrated in a GIS project framework.
- Gain and develop a strong working knowledge of standard image processing software for remote sensing applications.

LEARNING OUTCOMES

At the end of the course, students will have a stronger understanding of the remote sensing approach to monitoring and mapping the Earth surface. Students will understand and be able to apply judiciously a range of information extraction methods and be able to quantify the error and uncertainty in the methods used. Students will also be ready to undertake GEOG 471, the Remote Sensing Project.

SUPPORT STAFF

- ***Teaching Assistants:***
  (Office hours: TBA – posted on LEARN Location: General Use Lab, EV2-1001)

  Veniamin Bondaruk vbondaru@uwaterloo.ca
  Aaron Thompson a4thompson@uwaterloo.ca

- ***MAD Assistant – Remote Sensing Specialist:***

  Mike Lackner
  Office: By appointment only (ask at MAD Helpdesk)
  Phone: 519-888-4567 Ext. 36563
  E-mail: mlackner@uwaterloo.ca (use LEARN mail system)

PREREQUISITE

It is essential that you can recall your knowledge from GEOG 165/GEOG 181 and GEOG 271, since these courses form the foundations for GEOG 371.

WEEKLY LECTURES AND CONDUCT

Each week, a lecture will be delivered presenting new material to students. Where appropriate you will be encouraged to participate in what should be a supportive learning environment. You may use a laptop or device to make notes only. Otherwise, laptops and devices must be shut down during the course of the lecture. Use of a device or laptop for purposes other than notetaking may result in you being asked to leave the lecture hall.

WEEKLY LABS

Location: Geddes Computer Lab (EV2, Room 1002A)
Software: ENVI, eCognition Trial
Times: Schedule listed below [Lab section number in brackets]
*** Only attend the lab session you are assigned to, otherwise assignments submitted to different lab sections will not be marked ****

Tuesday:	**2:30 p.m.-4:20 p.m. [102]**	**Friday:**	**10:30 a.m.-12:20 p.m. [101]**
	4:30 p.m.-6:20 p.m. [104]		**4:30 p.m.-6:20 p.m. [103]**

- Lab sessions are held every week and conducted by teaching assistants (TA's)
- **Lab access:** Access to the Geddes computer lab is restricted by code to those enrolled in particular courses including GEOG 371. Food and/or drink are <u>not</u> permitted in the Geddes lab (EV2-1002A).

- **Back-ups:** Students are responsible for maintaining their own back-ups of their work. There are a number of options available for backing up your work, including the network drive for ENV students. It is suggested that you keep two copies of your work in separate locations. Remember that you are only as far ahead as your latest backup!
- **Teaching assistants (TAs):** Please contact your TA first for lab-related questions before contacting the instructor or MAD assistant.
    - The TA's are responsible for introducing new assignments and guiding you to learn concepts and software. TA's will not give you answers to assignment questions.
- **Switching lab sections:** In rare instances, the TA may be consulted at the beginning of the course and a switch may be granted if room is available.

EVALUATION

Labs: (total of 9 assignments)

Assignment 1 & 7 (5% each)	10 %
Assignments 2 to 6 & 8 to 9 (10% each)	70 %
Attendance Bonus Marks	+ 3% bonus

Exams:

Midterm Exam:	20 %

- **Lab assignment details:** There are **nine lab assignments to be submitted** that will form the final lab grade. Each assignment builds on lecture content and the lab exercises in the previous 2-3 weeks.
    - *Each lab assignment is to be completed and handed in hardcopy form at the start of their lab in the following week (as indicated in the course schedule). Students must also submit their digital copy via the drop box on LEARN.* It will be graded and returned to the student within two weeks of submission. Late student submissions will take longer to grade and return.
    - A cover sheet must be completed with all assignment hardcopy submissions (see below for the format).
- An unseen written **Midterm Exam** is set for 3 November *in class* and accounts for the remaining 20% of the course. Questions will be based on material and readings covered in preceding weeks of the course.
- **Academic Integrity:** Please make sure that you are familiar with what constitutes academic integrity from the University's web site http://www.lib.uwaterloo.ca/ait/**.** You should familiarize yourself with this web site. Sanctions/penalties will be applied to submitted work where the rules are not followed.

UNIVERSITY OF WATERLOO LEARN COURSE ENVIRONMENT

This course uses the LEARN course environment for course material dissemination and information exchange. It will also be used for submitting coursework. LEARN is a web-based course management system that enables instructors to manage course materials (posting of lecture notes, etc.), interact with their students (drop boxes for student submissions, on-line quizzes, discussion boards, course e-mail, etc.), and provide feedback (grades, assignment comments, etc.). PLEASE ENSURE THAT YOU CAN ACCESS LEARN.

Logging Into LEARN

LEARN is a web-based system – you will require use of a browser and enter in the following URL: https://learn.uwaterloo.ca. Please note that announcements regarding LEARN (service outages, etc.) and important course announcements (e.g., rescheduled classes) are posted. It is a good idea to check the LEARN course site regularly. For getting help, a LEARN student guide can be found at http://uwaterloo.ca/learn-help.

TEXT AND READINGS

Recommended Text:

Students should focus on material presented in lectures and lab sessions. The recommended text should be used to provide further explanation and examples of concepts and techniques discussed in the course.

Jensen, J.R., 2015. Introductory Digital Image Processing: A Remote Sensing Perspective, Fourth Edition. Prentice Hall, Toronto, Canada, 623pp.

- Hardcopy is available in the bookshop.
- Online version is available for purchase.
- 2 copies available in library for 3-hour loan (G70.4 .J46 2005, G70.4 .J46 2016)
- Used books?

Other Useful Remote Sensing Textbooks:

- Campbell, J.B., 2011. Introduction to Remote Sensing, Fifth Edition. The Guilford Press, 626pp.
- Jensen, J.A., 2007. Remote Sensing of the Environment: An Earth Resource Perspective, Second Edition. Prentice Hall, Toronto, Canada, 592pp.
- Lillesand, T.M., R.W. Kiefer, and J.W. Chipman, 2004. Remote Sensing and Image Interpretation, Fifth Edition. John Wiley & Sons, Canada, 784pp.
- Mather, P.M., 2004. Computer Processing of Remotely-sensed Images, Third Edition. John Wiley & Sons Canada, 442pp.
- Mather, P.M. and B. Tso, 2009. Classification Methods for Remotely Sensed Data, Second Edition. CRC Press, 376pp.
- Richards, J.A., 2013. Remote Sensing Digital Image Analysis: An Introduction, Fifth Edition. Springer. Available Online through UW Library Service.

This course deals with advanced remote sensing and digital information extraction methods. The recommended text (Jensen, 2015) covers many image processing aspects in the course with others covered by the other texts. For students planning to take GEOG 471, it is recommended that you obtain a copy of this text, as it will be a useful reference in this project course.

COURSE POLICIES:

Required Course Supplies:

USB flash drive for backing up work. Printing credit for lab assignment submissions, if necessary.

Resources:

ENVI software is used for all lab work in this course. Manuals are available as on-line help files. Students are expected to use the on-line help to obtain information on operations that are not fully detailed in the assignments. Other resources will also be posted on the LEARN webpage.

Late Penalty:

It is in your best interest to keep to the deadlines for assignment submission. Late work will be penalized with 10% deducted from the assignment for each day or part thereof for which the work is late. **Assignments which are submitted beyond 5 days after the due date will not be accepted and a mark of 0 will be awarded.** Late work will receive no feedback. Authorized medical notes, or requests that have been granted by the instructor ***prior to the deadline*** are the only valid way of obtaining an extension.

Submit all assignments directly to your TA at the beginning of your lab session. If an assignment is submitted after the start of the lab session in which it is due, it will be penalized for that day.

Late lab assignments should be submitted to Jesse MacLeod (Departmental Administrator) in EV1, Rm 115 during normal working hours, who will time stamp assignments upon receipt. All late lab assignments should be clearly labeled with your lab section number and TA. The late penalty will be counted from and including the submission date (as indicated by time stamp). You assume all risk for lost or missing material.

Lab Attendance:

A bonus 3% marks will be awarded for lab attendance. TA's will record lab attendance for each lab section. 1% of the total grade will be deducted for a recorded absence up to a maximum of three.

TA's will only accept submitted lab assignments from students in their assigned lab section. Therefore, students should only attend their assigned lab section, otherwise assignments submitted to a different session will not be graded.

Rescheduling Cancelled Classes:

Lectures may be cancelled (as indicated in the course schedule) and a make-up class may be rescheduled. A date/time will be selected based on a class poll of availability and with majority agreement. Maximum effort will be made to select a schedule conflict-free time, but if no such time is identified, the instructor will make alternative arrangements either individually, scheduling a Saturday class, or offering an alternate time/option.

UW POLICIES:

Unclaimed Assignments:

Unclaimed assignments will be retained until one month after term grades become official in Quest. After that time, they will be destroyed in compliance with UW's confidential shredding procedures. https://uwaterloo.ca/central-stores/confidential-shredding

Academic Integrity:

To create and promote a culture of academic integrity, the behavior of all members of the University of Waterloo is based on honesty, trust, fairness, respect and responsibility.
http://www.uwaterloo.ca/academicintegrity/
Students who are unsure what constitutes an academic offence are requested to visit the on-line tutorial at http://www.lib.uwaterloo.ca/ait/

Research Ethics:

Please also note that the University of Waterloo requires all research conducted by its students, staff, and faculty, which involves humans as participants to undergo prior ethics review and clearance through the Director, Office of Human Research and Animal Care (Office). The ethics review and clearance processes are intended to ensure that projects comply with the Office's Guidelines for Research with Human Participants (Guidelines), as well as those of provincial and federal agencies, and that the safety, rights and welfare of participants are adequately protected. The Guidelines inform researchers about ethical issues and procedures, which are of concern when conducting research with humans (e.g. confidentiality, risks and benefits, informed consent process, etc.). If the development of your research proposal consists of research that involves humans as participants, then please contact the course instructor for guidance and see http://iris.uwaterloo.ca/ethics/

Note for Students with Disabilities:

The AccessAbility Office, located in Needles Hall, Room 1132, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with the AccessAbility Office at the beginning of each academic term.

Mental Health:

The University of Waterloo, the Faculty of Environment and our Departments consider students' well-being to be extremely important. We recognize that throughout the term students may face health challenges – physical and / or emotional. **Please note that help is available.** Mental health is a serious issue for everyone and can affect your ability to do your best work. Counselling Services (www.uwaterloo.ca/counselling-services) is an inclusive, non-judgmental, and confidential space for anyone to seek support. They offer confidential counseling for a variety of areas including anxiety, stress management, depression, grief, substance use, sexuality, relationship issues, and much more.

Religious Observances:

Student needs to inform the instructor at the beginning of term if special accommodation needs to be made for religious observances that are not otherwise accounted for in the scheduling of classes and assignments.

Grievance:

A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70 - Student Petitions and Grievances, Section 4, http://www.adm.uwaterloo.ca/infosec/Policies/policy70.htm. When in doubt please contact your Undergraduate Advisor for details.

Discipline:

A student is expected to know what constitutes academic integrity, to avoid committing academic offence, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offense, or who needs help in learning how to avoid offenses (e.g., plagiarism, cheating) or about "rules" for group work/collaboration should seek guidance from the course professor, academic advisor, or the Undergraduate Associate Dean. When misconduct has been found to have occurred, disciplinary penalties will be imposed under Policy 71 - Student Discipline. For information on categories of offences and types of penalties, students should refer to Policy 71 - Student Discipline, http://www.adm.uwaterloo.ca/infosec/Policies/policy71.htm.

Appeals:

A student may appeal the finding and/or penalty in a decision made under Policy 70 - Student Petitions and Grievances (other than a petition) or Policy 71 – Student Discipline if a ground for an appeal can be established. Read: Policy 72 - Student Appeals, http://www.adm.uwaterloo.ca/infosec/Policies/policy72.htm

Turnitin:

Plagiarism detection software (Turnitin) will be used to screen assignments in this course. This is being done to verify that use of all materials and sources in assignments is documented. Students will be given an option if they do not want to have their assignment screened by Turnitin. In the first week of the term, details will be provided about arrangements and alternatives for the use of Turnitin in this course. For further information on UW's Turnitin guidelines, see: http://uwaterloo.ca/academic-integrity/home/guidelines-instructors

LEARN:

Users can login to LEARN via: http://learn.uwaterloo.ca/ using your WatIAM/Quest username and password. Available documentation: http://av.uwaterloo.ca/uwace/training_documentation/index.html

COURSE SCHEDULE

Term Week (*Week begins on Monday*)	**LECTURES**		**LABS** (*101, 102, 103, 104*)	
	Lecture Date (*Friday*)	**Lecture Topic**	**Lab Topic**	**Grade**
1 (Sep 4-8)	Sep. 8	**RS Instrument characteristics and orbits: Spatial and temporal resolution** (*Substitute Instructors: Aaron Thompson & Mike Lackner*)	None	N/A
	Readings: Jensen (2015) textbook: Chapters 1 & 2 Dewitte, O., Jones, a., Elbelrhiti, H., Horion, S., & Montanarella, L. (2012). Satellite remote sensing for soil mapping in Africa: An overview. *Progress in Physical Geography*, 36(4), 514–538. doi:10.1177/0309133312446981. Wang, K., Franklin, S. E., Guo, X., He, Y., & McDermid, G. J. (2009). Problems in remote sensing of landscapes and habitats. *Progress in Physical Geography*, 33(6), 747–768. doi:10.1177/0309133309350121			
2 (Sep 11-15)	Sep. 15	**Image quality, geometric and radiometric correction**	**A1 – Introduction to ENVI: Image contrast enhancement, spatial filters** (*Sep. 12 & Sep. 15*)	A1 (5%, due Week 3)
	Readings: Jensen, (2015) textbook: Chapters 4 - 7 Smith, D.P. and S.F. Atkinson (2001). Accuracy of rectification using topographic map versus GPS ground control points. *Photogrammetric Engineering and Remote Sensing*, 67(5): 565-570. (TA593.A2 P5) Song, C., Woodcock, C., Seto, K., Lenney, M., & Macomber, S. (2001). Classification and change detection using Landsat TM data: when and how to correct atmospheric effects? *Remote Sensing of Environment*, 75(00), 230–244.			
3 (Sep 18-22)	Sep. 22	**Image enhancements and image transformations**	**A2 – Image Pre-processing: Analyzing image quality, re-projecting data, and radiometric correction** (*Sep. 19 & Sep. 22*)	A2 (10%, due Week 4)
	Readings: Jensen (2015) textbook: Chapters 5 & 8 Huete, A., Liu, H., Batchily, K., & van Leeuwen, W. (1997). A comparison of vegetation indices over a global set of TM images for EOS-MODIS. *Remote Sensing of Environment*, 59, 440–451. Zhao, G. and Maclean, A.L. (2000) A comparison of canonical discriminant analysis and principal component analysis for spectral transformation, *Photogrammetric Engineering and Remote Sensing*, 66(7): 841-847. (TA593.A2 P5)			
4 (Sep 25-29)	Sep. 29	**Per pixel classification: Unsupervised [ISODATA] & supervised [MLC/SVM]**	**A3 – Image Transformation: TC, PCA, pan-sharpening** (*Sep. 26 & Sep. 29*)	A3 (10%, due Week 5)
	Readings: Jensen (2015) textbook: Chapter 9 Xie, Y., Sha, Z., & Yu, M. (2008). Remote sensing imagery in vegetation mapping: a review. *J. Plant Ecology*, 1: 9–23. doi:10.1093/jpe/rtm005 Wu, W. and Shao, G. (2002) Optimal combinations of data, classifiers, and sampling methods for accurate characterizations of deforestation, *Canadian Journal of Remote Sensing*, 28(4): 593-600. (TR810 .C35x)			

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5 (Oct 2-6)	Oct. 6	**Lidar I: Introduction to Lidar RS**	**A4 – Classification: ISODATA + MLC/MH/SVM** (*Oct. 3 & Oct. 6*)	A4 (10%, due Week 7)
	Readings: Jensen (**2007**) Chapter 10. Lidar Remote Sensing			
6 (Oct 9-13)	Oct. 13	**THANKSGIVING HOLIDAY & FALL STUDY DAYS**	No labs scheduled	N/A
7 (Oct 16-20)	Oct. 20	**Lidar II: Lidar data processing + Midterm Briefing**	**A5 – Lidar 1: Airborne Lidar & Analysis** (*Oct. 17 & Oct. 20*)	A5 (10%, due Week 8)
	Readings: Jensen (**2007**) textbook: Chapter 10. Lidar Remote Sensing Weltz, M., Ritchie, J., & Fox, H. (1994). Comparison of laser and field measurements of vegetation height and canopy cover. *Water Resources Research*, 30(5), 1311–1319. St-Onge, B., & Jumelet, J. (2004). Measuring individual tree height using a combination of stereophotogrammetry and lidar. *Canadian Journal of Forest Research*, 34(10), 2122–2130. doi:10.1139/X04-093 Special Issue: *Photogrammetric Engineering and Remote Sensing*, March 2011 (Vol 77, No. 3) Various papers on lidar RS for forest biomass. Hellesen, T., & Matikainen, L. (2013). An Object-Based Approach for Mapping Shrub and Tree Cover on Grassland Habitats by Use of LiDAR and CIR Orthoimages. *Remote Sensing*, 5(2), 558–583. doi:10.3390/rs5020558			
8 (Oct 23-27)	Oct. 27	**Accuracy Assessment**	**A6 – Lidar 2: Field Work & Airborne/Ground-based Lidar Integration** (*Oct. 24 & Oct. 27*)	A6 (10%, due Week 10)
	Readings: Jensen (2015) textbook: Chapter 13 Congalton, R. (1991). A review of assessing the accuracy of classifications of remotely sensed data. *Remote Sensing of Environment*, 37: 35–46. Foody, G. M. (2002). Status of land cover classification accuracy assessment. *Remote Sensing of Environment*, 80(1), 185–201. doi:10.1016/S0034-4257(01)00295-4			
9 (Oct 30-Nov 3)	Nov. 3	**MIDTERM EXAM**	**A6 (cont.) – Lidar 3: Field Work & Airborne/Ground-based Lidar Integration** (*Oct. 31 & Nov. 3*)	Midterm 20%
10 (Nov 6-10)	Nov. 10	**Object-based Image Analysis (OBIA)** *(possible rescheduling – TBA)*	**A7: Accuracy Assessment** (*Nov. 7 & Nov. 10*)	A7 (5%, due Week 11)
	Readings: Jensen (2015) textbook: Chapter 13 Blaschke, T. (2010). Object based image analysis for remote sensing. *ISPRS Journal of Photogrammetry and Remote Sensing*, 65(1), 2–16. doi:10.1016/j.isprsjprs.2009.06.004 Myint, S. W., Gober, P., Brazel, A., Grossman-Clarke, S., & Weng, Q. (2011). Per-pixel vs. object-based classification of urban land cover extraction using high spatial resolution imagery. *Remote Sensing of Environment*, 115(5), 1145–1161. doi:10.1016/j.rse.2010.12.017			
11 (Nov 13-17)	Nov. 17	**Radar I: Advanced radar systems (TSX, RSAT2, ALOS)**	**A8: OBIA eCognition example** (*Nov. 14 & Nov. 17*)	A8 (10%, due Week 12)
	Readings: Jensen (2007) textbook: Chapter 9			

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12 (Nov 20-24)	Nov. 24 **Radar II: Radar applications**	**A9: Radar Remote Sensing** (*Nov. 21 & Nov. 24*)	A9 (10%, due Week 13)
	Readings: Jensen (2007) textbook: Chapter 9 Rosenqvist, A., & Shimada, M. (2007). ALOS PALSAR: A pathfinder mission for global-scale monitoring of the environment. *IEEE Transactions on Geoscience and Remote Sensing*, 45(11), 3307–3316. Kovacs, J. M., Vandenberg, C. V., Wang, J. and F. Flores-Verdugo (2008) The use of multipolarized spaceborne SAR backscatter for monitoring the health of a degraded mangrove forest. *Journal of Coastal Research*, 24: 248-254. (doi:10.2112/06-0660.1)		
13 (Nov 27-Dec 1)	Dec. 1 **Change Analysis + Roundup**	**No Lab (A9 due only)** (*Nov. 28 & Dec. 1*)	N/A
14 (Dec 4)	-- --		

Notes:
- UW Fall 2017 term classes begin on Sep. 7 (Th) and end on Dec. 4 (M)
- All weeks indicated in the schedule begin on Mondays
- Labs are assigned and due at the start of your registered lab session in the week indicated
- The instructor reserves the right to modify the schedule and topics during the term
- The course instructor and TAs will endeavor to respond to e-mail queries within 3 business days, although this may vary depending on the timing of term and prior to course assignment/exam deadlines. Only University of Waterloo-derived email address requests will be answered.

Holidays and University Closures:
- Sep. 4 (M) for Labour Day
- Oct. 9 (M) for Thanksgiving Day
- Oct. 10, 11 (T, W) for Fall Study Days

GEOG 371 Lab Assignment Checklist
(*To be completed and submitted with ALL assignments*)

Please read the checklist below following the completion of your assignment. Once you have verified these points, hand in this signed checklist along with your assignment (e.g., stapled at the front or back).

1. I have referenced and footnoted all ideas, words or other intellectual property from other sources used in the completion of this assignment.

2. I have included a proper bibliography, which includes acknowledgement of all sources used to complete this assignment.

3. This assignment was completed by my own efforts and I did not collaborate with any other person for ideas or answers.

4. This is the first time I have submitted this assignment or essay (either partially or entirely) for academic evaluation.

Signed:_____ Date:_____

Print Name: _____ UW-ID# _____